Effect of Planting Parts and Potassium Rate on the Productivity of Sugarcane (*Saccharum officinarum* L.)

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Abstract

Planting part and K-application can enhance sustainable sugar cane production. Therefore to have a base-line information on the sustainable production of sugar cane (*Saccharum officinarum* L.), field trials were carried out on the growth and yield of the crop under plant and ratoon cultures in Nigeria at the National Cereal Research Institute, Badeggi, Treatments comprised all possible combinations of three planting parts (top, middle and bottom), three K- application rates (0, 60 and 90 Kg ha^{-1}) and two varieties of sugarcane (NCS 008 and Bida local). These were arranged in a randomized complete block design with three replications each. Except under plant crop where the stalk girth and establishment counts of Bida local plants were better than those of the NCS 008; the stalk length and yield of NCS 008 generally were significantly ($P<0.05$) higher than those of local. The establishment counts where the top parts were used as planting materials appeared most promising relative to other planting parts. Brix content of stalks obtained using top propagules was significantly ($P<0.05$) higher compared to those of other planting parts. Increasing K- fertilization up to 90 Kg ha^{-1} significantly ($P<0.05$) increased cane yield and Brix content; irrespective of the cropping system. There was a significant variety x propagules x K-application effect on most of the parameters assessed. This implies that the use of 90 Kg K ha^{-1} of the top planting part of NCS 008 should be recommended for sustainable cane production.

Keywords: Top, middle, basal parts, NCS 008 and Bida local

1. Introduction

Sugarcane (*Saccharum officinarum* L.) belongs to family Poaceae and is one of the most important crops in the world that produced sugar or sucrose (Kolo *et al*., 2005). The major world commercial production centres of this crop include Australia, Brazil, China, Cuba, India, Indonesia, Philippines, Thailand, USA and Sudan (Busari, 2004; Gupta *et al.*, 2004). In Nigeria, chewing sugarcane is grown on about 30,000 ha (Busari, 2004).This represents less than 0.6% of the areas of inland valley swamps (IVS) available for production. The combined production of both industrial and chewing sugarcane rose from 607,000 tons in 1970 to 920,000 tons in 1992, before production started declining in 1993 (Busari, 2004). The large scale cultivation of industrial cane in Nigeria is limited to 4 major areas including Bacita (6000 ha), Numma (5000 ha), Sunti (800 ha) and Lafiagi (300 ha) (Busari, 2004). Chewing sugarcane is grown widely by local farmers across Nigeria on the alluvia soils of Ogun, Ondo, Cross River, Oyo States and in other rainfed low areas especially at

Niger, Katsina, Jigawa, Kwara, Sokoto and Adamawa (Busari *et al*., 2000; Ojehomon *et al*., 1996). The production of industrial cane in estates is witnessing a decline, while more local farmers in especially in Northern Nigeria are into chewing cane production.

The functions of potassium (K) in sugarcane are many and have been extensively reviewed by Filho (1985). Among those functions which may be singled out is the main role of K as an enzyme activator in plant metabolisms such as in photosynthesis, protein synthesis, starch formation and translocation of proteins and sugars. According to Humbert (1968), the downward movement of potassium in sugarcane is from the leaves to the storage tissues in the stalks. The movement proceeds at the rate of 2.5 cm/minute in well-fertilized sugarcane, a lack of K reduces the rate to below half that value. Therefore without an adequate K in the plant, some of the sugar may remain in the leaves instead of being transported, stored and harvested in the stalks. Furthermore, if the K supply is inadequate, hydrolytic activity of invertase may be intensified resulting in cane with high reducing sugars but low sucrose level (Filho, 1985).

