CHAPTER 7

CLAY POT SUB-SURFACE IRRIGATION AS WATER-SAVING TECHNOLOGY FOR SMALL-FARMER IRRIGATION

7.1 Introduction

The most common problem in tropical and sub-tropical Africa in the last two decades has been lack of water due to droughts. This has brought about food insecurity at household level as a result of low food and fibre production to meet the demands of the ever increasing population in these regions. It is therefore prudent for scientists to think of conservation and efficient utilization of water to maximize production per unit volume of the limited available water resources. Water scarcity is never felt if it is needed only for few plants, especially where water is easily available and is in abundance. However, if many plants have to be watered and the water source is far away, regular watering may sometimes become a problem. Even if watering is accomplished, much of the water may be lost due to evaporation, especially under very hot and dry conditions, or deep percolation and seepage beyond the rootzone in sandy soils. These problems are more acute in arid areas and in places like the Western province of Zambia where the sand content in the soil is very high. A close look at these arid and semi-arid areas reveals a serious lack of tree plantation crops such as coffee, tea and citrus respectively. Such crops require particular attention with regard to water availability for irrigation especially in the first year of establishment if these trees have to survive.

A simple, but efficient, technological device (the clay pot) which entails creation of rural employment, savings on scarce water resources but maximizing yield and a reduction in irrigation frequency and total amount of water to grow crops has been introduced and tested by the author at the National Irrigation Research Station (NIRS) in Mazabuka

district. Sub-surface irrigation using unglazed porous clay pots is an ancient method still practiced today in several countries, notably India, Iran, Brazil (Power, 1985; Yadav, 1974;

Anon, 1978 and 1983) and Burkina Faso (Laker, 2000; personal communication). The technology is comparable of sub-surface drip irrigation. Water is made available as crops need it. The system has been used successfully for the irrigation of vegetables, orchards and woodlots.

Sub-surface irrigation employing indigenous clay pots made by rural women has been found to be appropriate and relevant for use by small-scale farmers in crop production without any resultant adverse effect on the soil in terms of salt accumulation as no waterlogging occurs. Weeds are suppressed advertently, thus reducing transpiration losses of irrigation water through weeds, as the surface soil layer remains dry throughout the growing season (except after a rain), a factor which also reduces evaporation losses of irrigation water from the soil surface.

This chapter gives highlights on the merits, demerits, economics and feasibility of the system for expansion under small-scale production. The principles of operation, maintenance and fertilization are elucidated. Future scope for adoption in sustainable small-farmer irrigated agriculture presented, with specific focus on vegetable and tree crops.

7.1.1 Objectives

(1) To compare the water requirements and yield responses of some vegetable crops grown under clay pot sub-surface irrigation and the conventional watering can.

(2) To establish the water use efficiencies of these vegetable crops and derive irrigation intervals and water savings with the clay pot system, compared with the conventional watering can irrigation system.

(3) To assess the suitability of clay pot irrigation to small-scale farmer-irrigation with regards to system performance and crop adaptability.

(4) To establish the radius of a wetting front for water distribution from clay pots in a sandy clay loam soil.

7.1.2 The Clay Pot as Sub-surface Irrigation

The clay pot used for irrigation is an unglazed indigenous earthen pot which has many micropores in its wall. The microporous wall does not allow water to flow freely from the pot, but guides water seepage from it in the direction where suction develops. When buried neck deep into the ground, filled with water and crops planted adjacent to it, the clay pot effects sub-surface irrigation as water oozes out of it due to the suction force which attracts water molecules to the plant roots. The suction force is created by soil-moisture tension and/or plant roots themselves.

7.2 Experimental Procedures

7.2.1 Site Selection

The experiments were conducted at Noole Dambo, located in a semi-arid area of Agro-ecological zone II of southern province of Zambia with an average annual rainfall of about 600-800 mm. The Dambo is classified as an upland Dambo.

