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Full Length Research Paper

Application of sand and geotextile envelope in subsurface drip irrigation

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Subsurface drip irrigation is a technology used for better management of irrigation water. This technique is more desirable in arid and semi-arid region, because of decreasing soil surface evaporation and more efficiency of irrigation system in comparison with the other irrigation systems. In addition, this system is a safer way for treated wastewater (TWW) reuse in irrigation lands. But roots and clay particles can clog drip emitters in systems buried below the soil surface. In this paper, sand and geotextile filtration methods have been suggested for solving root intrusion and biological plugging problems for subsurface drip applications. Sand envelope around the emitters has been recommended for deeper root zone and long term application of system, while geotextile envelope is suitable for seasonal crops with shallow root.

Key words: Subsurface drip irrigation, sand and geotextile, emitters.

INTRODUCTION

Drip or trickle irrigation is a very efficient method of applying water and nutrients to crops (Lamont et al., 2002). For many crops, the conversion from surface and sprinkler irrigation to drip irrigation can reduce water use significantly. Crop yields can increase through improved water and fertility management and reduced disease and weed pressure. When drip irrigation is used with polyethylene mulch, yields can increase even further (Lamont et al., 2002).

Two basic types of drip lines are most commonly used for commercial vegetable production, with turbulent flow drip tape. This polyethylene product is thin-walled which collapses when not pressurized, and has emitters formed into its seam during manufacturing. Drip tapes are operated at pressures ranging from 6 to 15 psi. Drip tubes with internally attached emitters are an alternative to turbulent flow drip tapes. Products with in-line or internally attached emitters tend to be more expensive, but often have better water distribution uniformity and better clogging resistance.

These products are common in permanent applications, such as subsurface drip irrigation, landscapes, or orchards (Lamont et al., 2002).

Three types of chemicals are typically injected into drip irrigation systems: fertilizers, pesticides and anti-clogging agents. Fertilizers are the most common; the ability to “spoon-feed” nutrients is partially responsible for the yield increases resulting from drip irrigation. Systemic pesticides are also frequently injected into a drip irrigation system to control insects and protect plants from disease. Chemicals that prevent or repair clogging problems are also injected. Chlorine is used to kill algae and acids are used to modify water pH and dissolve certain precipitated clogs. In contrast, injecting chemicals to prevent clogging requires an accurate and very low injection rate. Since these materials are usually injected continuously at concentration rates of 1 to 10 ppm, a separate injector is often used. Positive displacement, pressure differential and water powered injectors make up the majority of injectors used for chemigation (Lamont et al., 2002).

Subsurface drip irrigation (SDI) is a low-pressure and high efficiency irrigation system that uses buried drip tubes or drip tape to meet crop water needs. SDI technologies have been a part of irrigated agriculture since the 1960s, with the technology advancing rapidly in the last two decades. A SDI system is flexible and can provide

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Abbreviations: TWW, Treated wastewater; **SDI,** subsurface drip irrigation; **BOD_5,** biological oxygen demand$_5$; **COD,** chemical oxygen design.