Replace with Additionally, potassium plays vital role in plant growth and development (De Boer, 1999). As a consequence of active uptake of potassium and its accumulation in the cell, osmotic potential decreases, water moves in and increases the turgor pressure in the cell which is responsible for growth. Positive effect of potash fertilizer and FYM application occurred on cane yield and sugar contents confirming earlier reports (Kumar *et al.*, 2001). Potash application increased the growth and yield of sugarcane (Bangar, 1995). On the contrary, Singh *et al.* (1999) reported that potassium application had no significant effect on cane yield but increased commercial cane sugar content. Verma *et al.* (1998) reported that potassium application gave higher cane yield but had no effect on sugar content. Venekamp *et al.* (1989) results suggested that the positive role of FYM and potash fertilizer improved cane yield and sugar contents under saline conditions. Soils developed from basement complex material have higher content of total potassium than soils developed from sandstone. In general, soils under Savannah vegetation have higher potassium content than soils in forest regions (Anonymous, 1980). Adequate supply of potassium to sugarcane increases their ability to resist pest and disease attack thereby ensuring good quality produce (Anonymous, 1980). Application of 50 kg and 199 kg K/ha of muriate of potash showed that cane yield increased with increase in potassium fertilizer (Yanan *et al*., 1997). In an experiment conducted by Macalintal and Urgel (1990) it was observed that decreased sucrose concentration in the control plot where there is no application of K fertilizer resulted in increased purity coefficient. Therefore, the objective of this study is, firstly to evaluate various parts of sugarcane for their relative performance in the field, and secondly; to evaluate the effect K-application on their growth and yield.

2. Materials and Methods

The experiment was conducted at the upland sugarcane experimental field of the National Cereals Research Institute Farm, Badeggi ($09^0\ 45^1$ N; $06^0\ 07^1$ E) in the Southern Guinea savanna ecological zone of Nigeria in 2010 and 2011. The soil at the site of the trial has been classified as ultisol and sandy loam in texture with a bulk density of 1.459 m^{-1} (Ayotade and Fagade, 1993). The site has an average annual rainfall of 1124 mm and mean temperature of 23^0 – 33^0C. Two varieties of sugarcane used for the experiments include chewing sugarcane (Bida Local) and industrial sugarcane i.e. National Cereals Sugar 008 (NCS 008). The planting parts used consisted of the top, middle and base. The K–fertilization rates were 0, 60 and 90 Kg ha^{-1}. Muriate of potash (MOP) was used as the source of potassium.

The treatments comprises factorial combinations of two levels of variety (NCS 008 and Bida local), three levels of planting part (top, middle and base), and three K-levels (0, 60 and 90 Kg ha^{-1}), laid out in a randomized complete block design. There were three replications of each treatment.

Each treatment was accommodated in a plot size of 6 m^2 (3 m x 2 m) each containing 4 rows of sugarcane and a net plot of 1 m x 3 m (3 m^2). The alley way between plots was 1.0 m, and 1.0 m between blocks with an inter-row spacing of 1.0 m. The total land area was 583 m^2. Three setts of sugarcane were planted by laying them horizontally per row during the experiment. Ratoon for this experiment was observed for the next cropping season. The following parameters were measured during the experiment establishment count, number of tillers per plant, stalk length, stalk girth (cm), number of chewable stalk and yield/ha. All data collected were subjected to statistical analysis (ANOVA) to test treatment effects for significance using GENSTAT Edition 3 statistical package. The means were compared using F-LSD as outlined by Obi (2002).

3. Results and Discussion

Bida local significantly ($P < 0.05$) established faster than NCS 008 in the plant crops (PC) and vice versa in the ratoon crop (RC) (Table 1). Planting part significantly had effect on plant establishment. Top part had the highest for both plant crops (60.85%) and for ratoon crops (64.67%). Bottom part had the least value for both plant crops (19.74%), and for ratoon crops (49.14%). However, middle part was better than bottom part. Potassium significant ($P<0.05$) increase the establishment count. The application of 90 Kg ha^{-1} had the highest establishment count of 61.92 for RC, the least was obtained from 0 kg Kg ha^{-1} for PC. The interaction of Bida local x top parts x 90 kg K ha^{-1} significantly ($P<0.05$) reveals that Bida local established on the field faster and better than NCS 008 on both plant and ratoon crops (Table 2).

