SHORT, NON-REFEREED PAPER

THE ECONOMICS OF GREEN MANURING IN THE SOUTH AFRICAN SUGAR INDUSTRY

RHODES R[1], FERRER SRD[2] AND GILLITT CG[2]

[1]*South African Sugarcane Research Institute, P/Bag X02, Mount Edgecombe, 4300, South Africa*
[2]*South African Cane Growers' Association, PO Box 888, Mount Edgecombe, 4300, South Africa*
ruth.rhodes@sugar.org.za
Stuart.Ferrer@canegrowers.co.za Chris.Gillitt@canegrowers.co.za

Abstract

The economic costs and benefits of including green manuring as a regular component of a sugarcane cropping system in the North Coast region of KwaZulu-Natal are analysed for early, mid and late-season harvest of the final cane crop. The return on investment for an entire cane cycle (roughly 10-12 years) is compared for a green manure crop, a weed-only fallow of similar length, and, where possible, immediate plough-out/replant. Results indicate that the yield benefits required for weed fallows and green manures to be more profitable than no fallows are probably achievable, based on literature reviewed. Important considerations not addressed in this study include the impacts of green manuring and weed fallows on production risks.

Keywords: economics, green manure, improved yield, Modified Internal Rate of Return, weed fallow

Introduction

'Green manuring' is the practice of growing an alternative crop or plant species between planting cycles of the primary agricultural crop. The green manure crop is not harvested, but is instead returned to the soil to improve soil health and recycle organic matter and nutrients.

Benefits of green manures in sugarcane systems have been widely reported (Schumann *et al*., 2000), and tend to centre around breaking the monocropping cycle: pest and disease cycles are broken, and microbial populations are increased by incorporating green manures into the cropping cycle. Further benefits include nitrogen fixation (by legume crops), weed control, increased organic matter levels and water infiltration rates, and soil cover (providing reduced erosion and decreased surface capping). These factors together result in a yield increase in the first – and often subsequent – crops of sugarcane planted after the green manures (Garside and Bell, 2007).

Growing green manures also incurs costs. The practice takes land out of sugarcane production for, typically, three to 12 months, and involves increased management as well as land preparation and input costs. This study was conducted in response to growers' need to understand the economics of this practice under South African conditions. Due to the wide range of possible scenarios, this study focused on only one area – the KwaZulu-Natal north coast (14-month cycle) – on one soil type (loamy sand; 10-15% clay).

Literature Reviewed

Studies of the benefits of break crops in sugarcane production systems include Garside and Bell (2007), Loeskow *et al*. (2006) and Halpin *et al*. (2008). Garside and Bell (2007) concluded that, when legume break crops were grown for one season, the cumulative sugarcane yield for the system (Break Crop + Plant Crop + **three** Ratoons) equalled – or in some cases, exceeded – that from the system (Plough-out/replant without break crop, Plant Crop + **four** Ratoons). They further assessed the two systems over a common period (12 years), and found that whole-farm gross margins were 20-30% higher in the green manuring system than in the monocropped sugarcane. This analysis included the sale of the legume seeds (soybeans and peanuts) (Garside and Bell, 2007). Similar results were obtained by both Loeskow *et al*. (2006) and Halpin *et al*. (2008). However, in their studies the change in system included significant changes in other aspects of the farming system (e.g. controlled traffic) along with the use of legumes in crop rotation (Loeskow *et al*., 2006; Halpin *et al*., 2008).

The authors are not aware of any published studies on the economic costs and benefits of green manuring in sugarcane production systems in South Africa.

Materials and Methods

Eight scenarios, based on an early, mid or late-season harvest of the final cane crop, were considered.

- Early in the season (April) a field may be:
  - ploughed out immediately, and planted to a green manure such as oats (**Option-1**), or
  - left fallow (weeds only) until cane is re-planted in October (**Option-2**).

- Mid-season (July), the field may be:
  - left fallow until October, when it may be planted to cane (**Option-3**),
  - planted to a green manure (e.g. sunn hemp) with cane replanted the following January (**Option-4**), or
  - left fallow (weeds only) until cane is replanted in December (**Option-5**).

- Late season (November) a field might typically be sprayed out with glyphosate. Thereafter, it may be:
  - immediately replanted to cane (minimum tillage) (**Option-6**),
  - left fallow (weeds only) until the following September (**Option-7**), or
  - planted to a green manure (e.g. velvet beans) before replanting cane the following September (**Option-8**).

For each of the eight options identified above a schedule of farming activities was established on a monthly basis for an entire cane cycle, i.e. from harvest of the previous crop until the final harvest of the replanted crop (a period of roughly 10-12 years).

