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Full Length Research Paper

Using bamboo *(Bambusa vulgaris)* as a field drainage material in Nigeria

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Bamboo *(Bambusa vulgaris),* one of the most widespread member of its genus, was used as field drainage material in Akure, Nigeria. Pre-determined sizes of bamboo with uniform lengths and diameters were installed as sub-drains in agricultural field for drainage purposes, especially in developing countries like Nigeria. Soil properties such as the moisture content, bulk density, specific gravity and classification were determined. Though, with low efficiency, R-value ~0.2, the use of bamboo for agricultural land drainage looks promising. Further work on variations in drain holes diameter, slope, envelope materials and treatment of bamboo to increase its efficiency and also prolong its lifespan would be considered. Finally, it was concluded that the use of bamboo has enormous potential for alleviating many environmental problems facing the world today.

Key words: Bamboo, drain outflow, drainage, outflow rate.

INTRODUCTION

Bamboo *(Bambusa vulgaris)* is a group of plants that belong taxonomically to the sub-family of *Bambusoideae* under the family of *Gramineae* (Ohrnberger, 1999; Li and Kobayashi, 2004). Bamboo is a sustainable natural resource in many countries of the world. It prefers lowland humid habitats, but tolerates a wide range of climatic conditions and soil types (United Nations, 1972). It commonly naturalises, forming monospecific stands along river banks, roadsides and open ground (Sthapit and Tennyson, 1991). A culm can reach its full maturity in a matter of two to three months which make it one of the fastest growing, highest yielding renewable natural resources (Lessard and Chouinard, 1980; United Nations, 1972). Bamboo is used for construction of houses, huts, boats, fences, props and furniture; as raw material for paper pulp; planted as ornamental or boundary marker; used to support banana plants; split stems used for brooms, baskets (Ohrnberger, 1999). In rural Tanzania, a bamboo pipe network is being used for providing safe and constant water supply to a large rural population (Lipangile, 1991).

Drainage is the removal by artificial means of excess water (surface and subsurface) from the soil or land surface to make the land more suitable for use by man (Van Schilfgaarde, 1971). Drainpipes have been made from wood boards or box drains, bricks, and horseshoe shaped ceramic tile, circular clay tile, concrete tile, bituminized fibre perforated pipe, perforated smooth plastic pipe to corrugated plastic pipe. Currently, corrugated pipes are frequently used, although clay and concrete pipes are still being used as well. The use of drainage pipes made of various assorted materials is very common in our markets (Ami, 1987). These materials are very expensive, not readily available, require a high degree of maintenance, and pollute water which they convey due to the pipe's constituents (Singh et al., 2009). In the light of these shortcomings, bamboo pipes which serve as low cost substitute are used. In this study, an attempt was made by using Bamboo of pre-determined lengths and diameters as field drainage material in Akure, South-western part of Nigeria.

MATERIALS AND METHODS

The experiment was conducted at Akure, Ondo State, Nigeria.

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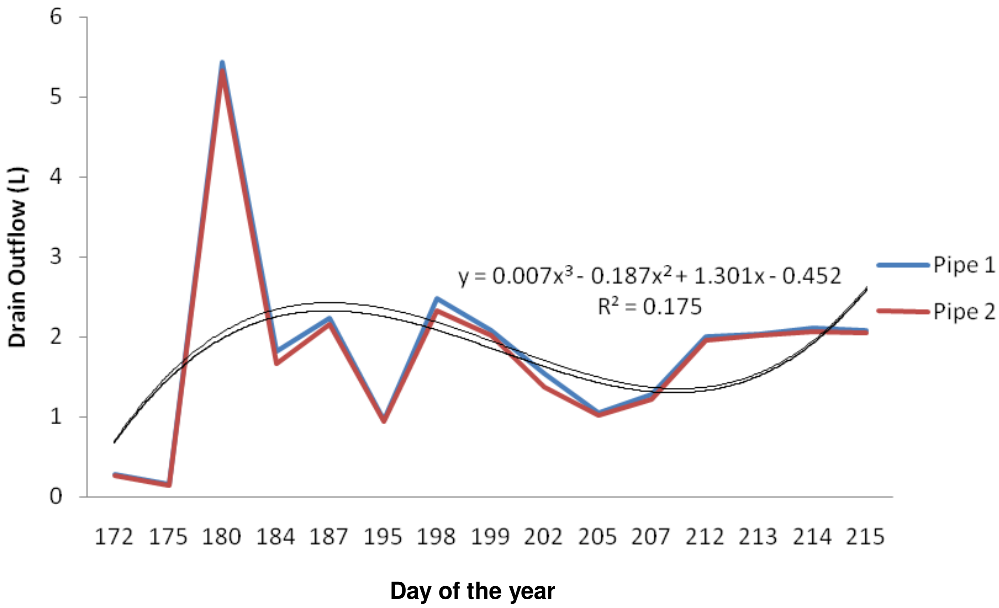

Figure 1. Response of the drain outflow of pipes 1 and 2 to rainfall.

