NITROGEN FIXATION OF SELECTED FORAGE LEGUMES FOR SMALLHOLDER FARMERS IN UGANDA

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1. Background and Objectives

Access to reliable forage of sufficient quality, especially during the dry season, poses the main challenge to smallholder dairy producers in semi-arid areas of East Africa (Hall et al., 2007). In contrast to most other crops, many forage species can be grown on marginal lands and thus provide an opportunity for farmers to build a livelihood. Legumes offer the extra benefit of improving the nitrogen-poor soils. Therefore, in this study, five forage legumes were tested for their ability to provide biomass and fix nitrogen (N) in a field trial in Uganda. We hypothesized that the legumes would differ in their stable N isotopic signatures, used here as a proxy for N fixation, and that the N yield would differ depending on water availability.

2. Materials and Methods

Five forage legumes, namely *Lablab purpureus*, *Desmodium uncinatum* cv Silverleaf, *Desmanthus virgatus*, *Macroptilium bracteatum* cv Burgundy bean, and *Canavalia brasiliensis*, were grown in a completely randomized block design (plots of 3 m x 6 m, 1 m in between plots) with five replicates with or without additional irrigation (by hand, if no precipitation had fallen the previous day; over the growing season 23,100 l water added/plot) in field sites in Uganda (National Livestock Resources Research Institute, Tororo district; annual rainfall 1130-1720 mm; AATF, 2009). On average, the soil water content of the non-irrigated plots was about 14% lower than in the irrigated ones (measured at five occasions throughout the season). Planting was done in the rainy season (October 2012) at recommended rates and spacing. Biomass was harvested 10 cm above the ground five times in two-monthly intervals until June 2013. Samples of about 200 g were oven-dried (60°C for 48 hours) and weighed. Just before harvest, the youngest leaf of several plants was sampled for stable isotope analysis at the first four harvest occasions. Isotope and N content measurements were done on an isotope ratio mass spectrometer (Delta plus Finnigan MAT, Bremen, Germany) coupled to an elemental analyser (NA2500 CE lnstruments, Rodano, Milano, ltaly) via an interface (Conflo lll Thermo Electron Cooperation. Bremen, Germany). Isotopic values are given as $\delta^{15}N$ values (‰; standard: air). Statistical analyses (ANOVA, harvest as random factor, testing for normality and homogeneity of variances) were done with SPSS version 16.

3. Results and Discussion

The total dry matter production of the legumes was on average about 600 g m^{-2}, with small, albeit not significant differences among species and between irrigation treatment (Table 1). The nitrogen isotopic values were most depleted for *L. purpureus* and *D. uncinatum*, intermediate for *M. bracteatum* and *C. brasiliensis* and most enriched for *D. virgatus* (Table 1, $P < 0.001$), suggesting a potentially larger proportion of N derived from air for *L. purpureus* and *D. uncinatum*. However, so far no B values of the plants are available. The percentage of N in the plant material was smallest for *M. bracteatum*, intermediate for *D. uncinatum* and *D. virgatus* and largest for *L. purpureus* and *C. brasiliensis* (data not shown, $P < 0.001$). Irrigation had no significant influence on $\delta^{15}N$ or N percentage ($P = 0.196$ and 0.961, respectively). This is not in line with our hypothesis and earlier studies (e.g. Ledgard and Steele, 1992). Least water was available at the third harvest, when the gravimetric soil water content fell to on average 17% in the irrigated plots, with that in the non-irrigated being around 72% of that value. Even at this harvest, no significant difference was observed in $\delta^{15}N$ values. Over time, the combination of larger biomass yields and changes in N content led to the observed increase in N yield (Fig. 1), with largest N yields from *L. purpureus* and *C. brasiliensis*.

4. Conclusions

L. purpureus and *C. brasiliensis* seem most promising in terms of biomass production and N yield under the conditions tested. The missing effect of drought stress on the N fixation has to be further tested.

Acknowledgements

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Table 1. Total annual dry matter yields of five forage legumes over five harvests (g m^{-2}) and $\delta^{15}N$ signatures of their youngest leaves at the fourth harvest. Shown are means and standard deviations (n = 5).

