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A review on role of micro irrigation for modern agriculture

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Abstract
Irrigation improves economic returns and can raise productivity by up to 400% in desert and semi-arid areas. The main issues with conventional (surface irrigation) irrigation in arid and semi-arid regions, however, include soil salinity, soil alkalinity, soil dispersion, soil infertility, a rise in the water table, and pollution of the surface and underground resources as a result of over-irrigation practices and excessive chemical agri-input application Micro irrigation is a technique used to deliver water and nutrients directly to plant roots in small amounts, as opposed to traditional irrigation methods that apply water to entire fields. This method provides many benefits to modern agriculture, including higher yields, better quality crops, and reduced water usage. Hence, current irrigation methods (micro irrigation) consume 5000–6000 m3 of irrigation water per hectare, but conventional irrigation uses more than 10 000 m3 per hectare. The effects of micro-irrigation technology on agricultural water consumption, crop production, the environment, efficient fertilizer usage, sustainability, and earnings for contemporary agriculture in Turkey and throughout the world are discussed in this study.

Keywords: Environment, micro irrigation, sustainability, water saving

Introduction
Agriculture is one of the most vital sectors in the global economy, feeding billions of people every day. However, this industry is facing increasing challenges, including water scarcity, climate change, and soil degradation. To sustainably meet the growing demand for food, modern agriculture needs to adopt innovative techniques that are more efficient, eco-friendly, and cost-effective, Utilization of water in agriculture is particularly essential for agricultural productivity and to lower the danger of drought. World water use in agriculture is roughly 70%, not just in Turkey but also around the world. As the world's largest consumer of fresh water, irrigation is under pressure to improve its efficiency. More effective irrigation water usage is required to boost irrigation's contribution to food production (FAO, 2003) [28]. Water-saving technology, especially drip irrigation, provides the dual benefits of reducing salinization and increasing yields. This is a significant advantage. Moreover, brackish water may be used with either approach for crops that are not very sensitive to salinity because neither method puts water in contact with the leaves (Cetin, 2004) [29]. Micro-irrigation, which is the targeted application of water on or beneath the soil surface at low pressure using tiny devices that spray, mist, sprinkler, or drip water, is becoming more alluring in light of irrigation efficiency and environmental concerns (Hla and Scherer, 2003) [25]. Micro-irrigation has been widely used in recent decades as a consequence of rising sales and technological advancements. A typical type of micro-irrigation is drip irrigation. According to irrigation statistics, the number of acres irrigated with drip irrigation has increased quickly across many nations (Madramootoo and Morrison, 2013) [30].

Use of Micro-Irrigation for Agriculture
A) Effect of Micro-Irrigation on Crop Yield and Water Saving
When compared to other irrigation techniques, micro-irrigation may use less irrigation water. Less water is evaporated as a result of the smaller wetted area. There is virtually no surface drainage in these systems.

In comparison to traditional irrigation techniques, micro irrigation offers a steady supply of water in the crop zone and has been shown to boost crop output and water usage efficiency.

In numerous applications, including irrigation of most vegetables, cotton, sugar cane, orchard, and vineyard crops, Postel asserts that drip irrigation has the potential to at least double crop production per unit water. A compilation of study findings from multiple Indian research institutes shows that drip irrigation often reduces water usage by 30–60% while typically increasing yields by 20–50% for a range of crops, including cotton, sugarcane, grapes, tomatoes, and bananas. According to Gleick, switching from traditional surface irrigation to drip irrigation in India enhanced water production overall by 42–255% for a variety of crops, including bananas, cotton, sugar cane, and sweet potatoes. Micro-irrigation is becoming more popular as a solution to combat water shortage and poverty due to its high-water usage efficiency. Shah and other researchers have highlighted the water savings and increased yields brought on by micro-irrigation (Table 1). Farmer income and food security are raised in addition to farm productivity. Labour expenses decrease with early harvests. Drip-irrigated crop quality improvements have also been noted.

Table 1: Drip and surface irrigation- water saving and increase in yield (Shah, 2011)

Crop	Yield (kg ha-1)			Irrigation		
	Surface	Drip	Increase %	Surface	Drip	Saving %
Beetroot	570	880	54	86	18	79
Bitter gourd	3200	4300	34	76	33	57
Broccoli	14000	19500	39	70	60	14
Chili	17100	27400	60	27	18	33
Cucumber	4230	6090	44	109	42	62
Potato	17200	29100	69	60	28	54
Tomato	6180	8870	44	50	11	79

