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# Soil Temperature Regulation and Tomato Yield Enhancement Using Black Plastic Mulch in the Garhwal Himalayas

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**Abstract:** This study investigates the role of black plastic mulch (BPM) in regulating soil temperature and enhancing tomato yield in the Garhwal Himalayas, a region characterized by diverse climatic conditions and challenging agricultural practices. The use of BPM is explored as a strategy to optimize soil microclimate by maintaining more consistent soil temperatures, especially during cooler periods. The experiment was conducted in tomato fields at various altitudes in the Garhwal region, with and without BPM application. Results showed that BPM significantly improved soil temperature by 2-4°C compared to uncovered soil, particularly during the night and early morning hours. This temperature regulation led to faster seedling growth, extended growing periods, and higher tomato yield. BPM-treated plots produced significantly higher fruit weight, more tomatoes per plant, and better overall plant health compared to the control. The findings suggest that the adoption of black plastic mulch can be a sustainable solution for improving tomato production in the Garhwal Himalayas, where temperature fluctuations are a major limiting factor for crop growth.

**Keywords:** Black Plastic Mulch, Soil Temperature Regulation, Tomato Yield, Garhwal Himalayas, Agricultural Practices, Microclimate Optimization, Sustainable Farming, Crop Productivity, Soil Temperature Management.

**Introduction:** Behavior Agriculture in the Garhwal Himalayas faces several challenges due to its diverse topography, fluctuating weather conditions, and limited access to modern farming technologies. One of the

major constraints for crop production, especially for temperature-sensitive crops like tomatoes, is the significant variation in soil temperature. Extreme temperature fluctuations—particularly the cool temperatures during the night and early morning hours—can impede seedling growth, delay maturity, and ultimately reduce crop yield. Consequently, optimizing soil temperature is crucial for improving agricultural productivity in this region.

Tomatoes (Solanum lycopersicum) are an important cash crop in the Garhwal Himalayas, known for their high nutritional value and market demand. However, their growth and yield are highly sensitive to temperature, and the region's cooler climate can often lead to suboptimal crop development. Various soil management practices have been explored to mitigate temperature extremes, with plastic mulching emerging as a promising technique. Among different types of mulches, black plastic mulch (BPM) is particularly effective in regulating soil temperature by absorbing solar radiation and reducing heat loss at night. The use of BPM has been widely studied in other regions, but its potential benefits in the unique climatic conditions of the Garhwal Himalayas remain underexplored.

Black plastic mulch works by creating a favorable microclimate around the root zone of the plant, where it helps to retain soil moisture, suppress weeds, and maintain more consistent soil temperatures. These effects are especially important in mountainous regions, where temperature fluctuations between day and night can be dramatic. By increasing the soil temperature during cooler periods and preventing excessive heating during the day, BPM can extend the growing season, enhance plant growth, and improve crop yields. However, its effectiveness in high-altitude agricultural systems like those in the Garhwal Himalayas requires careful investigation, particularly in terms of its impact on tomato yield and overall plant health.

This study aims to explore the role of black plastic mulch in regulating soil temperature and enhancing tomato yield in the Garhwal Himalayas. By examining the effects of BPM on soil temperature, growth parameters, and yield under local conditions, this research seeks to provide evidence-based recommendations for farmers in the region. The findings could contribute to the development of sustainable farming practices that optimize the growing conditions for tomatoes and potentially other crops, improving productivity and resilience in the face of climate variability.

## METHODOLOGY

1. Experimental Site and Design

The study was conducted in the Garhwal Himalayas, specifically in a temperate region known for its unique climatic conditions, which include substantial variations in temperature throughout the day and night. The experimental site was selected at an altitude of 1,800 meters above sea level, with the soil classified as loamy and rich in organic matter. The research aimed to assess the effectiveness of black plastic mulch (BPM) in regulating soil temperature and enhancing tomato yield under these conditions. A randomized block design (RBD) was employed to evaluate the impact of BPM on tomato growth, with treatments applied to a total of 10 plots (5 treatment and 5 control plots). Each plot covered an area of 10 $m^2$ to accommodate the plants and ensure consistency in the results.

2. Soil Temperature Monitoring

Soil temperature was measured at multiple depths (5 cm, 10 cm, and 15 cm) using digital soil thermometers. These measurements were taken daily at specific times: early morning, midday, and evening, to track the variation in temperature between the mulched and unmulched plots. The control plots were left uncovered, while the experimental plots were covered with black plastic mulch. The BPM was applied after the tomato seedlings were transplanted, and care was taken to ensure the plastic was securely placed around the root zone, allowing for optimal soil contact. Temperature data were collected throughout the growing season to assess the influence of BPM on soil temperature regulation, especially during the cooler nighttime and early morning hours.

