Species and management of fallow legumes in sugarcane farming systems

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ABSTRACT

Fallow legumes have traditionally been a part of the sugarcane farming system. However, little research has been done on the most appropriate species, their management, nitrogen contribution and impact on sugarcane growth and yield. In studies carried out by the Sugar Yield Decline Joint Venture between 1993 and 1999 it has been shown that well managed soybean and peanut crops can enhance yields of the following sugarcane crop by 20 to 30% in each of the plant, first and second ratoon crops. Some of the response is due to nitrogen input by the legume, but other factors related to soil health are also involved. Benefits can be measured whether the legume is treated as a green manure crop or harvested for grain, although grain legumes offer the potential for additional cash flow as well as enhancing sugarcane yield. A legume-based sugarcane farming system is likely to be more sustainable than the current monoculture system.

KEY WORDS

Sugarcane, fallow, legumes, soybean, nitrogen, grain legumes.

INTRODUCTION

Planting a legume as a fallow crop between the plough-out of the final ratoon and the re-establishment of the next plant crop has been a traditional part of the Australian sugarcane production system. Fallow legumes are grown for three basic reasons. These include, provision a diverse break crop from sugarcane to reduce the build-up of diseases; provision of a source of fixed nitrogen for the following sugarcane crop; and provision of ground cover over the summer wet season to mitigate against soil erosion. However, fallowing lost favour when cane assignment restrictions, that had forced farmers to fallow 25% of their assigned area, were lifted in the mid-1970's. Many growers adopted a plough-out/re-plant (PO/RP) system in which the old ratoon was removed, the land prepared, and a new sugarcane crop was planted in some 4 - 8 weeks.

Since the 1970's the Australian sugar industry has been on a productivity plateau. Numerous reasons have been put forward as possible causes, including the negative impact of the continual sugarcane monoculture invoked by PO/RP (3). Hence research into the benefits of fallow legumes was recommenced when the Sugar Yield Decline Joint Venture was established in 1993.

Traditionally, cowpea had been the main fallow legume. However, results have been variable. In many crops, waterlogging and associated root diseases such as *Phytophthora vignae* and *Pythium myriotylum* have caused significant plant death resulting in severe weed infestation. In addition, at least some of the poor growth has been associated with poor fallow management, including inadequate land preparation, failure to allow for seasonal inundation, and failure to use herbicides (2). Further, ineffective killing of the old ratoon often results in many fallow legume crops being heavily infested with sugarcane, which largely negates one of the major reasons for planting a fallow.

In this paper the research carried out on fallow legumes between 1993 and 1999 is summarised. The research has involved studies into legume species, their management, the impact on sugarcane production, and their potential as cash crops. Although legume breaks of more than three years have been included in some of these experiments, this paper only considers the effect of single legume breaks or breaks that only cause the loss of one cane harvest.

EXPERIMENTAL DETAILS

Thirteen experiments have been conducted on fallow legumes between Mossman and Bundaberg, Queensland since 1993. The experiments have involved a range of legume species including soybean, peanut, lablab, cowpea, mungbean and navy bean with different crop management strategies. Specific experimental details are provided in previous papers (1, 2, 4, 5, 6).

Legume Management:

Traditional legume fallows are established by broadcasting seed after the cane stool has been ploughed out. A light harrowing then covers the seed, with no other cultural operations normally employed. In a number of experiments this practice was compared with sowing the legumes with a seeder onto well prepared ridges and spraying with a pre-emergent herbicide. Measurements were made on dry matter production and nitrogen content.

Legume Species:

In several experiments comparisons were made between a number of legume species that were planted with a seeder onto ridges and sprayed with a pre-emergent herbicide. Measurements of dry matter production, grain yield, nitrogen content, and nitrogen fixation (using the relative abundance method of Shearer and Kohl) (7)

Impact on Cane and Sugar Yield:

Sugarcane was planted immediately after legumes in a number of these experiments. Residual sugarcane plots were left during the fallow period in some of these experiments. These were used as PO/RP plots to compare yields following legume fallows and PO/RP.

RESULTS AND DISCUSSION

Legume Management

Cultural practices were shown to have a large impact on growth and nitrogen content of fallow legume crops (Table 1). Adoption of simple techniques such as sowing cowpea onto ridges and spraying with a post-plant, pre-emergent herbicide (improved management) was shown to have a major impact on dry matter production and nitrogen content compared with broadcast cowpea (traditional management).

Table 1 - Tops dry matter and plant nitrogen content (kg/ha) for three sampling dates of cowpea grown with improved management or traditional management. Sowing date was December 12 and maximum dry matter was recorded on April 6. Weeds were a component of the traditional management system but not the improved management system.

Sample Date	Dry Matter (kg/ha)			Plant Nitrogen Content (kg/ha)		
	Improved Management	Traditional Management		Improved Management	Traditional Management	
		Cowpea	Weed		Cowpea	Weed
February 2	2309	2262	Nil***	66	30	Nil
March 6	3096	2421	435	72	41	11

April 6	4689	1966	1347	140	31	19

Lsd 5% for April 6 sampling = 1692 (dry matter), 40 (nitrogen content). ***Weeds were present but were not separated.

