# ECONOMIC FERTILISER RECOMMENDATIONS FOR SUGARCANE IN KWAZULU-NATAL, INCORPORATING RISK QUANTIFICATION USING THE KYNO-CANE COMPUTER PROGRAM

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### Abstract

Fertiliser recommendations for sugarcane are made with a view to achieving maximum probable yields based on response data derived from decades of research by the South African Sugar Association Experiment Station (SASEX). Adaptations are made according to the experience and knowledge of consultants, but the risks of under or over fertilising are seldom quantified in monetary terms. To address this problem, a computer program called KYNO-CANE has been developed by the Agronomy Research Unit of Kynoch Ltd from the databank of SASEX fertiliser trials. KYNO-CANE accommodates a range of factors which include the influence of rainfall, soil nitrogen mineralisation potential, geographic position and the inherent soil fertility status to derive N, P and K fertiliser recommendations based on basic economic principles. The program also has the ability to evaluate the economic consequence of under or over fertilising, and aids in the correct choice of fertiliser carrier. Using current cost/price ratios (1996-97) and median representative response curves, insignificant deviations from the existing recommendations of the Fertiliser Advisory Service (FAS) of SASEX were found. However, if risk scenarios are accommodated and/or a major change in the sucrose price occurs, significant differences in recommendations may be expected.

*Keywords:* production function, economic optima, fertiliser recommendations, KYNO-CANE, sugarcane

### Introduction

Traditionally, nitrogen (Moberly, 1971; Wood, 1979; Meyer *et al.*, 1983; Meyer *et al.*, 1986; Stevenson *et al.*, 1992; Allison and Haslam, 1993; Meyer and Wood, 1994), phosphorus (Meyer and Dicks, 1979; Meyer and Wood, 1989) and potassium (Wood and Meyer, 1986; Donaldson *et al.*, 1990) recommendations for sugarcane are made with a view to achieving maximum probable yields, based on response data acquired through decades of research by SASEX. During the 1980s, the concept of maximum economic yield was emphasised in the fertiliser industry with the increased awareness of the use of production functions and cost/price ratios (Colwell *et al.*, 1988). Simultaneously, the concept of margin loss curves, especially with regard to nitrogen, was introduced and developed by Bornman and Prins (1993) to quantify the risks of over and under fertilisation. In the South African sugar industry, marginal cost analysis was also used to quantify fertiliser recommendations using maximum return on fertiliser investment as the main criterion (Thompson, 1980), but no provision was made for incorporating risk into the fertiliser decision. More recent investigations have emphasised the need to optimise fertiliser requirement in regard to climatic risk ([1]unpublished data).

Basic fertiliser recommendations are made according to the insight, experience and knowledge of the consultant and producer, but the risk of over or under fertilising is seldom quantified. With greater exposure to a fluctuating world market price for sugar, as well as escalating input costs, there is an increasing need to quantify and accommodate the risk factor when making fertiliser recommendations. Such steps have been taken in other countries (Chapman, 1994; Herlihy and Hegarty, 1994). Much emphasis has also been placed on the fact that fertilisation according to economic optima reduces the risk of pollution, particularly with regard to nitrogen (Richards *et al.*, 1996; Schlegel *et al.*, 1996). The latter is becoming of utmost importance locally and needs to be addressed responsibly.

### Procedures

To accommodate the risk factor under South African conditions the databank of fertiliser trials (coastal and midlands regions of Kwazulu-Natal) of SASEX was re-examined and some 245 N, P, K, NP and NK data sets from trials carried out since 1959 were entered into a database. From these data sets, 279 yield response functions were calculated (Colwell, 1988). Production functions were fitted to the main effects of the different nutrients in the trials using the KYNECON program, developed by Kynoch Agronomy Research and based on the law of diminishing returns and related basic economic principles (Bornman and Prins, 1993). The data were entered into the database in sets comprised of site information, crop information, soil analysis and production functions. These functions were then subdivided into groups representing rainfall, soil nitrogen mineralisation, geographic location and inherent fertility.

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From the above inputs, 170 nitrogen, 14 phosphorus and 57 potassium data sets were extracted. The nitrogen data were subdivided into groups representing four rainfall regions and four soil mineralisation potential groups. Regions of annual rainfall <900 mm, 900 to 1 000 mm, 1 000 to 1 100 mm and >1 100 mm, as defined by the Normal Annual Rainfall Map prepared by SASEX in 1963, were used. The different soil nitrogen mineralisation potentials were linked to soil classification as defined by Meyer *et al.*, (1983; 1986). Division into plant and ratoon crops was also done. On the subdivided data representative functions of the median, first and third quartile responses were calculated to represent different climatic situations.

For phosphorus and potassium, similar production functions (median, first and third quartile) could be calculated for ratoon crops only, as data for plant crops were insufficient. Ratoon production functions for potassium were calculated by subdividing the available data into clay content categories of 30% below and more than 30% (Wood and Meyer, 1986). These functions were used in conjunction with soil norms and the standard recommendation tables used by the FAS.

