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RESEARCH ARTICLE

Assessment of Growth Parameters of Sugar Cane (*Saccharum officinarum* Linn.) Varieties in the Mangrove Forest Ecosystem in Ogonokom-abua, Rivers State, Nigeria

J.E.K. Aroh[1],
Mbakwe Roy and
A.C. Wada[3]*

[1]Niger Delta University,
Wilberforce Island, P.M.B. 071,
Yenagoa, Bayelsa State, Nigeria

[2]Michael Okpara University of
Agriculture, Umudike, Nigeria

[3]National Cereals Research Institute,
Badeggi, PMB 8, Bida, Niger State,
Nigeria Tel: +2348067715561

ABSTRACT

Background and Objective: The mangrove ecology has not been evaluated for the cultivation of crops particularly sugar cane. The present study was set up to evaluate growth parameters of four test sugar cane varieties over time and to identify which of them would get established and grow to maturation stage in the mangrove forest ecosystem in Ogonokom-Abua, Rivers State. **Materials and Methods:** Four varieties of sugar cane namely NCS-001, NCS-002, NCS-005 and "Bida local" were planted using different agricultural management practices in the un-amended mangrove forest soils of Ogonokom-Abua, Rivers State, Nigeria. All the varieties achieved diminutive growth statistics occasioned by various types and dimensions of perceived soil-related constraints in the studied environment. **Results:** The four test canes recorded growth curtailment in characters like plant height, internode length and many green leaves in the 6th or 9th Month after Planting (MAP). These decreased sharply to the maturation stage in the twelfth month suggesting reduced tolerance to soil constraints over time. Despite soil limitations, the test varieties showed significant differences in growth parameters. Variety NCS-002 recorded higher growth statistics of plant height, the number of internodes, internodes length and leaf length and was second-best in the number of tillers produced. Variety NCS-001 produced the highest cumulative average number of tillers. **Conclusion:** Thus varieties NCS-002 and NCS-001 can be choice candidates for cultivation as commercial canes in the unmodified mangrove forest ecosystem investigated. Further studies are to be conducted using supportive management practices such as manure, fertilizer and lime application to improve the fertility level and soil productivity of the mangrove forest lands in Ogonokom-Abua, Rivers State.

Key words: Environmental constraints, genetic constitution, growth response, millability, tolerance.

*Corresponding Author

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INTRODUCTION

The mangrove ecology has not been evaluated for the cultivation of crops particularly sugar cane. Extensive areas of mangrove swamp soils occur in the Niger Delta spanning about 973,000 hectares or 10,000 km^2 approx[1]. Despite the extensiveness of mangrove forest soils in Rivers State, occurring in eleven out of twenty-three Local Government Areas (LGAs)[2], they are uncultivated due to a multiplicity of natural constraints[3]. The mangrove forest belt in the Niger Delta is daily flooded by tidewater or seawater from the Atlantic Ocean. The soils are daily submerged during high tide and drained at low tide. Some plant species naturally survive temporary soil inundation or partial saturation while in most others growth is retarded regarded as the result of "flood injuries"[4] and sometimes resulting in the death of plants[5].

Seawater is saline and contains large amounts of dissolved salts[6,7]. Therefore, the mangrove forest soils in Rivers State are also saline[8] and very few plants can withstand soil salinity[8]. In addition to being saline, sulphides and polysulphides contained in such soils are reduced in waterlogged condition to sulphates, hydrogen sulphide (H_2S) compounds and elemental sulphur (S) or inorganic sulphur[9-13]. When exposed to atmospheric oxygen such as in drained wetlands, these materials are oxidized to sulphuric acid (H_2SO_4) and the acidity of the soil is drastically increased[14-17] and most cultivated plants cannot survive high acidity in soil[18].

However, salt marshes such as mangrove swamps and other wetlands are considered to be among the most productive ecosystems on earth including their agricultural use for the cultivation of lowland rice[19].

