Investigations into the Effect of Effective Microorganisms and Organic Amendments on Sugar Cane Production in South Africa

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Abstract : *Investigations were conducted on sugar cane production in the Mpumalanga Province of South Africa to compare and evaluate the nutrient utilisation efficiency of EM-treated organic-inorganically fertilised crops with those receiving chemical fertilisers only. The organic amendment used was CMS, a liquid by-product of the sugar cane industry with relatively high potassium content. This paper discusses application strategies of CMS and EM for the commercial production of sugar cane and the effects thereof on soil quality improvement, especially with respect to Ca+Mg/K ratios in intensively irrigated clay soils of relatively dry sub-tropical areas of South Africa. The effect of organic amendments and microbial inoculants on crop growth and yield, product quality, sucrose content and on total production costs is also discussed.*

Introduction

The sugar cane industry is a well-established agricultural activity in South Africa. It was established in 1851. Production areas include the KwaZulu-Natal coastal and Underberg (Mpumalanga) areas (Anderson, 1979). Currently 426,797 ha of land is under sugar cane cultivation, a 6% increase since 1990. A total of 23,876,162 tonnes of cane were harvested during the 2000/1 production cycle, from which 2,729,219 tonnes of sugar have been extracted thus contributing significantly to the agronomics of South Africa (SASA, 2001).

Production intensification has had a negative impact on the profitability of the industry as a whole. Substantial increases in production costs, particularly with respect to labour, chemical fertiliser and transport costs, have contributed negatively on the profitability of this industry and need to be addressed. Periodic droughts and prolonged periods of below-average rainfall, particularly in the Underberg area of Mpumapanga, have necessitated the use of irrigation to supplement the water requirements of the crop. This practice has resulted in increased soil salinity. Although sugar cane tolerance levels to saline soils is relatively high (Dickson et al., 1989) imbalances in the ratios of CA+Mg/K and Na may have a negative effect on the uptake of K, a key element in optimal sugar cane production. In addition, regular burning of organic material subsequent to harvesting of the crop negatively affects soil fertility. This practice results in soil exhaustion as no organic material is returned to the soil. The negative effects of alkalinity in soils increases whilst buffer capacity decreases.
The present investigation has the following aims:

1. To increase the sucrose content of sugar cane harvested through the introduction of organic amendments and microbial involvement. Simply increasing the yield of the sugar cane crop per hectare without increasing the sucrose content of the sugar cane harvested will not have a significant impact on the profitability of this industry;
2. To improve soil quality through the use of organic amendments and effective microbes (EM). The soil is of a heavy loam to clay type in which nutrients are fixed. These nutrients need to be released and made available to the sugar cane plant;
3. To reverse the negative effects of burning organic material between sugar cane production cycles by applying EM to the remaining plant material; and,
4. To gradually reduce the industry's dependence on chemical fertilisers by gradually making greater use of organic amendments and effective microbes, while decreasing the dependence on chemical fertilisers and using them selectively.

Materials and Methods

Experimental Plots

Three 8 ha blocks (24 ha) of the farm Bahati in the Komatipoort area of Mpumalanga were set-aside for evaluation purposes. The total area under cultivation was 45 ha, thus the experimental area represented roughly half of the total area under cultivation. The cultivar used is known as N14. The soil type of the area under cultivation is clay loam to loam. Soil quality is good, with no observable soil salination. The area under cultivation was irrigated by means of a drip irrigation system. The drip points were 1 m apart and irrigated at a rate of 2 l per hour.

Fertilisation Programme

A combination of chemical and organic constituents was used in the fertilisation programme of the experimental blocks at monthly intervals over a period of 5 months. The constituents were as follows: 5 tonnes CMS[1], 500 kg Kalmaphos[2], 180 kg Urea, 100 kg Sulphur. This represented approximately 150 kg/ha nitrogen; 50 kg/ha phosphorous and 250 kg/ha potassium.

