

# Hydraulic Properties of Bamboo for Transmission of Water in Low Volume - Low Pressure Irrigation System for Small Scale Farmers

## ABSTRACT

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Modern microirrigation materials and equipment, used extensively in the United States and Europe, are expensive for many of Uganda's small-scale rural farmers. This study investigated the hydraulic properties of bamboo for both transmission and distribution of water in low volume - low pressure microirrigation schemes. An important, but future objective is to demonstrate the cost effectiveness of this technology to small-scale farmers and technology transfer agents by using materials locally available. Fresh bamboo stalks were cut, dried, and bored. Tests were conducted to measure the pressure drop across different lengths of bamboo pipe, and to evaluate friction loss. Bamboo lengths of 1, 2, 3, 4 and 5 m were evaluated. The mean inside diameter of the inflow end of the bamboo pipes was 4.86 mm, the mean at the outflow end was 5.10 mm, and the overall mean was 4.98 mm. Emitter openings of approximately 2.11 mm were installed on six selected bamboo pipes. The number of emitters per unit length was 1.0/m for the 5-, 4-, 3- and 2-m length pipes, and 1.5 and 2.0/m for two additional pipes of 2- and 1-m length, respectively. Tests were conducted to measure flow rates, and then calculate coefficients of discharge. With these properties known, emitters of various sizes and spacing could then be installed on other bamboo pipe, designed for specified flow rates and operating pressures. The mean values of the coefficient of friction and roughness size over 18 bamboo pipes tested were calculated to be 0.032 and 0.127 mm, respectively. Analysis of the Reynolds Number (mean =  $1.23 \times 10^4$ ) implies that flow through the bamboo pipe is transitionally turbulent. The mean values of flow rate per emitter and coefficient of discharge, over the six bamboo pipes with emitters, were 3.86 l/h and 0.023, respectively. These values were considered higher than desired, but acceptable based upon the lack of replication within each pipe length - emitter spacing treatment combination, and variation in installed emitter orifice sizes. Recommendations are being developed for small-scale farmers. A summary of these will be presented along with a cost comparison and operation and maintenance of a water distribution system using bamboo distribution pipe.

## INTRODUCTION

Agriculture in Uganda is practiced by 5% large-scale commercial farmers, 25% semi-commercial smallholder farmers and 70% subsistence farmers. Much of the agriculture in Uganda has remained highly subsistence and rain fed moreover there currently exists an erratic rainfall pattern all over the many parts of the country. The Agricultural practice is therefore predominantly a "low-intensity, low-input and low-output" system. Although the Plan for Modernization of Agriculture (PMA, 2000), which is part of Uganda government broader strategy of poverty eradication envisions the transformation of subsistence agriculture to a profitable, competitive, sustainable and dynamic agricultural sector, there still a long way to achieve this. Therefore even the current government efforts for poverty eradication ought to empower the small-scale farmers with appropriate small-scale irrigation technologies like micro irrigation, which offers many unique agronomic, water conservation and economic advantages in order to ensure food security

Wade (1989) stated that low-pressure irrigation methods like micro irrigation apply water more precisely to plants. The methods do not only increasing the yields but also improving irrigation efficiency of most horticultural, orchard and field crops by matching frequent low volume applications of water and dissolved fertilizer to the rate of uptake by the crop. As the applications are localized close to the plant root zone, losses through drainage or by wetting inter rows and canopies are minimized. The initial cost of micro irrigation equipment is considered to be its limitation to adoption by small-scale farmers. Water delivery and distribution system costs are part of the main initial costs. Therefore, this study was conducted in view of seeking to alleviate the problem of the high initial costs to small-scale farmers in Uganda given the available local material, bamboo. Bamboo micro irrigation system is an indigenous technique of irrigation, evolved and used by tribal farmers of Jaintia Hills district in Meghalaya, India. The system is used on steep hill slopes for irrigating betel leaf and black pepper crops planted with arecanut. Water delivery and distribution using bamboo is also not new to the rural setting of Uganda but its hydraulic properties

that affect the micro irrigation system efficiency need to be studied. The expected lifetime of preserved bamboos, in contact with the soil and not protected against weather influences, is 10-15 years (Purus 1953). However, once the bamboo micro irrigation system is installed most of the materials last 2 to 3 years except minor components, which decompose early such as the supports for the bamboo pipes (ICAR).