Sugar cane (*Saccharum officinarum* Linn.) is a giant grass plant similar to lowland rice in some respects. The selection of sugar cane varieties for resistance or tolerance to flooding, drought, diseases, pests, salinity and other natural phenomena have been and are still great challenges to scientists in the major sugar cane producing nations of the world[20-27]. The demand for sugar cane and its several industrial by-products continue to escalate on global scale[28]. The cultivation of sugar cane in mangrove forestland, therefore, demands scientific inquiry in the Niger Delta to identify the variety(ies) of the crop that will be tolerant to the perceived soil constraints in the environment of the study area. Moreover, with a population density of 261 persons per square kilometer in Rivers State[29], pressure on land has necessitated the need to explore the agricultural potential of mangrove forest soils in the state.

The present study was, therefore, set up to identify which of the four varieties of the sugar cane would get established and grow to maturation stage in the mangrove forest ecosystem in Ogonokom-Abua, Rivers State; and to evaluate growth parameters of the test sugar cane varieties over time.

MATERIALS AND METHODS

Study area: The study was carried in Ogonokom-Abua, in Ahoada Local Government Area of Rivers State, Nigeria between the 2009/2010 growing season on the un-amended mangrove forest soils.

Raising of sugar cane seed nursery: The four sugar cane varieties NCS-001, NCS-002, NCS-005 and "Bida Local" were obtained from the National Cereals Research Institute (NCRI), Badeggi, Niger State, Nigeria. They were cut into one budded planting materials or "seed pieces" or "sugar cane setts" and raised under a shade in a nursery in the vicinity of the experimental site. Nursery bags measuring

40×35 cm were filled with 5 kg of topsoil. These were devoid of any form of basal fertilizer or lime application, whatsoever, to determine their intrinsic fertility level in the mangrove ecosystem being investigated. The nursery bags were watered with 750 mL of rainwater twice weekly.

Transplanting and data collection growth parameters: Sprouted plants were transplanted to the field thirty days after planting (30 DAP) into nursery bags. The plants were spaced 1.0 m along rows and 1.25 m rows as described by Amosun[30] with a 25 cm end-lap on each row. Two rows were provided to accommodate four sugar cane setts in each experimental unit. The blocks were separated by 3 m wide alleys.

The experiment spanned 12 calendar months from time of planting into nursery bags up to and including maturation of the "plant crop". Data collection was done at 3, 6, 9 and 12 Months after Planting (MAP) on three plants at random and the average value recorded for each growth parameter that was being determined. Measurements or observations were made on the following growth parameters:

- Number of tillers/stool
- Plant height/stool
- Stem girth/stool
- Number of nodes/stem
- Internode length/stem
- Number of green leaves/stem
- Leaf length/stem
- Leaf width/stem
- Leaf sheath length/stem. Leaf measurements were made on 3rd-6th Top Visible Dewlap (TVD) leaves

Data analysis: All data generated were subjected to the Analysis of Variance (ANOVA) method for significant differences at 95% confidence level using the split-split-plot format as described by Wahua[31] and Duncan's Multiple Range Test (DMRT) was used to separate the means.

The student's t-test was applied using four pairs of readings (n = 4) i.e., 3, 6, 9 and 12 months after planting (MAP) with n-2 degrees of freedom to test for a significant correlation between sugar cane growth parameters and time in a 2-tailed test at 0.05% level of significance. The Statistical Analysis for the Sciences (SAS Version 9.0) computer software package was used for the data analysis.

RESULTS AND DISCUSSION

Sugar cane growth parameters

Tiller production or number of tillers per stool: The average number of tillers produced by the four sugar cane varieties over twelve months ranged from 1.25-2.83 (Table 1).