The upper grassland zone of the Dambo was selected for setting up the experiment because of its good drainage in the rain season and difficulty to transport water from wet Dambo zones to irrigate citrus and vegetables grown in this zone during the dry season. Tree crops particularly do well in the upper grassland zone, as flooding is not a limiting factor at any time of the year.

7.2.2 Materials and Experimental Methods

A completely randomized block design with three replications was used for all the vegetable and cereal (maize) crop trials. Study plots measuring 4 m x 1 m were prepared by cultivating the soil to a fine tilth with a hand hoe after the soil was brought to field capacity. Beans, cauliflower, cabbage, maize, onion, rape and tomato were evaluated in this experiment.

Clay pots with a capacity of 5 liters each and made by rural women (see section 7.4) were installed at 0.5 m intervals in the study plots by burying them neck deep in the prepared seed beds. During irrigation a clay pot was filled with water and then covered with a ceramic lid. Lids made of wood are avoided as they are easily damaged by termites. The covering of clay pots prevents evaporation losses of water from them. It also prevents the possibility of rodents and other small animals drinking from the pots or falling into them. Covering of the pots also prevents soil being washed into them during rains or being deposited in them by wind.

Eight clay pots were required for each configuration in a given seed bed. Twenty one such seed beds were prepared and except for beans which was directly seeded, seedlings were transplanted adjacent to either sides of the clay pots in such a way that the first seedlings and last seedlings in a given study plot were 45 cm away from the clay pot and 10 cm away from the edge of the bed. The crop spacing in this configuration was as per horticultural recommendations of 30 cm x 90 cm for cabbage, cauliflower, maize, rape and tomatoes. Beans and onion were spaced at 10 cm x 15 cm drilled and transplanted in rows respectively between and on the side of the pots (Figure 31).

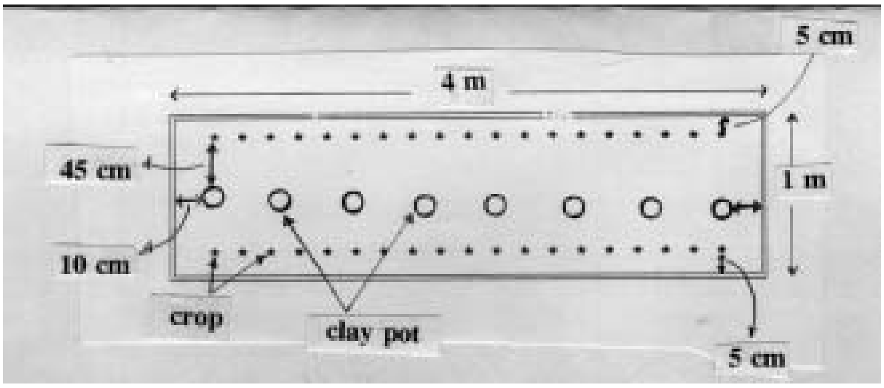

Figure 31: **Field layout configuration for clay pot irrigation.**

Control plots were established, which had similar arrangement and used the same crops but without clay pots. Irrigation was done by the traditional conventional method which employs irrigating with watering cans.

Water manometer tensiometers were used to determine the radius of the wetting front from clay pots and when to irrigate. Two tensiometers were installed per plot at a depth of 30 cm and distances of 20 cm and 45 cm away from the clay pot. In the case of the control plots, tensiometers were installed at distances of 20 cm and 45 cm away from the plant. Three random locations were selected in each of the replications and readings were taken every day in the morning and afternoon. The tensiometer at a distance of 20 cm away from the clay pot or a plant in the control plots and installed at 30 cm depth was used as an index instrument for monitoring irrigation cycles. The tensiometer located at 45 cm distance from the pot was used to check the wetting front from the clay pot.

Clay pots were refilled every time they reached a 50% depletion level and /or when index tensiometers recorded between -20 kPa and -40 kPa, whichever occurred first, in order to ensure that:

- The discharge rate was fairly constant.
- The soil moisture levels around the pots were maintained at high enough levels to avoid soil-induced water stress in plants.

