Response of Sugarcane (*Saccharum* hybrid spp.) Varieties SL 96 128 and SL 96 328 to Nitrogen, Phosphorous and Potassium under Irrigation at Uda Walawe, Sri Lanka: A Preliminary Analysis

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ABSTRACT

This study investigates the effects of N, P and K on cane yield and quality of the plant crop of two new sugarcane varieties, SL 96 128 and SL 96 328 and determines the optimum level of N. A field trial was carried out in a confounded-factorial design with 18 treatment combinations with 5 levels of N and 4 levels of each P and K, with 3 replicates at the research farm of the Sugarcane Research Institute, Uda Walawe, Sri Lanka from September 2010 to November 2011. Cane yield and quality parameters such as brix, pol, and fibre percent of cane were measured and pure obtainable cane sugar (POCS) was calculated at harvest of 12-month old crop. Sugar yields were estimated using cane yield and POCS.

The analysis of variance was performed on cane yield, POCS and sugar yield to examine the effects of N, P and K on these three variables. The optimum level of nutrients was determined by estimating the income and value:cost ratios for each fertiliser level.

The results showed that both varieties were responsive to N, and not so to P and K. The optimum level of N for the variety SL 96 128 was between 150 and 200 and that for the variety SL 96 328 was between 100 and 150. Analyses of soil and leaf in ratoon crops are required for devising a comprehensive recommendation.

Keywords: Fertiliser response, Nitrogen, Phosphorous, Potassium, SL 96 128, SL 96 328, Sri Lanka, Sugarcane

INTRODUCTION

The crop improvement programme of the Sugarcane Research Institute (SRI) develops high-cane- and sugar-yielding sugarcane varieties adaptable to various sugarcane-growing conditions in the island aiming at sustainable increase of the productivity and profitability of the Sri Lankan sugarcane industry (SRI, 2011). Selection of varieties for high cane and sugar yields is done under recommended management conditions at the initial and intermediate selection stages in the varietal development programme. The most promising varieties are subjected to nutrient response studies to determine the optimum nutrient levels for making fertiliser recommendations for those varieties at the final stage of varietal selection.

A substantial application of fertiliser, mainly Nitrogen (N), is required to achieve a successful harvest of high cane and sugar yields in sugarcane cultivation (Roy et al., 2006). Nitrogen application for sugarcane is as high as 300 kg/ha in India and China while in other countries like Guatemala, Mexico, Australia, South Africa and parts of the USA, the recommended N ranges from 150 kg/ha to 200 kg/ha (Thorburn et al., 2011). Tabayoyoung and Robeniol (1962) reported that N deficiency could decrease cane yields whereas excess N would also adversely affect the quality of cane juice. In Pakistan, the use of imbalanced fertiliser has caused constantly low cane yield which is the lowest among sugarcane-growing countries in the world (Khan et al., 2005). Nitrogenous fertiliser in the absence of Potassium (K) steadily decreases the sucrose percentage in cane, and addition of K counteracted this trend, producing a favourable response. The best N:K ratio lie between 1:1 and 1:1.5 (Stewart, 1969). Besides achieving maximum cane and

sugar yields, application of correct levels of fertiliser is important for minimising cost of cultivation and environmental pollution (Cheeseman, 2004; Thorburn et al., 2011). The profitability levels can also be considerably improved with the use of N, P and K fertilisers in balanced quantities (Khan et al., 2005), and it requires the determination of the optimum amounts of these nutrients (Kadian et al., 1981).

Thus, to realise the genetic potential of high-yielding new sugarcane varieties, the amount of nutrients removed should be replaced balancing the inputs and output, i.e., sugarcane as suggested by Janssen and De Willinen (2006) and Thorburn et al. (2011). In the sugarcane variety development programme of SRI, new sugarcane varieties are tested for their response to N, P and K to provide the growers with balanced fertiliser recommendations for those varieties to maximise cane and sugar yields at minimum cost to the grower and to the environment.

This study was conducted to determine the effects of N, P and K on cane yield and quality of two new sugarcane varieties SL 96 128 and SL 96 328 and to determine the optimum levels of these three nutrients for application based on plant crop data of these new sugarcane varieties. The experiment is being continued with the ratoon 1 crop.

Materials and Methods

Experimental design

The field experiment was conducted using a confounded-factorial structure with 18 treatment combinations of five levels (0, 50, 100, 150 and 200 kg/ha) of N, four levels (0, 20, 40 and 60 kg/ha) of P and four levels (0, 50, 100 and 150 kg/ha) of K with 3 replicates. Each plot was 7 m long with 5 rows prepared 1.37 m apart. The middle 3 rows were used for taking observations, and the 2 outer rows were maintained as guard rows. The land represented the general topography of the area of the Research Farm (6° 21' N, 80° 48' E) of the Sugarcane Research Institute. The field experiment was established in September 2010, and the crop was harvested in September 2011.

