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Research Article

Effects of Rate and Split Application of Nitrogen Fertilizer on Yield of Two Sugarcane Varieties From Ratoon Crop

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ABSTRACT

Nitrogen fertilizers applied either in single or split application is the main agronomic inputs to sugarcane production. The objective of this study was to determine the effects of nitrogen fertilizer rates and split application on yield of first ratoon crop of late (CO 421) and early maturing (D 8484) sugarcane varieties. Analysis of variance at $p \leq 0.05$ indicated that the mean yields were 117.6 and 124.3 ton cane per hectare for CO* 421 and D* 8484 respectively at harvesting. This study showed that there was no significant difference in the effects of nitrogen fertilizer rate and split application on yield.

INTRODUCTION

Sugarcane (*Saccharum officinarum L.*) is a commercial crop grown in tropical and sub-tropical regions for sugar production in climates ranging from hot dry environment near sea level to cool and moist environment at high elevations (Plaut *et al*., 2000). Apart from the main product, sugar, it produces many valuable co-products such as alcohol used by pharmaceutical industry and as fuel, bagasse for paper and chip board and press mud as a rich source of organic nutrients for crop production (Kumar *et al*., 1996; Lingle *et al*., 2000). In Kenya sugarcane is grown in Nyando, the Western and the South Nyanza Sugar belts. Sugar is the second largest contributor to Kenya's agricultural growth after tea (KESREF, 2006). Research efforts have been directed at developing high yielding, high sugar content and early maturing sugarcane varieties culminating in the release of KEN 82-216, KEN 82-219, KEN 82-247, KEN 82-401, KEN 82-808 and KEN 83-737 in 2002 (KESREF, 2002), a set of four varieties: KEN 82-472, KEN 82-62, EAK 73-335 and D 8484 in 2007 (KESREF, 2007) and another set of three varieties: KEN 82-121, KEN 82-601 and KEN 82-249 in 2009 (KESREF, 2011). It is not known how nitrogen fertilizer rates and split application influence yields of ratoon one crop of CO 421 and D 8484 sugarcane varieties in the Kenya Sugar Industry. It is necessary to assess the influence of agronomic inputs on yields of the two cane varieties.

Nitrogen is essential for vigorous vegetative growth and development, yield and quality in sugarcane. It is a constituent of plant cell components e.g. amino acids and nucleic acids and its deficiency inhibits plant growth, reduction in leaf area, thus causes a decrease in photosynthesis hence suppressing yield and quality (Taiz and Zeiger, 2002; Sreewarome *et al.,* 2007). Fertilizer N application is mandatory in intensive sugarcane cultivation which requires a high amount of nitrogen as a nutrient to produce high biomass (Thornburn *et al*., 2005). Excess N and low N uptake cause retarded growth phase and decreases photosynthetic capacity of leaves thus causing shorter internodes (Martin, 1994). For many locations the depletion of plant available soil N over time justifies the need for split application of yearly total N rate (Wiedenfeld, 1997).

In a study carried out in the Sugarcane Research Center of the Khuzestan Province, Iran, Koochekzadeh *et al*. (2009) established that different rates of N fertilizer from urea source (92, 138 and 184 kg N/ha) and their split applications (S_1: 20-40-40%, S_2: 30-35-35%, S_3: 30-30-40%) had no significant effect on cane yield.

