Hydraulics and uniformity performance of an innovative bamboo-drip system

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INTRODUCTION

In the context of water resources expected to become more scarce and variable in future due to climate and land-use changes versus a rising water demand driven by increasing food needs of a growing population, drip irrigation is potentially a very promising approach to raise irrigation efficiency and improve water productivity of cultivated crops. Yet, in West-Africa as in many developing regions of the world, the lack of financial resources for establishing, operating and maintaining drip systems is the main reason for their non-adoption by smallholder farmers. A promising attempt to step out of this dilemma is an innovative bamboo-drip system that would have the advantages of conventional plastic systems, but be less costly.

Construction of the bamboo-drip system

Bamboo culms were harvested in the wild, selected for good condition and cut to remove nodes. 20 cm internodes were selected for adequate inner diameters, treated to increase durability and reduce friction head loss during irrigation, and glued one to the other (with strong and waterproof glue) to construct drip pipes.

Emitters were hand-made from 2 mm ID ball pen tube pieces. Basal opening was closed and three tiny V-openings made alongside to regulate flow by up and down movement into bamboo pipes.

Bamboo plants in the wild

Harvested culms

Selected and treated internodes (used to form main and lateral pipes)

Bamboo-drip system

Distribution of *Oxytenanthera abyssinica (A.Rich.) Munro* in Africa

Ball pen ink tube

Emitters

RESEARCH QUESTIONS

- How would water flow in the bamboo system be affected by its two main components (i.e. bamboo material and emitters)? (➔ need to assess inherent variabilities in hydraulics)
- As a result of this influence, how uniformly could the bamboo system supply water to the plants? (➔ need to assess emitter flow uniformity in the system as a whole)

MATERIALS AND METHODS

▪ Assessment of inherent variabilities in hydraulics

Parameter	Formula	Expresses …	Test			Collected
			Unit	Unit number	Process	
CV(H)	**CV(H) =** $\frac{Sl}{\bar{q}l}$ *Sl* and $\bar{q}l$ being respectively standard deviation and average of lateral outlet flow	… how much of emitter flow variation is caused by the bamboo material	5 m bamboo lateral (without emitter)	03	Three 30 minutes tests per lateral (at four pressure heads)	Lateral outlet flow

Bamboo laterals
(junctions are protected to ease handling and prevent breaking during future transportation to the field)

Test set-up
Testing heads: 20, 40, 60 and 80 cm

Test of bamboo laterals : volumetric method

Parameter	Formula	Expresses …	Test			Collected
			Unit	Unit number	Process	
CV(M)	**CV(M) =** $\frac{Se}{\bar{q}e}$ *Se* and $\bar{q}e$ being respectively standard deviation and average of emitter outlet flow	… how much of emitter flow variation is caused by emitters' precision	Emitter alone	03	Three 30 minutes tests per emitter (at four pressure heads)	Emitter outlet flow

Weighing of empty cans before test

Test of emitters: volumetric method

Weighing of collected water

Parameter	Formula	Expresses …	Test			Collected
			Unit	Unit number	Process	
CE	**CE =** $\frac{\bar{q}}{q_{min}}$ $\bar{q}$ and q_{min} being respectively average and minimum emitter flow	… how much emitter flow variation is caused by the bamboo material	5 m bamboo lateral (without emitter)	03	Three 30 minutes tests per lateral (at four pressure heads)	Lateral outlet flow

Test set-up ; Testing heads: 20, 40, 60 and 80 cm

Water collection

▪ Assessment of emitter flow uniformity (Christiansen uniformity coefficient)

Parameter	Formula	Expresses …	Test			Collected
			Unit	Unit number	Process	
UCC	**UCC =** 1- $\frac{\bar{\Delta}q}{\bar{q}}$ $\bar{\Delta}q$ being mean deviation of emitter flow from the average	… how much water flow differs from one emitter to another	Entire bamboo system (32 emitters)	01	One 30 minutes test (at each pressure head)	Emitters outlet flow

