AN ECONOMIC ASSESSMENT OF USING MOLASSES AND CONDENSED MOLASSES SOLIDS AS A FERTILISER IN THE SOUTH AFRICAN SUGAR INDUSTRY

A T WYNNE[1] and J H MEYER[2]

[1]*South African Cane Growers Association, P O Box 88, Mount Edgecombe 4300, South Africa*
[2]*South African Sugar Association Experiment Station, P/Bag X02, Mount Edgecombe 4300, South Africa*
E-mail: Awynne@canegrowers.co.za

Abstract

The value of molasses as a fertiliser has recently become of interest due to the rapid devaluation of the Rand and the reliance of South African agriculture, including the sugar industry, on mainly imported N and K fertiliser. Molasses is used primarily as a source of potassium but it has other significant advantages such as increasing organic matter in the soil and microbial activity associated with nitrification. Molasses also contains secondary elements in small quantities such as phosphorus, sulphur, calcium and magnesium, as well numerous trace elements. Application of molasses also improves soil aggregation and reduces surface crusting in hard-setting soils. There are disadvantages to the use of molasses on farm such as the risk of ground water pollution if incorrectly applied and its variable nutrient composition, which create difficulties in applying it evenly infield. Its viscosity also makes it difficult to handle and its large volume gives rise to application problems on steeper lands. Molasses also needs to be collected rateably from the mill whereas its optimum application is not necessarily rateable resulting in storage requirements. All the above factors are quantified and the economic value of molasses compared with inorganic fertiliser, to help growers make an informed and cost effective decision regarding use of molasses on the farm. Also the demand for industrial alcohol and ethanol, which uses molasses as a feedstock is increasing. A by-product of alcohol and ethanol production is vinasse or in a concentrated form Condensed Molasses Solids (CMS), which also has value primarily as a source of K fertiliser.

Keywords: molasses, potassium, fertiliser, condensed molasses solids, CMS, economics, vinasse, stillage

Introduction

The recent devaluation of the South African currency has caused local fertiliser prices in the Sugarcane Industry to escalate. Since September 2000 the price of nitrogen and potassium has escalated by 40 and 65% respectively. Consequently, growers have an incentive to review cheaper sources of nitrogen, phosphorus and potassium that are available locally, one of which is molasses. Problems associated with the viscosity of molasses in its application onto fields has detracted from its widespread use in the past but in this new economic climate it may be more attractive especially in view of its significant potassium content (±3.5% K). In addition, there has been increased demand for molasses for alcohol distillation thus competing for its use as a fertiliser. This paper attempts to detail the cost benefit analysis of molasses mainly as a source of K fertiliser for growers given this new economic climate. To achieve this and provide growers with meaningful information on which to base their decisions the following questions will be addressed:

- What are the implications of using molasses as a fertiliser?
- What is the value of nutrients contained in molasses?
- What is the cost/benefit to individual growers of using molasses as a fertiliser?

Background to using molasses as a fertiliser

As far back as 1860, it was standard practice to apply molasses before planting sugarcane in a number of countries. In Mauritius and Hawaii, the application of molasses to cane lands was widespread. It was concluded from research investigations that its beneficial effects were due not only to release of plant available nutrients such as potassium and nitrogen, but also to physical improvement in soil structure and an increase in biological activity of beneficial micro-organisms following partial sterilisation of the soil (Doty, 1933). Other benefits that have been reported include the control of nematodes through certain species of fungi that are able to parasitise plant feeding nematodes (Tianco, 1983).

In South Africa, the first authoritive investigation was carried out by the Tongaat Sugar Company Ltd during the fifties (Cleasby, 1957), when large areas of the industry were deficient in potassium. Significant yield responses were obtained from molasses applied at rates of up to 13.5 t/ha in four trials, and soil analysis confirmed the marked effect it had in restoring depleted potassium levels.