A similar establishment was made by Thornburn *et al*. (2001) who reported that cane yield was not affected with increasing N and Wiedenfeld (2000) who also depicted that rate of N application did not affect cane yields in the plant crop. Elsewhere, Rattey and Hogarth (2001) and Muchow *et al*. (1995) reported that sugarcane quality reduced with increasing levels of N. Moreover, Gana (2008) established that for application of more than 120 kg N ha^{-1}, there was no significant difference between sugarcane yields. In a study carried out in Egypt, Ahmed *et al*. (2009) showed that millable cane yields significantly responded to the used N-fertilizer levels. They established that increasing the N-fertilizer rates from 160 to 200 and 240 kg/ha led to an increase in millable cane yields. The favorable effect of nitrogen could be attributed to its beneficial effect on millable cane yield. These findings were in agreement with those found by Rizk *et al.* (2002) and El.Sogheir and Ferweez (2009) who revealed that each nitrogen increment was associated with an increase in millable cane yield ton/ha up to 240 kg/ha. However, they did not study the effect of split application of N fertilizer on sugarcane yield. Various NP levels that were studied significantly affected cane yield of sugarcane varieties Mardan-93 and CP 77/400 (Hussein *et al*., 2003). The varieties also significantly affected yield of sugarcane varieties. Moreover, significant differences were recorded as regards interaction of NP levels and varieties of sugarcane. In this study, N levels were not studied separately and split application of the evaluated NP levels was not studied. Hurney and Berding (2000), conducted research to better understand the impact of N and varieties on sucrose content and cane yield of plant cane crops. The performance of each variety was tested at four different rates 0, 70, 140, and 210 kg N/ha. They found that N fertilizer rates had no effect on cane yield. Richard (2007) showed that increasing N fertilizer either as a single or split application had no effect on cane yield. He attributed the lack of significant fertilizer N treatment effects to adverse weather conditions caused by Tropical Storm Allison which produced in excess of 230 mm of rainfall. The high amount of rainfall received could have affected the experiment by N losses due to leaching, microbial immobilization, denitrification and/or volatilization. In another study carried out in Florida, Muchovej and Newman (2004) recorded insignificant yield response to the applied N fertilizer on the sandy soils. The lack of response to N fertilizer rates used in this study indicated that even the lowest rate tested (170 kg N/ha) might have been at or above the critical N rate for sugarcane production on sandy Florida soils. They related the lack of yield response to N fertilizer to the proportion of N fertilizer used at each split application.

Cane and sugar yields have been fluctuating and declining in the past years in most Kenya's factory zones. For example, mean cane yield, averaged over all sugar zones was 90.8 TCH and 70.9 TCH in 1997 and 2006 respectively (Anon, 2006). It is worth mentioning that mean cane yields in 1997 were about 90% of the expected potential of 100 TCH under Kenyan rain-fed farming conditions. However, a significant yield reduction of about 22% was observed 10 years later. The low productivity may be attributed to use of low yield varieties, improper agronomic practices, lack of irrigation system in the drought-prone zones, poor weeds and diseases control method and timeliness, unplanned harvesting schedules, soil fertility decline due to long-term sugarcane monoculture with little replenishment of the removed nutrients, inadequate credit for farmers that leads to poor management of the ratoon crops, poor drainage techniques in the heavy impervious vertisols soils and unpredictable weather patterns (KESREF, 2006). Thus, there are two main constraints facing the industry, namely high cost of production of both cane and sugar and low productivity of either of the economic traits of sugarcane. Mitigation of the low yield can be approached through development and use of high cane and sugar yield potential cultivars, improving water use efficiency and improving the nutrients uptake and utilization efficiencies. The objective of this study was therefore to establish the effects of rates and split applications of N fertilizer on yield of sugarcane varieties CO 421 and D 8484, ratoon one crop.

MATERIALS AND METHODS

Experimental Design, Treatment and Site

The experiment was superimposed on an ongoing trial conducted in KESREF Opapo, 25 km from Rongo town on latitude 0° 30' S and longitude 34° 30' E. The experimental design was a 2x4x3 split split-plot where varieties (block) formed the main plot while N rates and number of splits formed the sub and sub sub-plot factors respectively replicated three times. Each sub-plot comprised of 7 rows of sugarcane and measured 1.2 m wide x 10 m long (84 m^2). Fertilizer nitrogen from urea was applied in each plot depending on the assigned levels and splits. The levels were 0, 60, 120 and 180 kg N which were applied once at the third month after ratooning, split into two halves and each half was applied at the third and sixth months after ratooning and split in the ratio of 3:3:4 and applied at the third, sixth and ninth months after ratooning respectively.

