Improving the reliability of establishing legumes into grass pastures in the sub-tropics

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Abstract
Poor establishment is the most common reason for failure of pasture legumes sown into existing grass pastures on commercial farms in the sub-tropics. Although good establishment is recognised as critical to the long term productivity and persistence of legumes, most producers use low-cost and low-reliability establishment techniques such as broadcasting after either no or minimal pasture disturbance; one-pass cultivation with seed spread at the same time; or severe soil disturbance and a rough seed bed behind a blade plough. This paper reports the results of a study designed to test the impact of different fallow periods (medium – 4 months; short – 2 months; disturb at sowing and no disturbance); seedbed preparation (cultivation or zero tillage); drilling or broadcasting seed and post emergence herbicides when establishing legumes into existing grass pastures. The most common, commercially used establishment techniques of sowing legume seed into grass pastures with no disturbance or single pass cultivation treatments at sowing all resulted in establishment failure. Spraying at sowing resulted in adequate numbers of legumes. Short or medium fallows resulted in similar densities of legumes between all treatments, however treatments with greater control of the grass and post emergence weed control grew better which resulted in more seedling recruitment in the subsequent year. At 25 months after sowing only fallowed treatments with Spinnaker® post-emergence weed control achieved legume numbers above benchmark figures for establishment success. The study demonstrates that agronomic practices commonly used for grain cropping (such as fallowing to store soil moisture) can improve the reliability of establishing legumes into existing grass pastures.

Key words
Nitrogen, fixation, Caatinga stylo, desmanthus, buffel grass

Introduction

Commercially, pasture legumes have not established reliably in existing sown grass pastures in the sub-tropics (Peck *et al.*, 2011). Although good establishment is recognised as critical to the long term productivity and persistence of pasture legumes, most producers use low-cost and low-reliability establishment techniques such as broadcasting out of planes after either no or minimal pasture disturbance (e.g. fire) or one-pass cultivation where seed is sown at the same time or severe soil disturbance and a rough seedbed behind a blade plough used for controlling woody regrowth (Peck *et al.*, 2011). In the black spear grass zone of central and southern Queensland, surface sowing legumes has been shown to be unreliable with an 80% failure rate (Cook *et al.*, 1992); it is likely that sowing into competitive sown grass pastures like buffel grass in lower rainfall areas has even higher failure rates. This paper reports early results of an establishment study near Wandoan in southern inland Queensland.

Methods

The study site was established on a brigalow grey cracking clay, dominated by existing buffel grass (*Penessetum ciliare*) and included two replicates of 16 treatments. The study plots were 5.5m x 20m, with 4.5m of grass left between each plot. Fourteen of the treatments were of split plot design, where half of the plot (10m x 5.5m) was drilled using a single disc opener planter while the other half was broadcast onto the soil surface; the one-pass cultivation treatments described below did not have split plots as graziers would most likely spread seed at the same time as cultivation as opposed to drilling seed as part of a second operation. The study was planted on the 13th of February, 2013. Progardes variety desmanthus (*Desmanthus spp.*) seed was applied at 6kg seed/ha. Treatments were a combination of fallow period, seedbed preparation (zero tillage or cultivated) and post-emergent weed control. A summary of treatments applied in the study is presented in table 1. In this study, fallow was defined as the killing of grass to reduce competition and store

soil water (buffel grass is however a perennial grass with high seed production, therefore single treatments or short fallows rarely kill all tillers in all plants or the soil seed bank).

Table 1: Summary of study treatments applied

Fallow period	Fallow treatment	Post plant weed control
No disturbance	Slash at sowing	Nil
	None	Nil
Disturb at sowing	Deep rip	Nil
	Spray (glyphosate)	Nil
	Cultivate (tynes)	Nil
Short (2 months)	Spray (zero till)	Post-emergence herbicide as required
		Nil
	Cultivate	Spinnaker*® (active: 700 g/kg imazethapyr)
		Nil
	Spray + cultivate	Nil
Medium (4 months)	Spray (zero till)	Post-emergence herbicide as required
		Nil
	Spray + grass seed	Nil
	Cultivate	Spinnaker*® (active: 700 g/kg imazethapyr)
		Nil
	Cultivate + grass seed	Nil

At 5 and 9 weeks; and 9, 15, 23 and 25 months after germinating rains, legume numbers, height and dry matter (DM) production were recorded. At 15 months and 25 months legume numbers and dry matter production of both grass and legume were recorded. The trial site was grazed during winter after pasture measurements were taken in autumn.

Results

The site had a very dry spring and early summer leading up to sowing which resulted in relatively low amounts of stored soil moisture in fallowed treatments and reduced in-fallow spray efficacy. Very good germinating rains were recorded and rainfall was close to average in the nine weeks after planting. The good early season was followed by a very dry spring and early summer.

The undisturbed grass, slashed grass, cultivated at sowing (tynes) and deep rip treatments all resulted in low numbers of legumes (Figure 2), with very poor growth (Figure 1). Sprayed or cultivated fallows resulted in higher legume numbers with better growth than low disturbance treatments. Legume growth at 15 months after sowing is shown in figure 1. No significant difference was measured between sowing methods (drilling and broadcast).