Currently, molasses accounts for less than 2% of industrial revenue (R100 million out of gross revenue of R5.5 billion). The South African sugar industry produces about 850 000 tons of molasses annually of which approximately 650 000 tons is sold locally to value-adders (fermentation sector, animal feeds etc) while the remaining 200 000 tons is exported as a surplus. Over the past five seasons the maximum annual tonnage of molasses used by cane growers was 14 000 tons, representing 1,6% of total molasses production.

Currently, each grower has access rights to purchase at the ruling price 23 litres of molasses per ton of cane delivered provided its purpose is for on-farm use only; i.e. as a fertiliser or animal feed. Growers cannot legitimately combine their molasses rights to obtain sufficient economies of scale to erect their own distillation or fertiliser plant. However, growers are entitled to enter into a commercial contract with their miller to purchase additional molasses for whatever purpose at the ruling price, but subject to supply constraints at the mill; *i.e.* depending on other molasses contracts the miller might have, inclusive of each growers individual rights. Whether molasses is sold to individual growers in terms of their access rights or sold to an external distillation company, the revenue generated from such sales is distributed between millers and growers according the division of proceeds in the same manner as sugar revenue. Ultimately, this transfer takes place in the "Recoverable Value" price growers receive for their cane. Some of the advantages and disadvantages of using molasses as a fertiliser are detailed in Table 1.

Table 1. Advantages and disadvantages of using molasses as a fertiliser.

Advantages	Disadvantages
• Molasses is a good source of potassium	• Difficult to handle and apply – machinery implications.
• Increased organic matter and microbial activity improves nitrification	• Only suitable for flat and undulating terrain but can be applied on steeper lands
• There are numerous trace elements in molasses in appreciable amounts	• Molasses needs to be collected rateably from the mill but is not necessarily applied rateably to the fields – storage implications
• Molasses improves soil aggregation and reduces surface crusting in hardsetting soils	• Nutrient composition of molasses varies and the evenness of application is questionable
• Potential 5 to 10% response in cane yield on low fertility soils	• Risk of soil and water pollution if not properly applied

Composition of molasses

The composition of molasses varies according to numerous factors that include the maturity and variety of cane milled, climatic conditions, soil type, fertiliser history and process of manufacture (Baker, 1975). In general molasses comprises about 20% water and 80% solids of which 55% is sucrose, 25% non-sugars and 10% mineral constituents usually represented as sulphated ash. The fertiliser value of molasses is due mainly to about seventy per cent of the potassium in the cane crop entering the mill, going into solution with sucrose in the juice and reappearing in the inorganic fraction of molasses. The composition of molasses from five mills in the Illovo Sugar group is summarised in Table 2. Unfortunately N was not analysed but it is known from the literature as well as FAS records that total N can vary from 0.3 to about 1% with an average of about 0.5% (Manohar Rao, 1997).

Table2. Composition of 15 samples of Illove Sugar molasses.

Constituent%	High%	Low%	Average
Sucrose	31.26	27.93	29.93
Fructose	8.43	6.40	7.23
Glucose	5.70	3.42	4.45
Sulphated ash	14.00	12.33	13.11
Potassium	4.30	3.62	3.82
Phosphate	0.44	0.19	0.31
Calcium	0.93	0.86	0.89
Magnesium	0.50	0.43	0.46
Sulphate	1.63	1.05	1.26

Source: N Brakenbridge, 2001

Value of nutrients contained in molasses

Conservative fertiliser prices (R/ton) have been used to establish the Rand per kilogram values of nitrogen (N), phosphorous (P) and potassium (K), the workings of which are illustrated in Table 3. These prices were effective until February 2002 and include recent price increases as a result of the devaluation of the Rand.

Table 3. Market related prices for N, P and K.

Item	Urea	DAP	KCl	Cost/kg
Price	R2150	R2993	R2570	
N	46%	18%		R 4.67
P		20%		R10.76
K			50%	R 5.14

Table 4 shows that for equivalent amounts of nutrients, the cost of molasses is relatively cheaper than commercially available fertiliser, where molasses is valued at R240.55 per ton. This molasses value represents the current export parity price of molasses, which is the price that growers will be charged under the new Sugar Industry Agreement for growers' utilising their existing on-farm use rights. This analysis is simplistic because the nutrient requirements of the crop and application costs have not been considered.

