EVALUATING THE IMPACT OF SEASONAL WEATHER VARIABILITY ON SOIL MOISTURE CONSERVATION UNDER MULCHING SYSTEMS FOR DATE PALM PRODUCTION IN OASES

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ABSTRACT

Efficient soil moisture conservation is crucial for sustaining date palm production in arid Moroccan oases, where water scarcity is a significant challenge. This study evaluates how different mulching materials affect soil moisture retention in these regions. The research focuses on three mulching materials: polyethylene plastic (PP), polypropylene woven ground cover (PWGC), and date palm residues (DPR), examining their effectiveness under varying seasonal climates. Results demonstrate that the PP+DPR combination was the most effective in conserving soil moisture at shallower depths during high temperatures, while DPR and PWGC+DPR provided consistent moisture retention at greater depths. The findings highlight the importance of mulching systems in mitigating weather variability impacts, enhancing soil moisture conservation that can sustain the date palm production in arid regions.

INTRODUCTION

The date palm (Phoenix dactylifera) holds considerable importance in Moroccan oases. It primarily contributes to creating a favorable agricultural microclimate for other crops, which helps safeguard the land against desertification (Abdelaaziz et al., 2024). Furthermore, scientific research has demonstrated that date fruits to be highly nutritious and possess medicinal properties (Ouamnina et al., 2024). Consequently, date palm production is economically valuable in this region.

However, due to the climatic conditions in arid regions where precipitation is inadequate to offset evapotranspiration, irrigation becomes necessary to meet the water needs for date production (Yan et al., 2022). Though, with climate change, water resources in arid regions are becoming increasingly scarce over time. Thus, implementing solutions for reducing water usage and conservation are crucial in these areas (Morante-Carballo et al., 2022).

Mulching, a well-known water conservation practice, has demonstrated potential in enhancing soil moisture retention, reducing evaporation, and stabilizing soil temperature (Ramakrishna et al., 2006). Considering the interaction between the land and atmosphere, as weather transitions from winter to summer, fluctuations in atmospheric temperature and precipitation impact soil moisture content (Cho et al., 2016). Hence, mulching serves as a buffer by mitigating the adverse effects of these interactions.

This study aims to evaluate the effectiveness of three mulching materials—polyethylene plastic (PP), polypropylene woven ground cover (PWGC), and date palm residues (DPR)—in conserving soil moisture in date palm production under varying seasonal climate conditions. The implementation of mulching systems may mitigate the effects of weather variability on

soil moisture and enhance date palm production by stabilizing soil temperature, reducing evaporation, improving moisture retention and promoting the transpiration of the plants, particularly during periods of extreme seasonal changes.

MATERIALS AND METHODS

Experimental Site

The experiment began in early April 2024 and ended August 2024 at the experimental farm of the National Institute of Agricultural Research (INRA), located in Errachidia Province in the South-East of Morocco. The experiment occupies an area of a half hectare.

Experimental Design

This experiment was conducted on a date palm (Phoenix dactylifera) on the variety called *Nadja*, that is known for its resistance to the famous date palm disease *Bayoud* and other important agronomic traits. Drip irrigation was employed throughout the experiment, with the same amount of water applied across all treatments. However, the irrigation schedule differed, where from April to the end of May irrigation was done three times a week, and from June till August, irrigation was done four times a week.

Three mulching materials were tested: polyethylene plastic (PP), polypropylene woven ground cover (PWGC), and date palm residues (DPR). The synthetic mulches (PP and PWGC) were combined with the organic mulch (DPR). The experiment was set up using a randomized complete design, comprising 72 palm trees divided into 36 experimental units, each containing 2 trees, with 9 replications. Each experimental unit represented a different mulching treatment. The mulching treatments were distributed as follows:

- T0: Control (non-mulch) treatment (NM)
- T1: Organic mulch made from ground dry date palm leaves (DPR)
- T2: Polyethylene plastic (PP) combined with date palm residues (DPR)
- T3: Polypropylene woven ground cover (PWGC) combined with DPR

Data Collection

To measure soil moisture content as a representation of the entire field, 24 date palm trees with different mulching systems were selected. For each tree, a profile probe tube was installed at 30 cm from the irrigation dripper. Soil moisture data were collected consecutively on irrigation days, one hour before, using the Profile Probe (PR2) sensor that uses the gravimetric method. This sensor measured and recorded soil moisture data at depths of 0-100 mm, 100-200 mm, 200-300 mm, 300-400 mm, 400-600 mm, and 600-1000 mm.