	Lablab purpureus	*Desmodium uncinatum*	*Desmanthus virgatus*	*Macroptilium bracteatum*	*Canavalia brasiliensis*
	Dry matter yield [g m^{-2} a^{-1}]				
Irrigated	701 ± 114	530 ± 71	602 ± 143	542 ± 47	704 ± 105
Non-irrigated	635 ± 61	447 ± 44	625 ± 126	508 ± 67	634 ± 59
	$\delta^{15}N$ [‰]				
Irrigated	0.80 ± 1.49	0.43 ± 0.39	2.42 ± 0.67	1.09 ± 0.28	1.85 ± 0.69
Non-irrigated	1.78 ± 0.66	1.02 ± 0.59	2.72 ± 1.18	1.63 ± 0.80	1.86 ± 1.12

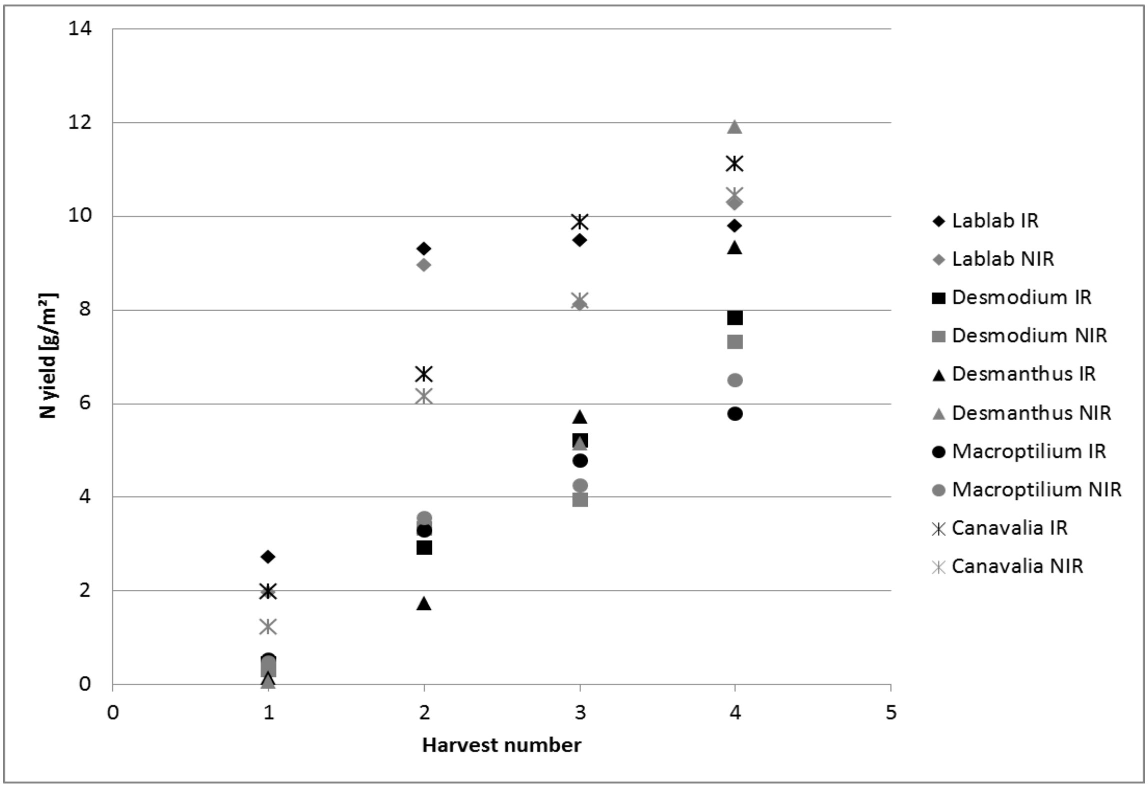

Fig. 1: Nitrogen yield of five legume species grown with (IR) or without (NIR) irrigation. Shown are averages (n = 5) for four harvests from December 2012 until April 2013.