Affordable small-scale drip irrigation in Africa: Potential role of the private sector

L'irrigation goutte-à-goutte à faible coût en Afrique: Rôle du secteur privé

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Abstract

The paper describes various low-cost drip irrigation kits that are offered for sale by manufacturers. Some difficulties or shortcomings in the presentations of information about these kits are discussed. The users' requirements are summarised, and advantages and disadvantages of drip technologies are described, with particular attention to the question of filtration needs. In the final section the author summarises pre-conditions for the successful and sustainable introduction of these types of equipment in African circumstances.

Résumé

Une description de divers matériel d'irrigation goutte-à-goutte à faible coût disponible sur le marché est présentée. Des difficultés et des insuffisances liées à la présentation d'information sur ce matériel sont mises en lumière. Les avantages et inconvénients de ces kits vis-à-vis les besoins des usagers sont abordés avec une attention particulière aux questions liées au filtrage. Enfin, l'auteur liste les pré-conditions pour réussir l'introduction de ce type de matériel en Afrique.

1. Introduction

With the objectives of reducing water losses and increasing the efficiency of irrigation, technologies have been developed to conduct water through pipes to the fields, to apply the water in small quantities, directly to the plant root area and to avoid wetting of large soil areas at the surface. Jar irrigation and irrigation through sub-surface porous clay pipes have been applied with success for many years. In both cases, the slow exudation of water through the porous baked clay provides a steady supply of water to the roots of the plant that develop preferably in the wetted area around the jar or the pipe.

Following the introduction of plastics in irrigation equipment, started some 50 years ago, a number of different localised irrigation systems have been developed and they continue to be improved. Drip irrigation systems that do not wet large areas of the soil surface are the most efficient. In addition to the irrigation water efficiency, drip irrigation systems require less labour, allow efficient application of fertilisers, and result in fewer occurrences of diseases and pests, and consequently higher quality products. In general, however, these systems are considered to be relatively expensive and to require a high level of technology.

Irrigation schemes in developing countries suffer from very low water efficiency, resulting in waterlogging and salinity problems. Also water scarcity is a problem in many developing countries in Africa. Most readily available water resources have been mobilised already for irrigation and a large part of the expansion of the irrigated area should come from the development by small-holder farmers of small local water resources such as small reservoirs and shallow groundwater. The optimal use of these limited resources is essential. The adoption of small-scale low-cost drip irrigation technologies by small-holder farmers in Africa has great potential and could be one of the solutions for increasing food production, increasing farmers' incomes and improving food security.

2. Appropriate drip irrigation systems

Generally, small-holder farmers in most countries in arid and semi-arid regions of Africa depend on one rain-fed cereal crop (millet, sorghum, maize) grown during the rainy season. In addition in many villages groups of women and young men grow vegetables on small plots of land in order to improve the family diet, or for sale at local or urban markets.

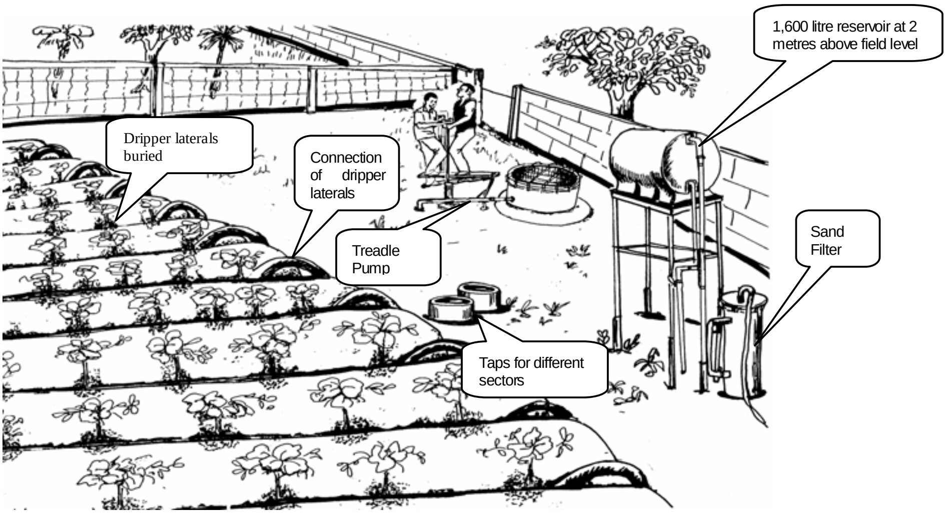
Urban and peri-urban agriculture is growing fast around all major cities. With the increase of urban population and consequent rising demand for fruits and vegetables, irrigated agriculture will need to expand rapidly in the future. However, water resources are limited and irrigation is very labour-demanding because in many urban and peri-urban gardens, the irrigation water is carried by hand from the well, reservoir or river to the fields.

