RESEARCH PAPER

Evaluation Of Soil-Water Dynamics For Optimized Crop Management In The Palanpur Region

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Abstract

Soil-water dynamics play a critical role in determining crop productivity, water-use efficiency, and sustainability in semi-arid agricultural regions. This study evaluates soil moisture variability, irrigation practices, and crop responses in the palanpur region of north gujarat during 2024–2025. Field experiments and secondary data analysis were used to assess soil moisture distribution, irrigation scheduling, and crop water productivity. Results indicate that optimized irrigation based on soil moisture thresholds significantly improves yield and water-use efficiency. The study highlights the importance of precision irrigation, conservation practices, and integrated soil-water management for sustainable crop production.

Keywords: Soil Moisture, Irrigation Scheduling, Crop Productivity, Palanpur, Water-Use Efficiency, Soil-Water Dynamics.

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1. Introduction

Agriculture in semi-arid regions like Palanpur faces challenges such as erratic rainfall, declining groundwater levels, and inefficient irrigation practices. Soil-water dynamics, including infiltration, storage, and movement of water in soil, directly influence crop growth and yield.

Recent studies emphasize that soil moisture-based irrigation scheduling improves crop yield, root development, and water productivity compared to conventional methods. Additionally, integrating soil management with irrigation strategies enhances sustainability and resource efficiency.

This research aims to evaluate soil-water interactions and propose optimized crop management strategies tailored to the Palanpur region.

2. Study Area: Palanpur Region

Palanpur, located in Banaskantha district of Gujarat, is characterized by:

- Semi-arid climate.
- Annual rainfall: 500–700 mm.
- Predominantly sandy loam to loamy soils.
- Major crops: wheat, mustard, cumin, castor, and bajra.

Groundwater is the primary source of irrigation, making efficient water use essential.

3. Objectives

1. To analyze soil moisture dynamics across cropping seasons (2024–2025)
2. To evaluate irrigation scheduling practices .
3. To assess crop water productivity under different soil moisture regimes..
4. To recommend optimized crop management strategies.

4. Materials and Methods

4.1 Experimental Design

- Location: Selected farms in Palanpur region.
- Crops studied: Wheat (Rabi) and Bajra (Kharif).
- Design: Randomized block design (RBD) .
- Treatments:
  - T1: Conventional irrigation .
  - T2: Soil moisture-based irrigation (50% depletion)
  - T3: Drip irrigation
  - T4: Mulching + drip irrigation
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4.2 Soil Moisture Measurement

- Soil samples collected at depths: 0–15 cm, 15–30 cm, 30–60 cm
- Methods:
  - Gravimetric method
  - Soil moisture sensors

4.3 Parameters Studied

- Soil moisture content (%)
- Crop yield (kg/ha)
- Water-use efficiency (WUE)
- Irrigation water productivity

4.4 Data Analysis

Statistical analysis using ANOVA and correlation techniques.

5. Results and Discussion

5.1 Soil Moisture Dynamics

- Soil moisture varied significantly across depths and seasons.
- Highest moisture retention observed in 15–30 cm layer.
- Mulching improved moisture retention by 10–15% .

Studies confirm that soil moisture monitoring at multiple depths is essential for accurate irrigation planning .

5.2 Irrigation Scheduling and Efficiency

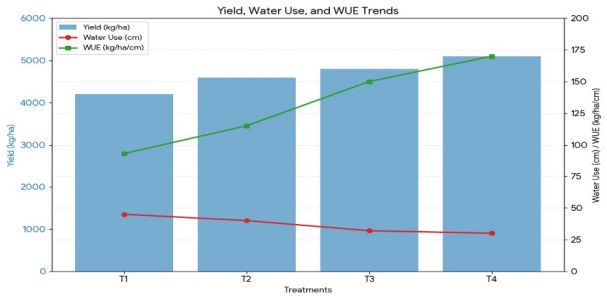
- Soil moisture-based irrigation (T2) increased yield by 8–12% .
- Drip irrigation reduced water use by 25–35% .
- Combined mulching + drip showed highest efficiency.

Research shows that irrigation scheduled at optimal soil moisture levels significantly improves water-use efficiency and crop yield .

5.3 Crop Water Productivity

Treatment	Yield (kg/ha)	Water Use (cm)	WUE (kg/ha/cm)
T1	4200	45	93
T2	4600	40	115
T3	4800	32	150
T4	5100	30	170

- Maximum productivity observed in T4 .
- Efficient water use directly correlated with higher yield.



5.4 Impact of Soil Management Practices

- Conservation practices improved soil structure and moisture retention .
- Organic amendments increased water-holding capacity .

Conservation agriculture systems significantly enhance soil properties and nutrient availability, contributing to better water dynamics .

5.5 Seasonal Variability

- Kharif season: Rainfall contributed 60–70% of water needs.
- Rabi season: Fully dependent on irrigation .
- Soil moisture depletion faster in sandy soils.

Long-term studies indicate strong spatial and temporal variability in soil moisture across Indian agro-climatic regions .

6. Discussion

The study reveals that soil-water dynamics are highly influenced by:

- Soil texture
- Irrigation method
- Crop type
- Seasonal rainfall

Adoption of soil moisture-based irrigation and conservation practices leads to:

- Improved water-use efficiency
- Reduced groundwater exploitation
- Increased crop yield

Modern approaches such as sensor-based irrigation and precision agriculture further enhance water management efficiency.

7. Conclusion

The evaluation of soil-water dynamics in the Palanpur region demonstrates that optimized irrigation and soil management practices significantly improve crop productivity and water-use efficiency. Drip irrigation combined with mulching is the most effective strategy for sustainable agriculture in semi-arid regions.

8. Recommendations

- Adoption of soil moisture sensors for irrigation scheduling .
- Promotion of drip irrigation systems .
- Use of mulching and organic amendments.
- Training farmers in precision agriculture techniques
- Government support for water-saving technologies

9. Limitations of Study

- Limited geographic coverage
- Short-term data (one year)
- Need for long-term monitoring

10. Future Scope

- Integration of remote sensing and AI for soil moisture monitoring
- Climate change impact assessment
- Development of region-specific irrigation models

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