Contribution of hay harvest losses and "leaf fall" to N cycling and the N nutrition of intercropped alfalfa and bromegrass.

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A significant amount of forage plant biomass is deposited on the ground as senescent leaves, petioles and flowers (leaf fall). In addition, a varying amount of plant biomass is lost during harvest of hay crops (hay loss). These two sources of plant biomass and nitrogen (N) were quantified over a 3-year period in replicated plots of single or intercropped alfalfa (*Medicago sativa* cv. Beaver) and meadow bromegrass (*Bromus riparius* Rhem. cv. Fleet) swards grown under irrigation near Outlook. Another experiment in the same field provided an estimate of the quantity of N in the hay losses or leaf fall that was recycled between or within the two species. Alfalfa plants grown on ^{15}N enriched soil supplied ^{15}N labelled leaf fall and hay loss biomass which was applied to intercropped swards. The proportion of N taken up by bromegrass or alfalfa was estimated. Similarly, ^{15}N labelled bromegrass biomass was applied to intercropped swards and the uptake by each of the species was estimated. Leaf fall from alfalfa, bromegrass or alfalfa+bromegrass swards contained an average of 22, 6, and 16 kg N ha^{-1} $year^{-1}$, respectively, whereas hay losses returned an average of 26, 9, and 22 kg N ha^{-1} $year^{-1}$, respectively. The accumulation of ^{15}N from those two N sources was detected in neighbouring plants as early as 13 days following application of the simulated leaf fall or hay losses.

INTRODUCTION

Leaf fall (senescent leaves, petioles and flowers) and hay losses during harvest are sources of N can be recycled or transferred to neighbour plants of the same or other species. This work as a part of a broader study on the mechanisms of nitrogen transfer (movement of N between growing plants) evaluates the importance of leaf fall and hay loss to the N nutrition and herbage yield of alfalfa and associated bromegrass.

Leaf fall is reported as the most important N transfer mechanism in tropical grass-legume associations (Whitney and Kanehiro, 1967). Similarly, hay lost during harvest contain N that is transferred or recycled by plants of the same species. Under fair conditions those mechanical hay losses amount to 10% of hay DM (Walton, 1982) and can be as high as 25% if herbage has a moisture content below 40% during raking (University of Saskatchewan, 1987).

Losses of N by volatilization and denitrification occur during mineralization of organic material. In addition, the type and amount of soluble polyphenolics present in leaves influences the net release or immobilization of N (Palm and Sanchez, 1991). Thus, only a fraction of N in leaf fall or hay loss becomes available for plant nutrition.

MATERIAL AND METHODS

Replicated plots of single or intercropped alfalfa (*Medicago sativa* cv. Beaver) and meadow bromegrass (*Bromus riparius* Rhem. cv. Fleet) were seeded on May 23, 1990, on an irrigated field near Outlook, Saskatchewan, (Saskatchewan Irrigation Development Centre), on a Bradwell sandy loam (Typic Boroll) soil.

Leaf fall was collected in 1 m^2 of each plot, by hand and/or with a vacuum cleaner. In addition, the amount of hay lost at harvesting was determined in the same sampling area.

The ^{15}N-labelled alfalfa and bromegrass herbage, used to simulate leaf fall/hay loss, was obtained in an area of the same swards that was fertilized with ammonium-^{15}N-nitrate-^{15}N at time of seeding.

Leaf fall and hay loss were removed from the entire plots which subsequently received a simulated ^{15}N-labelled leaf fall/hay loss. The ^{15}N-labelled herbage was applied on alfalfa-bromegrass microplots framed with metal quadrates (45.5 X 30.5 cm by 15 cm deep). One set of microplots received a rate of 200 g m^{-2} of ^{15}N-labelled alfalfa + 200 g m^{-2} of non ^{15}N-labelled bromegrass. Another set of microplots received identical rates of ^{15}N-labelled bromegrass + non ^{15}N-labelled alfalfa. The proportion of stems to fines (leaves, petioles and fine stems) on alfalfa herbage was of 1 : 3 by dry weight. The non-enriched herbage applied with the ^{15}N-labelled simulated leaf fall/hay loss had the purpose of mimic effects caused by the eventual interaction of compounds released by plant material of the two species under natural conditions. The fate of ^{15}N of leaf fall/hay loss applied in July 30, 1991 was determined on the three following forage harvests (August 11, 91; June 15, 92; and August 11, 92).

Herbage was analyzed for N and for ^{15}N on a Europa Scientific ANCA system mass spectrometer. Leaf fall or hay loss (residue) N use efficiency (%RUE) was calculated using the formula: (N derived from leaf fall or hay loss in harvested hay/ N in leaf fall or hay loss) *100). The calculations of % N derived from leaf fall/hay loss, %RUE and N transfer were based on the ^{15}N dilution technique.