NCS 008 significantly produced the longest stalk length than Bida local for plant and ratoon crops (Table 1). Top parts were significant ($P<0.05$) than middle part and bottom part. Potassium application significantly affected sugarcane height. Plants that received 90 kg Kha^{-1} were tallest compared to plants that received 0 or 60 Kg K ha^{-1} irrespective of the cropping system. Varieties significantly ($P<0.05$) increased the stalk girth of sugarcane. Bida local produced the largest stalk girth and was significantly ($P<0.05$) more than NCS 008, for both PC and RC (Table 1). Planting parts significantly ($P<0.05$) increased the stalk girth such that top parts produced the largest stalk girth, and were significantly higher than the middle and bottom parts. The bottom parts gave the least mean value of 3.01 cm and 3.00 cm at 12 MAP for PC and RC respectively. K-fertilization increased the stalk girth of the plant significantly ($P<0.05$). Application of 90 Kg ha^{-1} proved superior to 60 Kg ha^{-1}. The use of 0 Kg ha^{-1} gave the least mean value for two crops. The number of chewable stalks for plant and ratoon crops were significantly ($P<0.05$) affected by variety (Table 1). NCS 008 significantly produced the highest number of chewable stalk than Bida local for both PC and RC. Planting parts significantly increased the number of chewable stalk. Higher number of chewable stalks was significantly ($P< 0.05$) produced by the top parts compared to either the middle or bottom parts. Bottom parts produced the least number of chewable stalks (Table 1). Application of 90 Kg ha^{-1} produced significantly higher number of chewable stalks. Variety, planting part and K-fertilization significantly increased the number of tillers produced by the plant for the two crops (Table 1). NCS 008 produced the highest number of tillers and was significantly ($P < 0.05$) higher than the numbers produced by Bida local for plant and ratoon crops. Top parts gave the highest number of tillers, although there was no significant difference between middle and bottom parts for both plant and ratoon crops. However, application of K at the rate of 60 kg ha^{-1} produced the highest number of tillers, followed by 0 Kg ha^{-1} and the least was obtained from 90 Kg ha^{-1}.

Table 1. Effect of sugarcane varieties, planting part, K-fertilization and their interactions on the establishment count, tiller count, stalk length, stalk girth, chewable stalk count, % Brix and yield (Kg ha^{-1}) for plant and ratoon crops.

Treatment	Estab. count		Tiller count		Stalk length (cm)		Stalk girth (cm)		Chewable stalk count		% Brix		Yield (Kg ha^{-1})	
	PC	RC	PC	RC	PC	RC	PC	RC	PC	RC	PC	RC	PC	RC
Varieties														
Bida Local	41.35	43.92	10.89	6.93	118.93	82.78	4.56	4.15	31.54	37.19	13.29	17.08	17.30	11.00
NCS 008	36.30	67.47	20.96	8.67	201.48	117.52	3.04	2.90	57.30	59.30	21.03	25.74	39.20	82.00
F-LSD (0.05)	1.14	0.73	1.05	1.58	2.01	1.21	0.14	0.07	1.18	1.03	0.53	0.41	5.66	60.4
Planting Part														
TP	60.85	64.67	19.61	10.00	195.89	106.06	4,52	4.11	52.61	52.78	20.28	23.94	36.70	35.00
MP	35.89	53.28	15.50	7.61	154.50	100.78	3.86	3.47	45.33	48.17	16.58	22.12	28.40	77.00
BP	19.74	49.14	12.67	5.78	130.22	93.61	3.01	3.00	35.39	43.78	14.61	18.16	19.60	29.00
F-LSD (0.05)	1.39	0.88	1.29	1.94	2.47	1.48	0.17	0.08	1.44	1.26	0.65	0.50	NS	NS
K-Fertilization (kg K/ha)														
0	34.33	50.40	13.89	6.33	133.06	83.50	2.81	2.18	43.78	41.56	12.23	14.93	53.10	18.00
60	37.56	54.77	16.61	8.28	164.11	100.11	3.81	3.97	44.11	48.22	18.14	22.16	29.20	31.00
90	44.59	61.92	17.28	8.78	183.44	116.83	4.78	4.22	45.44	52.78	20.59	27.13	20.4	92.00
F-LSD (0.05)	1.39	0.88	1.29	1.94	2.47	1.48	0.17	0.08	NS	1.26	0.65	0.50	6.93	NS
Interaction														
V x PP	1.97	1.26	NS	NS	3.48	2.09	0.23	0.12	2.04	NS	0.93	070	9.80	NS
V x KF	1.97	1.26	NS	NS	3.48	2.09	NS	0.12	NS	NS	0.93	0.70	9.80	NS
KF x PP	2.41	1.54	NS	NS	4.27	2.56	NS	1.44	NS	NS	1.32	0.86	12.00	NS
V x PP x KF	3.40	2.18	NS	NS	6.04	3.62	NS	0.20	NS	NS	1.60	1.22	NS	NS

PC- plant crop, RC- ratoon crop, TP – top part, MP – middle part, BP – base part, PP – planting part, V – variety, KF – potassium fertilization, F-LSD- Least significantly different at 5% level of probability and NS – not significant.

