Smallholder Drip Irrigation Technology

Authors: Haile, Abraham Mehari, Depeweg, Herman, and Stillhardt, Brigitta

Source: Mountain Research and Development, 23(1) : 27-31

Published By: International Mountain Society

URL: https://doi.org/10.1659/0276-4741(2003)023[0027:SDIT]2.0.CO;2

Mountain Research and Development Vol 23 No 1 Feb 2003: 27–31

Smallholder Drip Irrigation Technology

Potentials and Constraints in the Highlands of Eritrea

Abraham Mehari Haile
Herman Depeweg
Brigitta Stillhardt

Irrigation in general and pressurized irrigation in particular are at an early stage of development in Eritrea. Currently, there are only about 28,000 ha under surface irrigation systems. There is no proper assessment of the extent of pressurized irrigation systems, but it has been estimated at less than 1000 ha. Smallholder irrigation technologies developed by International Development Enterprises (IDE) and consisting of bucket, drum, and micro-sprinkler kits were introduced in several villages in the highlands at the beginning of 2001 by the Center for Development and Environment (CDE). Joint research has been conducted by CDE and the Asmara College of Agriculture and Aquatic Science since March 2001 to assess the social, economic, and technical preconditions for successful implementation of the technology. As used here, the term "smallholder" refers to farmers who manage farms smaller than 1 ha entirely on their own, with little or no input from external government resources.

The problem of adequate water supply

Eritrea is a small country in the Horn of Africa with a total land area of 121,320 km^2 and a population of nearly 4.3 million. About 80% of the population is engaged in agriculture, the mainstay of the economy in a country with a GDP purchasing power parity of US$740. Agriculture consists mainly of subsistence rain-fed crop production and pastoralism. Twelve percent of the total land area (around 1.5 million ha) is arable. But 50% of this area lies in regions that have a mean annual rainfall below 200 mm, making crop production under rain-fed agriculture almost impossible.

The highlands of Eritrea, with an average elevation of 2000 m, cover only 16% of the total land area but are home to about 60% of Eritrea's farming population. A household's average landholding in the highlands ranges from 0.25 to 1 ha. Small farm plots are usually located on hilly terrain (Figure 1). Although the highlands receive an average annual rainfall of nearly 400 mm, rain-fed crop production is adversely affected by the erratic nature of the rain, among other things.

Drip irrigation systems

Several terms are widely used for drip irrigation: localized irrigation (United Nations Food and Agriculture Organization, FAO), micro irrigation (International Commission on Irrigation and Drainage, ICID), and trickle irrigation

FIGURE 1 Typical farm landscape in the highlands of Eritrea. (Photo by Brigitta Stillhardt)

"The income I earned by selling one-third of my pepper yield was sufficient to cover almost half of the basic food needs of my family." (A farmer in Mendefera, Eritrea, who used a bucket kit to grow pepper)

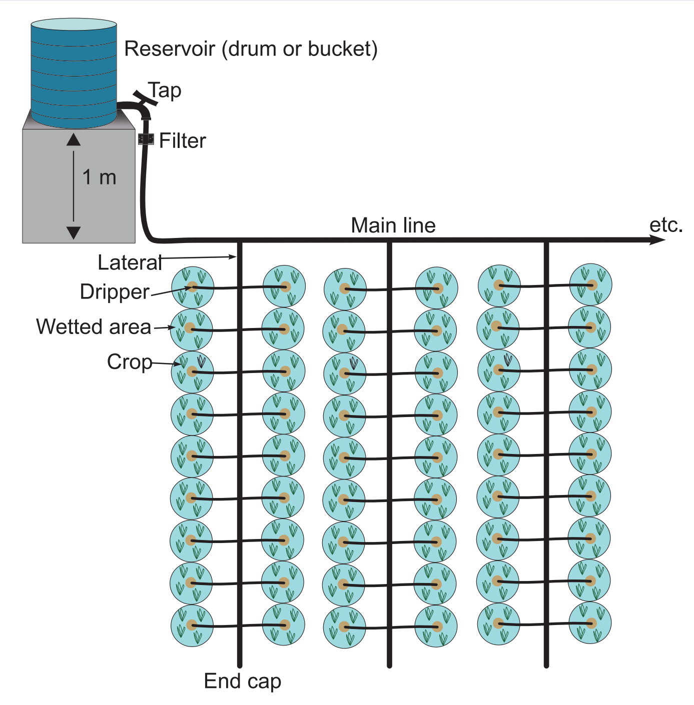
(American Society of Agricultural Engineers, ASAE). All are field irrigation systems that specifically wet the root zone. Drip irrigation is the supply of water to the soil at very low rates (0.5–2.0 l/h) from a system of small pipes fitted with outlets (emitters). Water can be supplied frequently, sometimes every day if required, which is very favorable for plant growth. The amount of water used and the rate of supply depend on water management and economic considerations.

