Molecular Soil Biology 2026, Vol.17, No.2, 124-134
http://bioscipublisher.com/index.php/msb

Feature Review Open Access

Soil Moisture Dynamics in Cherry Orchards under Different Mulching Practices

Zhibin Li [1,2,3]
1 Shandong Tree Mountain Agricultural Technology Co., Ltd., Zhucheng, 262200, Shandong, China
2 Zhejiang Beile Agricultural Development Co., Ltd., Hangzhou, 311121, Zhejiang, China
3 Zhejiang Agronomist College, Hangzhou, 310021, Zhejiang, China
Corresponding email: 15265606088@163.com
Molecular Soil Biology, 2026, Vol.17, No.2 doi: 10.5376/msb.2026.17.0010
Received: 12 Mar., 2026
Accepted: 15 Apr., 2026
Published: 29 Apr., 2026

Preferred citation for this article:
Li Z.B., 2026, Soil moisture dynamics in cherry orchards under different mulching practices, Molecular Soil Biology, 17(2): 124-134 (doi: 10.5376/msb.2026.17.0010)

Abstract To investigate the effects of different mulching methods on the dynamic changes of soil moisture in cherry orchards, a typical cherry-growing region was selected as the study site. Treatments involving plastic film mulching, straw mulching, and a bare-ground control were established to systematically monitor the spatiotemporal characteristics of soil moisture across different soil layers (0-20 cm, 20-40 cm, and below 40 cm). The results indicate that different mulching methods significantly influence soil moisture retention capacity and distribution patterns. Specifically, plastic film mulching proved most effective in inhibiting soil moisture evaporation, thereby effectively increasing the water content in the topsoil layer; conversely, straw mulching demonstrated advantages in regulating soil temperature and facilitating the slow release of moisture, which contributes to the stability of soil moisture in the middle and deep soil layers. Furthermore, these mulching measures improved soil moisture conditions, leading to enhancements in cherry growth parameters and water use efficiency. A case study further validated the practical value of adopting rational mulching strategies for improving water management levels in orchards. These findings provide a theoretical basis and technical support for scientific irrigation and mulching management in cherry orchards.
Keywords Cherry orchard; Mulching methods; Soil moisture; Moisture dynamics; Water use efficiency

1 Introduction

Efficient water management is central to the sustainable production of temperate fruit, especially in semi-arid and water-limited regions where orchards rely on irrigation to meet high crop water demand (Demo and Bogale, 2024; Yang et al., 2024). In sweet cherry, expanding production into drier or more variable climates amplifies the risk of low water-use efficiency (WUE), soil degradation, and competition for limited water resources (Luo et al., 2021). Mulching and improved irrigation scheduling have therefore become key strategies to regulate soil moisture dynamics, stabilize the root-zone environment, and sustain yields under increasing climate variability (Ananthakrishnan et al., 2025). However, the specific behavior of soil moisture over time and depth in cherry orchards under different mulching practices remains insufficiently quantified (Xing et al., 2025).

Water scarcity, rising temperatures, and erratic rainfall patterns intensify pressure on orchard systems and heighten the importance of practices that conserve soil water while maintaining fruit quality (Maliuk et al., 2021). In many orchard crops, surface mulching reduces soil evaporation, improves infiltration, and increases the proportion of plant-available water in the 0-60 cm layer where most roots are active (Jiang and He, 2021; El-Beltagi et al., 2022). Studies in cherry and other fruit orchards show that micro-irrigation combined with mulching can markedly reduce water consumption without yield loss, while enhancing WUE and stabilizing soil water profiles through the season (Webber et al., 2022). These benefits are particularly relevant for sweet cherry, which often faces limited irrigation allocations but high market and quality requirements.

Research on mulching in orchards has progressed from simple plastic films to a wide range of organic (straw, compost, woodchips, cover-crop residues) and inorganic (plastic, gravel, geotextile) materials, revealing distinct effects on soil hydro-thermal regimes and root-zone moisture (Jiang and He, 2021). In apple, jujube, citrus, pitaya, and other perennial systems, different mulches have been shown to increase soil water content, moderate soil temperature, improve soil structure, and enhance yield and WUE, though the magnitude and direction of effects depend on mulch type and climate (Stagno et al., 2024). Reviews highlight that plastic mulches are generally more effective in reducing evaporation and crop coefficients early in the season, while organic mulches contribute more strongly to long-term soil quality and biological activity (Maliuk et al., 2021). Yet, despite evidence from apple and other orchards, systematic, crop-specific studies on how various mulching materials shape temporal and spatial soil moisture dynamics in cherry orchards are still limited (Xing et al., 2025).

Building on this background, the present study focuses on soil moisture dynamics in cherry orchards under different mulching practices, aiming to link surface management with water distribution in the root zone and implications for water-saving irrigation strategies (Stagno et al., 2024). The main objectives are: (i) to compare how contrasting mulches (e.g., organic vs. plastic vs. bare soil) affect soil moisture evolution over time and depth in cherry orchards; (ii) to quantify their effects on indicators relevant to irrigation management, such as water consumption and WUE; and (iii) to provide guidance for selecting mulching-irrigation combinations suited to semi-arid and sub-humid cherry-growing regions. The technical approach integrates field experimentation under commercial-like conditions with soil moisture monitoring in the active root zone, using micro-irrigation strategies known to influence water distribution, and draws on concepts from recent mulching and deficit-irrigation studies in apples, cherries, and other fruit trees.

Water management in cherry orchards increasingly depends on practices that actively shape soil moisture dynamics, with mulching emerging as a central tool alongside improved irrigation. Existing work in cherries and other fruit trees shows that different mulching materials can substantially modify soil water storage, evaporation, and WUE, but responses are context- and material-dependent. A focused analysis of soil moisture behavior under contrasting mulches in cherry systems is therefore needed to design robust, water-efficient orchard management under current and future climate conditions.