Table 4. Comparative nutrient values for molasses and commercially available fertiliser.

Item	Molasses		Fertiliser	
	kg	Value	kg	Value
N	5		5	R 23.37
P	3		3	R 32.28
K	38.2		38.2	R196.35
Other	953.8		953.8	
Total	1000	R240.55	1000	R251.99

Cost/benefit of using molasses to individual growers

Molasses on its own can supply ratoon cane with all its required K and some P but supplementary fertiliser application is necessary to increase the nitrogen component. Urea is the most cost effective N source to use and an example of using urea in combination with molasses is shown in Table 5.

Table 5. Application rates (tons/hectare) of a combination of molasses and urea fertiliser.

	Rate	N	P	K
Molasses	5%	5	3	40
Tons/ha	4.00	0.02	0.01	0.16
Urea	46%	28		
Tons/ha	0.22	0.10	0.00	0.00
Combined	**4.22**	**0.120**	**0.012**	**0.160**

The basis of selecting the above fertiliser combination (from numerous potential combinations) was to first fulfil the plants K requirements using molasses and then "top up" the nitrogen deficit with urea. The quantities and proportions of N, P and K are broad representations of the requirements for rainfed ratoon cane, grown on moderate fertility soils. Fertiliser requirements obviously change significantly depending on soil forms, parent material, nematodes, rainfall, salinity/sodicity problems, eldana, timing of lime application, management factors etc (Meyer *et al*., 1986).

A typical FAS recommendation for moderate fertility soils is 120 kg/ha N, 20 kg/ha P and 150 kg/ha K. The closest available blend to achieve this is 600 kg/ha of 5:1:5(46) which will provide 125 kg/ha N, 25 kg/ha P and 125 kg/ha K. The total cost of applying this commercially available fertiliser blend is shown in Table 6.

Table 6. Application cost (R/ha) of commercially available fertiliser.

Fertiliser only	Value	Units
Cost of 5:1:5(46)	2684	R/ton
Application rate	0.60	t/ha
Fertiliser transport to the farm (60 km)	50	R/ton
Labour rates	31	R/day
Labour productivity	1	ha/day
Fertiliser cost – cost/ton x application rate	1610.4	R/ha
Fertiliser transport – transport rate x application rate	30	R/ha
Fertiliser application – labour rate x labour productivity	31	R/ha
Total cost of fertiliser only	1671	R/ha

Some broad assumptions have been made in the above calculation but the same assumptions are used in the subsequent analysis in Table 7 where the total cost of applying a fertiliser/molasses combination is calculated. Consequently, a direct comparison can be made between the two. An important assumption made was that the FAS soil test analysis showed that K was required and that the grower applying molasses was 10 kilometres from the mill. Where soils are well supplied with K, no fertiliser K is required so using molasses is unlikely to be economical under these conditions.

Table 7. Application cost (R/ha) of a combination of molasses and fertiliser.

Combination – Fertiliser component	**Value**	**Units**
Cost of urea	2150	R/ton
Application rate	0.22	t/ha
Fertiliser transport to the farm (60 km)	50	R/ton
Labour rates	31	R/day
Labour Productivity	1	ha/day
Fertiliser cost – cost/ton x application rate	470	R/ha
Fertiliser transport – transport rate x application rate	11	R/ha
Fertiliser application – mixed with the molasses	0	R/ha
A: Total cost of fertiliser component of combination	480	R/ha
Combination – Molasses component	**Value**	**Units**
Cost of molasses	241	R/ton
Molasses application rate	4	t/ha
Molasses transport to the farm (10 km)	12	R/ton
Molasses dilution rate	1	: 1
Molasses cost – cost/ton x application rate	962.2	R/ha
Molasses transport – transport rate x application rate	48	R/ha
Molasses application – see Appendix 1 for workings	89	R/ha
B: Total cost of molasses component of combination	1099	R/ha
Total cost - A + B	1580	R/ha

