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Research Paper

Wick Irrigation, a water conserving irrigation technique for small areas?

A. Rahim Junejo*1
Mohammad Usama Makhdoom[1]
Zahir Muhammad Larik[1]
Jahangeer Dahri[1]
WenquanNiu*[2]
1,Faculty of Agricultural Engineering, Sindh Agriculture University Tandojam, Sindh, Pakistan 70060.
2,Institute of Soil and Water Conservation, Northwest A&F University, Yangling, China 712100.

Abstract
Water scarcity is a dire situation that is already happening in Pakistan and around the globe, Decreasing cultivated area and climate variability requires adoption of effective irrigation methods for higher productivity in small scales farming. While new water-conserving irrigation technologies for small areas are becoming more popular in countries where a short amount of water is available in dry lands which hardly fulfill the requirement for drinking, and where electricity is almost none. Micro irrigation methods like wick irrigation is a simple, low cost, easy to maintain, water conserving technique in which no additional power system or capacity is required, in this method cotton ropes (Wicks) attached with any water holding bucket supply the required amount of moisture directly to the root zone of the plant, hence the plant water requirement will easily accomplished. The aim of this study is to review the literature of this irrigation system from different studies. The study reveals that water saving and crop water productivity using wick irrigation for small areas is quite beneficial because it does not require any planning, high installing or maintenance cost, or any skilled labors. Simple plastic bottles (container) collected from any area are connected with ropes (wicks) and half buried into the soil so: plants take water as per requirement. It is also suggested that wicks may be blocked due to high weight of soil, and it is such a difficult task for large areas, hence it is an efficient low cost irrigation technique for small scales, where electricity is almost negligible.

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I. Introduction

Water scarcity has become an urgent problem of global concern today. it is difficult to meet the food requirements of the growing world population by providing available fresh water resources using traditional irrigation systems. Therefore, there is a vital requirement to research, develop and implement effective irrigation techniques and effective irrigation management strategies. Among micro-irrigation systems, drip irrigation has been shown to save significant amounts of water and labor costs, increase yield, and often increase product quality as well. However, high investment and energy costs are obstacles holding back efforts to develop low-cost irrigation systems for subsistence farmers. There is therefore great interest in the design and development of new micro-irrigation systems to address the growing water crisis (Shaheen et al., 2017)

Small-scale irrigation is seen as a key method to help subsistence farmers out of poverty. With increasing water scarcity worldwide and insufficient access to electricity still prevalent in rural areas, there is a need to develop an energy-efficient irrigation system that simultaneously reduces water wastage while being low cost, efficient and auto regulative capability like wick irrigation system which use a short amount of water as per plant need (Kuntz et al., 2013)

Drip, sprinkler, bubbler, and other modern irrigation methods are expensive to install and maintain, and they require skilled labor to operate and maintain. Hence, there is a broad need for simple, smallscale, efficient, low-cost, and locally-made irrigation methods, from which farmers can get a high yield with a small amount of water. After conclusion it is showed that pitcher and wick irrigation are two of the low-cost, efficient, water-saving, easy-to-maintain methods which can be significantly used in the arid regions of Sindh, Pakistan for small-scale farming, vegetables, and small crops. (Dahri et al., 2022).

Innovative irrigation methods are needed for successful crop productivity in small areas. Modern irrigation methods such as sprinklers and subsurface drip irrigation can save about half the amount of irrigation water, but technical, economic and socio-cultural factors hinder the adoption of these technologies. That is, traditional and low-cost water-saving technologies need to be adapted for sustainable crop production in semi-arid and arid regions, which remains a major challenge for scientists. These methods include wick irrigation pitcher irrigation, deep pipe irrigation, porous capsule irrigation, tree canopy irrigation, and more which can be significantly used in countries where irrigation water is not quite enough and where people don't afford high cost irrigation system (Bhayo et al., 2018).

Wicks help move water further away from the clay pot to encourage root development, and wick irrigation can greatly increase water use efficiency, which is especially needed in areas of severe water shortage (Bainbridge, 2012). Wick irrigation is the most efficient and sustainable irrigation technology that can adapt to any weather situation, area, soil type, plant species and plant cultural life. Wick irrigation provides constant moisture so crops thrive (Bainbridge, 2007).

A wick irrigation system consists of a water tank, a hose and a wick. The tube protects the moisture of the wick from evaporation. The main part of a wick irrigation system is the wick, which delivers water to the plant roots as required. The wick component draws water from the reservoirs into the plant's root zone. The wick can be made of cotton, nylon, blankets or polyester fabrics (Wesonga et al., 2014). Gradual use of water in the soil it reduces the level of evaporation and the plant will have constant access to water. Wicks provide water and nutrients from the solution in which they are placed according to the needs of the plant,therefore, this method of irrigation an automatic irrigation system that reduces the need for labor (Joseph, 2016).