Tiller formation among the test varieties was generally close from 3-6 MAP even as Bida local trailed behind the others. While vars. NCS-001, NCS-002 and NCS-005 produced a practically similar number of tillers from 6-9 MAP, Bida local declined in the number of tillers produced during the same periods only to soar at 12 MAP but whose average value was still far behind those of NCS- 001, NCS-002 and NCS-005. It is possible that the sharp drop in tiller formation in Bida local from 6-9 MAP was environment-related since the plants continued with tiller production

Table 1: Tiller production and plant height of four sugar cane varieties, 2010

	Tiller Production				Plant height			
Varieties	3 MAP	6 MA	9 MPA	12 MAP	3 MAP	6 MA	9 MPA	12 MAP
NCS 001	1.75[a]	2.08[a]	2.50[a]	2.83[b]	45.70[ab]	60.96[ab]	59.63[a]	70.34[a]
NCS 002	1.75[a]	2.25[a]	2.50[a]	2.50[a]	51.90[a]	66.95[a]	68.83[a]	83.89[a]
NCS 005	1.92[a]	2.00[a]	2.17[ab]	2.58[a]	39.51[b]	50.18[b]	48.04[a]	55.13[a]
Bida local	1.67[a]	1.83[a]	1.25[b]	1.92[a]	24.73[c]	34.50[c]	44.94[a]	55.83[a]
	NS	NS		NS			NS	NS

Means with the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at p = 0.05 months after planting (MAP)

Table 2: Stalk girth and number of internodes of four sugar cane varieties, 2010

	Stalk girth (cm)				Number of internodes			
Varieties	3 MAP	6 MA	9 MPA	12 MAP	3 MAP	6 MA	9 MPA	12 MAP
NCS 001	4.92[b]	4.65[b]	3.68[b]	3.77[b]	3.42[a]	7.50[a]	10.17[a]	12.00[a]
NCS 002	4.68[b]	4.26[b]	3.74[b]	3.90[b]	4.33[a]	7.67[a]	10.58[a]	10.75[a]
NCS 005	4.77[b]	4.84[b]	3.63[b]	3.60[b]	3.50[a]	7.00[a]	8.25[a]	10.58[a]
Bida local	5.63[a]	7.03[a]	6.23[a]	5.98[a]	0.00[b]	3.92[b]	8.92[a]	12.58[a]
							NS	NS

Means with the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at p = 0.05 months after planting (MAP)

after 9 MAP up to 12 MAP. According to Jadoski *et al.*[32], tillers in sugar cane could number from 5-27 stalks at different stages of growth. Except in var. NCS-002 with higher actual or raw figures in a few instances, average tiller production that was far less than 5 tillers per stool in all the varieties tested indicates their extremely poor growth performance in the environment under investigation.

Plant height: Results presented in Table 1 also show that the average plant height of the test canes at 3, 6, 9 and 12 MAP ranged from 24.73-83.89 cm. Varieties NCS-001 and NCS-002 also attained 60.00 cm and above in average plant height at 6 MAP whilst vars. NCS-005 and Bida local were less than this value; particularly Bida local that had a plant height of less than 50.00 cm up to 9 MAP. At 12 MAP, vars. NCS-001 and NCS-002 had plant heights over 70 cm while NCS-005 and Bida local recorded heights of below 60 cm. The results show the relative superiority of NCS-001 and NCS-002 over NCS-005 and Bida local as concerned plant height.

As the growth period progressed, all the four varieties virtually recorded increases in plant height as from 3-12 MAP even with a decline in vars. NCS-001, NCS-002 and NCS-005 at 9 MAP. In particular, the increase in plant height over time in Bida local was clear-cut, although its maximum height at 12 MAP of 55.83 cm was less than the heights attained by vars. NCS-001 and NCS-002 at 6 MAP. In this case, Bida local exhibited a higher tolerance level to soil constraints for the simple reason that it increased in plant height without decline from 3-12 MAP, at least, for as much as environmental conditions permitted. This was, probably due to the genetic attribute peculiar to it. However in vars. NCS-001, NCS-002 and NCS-005, the somewhat congruent rise in plant height from 3-6 MAP as well as the matching decline at 9 MAP and harmonious increase again at 12 MAP could have been due to factors other than genetic since all three varieties experienced the same environment.