The bamboo species (*Arundinaria Alpina*) is commonly found in Uganda and particularly occupy the high altitude zone on Mount Elgon (2400m-3000m above sea level). It grows well in areas with a minimum annual rainfall of 1020 mm and temperatures between 9°C and 26°C. Apart from termites there is also a group of insects, the wet woodborers are attracted by bamboo with high moisture content. The chance for bacterial wood destruction of pipes is rather small in the saturated bamboo culm wall. A last threat for the bamboo pipes could be fungous deterioration. There is a probability of soft rot affection of the pipes because this fungus occurs under very wet conditions with sufficient oxygen (Bleijendaal, 1978; Cooling towers). Preservation of bamboo water pipes is done taking into account the non-contamination of water, cost of treatment and performance of the treatment on large scale. The suggestions for the protection of the pipes are divided into 2 groups

## METHODS AND MATERIALS

Materials used: Bamboo stalks of various lengths and diameters, Pump (3 bars, 550 rpm), Tractor engine of 2500 r.p.m., 2 Pressure gauges (0 -100 Psi and 0 - 200 Psi), Hose pipe of 6.0cm internal diameter, Reservoir (200 litres), Rubber bands/straps, Drill, Measuring cylinder, Vernier Calliper, Hack saw, Panga, Wood files, Stopwatch, Centre Punch, Nails of diameters 1.7mm, 2mm, 2.7mm., Tape measures, Vice, Twisted Iron rod, Centre Punch,

Boring of bamboo was the removal of the partition walls in the bamboo. the partition walls are a sponge like material which is much softer than the bamboo wall material.

Boring was accomplished by:-

The bamboo was held by a vice.

A twisted iron bar was pushed through the bamboo thereby breaking the partition walls. Fig.

4.2.7a & b.

For long bamboos

Fig. 4.2.7 a & Boring of bamboo

For long bamboo this was done by pushing the iron rod first from one end then removing it and pushing it in through the other end.

4.2.2 Cutting various sizes and sizing of diameter

The bored bamboos were cut into various sizes ranging from 1m to 5m using a hacksaw. the bamboos that had a diameter greater than that of the flexible hose pipe were reduced in diameter by use of a panga and then making a smooth finish with files. Others were not used because they were too big.

Internal Diameters of the bamboo were measured using vernier calliper at the entrance and exit of the pipe.

4.2.3. Fixing of Pressure Gauges

A node of bamboo was cut and a pressure gauge fixed on to it. The gauges were fixed by first drilling a hole in the bamboo and screwing in the pressure gauge. The gauge was tightly fitted by using rubber bands that were tied around it. To both sides of the bamboo node, pieces of the flexible hose pipe, were attached (also with the rubber bands) for attachment of the bamboo.

The node with the inlet pressure gauge, on one side was attached the outlet from the pump and onto the other end the bamboo was fixed (Fig. 4.2.3 (a))

The node with the outlet pressure gauge, on one side the outlet from the bamboo pipe was fixed and on the other side a flexible hose pipe of about 10m was attached. The hose pipe helps in recycling the water by returning it to the reservoir.

Fig. 4.2.3 (b) Making of a joint

All joints were made using rubber bands Fig. 4.2.3. (c). Illustrates making of the first joint i.e from pump to bamboo.

Fig. 4.2.3 (c) Making of a joint

#### 4.2.4 Pressure Testing

Pressure testing was done with a pump of 3 bars and 550 rpm. The pump was driven by tractor engine of 2500 rpm. A reservoir of 200 litres was used as the source of water. Fig. 4.2.1 (a) shows the pump and reservoir. Fig. 4.2.4. (b) shows the tractor engine. The whole assembly of the Engine. Pump and reservoir is shown in Fig. 4.2.4 (c).

Fig. 4.2.4 (a) The pump and reservoir.

4.2.4 (a) The tractor Engine.

Fig 4.2.4. (c) assembly of Engine pump and Reservoir

The engine was started and Engine adjusted to full speed. After the reading of the pressure gauges stabilised, readings were taken as shown in Fig. 4.2.4 (d)

Fig. 4.2.4. (d) Taking Pressure readings

The water that passed through the bamboo pipe were taken and bamboo pipe was recycled through the flexible hose pipe back to the reservoir Fig. 4.2.4 (e)

Fig. 4.2.4.(e) Recycling of Water

Readings for each bamboo pipe were taken and recorded as in (Table 4.2). A schematic drawing of the whole process of pressure testing is shown in Fig. 4.2.4.

Due to lack of the proper materials shown in

Fig 4. 2.4, improvisations had to be made so as to carry out the experiments. Examples of improvisations include rubber bands for adapters in making joints.