RESULTS AND INTERPRETATION

▪ Inherent variabilities in hydraulics

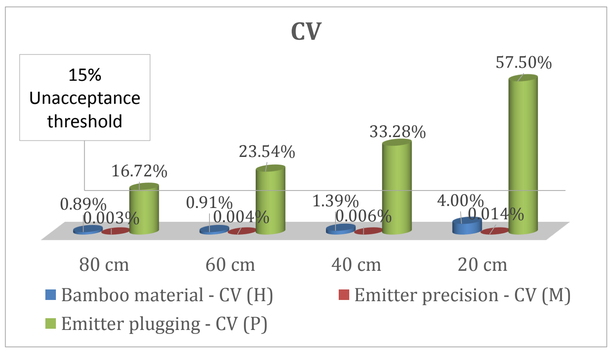

Figure 1. Emitter flow variations due to bamboo material, emitters' precision and emitter plugging

Interpretation criteria

Table 1: Criteria for micro-irrigation component manufacturing variability values.
Adapted from ASAE EP405.1 (2000)

Coefficient of variation	Interpretation
Below 5%	Excellent
5 – 10%	Average
10 – 15%	Marginal
Above 15%	Unacceptable

Interpretation

In the bamboo-drip system, flow variations due to bamboo material and emitters' precision can be assessed as excellent at four pressure heads, whereas that due to emitter plugging kept unacceptable overall. Emitter plugging is the strongest factor causing emitter flow variation in the bamboo system, as in conventional plastic drip systems.

Emitters plugging is due to flow velocity variations at emitter positions, resulting from singularities in bamboo internodes.

▪ Emitter flow uniformity

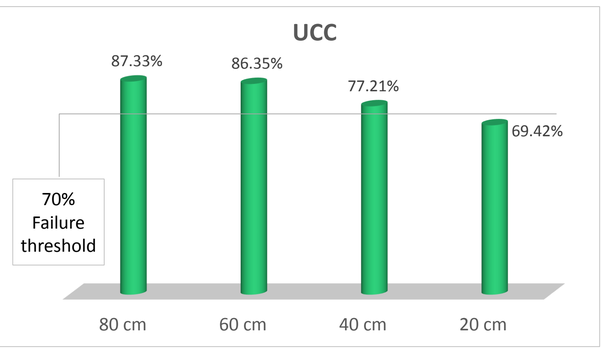

Figure 2. Emitter flow uniformity in the bamboo-drip system

Interpretation criteria

Table 2: Standards for uniformity in micro-irrigation systems. Adapted from ASABE EP458 (1999)

Uniformity coefficient	Classification
Above 90%	Excellent
90 – 80 %	Good
80 – 70 %	Fair
70 – 60 %	Poor
Below 60 %	Unacceptable

Interpretation

Emitter flow uniformity in the bamboo system is at least fair, but becomes poor at 20 cm pressure head. Pressure head being directly proportional to water flow velocity, this means flow velocity in the system at 20 cm head varies too much from an emitter position to another. This again is due to singularities in bamboo internodes and junctions, which become relevant at 20 cm head. Getting a good uniformity would imply to reduce these singularities by using more uniform bamboo internodes, or running the system at higher pressure heads.

CONCLUSION

The bamboo drip system is workable. It has good and similar hydraulic characteristics as conventional plastic drip systems under suitable pressure conditions. Its emitter flow variation is essentially due to emitter plugging, which can be reduced by running the system at high pressure heads, or improving internodes uniformity.

But although this system works well, questions remain regarding its real life performance, economic profitability, durability and fertigation potential. These issues should be addressed by further researches.

ACKNOWLEDGEMENTS

This research was funded by the Deutscher Akademischer Austauschdienst (DAAD) and the Stiftung Fiat Panis foundation. We warmly thank the Center for Development Research (ZEF) for their valuable assistance, and the European Alliance on Agricultural knowledge for Development (Agrinatura) for supporting our travel to Tropentag Conference.