SHORT NON-REFEREED PAPER

GROSS MARGIN ANALYSIS OF GENETICALLY MODIFIED INSECT RESISTANT HERBICIDE TOLERANT SUGARCANE IN RAINFED FARMS OF KWAZULU-NATAL

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Introduction

Increasing prevalence of the stalk borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae) (eldana), and the creeping grass weed, *Cynodon dactylon* (cynodon) have caused the costs of sugarcane production, and in particular the costs associated with control of pests and weeds, to increase. Nicholson *et al.* (2017) determined that in 2016 applications of pesticides and herbicides accounted for 13% and 18% of planting and ratoon management costs in sugarcane production, respectively. The South African Sugarcane Research Institute (SASRI) is currently developing an insect resistant (IR) and herbicide tolerant (HT) genetically modified (GM) sugarcane cultivar to help counter the challenges and costs of managing lepidopteran pests and weeds (Snyman and Rutherford, 2017).

The general objective of this study is to conduct an *ex ante* analysis of sugarcane farmers' willingness to adopt IR and HT sugarcane and to investigate its likely socio-economic impacts. The component of the study reported in this paper aims to compare the gross margins of various cane cultivars, including possible GM cultivars, in two cane supply regions (Gledhow and Eston) for an assumed scenario of input and Recoverable Value (RV) price.

Materials and Methods

A representative farm modelling approach was used in this study to investigate farmers' likely preferences for sugarcane cultivars in a scenario in which GM cultivars of sugarcane are available. Two study areas, where eldana and cynodon creeping grass are currently most problematic (Rutherford, 2015), were selected following meetings with SASRI extension staff and SACGA regional staff. Gledhow was aggregated into two representative farms (coastal and inland), and Eston areas aggregated into three representative farms (Eston Central, Mid-Illovo and Richmond). Aggregation was based on climatic conditions, cane yield distributions, land categories and soil types.

Following recommendations by SASRI biotechnologists, for the purpose of this study, N52 was hypothetically modified as GM cane by assuming a cultivar of sugarcane that is similar to N52 but also has the IR and HT traits. It was assumed that in the Gledhow cane supply region this cultivar will be produced on an 18-month cycle; however, in the Eston cane supply region it may be produced on an 18-month or 24-month cycle.

Gross margin computation

Revenue was calculated as the product of expected cane yield, RV% and the RV price (2012-2018 average). Information obtained from various experts (SACGA economists, SASRI scientists and extension specialists and farmers) was used to estimate cane planting, ratoon

management and harvesting costs for each likely combination of sugarcane cultivars (including the hypothetical GM cultivar), locality and land category.

Results and Discussion

A description of a possible GM cultivar of sugarcane that has both the IR and HT traits, including how its production is expected to differ from production of non-GM cultivars (e.g. a change in application of chemicals to control pests), and its expected performance (yield distribution) across various categories of arable land on each of the representative farms was compiled. The IR and HT traits are expected to improve the cane yield by 5% and 2%, respectively, above that of the non-GM cultivar to which full chemical eldana and conventional weed control is applied. Additionally, RV% is assumed to increase by 1 unit for the GM cultivar due to superior eldana control (personal communication[1]). The N52 cultivar was therefore modified with these traits in the different subject fields. Table 1 compares gross margins of N52 on 14-16 month and 18 month cutting cycles with the GM cultivar on a typical farm in the Gledhow area. Findings show that N52 on 18-month cycle outperforms N52 on 14-16 month cycle using chemicals to control eldana (Ducasse *et al*, 2017). The GM cultivar, however, has the highest expected revenue/ha due to both yield advantage and cost savings in weed and eldana control.

[1]Stuart Rutherford, Private Bag X02, Mount Edgecombe, 4300, (031) 508 7400

Table 1: Example of enterprise budget prepared for the coastal representative farm in the Gledhow cane supply region.

