Using Dolichos lablab (Lablab purpureus) as a rotation crop for cotton.

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Abstract

Lablab was grown in two field experiments at Narrabri, NSW. The aim was to determine the effect of irrigation and N fertiliser on dry matter production and N fixation by lablab in order to assess its potential as a green manure crop for use within a cotton farming system. The experiments found that dry matter production, water-use efficiency (WUE) of dry matter production and the amount of N fixed by lablab was increased by more frequent irrigation. Optimal WUE of dry matter production was found to be 55 kg ha^{-1} mm^{-1}. WUE of N fixation was not affected by irrigation frequency and was 0.62 kg ha^{-1} mm^{-1}. Lablab N fixation was reduced from a maximum of 189 to 95 kg N ha^{-1} by increasing rates of N fertiliser from 0 to 240 kg N ha^{-1}. The WUE of lablab compares favorably with other crops. With full irrigation lablab has the potential to produce up to 16000 kg dry matter ha^{-1} and fix up to 189 kg N ha^{-1}.

Introduction

Growing summer legumes for green manuring instead of including a long fallow period is a relatively new management trend in the Australian cotton industry. Lablab is one crop that has been considered for this use in Australian cotton production systems. The principal interest in growing lablab is to add N and organic matter to the soil. Lablab is an annual crop when grown in sub-tropical areas such as northwest NSW. It is normally planted in October to December and green manured by slashing, spraying with herbicide or dies off naturally when exposed to autumn frosts. While there is some information on the biomass production of lablab used for forage, there is little information on the amount of N fixed by lablab.

Legume green manure crops contribute N to a system through fixation of atmospheric N_2. Legume N fixation is affected by a number of factors. Farmers can manage two important factors affecting N fixation: soil moisture and the availability of mineral N. Knowledge of how these factors affect N fixation by lablab enables farmers to maximise the benefit derived from legume rotations.

Soil moisture stress affects N fixation by legumes (Sprent, 1979; Abdel-Ghaffar, 1988; Sprent and Zahran, 1988; Djekoun and Planchon, 1991). Water supply is limited in many irrigated cotton production areas in Australia. When considering using rotation crops to supply N, it is important to understand the effect of limited water supply on their potential to produce dry matter and fix N. In addition, substantial residual N can exist in the soil after a cotton crop, depending on previous rotations and N application (Hearn, 1986). Limited data from growth chamber studies have indicated that N fixation by lablab is relatively sensitive to mineral N, particularly nitrate, compared to other legume species (Harper and Gibson, 1984). However, there has been no work done on the response of N fixation by lablab to mineral N levels in the soil under field conditions.

Two experiments were conducted at the ACRI at Narrabri, NSW, in order to obtain information on the effect of drought stress and soil mineral N levels on the ability of lablab to provide N to a cotton farming system. The effect of soil moisture availability on dry matter production, N fixation and water use efficiency by lablab was examined in Experiment 1. In the Experiment 2, a range of nitrate levels was applied to determine the relationship between the level of soil mineral N and N fixation by lablab.

Materials and Methods

Experiment 1

The experiment was located at the ACRI on Field 14 on one-meter beds that had been previously planted to cotton. The soil type was a grey cracking clay. Lablab was grown from late November 1993 until it started to flower in May 1994, when the crop was sprayed with 5 ml L^{-1} Roundup®. Two furrow irrigation regimes were imposed: 1) a fully irrigated treatment that was well watered throughout the 1993/94 summer (5

applications); and 2) a partially irrigated treatment in which lablab was subjected to periods of drought stress (2 applications). Three replicates of each treatment were randomised within each irrigation treatment.

Water extraction to a depth of 120 cm by lablab was determined using a neutron moisture probe which was calibrated for the site according to the methods of Greacen (1981). Total water use was calculated as the cumulative daily water use of the crop at the end of its growing period. Input of water from irrigation and rainfall was estimated. N fixation was determined using the natural abundance of ^{15}N method. Reference plants used included cotton, non-nodulating soybean, and a range of non-N fixing weeds found in legume plots at the time of sampling.

Experiment 2

This experiment was also conducted at ACRI, on Field 14. Four rates of potassium nitrate fertiliser (0, 80, 160 and 240 kg N ha^{-1}) were applied to the soil. Nitrogen fertiliser treatments were replicated five times. The experiment was fully irrigated and N fixation was again measured using the natural abundance of ^{15}N technique. The reference plants used were maize, sorghum, cotton and non-nodulating soybean. Lablab and reference plants were planted on 7 November 1994 and lablab was sprayed with glyphosate in May 1995.

Results and Discussion

Experiment 1

At the end of the experiment, fully irrigated lablab had almost twice the biomass yield as partially irrigated lablab (Figure 1). Similarly, N uptake by fully irrigated lablab was significantly greater at 369 kg N ha^{-1} than that under partial irrigation (224 kg N ha^{-1}). Of the N taken up by lablab, the proportion of N fixed by biological N fixation was greater under full irrigation (0.58) compared to that under partial irrigation (0.47). Consequently the amount of N fixed by lablab was significantly reduced under partial irrigation from 192 kg N ha^{-1} (under full irrigation) to 125 kg N ha^{-1}.