Soil limitations may have impacted on plant height in these varieties much more at 9 MAP than at other times during the life of the canes. The sensitivity of crops to soil constraints such as high salinity and flooding among others often changes from one stage of growth to the next[32]. This assertion notwithstanding, the

genetic makeup of the varieties cannot be underscored. Whereas Bida local withstood the adversities in soil conditions better than vars. NCS- 001, NCS-002 and NCS-005 by exhibiting an uninterrupted increase in plant height, its genetically determined dwarfish height relative to vars. NCS-001, NCS-002 and NCS-005 were further hampered by the hazards that prevailed in the environment. As such, despite the environmental setback experienced at 9 MAP, vars. NCS-001, NCS-002 and NCS-005 still expressed their height advantage over Bida local by attaining heights considered as economically viable even as they were a little less tolerant of the prevailing daunting soil conditions. Since plant height is a critical growth trait in sugar cane cultivation, vars. NCS-001 and, especially NCS-002 are better suited to the mangrove ecosystem under investigation even as the final plant heights achieved at 12 MAP seem to fall short of findings in earlier studies[23,32].

Sugar cane is a tropical, perennial grass that can grow up to 4.25 m tall and is generally about 5.1 cm thick and when ripe, the cane is usually about 2-4 m tall[32]. In Nigeria, NCRI[33] reported plant heights of 2.0-4.5 and 1.7-3.0 meters in vars NCS-001 and NCS-002, respectively. The dismal performance of the test sugar cane in the present study can be attributed to the un-amended soil constraints earlier reported[6-14], including nutrient deficiencies and imbalances, elemental or ionic toxicities, high sodicity, acidity, salinity and an overbearing effect of flooding in some experimental units[3-5].

The results further show that at 3 and 6 MAP, there were significant differences in plant height among NCS-002, NCS-005 and Bida local where NCS-002 performed best followed by NCS-005 and then Bida local being the least. Variety NCS-001 was not significantly different from NCS-002 and NCS-005 at these periods (Table 1). At 9 and 12 MAP, however, there were no significant differences between the four varieties. In practical terms, NCS-002 and NCS-001, in that sequence are the varieties of choice with NCS-002 being the best performing member for plant height throughout the experiment.

Stalk girth: Table 2 shows that average stalk girth in the evaluated canes ranged from 3.60-7.03 cm in 12 months. The Table shows an unparalleled accomplishment in stalk girth by Bida local relative to vars.

NCS- 001, NCS-002 and NCS-005. Stalk girth of vars. NCS 001, NCS 002 and NCS-005 did not vary appreciably either among the varieties or over time as they generally decreased gently from 3-9 MAP and increased at 12 MAP. There is, therefore, not much to distinguish between these three varieties in terms of stalk girth. Conversely, Bida local recorded a sharp rise in girth from 3-6 MAP and attained a creditable girth close to 6.00 cm at 12 MAP, which was another impressive quality by the variety being a chewing cane that is desired, according to Bull[34], for its more succulent, bulkier and juicier stalks.

Stalk girth is one of the critical criteria for determining millability in sugar cane[35] and it ranges in sugar cane from 2-5 cm[32,35]. The minimum stalk girth for the millable cane is placed at 1.5 cm and the descriptor for stem girth in NCS-001 is 2.5-4.0 cm while in NCS-002, it is 2.0-3.5 cm[35]. In this respect, all the four varieties showed good prospects in achieving and sustaining millable cane girth right from 3 to 12 MAP.

For chewing cane, an acceptable minimum stalk girth is 2.0 cm[35] and the bigger the girth, the larger the amount of chewable stuff. It is important to point out that NCS-001 and NCS-002 are typical industrial canes and Bida local is a chewing cane while NCS-005 is a hybrid commercial and chewing cane. The results show that all four varieties met the requirements for millable as well as chewable canes in the environment under study. Thus, there were significant differences in stalk girth

between NCS-001, NCS-002 and NCS-003 on the one hand and Bida local on the other throughout the 12 months duration of the study (Table 2).

