Bangladesh J. Sugarcane, 18-20 : 141-148

July, 1998

Effects of Time and Rates of Nitrogen Fertilizer on Rainfed Sugarcane Production in the Southern Guinea Savanna Zone of Nigeria

S. S. Afolabi
Sugarcane Research Institute,
Faculty of Agriculture,
University of Ilorin,
P. M. B. 1515, Ilorin, Nigeria.

Received on 8.12.97

ABSTRACT

Two field studies on the effects of time and level of nitrogen fertiliser application on the yield and yield components of sugarcane (variety Co. 957) was investigated under natural precipitadtion in 1989 and 1990 cropping seasons. The applied nitrogen rates were 0,80,160 and 240 kg ha^{-1} as single dose application at four weeks after planting (WAP) and splits as half does at 4 WAP and half dose at 8 WAP in the plant cane and first ratoon cane. The results showed that nitrogen @ 80 kg ha^{-1} as single dose application at 4 WAP was opiimum for the plant cane while nitrogen @ 160 kg ha^{-1} as split application for the ratoon crop. Nitrogen rates and time of application had no significant effect on total soluble solids (T. S.S) and NPK content (%) of leaf. However, a significant difference for millable cane and cane yield was observed in both the plant and ratoon crops.

INTRODUCTION

Fertilisation is regarded as one of the most important cultural practices for commercial sugarcane production in most regions of the world. A judicious application of chemical fertiliser has been found to play vital roles in promoting cane growth and sustainable soil management (Afolabi, 1988 and Obakin, 1978). Prevoius studies indicated that 125 kg. N ha^{-1} applied as single dose is adequate for irrigated sugarcane production in the Guinea Savanna zone of Nigeria (Obakin, 1978 and Anon., 1990). However, at the Bacita Sugar Estate (9° N latitude) some times supplementary applications of N are done at various periods before the maturity of the canes (Anon., 1990). The effects of nitrogen fertilisation on cane tonnage and juice quality have been widely reported in different sugarcane growing regions of the world (Humbert, 1968; Clements, 1983; Samuel, 1983 and Afolabi, 1988). During nitrogen fertilisation, emphasis is given to control nitrogen in cane throughout the life by maintaining adequately high levels during the first few weeks of growth and ending up at low levels at the time of maturity or harvest of cane (Thomas, 1978 and Anon., 1990).

The experiment was fitted in a split plot design with four reaplications. The plot size was 5m x 12m with 1m alley ways between plots. Four rates of urea fertiliser namely 0, 80, 160 and 240 kg N ha^{-1} were applied as : (T_1) full dose at 4 WAP and (T_2) half dose at 4 WAP and rest half at 8 WAP. The tratments were repeated for the first ratoon. Phpshporus (P) and potash (K) fertilizers were applied as basal at the rate of 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1}, respectively. Weeds were controlled using hoes befor leaf canopy development. The number of millable canes (canes>ten internodes) were recorded at harvest for plant and first ratoon crop.

The six middle rows of cane were harvested, weighed and expressed in tons ha^{-1} for cane yield determintion. The total soluble solids or brix (%) of cane juice was determined at harvest for juice quality by standard methods (Meade and Chen, 1977). The data obtained were then analysed statistically following standard procedures.

RESULTS AND DISCUSSION

The Table 1 shows the results on the physical and chemical properties of the experimental soils before sugarcane plantion. The soil is loamy sand with low pH (pH 5.4). The organic matter content is considered to be low (1.4%). This is the characteristic of alfisols in the Guinea Savanna (Ogunwale and Udo, 1977). The values of total N (%) and available P (ppm) were 0.05% and 7.58 ppm, respectively for the experimental soils. Exchangeable K. Ca, Mg and Na were found to be adequate for good cane growth (Metson, 1971). The cation exchange capacity of the soil was 11.58 c mol kg^{-1} soil.

Table 1. Physical and chemical properties of soil samples of the experimental plots collected before and after planting.

