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Full Length Research Paper

Growth performance of bamboo in tobacco-growing regions in South Nyanza, Kenya

J. K. Kibwage[1]*, G. W. Netondo[1], A. J. Odondo[1], B. O. Oindo[1], G. M. Momanyi[1] and F. Jinhe[2]

[1]Maseno University, School of Environment and Earth Sciences, Tobacco Control Research Project Office, P. O. Box 333, Maseno, Kenya.
[2]International Network for Bamboo and Rattan (INBAR), P. O. Box 100102-86, Beijing, China.

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The study was carried out on 120 field experimentation sites where 2420 bamboo cuttings were planted under the same natural tobacco growing conditions in five different zones (that is, zone A = hillside/steep sloping farmland, B = hillside/gentle sloping farmland, C = flat farmland/not wetland/ riverbank, D = flat farmland/wetland and E = homestead) based on each farmer's preference during the short rain season between September and October 2006. The experiment comprised of 1210 giant bamboo (*Dendrocalamus giganteus*) and 1210 common bamboo (*Bambusa vulgaris*). Each cutting was planted in a cubical hole measuring 0.6 x 0.6 x 0.6 m. Each farmer was given 20 bamboo cuttings (that is, 10 each of giant bamboo and common bamboo). Out of the 20 cuttings planted, five clumps of each species were randomly selected and tagged for monitoring survival rates, number of culms, culm heights and culm diameter. Frequency tabulations were used to present the data. Both species of bamboo perform well in gentle slopes and flat farmlands but not on wetlands. A part from the wetlands, survival rates of *B. vulgaris* and *D. giganteus* were ranging between 69 and 94% respectively. *B. vulgaris* established faster and withstood water logging than *D. giganteus*. The findings show that the two species of bamboo can do well in soil and agro-climatic conditions similar to those of tobacco. To replace tobacco with bamboo in Kenya, this experiment needs to be replicated in the other 10 remaining tobacco-growing regions in the country. Capacity building will be very important through training and farmers empowerment in bamboo farming and processing.

Key words: Tobacco, bamboo, growth performance, Kenya.

INTRODUCTION

Kenya is one of the East African countries. Its' economy largely depends on agriculture and tourism. However, only 30% of the land is arable while 70% is semi- arid and this limits the range of agricultural activities. Most parts of the country have two main raining seasons (Long-March to May, and Short-October to November) which largely determine agricultural activities in the country.

Most agricultural activities in Kenya are subsistence oriented, although a number of small scale and large scale farms are commercial oriented and produce majority of the agricultural commodities for the market.

The main cash crops are tea, coffee, horticultural crops, pyrethrum and sugar cane. These are, however, grown in the high and medium potential areas where rainfall is more than 800 mm per year. In most of the medium and low potential areas, the main cash crops are cotton, tobacco and sisal. However, due to the collapse of cotton and sisal industries attributed to stiff competition from imports of cotton and sisal products, tobacco remains the main cash crop (Nyangito, 2000).

Kenya's tobacco production takes place in four main provinces, namely, Nyanza (Migori, Kuria, Suba and Homa Bay districts), Western (Bungoma, Busia, Teso and Mount Elgon districts), Central (Kirinyaga, Muranga, and Thika districts) and Eastern (Meru, Kitui and Machakos districts). However, 80% of the country's tobacco production comes from South Nyanza region (mainly in Kuria, Migori and Homa Bay districts) (GOK, 2002a, b, c, d; Ministry of Agriculture, 2004a, b, c, d).

*Corresponding author. E-mail: jkkibwage@yahoo.com. Tel.: +254 –57–351204/351620/2, Fax: +254 – 57 – 351221/351153.

Despite the global policies aimed at reducing world tobacco production and use, the Kenyan Government's poverty-reduction policies seem to encourage more tobacco production in tobacco growing regions. This is evidenced by the plans of the British American Tobacco Company Limited (BAT Ltd) to expand its activities to other districts such as Bondo and Siaya in central Nyanza, Borabu in Kisii area, Bomet, Transmara and Narok south in Rift valley province. The emergence of Stancom Company Ltd and Alliance One Company Ltd also indicate continued tobacco production activities in the region (Kibwage et al., 2008a; 2007a, b).