CMS was applied to the experimental blocks through the drip irrigation system at a rate of 2 tonnes for the first month and 1 tonne per month in months 2 to 4. A day after the CMS was administered 1 l of extended EM solution (1-1-20, Kyan et al., 1998) diluted in 2500 l water was applied to the experimental blocks through the irrigation system. The chemical fertilisation programme applied to the control blocks consisted of 5

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[1]CMS is a liquid by-product of the sugar cane industry and consists of: 5.5% Potassium, 1% Nitrogen, 0.3% Phosphate, 1% Calcium, 1.1% Sulphour. It also contains 63% crude protein made up of a number of amino acids and 6.6% reduced sugars, including furctose, sucrose and glycerol-all of which are microorganism growth stimulants.

[2]Kalmphos is a citric acid soluble organic fertiliser with the following constituents: 10% Potassium, 6% Magnesium, 21% Calcium, 10% Sulphur

applications per month of: 150 kg Urea, 650 kg Multi-KS (Potassium and Nitrogen), 50 kg Mono Ammonium Phosphate (MAP), 25 kg Calcium Nitrate, 50 kg Sulphur 95, 1 kg Micrel FE819, 5 kg Micrel Mycrobox, 0.075 kg Sodium Molybdate. This represented approximately 164 kg/ha nitrogen; 11 kg/ha phosphorous and 247 kg/ha potassium.

Moisture was maintained at 90% of field capacity as far as possible in both the experimental and control blocks.

Soil Analysis

Soil samples were taken at the end of the growing season (July) just before harvesting in September and compared to soil analyses done at the same time of the year during previous years.

Sampling

At the end of September the sugar cane was harvested and transported to the refinery for processing. Production figures for both the cane harvested and sugar extracted were compared to date from previous harvests.

Results

Soil

The soil analysis history, including physical and chemical parameters measured in the sugar cane trial are summarised in Table 1.

Table 1. Physical and Chemical Conditions of Soils from Experimental Blocks at the Bahati Farm in the Komatipoort Area, Mpumalanga after Consecutive Sugar Cane Harvests.

Year	Fertiliser Programme		Physical and chemical parameters (mean values as ppm)						
			pH N=3	P N=3	K N=3	Ca N=3	Mg N=3	Na N=3	Ca+Mg/K N=3
1995	C	mean	7.2	29	235	2595	741	226	8.9
		range	6.8-7.6	-	108-362	2260-2930	520-962	220-232	-
1997	C	mean	7.2	32	343	2395	1012	230	10.4
		range	7.0-7.4	30-35	275-433	2148-2739	914-1084	213-241	7.1-12.5
1999	C	mean	7.7	39	358	2605	1292	173	10.9
		range	7.4-7.8	25-50	341-391	2011-3051	1166-1470	117-217	9.3-13.3
2000	C	mean	7.4	43	310	2328	1232	131	11.1
		range	7.3-7.5	37-47	233-404	2062-2444	1050-1333	83-157	9.4-12.7
2001	C+O+EM	mean	7.7	29	377	3017	1346	-	11.8
		range	7.6-7.9	20-38	307-440	2256-3734	1280-1384		9.1-14.7

Fertilisation programme C = conventional chemical fertiliser programme; C+O+EM = chemical fertiliser supplemented with organic fertilisers and EM microbial inoculants.

Results from Table 1 indicate that soil pH has shown an upward tendency since 1995 and appears to be unaffected by the application of organic amendments and EM microbial inoculants; phosphate levels in the soil showed a gradual increase between 1995 and 2000 but decreases significantly during the experimental period in 2001. This is possibly due to the phosphates being released to the sugar cane as a result of the application of EM; potassium levels remain relatively low and continue to be an area of concern, although levels in 2001 did show an increase over the levels in previous years; calcium and magnesium are high, showing an increase in 2001 over previous years and may be an indication of salination problems; nitrogen levels in 2001 are not available, but appear to be decreasing from 1995 to 2000; and, the Ca+Mg/K, also an indication of soil salination, remains high and continues to increase.