Soil characteristics	Values	Soil characteristics	Values
Sand (%)	80.00	Exch. Na (c-mol kg^{-1} soil)	0.11
Silt (%)	10.50	Exch. Ca (c-mol kg^{-1} soil)	3.20
Clay (%)	5.00	Exch. Mg (c-mol kg^{-1} soil)	0.60
Textural class	Loamy sand	Exch. K (c-mol Kg^{-1} soil)	0.20
pH	5.40	Exch. K (c-mol kg^{-1} soil)	0.20
Organic matter (%)	1.40	CEC (c-mol kg^{-1} soil)	11.58
Total N (%)	0.05	Avail. P (ppm)	7.58

The effects of timing and rate of nitrogen fertiliser application on millable cane, cane yield and total soluble solids in the plant cane are shown in the Table 2.

Significantly, the lowest number of millable cane (64.1 x1000 ha^{-1}) was obtained from the contdrol plot while the highest number of millable cane (89.2-90.5x1000 ha^{-1}) was from the plot receiving 80 kg. N ha^{-1} applied as single dose and 160 kg N ha^{-1} applied as

At present, limited information is available on the efects of time and rates of nitrogen application on rainfed sugarcane production in the southern Guinea Savanna zone which has great potentials for boosting up cane production in Nigeria. Therfore, the objective of this study is to evaluate the effects of time and rates of nitrogen application on the yield and yield components of rainfed sugarcane production, with a view to find a suitable fertilisation programme for this farming practice in the Southern Guinea Savanna zone of Nigeria.

MATERIALS AND METHODS

The experiment was conducted at Unilorin Sugar Research Institute's farm, Bouranduro village, Ilorin during the 1989 and 1990 cropping seasons. The annual rainfall of the experimental site was 660 mm and 920 mm for the year 1989 and 1990, respectively (Figure 1). Prior to cane plantation, the soil of the experimental site was sampled and analysed for clay (%), sand (%) and silt (%) as described by Bouyoucos (1951). The soil acidity was determined with pH meter while total nitrogen was determined following the regular microkjeldahl method as described by Black (1965). The available soil P. K. Ca. Mg and Na were determined according to Jackson (1962). Cation exchange capacity (CEC) was determined as the summation of the exchangeable bases (Jackson, 1962). The nitrogen, phosphorus and potassium contents (%) of sugarcane leaf were determined from the sample taking from the top visible dew lap (TVD) leaf at 18 WAP for plant cane and 20 WAP for the first ratoon crop according to the methods described by Taylor (1972).

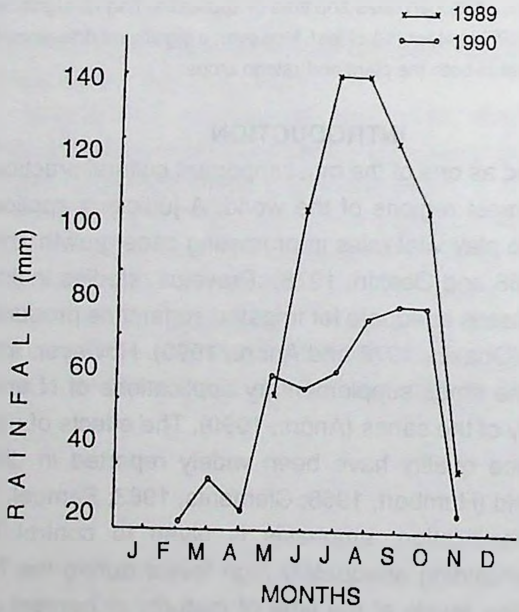

Figure 1. Mean monthly rainfall for Ilorin (1989 and 1990).

The experiment was fitted in a split plot design with four reaplications. The plot size was 5m x 12m with 1m alley ways between plots. Four rates of urea fertiliser namely 0, 80, 160 and 240 kg N ha^{-1} were applied as : (T_1) full dose at 4 WAP and (T_2) half dose at 4 WAP and rest half at 8 WAP. The tratments were repeated for the first ratoon. Phpshporus (P) and potash (K) fertilizers were applied as basal at the rate of 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1}, respectively. Weeds were controlled using hoes befor leaf canopy development. The number of millable canes (canes>ten internodes) were recorded at harvest for plant and first ratoon crop.

The six middle rows of cane were harvested, weighed and expressed in tons ha^{-1} for cane yield determintion. The total soluble solids or brix (%) of cane juice was determined at harvest for juice quality by standard methods (Meade and Chen, 1977). The data obtained were then analysed statistically following standard procedures.