The number of farmers contracted by the tobacco companies in Kenya increased by 67% in the period of 1972 to 1991, 36% from 1991 to 2000 and about 15% from 2001 - 2005. This directly translated to increased land acreage under tobacco at the expense of food crops. Traditional crops such as cassava, millet and sweet potatoes are scarce in the region since farmers devote most of the time on tobacco production (Ministry of Agriculture, 2004a, b, c, d).

Bamboo is a fast growing plant reaching its full height in two to four months, with a simple production process. It is a very valuable plant with diverse applications which include construction, furniture, handicrafts, baskets, human food, animal fodder, paper, wood fuel and bio-remediation (Kibwage et al., 2008b; Karina, 2006; UNIDO, 2006; Madhab, 2003; Ongugo et al., 2000; Liese, 1998; Salleh, 1996).

This paper covers mainly growth parameters of bamboo; the major aim was to determine the possibility of growing bamboo as a long-term panacea to tobacco related problems in the South Nyanza region. Such problems include; high demand for wood fuel, environmental degradation, low incomes and poverty, health problems due to lack of protective devices and high child labour during harvesting and curing periods (Asila, 2004; Shoba and Vaite, 2002; Kweyuh, 1997). Tobacco industry in South Nyanza is responsible for most of the occupational and environmental hazards. About 60% of medical cases in Kuria district are attributed to tobacco production and processing (Kibwage et al., 2005). The wood curing process of tobacco demands intense use of wood-fuel, hence a lot of indigenous trees are felled for that purpose, causing deforestation, acceleration of soil erosion and loss of biodiversity (Fernandez, 2003). Environmental pollution emanating from poor disposal of wastes (expired fertilizers, chemicals, uncollected tobacco) by the tobacco companies is also quite high (Kibwage et al., 2007c).

The Kenyan Government policy encourages crop diversification as a long-term solution. The World Health Organization (WHO) and Framework Convention on Tobacco Control (FCTC) also strongly recommended exploration of possible viable alternative crops to tobacco (Keyser, 2007; Vinayak, 2007; WHO, 2006, 2007). In India, tobacco farmers have been moving into other industries like bamboo furniture making, leaf plate making, and crockery manufacture due to tobacco related issues such as malnutrition, rising debts, family tensions and break-up of extended families (ILO, 2001). Panchamukhi (2000) and Ochola and Kosura (2007) also pointed out the need for field experimentation of possible alternative crops to tobacco production in the tobacco growing zones of Kenya. The objective of this study was, therefore, to study the growth performance of bamboo as an alternative crop to tobacco in the tobacco-growing regions.

MATERIALS AND METHODS

Study area

The study was carried out in South Nyanza region, which encompasses Kuria, Migori, Homa Bay and Suba districts (Figure 1).

The area is located in south western Kenya, along Lake Victoria region, and covers an area of about 7,778 km^2 (5,714 km^2 land area and 2,064 km^2 water), which is 48% of the land area of Nyanza Province (GOK, 1989). It also has a variety of soils and climatic characteristics. Secondary data from the Ministry of Agriculture and nearby weather stations were used to obtain information on the types of soils, their characteristics and climatic conditions in the four sites (Table 1).

Research design

To conduct this study, a research proposal was developed in consultations with 120 farmers (80 tobacco and 40 non-tobacco) in the region and formed four formally registered community-based bamboo farmers groups each with 30 farmers [that is, Migori Bamboo (Modi) Farmers Group, Kuria Bamboo (Imiere) Farmers Group, Homa Bay Bamboo (Modi) Farmers Group and Suba Bamboo (Modi) Farmers Group]. The consultations were meant to build bamboo research partnerships and participation by farmers interested in tobacco production control. Moreover, consultations helped to identify research and action points of entry. Field trips and trainings were also conducted to equip farmers with basic skills on bamboo cultivation, land preparation, bamboo farm inputs and general care of cuttings through field demonstrations as well as improving participatory project monitoring and evaluation.