The investigations on the impact of drip and traditional irrigation technologies on the yields of tomato, strawberry, banana, and citrus were carried out in Turkey by Tekinel *et al.* in 1989 [32]. The findings demonstrated that drip irrigation produced the best yields and crop quality. Moreover, Cetin (1996) [33] experimented on second-crop maize in Turkey's Harran Plain utilizing a surface (furrow) type of irrigation, and the highest. Yield of 10 150 kg/ha and calculated the amount of irrigation water needed for maize to be 1303 mm. Using furrow irrigation, Deirmenci conducted research in the same plain and recorded an average grain production of 9,260 kg/ha and 873 mm of irrigation water. With second-crop maize, Yazar achieved the greatest yield of 11,920 kg/ha by employing drip irrigation and applying 581 mm of irrigation water. In comparison to surface watering, drip irrigation might save as much as 55%, according to the research, while potentially increasing grain output by 15 to 23%. Studies on cotton in Turkey's Harran Plain have shown that furrow irrigation can meet water requirements of 1148 mm 1113 mm and 937 mm Whereas Cetin and Bilgel demonstrated that the water need for cotton could be reduced to 619 mm using drip irrigation in order to get a yield that was close to the same. As a consequence, drip irrigation increased cotton productivity while simultaneously saving a significant amount of water. According to Cetin el experiment findings, the average fruit production of fresh market tomatoes irrigated by drip was 132.2 t/ha, whereas the yield was 54.8 t/ha under conventional irrigation and local circumstances in Eskisehir.

B) Environmentally Effects of Micro-Irrigation on Soil and Water Resources

The ability of the system to utilize water with a rather high salt content is another important benefit of micro-irrigation systems. Moreover, both treated and untreated wastewater can be used in a way that only targets acceptable crops. Due to the lack of aerosol production and wastewater interaction with plant leaves, micro-irrigation is better suited for the reuse of wastewater than conventional irrigation techniques. Moreover, there are fewer issues with drainage, ponding, and odours. Also, research indicates that applying nitrogen directly to plant roots improves plant absorption and reduces the likelihood of groundwater contamination. It's crucial to prevent emitters from clogging when using wastewater for micro-irrigation. To maintain a uniform application and complete operation, the system has to be regularly watched. Contrarily, as compared to traditional irrigation, micro irrigation adds far less salt to the soil. According to research findings provided by Cetin and Bilgel, the water requirements for cotton in Turkey's Harran Plain for furrow and drip irrigation are roughly 1000 mm and 600 mm, respectively. The amount of salt in the soil is 0.2% if the salinity threshold value of 4 dS/m is reached. The salinity threshold value (10000 m2 x 0.90 m x 1.35 t/m3 x 0,002 =24.3 t/ha) is the salt content of the soil for 0.90 m of the effective root depth. This estimate shows that salt is introduced to the soil through drip irrigation and furrow irrigation at rates of 1.536 and 2.56 t/ha/year, respectively. Since drip irrigation uses less water than furrow irrigation, substantially less salt accumulates in the soil as a result (Cetin, 2004) [29].

Benefits of micro irrigation

Micro irrigation offers numerous benefits to modern agriculture, some of which are

Increased Crop Yields: By delivering water and nutrients directly to the root zone, micro irrigation ensures that plants receive optimal amounts of water and nutrients, leading to improved crop yields and higher quality crops.

Water Conservation: Micro irrigation systems are designed to deliver water in small, precise amounts, reducing water waste and increasing water use efficiency. Compared to traditional irrigation methods, micro irrigation can save up to 60% of water.

Reduced Labor Costs: Micro irrigation systems are automated and require less manual labor, reducing the costs associated with irrigation management, such as labor, equipment, and energy.

Improved Soil Health: By applying water and nutrients directly to the root zone, micro irrigation promotes healthy root growth, leading to improved soil structure, nutrient uptake, and soil health.

Reduced Fertilizer Use: Micro irrigation systems can deliver nutrients directly to the root zone, reducing the amount of fertilizers required for crop growth. This leads to cost savings and reduced environmental impact.

Reduced Weed Growth: By delivering water directly to the root zone, micro irrigation systems limit the amount of water available to weed seeds, reducing weed growth and competition with crops.

Adaptability to Various Crop Types: Micro irrigation systems can be adapted to various crop types, including row crops, fruit trees, vegetables, and turf, making it a versatile irrigation technique.

Overall, micro irrigation provides numerous benefits to modern agriculture, improving water use efficiency, crop yields, and soil health while reducing costs and environmental impact.

Classification of micro irrigation system

Micro irrigation systems can be classified into two main categories based on the way water is applied to the plants:

Drip Irrigation: In this system, water is delivered directly to the plant's root zone through small, slow-emitting devices called drippers. Drip irrigation is a highly efficient method of irrigation, as it minimizes water loss due to evaporation and runoff. It is commonly used for row crops, fruit trees, and vegetables.

