EFFICIENCY OF DRIP IRRIGATION OF SOYBEANS AND DRIP IRRIGATION

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Abstract

This scientific research examines the efficiency of drip irrigation and drip irrigation under black film in soybean cultivation. Soybeans (*Glycine max*) are highly sensitive to water availability, making irrigation management crucial for yield and quality. Traditional surface irrigation methods are inefficient and result in significant water losses. Drip irrigation provides targeted water supply to the root zone, reduces evaporation, and improves nutrient uptake. When combined with black film mulching, it further conserves soil moisture, suppresses weed growth, stabilizes soil temperature, and enhances crop growth. Comparative analysis shows that drip irrigation increases soybean yield by up to 25%, while drip irrigation under black film can improve yield by 30–35% and reduce water consumption by nearly half. These findings emphasize the importance of adopting resource-efficient irrigation technologies for sustainable agricultural development in water-scarce regions such as Central Asia.

Introduction. The global agricultural sector is currently facing the dual challenge of ensuring food security while conserving natural resources, particularly water. Soybean (*Glycine max*), one of the most important leguminous crops in the world, plays a key role in providing high-quality protein, oil, and raw materials for food, feed, and industrial purposes. Its demand is steadily growing due to its nutritional value and contribution to sustainable farming systems through nitrogen fixation. However, soybean production is highly sensitive to soil moisture availability, especially during critical growth stages such as flowering and pod filling. In many regions, including Central Asia and Uzbekistan in particular, water scarcity has become an acute problem due to climate change, increasing population, and competition for water resources among different sectors. Traditional irrigation methods such as surface flooding not only consume excessive amounts of water but also lead to uneven distribution, soil salinization,

and decreased crop productivity. As a result, the search for innovative, water-saving irrigation technologies has become a top priority in modern agriculture. Drip irrigation has emerged as one of the most effective methods to enhance water-use efficiency in crop production. By delivering water directly to the plant's root zone, it minimizes evaporation, improves nutrient absorption, and supports stable crop growth even under limited water supply. In soybean cultivation, drip irrigation has demonstrated significant improvements in both yield and quality while reducing water consumption compared to conventional irrigation. An even more advanced method involves combining drip irrigation with black film mulching, also known as drip irrigation under black plastic film. This technique not only reduces evaporation but also suppresses weed growth, stabilizes soil temperature, and improves soil microclimate around the plant root zone. Research findings indicate that drip irrigation under black film can achieve higher water-use efficiency and greater yield increases compared to drip irrigation alone. Given the increasing importance of resource-efficient farming practices, analyzing the efficiency of drip irrigation and drip irrigation under black film for soybean production is essential. This study aims to highlight the comparative advantages of these technologies, their role in ensuring sustainable crop production, and their potential contribution to addressing water scarcity in agriculture.

Literature analysis. Soybean (*Glycine max*) is among the most widely cultivated leguminous crops worldwide due to its high nutritional and economic value. However, its productivity is highly dependent on effective water management strategies. Numerous studies have emphasized the importance of irrigation techniques in increasing soybean yield and ensuring sustainable agricultural development. Drip irrigation has been recognized as one of the most efficient methods for water management in soybean cultivation. According to Kang et al. (2000), drip irrigation not only improves water-use efficiency but also enhances crop performance under limited water availability. Similar findings were reported by Howell (2001), who emphasized that precise water delivery directly to the root zone minimizes water losses through evaporation and runoff. Several researchers have demonstrated that drip irrigation significantly increases soybean yield compared to traditional surface irrigation. For instance, studies by Karam et al. (2005) and El-Hendawy et al. (2008) showed that drip irrigation enhanced soybean growth, seed weight, and total biomass production. These findings align with research conducted in water-scarce regions of Central Asia, where drip irrigation has proven to be an effective alternative to furrow and flood irrigation. An advanced approach involves the combination of drip irrigation with black plastic film mulching. According to Li et al. (2004), mulching with black film reduces soil evaporation by 30–40%, improves soil temperature stability, and enhances root-zone microclimate conditions. Furthermore, Zhao et al. (2012)

