Subsurface Indirect Drip Irrigation with Porous Reservoirs

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Abstract

The research is subsurface indirect drip irrigation with porous reservoirs relates particularly to a drip irrigation system for extreme scarcity of water. It includes water nozzles mounted on main water line, directly connected to the mouth of porous reservoirs and the complete system is subsurface around the plant roots. This method is useful for watering plants, mainly horticulture and medium plants, in extreme drought conditions with minimal water. The porous reservoir waters the plant roots only by seepage. The proposed method tackles many issues in conventional drip irrigation system and has many advantages like no evaporation, no weeds, no frequent watering, simple structure, low cost, ecological and long life subsurface drip irrigation with increased water holding ability. This system will facilitate economically growing plants even in extreme drought conditions with minimal water. The proposed innovation has the potential to bring the large barren land under plantation and save the ecosystem.

Keywords: *Subsurface Drip irrigation, Indirect Drip Irrigation, Porous Reservoirs, Plantation*

Introduction

Drip irrigation system is now widely used for irrigation, to tackle water shortage. Conventional drip irrigation system was developed to irrigate crops and plants, drop by drop. The drip irrigation system has many advantages over conventional canal irrigation system. The water requirement has drop down considerably. It also has facilitated fertilization through drip irrigation and has resulted in saving of time, efforts and effective utilization of water and fertilizers. Thus it has resulted more crop per drop. Still the method is not giving full benefits to its maximum potential.

The conventional drip irrigation system provides water close and around the plant, drop by drop for a specified period. That facilitates irrigating the plants avoiding wastage, reducing sand washout, providing fertilizers and pesticides. Still the water is dropped on the surface of the land and needs little more water to percolate deep till the roots of the plants for its actual utilization. The part amount of the water dropped on the surface of the land is again evaporated and some is used by the weeds (unwanted grass and plants) around the crop plant. Some areas are so drought-prone that they don’t have even that much amount of water.

Further drought-prone areas don’t have enough water to drip irrigate daily and hence need certain storage device or facility, which is not possible with current arrangement.

Review of Literature

A comprehensive review of published information on subsurface drip irrigation was performed to determine the state of the art on the subject. Subsurface drip irrigation has been a part of drip irrigation development in the USA since its beginning about 1960, but interest has escalated since the early 1980s. Yield response for over 30 crops indicated that crop yield for subsurface drip was greater than or equal to that for other irrigation methods, including surface drip, and required less water in most cases. Lateral depths ranged from 0.02 to 0.70 m and lateral spacings ranged from 0.25 to 5.0 m. Several irrigation scheduling techniques, management strategies, crop water requirements, and water use efficiencies were discussed. Injection of nutrients, pesticides, and other chemicals to modify water and soil conditions is an important component of subsurface drip irrigation. Some mathematical models that simulate water movement in subsurface drip systems were included. Uniformity measurements and methods, a limited assessment of root intrusion into emitters, and estimates of overall system longevity were also discussed. (Camp, 1998)

The aim of 'Determination of optimum irrigation strategies and effect of drip irrigation system' was to explore suitable drip irrigation system on the water saving and high yield of pear-jujube from 2009 to 2012 years in the mountain of northern Shaanxi. The treatments consisted of combinations of 5 drip irrigation systems (DP). (Ye, Han, & Liu, 2019)

Surface drip irrigation is widely used to irrigate perennial crops (trees and vines) and annual row crops. However, because the design and management of irrigation systems for these types of crops are different, this chapter addresses the two cropping systems separately. The design of surface drip irrigation systems for trees and vines is similar. Polyethylene drip tubing with on-line drip emitters is very common, but built-in or fused-in drip emitters are also used. Thin-walled collapsible emitting hoses, commonly referred to as drip tapes in the United States, are frequently used to irrigate annual crops, but seldom used to irrigate permanent crops because these drip-lines do not have the longevity required. (Schwankl & Hanson, 2007)