2 Materials and Methods

2.1 Overview of the experimental site

The experiment was conducted in a semi-arid temperate fruit-growing region where summer drought is common and rainfall is often concentrated outside the main growing season (Gerasko et al., 2021). Similar to other cherry and stone-fruit orchards in such climates, high summer temperatures and low organic matter content in the topsoil create a strong need for soil moisture conservation and temperature regulation (Kim et al., 2024). The site climate was characterized by hot, dry summers and relatively mild winters, with August typically the hottest and driest month, and substantial interannual variation in precipitation.

The orchard soil was a moderately deep, well-drained mineral soil typical of commercial fruit regions, with relatively low organic matter and high bulk density, conditions under which mulching has previously improved soil physical properties and water-holding capacity. The experiment was established in a mature sweet cherry (*Prunus avium* L.) orchard, similar in age and spacing to intensively managed systems reported for micro-irrigated cherry in northern China and organic orchards in southern Ukraine (Millán et al., 2020). Trees were trained to a central leader system with north-south oriented rows to standardize light interception, following layouts used in previous cherry and plum orchard experiments (Kim et al., 2024).

2.2 Mulching treatment design

The trial included multiple soil surface treatments representing common orchard floor management strategies: plastic film mulching, straw mulching, living or organic mulching, and a bare-ground or mechanically cultivated control (Millán et al., 2020). Plastic film mulching followed approaches used in micro-irrigated cherry and other orchards, where mulch film is placed along the tree row over the wetted strip to reduce evaporation and increase soil moisture in the 0-60 cm root zone (Yang et al., 2024). Straw mulching was applied as a continuous layer in the tree row, similar to studies showing increased soil water content, reduced soil temperature, and improved yield and water productivity in apple and jujube orchards.

The bare-ground treatment represented the conventional black fallow or mechanically cultivated floor, with periodic shallow tillage and manual weed control, as commonly used in cherry orchards in Ukraine (Millán et al., 2020). Where living or organic mulches were included, spontaneous vegetation or organic materials such as compost or woodchips were maintained under the tree row or in the alley and periodically mowed, reflecting designs that enhanced soil moisture and fertility in sweet cherry and other fruit orchards. All non-mulch management (fertilization, pruning, pest control) was kept uniform across treatments to isolate mulching effects on soil moisture dynamics (Gerasko et al., 2021).

2.3 Experimental design and data collection methods

The experiment used a randomized block design to account for spatial variability in soil and tree vigor, similar to mulching and irrigation trials in cherry and other orchards (Maliuk et al., 2021). Mulching treatments were assigned to plots within each block, with a minimum of three replicates per treatment and multiple trees per plot; border trees served as guards, and only central trees were used for measurements (Millán et al., 2020; Liao et al., 2021). Irrigation regimes, where applied, were standardized within blocks following micro-irrigation strategies that target the main root zone (0-60 cm) and are known to strongly influence soil moisture patterns in cherry orchards.

Soil moisture was monitored at multiple depths to capture the vertical distribution of water within the active root zone and below. Sensors or sampling points were installed from the surface down to at least 60 cm, and in some cases to 160-300 cm, reflecting depths used in cherry and jujube orchard studies to characterize seasonal soil water storage and consumption. Particular emphasis was placed on the 0-60 cm layer, where previous work has shown the strongest variability in soil moisture and the closest linkage to cherry water uptake (Yang et al., 2024).

Measurements were taken at relatively high temporal frequency during the growing season to capture responses to irrigation and rainfall events, following protocols that used automated capacitance or time-domain sensors recording at intervals from minutes to days in orchards (Ananthakrishnan et al., 2025). Sensor placement relative to tree trunks and emitters followed guidance from micro-irrigated orchard studies, with positions chosen to maximize sensitivity to changes in water status while remaining representative of the root zone; locations near 20-40 cm from the trunk and 10-30 cm depth have been shown to provide strong responses in tree crops (Wang et al., 2023b). Calibration and quality checks drew on methods developed for capacitance and electromagnetic probes in orchard soils to reduce sensor-to-sensor variability and ensure reliable estimation of soil water dynamics (Kim et al., 2024).

3 Effects of Different Mulching Methods on Soil Moisture Dynamics

3.1 Characteristics of soil moisture variation in the surface layer

In the surface layer, mulching primarily alters the balance between infiltration and evaporation, leading to distinct soil moisture dynamics compared with bare soil. Organic mulches such as straw or pruned branches reduce direct soil exposure, decrease evaporation, and promote rapid wetting after rainfall or irrigation, resulting in a characteristic curved pattern of sharp moisture increases followed by slower declines during dry periods (Gerasko et al., 2021). In cherry orchards, micro-irrigation under mulch increases the contribution of surface and upper-profile water to tree uptake, indicating that maintaining relatively stable moisture in the 0-20 cm layer is critical during key phenological stages (Gebretsadikan et al., 2022).

Different mulch materials show contrasting abilities to stabilize surface moisture and temperature. Straw mulching in orchards consistently raises soil water content in the upper profile and lowers temperature in the 0-10 or 0-20 cm layer, creating a cooler and more buffered environment, whereas living or grass mulches can increase evapotranspiration and reduce surface water availability under arid and semi-arid conditions. In sweet cherry, living mulch increased soil water at 20 cm depth relative to mechanical cultivation but also reduced tree trunk cross-sectional area, suggesting that competition in the surface layer can offset some water-conservation gains (Tang et al., 2021).

3.2 Patterns of soil moisture variation in the middle layer

The 20-40 cm layer often acts as a transition zone where the effects of surface management interact with root water uptake. In rain-fed jujube orchards, jujube branch mulching and straw mulching increased average moisture in the 0-60 cm "seasonal fluctuation layer," with particularly pronounced improvements in the 20-40 cm zone compared with clean tillage. Similar depth-dependent responses were observed under branch mulching and living mulch, where branch mulch maintained the highest average moisture from 0-70 cm and showed the smallest water deficit in the 20-40 cm layer, while living mulch exhibited the greatest deficit due to strong root competition in this band (Gerasko et al., 2021).