RESULTS AND DISCUSSION

Bromegrass did not shed leaves during the first year. During the three years of this study alfalfa's leaf fall and hay harvest losses returned larger amounts of N to the cropping system than bromegrass' (Table 1). The ^{15}N isotope dilution calculations show that alfalfa was more competitive than bromegrass at recovering N of either alfalfa or bromegrass leaf fall/hay loss (Table 2). The amount of N from leaf fall or hay loss transferred from bromegrass to alfalfa was larger than the N transferred from alfalfa to bromegrass (Table 3).

Over the three years the N recycled by alfalfa plus the N transferred from bromegrass to alfalfa amounted to double the N taken up by bromegrass plants (Table 3). However, the amount of N taken up by bromegrass constituted a larger proportion of the hay-N yield than that of alfalfa (Table 4) because the N yield of alfalfa was much larger, as it derived a large proportion of its N from N_2 fixation.

Table 1. Leaf fall and hay loss dry matter (DM) and nitrogen (N) yield, 3-year average.

Treatment	Leaf fall		Hay loss	
	DM	N	DM	N
	(kg/ha)			
Alfalfa, single	1179	22	1321	26
Bromegrass, single	527	6	640	9
Bromegrass, intercropped	168	3	480	7
Alfalfa, intercropped	637	13	761	15
SE	68	1	61	1

Note: n=4

Table 2. Leaf fall or hay loss (residue) N use efficiency (%RUE) at three hay harvests (13, 321 and 378 days) following a simulated leaf fall/ hay loss.

Treatment	Hay harvest time		
Donor → Recipient	Aug. 91 13 days	June 92 321 days	Aug. 92 378 days
	(%)		
Bromegrass → bromegrass	1.1±0.4	4.2±0.5	2.4±0.2
Bromegrass → alfalfa	0.2±0.3	8.6±2.6	1.3±0.5
Alfalfa → bromegrass	1.1±0.4	2.9±0.5	2.0±0.2
Alfalfa → alfalfa	0.2±0.1	5.3±1.3	0.9±0.4

Note: n=6

Table 3. Amount of N from leaf fall (LF) or hay loss (HL) transferred to alfalfa or bromegrass by its associated crop or recycled by plants of the same species over three years.

Treatment	year 1	year 2	year 3	Average of
Donor → Recipient	LF	LF + HL	LF + HL	3 years
	(grams of N ha^{-1})			
Bromegrass → bromegrass	0	879	222	367
Alfalfa → bromegrass	61	1361	651	691
Bromegrass → alfalfa	0	1799	454	751
Alfalfa → alfalfa	11	2440	1167	1206
SE	11	73	46	20

Note: n=6

Table 4. Proportion of N from leaf fall/hay loss contributing to the N yield in three consecutive hay harvests following a simulated leaf fall/hay loss (% N derived from leaf fall or hay loss).

Treatment	Hay harvest time		
Donor → Recipient	Aug. 91 13 days	June 92 321 days	Aug. 92 378 days
	(% of N yield)		
Bromegrass → bromegrass	2.8±0.8	9.4±0.7	6.8±0.6
Alfalfa → bromegrass	4.6±0.8	8.9±1.8	7.5±0.9
Bromegrass → alfalfa	0.1±0.1	3.2±1.0	0.3±0.1
Alfalfa → alfalfa	0.2±0.1	4.0±0.8	0.4±0.2

CONCLUSIONS

Nitrogen from bromegrass leaf fall plus hay loss amounted to an average of 10 kg.ha^{-1}.year^{-1} whereas N from alfalfa added to almost three times that amount (28 kg.ha^{-1}.year^{-1}).

The average by donor species of the sum of %RUE on the three hay harvests shows that a smaller proportion of leaf fall and hay loss of alfalfa than bromegrass (6.2 vs. 8.9%) was contributing to the hay-N yield. This is probably due to the more resistant nature of the alfalfa (simulated) leaf fall/hay losses which had a quarter of the DM made by stems. Alfalfa as a recipient of N from leaf fall/hay loss was more competitive than bromegrass (8.3 vs 6.9%).

Over the three years leaf fall plus hay losses contributed an average of 1 kg N.ha^{-1}.year^{-1} to the bromegrass hay-N yield and approximately twice as much to the alfalfa hay-N yield.

The average N transfer from the N-deprived bromegrass to alfalfa, in the three year period, was larger than the amount of N transferred from the N_2-fixing species to bromegrass which was relying mainly on soil mineral N. To the best of our knowledge this is the first report of N transfer from grass to legume plants.

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