Number of internodes per stalk: The average number of internodes produced within 12 months by the test sugar cane varieties ranged from 0 to 12.58 (Table 2). The results show that NCS-002 and NCS-001, in that order, exhibited the uncommon capacity to produce a reasonable number of nodes in the face of unsavory soil conditions in the environment, even as NCS-00 2 slipped a bit at 12 MAP. Also, NCS-005 was relatively better than Bida local in the number of internodes produced. The number of internodes is one parameter that increased with time despite the soil constraints discussed earlier and all four varieties added numbers indicative of continuous growth in the plants from 3-12 MAP as was the case with plant height. Variety NCS-002 suffered a sudden decline in the number of internodes produced during the later stages of the plants' life from 9-12 MAP.

The poor performance of NCS-002 relative to NCS-001, NCS-005 and Bida local then amounted to a major setback in a variety that appears to have the greatest prospect of survival and high yield in the environment. However, since the period from 9-12 MAP coincides with the maturation and ripening stages in the sugar cane crop, particularly for NCS-005 which is a hybrid industrial and chewing cane and Bida local, a known chewing cane as reported by Bull[34] and Jardoski *et al.*[32] the drawback may not be of immense consequence toward yield in the said varieties.

The greater concern is the production of fewer than twenty internodes in all the varieties tested in the present study. Bull[34] reported that there could be up to 20 or 30 internodes on a single stalk of sugar cane at maturity, therefore, an average number of 12.58 internodes in Bida local being the instantaneous highest across the test varieties at 12 MAP, indicate its less than satisfactory performance in the environment even in the light of overall superior performance by NCS-002.

Results presented in Table 2 also show that there were significant differences between NCS-001, NCS-002 and NCS-005 on the one hand and Bida local on the other at 3 and 6 MAP in the number of internodes possessed.

Internodes length: Results presented in Table 3 show that average internodes length of the test canes ranged from 0-5.13 cm in twelve months in NCS-001, NCS-002, NCS-005 and Bida local. Variety NCS-005 performed likewise only at 3 and 6 MAP while Bida local recorded internodes lengths that were less than these.

Over time, despite the early surge in internodes length in all of the varieties except in NCS-002, there was a general decrease in internodes length in NCS-001, NCS-002 and NCS-005 from 9-12 MAP while Bida local dipped at 12 MAP. Variety NCS-002 produced the longest internodes lengths despite all odds from the environment, followed by NCS-001 and NCS-005. The relatively shorter internode length in Bida local was, perhaps, characteristic of the variety and or was further curtailed by the growth environment in the study area.

The general decline in internode length was simply symptomatic of the pervasive soil constraints that impacted on all the varieties in the present study. This contention is, however, not oblivious of the well-established phenomenon of "diminishing returns" characteristic of all biological entities and systems, whereby growth rate naturally slows down after achieving an environmentally and genetically expressible maximum[36]. Again, the plants may have approached their ripening phase in their development, hence the drop in internodes length from 9-12 MAP.

The significance of internodes length in the sugar cane plant cannot be underestimated. Besides cane yield and sugar quality which are criteria that are of

paramount importance in sugar cane cultivation, plant height stalk girth and internodes length are also critical growth indices in the choice of millable or chewing cane[33,37,38]. In the present study, the length of the internode recorded in NCS-002 did add-on to its higher number of internodes as well as the attainment of greater plant height to place it above NCS-001, NCS-005 and Bida local notwithstanding its thinner stalk girth. Even then, the cumulative average stalk girth of 4.15 cm recorded by NCS-002 was far more than the minimum acceptable stalk girth of 1.5 cm for millable sugar cane[32,33]. Thus, NCS-001 was more comparable to NCS-002 than were NCS-005 and Bida local despite its robust stalk girth peculiar to it as it is a chewing cane and noble[33].