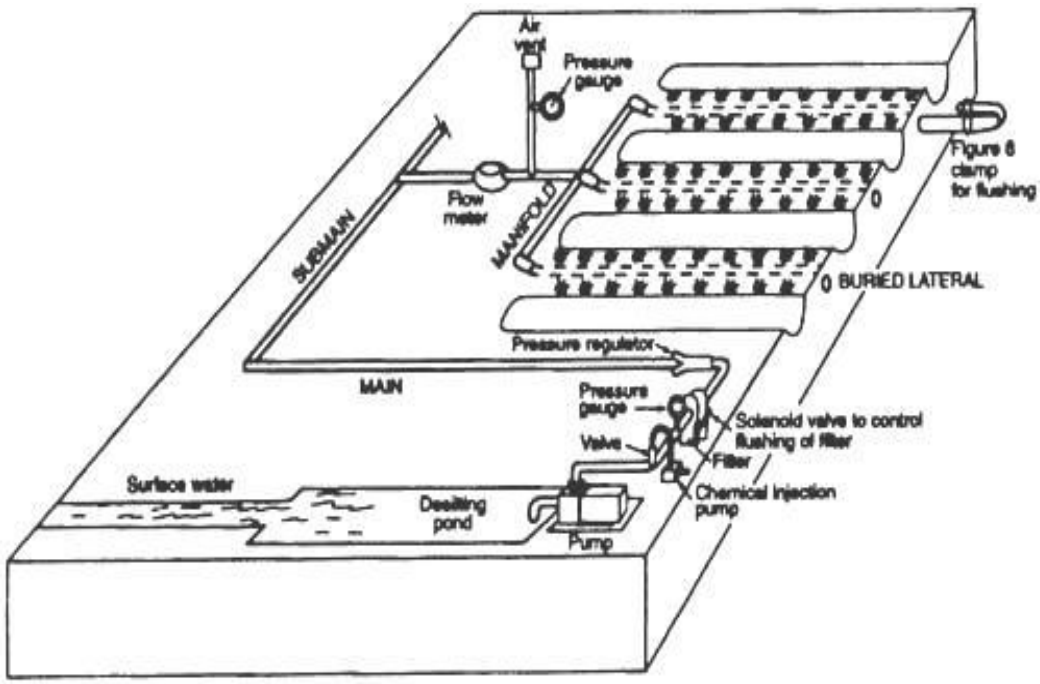

Figure 1. A typical subsurface microirrigation field layout (Reich et al., 2009).

frequent light irrigations. This is especially suitable for arid, semi-arid, hot and windy areas with limited water supply. Farm operations also become free of impediments that normally exist above ground with any other pressurized irrigation system (Reich et al., 2009). SDI is an efficient and cost effective method to irrigate agricultural crops, landscape and turf areas and to reuse or dispose effluent water. Roots and clay particles can clog drip emitters in systems buried below mulch or below the soil surface and this tendency historically limited the service life of the system (Geoflow, 2009). Tabatabaei and Najafi (2005) reported that in the case of SDI, due to minimal leaching, prevalence contamination (such as $N\text{-}No_3$) is minimized as a result of the usage of treated wastewater (TWW) in depth and groundwater.

Filters are essential to the operation of a drip system. Many devices and management techniques are available for filtration of irrigation water. Depending on the water source, settling ponds, self-cleaning suction devices, sand separators, media filters, screen filters and disk filters are used with drip irrigation systems (Lamont et al., 2002).

Clogging is a phenomenon which usually happens in a drip irrigation system, because of negative pressure at pump turn off and root growing toward the emitters. It has more risk in SDI. Keeping a drip system free of debris is critical because most clogs will irreparably disable a system.

The objective of this paper is to present a suggestion for solving the above mentioned problems. This suggestion provides controlled-release devices that establish clay and root barrier zone.

MATERIALS AND METHODS

A typical SDI system layout consists of a settling pond (where possible), pumping unit, pressure relief valve, check valve or one-way valves, a hydrocyclone separator (when a pond is not feasible to take out the coarse materials), chemical injection unit, filtration unit equipped with back-wash control solenoid valves, pressure regulators, air vent valves and polyvinyl chloride (PVC) pipe lines delivery system to carry the water to the field (Reich et al., 2009). Figure 1 shows a typical SDI system through a field.

This paper suggests an envelope (filter) unit around the emitters, in addition to a traditional filtration unit that are generally install in the beginning of a drip irrigation system. Based on this suggestion, two types of filtration for different conditions have been presented: sand media and geotextile filtration. The sand media is suitable for plant with deeper root zone and longer plant season. Sand envelope is installed around the emitters with about 5 cm thickness (Figure 2). The particles size is applied bigger than emitter opening. Material can be provided by sillies, prelate or zeolite.

In terms of geotextile, high density geotextile is applied for covering around the emitter opening. Easier installation and thinner thickness are two advantages of this method, but shorter survival and less capacity are the main disadvantages of geotextile application. This method is suitable for seasonal crops with surface distribution of root.

In addition, when low quality water such as wastewater is used, it is possible to inject many pollution ions and parameters to soil and cause health and environmental impacts. Furthermore, it is essential to have a filtration unit that will filter all the particles that are bigger than the emitter openings.

RESULTS AND DISCUSSION

Roots and clay particles can clog drip emitters in systems buried below mulch or below the soil surface, and this