Advantages

Some of the main advantages of drip irrigation over other field irrigation methods are listed below.

- Soil moisture: Soil moisture is kept at field capacity level, which allows easy uptake of nutrients and water by plants, thereby enhancing production.
- Water saving: Water is supplied where and when required and in the needed amounts. However, the efficient use of water largely depends on the experience of the irrigator.

FIGURE 2 Basic components of a bucket or drum kit. (Source: International Institute for Infrastructural, Hydraulic and Environmental Engineering [IHE])



- Hydraulics: Water control is easy and the number of irrigating points provides excellent uniformity of supply.
- Irrigation operation: Irrigation can be carried out day and night, regardless of wind, daylight availability or other cultivation activities.
- Agricultural considerations: Crop yields are higher and of better quality, with earlier maturity; plant diseases and pests are rare.
- Fertilizing: Nutrients can be supplied in a sustained way, and regulated in rate and composition, according to the age and requirements of plants.

Disadvantages

Among the disadvantages of drip irrigation are the following.

- Cost: The initial investment for drip systems ranges from US$ 1000 to 3000 per hectare (if the system is properly managed, the increased value of the crop in terms of quality, quantity, and time savings compensates this cost within a short time).
- Agricultural considerations: Root development is limited, resulting in insufficient protection against lack of water and in poor root anchorage. Root rot and dust problems are common.
- Technical requirements: Emitters can become clogged, and cleaning is problematic, costly, and not always successful. Control of the system is difficult and requires expertise and experience for careful operation and optimal results.
- Salinity: Accumulation of salts might occur at the interface between the wet and dry zones in the soil.

Improved smallholder drip irrigation systems

Several smallholder drip irrigation systems have been developed: the bucket kits developed by Chapin, IDE irrigation kits, Netafim family kits, and others. These systems try to retain the benefits of conventional drip irrigation while removing the factors that prevent smallholders from adopting them, such as the high purchase cost and complex operation and maintenance.

The basic components of a smallholder drip system (Figure 2) are the following.

- Reservoir: Water flows from a reservoir (bucket or drum) to a pipe system at the required pressure.
- Control: Valves (taps) in the pipe system control the flow and the pressure.
- Main line and laterals: These connect the reservoir to the emitters in the field. The lateral may be a porous pipe or have multiple outlet distributors (emitters).
- Emitters/drippers: These devices control the water flow from the laterals to the plants (Figure 3).

Smallholder drip systems have several characteristics in common: kit form for small plots of 20 to 1000 m^2; low pressure, ranging from 0.5 to 4 m; simple filters to prevent particles entering the laterals; and main and lateral pipes designed to be movable.

Although water must be brought and tipped into a bucket or drum, small quantities of water can irrigate a large area. Assuming a crop water requirement of 5 mm/day, which is usually used for highland areas with a mean daily temperature of about 20°C, one 200-l drum can irrigate an area of 100 m^2. It is possible to increase the area by using a number of buckets and drums. One disadvantage is that raising the water into the drums is hard work; this calls for low-level mechanical lifting technology that does not use electricity or petrol.

Potentials

Social and economic benefits

Smallholder irrigation technology can significantly reduce the drudgery of watering. It can also help solve water management problems faced by smallholder farmers by making it easier and simpler to supply the right amount of water to their crops at the right place at the right time. A technology alone however does not determine success, and it is essential to assess its usefulness within a social and economic context.

The low cost of the kits refers to low initial capital outlay; it does not necessarily imply low cost per hectare. The smallholder drip systems are sold as inexpensive kits that cover small areas (20 to 1000 m^2), giving farmers an opportunity to expand the area under irrigation from the profits gained. A number of farmers in Eritrea were willing and able to pay half the estimated market price, ie 60 Nakfa for a bucket kit and 200 Nakfa for a drum kit (1 US$ = 14 Nakfa; 2002 estimate). This is an indication that the kits are affordable and that the farmers are ready to experiment.