Wick irrigation is an inexpensive alternative that can help many small ones farmers. A wetting cloth or rope is used to carry water from a tank or pipe to the roots of the plant. Wick irrigation is the simplest form that can be done with rags and recycled bottles at almost no cost. Wicks were also used for watering container plants for decades (Editor, 1955). Well-developed wick a window box irrigation system is also sold in commercial kits (Editor, 2010). Wick irrigation has been shown to work well and should be considered field planting of trees and shrubs in the agroforestry system introduced an environmental restoration. It provides critically needed water while the plants are receiving established in micro catchments or runoff systems (Evenari et al., 1982; Cohen, 2002). Wick can be used to reduce drip vulnerability system to clog and block.

However, as the wick irrigation technology is not well understood by users, the technology needs to be further understood and promoted.Therefore, it was summarized the main working principle, advantages and disadvantages of wick irrigation technology, so as to provide reference for better promotion and application of wick irrigation technology.

Overview of method

Wick irrigation involves the use of "ropes as wicks that bring water to plant roots below the soil surface, thereby minimizing evaporation." Water inside a pot or raised water container can be transferred to the soil using a rope wick (often inside a plastic tube to prevent evaporation). The concept is similar to a kerosene lantern with a wick that continuously draws fuel into the wick when the lantern is lit. Initially, the water moves through the wick by capillary action. Later, water is continuously drawn through the wick to replace the water taken up by the plant roots. (Berkelaar et al., 2012)

This system can be classified in two ways:

1 surface wick irrigation method: plastic bottles/buckets are placed on the soil's surface, and ropes are buried into the soil near plant roots to provide the necessary amount of moisture to plants (Fig 1).

2 Subsurface wick irrigation methods: plastic bottles are half-buried in soil and ropes are wrapped around the root zone to increase the depth of water supply to plants (Fig 2)

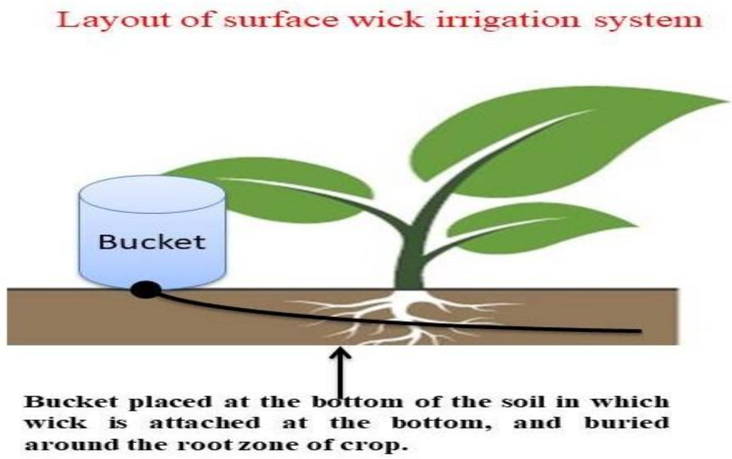

Fig 1: Method of applying water using surface wick irrigation system.

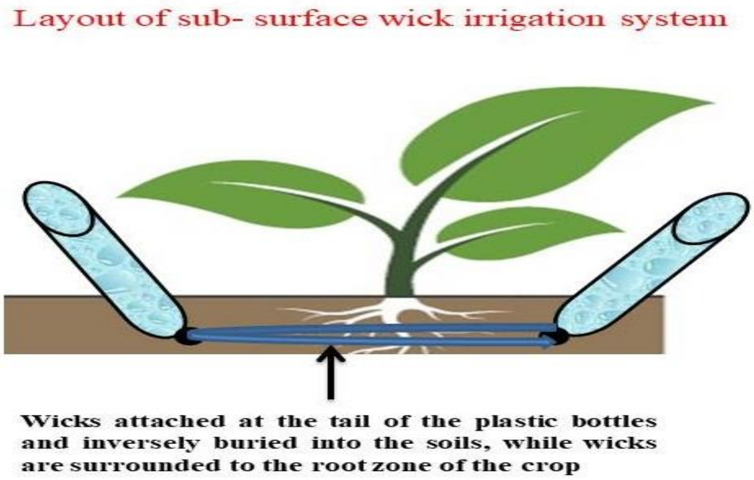

Fig 2: Method of applying water using sub-surface wick irrigation system.

It works equally well on flat or steeply sloping land. Installation does not require much in the way of planning or design, nor highly skilled labor. Because plants hopefully take up water as needed, the system does not require calculations and advanced planning. If the bottle is empty, it is time to add more water. (Wick Irrigation, a sustainable technology available to everyone; Pedro Ochoa Mena; Baracoa; 02/2010)

Advantages of wick irrigation technology

1. Low cost, only wicks and ropes are quite enough to fulfill the requirement.
2. High efficiency for crops with low water requirement.
3. Water consumption is reduced because evaporation is almost eliminated.
4. Less time is needed for refilling containers.
5. There may be fewer problems with salt build-up because the water will not evaporate on the surface and leave salt behind.
6. Auto regulate capability, does not required any external power source.
7. Proper distribution of fertilizer, required fertilizer can be easily dropped in bucket as per requirement.
8. Best practice in countries with dry lands, where water is almost negligible.

