

# Mulching: A Sustainable Approach to Soil Moisture Conservation

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Water scarcity is one of the most pressing challenges in modern agriculture, particularly in arid and semi-arid regions where rainfall is limited and erratic. Increasing competition for water among agriculture, industry, and domestic sectors further intensifies the problem. Under such conditions, efficient water management practices become essential to sustain crop productivity and ensure food security.

Mulching has emerged as a simple, practical, and cost-effective technique for conserving soil moisture. By covering the soil surface with a protective layer, mulching minimizes water loss, improves soil conditions, and creates a favorable microclimate for crop growth. In recent years, it has gained significant attention as a key component of climate-resilient and resource-efficient agriculture. In addition to moisture conservation, mulching also protects soil structure, reduces erosion, and enhances biological activity

## Concept and principle of mulching

Mulching is the practice of covering the soil surface around plants with a layer of material such as crop residues, plastic films, or other suitable substances. This protective layer acts as a physical barrier between the soil and the atmosphere. By doing so, it reduces the direct exposure of soil to solar radiation, wind velocity, and the impact of raindrops.

The core principle of mulching is to interrupt the soil-atmosphere interaction, which is primarily responsible for moisture loss through evaporation. When soil is left bare, water from the upper layers easily evaporates due to heat and air movement. Mulch reduces this process by creating a buffer zone that conserves moisture, stabilizes soil temperature, and improves the overall microenvironment for plant growth.

## Types of Mulching Materials

### 1. Organic Mulches

Organic mulches are derived from plant and animal residues. Common examples include:

- Crop residues (wheat straw, rice husk, sugarcane trash)
- Dry leaves and grass clippings

- Farmyard manure (FYM)
- Compost and sawdust

### Characteristics and Benefits:

- Biodegradable and environmentally friendly
- Improve soil organic matter and fertility
- Enhance microbial activity and soil structure
- Gradually release nutrients into the soil

### 2. Inorganic Mulches

These include synthetic or non-biodegradable materials such as:

- Plastic films (black, silver-black, transparent)
- Stones and gravel
- Polyethylene sheets and geo-textiles

### Characteristics and Benefits:

- More durable and long-lasting
- Provide excellent weed control
- Higher efficiency in reducing evaporation
- Suitable for high-value crops like vegetables and fruits

## Mechanisms of Moisture Conservation through Mulching

Mulching conserves soil moisture through a combination of physical, biological, and microclimatic modifications at the soil surface. By acting as a protective layer, mulch alters the energy balance, water movement, and soil structure in ways that significantly reduce water loss and improve its availability to plants. The key mechanisms are explained below in detail:

### 1. Reduction in Evaporation Losses

Evaporation is one of the primary pathways through which soil loses moisture, especially under high temperature and windy conditions.

- **Barrier Effect:** Mulch forms a protective layer over the soil surface, blocking direct solar radiation and reducing wind speed at the soil interface. This lowers the energy available for evaporation.
- **Reduced Vapor Pressure Gradient:** By maintaining higher humidity just above the soil surface, mulch

reduces the gradient that drives water vapor movement into the atmosphere.

- **Lower Soil Surface Temperature:** Since mulch shades the soil, it prevents excessive heating, which directly reduces evaporation rates.
- **Extended Moisture Availability:** As a result, water remains in the root zone for longer periods, reducing the need for frequent irrigation.

## 2. Improved Infiltration and Water Retention

Mulching enhances the entry and storage of water in the soil profile.

- **Reduction in Surface Runoff:** The mulch layer slows down the movement of water across the soil surface, allowing more time for infiltration.
- **Protection of Soil Structure:** It prevents the breakdown of soil aggregates caused by raindrop impact, thereby maintaining soil porosity.
- **Increased Water Holding Capacity:** Organic mulches, in particular, absorb water like a sponge and gradually release it into the soil.
- **Enhanced Root Zone Moisture:** Improved infiltration ensures that water reaches deeper into the root zone, making it more accessible to plants over time.

## 3. Regulation of Soil Temperature

Soil temperature plays a crucial role in water dynamics and plant growth, and mulching helps in moderating extreme fluctuations.