In cherry orchards managed with micro-irrigation and mulch film, soil water in the main root zone (0-60 cm) contributed the majority of tree water uptake, emphasizing the functional importance of stable moisture in the 20-40 cm layer for efficient use of irrigation and rainfall (Song et al., 2020; Gebretsadikan et al., 2022). Studies on high-density apple and other orchards further show that plastic or grass mulches increase mid-profile moisture during sensitive growth stages, but the degree of improvement depends on seasonal rainfall patterns and irrigation level. These findings indicate that the 20-40 cm layer is a key target for optimizing mulch-irrigation combinations in cherry orchards.

3.3 Soil moisture response characteristics in the deep layer

Below 40 cm, soil moisture dynamics are less sensitive to short-term atmospheric conditions but strongly influenced by long-term mulching and irrigation regimes. In jujube orchards, straw and branch mulching increased moisture not only in the shallow root-dense layer (0-60 cm) but also in deeper layers down to 160-280 cm, and slowed moisture attenuation during extended droughts compared with clean tillage (Gerasko et al., 2021). Under integrated catchment plus mulching systems, deep soil layers (60-180 cm and beyond) exhibited positive water compensation after the rainy season, reflecting enhanced infiltration fronts and greater deep storage that can buffer trees during dry periods (Chen et al., 2024).

Deep soil water in orchards has been identified as relatively stable but finite; long-term extraction without sufficient recharge can create persistent low-humidity zones. Surveys in apple orchards divided the profile into shallow rapidly changing, redistribution, transition, and stable layers, showing that deep water (>2 m) becomes increasingly depleted with stand age (Jakhro et al., 2025). For cherry orchards under different irrigation regimes, the contribution of soil water below the main 0-60 cm root zone to tree water use is smaller but still detectable, especially where micro-irrigation under mulch increases wetting depth and improves coupling of water and nutrients throughout the profile (Song et al., 2020; Wang et al., 2023a). These patterns highlight that mulching which promotes deep infiltration while limiting surface evaporation can help sustain deeper reserves and reduce the risk of chronic deep-layer desiccation in long-lived cherry systems.

4 Mechanisms of How Mulching Methods Affect Soil Moisture Retention Capacity

4.1 The evaporation-inhibiting effect of mulching materials

Mulching reduces direct soil-atmosphere contact, thereby limiting solar radiation at the surface and lowering the vapor pressure gradient that drives soil water loss. Organic mulches such as straw or pruned branches form a porous layer that intercepts raindrop impact and wind, so that part of the water first evaporates from the mulch itself, while the mulch simultaneously acts as a barrier slowing diffusion of water vapor from the underlying soil. In rain-fed jujube orchards, branch and straw mulches consistently increased soil moisture in the 0-280 cm profile and reduced seasonal water consumption compared with clean tillage, indicating strong suppression of non-productive evaporation (Tang et al., 2022a).

Plastic films and gravel or fabric mulches inhibit evaporation primarily by physically sealing the surface and reducing exchange of water vapor, while still permitting upward capillary flow from deeper soil layers. Experiments in jujube and apple orchards show that film, concrete, fabric, and straw mulches all significantly reduced soil evaporation and total evapotranspiration, with evaporation under mulching treatments dropping by around 15%-20% relative to bare controls (Ananthakrishnan et al., 2025). In micro-irrigated orchards, film and straw mulches lowered daily soil evaporation compared with clean tillage, while maintaining or increasing soil water content throughout the 0-120 cm profile, confirming that mulching shifts water use from evaporation toward more productive transpiration (Webber et al., 2022).

4.2 The impact of mulching on soil temperature and moisture migration

Mulching alters the soil thermal regime, which in turn influences water migration through changes in viscosity, vapor pressure, and hydraulic gradients. Straw and branch mulches generally decrease maximum surface temperatures and narrow diurnal temperature ranges, creating a cooler, more buffered environment that slows upward movement of water and vapor toward the surface. In rain-fed jujube orchards, straw and branch mulching reduced soil temperature in the upper 10-20 cm and dampened temperature fluctuations with depth, while simultaneously stabilizing soil moisture and decreasing moisture attenuation during prolonged drought (Tang et al., 2022a).

By modifying soil structure and porosity, mulches also affect liquid-phase water movement and redistribution within the profile. Long-term mulching in apple orchards improved soil physical properties, increased porosity, and enhanced the regulation capacity of the soil water reservoir, leading to higher water contents under straw and film mulches compared with bare or gravel treatments. In young apple orchards with drip irrigation, straw mulching increased soil water content in all layers down to 120 cm and decoupled evaporation from short-term meteorological extremes, indicating that improved structure and moderated temperature together reduce rapid drying of the upper profile and support more even vertical moisture distribution (Webber et al., 2022).

4.3 The regulatory role of different mulching methods on precipitation infiltration processes

Mulching modifies how rainfall is partitioned among interception, infiltration, and runoff, thereby controlling the effectiveness of natural precipitation for replenishing soil water. Organic mulches increase surface roughness and protect soil aggregates from raindrop impact, which maintains macropores and promotes infiltration. In rain-fed jujube orchards, straw and branch mulches significantly enhanced soil water storage after rainfall, reduced post-rainfall moisture loss rates, and increased effective use of precipitation compared with clean tillage. Simulated rainfall studies on sloping jujube systems further showed that branch mulching increased infiltration and reduced runoff and sediment, improving the retention of both water and nutrients on-site (Ferreira et al., 2025).

