Research Brief

Sustainable Agriculture and Natural Resource Management
Collaborative Research Support Program

Issue No. 9

# Improving rural livelihoods through low-cost irrigation

Increasing production on small family farms in developing countries can be challenging. Technologies such as fertilizers, irrigation systems, and mechanized farm equipment can be expensive, and may exceed available financial resources. To address this issue, inexpensive, simple, and effective technologies are becoming more widely available. Low-cost drip irrigation systems, an alternative to conventional irrigation systems, are gaining in popularity because of its small startup and maintenance costs.

A low-cost, gravity-driven drip irrigation system is one of the best options available to small farms. The system, comprised of a series of plastic emitter tubes connected to a water reservoir, can cost as little as five dollars. The system requires no electricity -- pressure to move water through the system is created by placing the water reservoir at an elevation higher than the emitters. The gravity-driven system can also reduce water use by 30 to 50 percent versus conventional irrigation systems.

## Understanding field conditions

The gravity-driven drip irrigation system is designed for easy installation and maintenance, but assuring maximum water distribution uniformity can be difficult under field conditions. Water distribution can be affected by slope, uneven surfaces, and variability in emitter tube diameters affected by water volumes.

Understanding how drip irrigation systems operate in the field can be valuable to local engineers installing these systems. SANREM CRSP researchers Victor B. Ella of the University of Philippines Los Baños and Manuel R. Reyes of North Carolina A & T, along with Robert Yoder of International Development Enterprises, wanted to determine how field conditions affected distribution uniformity. They completed the first study of low-cost drip irrigation systems in sloped conditions. The researchers also analyzed reservoir head height since head pressure also impacts water distribution.

Water distribution from a drip irrigation system is affected by height and slope. Understanding the relationship between these two factors can lead to increased crop production.

A 100 $m^2$ system manufactured in India was used for the experiments. The system had a 10 m mainline connected directly to the reservoir with ten 10 m laterals connected to the mainline. Each lateral had 33 emitters spaced 30 cm apart. The system was tested under a 1, 2, and 3 m operating reservoir head height on 0, 10, 20, 30, 40, and 50 percent slopes. Zero percent slope was used as the reference.

Water distribution uniformity was assessed through the collection of water from the emitter over a ten minute period. These values were input into two different uniformity equations to determine overall system distribution uniformity and assess the application of these equations to these types of irrigation systems.

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The discharge data was used for evaluating the water distribution uniformity. Two indices of uniformity were used in this study, namely the Christiansen's coefficient of uniformity (CU) and the Merriam and Keller's distribution uniformity (DU). The former (CU) is a measure of degree of uniformity based on the lowest one-half of measured discharge values while the latter (DU) is a uniformity distribution index based on the lowest one-fourth of the measured values (Keller and Bliesner, 1990). Both indices were used in this study to determine how the performance of the drip is affected by the differences in magnitude of extreme values.

The results of water distribution uniformity evaluation using these indices have practical implications on soil moisture availability for plant uptake and consequently on crop performance and crop yield using this drip system. The higher the water distribution uniformity, the higher is the likelihood that crop yield is maximized in the entire crop production area.

## Reservoir height, slope and distribution

Several major findings were obtained through this research, all of which supported previous findings of drip irrigation systems. Mathematical relationships were also formulated for predicting uniformity under a given slope and reservoir height.

### *Emitter discharge*

- Emitter discharge increased with an increase in reservoir head height at every slope.
- Increased slope of the mainline did not have a significant impact on average emitter discharge.
- No-emission of water generally occurred at the upstream laterals at mainline slopes of more than 20 percent.
- Emitter discharge generally decreased as one moved from the mainline to the end of the lateral.

### *Discharge uniformity*

- At 0 percent slope discharge uniformity increased from 0 to 3 m of reservoir height, then decreased from 3 to 5 m in height.
- Discharge was most uniform at 0 percent slope versus other slopes.
- Higher reservoir head height results in higher uniformity of water distribution regardless of slope up to 3 m in head height.
- Generally, water distribution uniformity decreased with increasing slope regardless of head height.

## Ideal field conditions

Research of the gravity-driven system has shown that the system functions best with a 3 m head height and 0 percent slope. However, farming on steep slopes is a reality; therefore, the linear relationships established by the research could prove useful in determining ideal height/slope relationships for maximizing distribution uniformity. Additionally, the researchers suggest that placing affordable flow regulation control valves in the gravity-driven drip irrigation system could improve water distribution uniformity and thus increase the productivity of small family farms.

Smiles from Bogor Agricultural University students and professors at a SANREM-sponsored drip irrigation training and workshop in Bogor, Indonesia

**More information**: Ella, V.B., M.R. Reyes and R. Yoder. 2009. Effect of Hydraulic head and slope on water distribution uniformity of a low-cost drip irrigation system. *Applied Engineering in Agriculture* 25(3): 349-356. http://asae.frymulti.com/abstract.asp?aid=26885&t=1. A powerpoint presentation of the researchers' work can be found at the SANREM Knowledgebase: http://apps.cals.vt.edu/cgi-bin/WebObjects/SANREM.woa/wa/viewMetadata?resourceID=3649

SANREM CRSP is made possible by the United States Agency for International Development and the generous support of the American people through USAID Cooperative Agreement No. EPP-A-00-04-00013-00.