A field experiment was conducted to study the effect of different level of drip irrigation along with various fertigation level on growth, yield and water use efficiency in fennel during Rabi season of 2010-11 at Swami Keshwanand Rajasthan Agricultural University, Bikaner. (Godara & Verma, 2013)

The main objective of this study was to explore the viability of drip irrigation for organic spinach production and the management of spinach downy mildew disease in California. The experiment was conducted over two crop seasons at the University of California Desert Research and Extension Center located in the low desert of California. Various combinations of drip line spacing and installation depths were assessed and compared with sprinkler irrigation as control treatment. Comprehensive data collection was carried out to fully understand the differences between the irrigation treatments. Statistical analysis indicated very strong evidence for an overall effect of the irrigation system on spinach fresh yields, while the number of drip lines in bed had a significant impact on the shoot biomass yield. The developed canopy crop curves revealed that the leaf density of drip irrigation treatments was slightly behind (1–4 days, depending on the irrigation treatment and crop season) that of the sprinkler irrigation treatment in time. The results also demonstrated an overall effect of irrigation treatment on downy mildew, in which downy mildew incidence was lower in plots irrigated by drips following emergence when compared to the sprinkler. The study concluded that drip irrigation has the potential to be used to produce organic spinach, conserve water, enhance the efficiency of water use, and manage downy mildew, but further work is required to optimize system design, irrigation, and nitrogen management practices, as well as strategies to maintain productivity and economic viability of utilizing drip irrigation for spinach. (Montazar & Cahn, 2019)

An alternative subsurface irrigation method that is able to avoid most of the aforementioned drawbacks has been introduced in southern Spain. The objective of this work is to assess the performance of this method and to compare it to a surface drip-irrigation system. To achieve this objective, a three-year field experiment was carried out in an organic olive orchard (*Olea europaea* L.) located in the province of Almería, Spain. The water-use efficiency of both irrigation methods was analyzed under three different irrigation water supplies. The results show that the alternative subsurface irrigation method seems to perform better than the drip irrigation one because the yield and the irrigation water use efficiency were higher for the first one. (Martinez & Reca, 2014)

Use of subsurface drip irrigation (SDI) has progressed from being a novelty employed by researchers to an accepted method of irrigation of both perennial and annual crops. This paper reviews the SDI research conducted by scientists at the Water Management Research Laboratory over a period of 15 years. Data are presented for irrigation and fertilization management on tomato, cotton, sweet corn, alfalfa, and cantaloupe for both plot and field applications. (Ayars, Phene, Hutmacher, Davis, Schoneman, & Mead, 1999)

Objectives of the research

The objectives of this research are to develop effective drip irrigation system which overcome the deficiencies of the earlier all methods of drip irrigation system. Figure 1 shows the proposed subsurface indirect drip irrigation system with porous reservoirs around the plant. The water nozzles of the proposed drip irrigation system are directly connected to the mouth of the reservoirs and the reservoirs are filled with water with the system. No water is dropped elsewhere in this system. This ensures no water on the surface of land and hence no evaporation losses and no weeds are grown. The water seepage from the reservoir will keep the surrounding soil wet and will help the plant to sustain and grow. Further, the watering intervals can be prolonged, in case of extreme water scarcity and still the reservoirs will ensure wetness for longer durations facilitating the plant to survive. From minimum 1 reservoir to 8 reservoirs can be placed in the close periphery of the plant. The number of reservoirs can be increased, ensuring balance of watering from all sides of the plant, depending upon the type and variety of the plant, climatic conditions and water availability. The reservoir arrangement is described in Figure 2, 3 & 4.

The subsurface indirect drip irrigation system

In accordance with the present research, the proposed subsurface indirect drip irrigation system is a low cost, sustainable system which stores and provides water to the plant roots through seepage only. The system has submerged water piping and the watering nozzles are pressed in the mouth of the reservoirs which are submerged in the close periphery of the plant. So minimal water is provided to the plants through seepage and that keeps the surrounding wet. Further the system facilitates prolonged watering intervals in case of extreme drought conditions and still keeps the soil wet for longer durations and help plants survive longer periods without watering. It restricts evaporation as no watering is done at the surface of soil and restricts weeds also.