Set-up of field bamboo experimentation sites (farms)

The research team collaborated with the Ministry of Agriculture and identified 120 field experimentation sites (that is, 30 in Kuria, 30 in Migori, 30 in Homa Bay, and 30 in Suba). The criteria used in the selection of farmers included: whether or not one was a tobacco farmer, gender, age, poverty status, farming scale, access to water and the willingness to provide land for the bamboo experimentation. A total of 2,420 sympodial type of bamboo cuttings (that is, *Dendrocalamus giganteus* -1210 and *Bambusa vulgaris*- 1210) were selected based on their readiness for planting (Table 2). The sympodial type of bamboo was selected because of its smoothness and high resistance to wear. Its commercial value is higher than monopodial type of bamboo. The sympodial bamboo propagates itself as a clump, sending up shoots from around its circumference and gradually spreads across the ground unlike monopodial that sends out runners in all directions, sending up shoots wherever conditions are favourable and cover a wider space. This means that sympodial bamboo is more economical in terms of land utilization.

Each cutting was planted in a cubical hole measuring 0.6 x 0.6 x 0.6 m. Spacing between two-bamboo cuttings was 5 m. The cuttings were sourced from Githumbuini estate in Thika district, loca-

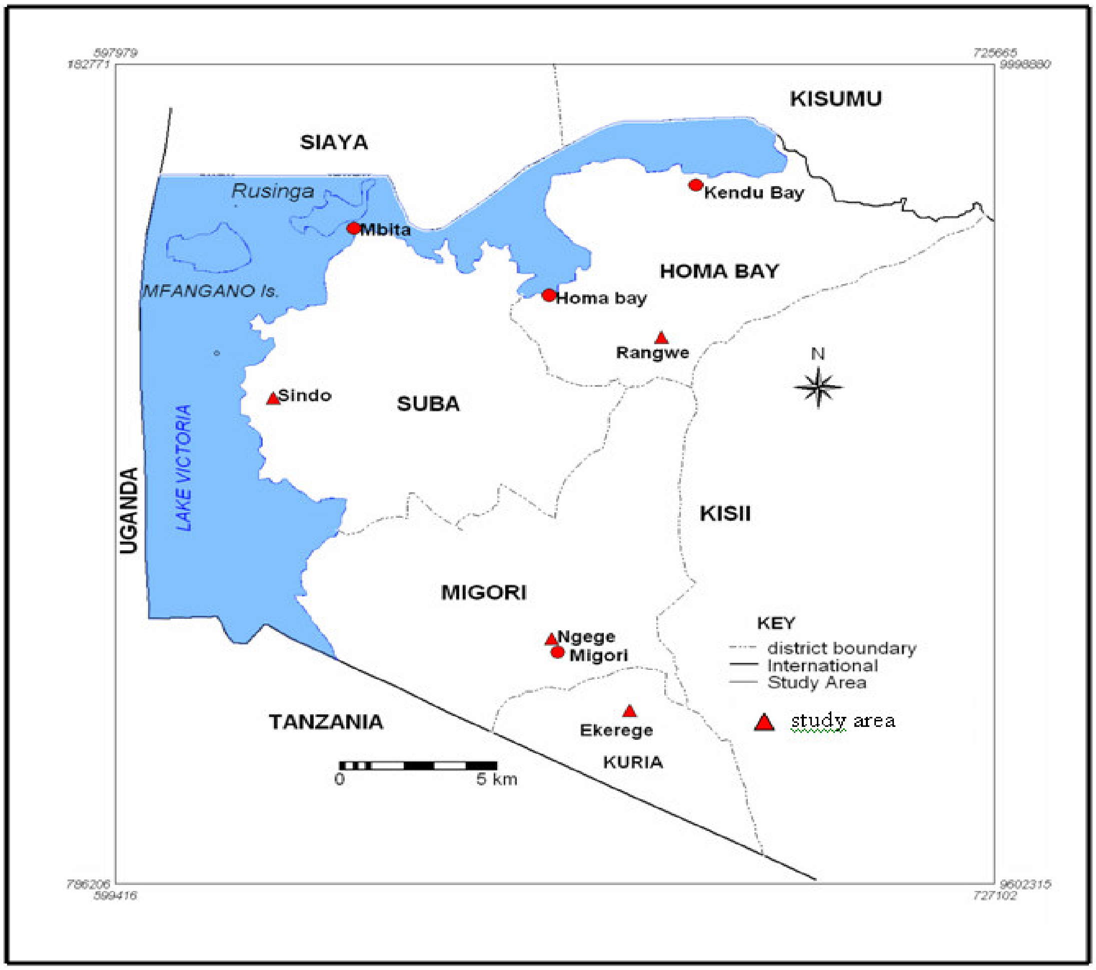

Figure 1. Study Sites.
Source: GOK, 1989.

Table 1. Soil and climatic characteristics of the four study sites in South Nyanza, Kenya.

Sites characteristics	Climatic characteristics	General soil
Kuria (Ekerege)	Altitude: 1,400 – 1887 m above sea level Mean annual rainfall: 1500 – 2600 mm Mean annual temperature: 27 - 31°C	Silty clays and loams soils. Sandy soil with humus and rock out crops are common.
Migori (Ngege)	Altitude: 1150 – 1700 m above sea level Mean annual temperature: 25 – 33°C Mean annual rainfall: 900 - 1800 mm	Deep loamy to sandy soils and Murrum soils which have relatively good water holding capacity with minimum water logging.
