OPTIMIZING MAIZE PRODUCTION THROUGH DRIP IRRIGATION SCHEDULING: A SYSTEMATIC REVIEW OF GLOBAL RESEARCH TRENDS AND PRACTICAL OUTCOMES

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Abstract. *Maize (Zea mays L.) is a globally important cereal crop that contributes significantly to food security, livestock feed, and agro-industrial systems. Despite its adaptability, maize is highly sensitive to water stress, particularly during flowering and grain-filling stages, where yield losses can be substantial under inadequate irrigation conditions (Malčauskienė et al., 2015; Shaheen & Zhang, 2023). Increasing water scarcity and climate variability have intensified the need for irrigation systems that ensure high productivity while minimizing water consumption.*

Drip irrigation has been widely recognized as an efficient irrigation method due to its ability to supply water directly to the root zone, thereby reducing evaporation, runoff, and deep percolation losses. However, the effectiveness of drip irrigation largely depends on appropriate irrigation scheduling, which determines the timing and amount of water application throughout the crop growth cycle (Iqbal et al., 2016).

Keywords: *drip irrigation; irrigation scheduling; maize (Zea mays L.); water use efficiency; deficit irrigation; soil moisture dynamics; evapotranspiration-based scheduling; precision irrigation; systematic review.*

Introduction. Numerous experimental studies have evaluated drip irrigation scheduling for maize using different approaches, including evapotranspiration (ET)-based scheduling, deficit irrigation, and fixed-interval methods. While these studies report improvements in yield and water use efficiency, results vary considerably across regions due to differences in climate, soil type, and experimental design (Al-Ani & Al-Zubaidi, 2024; Wang et al., 2021). The absence of a consolidated synthesis limits the development of robust irrigation scheduling recommendations applicable to diverse agroecological conditions.

This systematic review synthesizes peer-reviewed evidence from Scopus-indexed studies to evaluate how drip irrigation scheduling affects maize yield, water use efficiency, and soil moisture dynamics under different environmental conditions.

The objective of this systematic review is to critically synthesize empirical evidence on drip irrigation scheduling strategies for maize cultivation, focusing on their effects on grain yield, water use efficiency, and soil moisture behavior. The review evaluates methodological approaches, compares scheduling strategies across agroclimatic regions, and identifies research gaps that require further investigation. The synthesis is based exclusively on peer-reviewed, Scopus-indexed open-access studies selected through a transparent and PRISMA-compliant process.

Methodology. A systematic literature search was conducted using the Scopus database.

The search employed combinations of keywords related to maize, drip irrigation, irrigation scheduling, yield, water use efficiency, and soil moisture. The search was limited to English-language publications released between 2010 and 2025. Only open-access research articles were considered to ensure full methodological transparency. The initial search identified 44 records.

Studies were included if they investigated maize under drip irrigation systems and clearly described irrigation scheduling strategies such as ET-based scheduling, regulated deficit irrigation, or fertigation-linked scheduling. Eligible studies were required to report quantitative outcomes related to yield, water use efficiency, soil moisture, or economic performance.

Studies were excluded if they focused on crops other than maize, applied non-drip irrigation systems, lacked explicit scheduling descriptions, or did not provide original experimental data. After title and abstract screening, 29 studies were excluded, leaving 15 articles for full-text assessment.

Full-text analysis of the 15 eligible articles resulted in the exclusion of five studies due to incomplete datasets or limited methodological clarity. Consequently, 10 studies were included in the qualitative synthesis. Extracted data included geographic location, climate, soil type, irrigation scheduling method, irrigation level, and performance indicators. A thematic synthesis approach was applied to compare outcomes across studies.

The study selection process followed PRISMA guidelines. From 44 initially identified Scopus records, 29 were excluded during screening, 15 were assessed for eligibility, and 10 studies were included in the final synthesis. The PRISMA flow diagram illustrates this selection process.

Thematic Review of Literature. ET-based irrigation scheduling was the most commonly applied approach across studies and was shown to effectively align water application with crop water demand (Shaheen & Zhang, 2023). Deficit irrigation strategies, including regulated deficit and partial root-zone drying, were widely used to enhance water productivity under limited water availability (Kumar et al., 2024; Wang et al., 2021). Fixed-interval scheduling was mainly reported in earlier studies and demonstrated lower efficiency compared to dynamic scheduling approaches (Iqbal et al., 2016).

Most studies reported increased maize yield and improved water use efficiency under optimized drip irrigation scheduling. ET-based scheduling at 75–100 % ETc often produced high yields with superior WUE (Shaheen & Zhang, 2023). Deficit irrigation reduced total water use while maintaining acceptable yield levels, particularly in arid environments (Al-Ani & Al-Zubaidi, 2024; Kumar et al., 2024). In sub-humid regions, moderate irrigation levels optimized both yield and economic returns (Malčauskienė et al., 2015).

Several studies reported improved soil moisture distribution under drip irrigation, with reduced deep percolation losses and enhanced root-zone moisture retention (Eum et al., 2020). Regulated deficit irrigation improved soil water dynamics when applied outside critical growth stages, maintaining crop performance while conserving water (Wang et al., 2021).

The effectiveness of irrigation scheduling strategies varied by region. Studies conducted in arid and semi-arid regions of Asia and the Middle East emphasized deficit and ET-based scheduling to manage water scarcity (Al-Ani & Al-Zubaidi, 2024; Kumar et al., 2024), while studies in sub-humid and temperate regions highlighted the role of optimized irrigation levels for economic efficiency (Malčauskienė et al., 2015).

Integration of fertigation, crop modeling, and canopy temperature indices further enhanced irrigation performance and decision-making accuracy (Iqbal et al., 2016; Eum et al., 2020). These approaches support precision irrigation and improve resource-use efficiency.

Conclusion. The reviewed studies collectively demonstrate that drip irrigation scheduling significantly influences maize yield, water use efficiency, and soil moisture behavior. ET-based scheduling provides consistent performance across environments, while deficit irrigation offers substantial water savings when carefully managed. However, methodological variability and limited long-term experiments indicate the need for further region-specific research.

This systematic review confirms that optimized drip irrigation scheduling is essential for sustainable maize production under water-limited conditions. ET-based and deficit irrigation strategies consistently improve water productivity while maintaining yield stability. Future research should focus on long-term field validation, integration of real-time monitoring technologies, and economic assessments to support large-scale adoption.

References

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