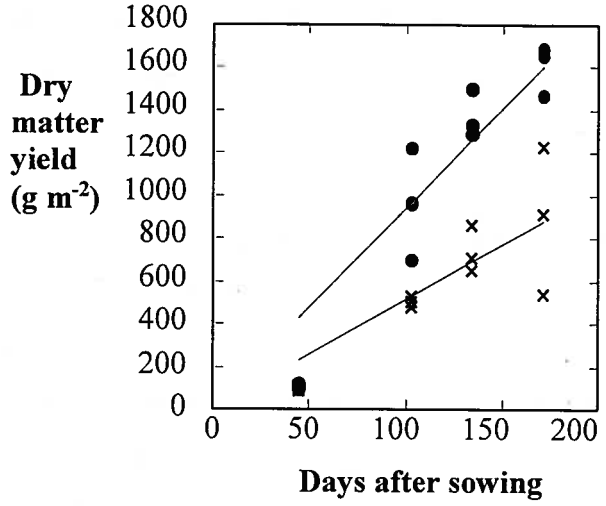

Figure 1: Accumulation of biomass by lablab under full (•) and partial (x) irrigation.

As could be expected there was significantly different water use in the two irrigation treatments. Figure 2 shows the soil water deficit for the two treatments over the duration of the experiment. Total water use for fully irrigated lablab was 292 mm and 208 mm for the partially irrigated treatment. The calculated water use efficiency of biomass production was greatest for the fully irrigated treatment (55 kg ha^{-1} mm^{-1}) and was reduced for the partially irrigated treatment (42 kg ha^{-1} mm^{-1}). In the same experiment lucerne was grown alongside lablab and its WUE of dry matter production for the rotation period was only 15 kg ha^{-1} mm^{-1} in both irrigation treatments.

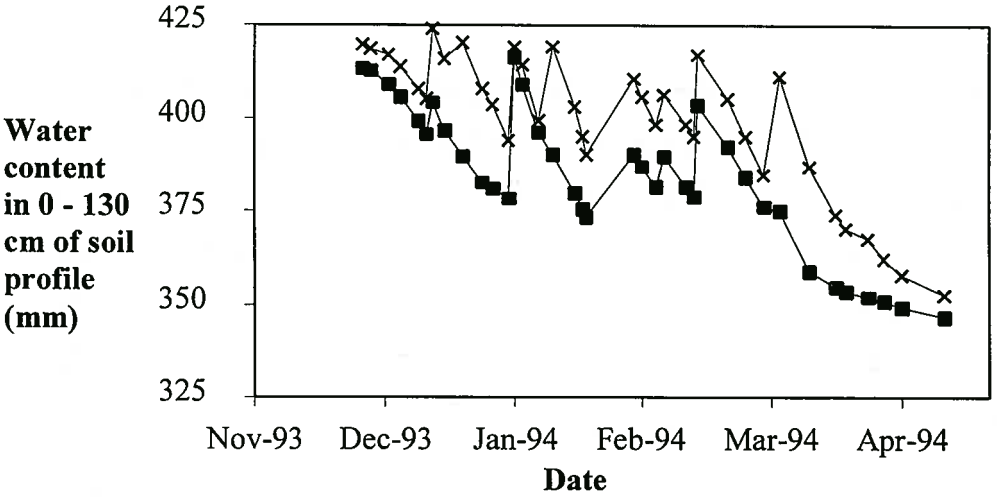

Figure 2: Total soil water content (mm) in the profile of fully (✳) and partially (■) irrigated lablab plots.

While WUE of dry matter production was decreased in the partially irrigated treatment, the WUE of N fixation was unaffected by irrigation frequency and was calculated at 0.62 kg N ha^{-1} mm^{-1}.

Experiment 2

Soil nitrate N levels increased with increasing rates of N fertiliser (Figure 3). After 67 days after planting of lablab, soil nitrate levels decreased dramatically at all rates of fertiliser. This was attributed mainly to N uptake by lablab, demonstrating lablab is able to take up large amounts of nitrate from the soil.

Increased application of N fertiliser had no effect on the amount of biomass or N taken up by lablab, with an average of 15790 kg ha^{-1} biomass produced and 275 kg N ha^{-1} taken up by lablab during the experiment. Increasing rates of N fertiliser were found to have a negative effect on the proportion and amount of N that came from biological N fixation (Figure 4). For each kg of N fertiliser applied, the proportion of N fixed decreased by between 0.016 and 0.02 from a maximum of 0.71 and the amount of N fixed decreased by between 0.39 kg N ha^{-1} from a maximum of 189 kg N ha^{-1}.