Homa Bay (Rangwe)	Altitude:1163 – 1219 m above sea level Mean annual rainfall: 500 - 1000 mm Mean annual temperature: 17.1 - 34.8°C	Sandy loam soils and Black cotton soils in most parts of the district
Suba (Sindo)	Altitude: 1,125 - 2,275 m above sea level Mean annual rainfall: 600 – 1200 mm with 60% reliability. Mean annual temperature ranges from 22 - 30°C)	Soils range from lower volcanic to moderate fertile soils. Black cotton soils are dominant in most parts of the district.

Source: GOK, 1989, 1997, 2002a, 2002b, 2002c, 2002d.

Table 2. Number of bamboo cuttings in different zones at different planting sites

Zones	A		B		C		D		E		Total
Species	Bv	Dg	Bv	Dg	Bv	Dg	Bv	Dg	Bv	Dg	
Kuria	10	10	50	50	60	60	140	140	40	40	600
Migori	30	30	130	130	40	40	20	20	80	80	600
Homa Bay	20	20	220	220	40	40	10	10	20	20	620
Suba	40	40	210	210	30	30	20	20	-	-	600
Total	100	100	610	610	170	170	190	190	140	140	2420

Key: Bv: Bambusa vulgaris; Dg: Dendrocalamus giganteus
Zone A = hillside/steep sloping farmland, Zone B = hillside/gentle sloping farmland, Zone C = flat farmland/river bank/not wetland, Zone D = flat farmland/wetland and Zone E = homestead.

Table 3. Number of farmers who planted bamboo cuttings in different zones

Sites	Planting zones					
	A	B	C	D	E	Total
Kuria	1	5	6	14	4	30
Migori	3	13	4	2	8	30
Homa Bay	2	22	4	1	1	30
Suba	4	21	3	2	-	30
Total	10	61	17	19	13	120

Key: Zone A= hillside/steep sloping farmland, Zone B= hillside/gentle sloping farmland, Zone C= flat farmland / river bank/not wetland, Zone D= flat farmland/wetland and Zone E= homestead.

Figure 2. *Dendrocalamus giganteus* (giant).

Figure 3. *Bambusa vulgaris* (common bamboo) tagged.

ted 40 km north east of Nairobi city of Kenya. Planting of the cuttings in the four study sites were undertaken during the short rain season of September - December, 2006. Compost manure was applied to promote prolific growth of the cuttings. Intercropping with kales and legumes such as beans and cowpeas was also done to minimize losses that the farmers would incur during the growth cycle of bamboo since bamboo takes 3 - 5 years to mature.

