Nitrogen fixation inputs from lucerne-dominated pastures in the central-east of NSW

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ABSTRACT

In research to improve the nitrogen (N) management of phased lucerne-crop systems in the central-east of NSW, participating farmers and NSW Agriculture advisers and researchers identified the need to quantify the inputs of fixed N by the lucerne-dominated pastures and relate those estimates to soil N accumulation. In the first year of the pasture phase (1999), estimates of total N fixed (shoot + root) ranged between 113-499 kg N/ha at 6 different field sites. The % legume N derived from N_2 fixation ranged from 20-91% for lucerne and 48-91% for the annual legumes present in a number of the pastures. Annual shoot dry matter production varied from 5.5 to 12.3 t/ha. Rainfall, lucerne density, % grass composition, soil N fertility and sub-surface soil constraints were all likely factors affecting total N fixed.

KEY WORDS

Nitrogen, N_2 fixation, lucerne.

INTRODUCTION

Farmers from the mixed animal production-cropping region of the central-east of NSW were keen to quantify amounts of N fixed during the pasture phase of their systems to enable them to match pasture length to crop N requirements. Total N fixed by legumes is a function of dry matter (DM) produced and the proportion of N in the DM derived from atmospheric N_2 (%Ndfa). Research in southern Australia indicates about 20-25 kg of shoot N is fixed per tonne shoot DM produced (1); however, other work at Condobolin in the central-west of NSW suggests the value could be as low as 9 kg N/t DM (2). In a low productivity environment, the uncertainty of fixed N inputs has implications for the overall N management of the system, which in turn can have a major impact on rotation gross margins.

MATERIALS AND METHODS

Six wheat paddocks, undersown with pasture, were selected in December 1998 within a 100km radius of Gilgandra in the central-eastern cropping belt of NSW. Site selection was mainly determined by soil type. Three of the sites were grey vertosols (Roc, Col and Tug), one was a red vertosol (Won), and two were red chromosols (Wes and Tex). Soil pH in the top 1 m ranged from 5.5 to 8.0 across all sites. At 1.0-1.5 m depth, pH remained neutral-alkaline (range 6.2-8.1), except at Col where pH was 4.2 at 1.5 m. Nitrate N (0-1.5 m) was negligible at 5 of the 6 sites; at Col, 40 kg N/ha was present below 1.0 m. Lucerne was the dominant legume species at all sites. Minor legume species were annual clovers and/or medics. Won, and to a lesser extent Tex, also contained phalaris and ryegrass (not measured) in the pasture. Four 1 m^2 exclusion cages were placed in each paddock for estimating shoot DM. About 4-6 weeks after major rain events, all pasture foliage within each cage was harvested. The leguminous material (plus phalaris at Won) was dried at 70˚c for 48 h, ground and analysed for %N and ^{15}N. The %Ndfa and the amount of N_2 fixed (kg N/ha) was then calculated using the natural ^{15}N abundance method, as described in Unkovich et al (3). To estimate total N fixed, it was assumed 50% of total plant N was present in the root system (1).

RESULTS AND DISCUSSION

The %Ndfa for lucerne and annual legumes, pasture DM and total N fixed during 1999 are shown in Figs 1and 2. Dry matter cuts were not undertaken at Won and Col in February due to insufficient growth. After initial variations, the %Ndfa remained relatively constant for lucerne at each site (Fig 1a). Values ranged between about 25% for the Col site to about 85% for Won and Tex. In early autumn there was a peak in %Ndfa at 5 of the 6 sites, most likely because of low available nitrate. The Col site had access to deep

nitrate and gave the lowest %Ndfa values. Monitoring during 2000 will determine whether %Ndfa remains relatively constant for each site or if there are seasonal fluctuations in plant reliance upon N fixation for growth. The %Ndfa for annual legumes was similar at all sites in October (85%) (Fig 1b), coinciding with peak periods of growth. Pasture DM production varied substantially between sites (5.5-12.3 t/ha), with most of it derived from lucerne (70-100% at all sites except Won at 33%) (Fig 2). There was similar variation in total N fixed, ranging from 113 kg N/ha at Col to 499 kg N/ha at Wes. At 5 of 6 sites, total N fixed was consistent with DM production.

