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To determine the water requirement of onion crop with and without plastic mulch of semiarid region in Bihar

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Abstract
This study investigated the effectiveness of drip irrigation and plastic mulch in Red Nasik onion cultivation at the Precision Farming Development Centre in RPCAU Pusa, Bihar, India. Conducted from February to May 2024, the research examined water requirements across different irrigation levels (100%, 80%, and 60%) with and without plastic mulch. The experimental site, characterized by a sub-humid climate and sandy loam soil, utilized a comprehensive methodology to assess crop water dynamics. Results demonstrated significant water conservation potential with plastic mulch. Across all irrigation levels, mulched treatments consistently reduced water requirements by 34.8% compared to non-mulched treatments. Monthly water requirements varied from 15.55 mm to 109.20 mm under mulched conditions, reflecting crop growth stages and environmental factors. Peak water demand occurred in April, coinciding with critical bulb formation. The findings align with previous research by Patel and Rajput (2013) and highlight the potential of integrated water management strategies in agricultural systems. By optimizing irrigation techniques and implementing plastic mulch, farmers can potentially enhance water use efficiency, reduce resource consumption, and maintain crop productivity in similar agro-climatic regions. The implications include substantial water savings, improved crop water management, and a promising approach for sustainable agricultural practices in water-scarce environments. Protection, mental health interventions, rehabilitation, and community-driven prevention strategies.

Keywords: Crop water requirement with and without mulch, irrigation depth, Irrigation scheduling, onion crop

Introduction

"Water is the essence of life and at the core of the agri-food systems. The path to water efficiency passes through sustainable agri-food systems" (FAO 2001) [5]. The hugest amount of water is consumed by Agriculture. The total water resources in the world are estimated in the order of 43750 km^3/year (FAO 2012). America has the largest share of the world's total fresh water resources with 45%, followed by Asia with 28%, Europe with 15.5% and Africa with 9% respectively. Annual global water withdrawals are estimated at 3830 km^3, 70% of which is used for agriculture (i.e., 2664 km^3). One of the world's most populous nations, India provides 4% of the world's fresh water (4000 km^3), 17.1% (>1.3 billion) of the world's people, and around 500 million animals, or 20% of all animals worldwide. As per the central water commission, 85.3% of the total water consumed was for agriculture in the year 2000, which is projected to decrease to 83.3% by 2025.

In India among various sector, most important sector is agriculture, because 55% population is dependent on agriculture for their livelihood. The problem facing the agricultural sector is to increase crop water productivity in order to produce more food with less water. Water scarcity is the primary limitation to expanding the area for the production of most crops, including onions.

In present scenario there is a need to manage the irrigation water in order to optimum agricultural yields under the limited quantity of irrigation water. Raising the crop water production level, irrigation practices is one of the best options for water saving and optimal production. It is old as cultivation. There is a various method of irrigation but drip irrigation method is one of the best method, which efficiently supplying irrigation water to the plant precisely close to the root zone.

It is basically use for horticulture crop as well as vegetables crops. During last 50 years, drip irrigation with synthetic plastic mulching techniques is extensively used throughout the world to maximize water use and improve agricultural productivity, particularly in areas where water is scarce. Synthetic plastic mulch made by HDPE (high density polythene), LDPE (high density polythene) and LLDEPE (linear low-density polythene). Basically, two types of plastic mulch are, color and clear. Basic differences between these two plastic mulches are that colored plastic prevents the sunlight to pass through the film, while clear (transparent) film allows it to transmit through the film. The principal objective of mulching is to protect the soil's surface from sun radiation, which will stop temperature variations and lower evaporation rates. Thus, mulching layer helps in retain the moisture, which means there will be more water available for crop growth. According to a various finding, yield improved by approximately 33% when mulch was spread compared to not spreading mulch. Kumari *et al*., (2020) [13] found that providing 80% of the water needed for crops is provided by a drip irrigation system using black plastic mulch (25 microns) not only saved 68% of water but also resulted in a yield of cauliflower that was 3.2 times higher than that achieved with surface irrigation. Similarly, Singh *et al*. (2023) [17] noted that using drip irrigation at 80% of crop evapotranspiration (ETc) with polyethylene mulch led to taller onion plants, increased leaf counts per plant, larger bulb diameters, along with 47% water savings and a 48% increase in yield compared to surface irrigation.

Materials and Methods

Study area and Soil

The experiment was conducted at the Precision Farming Development Centre, Department of Soil and Water Conservation Engineering, CAET, DRPCAU, Pusa, Samastipur, Bihar, India (25.98°N, 85.67°E; 52 m above sea level). The region, characterized by a sub-humid climate influenced by the southwest monsoon. The study focused on assessing the effectiveness of drip irrigation for Red Nasik onion crops, considering environmental factors like temperature, rainfall, and humidity for broader applicability in similar agro-climatic regions.

The experimental soil, formed from Budhi Gandak river sediments, was calcareous with 26.6% calcium carbonate. It was sandy loam, comprising 52% sand, 18% silt, and 30% clay, with an average bulk density of 1.56 g/cc determined using the core method. Field capacity (19.62%) and saturation soil moisture were measured in the field, while the permanent wilting point (7.2%) was determined using pedo-transfer function software.

Details of Treatments

Sr. No.	Treatments	Treatments details
1.	T_1	Application of 100% water requirement without plastic mulch (control)
2.	T_2	Application of 100% water requirement with plastic mulch
3.	T_3	Application of 80% water requirement without plastic mulch
4.	T_4	Application of 80% water requirement with plastic mulch
5.	T_5	Application of 60% water requirement without plastic mulch
6.	T_6	Application of 60% water requirement with plastic mulch.