The proposed subsurface indirect drip irrigation system overcomes the deficiencies in the prior art and provides a very low cost, no maintenance system using minimal water and thus useful even in extreme water scarcity for survival of the plants. The system is submerged and hence not possible to remove and place again and again and hence useful in case of horticulture or other medium plants.

Figure 1 - Schematic diagram of the proposed mode

Figure 2 -Schematic diagram of reservoir arrangement for plantation distance more than 5’*5’

Table 1 – Angle between pots

No. of Pots	Angle between pots	
2	360/2	180
3	360/3	120
n	360/n	360/n

The angle of porous reservoirs or clay pots around the plant can be decided using above formulae, based on the plantation type and requirement of the particular plant species. Further, if required, initially less number of pots can be placed and then number can be increased subsequently as per the need of the plant.

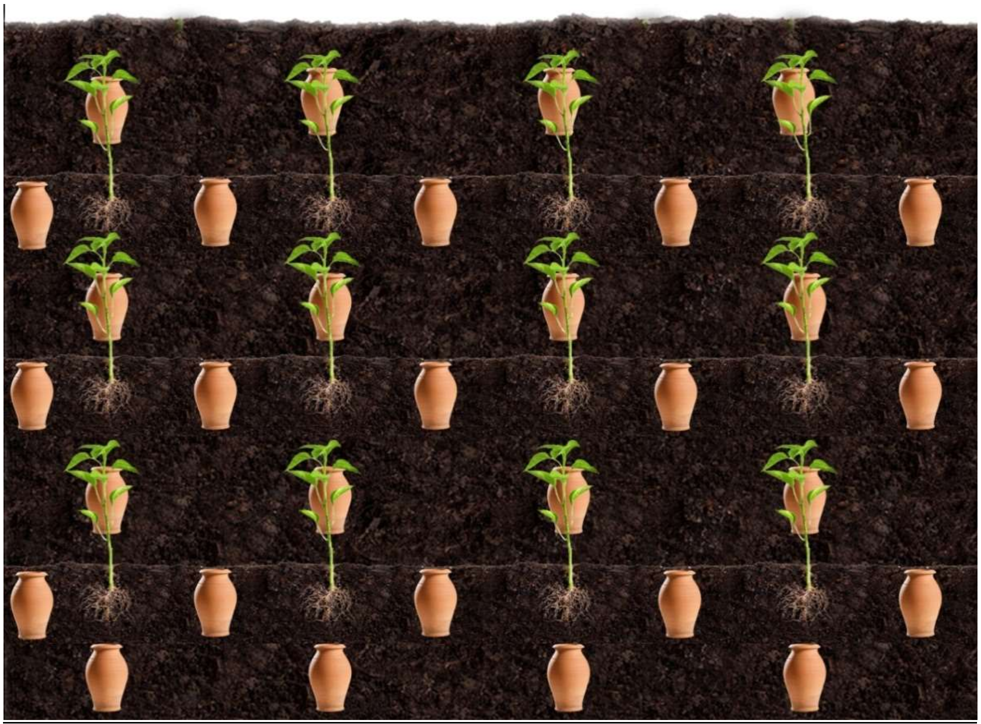

Figure 3: Schematic diagram of reservoir arrangement for plantation less than 5'*5'