When mulching is combined with micro-catchment structures such as fish-scale pits, its influence on rainfall utilization is amplified. In sloping jujube orchards, integrating pits with straw or branch mulching increased rainfall infiltration by more than 40% relative to bare land, while simultaneously reducing evaporation and improving soil water storage throughout 0-180 cm (Tang et al., 2022b). Similar principles apply in high-density apple orchards, where grass mulches enhanced rainfall infiltration, slowed surface flow, and maintained higher moisture during later growth stages than plastic mulch, demonstrating that mulch type (organic vs. plastic) governs whether precipitation is primarily conserved through enhanced infiltration or through surface sealing and evaporation suppression (Ananthakrishnan et al., 2025).

5 Analysis of the Spatiotemporal Distribution Characteristics of Soil Moisture Under Different Mulching Methods

5.1 Patterns of soil moisture variation across different seasons

Across years with contrasting precipitation, mulching produces consistent seasonal curves of soil moisture, with rapid increases after rainfall and gradual declines during dry intervals. In rain-fed jujube orchards, straw and branch mulching generated similar seasonal trajectories to clean tillage, but with higher water storage in 0-280 cm and slower moisture attenuation, especially in dry years. The 0-60 cm layer behaved as a distinct “seasonal fluctuation layer” in all treatments, responding most strongly to shifts between rainy and drought periods.

Seasonal compensation of deep soil water also depends on surface management. Integrating catchment structures with branch or straw mulching increased soil water storage in 0-180 cm by more than 10% and produced positive water compensation values from the beginning to the end of the rainy season, whereas bare land showed negative compensation in much of the profile. In long-term mulched orchards, deep layers (60-160 cm and below) act as slow-changing reservoirs that are better replenished under straw or branch mulch than under clean tillage, helping to buffer trees against multi-year droughts.

5.2 Soil moisture dynamics during the growing season

During the growing season, mulching modifies both the timing and magnitude of soil moisture peaks associated with key phenological stages. In rain-fed jujube, straw and branch mulching increased soil moisture in 0-280 cm throughout sprouting, flowering, fruit expansion, and ripening; moisture rose sharply after effective rainfall and then declined more slowly under mulched than under uncovered soil. Clean tillage frequently produced soil water contents in the fine-root dense layer (0-60 cm) below wilting point during fruit development, particularly in dry years, while mulched plots maintained moisture above critical thresholds.

Temporal differences among mulching patterns are also evident within the same season. Branch mulching maintained the highest soil water in 0-70 cm and the smallest water deficit during the jujube growth period, whereas living grass cover showed the largest deficit, especially in the 20-40 cm layer where competition for water is strongest (Tang et al., 2021; Tang et al., 2023). When mulching was combined with micro-catchments, branch and straw treatments increased rainfall infiltration and tree evapotranspiration relative to bare or unmulched catchments, indicating that seasonal water use can be intensified without depleting the root-zone reservoir (Figure 1).

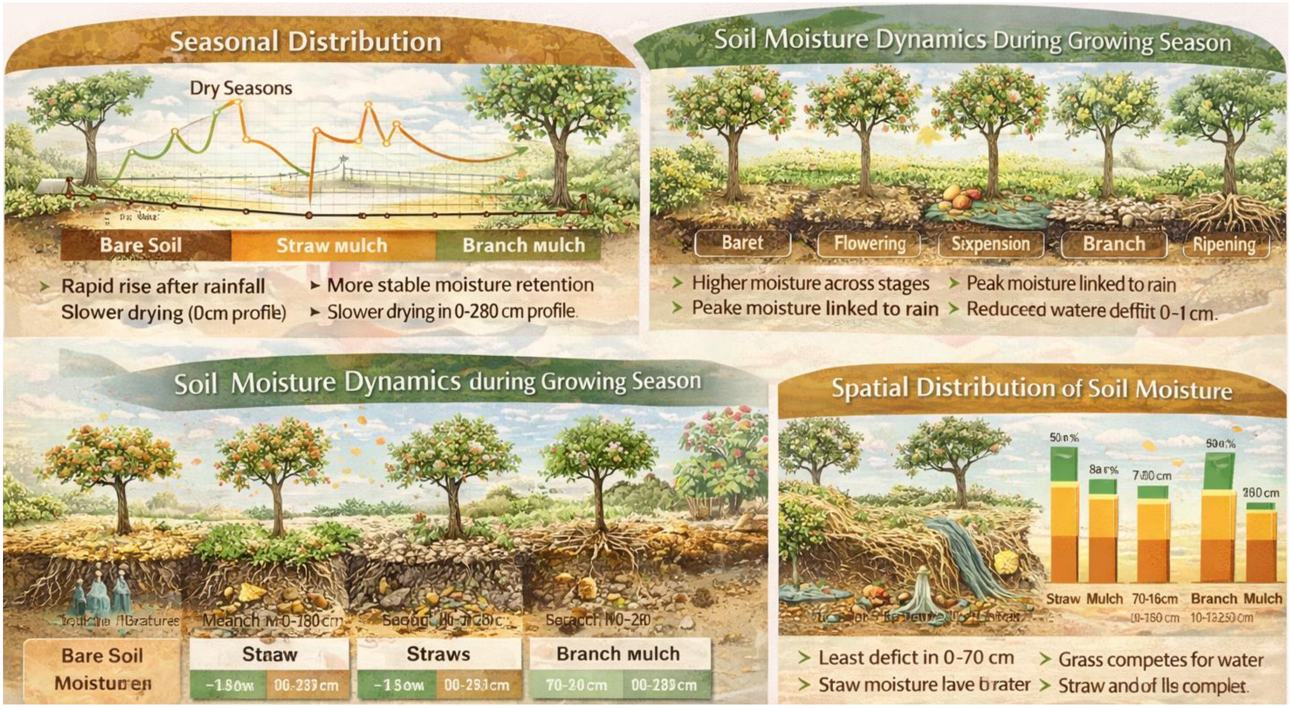

Figure 1 Spatiotemporal distribution characteristics of soil moisture under different mulching methods

5.3 Spatial distribution differences and their influencing factors

Spatially, mulching reshapes the vertical distribution of soil moisture by strengthening storage in the main root zone while enhancing recharge of deeper layers. In jujube orchards, straw mulch increased moisture across 0-280 cm and was particularly effective in the fine-root dense layer (0-60 cm), whereas branch mulch mainly improved water in 40-100 cm and 220-280 cm, reflecting material-specific infiltration patterns. Branch mulching also produced the most uniform moisture profile from 0-70 cm, while living mulch created pronounced deficits in the 20-40 cm band due to shallow grass roots (Tang et al., 2021; Tang et al., 2023).