All the above mentioned production functions and related information were used to develop a computerised recommendation program called KYNO-CANE running on Windows® Microsoft® Excel® to generate site specific fertiliser recommendations accommodating price scenarios and producer risk perception.

## The KYNO-CANE program: concepts and modules

*Basic input*

Basic information needed to run the program includes grower and site information, soil analysis, control yield (probable yield without fertiliser), unit prices of N, P and K, price of sucrose, fixed costs and the degree of risk perception (high, medium or low) of the grower. Prices of N, P and K could include transport cost and interest. Soil analysis information is entered from the FAS analysis sheet. Current fertiliser and sucrose prices are used, and any changes can be readily updated.

Additional information windows regarding rainfall regions, cumulative control yield probability and yield response as well as applicable prices can be activated at any stage of the program.

*Output*

The information from the data input sheet is used to access a database containing the relevant recommendation tables and production functions. The production functions are used to calculate the economic optimum rate (maximum margin above fertiliser cost) per application of N, P and K based on the cost/price ratios as specified (Heady and Dillon, 1972). The rate of return on the total cost of production and return on the input (fertiliser) cost for the different nutrients is also calculated. These calculated rates represent the extremes of rational fertilisation, between which the grower's choice would lie.

Each grower's perception of risk is different. Various factors such as rainfall probability, financial status and even personality determine whether certain growers are more, or less, optimistic about input management. KYNO-CANE covers a spectrum of risk scenarios in terms of probable over or under fertilisation in order to offer the grower a variety of strategies to suit individual circumstances. Most output data can be displayed graphically, as shown in Figure 1. From the graph it can be deduced that up to R2 500 may be lost due to under fertilising with nitrogen (loss of sucrose yield). A similar deduction may be made for over fertilising. Should the grower's N input differ from the recommended rate, the potential loss due to this deviation will be quantified and displayed.

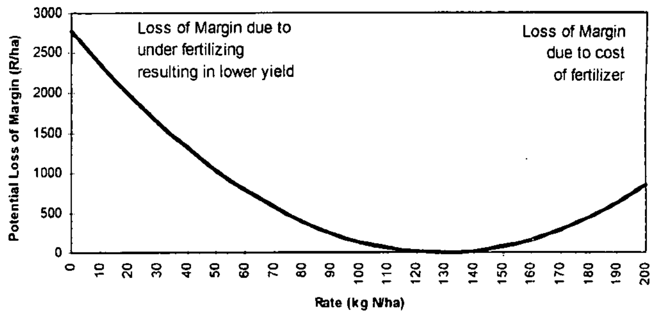


**Figure 1.** Influence of over or under fertilising with nitrogen on potential loss of margin (an example).

*Most economic product choice*

A module of the KYNO-CANE program determines the most economic choice of fertiliser products based on prices of the day, specifically applicable to a particular grower, while accommodating the fertiliser recommendations proposed by the program.

## Results

*Comparison of KYNO-CANE recommendations with 1996 FAS recommendations*

*Fertiliser recommendations: nitrogen*

Using KYNO-CANE and the price for nitrogen (Kynoch price list and published cane prices, September 1996) and median response functions, deviations from the FAS recommendations are given in Table 1.

Compared with FAS recommendations, the KYNO-CANE recommendations are slightly higher (70% of cases), but do not differ by more than 11 kg N/ha. The above comparison is based on the current cost/price ratio of 4,139, but a much larger difference could occur if the ratio increased due to a sudden drop in the price of sucrose. Recommendations are relatively insensitive to varying nitrogen prices. This was reported also by the Australian sugar industry (Chapman, 1994). Furthermore, if risk scenarios are taken into account, other marked differences will also be noticeable.

**Table 1**
**Differences in N recommendations between FAS and the KYNO-CANE program (all figures in kg N/ha).**

| Soil mineralisation potential | Source of recommendation | Crop | | | | |
|---|---|---|---|---|---|---|
| | | Plant cane | Ratoon cane | | | |
| | | | Rainfall (mm) | | | |
| | | | <900 | 900-1 000 | 1 000-1 100 | >1 100 |
| Low | FAS<br>KYNO-CANE | 120<br>120 | 128 | 140<br>141 | 148 | 151 |
| Medium | FAS<br>KYNO-CANE | 100<br>103 | 125 | 140<br>129 | 134 | 131 |
| High | FAS<br>KYNO-CANE | 80<br>82 | 117 | 120<br>125 | 125 | 125 |
| Very high | FAS<br>KYNO-CANE | 60<br>65 | 107 | 100<br>109 | 109 | 109 |

Cost/price ratio = 4,139 (nitrogen price = R3,56/kg; sucrose price = R860/ton).