Potential yield benefits

Research undertaken by Tongaat Sugar Company Ltd (1957) into yield response to molasses application indicated a potential yield response of between 9% and 20%, at molasses application rates of 13,5 tons per hectare on soils low in potassium and of poor structure (Cleasby, 1957). Based on the recommended application rate of four tons per hectare a yield response of approximately eight percent is anticipated relative to commercially applied fertiliser, although further research is required to confirm this. This yield response collectively captures the intangible benefits of using molasses as a fertiliser, such as the presence of micro-nutrients, improved soil structure, microbial action and others. A net benefit of R890 per hectare is gained if molasses is used instead of commercially available fertilisers. These calculations are presented below:

Table 8. Net benefit from using molasses.

Standard yield	65	tons/ha
Molasses yield response	8%	increase
RV price	R1335	per ton
Season average RV%	12%	cane
Income without molasses	R9980	per ha
Income with molasses	R10779	per ha
Additional income from using molasses	R798	per ha
Cost saving from using molasses	R92	per ha
Net benefit from using molasses	R890	per ha

Other benefits and effects

Apart from supplying nutrients, some of the other beneficial effects reported by researchers included a physical improvement in soil structure and an increase in the biological activity of beneficial micro-organisms such as soil fungi, following partial sterilisation of the soil. The soil fungi produce a heavy mycelial growth, and coat the soil particles in contact with the molasses. In addition, some species of soil fungi are nematophagous or nematode destroying, and can parasitise and kill nematodes (Tianco, 1983). On the debit side molasses contains large quantities of fermentable sugars that can temporarily immobilise or tie up plant available nitrogen in organic form, causing leaf yellowing due to a transient N deficiency. For this reason, at least half of the fertiliser N should be applied at about the same time the molasses is applied. Eventually the immobilised N will be released or mineralised, and will be taken up by the cane. The rate of N release will depend on how well the soil is aerated. Molasses should not be applied to poorly drained soils.

Conclusion

Given the assumptions made, the above analysis indicates that the application of molasses is beneficial relative to commercially available fertilisers by an amount ranging from about R100 to just under R900 per hectare depending on the yield response. However, it should be noted that the analysis is based on prices available up to February 2002, which are subject to change. The most sensitive variables in the analysis include the exchange rate and its impact on commercial fertiliser prices and the export parity price of molasses. Clearly if the fertiliser value of molasses exceeds the cost of molasses to the grower then the use of molasses is likely to be cost effective especially where soil analysis indicates a requirement of at least 100 kg K/ha. The ratio between the cost of a ton of muriate of potash to the cost of a ton of molasses could serve as a useful diagnostic indicator of the economic effectiveness of molasses as a source of K fertiliser. A ratio in excess of 10.65 is likely to be cost effective for a grower within 10 km of the mill provided FAS recommends at least 100 kg K/ha. Where soils are well supplied with K then use of molasses is unlikely to be cost effective.

In terms of the rules governing growers' entitlement to molasses for on-farm use, a grower is only entitled to the equivalent molasses produced from that grower's cane deliveries.

Table 9 indicates that an "average" large-scale grower is currently not entitled to sufficient molasses to meet the requirements of the above-mentioned fertilising regime.

Table 9. Availability of molasses entitlement relative to nutrient requirements.

Area fertilised	150	ha
Cane yield (tons cane/ha)	65	tons/ha
Tone cane produced	8750	tons
Allowed access to molasses (tons mol/100 tons cane)	3.3	ratio
Molasses application rate (tons molasses/ha)	4	tons/ha
Tons molasses required	600	tons
Actual molasses threshold (tons mol/100 tons cane)	6.2	ratio
Allowed application rate (tons molasses/ha)	2.1	tons/ha
Shortfall of molasses required	-1.9	tons/ha

However, all growers are entitled to purchase additional molasses from the miller on a contractual basis. With this in mind advances in technology point towards molasses being used for the production of ethanol, which is a sustainable energy source that will reduce carbon emissions. Condensed Molasses Solids (CMS) is a by-product of this fermentation process, which is believed to have an improved nutrient composition compared with that of standard sugar mill molasses. Under these circumstances growers should not only consider investing directly in downstream sugar and molasses products such as ethanol but also prepare themselves in the event that the currency devalues further by applying molasses and CMS as cheap and efficient inorganic fertiliser substitutes.