Figure 4 - Schematic diagram of reservoirs arrangement for alternate plantation

The objectives of the research are accomplished and the problems and shortcomings associated with prior art techniques and approaches are overcome by the present research. As shown schematically in Figure 1, the proposed subsurface indirect drip irrigation system will be submerged in the soil preferably more than 2" so that it will not come to the surface accidently. This subsurface indirect drip irrigation system is related to a drip irrigation system for extreme scarcity of water. It includes water nozzles (2) and (2a) mounted on main water line (1) and directly connected to the mouth of porous reservoirs (3) and (3a) and the complete system is subsurface around the plant roots. The quantity and location of the reservoirs for each plant can be chosen depending upon the type and variety, climatic conditions and water availability. The typical locations are described in Figure 2 based on number of reservoirs ranging from 1 to any number 'n' where plantation of large trees is more than 5'*5'. Balance watering from all sides is the main objective of using more reservoirs. So two reservoirs can be placed 180 degree apart, three reservoirs can be placed 120 degree apart, four reservoirs can be placed 90 degree apart and so on. This will ensure water from all sides and help growth of roots in all directions for better strength and growth. The similar typical locations are described in Figure 3 but more suitable for medium plants where plantation is less than 5'*5'. So in such cases, the reservoirs can be shared between two plants and thus the number of reservoirs can be saved. This will further save water quantity. Figure 4 describes the clay pot arrangement for alternate plantation where the reservoirs can be shared with more plants.

Once the drip system is switched on, the water will flow to the reservoirs and fill the reservoirs. The water then will make the surrounding soil wet by way of seepage. The watering only through seepage will ensure minimal but continuous watering to the plants. As the reservoirs are filled with water, the watering intervals can be prolonged, in case of extreme water scarcity. Further, all the water available will be filled in the reservoirs effectively, without any wastage and evaporation. Even in extreme conditions when no water is available, it will maintain certain wetness and coolness around the plant and help plants to survive. Whenever little water is made available, it can be filled in the reservoirs directly and will go to the roots effectively.

Best method to use this invention is to use clay-pots as the reservoirs and these clay-pots has inherent porous characteristics. Additionally, after use, there is no need to remove them as they do not contaminate the soil. The clay-pots cost is also low as compared to other reservoirs.

Summary

The present research, the proposed subsurface indirect drip irrigation system is a low cost, sustainable system which stores and provides water to the plant roots through seepage only. The proposed subsurface indirect drip irrigation system overcomes the deficiencies in the existing drip irrigation system and provides a very low cost, no maintenance system using minimal water and thus useful even in extreme water scarcity for survival of the plants. The system is submerged and hence not possible to remove and place again and again and hence useful in case of horticulture or other medium plants.

The existing drip irrigation system is beneficial only in the areas where considerable water is available during summer. But there is ample land still barren where the farmers in such resource-poor area cannot do plantation due to non-availability of water in peak summer. The proposed system has potential to water the plants in such areas with very minimal water. Hence the proposed innovation has the potential to bring the large barren land under plantation and save the ecosystem. Also it will provide earning source to the resource-poor families in addition to the nature conservation. Further it will generate employment opportunities to the potter community as well. The proposed innovation is the best example of Indian frugal innovation, using locally available clay pots as reservoirs for extreme draught prone area and facilitate plantation in the barren land for plantation and nature conservation. Thus it is frugal way to bring barren land under plantation and create earning opportunities for resource-poor families in addition to the nature conservation and sustainability. The overall cost of the proposed system will be almost comparable with existing drip irrigation system, with marginal cost impact of porous reservoir (mostly clay pots) which are easily available locally in very affordable cost.

The objectives of the research are accomplished and the problems and shortcomings associated with conventional techniques and approaches are overcome by the present research as described.

Advantages:

1. The subsurface indirect drip irrigation system facilitates watering the plants through seepage, thus ensures watering with minimal water, so useful in drought prone areas.
2. It has many advantages like no evaporation, no weeds, no frequent watering, simple structure, low cost, ecological and long life subsurface drip irrigation with increased water holding ability.
3. It has potential to bring barren land under plantation and nature conservation.

Note

The innovation is filed for patent and published by India Patent office - Application No. 201821006321 A, Publication No. 34/2019 Dated 23/08/2019

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