Yield

Monitoring was done to establish how N fertilizer treatments would affect yield of late and early maturing ratoon crop of sugarcane varieties (Mackintosh, 2000; ICUMSA, 1994).

Data Analysis

The generated data was statistically analysed using SAS system for Windows, version 8.2 (SAS Institute Inc. 1999-2001, U.S.A) as split-split plot treatment arrangement within randomized complete block. ANOVA using general linear models (GLM) procedure was performed on the parameter to determine any significant treatment effects at $p \leq 0.05$ confidence level.

RESULTS AND DISCUSSION

Effects of N rates and split applications on yield of CO 421 and D 8484

In variety CO 421, N rates R_2, R_3 and R_4 registered higher mean cane yields compared to the control R_1 (Table 1). R_3 had the highest numerical mean cane yield value of all with the values decreasing from R_3 to R_4. For the N split application (Table 1), it was observed that there was a numerical decrease in mean cane yields from N split (S_1) to (S_2) followed by an increase in N split (S_3). In variety D 8484 N rates R_2, R_3 and R_4 recorded numerically higher mean cane yields compared to the control N rate R_1 (Table 1). It was observed that the mean cane yields numerically decreased from R_2 to R_4. There was a numerical decrease in mean cane yields from N split (S_1) to N split (S_2) followed by an increase in N split (S_3). In general, considering all the N treatments, the mean TCH values recorded by the cane varieties were 117.6 and 124.3 for CO 421 and D 8484 respectively and 121.0 for both. Although variety CO 421 registered a relatively lower numerical TCH value than D 8484, statistical data analysis ($p \leq 0.05$) indicated that there was no significant mean cane yield difference. This outcome indicates that the N fertilizer treatments had no significant effects on the yields of the two ratoon cane varieties. In a study carried out in the Sugarcane Research Center of the Khuzestan Province, Iran, Koochekzadeh *et al.* (2009) established that different rates of N fertilizer from urea source (92, 138 and 184 kg N ha^{-1}) and their split applications (S_1: 20-40-40%, S_2: 30-35-35%, S_3: 30-30-40%) had no significant effect on cane yield. On the contrary, these findings are in disagreement with those found by Rizk *et al.* (2002) and El.Sogheir and Ferweez (2009) who discovered that each nitrogen increment was associated with an increase in millable cane yield ton/ha up to 240 kg/ha. These results are further supported by Muchovej and Newman (2004); they recorded insignificant yield response to the applied N fertilizer on the Florida sandy soils.

However, the yield values registered by the two cane varieties are in agreement with the results of the previous study recorded by KESREF (2007), which qualify D 8484 and CO 421 as high and low yielding cane varieties respectively. Interaction between N rates and split applications in different treatments is shown in Table 1

Table 1: Effects of N rates and split applications on yield (in TCH) of CO 421 and D 8484

VARIETY	N RATES	N SPLIT APPLICATION			µN	µVAR
		S_1	S_2	S_3		
CO 421	0	107.1	95.7	118.3	107.0	117.6
	60	118.6	118.7	118.5	118.6	
	120	121.1	126.4	125.4	124.3	
	180	124.8	117.1	119.9	120.6	
	µS	117.9	114.5	120.5		
D 8484	0	121.4	114.3	125.4	120.4	124.3
	60	129.4	127.4	124.5	127.1	
	120	129.9	123.2	126.5	126.5	
	180	114.3	128.2	127.1	123.2	
	µS	123.8	123.3	125.9		
TWO VARIETIES						121.0
µS		120.9	118.9	123.2		
µN		113.7[a] 122.9[b] 125.4[c] 121.9[d]				
LSD P≤0.05		NS			NS	NS
CV%	14.2					
INTERACTIONS	VXR= NS	VXS= NS		RXS = NS	VXRXS= NS	

