INTERPRETING INDICATORS OF A TRANSFER OF N FROM LEGUME TO GRASS IN COMPETITION STUDIES

P. G. Tow

Department of Agronomy and Farming Systems The University of Adelaide, Roseworthy Campus, Roseworthy, South Australia, 5371, Australia

ABSTRACT

The transfer of N from legume to grass in mixtures is important for regulating competition. In competition studies which include both monocultures and mixtures, N transfer should be detectable by grass N measurements but may be masked by competitive reductions in grass growth. In the study reported here, whole plant DM and N were measured in *Panicum maximum* var *trichoglume* and *Neonotonia wightii* grown in monocultures and additively in mixtures. While competition reduced whole grass plant DM and N in mixture relative to monoculture, higher grass shoot % N and N yield in the mixture at early harvests appeared reliable indicators of N transfer. In another experiment, monocultures and mixtures were grown in a replacement series with and without rhizobial N fixation. Higher grass shoot %N was a reflection of lower grass plant density in the mixtures. However grass shoot N yields in the mixtures consistently greater than in monoculture over at least a few harvests appeared a reliable indication of N transfer.

KEYWORDS

Grass, legume, competition, N Transfer, Additive Design, Replacement Design

INTRODUCTION

The transfer of nitrogen from pasture legumes to associated grasses is important in regulating competition between these components. Nitrogen gained by the grass increases its competitive ability. This in turn may reduce N fixation and transfer by the legume. Thus a dynamic equilibrium may result (deWit *et al*. 1966; Tow 1993).

Where grass and legume are grown in both monoculture and mixture, improved grass growth and N transfer in the mixture eventually become apparent because of death and mineralisation of legume plant residues. However, over shorter periods small amounts of transfer may be masked by competitive reductions in grass growth.

In this paper, results from two studies (deWit *et al*. 1966; Tow 1968) are used to test the possibility of using grass shoot N yield and % N as indicators of N transfer in short term studies using low N soil.

MATERIALS AND METHODS

The experiment was conducted on the Atherton Tableland, Queensland, Australia (17°14'S and 145°30'E). The main experiment (Experiment A) lasted 2 1/2 years and a partial repetition (Experiment B), 1 year.

EXPERIMENT A

The tropical species *Panicum maximum* var *trichoglume* cv. Petrie green panic and *Neonotonia wightii* cv. Tinaroo glycine were grown in monocultures and mixtures in volcanic red clay loam in 58 l containers outdoors. Plant densities were 3 plants/container in monocultures and six (three of each species) in the mixture (additive design). There were initially 24 replications of each of the three cultures (72 containers), to provide for 3 replications each of 8 Time treatments (serial excavations of whole plants) in the second year after establishment.

The experiment was sown on 16 April 1960. Following slow winter growth, the first harvest was made on 14 December. Complete mineral nutrients except nitrogen were added periodically during the experiment. Rainfall was supplemented with N-free water to prevent water deficits with minimal leaching. Leachate was tested regularly for nitrate and ammonium content.

At all harvests, shoots of grass and legume in mixtures were separated for DM and N determinations. In year 1 (to September 1961) there were five defoliation harvests of all containers. Defoliation harvests continued in year 2 on those containers awaiting excavation. At excavation all root systems were washed free of soil. Roots of green panic and glycine in mixture were separated under water. From Excavation 4, grass shoots were separated into leafy shoot and shoot base components.

Nitrogen analyses were done on shoot clippings bulked to form 3 replications of each treatment, and on plant components of each replication of each Time treatment. Samples of topsoil and subsoil were cored from each container just prior to excavation for total N determination.

EXPERIMENT B

A partial repetition of the experiment was sown on 12 January 1962 to re-examine grass-legume relationships in the first year. Three shoot harvests were made before Time treatment 1 was excavated on 26 September. Plants of Time treatment 2 were harvested 5 times before excavation on 7 December.

RESULTS AND DISCUSSION

The whole plant data for year 2 (Table 1) provide strong evidence for a transfer of N from legume to grass. By the end of the experiment (Time treatment 8), cumulative grass shoot N yields over year 2 were 501 mg per container in mixture and 234 mg in monoculture.

There was a significant ($P<0.01$) trend over year 2 for total soil N values in the grass-legume culture to increase over those in the grass monoculture. The final estimated gain was 5.2g N per container. Because fallen glycine leaf was removed from the soil surface, little if any transferred or accumulated N would have originated from this source.

In contrast to year 2 there was no net gain of N by the grass in the mixture in year 1, (Experiment B data). The higher plant density in the mixture reduced grass plant size compared to the monoculture throughout year 1. This was more apparent in root yields than shoots (Tow 1968). However, there were indications of improved N status of grass in mixture in the higher % N and N yield of harvested leaf (Table 2). Furthermore at Excavation 1 in Experiment B, the leafy shoot of green panic in mixture contained 42% of total plant N compared with 30% in monoculture plants. Corresponding values for Excavation 2 were 45% and 33%.