The cuttings were planted on the farms as per individual farmer's preferences in any of the following five zones with variable terrain characteristics: Zone A = hillside/steep sloping farmland, Zone B = hillside/gentle sloping farmland, Zone C = flat farmland/river bank/not wetland, Zone D = flat farmland/wetland and Zone E = homestead (Table 3). Zone E was actually the same as Zone B and C in terms of topography, but it was intentionally separated to assess human factor in the management of bamboo farms.

Assessments of the bamboo performance parameters were carried out at an interval of 3 months from the time of planting. To reduce sampling errors thereby enhancing sampling precision, 50% of bamboo clumps were randomly selected. The selected clumps were tagged with codes indicating the district (site), farmer's number, species and the number of clump selected for easy identification and monitoring (Figures 2 and 3).

Hence, 5 plants of each species were selected from the average 20 planted by each farmer for the general performance monitoring. The farmers had also been trained on how to maintain the experimental plots through regular weeding around the clumps, mulching and slashing within and around the plots. The parameters assessed included:-

Table 4. Average survival rates of *Dendrocalamus giganteus* and *Bambusa vulgaris* per zone and site.

Zones Sites	*D. ganteus* (%)						B. *vulgaris* (%)					
	A	B	C	D	E	Average	A	B	C	D	E	Average
Kuria	-	37	63	45	70	54		86	98	98	85	92
Migori	81	80	55	47	76	68	87	93	87	90	95	90
Homa Bay	60	74	96	70	90	78	95	94	95	100	100	97
Suba	-	86	69	90	-	82	90	97	97	100		96
Average	**71**	**69**	**71**	**63**	**79**	**70**	**91**	**93**	**94**	**97**	**93**	**94**

Zone A = hillside/steep sloping farmland, Zone B= hillside/gentle sloping farmland, Zone C = flat farmland / river bank/not wetland, Zone D = flat farmland/wetland and Zone E = homestead.

Table 5. The ratios of *Dendrocalamus giganteus* and *Bambusa vulgaris* culms to clumps in different zones

Zone	*D. giganteus*	*B. vulgaris*
A	1.7	2.3
B	2.3	2.5
C	2.7	2.6
D	2.5	3.1
E	3.4	3.4

Zone A = hillside/steep sloping farmland, Zone B = hillside/gentle sloping farmland, Zone C = flat farmland / river bank/not wetland, Zone D = flat farmland/wetland and Zone E = homestead.

Table 6. The ratios of *Dendrocalamus giganteus* and *Bambusa vulgaris* species culms to clumps in different sites

Sites	*D. giganteus*	*B.vulgaris*
Kuria	2.5	2.1
Migori	2.8	2.8
Homa Bay	2.3	2.8
Suba	2.3	2.6

Zone A = hillside/steep sloping farmland, Zone B = hillside/gentle sloping farmland, Zone C = flat farmland / river bank/not wetland, Zone D = flat farmland/wetland and Zone E = homestead.

Survival rates

The survival rate was calculated by counting the number of surviving clumps in every farm after six months of planting the bamboo cuttings.

Number of culms

Culms in the tagged clumps were counted and recorded. This was done at an interval of three months starting from the planting date to ascertain the rate of culm development.

Culm height

In the third month after planting bamboo cuttings of the two species, ten clumps (that is, *D. giganteus*-5 and *B. Vulgaris*-5) were systematically randomly selected from each farm. Subsequently, three dominant culms were selected from each of the five selected clumps and tagged. The culms were marked and the height of each measured from the ground level to the top of its apical bud using a Suunto height meter, tape measure or a tall straight pole marked in meters. Bent stems were straightened so that the actual length of the stem could be measured.

Culm diameter

Twelve months after planting bamboo cuttings of the two species, the diameter of each of the selected bamboo culms was measured using a diameter tape. .

Data analysis

Descriptive statistics were used in the analysis. Frequency tabulation was used to present the analyzed information.

