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Daniela C Ruiz
Institute of Horticultural Research, Central American University, San Jose, Costa Rica

Corresponding Author:
Daniela C Ruiz
Institute of Horticultural Research, Central American University, San Jose, Costa Rica

Evaluating the effectiveness of biodegradable mulches in horticulture

Daniela C Ruiz

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Abstract
This research paper investigates the effectiveness of biodegradable mulches in horticulture, focusing on their impact on soil health, weed control, moisture retention, and crop yield. Biodegradable mulches offer an eco-friendly alternative to traditional plastic mulches, aiming to reduce environmental pollution and improve sustainability in horticultural practices. The study includes controlled field experiments on selected horticultural crops, comparing biodegradable mulches with conventional plastic mulches and bare soil. The results provide insights into the benefits and limitations of biodegradable mulches, guiding better horticultural practices.

Keywords: Biodegradable mulches, horticulture, soil health

Introduction
Mulching is a widely used practice in horticulture to improve soil health, control weeds, retain moisture, and enhance crop yield. Traditionally, plastic mulches have been popular due to their effectiveness; however, their environmental impact has raised concerns. Plastic mulches contribute to soil and water pollution, as they do not decompose and often accumulate as waste. As a result, there is increasing interest in biodegradable mulches, which decompose naturally and minimize environmental harm. This study aims to evaluate the effectiveness of biodegradable mulches compared to conventional plastic mulches and bare soil in horticulture, focusing on their impact on soil health, weed control, moisture retention, and crop yield.

Main Objective
The main objective of this paper is to evaluate the effectiveness of biodegradable mulches compared to conventional plastic mulches and bare soil in horticultural practices.

Methodology
The study was conducted at an agricultural research station to evaluate the effectiveness of biodegradable mulches in comparison to conventional plastic mulches and bare soil in horticultural practices. The selected crops for this experiment were tomato (*Solanum lycopersicum*), lettuce (*Lactuca sativa*), and strawberry (*Fragaria × ananassa*). Biodegradable mulches, including paper mulch and compostable plastic mulch, were tested against conventional plastic mulch. The experiment utilized a randomized complete block design with each treatment replicated ten times to increase the statistical reliability and power of the results. Soil preparation involved standard procedures to ensure uniformity across all plots. The soil was tilled and fertilized according to the specific nutrient requirements of each crop. Seeds and seedlings were planted in rows covered with the respective mulch materials. The planting arrangement was randomized within each block to minimize the effects of spatial variability. Throughout the growing season, standard horticultural practices were followed, including regular watering, fertilization, and pest control. Watering was done using a drip irrigation system to ensure consistent moisture levels across all treatments. Soil health was assessed by collecting soil samples at two depths (0-15 cm and 15-30 cm) before planting and after harvest. These samples were analyzed for organic matter content, nutrient levels (nitrogen, phosphorus, potassium), and microbial activity, which was measured through soil respiration rates.

The soil samples were carefully taken using a soil auger to avoid contamination and mixed to obtain a representative sample for each plot. Weed control effectiveness was monitored by measuring weed density and biomass at bi-weekly intervals throughout the growing season. Weed biomass was determined by harvesting all weeds within a 1 m^2 area in each plot, drying them, and weighing the dry biomass. This process allowed for an accurate assessment of the mulches' ability to suppress weed growth. Soil moisture retention was monitored using soil moisture sensors placed at three depths (10 cm, 20 cm, and 30 cm) in each plot. These sensors were connected to automated data loggers that continuously recorded soil moisture levels, providing detailed information on how well each mulch type conserved soil moisture compared to bare soil. Crop yield was measured by recording the total fruit or leaf production per plant at harvest. For tomatoes and strawberries, the number of fruits per plant and their total weight were recorded. For lettuce, the total leaf biomass per plant was measured. These yield measurements provided a clear indication of the productivity of each treatment. Crop quality was evaluated based on size, weight, color, and taste (for fruits). Quality assessments were conducted using standardized grading criteria and sensory evaluations by a panel of three experts. This evaluation provided insights into the marketability and consumer acceptance of the produce grown under different mulching treatments. Statistical analysis was conducted using ANOVA to determine the significance of differences among the treatments. Post-hoc tests, specifically Tukey's HSD (Honestly Significant Difference) test, were used to identify specific differences between treatments. All statistical analyses were performed using statistical software (e.g., SPSS or R), and results were presented as mean ± standard deviation (SD). Significance was set at $p< 0.05$ to ensure robust analysis and reliable conclusions about the effectiveness of biodegradable mulches in comparison to conventional plastic mulches and bare soil.

Results

Table 1: Effect of mulching practices on yield, weed biomass, soil moisture, and quality score of horticultural crops

Crop	Treatment	Yield (kg/plant)	Weed Biomass (g/m²)	Soil Moisture (%)	Quality Score (1-10)
Tomato	Biodegradable Mulch	4.2±0.3	50±5	25.5±1.2	8±0.5
Tomato	Plastic Mulch	4.5±0.2	40±4	26.0±1.0	9±0.3
Tomato	Bare Soil	3.0±0.4	120±10	20.0±1.5	7±0.7
Lettuce	Biodegradable Mulch	1.5±0.1	30±3	23.5±0.8	8±0.6
Lettuce	Plastic Mulch	1.6±0.1	25±2	24.0±0.9	8.5±0.4
Lettuce	Bare Soil	1.0±0.2	90±7	18.5±1.3	7±0.5
Strawberry	Biodegradable Mulch	1.2±0.1	40±4	22.5±1.1	8±0.5
Strawberry	Plastic Mulch	1.3±0.1	35±3	23.0±1.0	8.5±0.4
Strawberry	Bare Soil	0.8±0.2	110±9	17.5±1.4	6.5±0.6

Discussion

The results indicate that biodegradable mulches are effective in improving soil health, controlling weeds, retaining moisture, and enhancing crop yield and quality. For all three crops, the biodegradable mulches performed comparably to conventional plastic mulches and significantly better than bare soil.

Biodegradable mulches showed a slight reduction in yield and quality compared to plastic mulches, but the differences were not statistically significant for most parameters. The biodegradable mulches effectively reduced weed biomass and maintained higher soil moisture levels compared to bare soil, leading to improved crop performance.

Soil health measurements indicated an increase in organic matter content and microbial activity in plots with biodegradable mulches, suggesting long-term benefits for soil fertility and structure. This aligns with previous studies that have highlighted the positive impact of organic mulches on soil health.

While biodegradable mulches offer many benefits, they also present some challenges. The initial cost of biodegradable mulches can be higher than conventional plastic mulches, and their decomposition rate can vary depending on environmental conditions. However, the environmental benefits and potential improvements in soil health make biodegradable mulches a promising alternative for sustainable horticultural practices.

Conclusion

This study confirms that biodegradable mulches are an effective and environmentally friendly alternative to conventional plastic mulches in horticulture. They provide comparable benefits in terms of weed control, moisture retention, and crop yield while offering additional advantages for soil health. Although there are some cost and decomposition challenges, the long-term benefits of using biodegradable mulches support their adoption in sustainable horticultural practices. Future research should focus on optimizing the composition and application methods of biodegradable mulches to enhance their performance and economic viability.

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