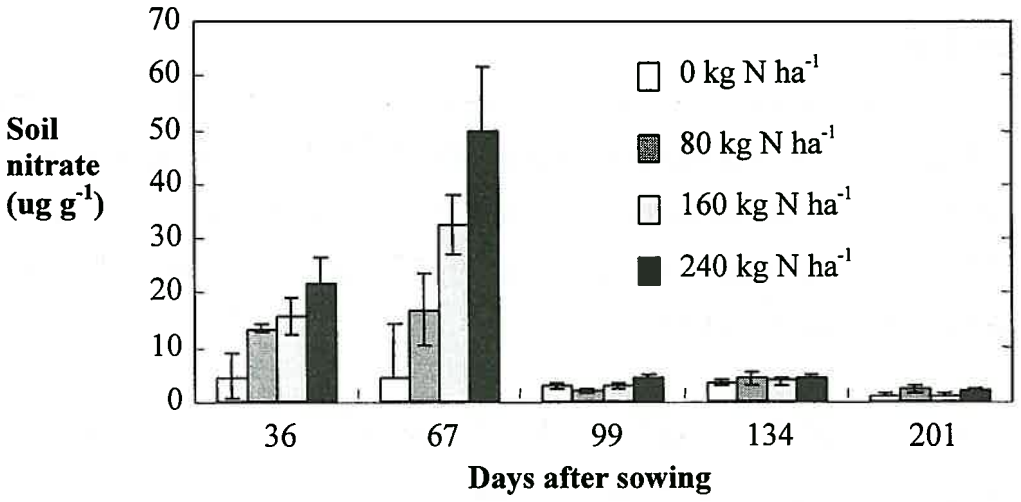

Figure 3: Change in soil nitrate N levels as affected by KNO_3 fertiliser application in Experiment 2. Bars show standard errors.

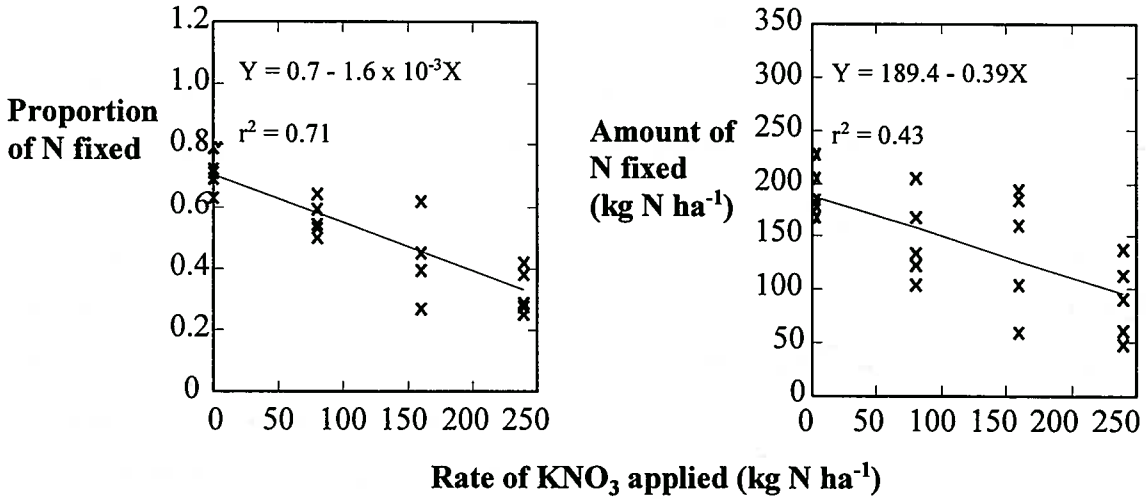

Figure 4: Relationships between rate of applied KNO_3 and proportion and amount of N fixed by lablab.

As soil nitrate levels increased with increasing N fertiliser rate and the proportion of N fixed by lablab decreased with increasing fertiliser rate, it was also observed that the proportion of N fixed by lablab was inversely related to soil nitrate levels 67 days after sowing. For every 1 ug g^{-1} increase in soil nitrate levels at 67 days after planting, final proportion of N fixed decreased by 0.04 from a maximum of 0.62 and the amount of N fixed decreased by 0.87 kg N ha^{-1} from a maximum of 171 kg N ha^{-1}.

Conclusion

If considering introducing a green manure crop rotation into a cotton farming system, the farmer must have a clear idea of what is the aim of the rotation. If the main aim is to add N to the system via biological N fixation, then the farmer must be aware of the limitations that limited irrigation water availability and excess soil mineral N levels can have on the addition of N by lablab.

Experiment 1 showed that partial irrigation of lablab provided a substantial addition of N to the system (fixing 125 kg N ha^{-1}). However a 41 % increase in water supplied to the crop resulted in a 54 % increase in the amount of N fixed. Thus, increasing irrigation frequency (in this case by 3 applications) gave a proportionally greater addition of N to the system. Lablab WUE was higher than that of lucerne over the same rotation period.

Experiment 2 illustrated that the soil mineral N status needs to be considered before using lablab as a rotation crop to add N to the system. Large amounts of available N can be taken up by lablab. However, when N is limiting, lablab has the potential to fix up to 0.71 of its N requirements, without biomass production being limited. Lablab can serve the purpose of mopping up excess N which can then be returned to the system when the crop is green manured - reducing the risk of losses of available nitrate via leaching and denitrification. However, in the situation where there appears to be substantial residual nitrate, it may be a more profitable option to include a cash crop rather than green manuring. In the situation where nitrate levels are low, then including a green manure crop such as lablab would be a better option than a long fallow.

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