The combination of surface engineering and mulch further amplifies spatial contrasts. Fish-scale pits with branch or straw mulching raised average 0-180 cm water storage by 9%-22% over bare land and shifted soil water compensation from negative to positive across most depths, especially in 60-100 cm where runoff-derived infiltration is captured. These spatial patterns are controlled jointly by precipitation regime, evaporation, root distribution, and mulch properties (coverage, thickness, and hydraulic behavior), which together determine where and how efficiently water is retained in the cherry root zone under different mulching strategies.

6 Effects of Mulching Methods on Cherry Growth and Water Use Efficiency

6.1 The impact of mulching on cherry growth indicators

Mulching in sweet cherry orchards modifies soil moisture and temperature, which in turn affects vegetative growth traits such as trunk cross-sectional area, shoot growth, and leaf area. In semi-arid cherries, organic mulches (compost, woodchips) increased tree growth and foliar nutrient status compared with bare soil, indicating improved vigor and canopy development under enhanced soil fertility and moisture conditions (Gebretsadikan et al., 2022). In contrast, living mulch (spontaneous vegetation) in an organic cherry orchard significantly reduced trunk cross-sectional area (by 1.2-2.1 times), despite higher soil water content at 20 cm depth and lower topsoil temperatures, suggesting that competition for below-ground resources can limit structural growth (Şahin and Pırlak, 2022).

Effects on leaf area and canopy efficiency can differ from effects on trunk size. Under living mulch, cherry trees showed higher shoot growth efficiency (1.5-2.9 times) and greater leaf area per unit trunk area (1.3-2.5 times) relative to mechanical cultivation, reflecting a shift toward more leaf-efficient canopies despite reduced trunk expansion (Şahin and Pırlak, 2022). In another cherry study, polyethylene mulching increased plant height, stem diameter, lateral branch number and length, and early fruiting compared with clear mulch or no mulch, indicating that plastic mulch can accelerate structural development and branching architecture in young trees (Li et al., 2025). Overall, mulching can either promote or constrain growth indicators depending on mulch type and the balance between moisture conservation, nutrient supply, and competition.

6.2 Comparison of water use efficiency under different mulching methods

Mulching improves the partitioning of water toward productive transpiration, often enhancing water use efficiency (WUE) in fruit trees. In semi-arid sweet cherry orchards, organic mulches maintained soil moisture and soil chemical properties while a postharvest deficit irrigation regime reduced irrigation water by 24%-28% without affecting stem water potential, tree growth, or yield, implying higher irrigation WUE under mulched conditions with reduced water inputs (Gebretsadikan et al., 2022). Living mulch in organic cherry orchards increased soil moisture at 20 cm depth and reduced soil temperature, but reduced trunk size, indicating that improved soil water conditions alone do not guarantee higher whole-tree water productivity when competition is strong (Şahin and Pırlak, 2022).

Evidence from other fruit trees helps clarify mulching-WUE linkages. In a drip-irrigated peach orchard, low-cost organic mulch increased water infiltration, improved tree water status, and raised agronomic WUE by about 50% compared with an unmulched control, while also greatly increasing yield over three years. Similarly, in a three-year-old mandarin orchard, combining geotextile mulch with sustained deficit irrigation increased crop water productivity by 35% relative to a fully irrigated control, because mulching improved soil water status and reduced the intensity of water stress without yield loss (Liao et al., 2021). These results suggest that, when competition is managed, mulching generally increases WUE by conserving soil water and stabilizing plant water status.

6.3 Indirect effects of mulching measures on yield and quality

Mulching can indirectly influence cherry yield and quality through changes in soil fertility, water status, and plant physiology. In semi-arid sweet cherry, compost mulch increased soil organic matter and nutrients and improved some fruit quality attributes, while woodchips enhanced tree growth and foliar phosphorus and manganese; postharvest deficit irrigation under these mulches reduced water use without affecting crop performance, supporting mulching as a strategy to sustain yield under limited water supply (Gebretsadikan et al., 2022). Studies in organic cherries show that living mulch did not strongly change basic fruit size or soluble solids but increased ascorbic acid and total anthocyanins in fruits, indicating enhanced accumulation of bioactive compounds under moderate, chronic stress and altered soil-plant interactions (Gerasko, 2020).

Broader orchard evidence confirms that ground cover and mulching tend to improve fruit quality and, in many contexts, yield. A meta-analysis across multiple fruit species found that ground cover systems significantly increased fruit yield by about 7% and enhanced soluble solids, sugar content, and vitamin C while reducing acidity, with mulches and cover crops both contributing to higher quality (Ferreira et al., 2025). In mandarin and peach orchards, mulching combined with optimized or deficit irrigation increased yields and improved quality traits such as sugar content and sugar-acid ratio, by improving soil moisture, nutrient availability, and canopy physiology (Berríos et al., 2024). For cherry orchards, these indirect effects suggest that appropriate mulch choice can help maintain or improve yield while enhancing nutritional and sensory fruit quality, particularly under water-limited or organic management conditions.