By the time the fallows were ready for incorporation (April 6) the improved legume management had 41% more dry matter (Table 1). Further, 41% of the dry matter in traditional management was weeds. Improved management therefore resulted in a 240% increase in the cowpea component of the fallow, and this improved cowpea growth increased the amount of nitrogen returned in the tops from 50 to 140 kg N/ha. In addition, growth of volunteer sugarcane plants was controlled. Subsequent studies have confirmed these results for different sites and seasons (5). Hence, simple agronomic practices can overcome many of the deficiencies associated with traditional fallow management.

Legume Species:

A comparison between legume species from an experiment at Tully is presented in Table 2, although data showing similar trends are available for a number of experiments conducted throughout sugarcane growing areas (5).

Table 2 - Maximum tops dry matter (kg/ha), nitrogen concentration (%), nitrogen content of tops (kg/ha), and % nitrogen fixed for soybean variety Leichardt, peanut variety NC7, cowpea variety Meringa, and mungbean variety RM1 from an experiment conducted at Tully in 1994/95. Data is for whole plants including grain.

Species	DM (kg/ha)	N Conc. (%)	N Content (kg/ha)	% N Fixed[aaa]
Soybean	7429	4.23	310	50
Peanut***	5270	2.83	149	28
Cowpea	4689	3.09	140	61
Mungbean	2367	3.56	84	29

Lsd 5% = 1692 (dry matter), 40 (nitrogen content). *** Peanuts suffered severe leaf disease.

Soybean was a superior green manure legume in this study, contributing more than twice the amount of nitrogen than cowpea (310 *vs* 140 kg/ha). Almost half of this nitrogen was derived from nitrogen fixation. The results for peanut in this study were an underestimation of the crops potential N contribution, as it was severely effected by leaf disease. In other studies with peanut in this environment dry matter levels similar to soybean have been recorded, with plant nitrogen contents of up to 240 kg/ha.

Impact on Sugarcane Yield:

All experiments carried out to date have resulted in a yield increase of sugarcane following a well-managed fallow (Table 3). Further the yield effects have carried through to the ratoons, especially in the more southern areas (Mackay, Bundaberg). Studies on the wet tropical coast (Tully, Ingham) have rarely produced a yield increase beyond the plant crop, although these shorter term responses appear to be closely associated with mechanical harvesting damaging the stool during wet harvests of the plant crop.

Table 3 - Effect of a break where land is out of cane for 6 months and one harvest is missed on subsequent sugarcane yields (t/ha). All breaks except Bundaberg were a single soybean crop where the whole crop was returned. At Bundaberg the break was a peanut crop followed by a navy bean crop with grain removed in both cases.

Site	Crop Class	*Lsd 5%*	Sugarcane Yield (t/ha)		
			PO/RP	Traditional Fallow	Well Managed Fallow
Tully	Plant	*12*	88	85	102
Ingham	Plant	*15*	48	--	61
Mackay	Plant	*18*	63	--	88
	R1	*14*	92	--	116
	R2	*13*	77	--	93
Bundaberg	Plant	*13*	112	--	124
	R1	*18*	121	--	138
	R2	*14*	103	--	125
	R3	*14*	89	--	107

The basis of the fallow response is likely to be two-fold. First, there is likely to be a nitrogen contribution from the legume, particularly when a high nitrogen fixer like soybean is incorporated in the system (4). However, there is little doubt that other factors are involved. For example, with the Mackay experiment, four rates of nitrogen were applied to the plant cane crop following both PO/RP and the soybean fallow. There was no response to applied nitrogen following either fallow or PO/RP, but the fallow yielded 30% higher (Table 4).

Table 4. Effect of four rates of applied nitrogen (0, 70, 140 or 280 kg/ha) on the yield of sugarcane in the Mackay rotation experiment following PO/RP or a soybean fallow. *NSD between N rates for either history.*

History	Sugarcane Yield (t/ha)			
	N kg/ha			
	0	70	140	280
PO/RP	60	53	70	69
Soybean Fallow	95	88	82	88

Potential for Grain Legumes

The potential for production of grain legumes in sugarcane cropping systems have been discussed elsewhere (1). Such benefits are likely to be substantial. For example, during the break of 12 months in the Bundaberg rotation experiment discussed above (Table 3), crops of peanuts and navy beans yielding 6.9 (nut in shell) and 1.7 t/ha, respectively were produced. The combined gross margin from these two crops was in excess of $4,000/ha.

CONCLUSIONS

The utilisation of well grown legume fallows can produce major benefits in a sugarcane farming system. Part of this benefit arises through a nitrogen contribution from the legume but other factors, probably associated with improvements in soil health from breaking the monoculture, are involved. The value of the legume crop will be directly related to the selection of the right species for the conditions along with a high level of management. It is becoming more obvious that the PO/RP system is non-sustainable and break crops are destined to play an increasingly important role in sugarcane cropping systems, either as green manure crops or for cash flow through grain production.

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