Akure is located within the humid region on latitude 9° 17'N and 5° 18'E. It lies in the Rain Forest zone with a mean annual rainfall of between 1300 to1600 mm and with an average temperature of 27.5°C. The relative humidity ranges between 85 and 100% during the rainy season and less than 60% during the harmattan period. It is about 351 m above the sea level. The major occupations of the people in this area are farming and business (Akinbile, 2006). For this research, soil classification using the United States Department of Agriculture (USDA) textural triangle was carried out to determine some of soil parameters such as the percentage composition of silt, clay and loam, moisture content, bulk density and specific gravity. Also, a set of bamboo pipes with uniform lengths and diameters were selected and cut into 2 m lengths. The septa at the nodes were removed from each of the 2 m long pipes by boring through with a sharp-ended iron rod. 6 mm diameter holes were drilled in the pipe at 5 cm spacing on a line along the length of the pipe. Four of such lines of holes were drilled evenly spaced around each pipe. Two parallel drains, 10 m long were installed across the slope in a sloping land at a drain spacing of 10 m. The distance from the upper drain to the crest of the slope was not measured, but the crest was a long distance away and completely outside the experimental farm. The depth of the drain was 0.5 m and the slope was 0.2%. Crushed stones, approximately 6.5 mm in diameter were used as envelope materials. These were used to prevent the movement of soil particles in the vicinity of drainage holes, which often leads to the blockage of pipe. This was to achieve a reduction in head loss at entry, reduce the velocity of flow converging onto the entry point and thus achieve a substantial reduction of fine soil intrusion into drainage pipes. Crushed stones were chosen ahead of the other pipe envelope materials because they are cheap, readily available and do not deteriorate; unlike the other materials (Nwa, 1981). A series of groundwater tubes, 1 cm in diameter were installed to depths of about 1.0 m along a line perpendicular to and across the middle of the drain lines to determine the depth of water table below the ground surface. The outflow from the drains was measured after each rainfall event and the depth of the water table below the ground surface was also measured in the groundwater tubes a day or two after each rainfall event.

RESULTS AND DISCUSSION

Soil classification

The soil classification was sandy clay loam (57.55% sand, 18.85% silt and 23.60% clay). The soil moisture content, bulk density and specific gravity during the period of the experiment was found to be 17.00% (dry basis), 1.43 and 2.57 g/cm^3 respectively. This inferred that the soil has high permeability rate to allow easy flow of water through its profile and with a combined value of over 75% of both sand and silt. This indicated that relatively high movement of sediment within the profile was also possible which may be responsible for blockage of the pores of the Bamboo if appropriate envelope material was not used. The moisture content of 17% (db), bulk density of 1.43 g/cm^3 and specific gravity of 2.57 showed that the soil could pose serious problem for the efficient use of Bamboo as a field drainage material due to the mobile nature of the soil but an excellent one for agricultural (cropping) purposes due to its high water retention capability and other associated purposes.

Bamboo performance in drain discharge measurement

The response of the drain outflow rate of pipes 1 and 2 to rainfall is as shown in Figure 1. The maximum drain outflow was 5.44 L, while the minimum drain outflow was 0.16 L for pipe 1. Similarly, the maximum drain outflow was 5.32 L, while the minimum drain out flow was 0.14 L for pipe 2. It would be noted that the maximum drain outflow for both pipes was obtained on June 29 (180th day of the year), while the minimum drain outflow for both pipes was obtained on June 24 (175th day of the year). Also, the drain outflow from pipe 1 was greater than that of pipe 2. This was because pipe 1 was laid in the ground surface with higher degree of slope when compared with the surface where pipe 2 was laid. The total drain outflows during the period of the experiment were 27.61 and 26.51 L for pipes 1 and 2 respectively, while the total drain outflow rates during the period of the experiment were 1.50 and 1.461L/min for pipes 1 and 2 respectively. A total drain outflow rate of 2.96 L/min was obtained during the period of the experiment. This was considered to be low. Nwa, (1981) conducted a similar experiment in Zaria and obtained a maximum drain outflow rate of 32 L/min between the end of July and September. Zaria lies in the Guinea Savannah with an average rainfall of between 1000 and 1500 mm while Akure lies in the Tropical rain Forest zone with an annual rainfall of between 1300 and 1600 mm (Ayinde, 1997; Iwena, 2000). Although there was a higher rainfall distribution pattern in the Tropical Rain Forest zone compared to the Guinea Savannah, Nwa's experimental site was seasonally waterlogged. His experiment also depended on a nearby stream which might have had its source from Rivers Hadejia, Katogum, Yobe and Ngadda which rise from the North Central Plateau and flow to the East as well as Rivers Sokoto, Rima, Zamfara, Kebbi, Kaduna, Kontagora and Yampere that flow westwards to the Niger. Also, it might have had its source from other smaller rivers like Mada, Gbako, Gurara, Wuse, Pai, Gongola, Hawai and Kilunga that flow southwards and either joined River Niger or Benue (Ayinde, 1997). These rivers drain the North Central Plateau (Iwena, 2000) in which Nwa's experimental site (Zaria) lies. This accounted for the high drain outflow rate he obtained, unlike this experiment that depended on rainfall only. Also, the position of the water table in Nwa's experimental site in Zaria was high which was responsible for the flooding of the site. The position of the water table in Akure is low, from previous studies Akinbile (2006) and this contributed to the low drain outflow rate. During the experiment, the rainfall was not sufficient to raise the low water table. The maximum amount of rainfall was 32.40 mm, obtained on the 29th of June (180th day of the year), while the minimum amount of rainfall was 12.35 mm, obtained on the 24th of June (175th day of the year). The nature of the soil also contributed to this. The soil contained a large proportion of pore spaces that ought to have been filled up with water and since these pore spaces were not filled up to capacity, super-saturation was not achieved and this made the water table not to rise. This was evident from the groundwater tubes that were installed between the drains. Low rainfall and the rainfall intervals were principally responsible for the observations. Rainfall was not continuous and consistent, and the days between successive rainfall events gave chance to various losses of water in the form of evaporation, transpiration and percolation. These losses caused the water table not to rise because the soil pore spaces were not filled to capacity and there was therefore no saturation. From the equation of the graph, the correlation coefficient is positive for the two drain pipes (R^2= 0.23). This implied that there was positive relationship between the drain outflow rate and the amount of rainfall, which also indicated that co-variability existed between these two quantities in the same direction. The values were low for the two drain pipes; these were due to the low rainfall observed during the period of the experiment. An increase in the amount of rainfall would naturally lead to a corresponding positive increase in the drain outflow rate and vice-versa. The low co-variability does not mean that the bamboo pipes were not effective. If the adequate conditions were available, that is, if the water table position had been high, the rainfall had been very high and the site was adequately waterlogged, the co-variability would have been high (Table 1).