#### 4.2.4 Flow rate measurement

Flow rate measurement was done after measuring of the pressure drop across each bamboo pipe. The flexible hose pipe was removed and the volume of water being discharged through the bamboo pipe measured. A measuring can of 15 litres (Fig. 4.2.5) was used.

Fig.4.2.5 Measuring can

The time taken to fill 15 litres was recorded for each experiment. Two readings were taken and the average time for the 2 reading used as the time, T. Results were recorded in Table 4.2.4. As shown in Fig. 4.2.5 the measuring cylinder was just improvised also.

### 4.3. EMITTERS

#### 4.3.1 Emitter Installation

Emitters of various sizes were installed on the bamboo pipes at various spacings as shown in Table 4.3. The emitters were installed by:-

i) Marking off points for drilling using a centre punch and measuring tape to measure the spacing.

ii) Using nails to make the emitters of various sizes.

iii) Using a drill to clear the hard top cover of the bamboo.

Three sizes of nails were used for making the emitters. These were:-

1 inch nail with diameter of 1.7 mm.

- 1.5 inch nail with diameter of 2.0mm
- 2 inch nail with diameter of 2.7mm

#### 4.3.2 Flow rate measurement

After installing the emitters, the bamboo were fixed as before to the pump and the volume collected from each emitter measured using a proper measuring cylinder. The time for the volume was recorded as shown in Table 4.3

lower flow) and lower design pressure. Such variability may result from the design of the emitter, materials, and care in manufacture. Solomon (1979) found that the statistical coefficient of variation may range from 0.02 to 0.40. The coefficient of variation for emitters should be available for emitters and provided by the manufacturer. ASAE guidelines for classification of emitter uniformity are shown in Table 4.5.8(a)

#### 5.1 Cost

The cost of a drip trailer with a capacity of about 550 GPM is approximately \$ 19,000. Excluding pumps and lay flat tubing, materials for this system range from \$200 to \$300 per acre (Irrigation Journal, May/June 1996). The bamboo drip irrigation system costs locally to tune of labour involved. Bamboo material growing in nature in abundance is available free. Once installed, most of the materials last for 2 to 3 years except minor components which decompose early such as last stage water distribution items.

##### 5.1.1 Maintenance

Emitter clogging caused by physical, chemical, or biological material is the biggest maintenance problem of micro irrigation systems. In modern systems, main filters and screen should be cleaned periodically to prevent emitter clogging. Monthly flushing can remove accumulations of sediment, bacterial slime and iron in the tubing and can remove accumulation of sediment.

The bamboo drip irrigation system maintenance requirement is bare and minimum. The system works round the clock once commissioned. Community and cooperative harmony of the tribal farmers does have positive effect on successful running of the system. Emitter clogging due to sediment is greatly redu

These are basically essential fro transmission of water through bamboo pipes.

Reynolds number =  $1.3 \times 10^4$ . This implies that flow through bamboo pipes is turbulent and from Fig. 4.5.7,  $k_x = 0.5$ . Thus the emitter opening is similar to an orifice.

In the distribution of water flow water of different diameters of emitters were calculated and according to the ASAE standards, the application of water to soil surface as drops or tiny streams through emitters for emitters is less than 12 l/hr, so according to the emitter discharge calculated from my study, Emitters of diameter = 2mm and discharge = 10 l/hr are suitable for bamboo pipes.

The emitter coefficient of discharge is 0.0295 for bamboo pipe emitters.

The coefficient of variation was not calculated due to lack of enough consistent emitter discharge values for each diameter of emitter.

### RECOMMENDATIONS

Most of the values calculated were not exact but experimental results due to lack of proper tools and time. So the following should be put into consideration for further experiments:-

Leakages at the joints should be avoided by using tighter joints e.g by gluing.

A properly levelled surface should be used for laying the bamboo pipes horizontally so as to get concise pressure gradients.

Modern boring equipment (e.g. flexible drive with adapted bit for node removal should be used so as to reduce the overall roughness size,  $k_s$  of the bamboo pipes.

Drilling of the emitters should be done in a better way for further studies so as to increase on the coefficient of discharge,  $C_d$  thus higher emitter discharge.

Finally due to the cost of the bamboo drip irrigation system as compared to the modern irrigation systems as far as the peasant farmers are concerned, bamboo pipe use should be encouraged where bamboo is available so as to alleviate poverty by enhancing the ecology and increasing the productivity of land through bamboo micro-irrigation systems.

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