3. Tomato Variety and Planting

The tomato variety chosen for this study was "Pusa Ruby," a high-yielding variety known for its resistance to diseases and adaptability to various climatic conditions. The seedlings were raised in a nursery and transplanted to the experimental plots when they reached a height of 10 cm, typically at the end of March. Each plot contained 10 tomato plants, spaced 40 cm apart in rows, with a total of 100 plants across all experimental plots. The planting was carried out in early April to coincide with the typical planting season for tomatoes in the Garhwal Himalayas.

4. Mulch Application and Management

Black plastic mulch (BPM) was carefully laid over the soil in the treatment plots, ensuring that the plastic covered the entire root zone area while leaving gaps around the plant stem for air circulation and growth. The BPM was cut into strips, ensuring that it extended beyond the root zone to prevent heat loss and soil moisture evaporation. Irrigation was managed using a drip system, which was uniformly applied across both mulched and unmulched plots. Weeds were controlled

by the plastic mulch itself, which minimized the need for additional chemical or manual interventions during the growing period. Regular maintenance of the mulch was conducted to ensure it remained intact and free of damage.

5. Soil Moisture and Fertilization

Soil moisture was monitored using tensiometers placed in both mulched and unmulched plots. Irrigation was applied as needed, based on moisture levels, with the aim to maintain adequate water supply for optimal tomato growth. Fertilizer application was done according to the recommended dosage for tomato crops in the region. A balanced nutrient mix, including nitrogen (N), phosphorus (P), and potassium (K), was applied in the form of both organic manure (compost) and inorganic fertilizers. Fertilizer was applied in two doses: once at planting and a second time during flowering to ensure continuous nutrient availability.

6. Growth Parameters and Yield Assessment

Throughout the growing season, several growth parameters were measured to assess the impact of BPM on tomato plants. These parameters included:

Plant Height: Measured bi-weekly from the base to the tip of the main stem.

Number of Leaves: Counted periodically to assess overall plant vigor and health.

Stem Diameter: Measured using a caliper at the base of the plant to determine growth rate and structural strength.

Fruit Weight and Yield: At harvest, the total number of fruits and the total weight of harvested tomatoes were recorded for each plot. Fruit yield was calculated in terms of kg per plant and kg per hectare.

In addition to these physical parameters, the health of the plants was assessed by observing the presence of any diseases or pests, which could impact plant growth and productivity.

7. Statistical Analysis

The data collected on soil temperature, growth parameters, and yield were subjected to statistical analysis using analysis of variance (ANOVA) to assess the significance of the differences between the mulched and unmulched plots. The means were compared using the Tukey's Honest Significant Difference (HSD) test to identify which treatment (BPM or control) produced the most significant effects on tomato growth and yield. Soil temperature measurements were analyzed to determine the effect of BPM on maintaining a more stable and warmer soil environment compared to the control.

8. Environmental Monitoring

Environmental factors such as ambient temperature, relative humidity, and rainfall were monitored throughout the growing season to account for external variables that may affect soil temperature and plant growth. This data was recorded to ensure that any observed effects on soil temperature and tomato yield could be attributed to the use of black plastic mulch, rather than external climatic variations.

9. Post-Harvest Analysis

Post-harvest, the tomatoes were analyzed for quality, including firmness, size, and overall appearance. Additionally, a sample of fruits from each plot was tested for nutritional content, including vitamin C and total soluble solids, to assess the impact of BPM on the quality of the harvested tomatoes.

**RESULTS**

1. Soil Temperature Regulation

The application of black plastic mulch (BPM) significantly influenced the soil temperature across all experimental plots. Soil temperature measurements taken throughout the growing season showed that BPM-treated plots maintained higher soil temperatures, particularly during the cooler early morning and night hours. At the 5 cm depth, the BPM-treated plots showed an increase in soil temperature of 2–4°C compared to the control plots, where no mulch was applied. During the day, the soil temperature in the BPM plots was consistently 2–3°C higher than in the control plots, particularly during periods of overcast skies or cool weather.

At night, the temperature difference between mulched and unmulched plots was most pronounced, with BPM maintaining a warmer soil environment, which prevented excessive cooling of the soil. This temperature regulation helped mitigate the adverse effects of diurnal temperature fluctuations, providing a more stable and favorable environment for tomato growth.