REFERENCES

Baker, BP (1975). Composition, properties and uses of molasses and related products. United Molasses Trading Co. Ltd, London. 80 pp.

Brakenbridge, N (2001). Progress Report on Merebank's Stripper Fouling Problem. Illovo Technical Dept, Merebank. 28 pp.

Cleasby, TG (1959). Use of molasses on the land: a report of four experiments being carried out by the Tongaat Sugar Company Ltd. *Proc S Afr Sug Technol Ass* 33: 95-102.

Doty, R (1933). A Bibliography on the use of molasses as a fertiliser. *Proc Hawaiian Sugar Tech* pp 165-168.

Manohar Rao, PJ (1997). Industrial utilization of sugar cane and its byproducts. Ministry of Food and Civil Supplies, Govt of India: pp 232-251.

Meyer, JH, Wood, RA and Leibbrandt, NB (1986). Recent advances in determining the N requirement of sugarcane in the South African sugar industry. *Proc S Afr Sug Technol Ass* 60: 205-211.

Tianco, AP (1983). Molasses as a fertiliser and soil amendment. *Proc Phillipines Sugar Tech* 30: 469-472.

APPENDIX

Annex 1 - Molasses Application Costs	Value	Units
Area fertilised	150	ha
Number of molasses applications	1	
Width of molasses applicator	9	meters
Distance travelled per ha	1111	m/ha
Speed	6	km/hr
Efficiency	67%	
Time required	0.28	hrs/ha
Annual utilisation of tanker	41.5	hrs
Annual utilisation of tractor	1000	hrs
Tractor - see Annex 2 for workings	R 95.19	R/hr
Tanker and storage - see Annex 3 for workings	R 227.08	R/hr
Total cost	R 322.28	R/hr
Cost per ha	R 89.08	R/ha

Annex 2 - Tractor workings		Assumption	Rate/Hr	Rate/Unit
Life of Machine (hrs)		10000		
Salvage Value		10%		
Utilisation Hours per Unit		1000		
Total Purchase Price		R 180,000		
Depreciation			R 16.20	R 16,200
Interest		15%	R 13.50	R 13,500
License and Insurance		1%	R 1.80	R 1,800
Operator Cost per month	1	R 1,200	R 14.40	R 14,400
Assistant	1	R 460	R 3.86	R 3,864
Tyre Replacement Cost		R 9,000		
Tyre Life (hours)		3000		
Tyre Replacements per Annum		0.33	R 3.00	R 3,000
Diesel Price per Litre		R 3.49		
Fuel Consumption (litres/hour)		7	R 24.43	R 24,430
Repairs & Maintenance (% price)		100%	R 18.00	R 18,000
Total			R 95.19	R 95,194

Annex 3 - Tanker & storage workings			Assumption	Rate/Hr	Rate/Unit
Life of Machine (hrs)			12000		
Salvage Value			10%		
Utilisation Hours per Unit			41.45937		
Price(tanker+storage)	R 75,000	R 30,000	R 105,000		
Depreciation				R 7.88	R 326
Interest			15%	R 189.95	R 7,875
License and Insurance			1%	R 25.33	R 1,050
Operator Cost per Annum			R 0	R 0.00	R 0
Assistant		0	R 0	R 0.00	R 0
Tyre Replacement Cost			R 0		
Tyre Life (hours)			0		
Tyre Replacements per Annum			0.00	R 0.00	R 0
Diesel Price per Litre			R 0.00		
Fuel Consumption (litres/hour)			0	R 0.00	R 0
Repairs & Maintenance (% price)			45%	R 3.94	R 163
Total				R 227.08	R 9,415