The use of drip systems would allow making optimum use of valuable water resources, and farmers in rural as well as in urban areas would be able to grow more crops per drop, per m^2 and per hour of work. In order to be adoptable by smallholder farmers, drip systems should be affordable, which means that they should:

- have low investment cost: in view of the smallholder farmer's income level, the investment cost for the equipment and supplies should be as low as possible;
- have low operation and maintenance costs;
- be easy to install and to operate by farmers without particular technical training;
- be cost-effective: the investment should be earned back in one season.

Different organisations and companies[1] propose systems that correspond more or less to the above requirements. These systems have a number of features in common.

Figure 1. Layout of a small-scale drip-irrigation system (Keita–Van Leeuwen).



- ***Water supply***. Most of the small-scale systems are supplied with water from a bucket, drum or other water container that is installed in the field close to the cultivated area. Depending on the dripper laterals, these reservoirs are installed on a stand or on a platform at 1 to 2.5 meters above field level. Dripper laterals can be connected directly to the water reservoir itself or to a main distribution pipe. In some cases it is assumed that the irrigation water is supplied by an existing pressurised water supply system, in which case no reservoir is installed.

[1]Chapin Watermatics Inc., International Development Enterprises (IDE), NETAFIM, Aquatec.

- ***Water quality control***. All systems have some kind of filtering of the irrigation water in order to avoid the clogging of the drippers by impurities. Such a filter is sometimes limited to a piece of cloth that filters the water where it enters the reservoir. Other systems are provided with a disk or screen filter. The need for a more secure filtering with a sand filter for those locations where the water is very dirty is mentioned by a number of suppliers.

- ***Water distribution.*** Several systems propose laterals that have drippers built-in at specific distances (such as 30, 45, 75 cm). Others have low-density polyethylene laterals on which drippers can be fixed at the desired spacing. Several lines of plants can be irrigated if microtubes are fixed to one lateral. Sometimes the drippers are reduced to a simple hole in the lateral.

- ***Cost.*** Investment cost for most of the systems is relatively low. The cost of the kits that are proposed varies between US$5 and US$100 per unit (depending on the area covered). These costs exclude any equipment for the mobilisation of water (boreholes, wells, pumps, canals, etc.) as well as the cost of the reservoir (buckets, drums, etc).

The information provided by suppliers varies from one system to the other and makes it difficult to proceed with a comparison. The general impression that is given in all the documentation is that these drip irrigation kits are cheap, do not require much water and are not labour-demanding. The reality can be somehow different.

3. Low-cost drip irrigation kits

While there is no doubt about the merit of low-cost small-scale drip kits, there is in most cases an over-simplification in the presentation. There are serious risks that users are confronted with unexpected problems and, not finding easy solutions, they may quickly abandon the drip system and return to their traditional watering methods with cans.

- ***Potential irrigated areas***. The area covered by the proposed drip irrigation kits varies between 25 and 500 m^2. This area is generally based on the length of the dripper laterals and the distance between the lines. Consequently the same kit can cover an area of 500 m^2 or 2000m^2, if the distances between the drip lines are increased from 0.75m to 3.00 m. A comparison between different systems should consequently not be based on the area covered but on the length of drip line provided in the kit. The distance between the drip lines should depend mainly on the optimal distance between the rows of plants, which varies from one crop to another. The area actually covered by the system will influence strongly the amount of water that is needed.

- ***Investment cost.*** The different kits are offered for prices that vary from US$5 to US$100. Independently of the actual areas covered by these systems, as discussed above, the cost per hectare would amount to some US$2,000. Not included are the costs of the water point, the pump, the sand-filter (if required) and the connecting pipes. Taking into account all these additional elements, the total cost of a complete set of equipment for small-scale drip-irrigation may vary between US$5,000 and US$7,500 per ha.

- ***Crop water requirements.*** Some of the kits are accompanied by indications that with two buckets or two drums of water a day a farmer can irrigate a given area. The actual amount of water supplied to the crops varies between 1.6 and 9 mm/day. Several kits give indications that in warm climates more water could be needed. None of the kits mentions that the water required depends also on the crop that is grown as well as on the development stage of that crop. The effect of plant population or plant density on the crop water requirements is similar to that of the percentage of ground cover (Doorenbos and Pruitt 1992). When the topsoil is kept relatively dry, evaporation from the soil surface is sharply reduced and ET crop will be less for low population crops than for high population crops. During the early stage of a crop a high population planting would normally require somewhat more water than a low density planting, due to quicker development of full ground cover. In irrigated agriculture, plant population has been considered to be of little importance in terms of total water needs. In general, water

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requirements will depend on the total area covered. Since drip irrigation does not allow visual control of the amount of water that is applied to each plant, farmers will need assistance to determine the quantity of water required and how to make sure that this quantity is applied.