7 Case Study: Empirical Analysis of Typical Mulching Patterns in Cherry Orchards

7.1 Selection and basic profile of the case study area

The case study focuses on semi-arid sweet cherry orchards where water scarcity and high summer temperatures make soil-water conservation a primary management goal. One representative site is an organic sweet cherry orchard in the Southern Steppe of Ukraine (*Zelene village*), characterized by frequent summer drought, hot and very dry Augusts, and strong year-to-year variability in rainfall. Trees (*Prunus avium* L.) were planted at wide spacing and trained to a central leader, creating a system similar to many commercial cherry orchards in continental climates (Gebretsadikan et al., 2022).

A second reference site is a semi-arid cherry-growing region in western North America (Okanagan Valley), where sweet cherry production has expanded but irrigation water is limited. Here, modern orchards on dwarfing rootstocks are drip-irrigated and managed with organic mulches (compost, woodchips) or bare soil, and in some cases combined with postharvest deficit irrigation to reduce water use (Maliuk et al., 2021). Together, these sites capture contrasting but typical combinations of climate, irrigation regime, and orchard floor management relevant to water-limited cherry production.

7.2 Measured soil moisture results under different mulching patterns

In the Ukrainian organic orchard, living mulch (spontaneous vegetation cover) increased soil moisture at 20 cm depth by about 3.9% on average compared with standard mechanical cultivation, and reduced soil temperature by about 1.5 °C over six years, indicating improved near-surface moisture and a cooler soil microclimate (Tang et al., 2022a). Despite higher soil water at 20 cm, trees under living mulch showed smaller trunk cross-sectional area, suggesting that part of the conserved water was used by the grass cover rather than the trees (Gebretsadikan et al., 2022).

In semi-arid Canadian cherry orchards, organic mulches such as compost and woodchips maintained soil moisture under both full irrigation and postharvest deficit irrigation, with no deterioration in tree water status or soil chemical properties compared with bare soil (Maliuk et al., 2021; Gaeta et al., 2025). Across three sites, mulched plots under postharvest deficit irrigation saved 24%-28% irrigation water after harvest without reducing soil moisture or crop performance, demonstrating that mulching can stabilize root-zone water even when applied water is reduced (Figure 2).

7.3 Implications of the case study results for production practice

The case studies show that mulching patterns must be matched to local climate and water supply. Where irrigation is available but limited, as in the Okanagan Valley, organic mulches combined with micro- or deficit irrigation can maintain soil moisture and tree water status while significantly reducing seasonal water use (Maliuk et al., 2021). Under these conditions, compost and woodchip mulches also improved soil fertility and tree growth, indicating a dual benefit for water and nutrient management (Gaeta et al., 2025).

In rain-limited organic orchards relying mainly on natural precipitation, as in southern Ukraine, living mulch increases soil moisture and lowers temperature near the surface, but can reduce tree trunk growth, pointing to competition for water in dry years (Gebretsadikan et al., 2022). For such systems, partial or strip mulching, careful choice of grass species, or combining organic mulches with supplemental irrigation may help to conserve soil moisture for cherry trees while still achieving ecological benefits. Overall, the empirical evidence suggests that well-designed mulching patterns are a practical tool to enhance soil moisture dynamics and water-use efficiency in cherry orchards under diverse production conditions.

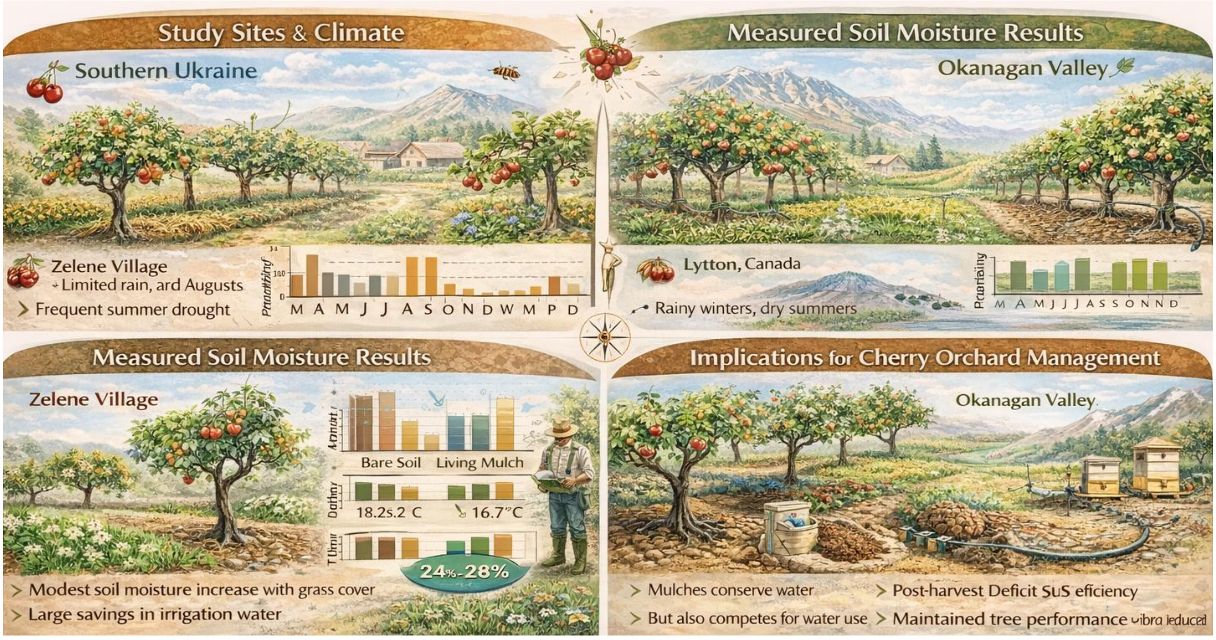

Figure 2 Empirical analysis of typical mulching patterns in cherry orchards under semi-arid conditions.

8 Conclusions and Recommendations

This study showed that mulching in cherry orchards markedly improves the soil water environment, especially in the 0-60 cm root zone that dominates cherry water uptake. Compared with bare or conventionally managed soil, mulched treatments enhance soil moisture retention, reduce evaporation, and often moderate soil temperature, thereby stabilizing water availability during critical growth stages.