Figure 2 shows the sensitivity of nitrogen recommendation on ratoon cane due to fluctuation of sucrose price using median response curves representative of two diverse long term rainfall expectancies. With a sucrose price varying between R800 and R1 000 and a fixed price for nitrogen of R3,56, recommendations would differ slightly between 150 and 158 kg N/ha for the high rainfall scenario, and between 128 and 130 kg N/ha for the low rainfall scenario. However, if prices should fall below R800, sensitivity would increase. A decrease in the price of sugar from R800 to R600/ton would mean a decrease in recommendation of 16 kg N/ha for the high rainfall scenario and 5 kg N/ha for the low rainfall scenario. The mentioned sensitivity is only due to sucrose price reduction. If the increase in price ratio due to the drop in sucrose price is accentuated by an increase in nitrogen price, more dramatic differences in recommendation would occur.

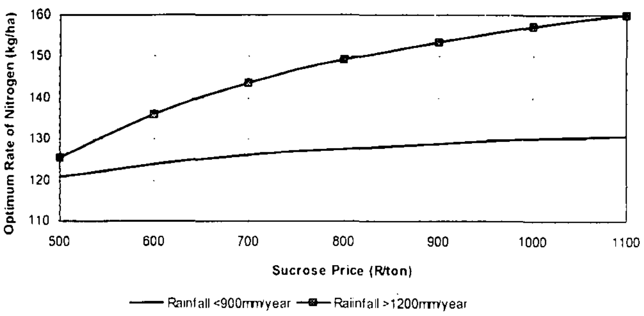


**Figure 2.** Influence of different sucrose prices on the optimum rate of nitrogen application on soils with low mineralisation potentiasl in two rainfall regions (nitrogen price = R3,56/kg).

*Fertiliser recommendations: phosphorus and potassium*

The P and K recommendations comparison between the two methods showed a similar outcome to that for nitrogen. Examples are given in Tables 2 and 3. Based on current prices of P, K and sucrose the largest differences in recommendations were 6 and 12 kg/ha for P and K respectively. Using the current cost/price ratio, 75% of K recommendations were lower than FAS recommendations.

**Table 2**
**Differences in phosphorus recommendations between the FAS and the KYNO-CANE program for fourth ratoon cane (all figures in kg P/ha).**

| Soil P (kg/ha) | Programme | |
|---|---|---|
| | FAS | KYNO-CANE |
| <49 | 20 | 23 |

Cost:price ratio = 6,55
(phosphorus price = R5,63/kg; sucrose price = R860/ton)

**Table 3**
**Differences in potassium recommendations between the FAS and the KYNO-CANE program for fourth ratoon cane (all figures in kg K/ha).**

| Clay % | Soil K (kg/ha) | Programme | |
|---|---|---|---|
| | | FAS | KYNO-CANE |
| <30 | 67 - 267<br><67 | 125<br>175 | 124<br>170 |
| >30 | 100 - 310<br><100 | 150<br>200 | 149<br>199 |

Cost:price ratio = 2,39
(potassium price = R2,06/kg; sucrose price = R860/ton)

*Impact of product choice on eventual profitability*

A module of KYNO-CANE determines the most economic choice of products that may have an important impact on the cost of fertilisation and the profit that may be obtained. Table 4 compares the cost of alternative ways of supplying the crop with 105 kg N/ha, 60 kg P/ha and 100 kg K/ha. Clearly, the choice based on using mixtures will be more economical than using straights, as the grower could save R171/ha.

**Table 4**
**Influence of product choice on the cost of fertilisation.**

| Nutrients required | Rate (kg/ha) | N 105 | P 60 | K 100 | Cost/ha (Rand) |
|---|---|---|---|---|---|
| **Product - Choice 1** | | | | | |
| DAP | 300 | 54 | 60 | – | 506,70 |
| 1.0.2(49) | 306 | 50 | – | 100 | 382,53 |
| Total | 606 | 104 | 60 | 100 | 889,23 |
| **Product - Choice 2** | | | | | |
| Superphosphate 10.5 | 571 | – | 60 | – | 510,93 |
| KCl | 200 | – | – | 100 | 204,80 |
| Urea | 228 | 105 | – | – | 345,02 |
| Total | 999 | 105 | 60 | 100 | 1 060,75 |

## Conclusion

The mean fertiliser recommendations of KYNO-CANE do not differ significantly from those of the FAS, based on current price ratios. This is largely due to the fact that the current cost/price ratio of fertiliser to sucrose has not changed greatly in economic terms since the FAS recommendations were last calibrated. However, significant differences could be expected if the sucrose prices changes appreciably and/or risk scenarios are taken into account. The program has the advantage that changes in fertiliser prices or the price of sucrose can easily be accommodated, and it has the ability to present a wide range of scenarios incorporating risk perception. It also quantifies probable results to help the grower in making a decision that suits his particular circumstances. With the availability of many fertiliser products at different prices, the program assists the consultant and grower in choosing the most economic fertiliser combination. KYNO-CANE provides a tool with which to derive environmentally conscious fertiliser recommendations by making use of sound site specific research data, basic economic principles and risk perception.

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