- ***Water mobilisation.*** The documentation on drip irrigation kits gives the impression that the mobilisation of irrigation water is not really a main problem. By providing just two buckets of water (of 20 litres each) in the morning and in the afternoon the water requirements would be covered. In fact this would just amount to 2 mm/day, and in certain circumstances the plants may require 8 mm/day, corresponding to eight trips from the water sources with two buckets of 20 l each. When it gets to filling a 200-l drum several times a day, there is clearly need to pump water into the system. In most cases individual farmers would be able to use a pump; however the cost of the pump, the dug-well and connecting pipes should be added to the investment cost the same as the cost of the buckets or drums. The labour cost for pumping the water should be added to the operations cost.

- ***Filters.*** For some of the bucket kits, the filtering of the water is done by a piece of cloth. Most kits have filters; some very simple screen filters, others more sophisticated screen filters, without however mentioning the actual performance of these filters. Sand or gravel filters are mentioned as they could be used to treat more heavily charged water. The documentation does not mention any specific filtering requirements for the different types of drip lines. It only mentions that some of the systems are easy to clean. The information received, after specific request, from one of the suppliers of driplines, has given clear indications with regard to the actual filtering requirements. These filtering requirements (from 125 to 80 microns) also depend on the actual discharge of the drippers: with a higher discharge (higher water pressure) the level of filtration can be reduced.

- ***Fertigation.*** The application, through the drip system, of nutrients dissolved in water is called fertigation. Since the fertiliser reaches the root zone directly, fertigation is the most efficient way of application of fertilisers. The increased production will allow a better valorisation of the investment made by the farmer in the drip-irrigation equipment. Only one supplier mentions the possibility of fertigation in its documentation. Farmers will need advice on the advantages of fertigation and should be trained in the selection of the liquid fertiliser and the procedures for its application through the drip system.

- ***Flexibility.*** Most of the kits are supposed to be used on flat land and rectangular fields, and include drip tapes that have fixed distances between the drippers. These systems present problems when used on sloping land, or when farmers need to irrigate crops that require a different spacing.

- ***Advice and training.*** In order to make successful use of the drip irrigation system; farmers will need advice and training. Part of the training and advice, dealing specifically with the irrigation system as such, could possibly be part of the package that the farmer purchases from the supplier. This package could also include trouble-shooting services during the first season. Other advice and assistance dealing with the selection of crop varieties, disease and pest control, marketing, etc., should be provided by specialised government services.

Most of the above-mentioned issues can be dealt with without too many problems. The quality of the water and the selection of the type of drip lines however will require special attention.

4. Physical water quality

Many decisions during the planning stage of a drip system have to focus on the issue of water quality. In particular, the physical quality of the irrigation water is the main factor that should be taken into account when selecting the water filter(s) and the type of drip lines and eventually the drippers to use. This is valid for large-scale projects where farmers have access to high-level technical expertise and have resources to adjust the equipment as and when required. This is, however,

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essential for smallholder farmers who, in case of major problems, will have no choice other than abandoning the system, as they do not have access to remedial solutions.

The physical water quality will be very different from one place to another. Depending on the source of water, it can also vary considerably during the season and even from one season to another. If water samples are available, it is not always easy to get these examined in a simple and quick way. The easiest way out would be to use always a drip system that, independently of the water quality, will present fewer clogging risks and can be easily cleaned. This would exclude drip lines with pre-manufactured drippers such as T-Tape and the Chapin Tape. The advantage of these drip lines is that their cost is much lower.[2] Driplines with pre-manufactured drippers can be installed without any additional costs. LDPE dripline pipes need micro-tubes or drippers at additional costs almost equal to the cost of the pipe itself. Driplines with pre-manufactured drippers also assure a more homogeneous distribution of water, are easy to use and require no maintenance. Since they are buried there is less risk for damage and the water efficiency is higher.

If the water is very clean, a simple screen filter for security purposes will be sufficient. If the water is charged with mineral particles there will be two options:

- Install only a security filter and use surface dripper lines that can easily be controlled and cleaned whenever needed; or
- Install the appropriate filter in addition to the security filter and use sub-surface drip lines with pre-manufactured drippers.

The following filters (FAO Irrigation Equipment Supply Database) are generally used to clean water for drip-irrigation systems.