Soil and climate

The soil of the selected experimental site is classified as Reddish Brown Earths (Order - Alfisols, Sub order - Ustalfs, Great group - Rhodustalfs), and its texture ranges from sandy loam to sandy clay loam. The area receives an annual rainfall of about 1450 mm and 900 mm at 75 % expectancy with a distinct bimodal distribution. The average annual minimum and maximum temperatures are 22 ± 1.4 °C and 33 ± 1.4 °C, respectively (Panabokke, 1996). Evaporation from a free-water surface is approximately 5 mm per day (Shanmuganathan, 1992).

Field operations

The land was prepared in accordance with the recommendations for commercial sugarcane planting (SRI, 1991). Three-budded stem cuttings (setts) obtained from ten-month-old sugarcane plants of the varieties SL 96 128 and SL 96 328 were used as seed material. Planting was done using 3 seedcane setts per metre. The experiment was carried out under irrigated conditions. The plots were fertilised according to the treatment levels of N, P and K, and their sources were Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MOP), respectively. At planting, 1/6 of N, total P and ½ K were applied. One third of N was applied 45 days after planting and ½ of N and ½ of K were applied 90 days after planting.

Measurements and analyses

The plant crop of the two varieties was harvested at 12 months, in September 2011 to determine the cane yield. Six cane stalks were sampled from each plot to determine cane juice quality, i.e., brix, pol and fibre percent. Pure Obtainable Cane Sugar was calculated using brix, pol and fibre contents. Sugar yield was estimated by multiplying POCS with cane yield.

The analysis of variance (ANOVA) was carried out to determine the effect of N, P and K on cane and sugar yields and POCS using GLM procedure of the SAS software system (Version 9.1.3).

Since the coefficients of N fertiliser of the production functions of various forms estimated using the method of Ordinary Least Squares were not significant, the economic analysis was done by estimating costs and returns of the above-mentioned fertiliser levels at the prices of fertiliser without the subsidy obtained from the fertiliser secretariat of Sri Lanka and at the farm-gate price of sugarcane. The income[1] was compared with the value:cost ratio for both varieties to determine the optimum level of N to be fertilised. The value:cost ratios of the two varieties were estimated at the fertiliser price with the subsidy (market price) as well for comparison of the effect without the subsidy.

Results and Discussion

The effects of N, P and K on yield and quality of sugarcane

The results indicated that only the level of N affects significantly the cane yield and quality of the sugarcane varieties, SL 96 128 and SL 96 328. Therefore, mean separation of cane yield, POCS and sugar yield of SL 96 128 and SL 96 328 were performed for N levels only (Table 1).

Table 1: Variation of cane yield, POCS and sugar yield of SL 96 128 and SL 96 328 with the level of N (kg/ha)

Level	SL 96 128			SL 96 328		
N (kg/ha)	CY (t/ha)	POCS %	SY (t/ha)	CY (t/ha)	POCS %	SY (t/ha)
0	73.45 d	13.21 a	9.78 c	64.65 c	14.19 a	9.23 b
50	77.51 cd	13.03 ab	10.08 bc	79.01 b	13.84 a	10.95 b
100	93.69 bc	13.04 ab	12.13 ab	90.48 ab	13.85 a	12.57 ab
150	103.65 ab	11.99 c	12.38 a	95.85 a	13.47 ab	13.01 a
200	114.59 a	12.43 bc	14.28 a	100.15 a	12.61 b	13.28 a

CY = Cane yield, SY = Sugar yield

Note: Means with the same letters are not significantly different at 5% probability.

The effect of N on cane yield

Of the N levels tested, 200 kg/ha which was the highest level tested, produced the highest cane yield of about 115 t/ha in SL 96 128 and 100 t/ha in SL 96 328. Further, both sugarcane varieties showed similar increasing trend in cane yield with the increase of the level of N. The cane yields at 150 kg and 200 kg of N per hectare were significantly higher than that at 0 kg and 50 kg of N per hectare. However, the cane yields at N levels 100 kg/ha and 150 kg/ha were not significantly different (Table 1 and Figure 1).