On the overall, the use of bamboo (*B. vulgaris*) as a field drainage material was found effective. It could be satisfactorily used as an alternative to the various assorted materials that are very common in our markets to provide an advantage of cost, as well as easy transportation, handling and laying. Also, bamboo pipes do not contaminate the water being conveyed and do not react with the soil; unlike the other assorted materials, thus preventing the excessive cost of treating the water being conveyed for the various human and animal uses.

Conclusion

The strategies that could be used to achieve success in drainage schemes, especially in developing countries of the world like Nigeria lies in the use of easy-to-install and locally available materials that are very cheap. Results showed that a total drain outflow rate of 2.96 L/min was obtained for the period of the study. Maximum drain outflow rates of 0.24 and 0.23 L/min were obtained for pipes 1 and 2 respectively with 32.40 mm rainfall, while minimum drain outflow rates of 0.02 L/min were obtained for both pipes with 12.35 mm rainfall. The soil moisture content, bulk density and specific gravity during the period of the experiment was found to be 17.00% (dry basis), 1.43 g/cm^3 and 2.57 respectively. Making bamboo pipes have demonstrated that drainage projects could be executed in developing countries of the world without much hindrance. On the whole, findings of this study lead to the fact that bamboo can be effectively used as field drainage material in Akure, Nigeria. Variations in drain holes diameter, slope and envelope materials were

Table 1. Drain discharge measurement.

Day of the year	Date	Amount of rainfall (mm)	Duration of rainfall (min)	Drain outflow (Litres)		Drain outflow rate (Litres/min)	
				Pipe 1	Pipe 2	Pipe 1	Pipe 2
172	21-June	14.10	10.16	0.29	0.27	0.03	0.03
175	24-June	12.35	7.06	0.16	0.14	0.02	0.02
180	29-June	32.40	23.04	5.44	5.32	0.24	0.23
184	3-July	22.52	17.58	1.83	1.66	0.10	0.10
187	6-July	23.14	19.42	2.24	2.15	0.12	0.11
195	14-July	16.24	12.03	0.96	0.94	0.08	0.08
198	17-July	23.70	20.22	2.48	2.33	0.12	0.12
199	18-July	22.90	18.47	2.08	2.01	0.11	0.11
202	21-July	20.54	17.26	1.54	1.37	0.09	0.08
205	24-July	19.20	12.55	1.05	1.02	0.08	0.08
207	26-July	20.00	15.08	1.29	1.22	0.09	0.08
212	31-July	22.56	18.09	2.01	1.96	0.11	0.11
213	1-August	22.72	19.46	2.04	2.01	0.10	0.10
214	2-August	22.90	20.04	2.11	2.06	0.10	0.10
215	3-August	22.78	19.54	2.09	2.05	0.11	0.11
Total		318.05	250.00	27.61	26.51	1.50	1.46

suggested for further work, while research into treatment of bamboo to increase its efficiency and also prolong its lifespan must be given due consideration. Finally, the study must be carried out in other regions of the country with varying soil conditions and different rainfall distribution to determine its efficacy and durability under such conditions.Due to its biological characteristic and growth habits, bamboo is not only an ideal economic investment that can be utilized in many different manners but also has enormous potential for alleviating many environmental problems facing the world today.

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