Disadvantages of wick irrigation technology

1. Wicks may be blocked due to high load, so buried them within 10-20 cm below the surface of the soil.
2. Cannot handle thirsty plants.
3. Low irrigation volume and speed.
4. can-not suitable plants with high water requirements.
5. It may not be suitable for large-scale irrigation projects, due to low irrigation volume & efficiency.

The major failure of this system in large scale areas is because of its low irrigation volume and low irrigation efficiency for crops with high water requirement, aside of that wicks may be blocked due to heavy weight of soil, inadequate placement of wicks may be lead to water losses, in results the surround plant will no able to take water, several irrigation interval as compare to traditional flood irrigation system, or other HEIS. The system can be improve by increasing WUE with proper wicks installments as per plant requirement's, high quality wicks to avoid the losses by blockage, developing special production equipment, realizing the industrial production of the wick emitters, and facilitating the installation of large-scale projects.

Water Saving and Crop yield under Wick irrigation

Bainbridge (2007), found that irrigation water use efficiency (iWUE) was excellent with a wick irrigation system.The yield watermelon was 33 tons/hectare with the application of 26 cm water by flood irrigation system, theyield watermelon ith pitcher irrigation systemwas 25 tons/hectare with the application of only 2 cm water, and (iWUE) was 165 kg /m3, 13 times of that of flood irrigation.

Comparative study between pitcher and wick irrigations on sandy loam soils is arranged in Sindh Agriculture University, Tandojam, Pakistan in an area of $72m^2$, the results will show that water saving, yield and crop water productivity are high as compare to pitcher irrigation for turnip crops (Bhayo et al., 2018). wick irrigation increased the leaf, stem, and total fresh weight in both foxtail millet and bitter vetch plants compared to surface irrigation In maize, there was no significant difference between irrigation methods in terms of stem fresh weight, but wick irrigation increased leaf and total fresh weight compared to surface irrigation.

Wick irrigation had higher relative leaf water content than surface irrigation. This was probably due to greater and more stable access to water in wick irrigation. Wick irrigation had higher plant and stem height than surface irrigation Wick irrigation outperformed surface irrigation in many characteristics. For example, water use efficiency and dry matter increased by 46 and 43%, respectively. Thus, wick irrigation appears to be one of the best irrigation systems in arid and semi-arid regions and small areas farming, because it requires less cost, water, installation time, maintenance as compare to other micro-irrigation systems in small farms (Zarei et al., 2017).Wick irrigation has been shown to work well and should be considered for fields planting trees and shrubs in establishing an agroforestry system and the environment restoration. It can provide critically needed water while the plants settle in the microorganismscatchment or runoff irrigation systems (Cohen, 2002; Evenari et al., 1982).

(Yeager and Henley., 2004) showed that capillary wick irrigation systems reduced water use by an average of 86% and 81%, respectively, compared to overhead and capillary mat irrigation. Additionally, they reported no runoff from the capillary wick system and an increase in fertilizer use efficiency due to reduced water application. Other benefits noted included reduced human effort (equipment demand automatically controls water supply) and electrical energy consumption (no pumping required). Wick systems tend to be limited to supporting small pot sizes or small non-fruit crops because the amount of nutrients and water it can supply is limited. In addition, capillary wick irrigation systems cannot deliver enough nutrients for high-nutrition crops such as tomatoes (Yane et al., 1947)

Limitations and Future Research Requirements

Wick irrigation systems are widely used in small plots, greenhouses, urban agriculture, and the literature reports several advantages compared to surface irrigation planting systems, considering both economic and environmental aspects. However, each technology seems to have one or more disadvantages as well. These disadvantages may explain why, although capillary irrigation systems are widely used for the cultivation of ornamental and nursery plants, the experimentation and use of such systems for the cultivation of fruit and vegetable crops - for example, in small-scale urban agriculture - is relatively rare. One reason may be that the ebb and flow system tends to be widely used for growing plants in small containers; the use of larger pots required for vegetable crops may require high volume pumps to recirculate the water.

The use of advanced technologies in these systems, such as technical components in the system and the use of computers for precisely scheduled irrigation, made them more complicated and expensive (Roeber et al., 2010). water drawn from the reservoir through the capillary wick may not be sufficient to cover the evapotranspiration rate of larger vegetable plants popular in small-scale farming, such as tomatoes. Furthermore, nutrients can stagnate at the bottom of the reservoir in capillary wick systems if the water is kept still for extended periods of time. The periodic application of water in ebb and flow irrigation systems results in frequent wet and dry cycles in the root zone, while capillary wick irrigation provides a continuous supply of water, which can often lead to the application of excess water in some low-water or drought-tolerant plants.

II. Conclusion and Suggestion

Water saving and crop water productivity using wicking system in small areas was quite beneficial because it does not require any planning, high installing or maintenance cost, skilled labors. Simple plastic bottles (container) collected from any area were connected with ropes (wicks) and half buried into the soil. Hence plants take water as much as it wants.

Wick Systems are passive, meaning they have no moving parts. This makes them easier and cheaper to maintain than active system such as Flow, but they also have the disadvantage of being less efficient and not well equipped for high maintenance plants or large plants that use a lot of water, it cannot handle very thirsty plants.

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