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Optimizing raised bed dimensions for enhanced maize yield, water footprint reduction, and improved soil moisture dynamics under furrow irrigation

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[1]Department of Irrigation and Water Management, Bangladesh Agricultural University. Mymensingh-2202, Bangladesh. Tel.: +880-29966-67401-6 Ext 68318, ♥email: adham.iwm@bau.edu.bd
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Abstract. *Islam MT, Bhuyan MY, Das N, Jahan N, Rahman MM, Jewel MAH, Adham AKM. 2024. Optimizing raised bed dimensions for enhanced maize yield, water footprint reduction, and improved soil moisture dynamics under furrow irrigation. Asian J Agric 8: 10-22.* Effective water management is crucial for sustainable agriculture, especially in regions facing water scarcity. This study examines the impact of different Raised Bed (RB) dimensions on maize (*Zea mays* L.) yield, Water Footprint (WF), and soil water content under furrow irrigation, with a focus on water conservation. The experiment, conducted at Bangladesh Agricultural University, Bangladesh, utilized a randomized complete block design featuring four irrigation treatments: the Conventional Method (CM) and three RB configurations with widths of 25 cm, 65 cm, and 110 cm. The RB65 treatment significantly improved maize yield, achieving 13.1±1.4 t/ha compared to 9.89±1.11 t/ha with CM. Additionally, RB65 peaked in water productivity, reducing irrigation water use by 37.72%, highlighting its potential for water conservation. Soil moisture retention was consistently higher across all RB treatments, with RB65 showing the greatest retention at depths up to 80 cm. It also recorded the lowest green WF (88.6±10.07 l/kg) and blue WF (12.63±1.43 l/kg), resulting in the lowest total WF (101.22±11.50 l/kg). These findings suggest that RB systems, particularly the 65 cm configuration, optimize water usage and enhance maize productivity, making it a viable strategy for resource management in water-limited areas. The study recommends adopting the RB65 configuration to maximize water efficiency and crop yields, contributing to food security and sustainable agricultural practices. However, these results are based on specific geographical and climatic conditions, limiting their generalizability to other regions or crops. Future research should explore long-term studies across diverse agro-ecological zones and examine various crops to validate the broader utility of the RB65 configuration.

Keywords: Maize yield, raised bed irrigation, soil water content, sustainable agriculture, water footprint, water management

INTRODUCTION

Water is undeniably crucial for the agricultural industry, serving as the foundation of food production. Agriculture, as the largest user of global water resources, accounts for approximately 70% of freshwater withdrawals, primarily for irrigation (Jeong and Zhang 2020). This heavy reliance places agriculture at the heart of global water scarcity challenges. While essential for food production, conventional agricultural practices, particularly inefficient irrigation methods, contribute significantly to water depletion, exacerbating the very scarcity upon which agriculture depends (Roushan et al. 2023). Among surface irrigation technologies, furrow irrigation is the most prevalent due to its simplicity and cost-effectiveness. It is widely used in water-stressed regions, such as arid and semi-arid areas, where water management is critical (Akbar et al. 2016; Mekonnen et al. 2020). Studies in Egypt and South Asia demonstrate that furrow irrigation can reduce water use while maintaining or improving crop yields for staple crops like maize and wheat (Sarker et al. 2020; Ismail et al. 2021; Yigezu et al. 2021). However, despite its popularity, furrow irrigation is associated with inefficiencies such as deep percolation and runoff, leading to significant water loss (Setu et al. 2023). Thus, optimizing these systems is vital for sustainable water management.

The adoption of improved water-saving agricultural practices, such as enhanced furrow irrigation and Raised Bed (RB) systems, can have profound socioeconomic impacts. These methods not only conserve water but also increase crop yields, thereby promoting food security and offering economic benefits to smallholder farmers, especially in developing countries like Bangladesh, where water scarcity limits agricultural potential (Sarker et al. 2020). Additionally, water-efficient practices reduce production costs, increase labor efficiency, and enhance resilience to climate variability, ultimately improving the livelihoods of rural communities (Yigezu et al. 2021). By boosting irrigation efficiency, these technologies significantly enhance water productivity and enable better resource management across agricultural systems (Islam et al. 2022; Rahman et al. 2022). Notably, 97.8% of farmers' fields are irrigated using surface methods, underscoring the widespread dependence on traditional systems, despite their water loss issues (Setu et al. 2023). Therefore, more