- Pot clogging due to salt accumulation, caused by possible prolonged drying of the pots, was avoided.

The control plots were irrigated every time as soon as crop stress was observed and/or when index tensiometer readings recorded between -20 kPa and -40 kPa.

Yield was measured by weighing actual harvested produce from the crops in the study plots on a standard hanging scale. The yield was measured in kilogrammes but translated to ton/ha for both treatments. Results by the Vegetable Research Team (VRT, 1996) on water requirements and yields of the same crops irrigated by sprinklers were used to compare with those obtained from this trial.

In view of the difficulty to irrigate and establish tree crops under conventional irrigation systems that use buckets or watering cans, the use of clay pots was tried with coffee, citrus and mexican sugar apples on an observational basis. Yield results are not reported here as the crops take a long time to start fruiting. However, experiences elsewhere are discussed in relation to observations made in this observational trial.

7.2.3 Statistical Analysis of Yields

A statistical computer package called AGSTATS was used to analyze the statistical significance in yield differences (Russ *et al*., 1987).

7.3 Results And Discussion

7.3.1 Yield Responses

Yield data for clay pot, sprinkler and conventional watering can irrigation systems respectively are presented in Table 24.

Table 24: Yield data (ton/ha) for various vegetable crops under clay pot, conventional watering can and sprinkler irrigation systems respectively.

Crop	**Clay-pot**	**Watering can**	**Sprinkler***	**LSD(5%)**	**CV(%)**	**SIGNF**
1. Beans	5.12	4.55	4.85	0.80	7.29	NS
2. Cabbage	56.82	60.07	62.00	5.58	4.13	NS
3. Cauliflower	**23.03**	**16.67**	16.67	**1.58**	3.70	**SNF**
4. Maize	**14.15**	**8.97**	9.27	**1.78**	7.27	**SNF**
5. Onion	36.13	36.62	35.71	2.73	3.3	NS
6. Rape	**33.17**	**26.37**	22.87	**2.05**	3.29	**SNF**
7. Tomato	45.33	40.40	47.17	8.23	8.20	NS

SIGNF = Significance; SNF = Significant; NS = Not Significant

The sprinkler irrigation experiment was not part of this study and conclusions regarding significant differences should not be drawn for it. The data are included for broad comparison purposes only. Sprinkler irrigation data from VRT (1996).

Although they are from different experiments, the remarkably close agreements between the yields obtained with the conventional watering can irrigation technique and those obtained with sprinkler irrigation for **all the crop** (Table 24) are noteworthy. This reinforces the finding of Kwaw-Mensah (1996) in Senanga district of Western Zambia that small-farmers are able to grow excellent vegetables with very simple techniques. This is well illustrated by the photographs from his study presented here in Figure 32 a,b.

32a: Cabbage

32b: Tomato

Figure 32(a, b): Cabbage and tomato grown by small-scale farmers using simple watering techniques.

In the present study statistically significantly higher yields with the clay pot irrigation system than with the watering can system were obtained for three of the seven crops, viz. cauliflower, maize and rape (Table 24). The yields with the clay pot system for these crops were also substantially higher than for the sprinkler system, although they cannot be compared statistically. In no case did the clay pot system give significantly lower yields than the watering can system or substantially lower yields than the sprinkler system. Even more noteworthy than the statistical significance of the increases in yield with the clay pot system over the watering can system are the large magnitudes of these increases on a percentage basis. For cauliflower it was 38%, for maize 58% and for rape 26%.

7.3.2 Crop Water Requirements and Water Use Efficiency

Crop water requirements and water savings by using the clay pot irrigation as compared to the conventional watering can system are presented in Table 25. From the results presented in Table 25, it is observed that water savings between 50% and 70% are achievable with the clay pot irrigation system as compared to the conventional watering can system where water is applied onto the soil surface, causing soil crusting and inducing excessive evaporation. Crusting is responsible for low infiltration of water in the soil, poor aeration and slow crop development under conventional systems. On the other hand aeration and soil moisture retention is very good under the clay pot sub-surface irrigation system.