Table 2. Interaction effects of sugarcane varieties, planting part, K-fertilization and their interactions on the establishment count, tiller count, stalk length, stalk girth, chewable stalk count and % Brix and yield (kg ha^{-1}) for plant and ratoon crops.

Varieties	PP	KF(kg ha^{-1})	Estab. Count		Tiller count		Stalk length (cm)		Stalk girth (cm)		Chewable stalk count		% Brix	
			PC	RC	PC	RC	PC	RC	PC	RC	PC	RC	PC	RC
Bida Local	TP	0	51.17	53.33	23.33	13.00	114.67	69.00	4.38	3.20	38.10	35.00	11.37	14.50
		60	57.47	47.60	27.33	15.00	154.00	88.00	5.57	5.53	38.33	38.00	16.70	18.10
		90	63.97	50.40	32.33	16.00	164.67	103.33	6.60	5.80	36.33	50.33	17.30	22.20
	MP	0	42.37	37.57	18.33	9.00	102.33	65.33	3.33	2.53	31.67	32.00	9.47	13.10
		60	42.07	43.40	18.00	11.00	121.33	84.67	4.70	4.27	34.00	36.00	12.77	15.30
		90	46.47	45.87	20.00	11.67	138.00	100.33	5.60	5.53	32.00	45.67	17.13	26.30
	BP	0	20.40	31.47	13.00	6.00	75.00	61.33	2.70	1.90	23.33	26.00	8.87	12.40
		60	24.07	41.33	16.33	8.00	94.00	78.33	3.53	3.87	25.67	30.33	10.90	12.53
		90	24.20	44.10	21.33	8.33	106.33	94.67	4.63	4.70	25.00	41.33	15.10	19.30
NCS 008	TP	0	59.47	74.93	28.00	21.33	231.00	105.00	2.57	2.43	68.00	55.00	17.73	16.03
		60	63.33	76.90	31.33	24.33	243.00	123.00	3.53	3.67	68.33	67.00	27.27	34.43
		90	69.69	84.67	37.00	28.00	268.00	148.00	4.53	4.00	66.67	71.33	31.30	38.40
	MP	0	17.87	54.40	20.67	19.00	150.00	101.33	2.40	1.60	57.00	52.00	15.13	18.43
		60	21.33	63.20	26.00	20.67	200.67	115.33	3.00	3.37	58.67	61.00	22.10	29.30
		90	45.23	75.23	27.00	21.67	214.67	137.67	4.10	3.50	58.67	62.33	22.90	30.30
	BP	0	14.73	50.50	24.00	15.00	125.33	99.00	1.50	1.43	44.00	49.33	13.83	15.13
		60	17.10	56.17	25.33	19.00	171.67	111.33	2.50	3.10	46.67	57.00	19.13	23.30
		90	17.97	71.27	29.33	19.67	209.00	117.00	3.20	3.00	47.67	58.67	19.83	26.30
F-LSD(0.05)			3.40	2.18	NS	NS	6.04	3.62	NS	0.20	NS	NS	1.60	1.22

Estab- Establishment, PC- plant crop, RC- ratoon crop, TP – top part, MP – middle part, BP – base part, PP – planting part, V – variety, KF – potassium fertilization, F-LSD- Least significantly different at 5% level of probability and NS – not significant.