[1] Since all management practices except the level of fertiliser application were the same for treatments, the income was calculated subtracting the fertiliser cost only

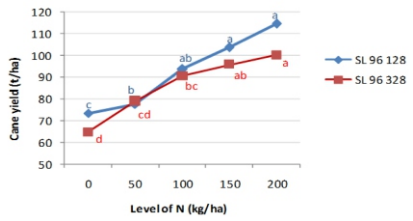

Figure 1. Variation of cane yield of SL 96 128 and SL 96 328 with the level of N
(Note: Means with the same letters are not significantly different at 5% probability)

The effect of N on sugar content

The results showed that the sugar content measured as POCS of the varieties SL 96 128 and SL 96 328 dropped with the increase of the level of N. The highest POCS level of nearly13.2% and 14.2% for the varieties SL 96 128 and SL 96 328, respectively were recorded at zero level of N (Table 1 and Figure 2).

The variety SL 96 128 showed a significantly low level of POCS at the N level of 150 kg/ha than at 0 kg/ha, 50 kg/ha and 100 kg/ha. The variety SL 96 328 exhibited a significant decrease in POCS at N level 200 kg/ha than at 0 kg/ha, 50 kg/ha and 100 kg/ha. There was no significant difference in POCS at 150 kg and 200 kg of N per hectare (Figure 2).

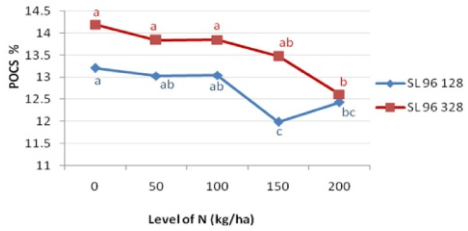

Figure 2. Variation of POCS of SL 96 128 and SL 96 328 with the level of N
Note: Means with the same letters are not significantly different at 5% probability

The effect of N on sugar yield

The highest sugar yields of 14.3 t/ha and 13.3 t/ha respectively for the varieties SL 96 128 and SL 96 328 were observed at the N level 200 kg/ha. Sugar yield increased gradually with the increase of the level of N for both varieties. The sugar yields at N level 150 kg/ha and 200 kg/ha were significantly higher than that at 0 kg and 50 kg of N per hectare (Figure 3).

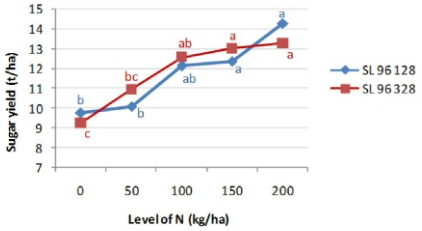

Figure 3. Variation of sugar yield of SL 96 128 and SL 96 328 with the level of N
Note: Means with the same letters are not significantly different at 5% probability

Though, POCS was inversely related to N level, sugar yields increased with the increase of the level of N through the greater contribution of cane yield to sugar yield than POCS.

The results of economic analysis

Since a significant response of cane yield and quality was observed only for the level of N, the economic analysis was confined only to the N application. The results of economic analysis performed based on cane and sugar yield of the varieties SL 96 128 and SL 96 328 are depicted in Figures 4 and 5.

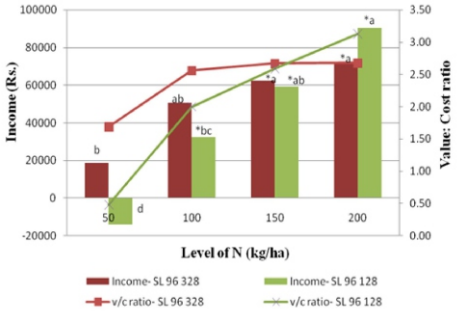

Figure 4. Variation of income and value-cost ratio based on cane yields at different N levels
Note: Means with the same letters are not significantly different at 5% probability

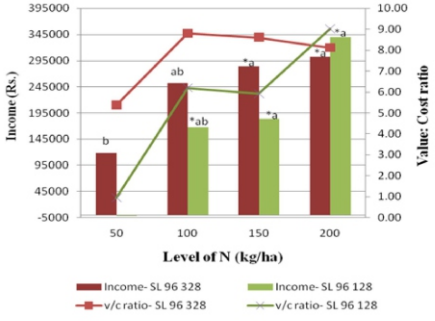

Figure 5. Variation of income and value:cost ratio based on sugar yield at different N levels
Note: Means with the same letters are not significantly different at 5% probability

SL 96 128

The income, based on the cane yield at 200 kg of N per hectare was significantly higher than that at N levels 50 kg/ha and 100 kg/ha. The value:cost ratios estimated based on the cane yields at 150 kg and 200 kg of N per hectare ranged between 2.5 and 3.25 (Figure 4). The incomes based on the sugar yield at N level 150 kg/ha and 200 kg/ha were significantly higher than that at 50 kg of N per hectare. The value:cost ratios estimated based on sugar yield ranged from 6 to 9 (Figure 5). Therefore, for the variety SL 96 128, the optimum level of N fertiliser application was between 150 and 200 kg/ha.