Evidence from index tensiometer readings showed that at 30 cm depth the soil around clay pots remained relatively close to field capacity during each irrigation cycle, with the tensiometer reading varying between -15 kPa and -20 kPa whilst the tensiometer located 45 cm away from the pot recorded between -20 kPa and -40 kPa. The irrigation cycle was thus found to be 7 days for clay pot irrigation and 4 days for conventional watering can systems.

Table 25: Seasonal crop Water Requirements of some Vegetable crops under Clay Pot and Conventional Watering Can Irrigation Respectively and Water Savings by Using Clay Pot Irrigation Instead of the Watering Can System.

Crops	**Clay-pot Irrigation (mm/season)**	**Conventional Watering can (mm/season)**	**% Water savings**
1. Beans	203	450	**55**
2. Cabbage	45	150	**70**
3. Cauliflower	250	500	**50**
4. Maize	200	500	**60**
5. Onion	67.5	225	**70**
6. Rape	180	400	**55**
7. Tomato	195	650	**70**

Peculiarly low water requirements were observed under both the clay pot and the conventional irrigation systems for cabbage and onion, a head and bulb forming vegetable respectively.

Tomato, cauliflower, beans and maize appear to demand more water with requirements of 650 mm, 500 mm, 450 mm and 500 mm respectively under the conventional system, compared to relatively much lower demands of 195 mm, 250 mm, 203 mm and 195 mm under clay pot irrigation respectively. The vast reduction in water use by crops under clay pots did not, however, reduce yields (Table 24).

By combining the data in Tables 24 and 25, water use efficiencies can be calculated (Table 26). Water use efficiencies can be expressed in two ways, i.e. either as amount of water used per unit yield harvested or the yield per unit water used. Both of these are given in Table 26. Higher water use efficiency is where a smaller volume of water is used to produce a unit yield or where a higher yield is obtained per unit water used. It is observed from Table 26 that all crops grown under the clay pot sub-irrigation system manifest **much** higher water use efficiencies than those under the conventional system. This means that crops under clay pots only require less water to produce a unit biomass yield as compared to the conventional traditional watering can irrigation system or produce a higher yield per unit water applied.

Table 26: Comparative water use efficiencies for various vegetables under clay pot and conventional watering can irrigation systems.

Crops	**Clay pot**			**Conventional Watering Can**		
	(m^3/ton)	**:**	**(kg/mm)**	**(m^3/ton)**	**:**	**(kg/mm)**
1. Beans	396.5	:	25.2	989.0	:	10.1
2. Cabbage	7.2	:	1262.7	25.0	:	400.5
3. Cauliflower	108.6	:	92.1	299.0	:	33.3
4. Maize	141.3	:	70.8	557.6	:	17.9
5. Onion	18.3	:	535.3	60.7	:	162.8
6. Rape	54.3	:	184.3	151.7	:	65.9
7. Tomato	42.0	:	215.4	160.9	:	62.1

The surface soil in clay pot irrigation systems remains dry thereby reducing weed prolification and direct evaporation of water. However, this does not mean that the clay pot which wets only part of the soil volume in the field reduces water consumption by plants but rather cuts back on the waste of water due to evaporation, deep percolation and competitive consumption of water by weeds. These reductions on water wastage enhance the crop water use efficiency.

The conventional system whose soil surface is usually heavily wetted at each irrigation cycle remains vulnerable to weed infestation. Weeds compete with crops on water and nutrient consumption and direct evaporation of water from the sun increases with a wet surface. These factors drastically reduce crop water use efficiencies.

Root development and root distribution within the wetted zone are important factors in regard to water use efficiency. At the end of the trial, it was found that the tomato plants had formed mats of fibrous roots all around the clay pot. In this way the crop enjoyed direct abstraction of water as it oozed out of the pot under atmospheric pressure head. Similarly rape, cauliflower and maize exhibited rooting systems that ramified the soil deeply, but were confined within the wetting zone of the pot.