The main income for most subsistence farmers in the highlands comes from sale of grain crops, which are used to purchase basic provisions such as pepper, onions, oil, tomatoes, salt, and a variety of vegetables. Nevertheless, owing to small fields and erratic rainfall, grain yields for many households rarely exceed 500 kg, which is barely sufficient to cover basic food necessities for even half a year. The irrigation kits have proven that they can increase household food security by contributing to the basic needs or generating the extra income required to purchase them.

Fostering gender equity

It is the policy of the government of the State of Eritrea to ensure gender equity. Tremendous efforts and progress have been made in the last 10 years toward the same. Achieving gender equity, particularly when it comes to division of labor for indoor and outdoor activities, however, requires behavioral change, which in turn calls for decades of sustained hard social work. In many rural highland areas, traditional beliefs and rules prohibit women from participating in outdoor farm activities, except within their own backyard. This confinement to non-income generating household tasks makes women almost entirely dependent on men, even for the purchase of basic food items, and has a negative impact on household food security.

The IDE smallholder bucket and vegetable kits could enable women to be breadwinners (while still respecting traditional obligations) because these kits can be installed in backyards to produce some basic food items. This could improve household living conditions and greatly reduce women's dependence on men. Furthermore, many villages in the high-

FIGURE 3 View of a drum kit lateral and an emitter applied to a maize crop. (Photo by Brigitta Stillhardt)

"We have to clean at least 5 micro tubes every 15 minutes and hence we have to be almost constantly around during the whole water application time." (Students in Hagaz, Eritrea)

lands are not accessible by any mode of transport and therefore have no access to marketplaces. Hence people must travel for as long as 3–4 hours, usually over unfriendly terrain, to buy basic foodstuffs. Producing the most frequently needed food items in home gardens can greatly reduce the number of shopping days, thereby saving precious time and labor for both men and women.

The small size of the kits and their customization to fit irregularly shaped strips of land make them ideal for backyard plots in many highland villages. The kits are simple in design and easy to install, operate, and maintain. If their use is properly demonstrated, women can manage them correctly (Figure 4).

Home gardens with surface irrigation systems may not be sustainable in the highlands. This is mainly because these systems demand a minimum of twice as much in terms of water, labor, and time when compared with the irrigation kits, which women cannot afford. In the highlands, fetching water, which is usually the responsibility of women, is very time-consuming. Women need a whole morning just to fetch 60–80 l. Besides walking for hours, many need to climb steep hills carrying 20–40 l on their back.

FIGURE 4 Although the Eritrean government is promoting gender equity, sociocultural constraints in highland Eritrea have made it difficult for women to participate in agricultural work reserved for men until now. The introduction of drip irrigation in home gardens is therefore an excellent way of enabling them to participate in crop production for everyday use, without radically questioning the traditional division of labor. (Photo by Brigitta Stillhardt)

Efficiency and uniform distribution

Surface runoff, deep percolation, and evaporation losses are negligible in this system. In the village of Hamelmalo, Eritrea, tests with 1 kit in a field of the same size and with the same crops as a traditionally irrigated field saved almost 40% of the water needed. However, in cases of poor management the efficiency of the kits may be low.

Small drip systems do not include pressure regulators, but this does not mean that they do not distribute uniformly, as proven by field tests with bucket kits. These tests underlined that a smallholder drip system is highly appropriate for farmlands in hilly terrain. Distribution uniformity as high as 90% was obtained in flat areas.

Constraints

Clogging

The major technical problem, particularly with the bucket kit, is clogging of micro tubes. This occurs mainly because of high amounts of suspended material and also when salty water is used. Clogging can be very severe, as argued by students in Hagaz: "We have to clean at least 5 micro tubes every 15 minutes, and hence we have to be almost constantly around during the whole water application time." And an agronomist in Halhale remarks: "If I have to take care of at least 5 vegetable kits, I think that the time I would spend in cleaning the micro tubes and adjusting the pegs would almost be the same as the time I need to weed the same area under surface irrigation systems."