RESULTS

Growth performance of *D. giganteus* and *B. vulgaris*

Bamboo survival rates: Table 4 shows that the mean survival rate for *B. vulgaris* species in the four sites was 94% while that for *D. giganteus* was 70%. Generally, *B. vulgaris* species has a higher survival rate as compared to the *D. giganteus*. At least 90% of *B. vulgaris* cuttings survived in all the four sites. Survival rate was highest (97%) in Homa bay district, followed by Suba district (96%). Kuria and Migori districts had 92 and 90% respectively. In the case of giant species, Suba district was leading with 82% followed by Homa bay district (78%). Migori and Kuria districts had 68 and 54% respectively.

Bamboo culms: Table 5 shows that the ratios of *D. giganteus* and *B. vulgaris* culms to their existing clumps is highest in the homesteads (Zone E) most of which were situated in gentle sloping terrains. Furthermore, performance of the two species (*B. vulgaris* and *D. giganteus*) seems to be equal as shown by the 3.4 ratio in both cases. *B. vulgaris* seem to perform better than *D. giganteus* in the wetlands (Zone D), a scenario which suggests that it can withstand water logging than *D. giganteus*. Apart from flat land/not wetland or riverbank

Table 7. Maximum and Mean heights of three *Dendrocalamus giganteus* and *Bambusa vulgaris* species culms per clump in every site.

Site	*D. giganteus*		*B. vulgaris*	
	Maximum Height (m)	Mean Height (m)	Maximum Height (m)	Mean Height (m)
Kuria	5.6	3.1	4.7	2.6
Migori	6.4	3.2	5.6	3.1
Homa Bay	7.0	3.8	6.6	3.5
Suba	6.6	3.4	5.2	3.3

Table 8. Height categories of three dominant *Dendrocalamus giganteus* and *Bambusa vulgaris* culms per clump in every zone.

Height Category (m)	*D. giganteus*					*B. vulgaris*				
	A	B	C	D	E	A	B	C	D	E
Below 1	0	0	0	0	0	0	5	0	2	2
1.00 - 1.99	0	36	13	3	11	3	87	9	9	10
2.00 - 2.99	15	132	22	8	40	17	138	28	17	35
3.00 - 3.99	12	143	23	25	33	25	156	31	11	37
4.00 – 4.99	7	121	21	16	16	10	99	38	20	30
5.00 – 5.99	11	31	11	5	7	6	25	3	0	4
6.00 – 6.99	0	17	4	0	0	0	3	0	0	0
≥7.00	0	1	0	0	0	0	0	0	0	0

Zone A = hillside/steep sloping farmland, Zone B = hillside/gentle sloping farmland, Zone C = flat farmland / river bank/not wetland, Zone D = flat farmland/wetland and Zone E = homestead.

Table 9. Heights of *Dendrocalamus giganteus* and *Bambusa vulgaris* culms in the first 12 months after planting.

Height category (m)	*D. giganteus*	*B. vulgaris*
Below 1	0	15
1.00 - 1.99	72	145
2.00 - 2.99	235	315
3.00 - 3.99	252	315
4.00 – 4.99	186	238
5.00 – 5.99	68	39
6.00 – 6.99	23	3
≥7.00	1	0

(zone C) and homesteads (Zone E), *B. vulgaris* species seem to perform better than *D. giganteus* in the rest of the Zones (A, B and D).

Table 6 shows that in Migori district, *D. giganteus* and *B. vulgaris* had equal culm to clump ratios of 2.8. In Homabay and Suba districts, the culm to clump ratios in the case of *B. vulgaris* were higher than those of *D. giganteus*. *B. vulgaris* had a ratio of 2.8 in Homa bay district and 2.6 in Suba district, while *D. giganteus* had a ratio of 2.3 in each case.

Bamboo culm height: Table 7 shows that the maximum height for *D. giganteus* culm was 7.0 m in Homa bay, 6.6 m in Suba, 6.4 m in Migori and 5.6 m in Kuria districts. On an average, the giant bamboo species in Homa bay district were the tallest (3.8 m) followed by Suba district 3.4 m. Migori and Kuria districts had 3.2 and 3.1 respectively.