The capability of the roots to absorb water depends on their surface area, which is a function of their length, number and diameter. Thin roots have relatively high surface area per unit cross-sectional area or per unit of root mass (Taylor and Fenn, 1985). A concentration of thin fibrous roots in the confined volume of irrigated soil under clay-pots will therefore have a tremendous capacity to supply water to the above ground canopy due to increased root surface area, a relative low dependence on water movement to the roots in the soil.

Observations have also shown that cabbage and onion have shallow rooting which is also not fibrous. Despite their shallow, non-fibrous roots, both cabbage and onions had absolutely incredibly high water use efficiencies. Although yields of cabbage and onion were slightly lower under clay pot irrigation than the conventional system, their water use efficiencies were highly superior with this system because the rootzone remains moist whereas it quickly dries up under the conventional watering can irrigation system.

7.3.4 Application of Clay Pot Irrigation to Perennial Crops

Trial plantings of fruit trees (Mexican apple and citrus) and a plantation crop were made to compare the suitability of clay pot irrigation as an alternative to conventional small-scale irrigation for these crops. Comparisons were made in terms of early growth rate and mortality rates of young trees. The system was not evaluated in terms of yield, because that would require growing the trees for a number of years. The clay pot system, as observed in mexican apple and citrus tree seedlings, performed very well in terms of growth and establishment as compared to the slower growth rates and high mortality rates experienced with conventional plantings four months from transplanting in August 1996 (Tables 27 and 28).

Table 27: Height and stem diameter of Mexican apple and Citrus plants as affected by different treatments.

Treatment	**Height**			**Stem diameter**		
	Initial (cm)	**Final (cm)**	**Increase (%)**	**Initial (cm)**	**Final (cm)**	**Increase (%)**
Mexican apple						
Clay Pot	**20**	**37.50**	**87.5**	**0.30**	**0.54**	**80.0**
Watering Can	**20**	**23.84**	**19.2**	**0.25**	**0.40**	**58.0**
Citrus						
Clay pot	**30**	**57.00**	**90.0**	**0.25**	**0.45**	**78.5**
Watering Can	**30**	**35.55**	**18.5**	**0.25**	**0.39**	**55.2**

Table 28: Mexican apple and Citrus seedlings mortality rates during establishment in Clay Pot and Conventional Watering Can Irrigation systems.

Treatment	**Seedling establishment plant count**		**Mortality Rate (%)**
	Initial plant count	**Number of plants replaced due to mortality**	
Mexican apple			
Clay pot irrigation	**50**	**3**	**6.00**
Watering Can irrigation	**50**	**18**	**36.00**
Citrus			
Clay pot irrigation	**80**	**1**	**1.25**
Watering Can irrigation	**80**	**13**	**16.25**

Fast tree growth and absence of water stress was evident in the early stages of establishment. Clay pots also ensure better establishment of trees as plant mortality is reduced to reasonable levels with more plant seedlings surviving. The system also reduces the frequency of irrigation during establishment of tree plants as well as the total amount

of water applied. Plant height increases of 87.5% and 90% for mexican apple and citrus, respectively, were observed in clay pot irrigation compared to 19.5% and 18.5%

increases for the same crops under conventional watering can (Table 27). Higher stem growth rates are also observed for clay pots than the conventional watering can. Table 28 illustrates better tree seedling establishment under clay pot irrigation (94% - 98.75%) than the conventional watering can (64% - 83.75%).

In India, Gupta *et al*. (1988) found similar trends in water utilization by plants grown in double walled clay pots compared to conventional planting. In their studies they observed that one month old Ziziphus memmularia - a thorny tree which bears edible fruits and grows in association with Acacia species, showed 85.7% height increase from double walled clay pots as opposed to 17.9 % in the latter. Observations on stem girth indicated the same pattern, with 78.1% increase with clay pot irrigation, against 55% increase with conventional methods. It was observed that in double walled clay pots called **'Jaltrip',** water is well regulated and maintains a constant soil moisture around the rootzone. This accords with my observations in citrus and mexican sugar apple fruit trees. Ziziphus memmularia is commonly known as Muchechete tree.