RESULTS AND DISCUSSION

The Table 1 shows the results on the physical and chemical properties of the experimental soils before sugarcane plantion. The soil is loamy sand with low pH (pH 5.4). The organic matter content is considered to be low (1.4%). This is the characteristic of alfisols in the Guinea Savanna (Ogunwale and Udo, 1977). The values of total N (%) and available P (ppm) were 0.05% and 7.58 ppm, respectively for the experimental soils. Exchangeable K. Ca, Mg and Na were found to be adequate for good cane growth (Metson, 1971). The cation exchange capacity of the soil was 11.58 c mol kg^{-1} soil.

Table 1. Physical and chemical properties of soil samples of the experimental plots collected before and after planting.

Soil characteristics	Values	Soil characteristics	Values
Sand (%)	80.00	Exch. Na (c-mol kg^{-1} soil)	0.11
Silt (%)	10.50	Exch. Ca (c-mol kg^{-1} soil)	3.20
Clay (%)	5.00	Exch. Mg (c-mol kg^{-1} soil)	0.60
Textural class	Loamy sand	Exch. K (c-mol Kg^{-1} soil)	0.20
pH	5.40	Exch. K (c-mol kg^{-1} soil)	0.20
Organic matter (%)	1.40	CEC (c-mol kg^{-1} soil)	11.58
Total N (%)	0.05	Avail. P (ppm)	7.58

The effects of timing and rate of nitrogen fertiliser application on millable cane, cane yield and total soluble solids in the plant cane are shown in the Table 2.

Significantly, the lowest number of millable cane (64.1 x1000 ha^{-1}) was obtained from the contdrol plot while the highest number of millabie cane (89.2-90.5x1000 ha^{-1}) was from the plot receiving 80 kg. N ha^{-1} applied as single dose and 160 kg N ha^{-1} applied as splits. Furthermore, the millable cane number was found to increase with increased N rates to and optimum level above which there was a decline. The highest cane yield (49.4 tons ha^{-1}) was obtained from the 80 kg N ha^{-1} applied as single dose in the plant cane while the lowest cane yield (39.2 tons ha^{-1}) was obtained from the 160 kg. N ha^{-1} applied as splits and which was not significantly different from that of the control plot. A close relationship was observed between the millable cane number and cane yield. This findings also agree with the reports of Yadav and Verma (1990) and Afolabi (1988). Millable cane stalks per unit area is one of the most important variables for sugarcane production. Neckel (1984) showed that it is necessary to induce tillering at early stage of growth in cane plants because of its positive effects on cane tonnage. The N fertilisation showed no significant effects on total soluble solids or cane juice quality in the plant cane (Table 2).

Table 2. Effects of time and nitrogen levels on millable cane, cane yield and total soluble solids (T. S. S.) of the plant cane.

Time of N application	Fertilizer rate (kg N ha^{-1})	Millable cane (x 1000 ha^{-1})	Cane yield (tons ha^{-1})	T.S.S. (%)
T_1 = Single dose	0	64.1f	41.8d	23.5a
at 4 WAP*	80	89.2a	49.4a	22.7a
	160	73.2e	46.4b	23.8a
	240	86.2b	43.4c	24.2 a
T_2 = 1/2 dose at				
4 WAP	80	84.6e	42.6 c	23.2a
and 1/2 dose	160	90.5a	392.d	23.7a
at 8 WAP	240	81.4d	43.5c	23.0a
Time mean		83.8	43.5	23.4

Means followed by the same letter in a given column are not significantly different from each other by the DNMRT (P=0.05))

* Means week after planting.

The effects of time and rate of fertiliser application on the millable cane production, cane yield and total soluble solids in the first ratoon crop are presented in the Table 3.

A significant difference was observed for millable cane production. The highest number of millable cane was obtained at a split application of 160 kg N ha^{-1}. However, this value was not significantly different from the millable cane number obtained at single dose application of 160 kg N ha^{-1} and 240 kg N ha^{-1} (Table 3). The lowest number ofj millable cane was obtained form the control plot. Furthermore, it is rvealed that millable cane production increased with increase in fertiliser levels to an optimum and declined there after in case of the first ratoon crop. A similar trend was also observed in the plant cane.