Mulching also interacts positively with water-saving irrigation strategies. In semi-arid sweet cherry, organic mulches maintained soil moisture and fertility while postharvest deficit irrigation reduced water use by about one quarter without compromising soil water status, growth, or yield. For micro-irrigated cherry, the combination of drip irrigation and mulch film significantly reduced water consumption while maintaining yield and improving water-use efficiency relative to traditional furrow irrigation.

Across cherry and other fruit orchards, organic mulches such as compost, woodchips, or straw consistently improve soil structure, moisture, and fertility, and often enhance tree growth and fruit quality, making them strong candidates for primary use in cherry systems. In semi-arid sweet cherry, compost particularly increased soil organic matter and nutrients, while woodchips promoted tree growth and foliar P and Mn, all without negative effects on yield under reduced irrigation.

Where irrigation water is scarce, pairing organic mulches with optimized micro-irrigation or postharvest deficit irrigation can further increase water-use efficiency and profitability. In cherries, micro-irrigation with mulch film improved WUE and maintained yield and fruit quality, while in apples and peaches, straw or organic mulches combined with moderate deficit irrigation or reduced ETc levels increased WUE and sustained or improved yields. These results support recommending organic mulching, optionally complemented by film in drip-irrigated systems, as the optimal strategy for water-limited cherry orchards.

Most robust evidence comes from apples, citrus, and peaches, with relatively few long-term, multi-factor trials focused specifically on cherry, which limits the direct transferability of all quantitative effects. In addition, many studies evaluate only a narrow set of mulching materials or single irrigation regimes, providing limited insight into trade-offs such as root competition under living mulches or long-term impacts on deep soil water and nutrient leaching.

Future research in cherry orchards should therefore prioritize long-term experiments comparing multiple mulch types (organic, film, and living covers) under graded deficit-irrigation regimes, with full monitoring of soil water profiles, tree water status, yield, and fruit quality. Integrated management approaches that combine mulching with cover crops or improved fertilization, as tested in apple orchards, also merit evaluation for their potential to enhance water-use efficiency while reducing nitrate leaching and improving soil health in cherry systems.

Acknowledgments

Thanks to the reviewers for providing detailed comments and guidance on the manuscript of this study. The reviewers' keen insights into the issues and attention to detail have greatly benefited the authors.

Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

References

Ananthakrishnan S., Sharma J.C., Sharma N., Kumar S., Shankar S.V., Ranjha R., Lalkhumliana F., Sharma K., and Aravinthkumar A., 2025, Mulching and irrigation strategies for climate resilient apple cultivation in high-density orchards, Scientific Reports, 15: 17125.
https://doi.org/10.1038/s41598-025-86552-4

Berríos P., Temnani A., Zapata-García S., Sánchez-Navarro V., Zornoza R., and Pérez-Pastor A., 2024, Effect of deficit irrigation and mulching on the agronomic and physiological response of mandarin trees as strategies to cope with water scarcity in a semi-arid climate, Scientia Horticulturae, 323: 112572.
https://doi.org/10.1016/j.scienta.2023.112572

Chen M., Feng S., Gao M., Liu M., Wang K., Wang J., Shangguan Z., and Zhang Y., 2024, The difference in the photosynthetic characteristics and soil moisture of different varieties of sweet cherry (*Prunus avium* L.), Agricultural Water Management, 301: 109002.
https://doi.org/10.1016/j.agwat.2024.109002

Demo A., and Bogale G., 2024, Enhancing crop yield and conserving soil moisture through mulching practices in dryland agriculture, Frontiers in Agronomy, 6: 1361697.
https://doi.org/10.3389/fagro.2024.1361697

El-Beltagi H.S., Basit A., Mohamed H.I., Ali I., Ullah S., Kamel E.A.R., Shalaby T.A., Ramadan K.M.A., Alkhateeb A.A., and Ghazzawy H.S., 2022, Mulching as a sustainable water and soil saving practice in agriculture: a review, Agronomy, 12(8): 1881.
https://doi.org/10.3390/agronomy12081881

Ferreira S., Sánchez J., Gonçalves J., Eugénio R., and Damásio H., 2025, Remote sensing-assisted estimation of water use in apple orchards with permanent living mulch, Agronomy, 15(2): 338.
https://doi.org/10.3390/agronomy15020338

Gaeta L., Tarricone L., Persiani A., Fiore A., Montemurro F., De Benedetto D., Vitti C., Campi P., and Diacono M., 2025, Sustainable fertilization of organic sweet cherry to improve physiology, quality, yield, and soil properties, Agronomy, 15(1): 135.
https://doi.org/10.3390/agronomy15010135

Gebretsadikan T., Munro P., Forge T., Jones M., and Nelson L., 2023, Mulching improved soil fertility, plant growth and productivity, and postharvest deficit irrigation reduced water use in sweet cherry orchards in a semi-arid region, Archives of Agronomy and Soil Science, 69(9): 1419-1436.
https://doi.org/10.1080/03650340.2022.2095621

Gerasko T., 2020, Effect of living mulch on physiological and biochemical parameters of cherry leaves and fruits with organic growing technology, Scientific Bulletin of UNFU, 157(1): 20-28.
https://doi.org/10.33245/2310-9270-2020-157-1-20-28

Gerasko T., Pyda S., and Ivanova I., 2021, Effect of living mulch on soil conditions and morphometrical indices of sweet cherry trees, International Journal of Applied Agricultural Sciences, 7(1): 50-55.
https://doi.org/10.11648/j.ijaas.20210701.14

Jakhro M.I., Feng C., Zhai B., Cao W., and Li Z., 2025, Unraveling depth-dependent patterns of soil physicochemical properties: the role of integrated fertilization regimes in apple orchard profiles, Journal of Environmental Management, 395: 127810.
https://doi.org/10.1016/j.jenvman.2025.127810