Varieties, planting part and K-fertilization increased the percentage of brix for plant and ratoon crops (Table 1). NCS 008 had 21.03% and 25.74% Brix contents respectively, for plant and ratoon crops, while local had 13.29 % and 17.08 % respectively. The PC and RC yield of Brix from the top parts (20.28 % and 23.94 %) was significantly higher than the yield of either the middle (16.58 % and 22.12 %) or the bottom parts (14.61 % and 18.16 %). Application of 90 Kg ha^{-1} gave the highest per cent brix of 20.59 % and 27.13 % for PC and RC respectively, compared to 60 Kg ha^{-1} (18.14 % and 22.16 %) or 0 Kg ha^{-1} (12.23 % and 14.93 %). Varieties and potassium application significantly ($P < 0.05$) increased the stalk yield of sugarcane for PC and RC (Table 1). Planting parts did not show significant difference although top parts gave the highest yield (t ha^{-1}) and the least was obtained from bottom parts. However, 90 Kg ha^{-1} gave the best stalk yield (t ha^{-1}) compared with the application of 60 and 0 Kg ha^{-1}. No significant difference amongst stalk yield was detected between 60 and 0 Kg ha^{-1}.

Conversely, there was a significant variety x planting part x K-fertilization interaction effect (Table 2). Application of 90 Kg ha^{-1} on NCS 008 top parts had the tallest stalk height of 268 cm and 148 cm respectively for plant and ratoon crops. The least stalk length of 75 cm and 61 cm was obtained for plant crops and ratoon respectively in Bida local by the bottom part at 0 Kg ha^{-1}. Generally, Bida local x top part x 90 Kg ha^{-1} interaction gave the longest girth of 5.80 cm, followed by Bida local x top part x 60 Kg ha^{-1} of 5.53 cm. The least was obtained from NCS 008 x bottom part x 0 Kg ha^{-1} (1.43 cm). NCS 008 x top part produced the highest number of chewable stalk. The number of chewable stalks that were obtained by NCS 008 at top, middle and bottom part was significantly higher than Bida local x top part that performed best using that variety as a test crop for plant and ratoon crops (Table 2). NCS 008 x top part x 90 Kg ha^{-1} had the highest number of tillers (37). Application of 90 Kg ha^{-1} on each planting part and variety gave the highest tiller count than 0 and 60 Kg ha^{-1} for plant and ratoon crops (Table 2). NCS 008 x top part x 90 Kg ha^{-1} gave the highest percentage of brix of 31.8 and 38.4 for PC and RC respectively, followed by NCS 008 x middle part x 60 Kg ha^{-1} of 21.1 and 29.3 for PC and RC respectively. The least was obtained from local x bottom part x 0 Kg ha^{-1}, which had 8.87% for PC and 12.40% for RC.

The superior performance of top (apex) part over other parts in all the parameter taken is not surprising. This could be attributed to the juvenile age of this part. According to Kolo *et al.* (2005), in sugarcane production, planting materials (cane setts) should be obtained from the middle and the apex of the stalk. Although both the middle and top are used, the top of the stalk is the part mostly used by the local farmers as planting material. Busari (1997) stated that, the middle portion is often used mainly to supplement the tops since the latter often becomes inadequate especially in areas where large hectares are put to sugarcane cultivation. The top and middle parts are used because of the presence of young buds with very active primordial cell, which contain enzymes that are easily activated under favourable environmental conditions. The top segment had an ample supply of nutrient that renders it valuable for planting purposes (Barnes, 1974). Kolo *et al*. (2005) reported that in estate, the whole stalk is cut into setts, and planted. It is believed that the buds in the relatively older lower part of the stalk tend to take longer time for enzymes to get activated for germination. This explained the significant difference observed between the upper parts and the base of the stalk. Kolo *et al*. (2005) also reported and observed that once the bud had sprouted, it had a capacity to produce large number of tillers normally under favourable condition.

Potassium initiates the establishment of plant and ratoon crop and significantly increased the growth parameters of plant and ratoon crop of sugarcane which aggress with Sachan *et al*. (1993) who observed that plant and ratoon crop of sugarcane respond significantly to potassium application but disagrees with Paneque *et al*. (1992) that reported that in Brazil neither plant and ratoon crop responded to application of potassium as a result of environmental and edaphic factors. Similarly, De Boer (1999) reported that potassium plays vital role in plant growth and development. The performance of 90 kg K ha^{-1} in this study is in agreement with Hong *et al*. (2006)

5. Conclusion

Top part (apex) of sugarcane stalk proved superior among the middle and bottom part. Hence, top (apex) and middle is mostly recommended for out grower and estate to use as planting material. Potassium application of 90 Kg ha^{-1} is recommended for optimal growth and yield.

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