SL 96 328

The income, based on the cane yield at both 150 kg and 200 kg of N per hectare was significantly higher than that at N level 50 kg/ha. The cane yield at 100 kg of N per hectare did not show a significant difference with that at150 kg and 200 kg of N per hectare. The value:cost ratios estimated based on cane yields at 100 kg, 150 kg and 200 kg N per hectare were slightly above 2.5 (Figure 4) and that based on sugar yields were between 8 and 9 (Figure 5). The highest value:cost ratio was obtained at N level 100 kg/ha. Therefore, considering the results obtained for the variety SL 96 328, the most economic level of N application was between 100 kg/ha and 150 kg/ha.

The effect of fertiliser subsidy on value:cost ratios

The value:cost ratios of the two varieties, SL 96 128 and SL 96 328 cane and sugar yields have almost doubled due to the fertiliser subsidy (Table 2).

Table 2: Value: Cost ratios of SL 96 128 and SL 96 328 with and without fertiliser subsidy

Variety	Level N (kg/ha)	V/C ratio based on cane yield (kg/ha)		V/C ratio based on sugar yield (kg/ha)	
		Without subsidy	With subsidy	Without subsidy	With subsidy
SL 96 128	50	0.48	1.06	0.94	2.08
	100	2.00	4.37	6.19	13.49
	150	2.59	5.55	5.91	12.68
	200	3.13	6.64	9.01	19.11
SL96 328	50	1.69	3.75	5.37	11.94
	100	2.56	5.58	8.80	19.17
	150	2.67	5.73	8.60	18.44
	200	2.68	5.68	8.11	17.20

CONCLUSIONS

The results presented in the forgoing section proved that the varieties SL 96 128 and SL 96 328 are highly responsive to N level, but not so to P and K. The optimum level of N for the plant crop of the variety SL 96 128 was between 150 kg/ha and 200 kg/ha and that for the variety SL 96 328 was between 100 kg/ha and 150 kg/ha.

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REFERENCES

Cheeseman, O.D. 2004. The environmental impacts of sugar production. CABI Publishing, Wallingford.

Janssen, B.H., and De Willinen, P. 2006. Ideal and saturated soil fertility as bench marks in nutrient management1. Outline of the framework. Agric. Ecosyst. Environ. 116:132-146.

Kadian, V.S., Srivastava, S.N.L., and Sing, V.R. 1981. Effects of doses of nitrogen, phosphorous and potash on yield and quality of sugarcane. Indian Sugar. 31(6):405-408.

Khan, I.A., Khatri, A., Nizamani, G.S., Siddiqui, M.A., Raza, S., and Dahar, N.A. 2005. Effect of NPK fertilisers on the growth of sugarcane clone AEC86-347 developed at NIA, Tando Jam, Pakistan. Pak. J. Bot. 37(2):355-360.

Panabokke, C.R. 1996. Soils and agro-ecological environments of Sri Lanka. Natural Resources, Energy and Science Authority. 47/5, Maitland place, Colombo 7, Sri Lanka.

Roy, R.N., Finck, A., Blair, G.J., and Tandon, H.L.S. 2006. Plant nutrition for food security-A guide for integrated nutrient management. FAO Fertiliser and Plant Nutrition Bulletin 16, FAO, Rome.

Sanmuganathan, K. 1992. Modelling growth of rain-fed and irrigated sugarcane in the dry zone of Sri Lanka. Unpublished MPhil. Thesis, University of Newcastle, UK. 7-23.

SRI 1991. Methods of Sugarcane Cultivation. Sugarcane Research Institute of Sri Lanka, Uda Walawe. 141-150.

SRI 2011. Corporate Plan 2011-2015. Sugarcane Research Institute, Uda Walawe.

Stewart, M.J. 1969. Potassium and Sugarcane. South Africa Sugar Journal. Vol. 53, No. 2.

Tabayoyong, F.T., and Robeniol, M. 1962. Yield response of sugarcane fertilisers. Proc. ISSCT. 11:177-185.

Thorburn, P.J., Biggs, J.S., Webster, A.J., and Biggs, I.M. 2011. An improved way to determine nitrogen fertiliser requirements of sugarcane crops to meet global environmental challenges. Plant and Soil. 339:51-67.