Gravel or sand filters.[3] These filters, also called media filters, are closed cylindrical tanks that contain a gravel of 1.5–3.5 mm grain size or a basalt sand filter bed. Where the irrigation water source is an open reservoir, they are installed at the beginning of the head control of the system. Water entering the tank from the top passes through the gravel bed, which traps the large particles of unbroken organic matter, mostly algae, and the water exits through the outlet at the bottom of the tank. They are equipped with the necessary inlet, outlet and drain valves, and a back-flushing arrangement. The filter body is epoxy coated metal, minimum 8.0 bars PN, and is 50–180 cm high and 40–100 cm in diameter. They are available in threaded connection sizes of 1–8 in.

Disk type filters. These are cylindrical, made of reinforced plastic, horizontal in-line or vertical angle-shaped. The filtering elements consist of stacks of grooved plastic rings with multiple intersections, providing a three-dimensional filtration of high level. They are very effective in removing all kinds of impurities of inorganic and organic origin, algae included. The degree of filtration can range from 40 to 600 mesh (400–25 microns). They are available in all sizes (¾–6 in), PN 8.0 bars, with threaded joints. They are placed at the end of the control unit before the main pipeline.

Screen type filters. These are used for final filtration, as a safeguard for either moderate quality-water or following a primary filtration with gravel or hydrocyclone filters. They are installed at the end of the head control before the main pipeline. They are made of epoxy coated metal or high engineering plastics in various cylindrical shapes (horizontal on-line, vertical angle, etc.), and are equipped with interchangeable perforated filtering elements, inlet, outlet and drain valves and pressure inspection gauges. They can withstand a working pressure (PN) of 8.0 bars. The degree of filtration ranges from 60 to 200 mesh (75 microns). They are available in sizes of ¾ - 4 in. Smaller sizes are made of reinforced plastic.

If it does not exist already, an easy-to-use water testing device should be developed. Since most of the small-scale drip-irrigation systems will work under low pressure with corresponding low discharge of the drippers, the highest required level of filtration should be adopted. Farmers should also be trained in proper operation and maintenance of the filters.

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[2] In Project GCP/RAF/340/JPN (Burkina Faso) actual cost (CIF) of T-Tape is 40 percent of 16 mm low-density poly-ethylene tube with drippers.

[3] Sand filters have been manufactured locally in Burkina Faso by project GCP/RAF/340/JPN and were using four layers of sand from 1 mm to 4.5 mm. This filter appeared to be insufficient for water charged with loam.

5. Sustainable introduction of small-scale low-cost drip irrigation in Africa

From a long-term perspective, irrigation development should be based on two guiding principles: the generalisation of private irrigation and the professionalisation of the actors operating in the irrigation sector (Soumaila 2001). In order to follow these guiding principles, irrigation should be:

- essentially initiated and managed by the operators themselves;
- low-cost, oriented towards water management and low water use;
- providing a good cost-benefit ratio;
- sustainable and respecting the environment.

Several distributors of small-scale drip-irrigation kits are working in the same direction by trying to assemble their irrigation kits at country level and to set up national distribution networks. In emergency cases, the kits can be assembled elsewhere and shipped in containers. It is, however, much cheaper to ship supplies in large quantities and assemble the kits locally. The assembling of such kits is, in fact, very simple and could even be further decentralised to the local distributors of irrigation supplies in smaller cities. The main advantage of such decentralisation is that, it opens the possibility to customise the equipment.

In view of the many variables, such as water quality, soil texture, crops and cultivation methods, shape and slope of the farmer's field, technical capacity and financial resources of the farmer, etc., there is a need for an individual approach to select the most appropriate set-up for each drip irrigation system. Since the design of the system is closely related to the local availability of materials, it would be most appropriate if the supplier of the equipment could provide assistance to individual farmers for the design of small-scale drip irrigation systems. This assistance should not be limited to the design of the system but should also include advice on irrigation practices. Such an individual approach will also allow setting up a system that can evolve in time. Local distributors of irrigation equipment will have special interest in selling systems that work correctly, as this will increase their business in the future.

Clear and simple guidelines, covering all aspects of small-scale drip irrigation, should be prepared for these local distributors of irrigation equipment, to make them capable of providing such services to farmers. Short training courses on design and operation of small-scale drip irrigation systems should also be organised for interested equipment distributors at national level.

It is further recommended that experiences with small-scale drip irrigation in sub-Saharan Africa be collected and analysed to draw lessons for the expansion of this type of irrigation. In particular, experiences with the adoption of these new irrigation technologies by women farmers should be shared with a large public. Many women farmers are cultivating small irrigated plots and they have the largest constraints in terms of labour availability, and generally limited access to new technologies and to credit. Finally, methodologies for simple and quick analysis of water quality should be identified and made available to the professionals.

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