The maximum height (6.6 m) of *B. vulgaris* was in Homa bay district followed by Migori district (5.6 m). Suba and Kuria districts had 5.2 and 4.7 m respectively. On an average, the *B. vulgaris* in Homa bay district had the highest height (3.5 m), followed closely by those of Suba and Migori districts which had 3.3 and 3.1 m respectively. Kuria district bamboo had the least average height of 2.6 m.

Table 8 shows that zone B had the highest number of *D. giganteus* and *B. vulgaris* culms in every height category. The zone had a total of 143 giant bamboo culms and 156 *B. vulgaris* culms with heights falling between 3.00 - 3.99 m. Zone E had 33 while C and D had 23 and 25 *D. giganteus* bamboo culms in the same height category respectively. Unlike the other zones, zone B and C had the tallest *D. giganteus* culms in the height category of 6.00 – 6.99 m. The tallest (≥ 7 m) *D. giganteus* culm was also found in Zone B.

Table 9 shows that most (252) of the *D. giganteus,*culms had their heights falling between 3.00 - 3.99 m in the first 12 months after planting. The number of *D. giganteus* culms falling in the categories 1.00 - 1.99 m, 2.00 - 2.99 m, 4.00 – 4.99 m, 5.00 - 5.99 m, 6.00 - 6.99 m

Table 10. Maximum and mean culm diameters of *Dendrocalamus giganteus* and *Bambusa vulgaris* per site in the first 12 months after planting

Site	*D. giganteus*		*B. vulgaris*	
	Maximum Diameter (cm)	Mean Diameter (cm)	Maximum Diameter (cm)	Mean Diameter (cm)
Kuria	4.6	2.0	3.2	1.5
Migori	5.6	2.0	4.8	1.8
Homa Bay	6.2	2.3	5.5	2.2
Suba	5.2	2.3	4.1	2.1

Table 11. Maximum and mean culm diameters of *Dendrocalamus giganteus* and *Bambusa vulgaris* per zone.

Zone	*D. giganteus*		*B. vulgaris*	
	Maximum Diameter (cm)	Mean Diameter (cm)	Maximum Diameter (cm)	Mean Diameter (cm)
A	5.2	2.2	3.9	2.2
B	6.2	2.2	5.5	2.0
C	5.2	2.4	4.1	2.2
D	4.5	2.4	3.7	2.1
E	5.5	2.0	4.0	1.8

Zone A = hillside/steep sloping farmland, Zone B = hillside/gentle sloping farmland, Zone C = flat farmland / river bank/not wetland, Zone D = flat farmland/wetland and Zone E = homestead.

and ≥7.00 m were 72, 235, 186, 68, 23 and 1 respectively. Unlike *D. giganteus*, 15 culms of *B. vulgaris* had their heights falling below 1 m. Height categories of 2.00 - 2.99 m and 3.00 - 3.99 m had equal (315) number of *B. vulgaris* culms. Height category 1.00 - 1.99 m had 145 *B. vulgaris* culms while category 4.00 – 4.99 m had 238. Category 6.00 – 6.99 m had 3 *B. vulgaris* culms.

Bamboo culm diameter: Table 10 shows that Homa bay district had the highest culm diameter (6.2 cm) of *D. giganteus* and 5.5 cm of *B. vulgaris*. It was followed by Migori district which had 5.6 cm in the case of *D. giganteus* and 4.8 cm in the case of *B. vulgaris*. Suba district had 5.2 cm for *D. giganteus* and 4.1 cm for *B. vulgaris*. The least diameters in both cases were recorded in Kuria district where *D. giganteus* had 4.6 cm and *B. vulgaris* having 3.2 cm. On an average *D. giganteus* had a diameter of 2.3 and 2.0 cm in both Homa bay and Suba districts and Migori and Kuria districts, respectively. Contrarily, *B. vulgaris* in Homa bay district had a diameter mean of 2.2 cm followed by those of Suba district (2.1 cm), Migori district (1.8 cm) and lastly Kuria district (1.5 cm).