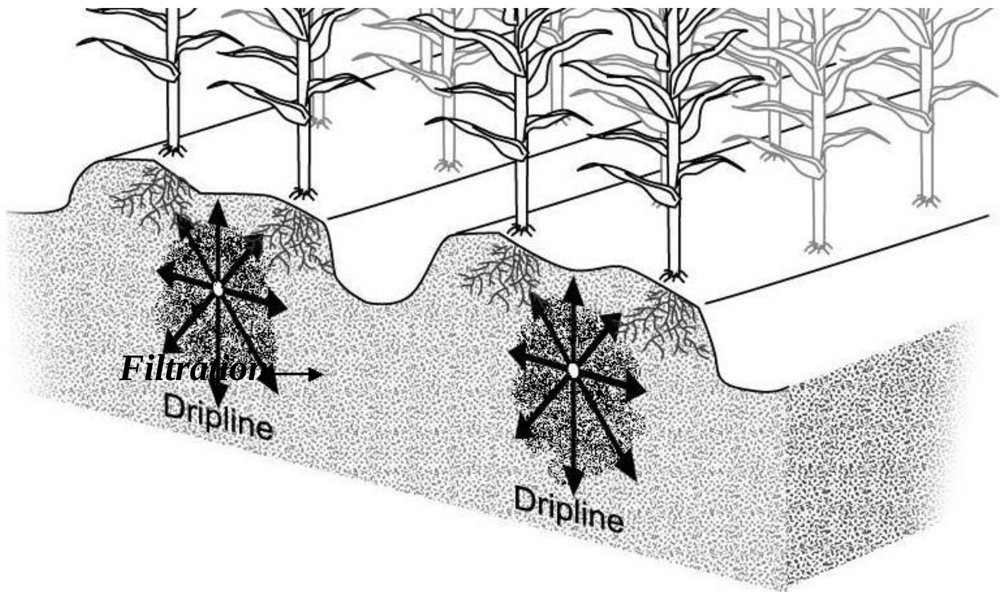

Figure 2. Sand filtration around the emitter opening.

Figure 3. Root density around the emitter opening in SDI system.

ztendency historically limited the service life of the system (Geoflow, 2009). In the condition of SDI system, more volume of roots moved around emitters (Figure 3) and high density of root near source point of moisture caused clog emitters. Application envelope around the emitters applies a burier layer.

In arid and semi-arid region, because of low quality of irrigation water, poor soil quality and unsuitable condition for plant coverage, the soil structure is unsustainable. Therefore, fine particle of soil move to emitter opening after the turn off of the SDI system and finally can make problem for emitters. Applying sand filtration based on d_{10} and d_{60} of effective diameter of soil and choosing high density of geotextile texture is essential to providing safe condition for SDI emitters.

SDI system as compared to other irrigation methods reduces considerable surface evaporation (Najafi and Tabatabaei, 2007). This reduction depends on depth of emitter placement. Emitter's envelope is a parameter which can potentially affect the soil surface evaporation and soil moisture pattern. Lanjabi (2009) showed that because of more contact between soil and the geotextile envelope, soil moisture pattern tend to be distributed more horizontally in a sand-loam soil and high density geotextile. In this case, a higher soil surface evaporation is expected. Therefore, this method is suitable for crops with shallow distributed root. On the other hand, sand envelope has a thicker layer and lower hydraulic conductivity in comparison with the geotextile, so it will cause a more vertically and narrower soil moisture pattern, therefore less evaporation will occur. Based on this reason, this method is acceptable for crops with deep root.

Irrigation with wastewater could raise issues relating to sanitary (risk of viral and bacterial infection both for farmers and crops) as well as agronomic nature (due to the presence of toxic substances). In order to avoid health hazards and damage to the natural environment, wastewater must be treated before been used for agricultural and landscape irrigation (Pereira et al., 2002). This criterion has to comply with the reuse standards so that environmental and health risks could be reduced. Filtration of water in a SDI system could enhance the water quality with regards to health concerns (Tabatabaei and Najafi, 2009). Application of SDI can decrease the wastewater reuse problems (e.g health concerns). This system is suitable for irrigation of landscapes, agricultural farms and gardens by wastewater. In this method, it is very crucial to inject wastewater through the root zone area for improving the wastewater quality Therefore, installing, monitoring and maintenance of the SDI system need to use new drilling system such as trenchless technology (Najafi and Tabatabaei, 2009). Emitter envelope serves as a supplemental treatment for decreasing the environmental and health impacts. The envelope acts to reduce the amount of suspended solids and dissolved organic material present in the water. The most common suspended solid is algae. Microorganisms attached to the sand particles are able to aerobically digest the organic material within the wastewater. This filtration can affect many of the quality parameters such as biological oxygen demand$_5$ (BOD_5) and chemical oxyben design (COD).

Conclusion

Clogging is a phenomenon which usually happens in a drip irrigation system, due to the negative pressure at pump turn off and root growing towards the emitters. There are more risk in SDI. Application of sand and geotextile envelope in SDI emitter is a new suggestion for controlling the clog of emitter opening. Sand envelope around the emitter has been recommended for deeper root zone and long term application of system, while geotextile envelope is suitable for seasonal crops with shallow root. In addition, the above mentioned filters can provide better hydraulic conductivity around the outside of the emitter. Moreover, when marginal quality water such as wastewater is reuse, filter could affect pollution parameters of irrigation water and decrease the environmental hazards.

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