However, since the varieties are for two different uses, NCS-002 and NCS-001 may be preferred as industrial canes while NCS-005 may pass as chewing cane for cultivation in the study area. The principal disadvantages in Bida local include its compressed internode lengths and its dwarfish heights as shown in the present study (Table 1 and 3). Its robust girth notwithstanding, it lacked the appeal even as a chewing cane in the present study.

Number of green leaves per stalk: Results presented in Table 3 show that the average number of green leaves produced by the test canes at 3, 6, 9 and 12 MAP ranged from 4.17-7.00. This domination in the number of green leaves is similar to stalk girth where Bida local also exceeded the other varieties.

As the canes progressed in growth from 3-12 MAP, they generally decreased in the production of green leaves regardless of the mild increases in NCS-001 and NCS-005 at 6 MAP. As inconsequential as these increases were recorded in NCS-001 and NCS-005, the general drop beyond 6 MAP in all the varieties suggests that soil conditions became quite overbearing, thus resulting in the widespread reduction in their ability to sustain growth. Castro-Nava *et al*.[39] reported that there can be between 5 and 15 green leaves on a single sugar cane stalk. The highest average number of green leaves of seven in NCS-001 was somewhat low for the proper development of the plants and is at variance to the report of these workers. In particular, the wide-ranging fall in the number of green leaves from 6-12 MAP in all the test varieties may be due to harmful environmental impacts on the plants. This is because the health of a plant is reflected in its number of green or active photosynthetic leaves[40]. The radical decrease in the number of green leaves as early as 6 MAP in the life of the test canes means that they were under severe stress, understandably, from intense growth-limiting soil conditions.

Since all four varieties were more-or-less impacted equally and they responded similarly, there were no significant differences in the number of green leaves produced by any of them through the period of the investigation (Table 3) an

Table 3: Internodes length and number of green leaves per stalk of four sugarcane varieties, 2010

	Internodes length (cm)				Number of green leaves/stalk			
Varieties	3 MAP	6 MA	9 MPA	12 MAP	3 MAP	6 MA	9 MPA	12 MAP
NCS001	4.05^{ab}	5.09^{a}	3.83^{ab}	3.19^{ab}	6.75^{a}	7.00^{a}	4.75^{a}	4.67^{a}
NCS002	5.13^{a}	4.89^{a}	4.74^{a}	3.89^{a}	6.33^{a}	6.00^{a}	4.92^{a}	4.42^{a}
NCS005	3.58^{b}	3.92^{a}	2.80^{b}	2.49^{ab}	6.25^{a}	6.58^{a}	4.67^{a}	4.17^{a}
Bidalocal	0.00^{c}	1.59^{b}	2.06^{c}	1.97^{b}	6.67^{a}	6.58^{a}	5.67^{a}	5.17^{a}
					NS	NS	NS	

Means with the same letters are not significantly different according to DMRT: Duncan's multiple range test at p = 0.05 MAP: Months after planting

Table 4: Comparison between sugar cane varieties in leaf length and leaf width, 2010

	Leaf length (cm)				Leaf width (cm)			
Varieties	3 MAP	6 MA	9 MPA	12 MAP	3 MAP	6 MA	9 MPA	12 MAP
NCS 001	97.92^{ab}	99.54^{ab}	93.45^{ab}	89.93^{a}	2.20^{ab}	2.18^{b}	1.97^{b}	1.93^{b}
NCS 002	111.81^{a}	117.34^{a}	111.33^{a}	100.09^{a}	1.50^{b}	1.63^{b}	1.53^{b}	1.55^{b}
NCS 005	84.07^{b}	94.79^{b}	79.13^{b}	78.89^{a}	2.63^{a}	2.06^{b}	1.48^{b}	1.50^{b}
Bida local	86.18^{b}	87.34^{b}	91.57^{ab}	90.95^{a}	2.84^{a}	3.06^{a}	3.54^{a}	3.24^{a}

Means with the same letters are not significantly different according to Duncan's Multiple Range Test (DMRT) at p = 0.05
MAP: Months after planting

indication of a pervasive soil environment despite their various peculiarities. In other words, none of the varieties in the study was able to totally or substantially overcome the adversities in the soils for leaf proliferation beyond 6 MAP. Perhaps, they were just able to tolerate the hardships by slowing down their biological activities by simply remaining animate up to 12 MAP.