Table 3. Effect of time and nitrogen levels on millable cane, cane yield and total soluble solids (T.S.S.) of the first ratoon crop.

Time of N application	Fertilizer rate (Kg N Ha^{-1})	Millable cane (x 1000 ha^{-1})	Cane yield (tons ha^{-1})	T.S.S. (%)
T_1 = Single dose at 4 WAP*	0	76.0 c	27.0 d	25.0 a
	80	98.2 b	37.2 c	24.8 a
	160	103.5 a	40.0 b	24.1 a
	240	104.2 a	42.0 b	23.7 a
T_2 = 1/2 dose at 4 WAP and 1/2 dose at 8 WAP	80	89.0 b	40.0 b	24.8 a
	160	104.5 b	45.0 a	25.5 a
	240	90.5 b	32.2 c	25.5 a
Time mean		92.4	37.7	24.7

Means followed by the same letters in a given column are not significantly different from each other by the DNMRT (P = 0.05).

* Means week after planting.

Significantly, the highest cane yield (45 tons ha^{-1}) was obtained at 160 kg N ha^{-1} applied as split application (Table 3) while the lowest yield (27 tons ha^{-1}) was from the control plot. Afolabi (1988) indicated the importance of nitrogen fertiliser application on sugarcane production under irrigation in the Guinea Savanna. The finding of the present study is in consistent with that report.

The time and different fertilizer levels had no appreciable effect on total soluble solids or juice quality. However, the T.S. S. values obtained in this study showed indentical trend with those recommended by Agbana (1991). This observation showed that the timing/fertiliser levels had no detrimental effect on juice quality whice is in agreement with the findings of Thomas (1978).

The number of millable cane obtained in this study is lower than the recommended values for commercial sugafdrcane production in the Guinea Savanna zone as descrbed by Agbana (1991). This may be related to the low annual rainfall during the period of this stydy (Figure 1). Yadav and Verma (1990) had reported that the efficiency of nitrogen application on sugarcane is mostly influenced by soil moisture status. Allison (1980) recommended a minimum rainfall of 1110 mm per annum for usccessful sugarcane production under rainfed condition in the southern Guinea Savanna. The annual rainfall obtained in this study was lower than the above value (Figure 1). The plant cane had better over all yield than the first ratoon crop (Tables 2 and 3).

Yield performance between plant cane and ratoon crop was however not consistent. Panol and Elevado (1972) obtained higher cane yield in the plant cane than in the ratoon while Ferratis and Lackson (1964) reported lower cane yields in plant cane than ratoon crop. These discrepancies in yields of plant cane and ratoon crop could be attributed to the differences in climatic conditions prevailing in the plant cane grown a year ahead of the first ratoon crop, cane variety, fertilization and occurrence of pests and diseases (Castellanos *et al.* 1980).

The effect of single does and split application of N fertiliser on NPK content of the cane leaf are presentted in the Table 4.

The nitrogen fertiliser did not show any significant effect on major nutrient elements in the cane leaf. A study of cane foliar analysis by Afolabi (1988) using irrigated cane fields fertilised at 125 kg No ha^{-1} at the Bacita Sugar Estate showed that when levels of N(%) and K(%) in the cane leves were not lower than 2.0 and 1.2, respectively, the cane plants required no additional nitrogen and potassium. In this study, since none of the fertilised plots had N and K content (%) lower than these values, there was no need for supplementary application of nitrogen and potassium to the plant. The phosphorus content (%) in the sugarcane leaves are however, moderately low (Table 4). Taylor (1972) had recommended 2.0% leaf P as an optimum for successful sugarcane production in the Guinea Savanna zone of Nigeria.

The over all results of this study showed that single dose application of 80 kg N ha^{-1} at 4 WAP is adequate for the plant cane while a split application of 160 kg N ha^{-1} was found optimum for the first ratoon crop. Interaction between time and N levels were not significant. Since nitrogen application is mostly affected by the soil moisture status, a fixed schedule of single or split application of nitrogen fertiliser should be used with care.

Table 4. Effect of time and N levels on the NPK content (%) of sugarcane leaf.