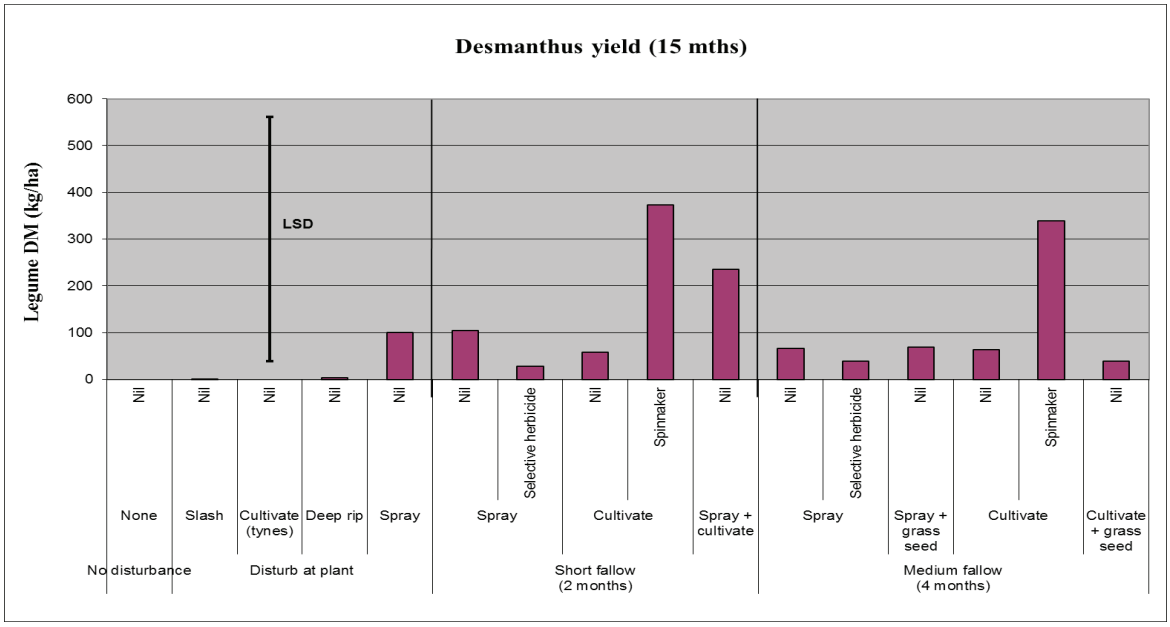

Figure 1: Legume dry matter production (kg/ha) at 15 months after sowing. No significant difference was measured between sowing methods (drilling and broadcast) and for this reason, results are presented as combined drill and broadcast averages for each treatment. Undisturbed grass, slashed grass, cultivated at sowing (tynes) and deep rip treatments failed to produce statistically meaningful biomass. No significant difference was measured between any of the other treatments.