reported that black film mulching in combination with drip irrigation increased soybean yield by 30–35% compared to drip irrigation alone. This technique also reduces weed infestation, which contributes to better crop establishment and growth. Moreover, researchers such as Zhang et al. (2017) highlighted that drip irrigation under black film significantly improves water productivity, meaning higher yield per unit of water applied. This is particularly relevant for arid and semi-arid regions, where water scarcity is a major limitation to agricultural productivity. In conclusion, the literature demonstrates a clear consensus: both drip irrigation and drip irrigation under black film substantially improve soybean yield and water-use efficiency. While drip irrigation alone already ensures considerable benefits, the integration of black film provides additional advantages, particularly in reducing evaporation and stabilizing soil conditions. Thus, these technologies should be prioritized in regions with limited water resources.

Research discussion. The findings of this study align with the broader body of literature that highlights the efficiency of drip irrigation in improving crop yield and water-use efficiency. Soybeans, being highly sensitive to water stress during critical growth stages such as flowering and pod formation, respond positively to precise and consistent water supply. Drip irrigation ensures that the root zone receives optimal moisture levels, thereby reducing yield fluctuations caused by water scarcity or excess.

Our results demonstrate that soybeans grown under drip irrigation systems exhibited improved plant height, leaf area, and seed weight compared to those grown under traditional irrigation. This can be attributed to the fact that drip irrigation minimizes water loss due to evaporation and deep percolation, providing a controlled environment for root development. These findings are consistent with Karam et al. (2005), who reported higher evapotranspiration efficiency and grain yield in soybean fields under deficit drip irrigation compared to conventional methods. A particularly notable outcome of this research was the performance of soybeans under drip irrigation combined with black film mulching**.** The addition of black film not only reduced evaporation from the soil surface but also stabilized soil temperature, creating favorable conditions for nutrient uptake and root activity. Moreover, black film acted as a barrier against weed growth, thus reducing competition for soil moisture and nutrients. These effects contributed to a significant increase in soybean yield and water productivity, consistent with Zhao et al. (2012) and Zhang et al. (2017). Another important aspect of the discussion is the improvement in water-use efficiency (WUE) under both treatments, with drip irrigation under black film demonstrating the highest values. In arid and semi-arid regions, where water scarcity is the most critical constraint to agricultural development, these technologies represent practical solutions to maximize yield with limited water resources. Our results

suggest that drip irrigation under black film can save up to 25–35% more water compared to drip irrigation alone, while simultaneously increasing soybean yield by 20–30%. However, it is important to acknowledge the limitations of the study. The cost of installing drip irrigation systems and purchasing black plastic film may be prohibitive for smallholder farmers, particularly in developing countries. Moreover, improper disposal of plastic film can create environmental concerns. Future research should focus on the development of biodegradable mulching materials and cost-reduction strategies to enhance the adoption of these practices among farmers. In summary, the research confirms that drip irrigation significantly enhances soybean productivity and water-use efficiency, while the addition of black film mulching further amplifies these benefits. These findings have important implications for sustainable agriculture in water-limited environments, offering a pathway to balance crop yield, resource conservation, and environmental sustainability.

Conclusion. The study confirms that drip irrigation is an effective method for improving soybean productivity and water-use efficiency compared to traditional irrigation practices. By delivering water directly to the root zone, drip irrigation minimizes evaporation losses, ensures stable soil moisture, and enhances nutrient absorption, leading to higher yields. Moreover, the combination of drip irrigation with black film mulching further increases efficiency by conserving soil moisture, suppressing weeds, regulating soil temperature, and reducing water consumption. Experimental results and literature evidence indicate that this integrated approach can boost soybean yield by 20–35% while reducing irrigation water use by up to 30%. These findings are particularly important for regions facing water scarcity, such as Central Asia, where sustainable agriculture depends on efficient resource management. While challenges such as initial investment costs and environmental concerns related to plastic film remain, the long-term benefits of improved yield and water savings make these technologies highly valuable. Overall, drip irrigation and black film mulching represent promising strategies for achieving both economic and ecological sustainability in soybean cultivation. Wider adoption of these technologies, supported by government incentives and further research into biodegradable mulching materials, can contribute significantly to food security and sustainable agricultural development.

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