Gupta *et al*. (1988) believes that under conventional planting (pit hole planting) and watering methods, soil water levels remain high only for a short period after watering and dries out quickly to levels where it is no longer readily available to plants. Seedlings planted in double walled clay pots are later transplanted to the field where pit holes are dug. They grow in-situ during the establishment stage and their roots would remain pot bound if left for longer periods of time. The fact that the double walled clay pot has to be filled with soil as a medium for seedling growth, however, make them cumbersome to work with.

In Burkina Faso clay pots are used to irrigate trees, including eucalyptus trees grown in communal woodlots (Figure 33)

Figure 33: **Irrigation of eucalyptus trees using clay pots in communal woodlots of Burkina Faso.**

***(Note clay lid in the hands of person at right hand:* Photo by Prof.M.C. Laker)**

The clay pots have been found to be appropriate for use in Dambo margins for growing fruit trees without any attendant problems of regularly irrigating. This is possible because of their ability to save water and supply it to crops efficiently. Once established, the trees have their root system deep enough to extract water from the capillary fringe above the water table which is usually within 2-3 m depth in this Dambo margin.

7.3.3 Fertigation in Clay Pots

In clay-pot irrigation, fertilizer application can be done in the irrigation water wherein it dissolves and is absorbed by the plants as a solute during the process of water oozing out of the clay pot. It is possible to apply less fertilizer under clay pot irrigation as compared to the conventional system where not all the fertilizer applied to the soil is used by the plants as some remain fixed to the soil while some is leached beyond the root zone.

Because of this efficiency in fertilizer uptake under clay pot irrigation there is a need to adapt fertilizer applications to the needs of the plants. It was observed that applying the same amounts of fertilizer as for conventional applications in clay pot irrigation systems, had adverse effects, eg. scorching and killing of seedlings, particularly in vegetable crops. Half of the recommended doses for conventional systems proved to be suitable for the clay pot irrigation system. ***This is a tremendous advantage, since high fertilizer costs often pose severe limitations to small-scale resource poor farmers.***

7.3.4 Advantages and Disadvantages of the Clay Pot Irrigation System

7.3.4.1 Advantages of the System

The clay pot sub-surface irrigation has been found to have multiple advantages as a technology for small-scale farmers, particularly for rural development. The following advantages accrue in this system:

1. Since clay pots are made by rural women they create employment and opportunities for small-scale home industries to manufacture them in rural areas. This will help generate rural income for household food security.
2. They are affordable. A 5 liter capacity clay pot costs US$0.25.
3. Clay pot irrigation allows a farmer to raise seedlings **in situ** instead of transporting them from nurseries. Clay pots are installed directly where seedlings are to be planted and this allows a farmer to plant the seed next to the clay pot where it germinates and gets established.
4. The system is suitable for vegetables as well as perennial horticultural orchard or plantation crops and woodlots.
5. Water savings of 50-70 % are realized, particularly for vegetable crops. Loss of water due to deep percolation beyond the rootzone is reduced if not avoided.
6. Soil moisture is always available almost at field capacity giving the crop full security against water stress.
7. The system inherently checks against over-irrigation.

8. The much smaller quantities of water and less frequent watering required, reduce the amount of labour required for irrigation tremendously.
9. Much less labour is required for weeding since weeds do not prosper, as the soil surface remains dry throughout the growing season.
10. Domestic water effluent from kitchens can easily be recycled and used in clay pot irrigation in backyards. The water used for cleaning utensils in the kitchen can be used to refill the pots in a backyard garden. This saves on scarce water and reduces the need to use fresh water.
11. It saves on the amount of fertilizer to be applied per unit area of land if the fertilizer is applied in clay pots and is later absorbed as solute via water movement to the plants.
12. The soil of the seedbed under the clay pot system does not get sealed due to water impact but remains loose and well aerated.
13. The clay pots can be installed on undulating ground.