Micro-Sprinkler Irrigation: In this system, water is applied in small droplets through sprinkler heads, which are designed to deliver water in a gentle, uniform pattern. Micro-sprinkler irrigation is particularly suitable for irrigating orchards, vineyards, and other permanent crops.

Micro irrigation systems can also be classified based on their operation and design:

Surface Drip Irrigation: This system involves laying drip lines on the soil surface, delivering water directly to the root zone. This method is commonly used for row crops, vegetables, and fruit trees.

Subsurface Drip Irrigation

In this system, drip lines are buried beneath the soil surface, delivering water directly to the root zone. This method reduces water evaporation, minimizes soil erosion, and can improve crop yields.

Micro-Sprinkler System

This system involves a series of micro-sprinklers placed along the crop rows, delivering water in a fine mist or spray. This method provides uniform water distribution and is commonly used for orchards, vineyards, and other permanent crops.

Micro-Bubbler System

This system involves a series of small bubbler emitters that apply water directly to the soil surface, creating a small basin around the plant. Micro-bubbler systems are commonly used for trees, shrubs, and landscape plants.

In summary, micro irrigation systems can be classified based on the way water is applied to the plants (drip or micro-sprinkler) and their operation and design (surface or subsurface drip, micro-sprinkler, or micro-bubbler).

Area and Scope of Micro-irrigation

The area and scope of micro-irrigation are vast and can be applied in various sectors, including agriculture, landscaping, and urban forestry.

Agriculture

Micro-irrigation systems are widely used in agriculture for crop production. It is particularly useful in arid and semi-arid regions with limited water resources, where water scarcity is a significant constraint to agricultural production. Micro-irrigation can be used for a wide range of crops, including vegetables, fruit trees, row crops, and horticultural crops.

Landscaping

Micro-irrigation systems are commonly used in landscaping for watering lawns, gardens, and other ornamental plants. This method provides a more efficient way of watering landscapes compared to traditional overhead irrigation systems.

Urban Forestry: Micro-irrigation systems can be used for urban forestry to maintain the health of trees and plants in urban environments, where soil conditions are often poor, and water resources are limited. Micro-irrigation can improve the survival rate and growth of trees and plants in urban settings.

Greenhouses: Micro-irrigation systems can be used in greenhouses for growing vegetables, flowers, and other crops. Micro-irrigation systems provide precise control of water and nutrient delivery, leading to higher yields and improved crop quality.

Aquaculture: Micro-irrigation systems can be used in aquaculture for providing oxygen and nutrients to fish and other aquatic organisms. Micro-irrigation can also be used for hydroponic farming, where crops are grown in nutrient-rich water without soil.

In summary, the area and scope of micro-irrigation are vast and can be applied in various sectors, including agriculture, landscaping, urban forestry, greenhouses, and aquaculture. Micro-irrigation provides a more efficient and sustainable way of delivering water and nutrients to plants and aquatic organisms, leading to higher yields, improved crop quality, and reduced water usage.

Result and Discussion

Microirrigation systems offer several advantages for modern agriculture, as evidenced by the results discussed above. The water-saving potential of microirrigation is crucial, particularly in regions facing water scarcity, where farmers must maximize water use efficiency to sustain agricultural production. By minimizing water losses through evaporation and runoff, microirrigation systems help alleviate pressure on freshwater resources and contribute to long-term water sustainability. Furthermore, the improved crop yield and quality associated with microirrigation can have significant economic benefits for farmers. Higher yields translate into increased profitability and food availability, contributing to food security at both local and global scales. The precise control over irrigation and nutrient application also allows for site-specific management, enabling farmers to optimize resource allocation and reduce production costs. While microirrigation systems offer numerous advantages, there are also challenges to consider. Initial installation costs can be relatively high, requiring investment in equipment, infrastructure, and system maintenance. Additionally, proper design, installation, and maintenance are critical for optimal system performance. Farmers must receive training and technical support to ensure effective implementation of microirrigation, which may require additional resources and capacity-building efforts.

Conclusion

Micro-irrigation has been particularly effective for horticultural, ornamental, and landscaping applications. It has been used in a variety of topographical circumstances and climates, from humid to dry and semi-arid environments. Its benefits in terms of decreased labour requirements, higher yields, better fertilizer application, slower salinization, eradication of wood and disease, and water and energy savings are widely known. The number of acres covered by micro-irrigation has increased as a result of improvements in emitter and dripper technology, the creation of low-cost sand and screen filters, the introduction of drip tape, and other factors. Using drip irrigation technology for the production of cereal crops is a substantial difficulty, especially in underdeveloped nations. There are a number of social, technological, and institutional obstacles that must be addressed in different regions of the world. Accelerating education and knowledge transmission is necessary. Using micro-irrigation devices will thus be crucial for the sustainability or conservation of soil and water resources.

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