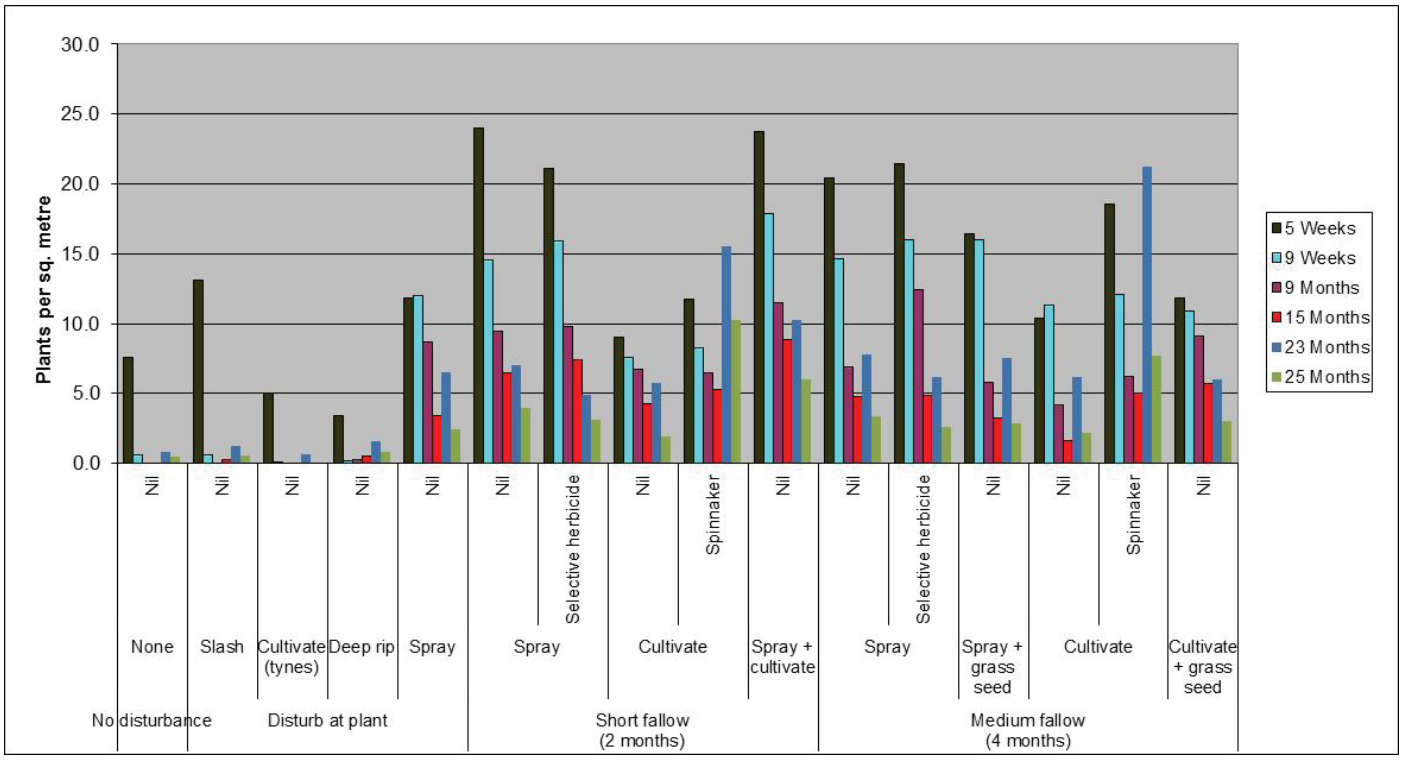

Figure 2: Legume numbers per square metre (*Desmanthus spp.*) at six recording periods after sowing for the different treatments. Treatments were a combination of fallow period (medium, short, disturb at sowing or no disturbance of the grass pasture); seedbed preparation of cultivated fallow or zero tillage fallow (labelled spray) or a combination of both; and post-emergence weed control by using Spinnaker® on cultivated plots or a combination of herbicides for zero tilled treatments.

Discussion

For the purposes of this study, the benchmark target for legume density for the species was greater than 4 legumes per square metre. Referring to this benchmark, the establishment techniques most commonly used by industry of either no disturbance of the existing grass pasture or one-pass cultivation treatments all resulted in establishment failure (<1 legume/m^2) (Figure 2). At 15 months after planting, all fallowed treatments and the spray at sowing treatments were close to this benchmark. By 25 months however, most treatments had recorded strong declines in legume numbers with increasing time since sowing, with the exception of the Spinnaker® and spray plus cultivate treatments, which declined less than other treatments, and exceeded the benchmark at 25 months (Figure 2).

Legume biomass data for 15 months post-sowing was analysed using ANOVA. The undisturbed grass, slashed grass, cultivated at sowing (tynes) and deep rip treatments produced statistically insignificant biomass and were thus deemed failures. No significant difference was detected between any of the treatments that did record legume biomass at 15 months (Figure 1). Raw data totals showed Spinnaker® treatments and the spray plus cultivated short fallow treatment recorded the greatest DM, while other short and medium fallows were intermediate. While not statistically different from other treatments that produced legumes at 15 months, the recorded greater legume productivity of the Spinnaker® and spray plus cultivate treatments is presumably due to a greater reduction in grass competition. It seems apparent that this greater legume productivity gave rise to these treatments having greater recruitment (23 month recording) and increased legume number by 25 months (Figure 2). These treatments were the only ones to end up with >5 legumes/m^2. Given that nitrogen fixation and animal production are directly related to legume production, these three treatments with greater DM production were considered successful at 25 months. The establishment techniques that resulted in more moderate legume numbers and DM production may still ultimately be successful, but they will take longer to reach their production potential.

At 23 months all treatments recorded increases in total legume numbers (Figure 2). For the treatments with very poor legume growth in the previous year (i.e. no disturbance, slash and cultivate at sowing treatments) this increase in legume numbers would largely be on account of a softening of originally sown hard seed as

legume were small with low numbers and therefore very little seed would have been set. For other treatments that grew greater amounts of legume, the increase in legume numbers was likely to have been a combination of both seed softening and seed set by legumes established in the previous summer growing season. The much greater recruitment within the Spinnaker® treatments reflects reduced grass competition and greater legume DM, though this is not statistically verifiable. This greater productivity led to these being the only treatments to meaningfully increase legume numbers from the 15 month to the 25 month measurements. The spray at sowing treatment produced much greater legume numbers and DM production than the cultivate at sowing treatments. The spray treatment produced a particularly good kill of the grass pasture as it was timed when the grass was very leafy and actively growing. There was very good germinating rain and follow up rain within a fortnight after planting which also contributed to the success of this treatment. In other years this treatment is likely to have been less successful if the initial kill and good follow up rain had not occurred. In subsequent trials the spray at sowing treatment has resulted in low legume numbers in the first season after sowing due to a lack of effective grass kill and variability of follow up rain.

Conclusions

Poor establishment is the most common reason for failure of pasture legumes in existing commercial grass pastures. Fallowing to store soil moisture and control competition from the existing grass pasture improved establishment. Greater control of competition through the use of post-emergence herbicides like Spinnaker® increased establishment success. Industry needs to adopt longer fallow management when establishing legumes into existing grass pastures for them to realise their potential to improve productivity and economic returns in the sub-tropics.

References

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