7.3.4.2 Disadvantages of the System

The following disadvantages were observed in fields where clay pots are used:

1. The clay pots can break if dropped while working with them during installation.
2. If left dry for a long time, the pores will clog due to salt accumulation and precipitation.
3. Discharge rates may vary due to poor sand B clay mixture being used during the manufacturing of clay pots that may not guarantee a good porosity that will give adequate outflow of water to match plants' water demand.
4. Very heavy soils may not effect a good wetting front. Medium textured soils such as loamy sand, clay loam and silt loam are good.

5. The system may clog as porosity declines with time during prolonged use. When porosity progressively decreases unabated, it becomes difficult to cope with high crop water requirements.

7.4 Manufacturing Of Clay Pots

The clay pots are made from a mixture of clay and sand in the ratio of 4:1 and with an effective porosity ranging from 10-15%. The clay pots are made by rural women using their hands to mould them into different shapes, i.e. cylindrical/round with somewhat flat bottom.

After they are made, glazing is not done so as to retain their natural porosity i.e. the walls remain micro-porous. The pots are then tempered by burning them in a pit fire from firewood at undetermined temperature. Small-scale earthen-ware manufacturers use kilns to temper such ceramic pots at 1200^{o}C. This is done in order to eliminate the swelling and shrinking properties of clay, which would cause cracking of the pots. Women believe that the type of clay used to make the pots is very important and it requires an experienced old woman to identify clay that would not crack unduly during the tempering process and indeed when installed under field conditions. Figure 34 shows clay pots after going through the manufacturing process and ready for use in the field.

Figure 34: Clay pots ready for installation in the field.

7.5 Principles Of Operation

Figure 35 shows a clay pot in operation when installed neck-deep into the ground and filled with water.

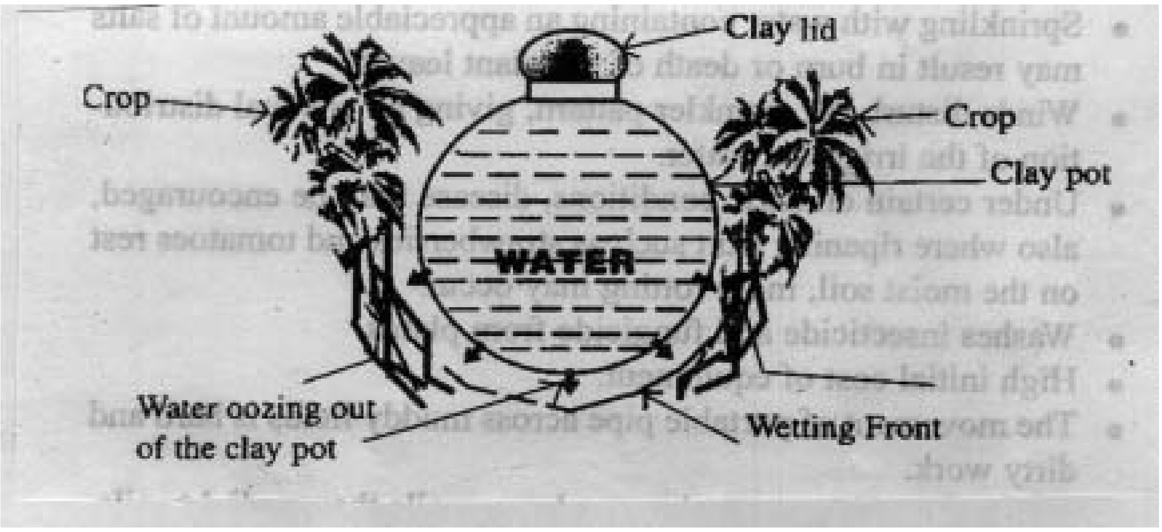

Figure 35: Clay Pot Operation Principles.