Sugarcane yields were based on the average Canesim estimates for the period 1966-2011, using weather records from the Tongaat – Klipfontein weather station, and based on the

appropriate months of planting/ratooning and harvesting for each option. Conservative[1] yield increases were assumed and applied to cane grown after green manure or weed fallows:

- Short (3-month) weed fallows:
  - 12% (plant crop),
  - 6% (first ratoon) and
  - 3% (second ratoon).
- Oats, sunn hemp and longer (6-month) weed green manures:
  - 16% (plant crop),
  - 8% (first ratoon) and
  - 4% (second ratoon).
- Velvet beans:
  - 20% (plant crop),
  - 10% (first ratoon) and
  - 5% (second ratoon).

The following assumptions and conditions were applied:

- Green manure benefits were restricted to a simple yield increase in the subsequent three cane crops. Improvements in soil health were not taken into account due to their complexity.
- All green manure crops of the same duration were assumed to give the same yield benefit. Garside and Bell (2011) found little overall effect of break type, climate, season, soil or management.
- Yield increases following the longer green manure fallow were greater than those after the shorter fallow, as was generally the case in studies by Garside *et al*. (1999) and Garside and Bell (2011).
- Cane yield benefit following a weed fallow was lower than after a green manure fallow, as per Garside and Bell (2011) and Garside *et al*., 1998.
- Where legumes were chosen as the green manure crop, an additional benefit of reduced inorganic nitrogen application to the plant crop of cane was assumed (in accordance with recommendations by the Fertiliser Advisory Service at the South African Sugarcane Research Institute).
- No fertiliser was applied to the green manures, and 'average' green manure biomass yields were assumed. No green manure seeds were harvested, and no herbicide or pesticide was applied to the green manures during growth.
- Green manure mulch was not incorporated, as studies have shown that leaving the residue on the soil surface gave the same – or better – results than incorporation into the soil (Noble and Garside, 2000; Garside and Berthelsen, 2004; Garside *et al*., 2006; Rhodes *et al*., 2009).
- Average seed costs[2] as at January 2012 were utilised.

[1]In an extensive literature survey, cane yield increases after ≤12 months of green manure fallow ranged from 10% to 58% (Singh, 1974; Garside *et al*., 1998; Garside *et al*., 1999; Garside and Bell, 2001; Bokhtiar *et al*., 2003; Nixon and Simmonds, 2004; Nixon, 2005; Garside *et al*., 2006; Garside and Bell, 2007; Janboonme *et al*., 2007; Umrit *et al*., 2009; Ambrosano *et al*., 2010; Garside and Bell, 2011) in the plant crop. Yield benefits decreased over time until the third ratoon.
Cane yield increases following a weed fallow (≤12 months) ranged from 3% to 20% for plant crop (Garside and Bell, 2011), with benefits recorded into third ratoon.

[2]Simon Hodgson, Southern African Cover Crop Solutions, Ingomankulu. wensim@mweb.co.za

Fixed costs of land, management and farm overheads were included in the analysis on a monthly basis. Per hectare operational costs and revenues were projected using 2011/12 season prices and monthly net cash flows were computed for each of the eight options. Farm land was priced at its opportunity cost (rent) and fixed overhead costs were set at levels typical of an average commercial dryland sugarcane farm. A sensitivity analysis investigated the extent to which the size of the post-green manure cane yield increase affected the ranking of alternative options.

The Modified Internal Rate of Return (MIRR) is a measure of investment profitability that represents the anticipated increase in the farm's wealth position from undertaking the investment after accounting for the timing of cash in-flows and out-flows (Barry *et al*., 2000). Following Barry *et al*. (2000), the MIRR of each option was computed assuming an average real cost of capital of 4.8% per annum and an annual real rate of return on reinvested returns of 6%. This analysis does not include the effects of financing, so estimated MIRRs are interpreted as a weighted average real cost of debt and equity capital.

Results

Early season
The oats green manure incurs higher costs than does a weed fallow period, yet the two options have similar yield benefits; consequently, the weed fallow, with a MIRR of 7.61% p.a., is more profitable than the oats (MIRR: 7.36% p.a.).

Mid-season
The sunn hemp green manure option (MIRR: 7.02%) was found to be less profitable than either the weed fallow (MIRR: 7.51%) or having no fallow period (MIRR: 7.45%). To outperform the 'no fallow' option, sunn hemp would need to increase cane yields by at least 27.3% (plant), 13.6% (1st ratoon) and 6.8% (2nd ratoon). These figures fall comfortably within the range of yield increases recorded by numerous researchers (see footnote 1).

Late season
Profitability of the 'no fallow' option was found to be similar to the velvet beans green manure option (7.41% MIRR for both options). The lengthy weed fallow period was most profitable (MIRR: 7.62%). The velvet beans moved into first position in the ranking if the yield increase was at least 26.4% (plant crop), 13.2% (1st ratoon) and 6.6% (2nd ratoon), *ceteris paribus*. This is considered achievable based on extensive research results.

Discussion and Conclusions

Results showed that benefits of green manures and fallow periods can outweigh their added costs after accounting for the time-value of money principle. Weed fallows are more profitable than planted green manures under the yield impact assumptions made in this study. Case studies are necessary to better quantify the yield benefit of various green manures, including weed fallows.