FIGURE 5 Successful use of drip irrigation depends on support from specialists for installation and maintenance. (Photo by Brigitta Stillhardt)

Irrigation practice

The manuals supplied with the kits suggest irrigation with 2 buckets/barrels per day for highland areas. On this basis, farmers provide 1 bucket/barrel in the morning and 1 in the afternoon throughout the growing period. But there are 4 distinct stages in the life cycle of a plant: the initial stage, the mid-season stage, the late season stage, and the harvest stage. At each stage, crop water requirements are different.

A study in Kiambu, Kenya, compared water use efficiency under current practices with an alternative that uses the same amount of water (2 barrels/buckets), but for a different fixed schedule of 7, 2, 2, and 14 days during the 4 growing stages, respectively; the latter practice saved about 40% of the water consumed by the former.

Conclusions and recommendations

"Smallholder" does not necessarily mean "simple." The couplings, fittings, and control valves could make systems as simple as the IDE kits appear complex for smallholder farmers in rural areas, since these are unfamiliar. Farmers may not be able to operate and maintain the system if they do not get the necessary theoretical and practical information. The attitude that a farmer knows better than others how to irrigate his field needs to be changed. This attitude usually leads to the tendency not to provide sufficient explanation about the installation, operation, and maintenance of the system, as many of the steps involved are assumed to be simple (Figure 5).

The main objective of farmers is to improve their crop yields, which is possible with drip irrigation. However, this cannot come about unless the clogging problem is addressed. For low cost drip systems, practical solutions could include the following:

- Enlarging the area of the bucket kit filter and chlorinating, when clogging is mainly due to suspended sediments.
- Preparation of acidic chemicals from locally available materials to neutralize the salts in saline water.

Smallholder drip systems require little initial capital. Nevertheless, the low initial investment of US$10 needed for the IDE bucket and US$20 for a drum kit may still be expensive for poor farmers. This could impede the adoption of the system because most farmers will not risk their limited resources and fields. The government or international development organizations should thus support the introduction of such sustainable new technologies.

The success of smallholder drip systems also depends greatly on convincing farmers that the system will pay for itself within a maximum of 1–2 years. Hence, investigating means of further reducing costs without decreasing quality should be a research priority.

Many villages in the highlands of Eritrea are remote and difficult to access. The following strategies are thus crucial to disseminate the technology quickly and ensure that it is sustainable:

- Development of a network of traders and dealers that can deliver goods to remote areas for a reasonable profit.
- Conducting a massive public information campaign to stimulate demand for the product at a sustainable level.

Identification and promotion of simple and low-cost technologies that enable access to and delivery of water is also essential for a successful adoption of drip technology. For example, treadle pumps can be used when the water source is a shallow open well. The hilly topography of the highlands also allows gravity flow to the tanks if water is tapped at upstream sites.

Last but not least, introducing a new technology means a change in the land use system; therefore, capacity building is essential.

AUTHORS

Abraham Mehari Haile and Herman Depeweg
International Institute for Infrastructural, Hydraulic and Environmental Engineering (IHE), PO Box 3015, 2601 DA Delft, The Netherlands. abr@ihe.nl

Abraham Mehari Haile is a PhD fellow in hydraulic engineering at the International Institute for Infrastructural, Hydraulic and Environmental Engineering (IHE), Delft, The Netherlands, and a lecturer in irrigation engineering at the Department of Agricultural Engineering, University of Asmara, Asmara, Eritrea.

Herman Depeweg is a senior lecturer in hydraulic engineering at the Water Engineering Department, Land and Water Development Core, at IHE, Delft, The Netherlands.

Brigitta Stillhardt
Centre for Development and Environment, Institute of Geography, University of Berne, Steigerhubelstrasse 3, 3008 Berne, Switzerland. bst@giub.unibe.ch

Brigitta Stillhardt is a scientist at the Centre for Development and Environment, University of Berne, Switzerland. She has specialized in soil conservation research and applications, with a focus on East Africa, particularly Eritrea.

FURTHER READING

Depeweg H. 2001. *Design and Operation of Tertiary Units.* Lecture notes, IHE, Delft. Available from the authors of this article.

Kay M. 2001. *Smallholder Irrigation Technology. Prospects for Sub-Saharan Africa*. Rome: FAO (United Nations Food and Agriculture Organization).

Leeuwen NH. 2001. *Affordable Smallholder Drip Irrigation in Africa: Potential Role of the Private Sector*. Unpublished paper, regional seminar on Private Sector Participation and Irrigation Expansion in Sub-Saharan Africa, Ghana. Available from the authors of this article.