Table 11 shows that *D. giganteus* had the maximum (6.2 cm) culm diameters in zone B, 5.5 cm in *B. vulgaris* in Migori and Kuria districts. Zone E is the second after B with 5.5 cm in *D. giganteus* but appears the third with 4.0 cm after zone C which had 4.1 cm in *B. vulgaris*. Zones A and C had equal (5.2 cm) maximum diameters of *D. giganteus* while zone D was the least with 4.5 cm. Zones A and D each had 3.9 and 3.7 cm of *B. vulgaris* diameters respectively. Considering the mean diameters, zones C, D each had 2.4 cm while zones A, and B had 2.2 cm each for the *D. giganteus*. Zone E had 2.0 cm. In *B. vulgaris*, Zones A and C had 2.2 cm diameter each while D had 2.1 cm. Zones B and E each had a mean diameter of 2.0 and 1.8 cm respectively.

DISCUSSION

Survival rates of the two species of bamboo were more than 70%, indicating that the two species of bamboo can survive in most of the existing soil and climatic conditions of South Nyanza region of Kenya. The average survival rates of *B. vulgaris* and *D. giganteus* were 94 and 70% respectively (Table 4). This variation may be ascribed to the site differences whereby some farmers especially in Kuria district preferred the wetland areas, which were not favourable for the survival of *D. giganteus* (Table 3). The study revealed that most of the *D. giganteus* that survived in Kuria district were planted on well drained soils and anthills. Such plants grew taller than others in the same district and had almost the same heights with other *D. giganteus* in non-water logged areas of Homa Bay, Suba and Migori districts. In Homa Bay, Suba and Migori districts, most of the cuttings were planted on the hill side/gentle sloping farmland and homesteads (Table 2).

The high survival rate of bamboo in those zones suggests that bamboo generally survives better in non-waterlogged areas similar to tobacco farms. Apart from water logging, a few cases of inter-cropping with un-recommended crops (like maize and sorghum), weeds, damaged by termites, domestic and wild animals also affected the overall bamboo growth performance.

Table 4 shows that survival rates of *B. vulgaris* and *D. giganteus* are higher in Homa Bay and Suba districts. Seemingly, moderate mean annual temperature (26°C) in these districts (Table 1) favours low evaporation leading to moist soils that promote growth of the two species of bamboo. This observation is in agreement with NMBA (2004) and Kigomo et al. (1995) who concluded that both *B. vulgaris* and *D. giganteus* prefer moist soils. Fernandez (2003) also concurred that adequate soil moisture content largely promote vegetative growth of bamboo. In addition, black cotton soils that are in most parts of Homa Bay and Suba districts (Table 1) seem to favour fast growth of the two species of bamboo. Moreover, moderate mean annual temperature (26°C), moderate mean annual rainfall (750 – 900 mm) and moist fertile soils (Table 1), are likely explanations for the high mean culm heights and culm diameters in Homa Bay and Suba districts (Tables 7 and 10).

According to GOK (1997), gentle hill slopes are suitable for tobacco production. This study has demonstrated that even the two species of bamboo can survive and grow well in gentle sloping farmlands and homesteads (Tables 4, 5, 8 and 11). This is indicated by the highest number of culms and culm heights. Most of the homesteads were situated in gentle slopes and flat lands but not wetlands. This suggests that *B. vulgaris* and *D. giganteus* grow faster on gentle sloping land, especially in zone B than in the other zones. The bamboo culms to clump ratio indicates that both *D. giganteus* and *B. vulgaris* produce the largest number of culms per clump at the homestead. Therefore from the growth performance point of view, the two species of bamboo can be substitutes of tobacco in the south Nyanza region. Continued monitoring is important since this would be helpful in guiding the farmers on the rate of harvesting mature culms to avoid depletion of the plantations.

Conclusion

Both *D. giganteus and B. vulgaris* can do well in the tobacco growing zones of south Nyanza, Kenya. Performance of the two species of bamboo is best realized on the gentle sloping farm lands. However, it has been demonstrated that water logging negatively affects the survival and growth of bamboo cuttings, particularly the giant species. Higher bamboo production performance rates can be achieved if water logging, accessibility by animals to the bamboo farms, inter-cropping with un-recommended crops (like maize and sorghum), weeds, damage by termites, and domestic and wild animals can be controlled.

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