Time of N application	Fertilizer rate (Kg N Ha-1)	N (%)	P (%)	K (%)
T_1 = Single dose	0	1.8 a	0.11 a	1.40 a
at 4 WAP*	80	2.1 a	0.13 a	1.60 a
	160	2.1 a	0.14 a	1.90 a
	240	2.1 a	0.13	1.70 a
T_2 = 1/2 dose	80	2.2 a	0.13 a	1.50 a
at 4 WAP	160	2.1 a	0.13 a	1.70 a
and 1/2 dose	240	2.1 a	0.12 a	1.60 a
at 8 WAP				

Means followed by the same letters in a given column are not significantly different from each other by the DNMRT (P = 0.05)

* Means week after planting

ACKNOWLEDGEMENT

The author is grateful to the Director, Unilorin Sugar Research Institute (USRI) for his kind permission to publish this work and messrs G.O. Awolola and Ogungbesan for their field assistance.

REFERENCES

Afolabi, S.S. 1988. Effect of nitrogen fertilisation on sugarcane yield and juice quality in Bacita. *Bangladesh J. Sugarcane*, 10 : 59-62.

Agbana, S.B. 1991. Description of commercial varieties under cultivation at the Nigerian Sugar Company Ltd. Bacita. A paper presented at the meeting of programme leaders of the nationally coordinated .research on Sugarcane. Univ. Ilorin, 13th January, 1991. p. 20.

Allison, I.I.O. 1980. Problems and prospects of sugarcane industry in Nigeria. In proc. The sugarcane industry in Nigeria. Ed. M.O. Fawole. June 24-25, 1980. p. 137.

Annonymous, 1990. Field technique reports. NISUCO. Bacita. p. 25.

Bouyoucos, C.H. 1951. A recalibration of the hydrometer for making mechanical analysis of soils. *Agronomy J.*, **43** : 434-438.

Black, C.A. 1965. Methods of soil analysis. Agronomy (9) part II. American Society of Agronomy. Madison, Wisconsin, USA. pp. 1162-1164.

Castallanos, A.; Gerret, J.L.; Reyes, R. and Piemental, B. 1980. Study on four nitrogen levels in four sugarcane varieties. Abstract. *Tropical Agriculture*, **6** : 129-132.

Clements, H.F. 1983. Interaction factors affecting yield. Ann. Rev. *Plant Physiol.*, **15** : 409-442.

Ferratis, I.P.T.R. and Lacson, M.V. 1964. Effect of system and rate of planting on yields of five sugarcane varieties in Guimbalaon clay. Proc. Phylsutech.

Humbert, R.P. 1968. The growing of sugarcane (Rev. ed.). Elsevier publishing com. Now York. 779 p.

Jackson, M.L. 1962. Soil Chemical Analysis 2nd ed. Prentice Hall, New York. p. 430.

Meade, G.P. and Chen, J.C.P. 1977. Cane Sugar Hand Book. 10th ed. John Willey, New York. p. 895.

Metson, A.J. 1971. Methods of chemical analysis for soil survey samples (ed). Longman, U.K. p. 115.

Nikel, L.G. 1984. A renew of plant growth regulators in sugarcane industry. *Sugar-Y-Azucar*, **79** (3) : 17-20.

Obakin, F.O. 1978. The effect of nitrogen fertilisation on sugarcane juice quality. *In Proc. International Symposium on Sugarcane Research and Production*, NCRI, Ibadan. p. 115.

Ogunwale, J.A. and Udo, E.J. 1977. Phosphorus fractions in selected Nigerian soils. *Soil Sci*, **41** : 1141-1146.

Panol, F.Y. and Elevado, C.N. 1972. Economics of ratooning. *In Proc. Phylsuteck, Mamillar,* **20** : 131-132.

Samuels, G. 1983. Soil and foliar analysis as a guide for sugarcane fertiliser recommendation. *In* Proc. Inter. American Seminar on Sugarcane, Miami, Florida. p. 273.

Toylor, R.D. 1972. Some notes on the interpretation of foliar analysis data and subsequent fertiliser application. Savanna Sugar Comp. Field Tech. Report. p. 15

Thomas, J. R. 1978. Sugarcane juice quality as related to nitrogen fertilisation. *In proc. ASSCI,* **8** : 24-30.

Yadav, R.L. and Verma, R. S. 1990. Nitrogen and yield of sugarcane. *Journal of Agric. Sci.*, (Cambridge) **114** (2) : 225-331.