Data analysis

The experimental data collected were analyzed with d software tools, specifically Python's Matplotlib and R's ggplot2. These tools facilitated the precise visualization and comparison of soil moisture content across various experimental conditions, enhancing the clarity and interpretability of the data. Microsoft excel was used to analyze the weather data (temperature and precipitation)

RESULTS AND DISCUSSION

1. Weather variability (average temperature and precipitation)

Figure 1 illustrated the variations in average temperature and precipitation from April 1st to August 21st at the experimental farm in the Errachidia region. The graph indicated that average temperatures gradually increase from April, reaching a peak during the mid-summer months (June to August) and remaining consistently high. Although there were minor fluctuations, the mean temperatures generally fell between 20°C and 35°C. In contrast, the precipitation pattern remains relatively low throughout this period, with occasional spikes representing rainfall events, but most days experience little to no precipitation.

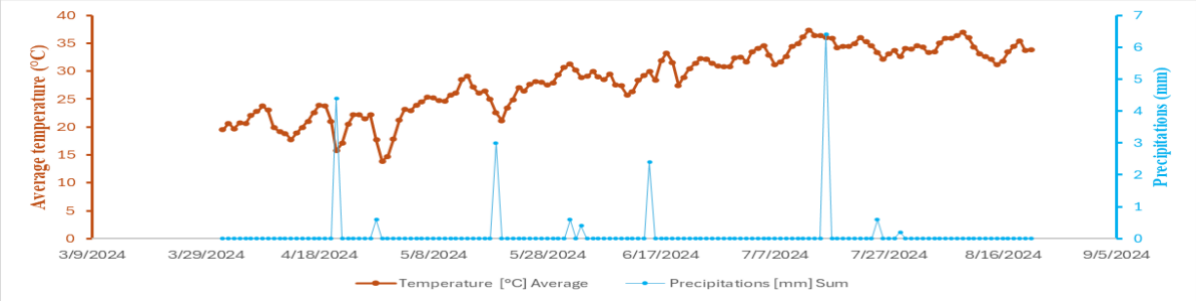

Figure 1. Temporal Trends in Average Temperature and Precipitation from March to August.

2. Mulching materials on soil moisture retention at different depths under seasonal temperature fluctuations.

Figures 2 and 3 demonstrated that different mulching systems (DPR, PP+DPR, and PWGC+DPR) had a significant impact on soil moisture retention across various soil depths and seasonal temperature fluctuations, compared to no mulch (NM). At depths of 100mm, 200mm, and 300mm, Figure 2 showed that the PP+DPR mulching system was the most effective in conserving soil moisture, particularly as temperatures increase, outperforming other mulching type, though there was an increase in irrigation schedule. Conversely, the NM system consistently proved to be the least effective, especially under conditions of high temperature variability. Additionally, at a depth of 400mm, the PP+DPR system markedly increased soil moisture levels with rising temperatures, while both DPR and PWGC+DPR systems also exhibited strong moisture retention capabilities, demonstrating their ability to maintain consistent soil moisture in deeper soil profiles under varying temperature conditions.