Leaf length: Results presented in Table 4 show that leaf lengths in NCS-005 and Bida local were significantly different from those in NCS-002 at 3 and 6 MAP. At 9 MAP, NCS-005 was still significantly different from NCS-002. Thus, NCS-002 was the overall best in leaf length all through the period of the study when compared to the other three varieties.

It is natural for leaf length to decrease as plants approach maturation especially for twelve months of growth in a crop like sugar cane[36]. Therefore, the drop in leaf length beyond 9 MAP was not surprising but the untimely reduction in leaf length beginning from 6-9 MAP which marked the period of vigorous vegetative growth in sugar cane was astonishing[32,36]. It is possible that the stress exerted on the canes by the harsh soil conditions were severe enough to have initiated early-maturing processes in them even as their full potential in growth had not been fully expressed.

Leaf-blade lengths normally range from 60-150 cm in sugar cane[35] while Bull[34], reported between 90 and 200 cm. In particular, leaf lengths of less than 100 cm in NCS-005 viewed against the lengths of 120-126 cm reported by NCRI[35] was an under-performance by the variety. Leaf lengths of between 70 and 120 cm attained by all the four varieties in the study fell a little short of known standards[32,39,41], thereby bringing to bear on the unsavory environmental conditions which are believed to be soil constraints which must have substantially hampered growth in the canes.

Leaf width: The average leaf width of the test canes ranged from 1.48-3.54 cm (Table 4). Throughout the study, leaf width in NCS-001 and NCS-005 showed a decline from 3-12 MAP. The decrease in leaf width was huge and impactful in NCS-005, especially from 3-9 MAP suggesting its reduced tolerance level to soil-related hazards. In NCS-002 and Bida local, there were minor increases in leaf width in which NCS-002 maintained a very narrow range in leaf width of 1.50-1.63 cm from 3 to 12 MAP.

Leaf width in sugar cane generally ranges from 2-10 cm[32] while in NCS-005, it is reported to be from 2.5-2.8 cm[35]. Except in Bida local that recorded leaf widths greater than 3cm, the results show that NCS-001, NCS-002 and NCS-005 recorded poor leaf expansion in the present study. Bida local is a variety traditionally grown for its robust vegetative parts as a chewing cane in Nigeria[33].

Table 5: Leaf sheath length of four sugar cane varieties at different stages of growth, 2010

	3 MAP	6 MAP	9 MAP	12 MAP
NCS-001	18.28[b]	22.23[b]	18.23[ab]	17.67[ab]
NCS-00	33.27[a]	29.01[a]	24.63[a]	22.85[a]
NCS-005	14.73[b]	20.63[b]	15.57[b]	15.61[b]
Bida local	16.39[b]	22.18[b]	19.18[ab]	18.48[ab]

Means with the same letter(s) are not significantly different according to Duncan's Multiple Range Test (DMRT) at p = 0.05, MAP: Months after planting

The data show that NCS-005 and Bida local were significantly different from NCS-002 at 3 MAP (Table 4). Also, Bida local was significantly different from all the other varieties at 6, 9 and 12 MAP. If leaf width should be a factor or growth trait of special interest, like for increased surface area in photosynthesis, then, Bida local stands out as one that has a higher potential for growth and perhaps, should be the preferred choice for small ruminant feedstuff[42-5].