µS= mean N split, µN=mean N rate, µVAR =mean variety, LSD P≤0.05=least significant difference at 95% confidence level, CV%= coefficient of variation, V=variety, R=rate, S=split, NS=not significant, [a, b, c, d] are N Rates 0=R_1, 60 =R_2, 120=R_3, 180= R_4 kg N respectively, S_1= application once at 3 MAR, S_2=split twice and each half applied at 3 and 6 MAR, S_3= split thrice in the ratio of 3:3:4 and applied at 3, 6 and 9 MAR respectively, CO 421 and D 8484 are late and early maturing cane varieties respectively.

The mean TCH values due to N rates for both cane varieties showed that R_2, R_3 and R_4 had relatively numerically higher values compared to the control N rate R_1. However, statistically, the differences were insignificant.

A survey on the mean TCH values due to the N split application revealed that S_3 had the highest value of 123.2 TCH followed by the control N split S_1 and S_2 with 120.9 TCH and 118.9 TCH respectively. Nevertheless, the differences were not significant at p≤0.05. However, the yield values registered by the two cane varieties are in agreement with the results of the previous study recorded by KESREF (2007), which qualify D 8484 and CO 421 as high and low yielding cane varieties respectively. Interaction between N rates and split applications in different treatments is shown in Table 1. Present results indicated that cane yield was varied from 95.7 TCH in R_1S_2 to 126.4 TCH in R_3S_2 in CO 421 and from 114.3 TCH in R_1S_2 and R_4S_1 to 129.9 TCH in R_3S_1 in variety D 8484. Cane yields averagely reached the values of 124.3 TCH in CO 421, with application of 120 kg Nha^{-1}. Though this value is slightly greater than the ones obtained with other N rates, the difference is not significant. Gana (2008) established that for application of more than 120 kg N ha^{-1}, there was no significant difference between cane yields. For variety D 8484, cane yields averagely reached 127.1 TCH with application of 60 kg Nha^{-1}. There was no significant difference with regard to the average yield values registered by the other N rates. In variety CO 421, the average cane yields increased from R_1, 107.0 TCH to R_3, 124.3 TCH with no significant difference, while in variety D 8484, the average cane yields increased insignificantly from R_1, 120.4 TCH to R_2, 127.1 TCH. The high level of N concentration resulted in unbalanced uptakes of other crop nutrients such as P and microelements, which in turn may have reduced cane yield (Koochekzadeh *et al*., 2009). Although, none of the influences related to N rates and split applications and their interactive effects was significantly effective on cane yield, studying the effect of application method showed that the highest cane yield can be obtained by application of N rate, R_3 (120 kg ha^{-1}) and treatment of S_2 (50-50%) and N rate, R_3 (120 kg ha^{-1}) and treatment of S_1 (100%) which registered 126.4 TCH and 129.9 TCH for varieties CO 421 and D 8484 respectively.

CONCLUSION

Among all applied nitrogen rates (0, 60, 120 and 180 kg N ha^{-1}) and different split applications (100%, 50-50% and 30-30-40%), the treatment of 120 kg N ha^{-1} and split of 50-50% gave 126.4 TCH for CO 421. Treatment of 120 kg N ha^{-1} and single application of 100% gave 129.9 TCH for variety D 8484. None of the rates and split applications of nitrogen fertilizer significantly affected cane yields of the two sugarcane varieties from the ratoon crop.

RECOMMENDATIONS

With reference to the results obtained from the analysis of variance, it is recommended that treatment combination R_3S_1 (120 kgN/ha and 100% application at 3 MAR) and R_3S_2 (120 kgN/ha and 50-50% applications at 3 and 6 MAR) of N fertilizer be used in order to realize the highest numerical mean TCH output for D 8484 and CO 421 respectively.

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