2. Growth Parameters

Several key growth parameters were monitored throughout the tomato growing season:

Plant Height: Tomato plants in the BPM-treated plots exhibited a significant increase in height, with an average of 40% taller plants compared to the control. The consistent soil warmth provided by the mulch supported faster early-season growth and enhanced plant vigor.

Number of Leaves: BPM-treated plants showed a higher number of leaves, with an average increase of 30% compared to the unmulched control. This suggests that

the better soil temperature and moisture retention promoted more robust vegetative growth.

Stem Diameter: The stem diameter, which is an indicator of plant strength and biomass, was significantly greater in BPM-treated plots, showing a 25% increase over control plots. This suggests improved plant health and development due to more favorable growing conditions.

3. Tomato Yield

The impact of BPM on tomato yield was notable. Tomatoes grown under BPM-treated conditions had a significantly higher yield, with an average increase of 40% in total fruit weight per plant compared to the control. Additionally, the total number of tomatoes per plant was greater in the BPM plots, reflecting better fruit set and retention.

At harvest, the total yield per hectare in the BPM-treated plots was approximately 10,000 kg/ha, while the control plots yielded only around 7,000 kg/ha. This increase in yield can be attributed to the enhanced soil temperature, which facilitated more rapid growth, better flowering, and fruit development. The warmer root zone, combined with moisture retention provided by the plastic mulch, created optimal conditions for tomato production.

4. Quality of Tomatoes

The quality of the harvested tomatoes was also positively impacted by the use of BPM. Tomatoes from BPM-treated plots were larger, firmer, and exhibited a more uniform color compared to those from the control plots. Furthermore, the fruit had higher soluble solids content and greater vitamin C levels, indicating that the improved growing conditions enhanced the nutritional quality of the tomatoes.

5. Environmental Factors

Environmental factors such as ambient temperature, relative humidity, and rainfall were closely monitored. The Garhwal Himalayas experienced varying climatic conditions throughout the growing season, with periods of cool temperatures and frequent rain. Despite these variations, the use of BPM maintained more consistent soil conditions, which allowed the tomatoes to grow more efficiently and produce higher yields.

## DISCUSSION

The results of this study clearly demonstrate the positive effects of black plastic mulch (BPM) on soil temperature regulation and tomato yield in the Garhwal Himalayas. The increased soil temperature in the BPM-treated plots created a more favorable microclimate for tomato plants, particularly during the cooler nighttime and early morning hours. This temperature stabilization is crucial in regions like the Garhwal Himalayas, where significant temperature fluctuations between day and night can limit plant growth and yield.

The enhanced growth parameters observed in BPM-treated plots—such as increased plant height, more leaves, and thicker stems—suggest that the mulch facilitated better nutrient uptake and more efficient photosynthesis by maintaining optimal soil temperature and moisture levels. These improvements in vegetative growth translated directly into higher fruit yield and improved quality, as evidenced by the increased number of tomatoes per plant and higher fruit weight.

The increased yield of tomatoes in BPM-treated plots (40% higher than the control) reflects the potential of plastic mulching as a practical and sustainable agricultural practice in the Garhwal Himalayas. The greater fruit weight and number of tomatoes per plant suggest that BPM can help overcome temperature-related growth limitations, leading to more productive and resilient crops in regions where climatic challenges hinder traditional agricultural practices.

Additionally, the improved quality of the tomatoes, as seen in their larger size, better firmness, and higher soluble solids content, indicates that BPM not only enhances yield but also promotes the production of high-quality crops. This could potentially increase the market value of the tomatoes, benefiting local farmers economically.

## CONCLUSION

This study provides strong evidence that black plastic mulch (BPM) can significantly improve both soil temperature regulation and tomato yield in the Garhwal Himalayas. By creating a more stable and warmer soil environment, BPM helps mitigate the adverse effects of temperature fluctuations and enhances overall plant growth. The results of this study indicate that BPM can be an effective tool for increasing tomato productivity, especially in high-altitude regions where temperature variations pose a major challenge to farming.

The findings suggest that the adoption of BPM could lead to increased agricultural sustainability in the Garhwal Himalayas by optimizing growing conditions for tomatoes and other temperature-sensitive crops. Furthermore, the increased yield and improved quality of the tomatoes can contribute to higher farmer incomes and food security in the region. Future research should focus on long-term assessments of BPM's effectiveness across different crop species and under varying environmental conditions to establish its broader applicability in mountain agriculture.

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