Jiang X., and He L., 2021, Investigation of effective irrigation strategies for high-density apple orchards in Pennsylvania, Agronomy, 11(4): 732.
https://doi.org/10.3390/agronomy11040732

Kim J., Kim H., Kang K., and Kim J., 2024, Comparison of soil moisture changes based on the installation position of soil moisture sensors in the Korean orchard field soils, Journal of Bio-Environment Control, 33(2): 107-115.
https://doi.org/10.12791/KSBEC.2024.33.2.107

Li H., Li P., Cao G., Zhao M., Zhu Z., Wang Y., Wang W., Cao S., Xu Y., and Dong C., 2025, Mulching influences pear yield and quality by changing rhizosphere microbial community structure in the arid region of Northwest China, Frontiers in Plant Science, 16: 1633540.
https://doi.org/10.3389/fpls.2025.1633540

Liao Y., Cao H., Liu X., Li H., Hu Q., and Xue W., 2021, By increasing infiltration and reducing evaporation, mulching can improve the soil water environment and apple yield of orchards in semiarid areas, Agricultural Water Management, 253: 106936.
https://doi.org/10.1016/j.agwat.2021.106936

Luo J., Xu M., Liu C., Wei S., and Tang H., 2021, Effects comparation of different mulching methods on soil in pitaya orchards, International Agrophysics, 35(4): 431-438.
https://doi.org/10.31545/intagr/142845

Maliuk T., Kozlova L., and Pcholkina N., 2021, Soil irrigation and mulching as an effective method of its water regime optimization in the sweet cherry (*Cerasus avium* Moench.) intense orchards, Horticulture: Interdepartment Subject Scientific Collection, 76: 82-92.
https://doi.org/10.35205/0558-1125-2021-76-82-92

Millán S., Campillo C., Vivas A., Moñino M.J., and Prieto M.H., 2020, Evaluation of soil water content measurements with capacitance probes to support irrigation scheduling in a "Red Beaut" Japanese plum orchard, Agronomy, 10(11): 1757.
https://doi.org/10.3390/agronomy10111757

Ramos T.B., Darouich H., and Pereira L.S., 2024, Mulching effects on soil evaporation, crop evapotranspiration and crop coefficients: a review aimed at improved irrigation management, Irrigation Science, 42: 525-539.
https://doi.org/10.1007/s00271-024-00924-8

Şahin M., and Pırlak L., 2022, Effect of some bacterial strains on some morphological and pomological characteristics against cadmium toxicity in three strawberry (*Fragaria* × *ananassa* Duch.) cultivars, Türkiye Tarımsal Araştırmalar Dergisi, 9(3): 335-344.
https://doi.org/10.19159/tutad.1171832

Song X., Gao X., Zou Y., Chau H.W., Wu P., Zhao X., and Siddique K.H.M., 2021, Vertical variation in shallow and deep soil moisture in an apple orchard in the loess hilly-gully area of north China, Soil Use and Management, 37(3): 595-606.
https://doi.org/10.1111/sum.12598

Stagno F., Brambilla M., Roccuzzo G., and Assirelli A., 2024, Water use efficiency in a deficit-irrigated orange orchard, Horticulturae, 10(5): 498.
https://doi.org/10.3390/horticulturae10050498

Tang M., Gao X., Zou Y., Chau H.W., Wu P., Zhao X., and Siddique K.H.M., 2022a, Effects of living mulch and branches mulching on soil moisture, temperature and growth of rain-fed jujube trees, Plants, 11(19): 2654.
https://doi.org/10.3390/plants11192654

Tang M., Li H., Zhang C., Zhao X., Gao X., and Wu P., 2021, Mulching measures improve soil moisture in rain-fed jujube (Ziziphus jujuba Mill.) orchards in the Loess Hilly Region of China, Sustainability, 13(2): 610.
https://doi.org/10.3390/su13020610

Tang M., Liu R., Li H., Gao X., Wu P., and Zhang C., 2023, Optimizing soil moisture conservation and temperature regulation in rainfed jujube orchards of China's Loess Hilly Areas using straw and branch mulching, Agronomy, 13(8): 2121.
https://doi.org/10.3390/agronomy13082121

Tang W., Yang H., Wang W., Wang C., Pang Y., Chen D., and Hu X., 2022b, Effects of living grass mulch on soil properties and assessment of soil quality in Chinese apple orchards: a meta-analysis, Agronomy, 12(8): 1974.
https://doi.org/10.3390/agronomy12081974

Wang C., Cao C., Qiang C., Wang J., Wang Z., Zhang Z., Chen W., and Yang J., 2023a, Mulching with oilseed rape improving soil moisture and fertility and apple yield in orchard in semi-arid region, Agronomy Journal, 115(5): 21457.
https://doi.org/10.1002/agj2.21457

Wang Y., Han X., Yan W., Cheng L., Dang X., and Liu W., 2023b, Apple trees can extract soil water from both deep layers and neighboring cropland in the tableland region of Chinese Loess Plateau, CATENA, 229: 107396.
https://doi.org/10.1016/j.catena.2023.107396

Webber S.M., Bailey A.P., Huxley T., Potts S.G., and Lukac M., 2022, Traditional and cover crop-derived mulches enhance soil ecosystem services in apple orchards, Applied Soil Ecology, 178: 104569.
https://doi.org/10.1016/j.apsoil.2022.104569

Xing Y., Chen M., and Wang X., 2025, Enhancing water use efficiency and fruit quality in jujube cultivation: a review of advanced irrigation techniques and precision management strategies, Agricultural Water Management, 305: 109243.
https://doi.org/10.1016/j.agwat.2024.109243

Yang Y., Yin M., and Guan H., 2024, Responses of soil water, temperature, and yield of apple orchard to straw mulching and supplemental irrigation on China's Loess Plateau, Agronomy, 14(7): 1531.
https://doi.org/10.3390/agronomy14071531