	Cane cultivars	N52[1]	N52[2]	GM[2]
	% area under cane/annum:			
a	Area harvested	75,00%	66,67%	66,67%
b	Area planted	10,00%	11,11%	11,11%
c	Area ploughed out	10,00%	11,11%	11,11%
d	Area green manured	7,50%	8,33%	8,33%
e	Area Ratooned	63,75%	55,56%	55,56%
F	RV price per ton	4502,98	4502,98	4502,98
g	Average yield cane (t/ha harvested)	67	78	83,46
h	RV%	0,121	0,123	0,133
i	**Gross Income/ha under cane (a*f*g*h)**	**27 379,21**	**28 801,03**	**33 322,59**
	Planting costs per ha planted			
	Mechanical land prep			
j	Land preparation	3253	3253	3253
k	Hand planting	3463	3463	3463
l	Seed cane	8520	8520	8520
m	Fertiliser and lime	4042	4042	4042
n	Weed control	2588,97	2588,97	1850,49
o	Sundries and contingencies	3354	3354	3354
p	**Total (j+k+l+m+n+o)**	25220,97	25220,97	24482,49
q	**Planting costs/ha under cane (b*p)**	**2522**	**2802,33**	**2720,28**
	Harvesting costs per ha harvested			
r	Cutting of burnt cane	3937,59	4584,06	4904,94
s	Infield-cane haulage	1693,76	1971,84	2109,87
t	Loading and transhipment of burnt cane	939,34	1093,56	1170,11
u	**Total (r+s+t)**	6570,69	7649,46	8184,92
v	**Harvesting costs/ ha under cane (a*u)**	**4928,02**	**5099,64**	**5456,61**
	Ratoon management (RM) costs: Dryland cane early harvest			
	Field management	528.28	528.28	528.28
x	Fertilizer	3232,97	3233,00	3233,00
y	Weed control	730,97	671,07	181,52
z	**Total (w+x+y)**	4492,22	4492,25	3942,80
aa	**RM costs/ ha under cane (e*z)**	**2863,79**	**2495,69**	**2190,45**
ab	Green manuring (Gm)	3106,87	3106,87	3106,87
ac	**Gm/ ha under cane (d*ab)**	233,01	258,91	258,91
ad	**Eldana control/ ha under cane**	1970	2955	985
ae	**Total Costs/ ha under cane**	13502	13612	11611
	Gross margin per hectare (i-ae)	**14862**	**15223**	**21711**

[1]14-16 month cutting cycle
[2]18 month cutting cycle

The analysis was extended to include additional cane cultivars, as advised by SASRI extension staff in each of the two regions. The findings are summarised in Table 2, which reports the performance of different cultivars in different localities.

Table 2: Comparisons of the gross margins of GM cultivars against the best performing non-GM cultivars in Gledhow and Eston can supply areas.

Locality		Land Category	Expected Gross Margin of GM cultivar	Best performing non-GM cultivar	Second best non-GM cultivar
			Gross Margins in R/Ha under cane		
Gledhow	Coastal area	Sandy Soils	**GM[1]: R 20 452**	N52[1]: R15 145	N41[1]: R14 542
		Loamy Soils	**GM[1]: R 21 711**	N52[1]: R15 223	N41[1]: R14 152
		Clay Soils	GM[1]: R 21 015	**N59[1]: R21 125**	N52[1]: R15 124
	Inland	Sandy Soils	**GM[1]: R 20 458**	N52[1]: R16 246	N41[1]: R14 528
		Loamy Soils	**GM[1]: R 21 895**	N52[1]: R17 056	N59[1]: R15 562
Eston	Eston Central	Poor soils	**GM[2]: R 24 501**	N52[2]: R18 190	N12[2]: R13 876
		Sandy soils	**GM[2]: R 26 345**	N52[2]: R18 270	N31[2]: R18 181
		Clay soils	**GM[2]: R 28 980**	N54[1]: R25 922	N48[2]: R18 664
	Mid-Illovo	Poor soils	**GM[2]: R 26 445**	N12[2]: R24 274	N31[2]: R11 719
		Sandy soils	**GM[2]: R 28 189**	N31[2]: R26 093	N52[2]: R23 174
		Clay soils	GM[2]: R 31 004	**N54[1]: R35 241**	N48[2]: R19 476
	Richmond	Poor soils	**GM[2]: R 25 028**	N12[2]: R22 865	N31[2]: R18 153
		Sandy soils	GM[2]: R 26 780	**N54[1]: R33 770**	N48[2]: R26 019
		Clay soils	GM[2]: R 29 454	**N35[2]: R30 961**	N54[1]: R25 922

[1]18-month cutting cycle.
[2]24-month cutting cycle

Sugarcane with the N52 genotype, genetically modified to have the IR and HT traits, is expected to achieve higher gross margins than existing cane cultivars using chemical control for eldana and creeping grass on sandy and loamy soils in the Gledhow cane supply region for both the coastal and inland farms. For the Eston supply region, the GM cultivar is expected to perform better than existing cane cultivars in all soil types in the Eston central area. However, there are cultivars that generate higher gross margins than GM cultivars in clay and sandy soils in the Mid-Illovo and Richmond representative farms. Analysis of the socio-economic impacts (e.g. farm income, employment, use of agro-chemicals) cannot be assessed before other considerations are included in the analysis. These include risk considerations, farm risk preference, the opportunity cost of land, and the limit to the area under any cane cultivar and under GM cultivar. Further analysis is required to include risk considerations, as well as constraints to limit the area under any one cultivar to no more than one-third of the area under cane on each representative farm, as per SASRI recommendation.

Conclusions

The general findings of this analysis is that a GM cane based on the N52 genotype with both IR and HT traits is likely to be adopted by both farmers in the Gledhow and Eston cane supply areas in preference to currently available cultivars. The benefits of GM IR and HT cane are mainly attributed to decreases in cost of chemical control and increased gross income owing to the improvement of cane yield and quality.

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