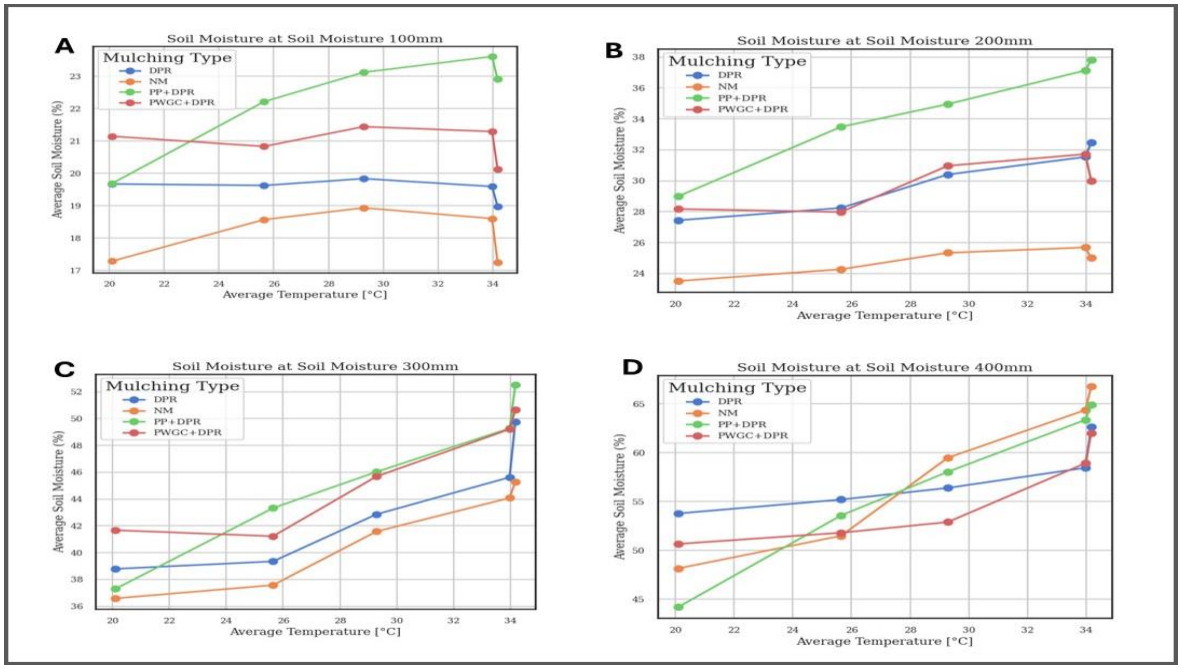

Figure 2. Soil moisture variability at 100mm (A), 200mm (B), 300mm(C) to 40mm (D)soil depth at date palm experiment with seasonal temperature variation from April (Spring) to August (summer) under different mulching systems (DPR (Dry palm residue), PP (Polyethylene plastic) + DPR, PWGC ((Polypropylene woven ground cover) +DPR, NM (Non-mulch)).

A study conducted by Ma et al. (2009) on corn plastic mulching in the East area of Jilin Province clearly reported that the corn soil moisture increased under plastic mulching particularly in the dry and rainless days, which quite like our study especially for the topsoil profile.

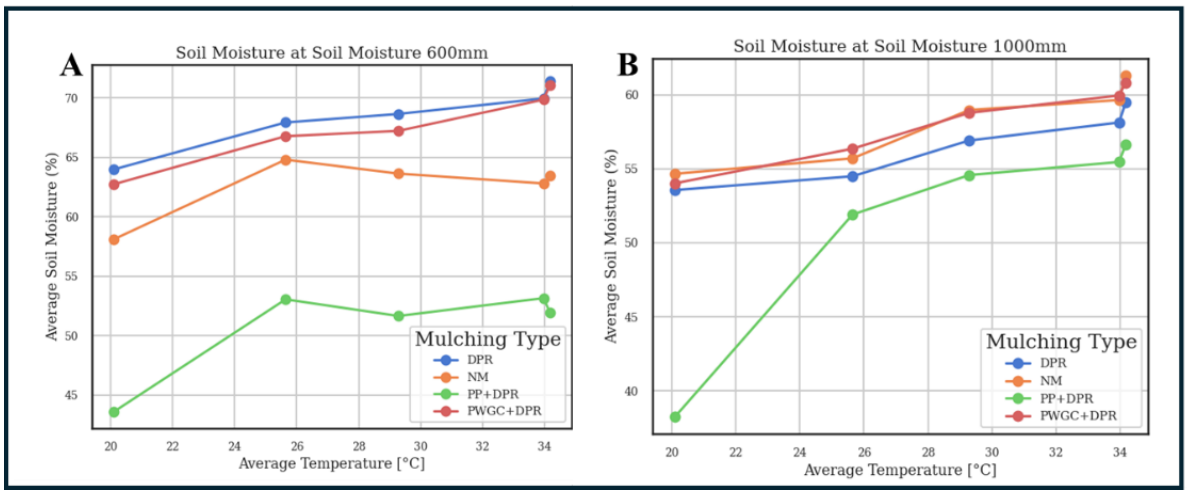

Figure 3. Soil moisture variability at 600mm (A) and 1000mm (B) soil depth at date palm experiment with seasonal temperature variation from April (Spring) to August (summer) under different mulching systems (DPR (Dry palm residue), PP (Polyethylene plastic) + DPR, PWGC ((Polypropylene woven ground cover) +DPR, NM (Non-mulch)).

At a depth of 600mm (Figure 3(A)), the DPR system was the most effective in conserving soil moisture as temperatures increase. The PWGC+DPR system also performed well, closely matching the effectiveness of the DPR system, and both outperform the NM system. At a depth of 1000mm (Figure 3(B)), soil moisture retention varied among the different mulching systems, with the DPR and PWGC+DPR systems providing the most consistent moisture retention as temperatures rise. The NM system exhibited minimal variation, suggesting that deeper soils retain moisture more naturally. Meanwhile, the PP+DPR system, effective at shallower depths, showed reduced effectiveness at both 600mm and1000mm soil depths. These results matches with the findings in the study that Yin et al. (2022) conducted on the effect of plastic film mulching system on deep soil moisture where they found that plastic mulching reduced soil water storage (SWS) in the 0–100 cm- 200cm and 300 cm soil profile. This shows that less water is accumulated in the deeper soil profile compared to other mulching systems.