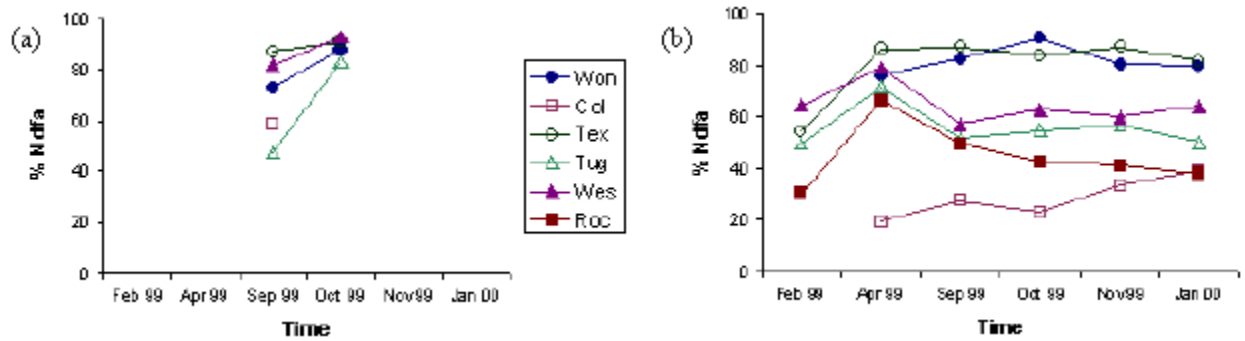

Figure 1. Changes in % Ndfa in (a) lucerne and (b) annual legumes at the 6 sites in 1999.

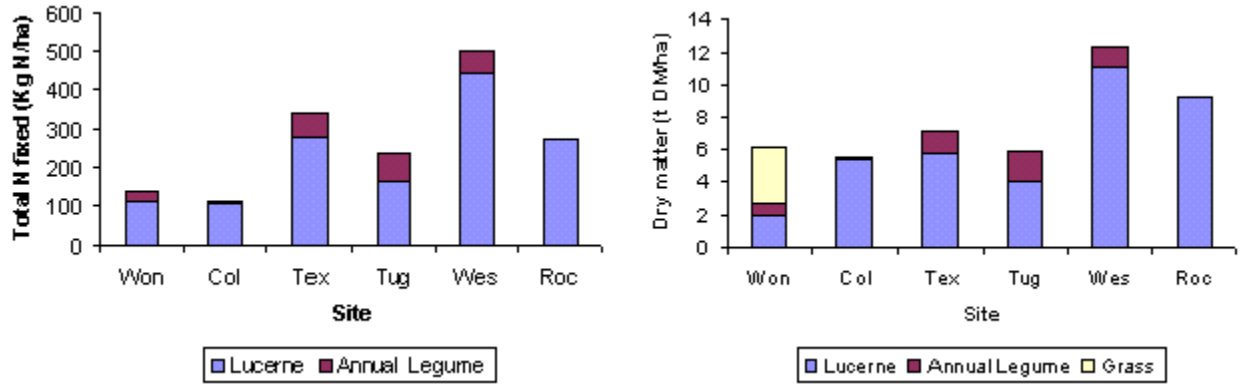

Figure 2. Dry matter production and total N fixed (shoot + root) for lucerne-based pastures at the 6 sites in 1999.

CONCLUSIONS

The factors most likely determining amounts of N fixed by the 6 lucerne-dominated pastures are outlined in Table 1. Each site was given + to +++ for each factor, which were then summed (final column). For instance, rainfall ranged across the sites from 550 mm (+) to 875 mm (+++), while lucerne density varied between 10 (+) and 25 (+++) plants/m^2. The different factors were given equal weighting, which probably resulted in an underestimation of the impact of a high grass component at Won and sub-surface constraints at Col. Notwithstanding the limitations of the rating approach, the final ranking of the sites (final column, Table 1) is similar to the ranking of sites for total N fixed (Fig 2).

Table 1. Factors determining N fixed at each site, mediated through yield and %Ndfa (more +'s is better).

Site	Yield	%Ndfa	Total

	Rainfall	Density	Low grass/weed density	Lack of sub-surface constraints	Grass/weed competition for soil nitrate	Low soil nitrate fertility	
Won	+	+	+	+++	+++	++	11
Wes	+++	+++	+++	++	+	+++	15
Roc	+++	++	+++	+++	+	+	13
Col	+	+++	+++	+	+	+	10
Tug	+++	+	++	+++	++	+	12
Tex	+++	++	++	++	++	+++	14

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