Production

The production results obtained to date are listed in Table 2.

Table 2. Mean Yields in Tonnes/ha of Harvested Sugar Cane and Sugar Extracted from Experimental Blocks at the Bahati Farm in the Komatipoort Area of Mpumalanga During Consecutive Years from 1998 to 2001

Date		Yield in Harvested Sugar Cane Tonnes/ha	Yield in Sugar Extracted Tonnes/ha	Ratio of Sugar Cane to Produce 1 Tonne of Sugar Tonnes
1997	mean	160	-	-
	range	133 - 209		
1998	mean	135	16.7	8.1:1
	range	132 - 140	16.6-17.1	
1999	mean	133	16.6	8.0:1
	range	123 - 156	14.8-19.9	
2000	mean	120	12.5	9.6:1
	range	111 - 140	12.3-12.6	
2001	mean	126	16.0	7.8:1
(expt)	range	119 - 138	15.5-16.8	

1998 to 2000 = chemical fertiliser application only; 2001 = chemical fertilisers plus organic amendments and EM inoculants.

The data on sugar cane production (Table 2) clearly shows a gradual decline in yield between 1997 and 2000. During the experimental cycle (2001) a slight increase of 5% above yields obtained in 2000 are noticed. Extracted sugar shows a similar decline between 1998 and 2000 but a significant upswing of 28% in 2001. This tendency is also reflected in the ratio of tonnes of sugar cane required to produce 1 tonne of sugar. A gradual increase in the ratio between 1998 and 2000 followed by a decline in 2001.

Discussion

The South African Sugar Association Experiment Station (SASEX) conducts research in sugar cane technology to ensure the economic viability of the sugar industry. Part of their activities include the development of new sugar cane varieties that are more resistant to diseases and pests and producing greater yields of sugar at lower production and milling costs with the aim of providing maximum economic returns (SASA, 2001). No information exists regarding the effects of organic amendments such as CMS and microbial inoculants, such as EM on sugar cane production in South Africa. The main objective of the present investigation was therefore to evaluate the effects of such amendments and inoculants on sugar cane production under commercial conditions.

Because of the approach followed in the present investigation, no exact data could be presented at this time. Findings and conclusions should, therefore, be considered of a preliminary nature and require a more rigorous and detailed scientific investigation before definite conclusions can be made.

Results obtained from the physical and chemical analysis of soil properties in the study area clearly indicated an increase in soil alkalinity. Increased values for CA, Mg and Ca+Mg/K are cause for concern and need to be addressed by introducing corrective measures. An interesting phenomenon is the reduction of phosphorous levels of the soil during the 2001 production cycle. This may be attributed to the regular application of EM, thus making phosphorous more readily available to the crop.

According to Higa, (1991) and Alan et al., (1997), the effect of EM on crop yield was usually not evident during the first year of application. Zacharia (1995), however, indicated a 6.5-7.5% increase in sugar cane yield in plots fertilised with NPK supplemented with farm yard manure and inoculated with EM. Similar observations were made during the present series of investigations where a 5% increase in sugar cane production was achieved when compared to previous years yields. In the control blocks, yield increases were only 1% (Kruger, 2001 pers.com.). Of significance, however, was a 28% increase in sugar production from the experimental blocks when compared to a 9% increase in the production from control blocks. It appears that CMS, with its relatively high carbon and amino acid content, in combination with EM contributed significantly to sugar production. This aspect need further investigation.

Important other observations made include a dramatic increase in root development, a significant reduction in plume formation, reduction of the physiological ripening period of the cane by two weeks, a reduction of 50% in fertilising costs which, together with increased sugar production, increased the profit margin by US$650 per hectare when compared to the income generated during previous years.

Observations made during the present investigations merit a detailed study for the effects of organic amendments and microbial inoculants, not only in yields, but also in soil quality improvements to serve long term sustainability of the sugar cane industry in South Africa.

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