Profitability is only one economic consideration in green manuring decisions. The impacts of green manuring on production risk (especially the impact on drought resilience of cane) and yield decline due to pests and diseases (not considered in Canesim) are also important. Potential drawbacks to the weed fallow – such as the risk of an increased weed seedbank, and greater weed combatting costs – were not considered here, and could play a role in rendering

this option less profitable. The numerous recorded benefits associated with a managed green manure crop – including improved soil health, nematode control and weed suppression – are often intangible, and hence difficult to value.

Acknowledgements

Many thanks to Rowan Stranack (SASRI) for his advice on the scheduling of sugarcane farming activities for each of the eight options considered in this study.

REFERENCES

Ambrosano EJ, Azcón R, Cantarella H, Ambrosano GMB, Schammass EA, Muraoka T, Trivelin PCO, Rossi F, Guirado N, Ungaro MRG and Teramoto JRS (2010). Crop rotation biomass and arbuscular mycorrhizal fungi effects on sugarcane yield. *Sciencia Agricola* (Piracicaba, Brazil) 67(6): 692-701.

Barry PJ, Ellinger PN, Hopkin JA and Baker CB (2000). *Financial Management in Agriculture*. Sixth Edition. Interstate Publishers Inc, Illinois, USA.

Bokhtiar SM, Gafur MA and Rahman ABMM (2003). Effects of *Crotalaria* and *Sesbania aculeata* green manures and N fertilizer on soil fertility and the productivity of sugarcane. *J Agr Sci* 140: 305-309.

Garside AL and Bell MJ (2001). Fallow legumes in the Australian sugar industry: Review of recent research findings and implications for the sugarcane cropping system. *Proc Aust Soc Sug Cane Technol* 23: 230-235.

Garside AL and Bell MJ (2007). The value of legume breaks to the sugarcane cropping system – cumulative yields for the next cycle, potential cash returns from the legume, and duration of the break effect. *Proc Aust Soc Sug Cane Technol* 29: 299-308.

Garside AL and Bell MJ (2011). Growth and yield responses to amendments to the sugarcane monoculture: Effects of crop, pasture and bare fallow breaks and soil fumigation on plant and ratoon crops. *Crop Pasture Sci* 62: 396-412.

Garside AL and Berthelsen JE (2004). Management of legume biomass to maximise benefits to the following sugarcane crop. *Proc Aust Soc Sug Cane Technol* 26 (CD-ROM).

Garside AL, Bell MJ, Cunningham G, Berthelsen JE and Halpin N (1999). Rotation and fumigation effects on the growth and yield of sugarcane. *Proc Aust Soc Sug Cane Technol* 21: 69-78.

Garside AL, Berthelsen JE, Robotham BG and Bell MJ (2006). Management of the interface between sugarcane cycles in a permanent bed, controlled traffic farming system. *Proc Aust Soc Sug Cane Technol* 28: 118-128.

Garside AL, Noble AD, Berthelsen JE and Richards CL (1998). Fallow histories: Effects on nitrogen contribution, growth and yield of plant and ratoon crops of sugarcane. *Proc Aust Soc Sug Cane Technol* 20: 104-111.

Halpin NV, Cameron T and Russo PF (2008). Economic evaluation of precision controlled traffic farming in the Australian sugar industry: A case study of an early adopter. *Proc Aust Soc Sug Cane Technol* 30: 34-42.

Janboonme S, Tippayaruk J, Dhummarangsi P and Bantilan MCS (2007). Impact of pigeonpea research in enhancing sugarcane production in Thailand. SAT eJournal (Journal of SAT Agricultural Research 5(1).

Loeskow N, Cameron T and Callow B (2006). Grower case study on economics of an improved farming system. *Proc Aust Soc Sug Cane Technol* 28: 96-102.

Nixon DJ (2005). Fallowing and green manuring practices for sugarcane. *Sug Cane Int* 23(5): 18-23.

Nixon DJ and Simmonds LP (2004). The impact of fallowing and green manuring on soil conditions and the growth of sugarcane. *Expl Agric* 40: 127-138.

Noble AD and Garside AL (2000). Influence of soybean residue management on nitrogen mineralisation and leaching and soil pH in a wet tropical environment. *Proc Aust Soc Sug Cane Technol* 22: 139-146.

Rhodes R, van Antwerpen R and Berry SD (2009). Green manure fallow duration: Does it matter? *Proc S Afr Sug Technol Ass* 82: 570-579.

Schumann RA, Meyer JH and van Antwerpen R (2000). A review of green manuring practices in sugarcane production. *Proc S Afr Sug Technol Ass* 74: 93-100.

Singh A (1974). Use of organic materials and green manures as fertilizers in developing coutnries. pp 10-30 In: Swedish International development authority: FAO of the UN. Organic materials as fertilizers.

Umrit G, Bholah MA and Ng Kee Kwong KF (2009). Nitrogen benefits of legume green manuring in sugarcane farming systems in Mauritius. *Sugar Tech* 11(1): 12-16.