When neck-deep into the ground, filled with water and their mouths covered with a clay lid, the inside part of the pot is under atmospheric pressure. The atmospheric pressure, soil tension and root-suction tension will force the water to ooze out of the pot, forming a wetting front that wets the soil surrounding the clay pot. The wetting process continues until the soil moisture status is in equilibrium. As long as there is water uptake by plants, water continues to flow out of the pot. It is by this mechanism that advantage to irrigate crops by planting them on the side of the pot should be taken. Crops planted in seedbeds installed with clay pots take up this water to satisfy their requirements up to maturity. The wetting front depends on the soil texture. Sandy soils do not allow water to move horizontally away from the point source much but responds more to the vertically acting gravitational force.

7.6 Maintenance Of Clay Pots

It is important to keep the system well maintained if its potential benefits have to be realized fully. In order to achieve this the following points ought to be followed:

1. Always keep the pots wet by not allowing water to deplete beyond 50% capacity. This will counteract possible clogging and enhance water flow out of the clay pot.
2. Long irrigation intervals entailing total depletion of the pots should be avoided as this will encourage clogging particularly if the water is highly carbonated.
3. When not in use, the pots should be removed from the soil, washed and dried to avoid clogging of micro-pores. A safe storage place should be found so that undue breaking does not take place.
4. Hydrochloric acid should be used to unblock the system once clogged.

7.7 Sustainability And Economics

The clay pot technology is sustainable since the pots are made from readily and locally available materials which are in abundance. They are low-cost and are made by rural women whose activity to manufacture them at village level offers possibilities of rural income generation at household level.

At a cost of US$0.25 they are affordable by the majority of end users. When properly used and maintained, they can be re-used year in and out for a period of up to 5 years. The fact that very little water is required to raise crops, offers a high potential for their demand particularly in regions with scarce water. No skill is required to operate and maintain the system. The low fertilizer requirements, as compared to conventional recommendations, greatly enhances the economic benefit of the system.

7.8 Optimizing The Clay Pot System By Combining It With Treadle Pump Technology

Although the clay pot requires much less water than the traditional watering can system, it is still relatively tedious and requiring a lot of labour if water extraction is done by means of a rope-and-bucket system and filling of pots is done by carrying water to them with watering cans. In the previous chapters it was shown that treadle pumps provide a much more efficient and less laborious system for abstracting water from wells or rivers than the rope-and-bucket system. By connecting a hosepipe to the treadle pump, water can be delivered at the point where it is needed. The pots can be filled directly from the hosepipe or watering cans can be filled close to the point where they are used to fill pots. Combining the two technologies in this way can clearly optimize the clay pot system.

7.9 Conclusions

1. Clay pot sub-surface irrigation is a drip irrigation system by way of its water application to the plants. Water oozes out through the micro-pores of the pot and wets the surrounding soil. The crops grown around the pot take up the water as they need it.
2. It has been found that as long as the water is not completely depleted in clay pots, it will be in continuous phase of moving out of the pot as long as water uptake by a crop takes place. In this way the surrounding soil is kept moist.
3. The technology is a conservation irrigation system, which saves between 50% and 70% water when compared to the conventional watering can irrigation system. Water is a scarce resource and thus its use must be optimized.
4. Clay pots reduce water use without reducing yields. Therefore it is a water saving technology which optimizes yields per unit water.
5. The clay pot irrigation system is a labour saving technology, both because of less labour required for irrigation and less labour required for weeding.
6. The fact that most rural women of Africa locally make clay pots, means that making clay pots for irrigation will potentially contribute towards creation of employment for them by means of a technology that they are proficient in.
7. The clay pot irrigation system greatly reduces fertilizer requirements, which greatly improves the economy of small-scale irrigation farming.

8. The clay pot irrigation system could be optimized by combining it with treadle pump technology.