Leaf sheath length: Results presented in Table 5 show that the average leaf sheath length of the test canes ranged from 14.73-33.27 cm. Throughout the trial, there were substantial increases in leaf sheath length in NCS-001, NCS-005 and Bida local from 3-6 MAP and then a synchronized decrease from 9-12 MAP, which further suggests the effect of hash soil conditions beyond 6MAP as was observed in most of the other growth parameters discussed earlier. In the case of NCS-002, there was a sharp and steady decline in leaf sheath length right from 3-12 MAP.

The steady fall in leaf sheath length over time observed in NCS-002 from 3-12 MAP shows the severity of the impact of soil constraints on leaf sheath length in the variety, presumably, much more than in NCS-001, NCS-005 and Bida local. Variety NCS-002's lead in leaf sheath length over the other three varieties is not in doubt and it shows that it was more influenced as the canes advanced in growth though negatively, thereby becoming less tolerant and more vulnerable to soil limitations with age. On the contrary, NCS-001, NCS-005 and Bida local were less responsive to increases in soil constraints as they aged and showed little change in leaf sheath length from seedling to maturity. Thus, soil factors affected them rather mildly as shown by leaf sheath length which declined and evened-out uniformly beyond 6 MAP. Leaf-sheath length in NCS-005 is reported to be 35-40 cm[35] but in the present study it recorded an average of 14.73-20.63 cm.

In the present study, NCS-002 achieved greater plant height, the number of internodes, internodes length, leaf length and width[35] as well as leaf sheath length than NCS-001, NCS-005 and Bida local. These much sought-after qualities in the variety are some of the key determinants for acceptability in sugar cane cultivation whether as an industrial cane or for chewing purposes. The cane stems and leaf discards can also be used as browse/fodder materials in small ruminants farming systems involving grass cutter and rabbits[42]. Therefore, NCS-002 holds the greatest prospect for cultivation as industrial cane and ruminant feedstuff[42-44] in the environment under investigation. Variety NCS-001 also showed some measure of promise being the second choice in leaf sheath length and other growth indicators considered in the study. These two varieties may be considered as preferred candidates for cultivation in the mangrove forest ecosystem in the present study.

Notwithstanding the poor performance of NCS-005 relative to NCS-002 and NCS-001, it is nonetheless preferred to Bida local as a chewing cane since the growth characteristics of the latter were highly disappointing in the present environment. Varieties NCS-005 and Bida local cannot, therefore, be considered as commercially viable sugar cane for cultivation in the present environment investigated.

CONCLUSION

Of the four sugarcane varieties tested, variety NCS-002 had higher growth indices and together with NCS-001 as second in the ranking, the two varieties may be considered as choice candidates for cultivation as industrial canes at the site. Variety NCS 005 was the third-best in several growth parameters even though scantily. Since Variety NCS 005 is both an industrial and a chewing cane, it may be cultivated as a chewing cane for reasons that Bida local which is a typical local chewing cane did not perform appreciably well and may, therefore, not fit for cultivation in the study area.

The study has shown unequivocally that sugar cane crop particularly NCS-002, NCS-001 and perhaps NCS-005can be established and grown to maturity in the unmodified mangrove forest ecosystem investigated in the present report.

RECOMMENDATIONS

It is recommended that further trials be conducted using supportive or ameliorative management practices such as manure, fertilizer and lime application among others to bring about improvement in the fertility level and soil productivity in the mangrove forestlands of Ogonokom-Abua, Rivers State and, possibly, other mangrove ecosystems in the Niger Delta.

SIGNIFICANT STATEMENT

The study has shown unequivocally that sugar cane crop particularly NCS-002, NCS-001 and perhaps NCS-005 can be established and grown to maturity in the unmodified mangrove forest ecosystem investigated in the present report.

Further trials are to be conducted using supportive or ameliorative management practices such as manure, fertilizer and lime application among others to bring about improvement in the fertility level and soil productivity in the mangrove forestlands of Ogonokom-Abua, Rivers State and, possibly, other mangrove ecosystems in the Niger Delta.

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