Higher shoot:root ratios and higher % N can be caused by shading. Shading of grass by legume is unlikely to be the cause of these effects in the present experiment because, after harvest 1, shoot growth of the grass was no longer significantly lower than in the monoculture in the mixture. Furthermore, photographs of the experiment show little if any shading of the upright grass by the trailing in the well-spaced pots. Thus in this experiment, the higher % N and subsequent

higher shoot N yields in green panic associated with glycine in the first year appear to be reliable indicators of a transfer of N from legume to grass.

In another experiment conducted by the author with green panic and glycine (deWit *et al.*, 1966), a replacement series planting design was used, with 4 grass plants per pot in the monoculture and 3, 2 and 1 grass plants per pot in three mixtures using low N soil. Mixtures and legume monoculture were grown with (R1) and without (Ro) rhizobial inoculation.

The % N of the grass was higher in each R1 mixture than in the monoculture at each of 7 harvests. On the basis of the discussion above, this should indicate a transfer of N from legume to grass. However the same effect was obtained in the Ro treatment. In both treatments (with and without N fixation) % N of mixture grass increased with decreasing number of grass plants in the mixture. This indicates an increase in availability of N per grass plant with decreasing grass plant density and leaves the question of N transfer unanswered.

Better evidence from N transfer was provided by a comparison of shoot harvest N yields per container. It was found that in R1, green panic in mixture yielded more N than in monoculture in almost all mixtures from Harvest 2 onwards. In contrast, in Ro, grass N yield per pot was almost always lower in mixture than in monoculture especially at a grass density of 1 plant/pot, because of competition from the legume. These differences are clearly shown by total N yields (mg per pot) of the 7 harvests, and are strong indications that a transfer of N from legume to grass occurred in the R1 treatment.

	1 plant	2 plants	3 plants	Monoculture
Ro	25.5	36.8	33.3	42.1
R1	43.5	46.2	42.1	42.6

These experiments provide evidence that nitrogen transfer from legume to grass can be detected as an increase in grass shoot N yield, even when grass DM production is being reduced by competition from the legume. With an additive type of design an increase in % N in grass leaf is likely to be an even earlier indicator of N transfer. With a replacement series design however, increased % N alone may simply be the result of lower grass plant density in the mixture.

REFERENCES

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Table 1

Mean total plant dry matter and nitrogen yields per container of green panic in monoculture and mixture at each excavation of Time treatments.

Excavation Date	Dry Matter (g/container)		Nitrogen (mg/container)	
	Monoculture	Mixture	Monoculture	Mixture
Experiment A				
7.11.61	62	56	333	394
14.12.61	67	64	328	439
22. 1.62	75	67	342	445
5. 3.62	99[B]	69	595[B]	512
16. 4.62	81[A]	70	415[A]	516
19. 6.62	72	74	385	590
6. 8.62	73	75[A]	343	546[A]
21. 9.62	76[A]	76[A]	372[A]	491[A]
LSD (P<0.05)	14.8		101	
Experiment B				
26. 9.62	39	32	243	218
7.12.62	48	39	288	264

No significant differences for DM or N.

A. Bee hives found in soil of one of three replications.

B. Bee hives found in soil of two of three replications.

(Control measures applied to all containers March 1962).

Table 2

Mean DM and N yields per container and N percentage, for green panic leaf at each harvest prior to excavation.

Harvest Date	Dry Matter (g/container)			%N		Nitrogen (mg/container)		
	Mono-culture		Mixture	Mono-culture		Mixture	Mono-culture		Mixture
Experiment A									
14.12.60	7.77	*	5.50	0.93	*	1.07	72	**	59
24. 2.61	10.82	NS	11.22	0.76	NS	0.76	82	NS	85
17. 4.61	2.60	NS	3.08	1.39	NS	1.48	36	*	46
20. 6.61	0.75	NS	0.85	1.77	*	1.97	13	NS	18
5. 9.61	1.23	NS	2.16	1.32	*	1.49	16	**	32
LSD two culture/harvest means (P<0.05)			2.19			0.14			7.4
Experiment B									
27. 4.62	12.7	*	8.6	0.80	NS	0.83	101	*	71
22. 6.62	3.4	NS	3.2	1.50	*	1.69	51	NS	54
17. 8.62	2.2	NS	2.1	1.95	NS	1.95	43	NS	41
1. 10.62	3.4	NS	3.0	1.35	*	1.47	46	NS	44
6.11.62	2.9	NS	3.4	1.42	*	1.53	41	*	52
LSD two culture/harvest means (P<0.05)			2.48			0.10			10.3

* Significantly different (P<0.05).