Bed preparation, Planting and mulching

Experimental beds were prepared as per the field layout, with each plot measuring 11 m × 0.7 m and a 0.15 m gap between plots for observation and monitoring. This arrangement ensured consistent conditions, facilitated clear visibility, and provided access to plants and irrigation systems for accurate data collection. The Red Nasik onion variety, suitable for RPCAU local climate, was selected. Synthetic mulch (HDPE plastic) was applied to furrows, and onion plants were transplanted on February 3rd, 2024, in both mulched and non-mulched sections with a 15 × 10 cm plant spacing. Two lateral pipes were installed per plot, positioned between plant rows to ensure proper irrigation.

Crop water requirement

The crop water requirement, influenced by factors like surface area coverage and evapotranspiration rate, was calculated using the formula recommended by NCPA & H.

$$V = E_P \times K_P \times K_C \times W_P \times S_P \qquad \text{(i)}$$

V = Water requirement (Litre/day/plant)
E_P = Pan evaporation (mm/day)
K_P = Pan factor
K_c = Crop coefficient or crop factor
W_P = Wetted area factor (m^2)
S_P = Spacing of crops/plant (m^2)

The crop coefficient (Kc) values for onion were 0.50, 0.75, 1.0, and 0.8 for the initial, development, mid-season, and end-season stages, respectively (FAO-56). The pan factor (Kp) was 0.8 (FAO, 1979), and the wetted area factor (Wp) was 1.0, with a spacing of 0.015 m² per plant. K_c value is 35% less for mulch condition crop according to the Kumari *et al.* 2020 [13].

Irrigation Scheduling

Drip irrigation, a high-frequency method applying small water amounts at short intervals, was scheduled daily for the onion crop to ensure consistent moisture. This approach minimized water wastage, enhanced water use efficiency, prevented soil saturation, and reduced moisture-related diseases, promoting healthier plants and optimal yields.

Results and Discussion

Crop water requirement of onion crop without mulch

The onion crop was planted in February 2024 and harvested in May 2024, with a crop duration of 109 days. The crop water requirement (CWR) was computed daily for this period. Table 1 summarizes the CWR without mulch, showing the highest water requirement of 168.84 mm recorded in May, corresponding to the critical bulb formation stage where water demand was at its peak.

Table 1: Average daily water requirement of onion plant during different months (without mulch)

Month	Monthly rainfall (mm)	Avg. daily evapo (mm/day)	Pan coefficient (K_p)	Crop coefficient (K_c)	Avg. wetted area factor (W_p)	Area (m^2)	Crop water requirement		Monthly depth of water applied (mm)
							l/day/plant	Monthly WR (mm)	
Feb.	6.2	2.3	0.8	0.5	1.0	0.015	0.0138	24.03	17.83
Mar.	43.8	3.6	0.8	0.75	1.0	0.015	0.0324	67.29	23.49
Apr.	0	7.0	0.8	1.0	1.0	0.015	0.084	168.84	168.84
May.	119.8	5.8	0.8	0.8	1.0	0.015	0.0556	78.22	0
Total								338.40 mm	210.17 mm

Crop water requirement under plastic mulch condition

Under plastic mulch conditions, the water requirement increased from 15.55 mm in February to a peak of 109.20 mm in April, then declined to 53.08 mm in May (Table 2). The peak in April reflects higher temperatures and increased crop demand, while the decline in May indicates cooler conditions or crop maturity, emphasizing the dynamic irrigation needs influenced by environmental factors and growth stages.

Table 2: Average daily water requirement of onion plant during different months (with plastic mulch)

Month	Monthly rainfall (mm)	Avg. daily evapo. (mm/day)	Pan coefficient (K_p)	Crop coefficient (K_c)	Avg. wetted area factor (W_p)	Area (m^2)	Crop water requirement		Monthly depth of water applied (mm)
							l/day/plant	Monthly WR (mm)	
Feb.	6.2	2.3	0.8	0.33	1.0	0.015	0.0090	15.55	9.35
Mar.	43.8	3.6	0.8	0.48	1.0	0.015	0.0207	42.85	0
Apr.	0	7.0	0.8	0.65	1.0	0.015	0.0546	109.20	109.20
May.	119.8	5.8	0.8	0.52	1.0	0.015	0.0362	53.08	0
Total								220.68 mm	118.55 mm

At each irrigation level (100%, 80%, 60%), treatments with plastic mulch (T_2, T_4, T_6) show significantly lower water requirements, compared to non-mulch treatments (T_1, T_3, T_5). This indicates that plastic mulch is effective in reducing water requirements for onion cultivation. At a 100% water requirement, T_2 (with mulch) uses 34.8% less water compared to T_1 (without mulch). Similarly, at an 80% water requirement, T_4 (with mulch) requires 34.8% less water than T_3 (without mulch). At a 60% water requirement, T_6 (with mulch) uses 34.8% less water compared to T_5 (without mulch). This was showing that the significant water-saving benefits of using mulch across varying irrigation levels. Patel and Rajput (2013) reported water savings of up to 30-40% with mulch use, which aligns closely with our observed 34.8% reduction of water in mulch condition.

Conclusions

The study reveals that plastic mulch and drip irrigation significantly enhance water conservation in Red Nasik onion cultivation, reducing water requirements by 34.8% across different irrigation levels. Conducted in Bihar, India, from February to May 2024, the research demonstrated monthly water requirements ranging from 15.55 mm to 109.20 mm under mulched conditions. These findings validate the potential of integrated water management strategies, offering farmers in similar agro-climatic regions a sustainable approach to optimize water use efficiency, reduce resource consumption, and maintain crop productivity while addressing water scarcity challenges.

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