- **Cooling Effect in Summer:** Mulch reflects or absorbs solar radiation before it reaches the soil, keeping the soil temperature lower. This reduces evaporation and prevents heat stress on roots.
- **Insulating Effect in Winter:** Mulch acts as an insulating layer that reduces heat loss from the soil during cold nights, protecting roots from temperature stress.
- **Stable Micro environment:** A more uniform temperature regime improves root growth, nutrient uptake, and microbial activity, all of which contribute to efficient water use.

## 4. Prevention of Soil Crusting and Compaction

Soil crusting is a common problem, especially in fine-textured soils, and it significantly reduces water infiltration.

- **Absorption of Raindrop Impact:** Mulch absorbs the kinetic energy of raindrops, preventing the disintegration of soil aggregates.

- **Maintenance of Soil Porosity:** By protecting the soil structure, mulch ensures that pores remain open for water and air movement.
- **Reduction in Surface Sealing:** Without mulch, soil particles can form a hard crust after rainfall or irrigation. Mulch prevents this, allowing continuous infiltration of water.
- **Improved Root Penetration:** A loose and porous soil surface facilitates better root growth, enabling plants to access deeper moisture reserves.

## 5. Reduction in Evapotranspiration Demand

Evapotranspiration (ET) includes both soil evaporation and plant transpiration. Mulching influences both components.

- **Microclimate Modification:** Mulch increases humidity and reduces temperature near the soil surface, lowering the atmospheric demand for water.
- **Reduced Soil Evaporation Component:** Since the soil is covered, direct evaporation is minimized, which is a major component of ET.
- **Improved Plant Water Status:** With more moisture available in the root zone, plants experience less water stress and regulate transpiration more efficiently.
- **Enhanced Water Use Efficiency (WUE):** Crops grown under mulched conditions utilize water more effectively, producing higher yield per unit of water consumed.

## Impact of Mulching on Crop Productivity

Numerous studies have demonstrated that mulching can significantly increase crop yields. This is due to:

- Improved soil moisture availability
- Enhanced nutrient use efficiency
- Better root development
- Reduced weed competition

Yield increases of 10–50% have been reported in crops like tomato, chilli, cotton, and sugarcane when mulching is combined with efficient irrigation methods such as drip irrigation.

## Role in Soil Health Improvement

Mulching contributes to long-term soil sustainability by:

- Increasing soil organic carbon content
- Enhancing microbial biomass and activity
- Improving soil structure and aeration
- Reducing erosion and nutrient losses

Organic mulches, in particular, play a vital role in maintaining soil fertility and biological health.

**Application Techniques and Best Practices**

- Apply mulch immediately after sowing or transplanting
- Ensure adequate soil moisture before application
- Maintain appropriate thickness:
  - Organic mulch: 5–10 cm
  - Plastic mulch: 25–50 microns thickness depending on crop
- Keep mulch slightly away from plant stems to prevent disease
- Secure plastic mulch properly to avoid displacement by wind
- Integrate mulching with drip irrigation for maximum efficiency

**Economic and Environmental Benefits**

- Reduces irrigation frequency and water use
- Lowers labor costs for weeding
- Increases water use efficiency (WUE)
- Promotes sustainable agriculture practices
- Helps in climate change adaptation

**Constraints and Limitations**

Despite its advantages, mulching has certain challenges:

- High initial cost of plastic mulch
- Disposal and environmental concerns of non-biodegradable materials

- Risk of pest and rodent infestation under mulch
- Requirement of technical knowledge for proper application

**Future Prospects**

The development of biodegradable plastic mulches and integration with precision irrigation technologies offers promising future potential. Research is also focusing on region-specific mulch recommendations to optimize water savings and crop productivity.

**Conclusion**

Mulching is a highly effective agronomic practice for conserving soil moisture and improving crop performance. By reducing evaporation, enhancing water retention, and improving soil health, it plays a crucial role in sustainable agriculture. Adoption of mulching, particularly in water-limited regions, can significantly enhance farm productivity and resilience to climate variability.

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