Journal of Natural Science Review

Vol. 3, No. 4, 2025
https://kujnsr.com
e-ISSN: 3006-7804

Effects of Organic and Inorganic Mulches on Soil Physico-Chemical Properties Under Temperate Conditions of Kashmir

Zahedullah Zahed✉[1], Hikmatullah Hikmat[2], Hamid Salari[3], Mohammad Khalid Rashidi[4]

[1,2]Horticulture Department, Agriculture Faculty, Wardak University, Maidan Wardak, Afghanistan.
[3,4] Horticulture Department, Agriculture Faculty, Kabul University, Kabul, Afghanistan.
✉E-mail: zazahedullah@gmail.com (corresponding author)

ABSTRACT

Mulching is a widely adopted agronomic practice for improving soil health, conserving moisture, and enhancing crop productivity, particularly under temperate conditions. A field experiment was conducted during 2020–21 at SKUAST-Kashmir to evaluate the effects of different organic and inorganic mulches on soil physico-chemical properties and moisture–temperature regimes under potato (Solanum tuberosum L.) cultivation. The study employed a Randomized Complete Block Design with ten treatments, including six colored polyethylene mulches and three organic mulches, along with an un-mulched control. Soil parameters such as pH, organic carbon, electrical conductivity (EC), bulk density, available N, P_2O_5, K_2O, soil moisture, and temperature were assessed before and after the experiment. Results revealed significant improvements in soil properties under both mulch types compared to the control. Plastic mulches, particularly black and green polyethylene, reduced soil pH, EC, and bulk density while enhancing soil moisture retention and thermal conditions. Among organic mulches, farmyard manure mulch recorded the highest organic carbon, reduced EC, improved nutrient availability, and maintained favorable soil temperature and moisture levels. Overall, mulched treatments significantly increased available nitrogen, phosphorus, and potassium compared to the initial soil status and the un-mulched control. Black polyethylene mulch and farmyard manure mulch consistently outperformed other treatments in improving soil hydrothermal regimes. The findings highlight the potential of both organic and inorganic mulches to enhance soil quality and support sustainable potato production under temperate conditions.

ARTICLE INFO

Article history:

Received: September 17, 2025
Revised: October 12, 2025
Accepted: November 26, 2025
Published: December 31, 2025

Keywords:

Inorganic mulches; Mulches; Organic mulches; Soil physico-chemical properties; Temperate agroecosystem

To cite this article: Zahed, Z., Hikmat, H., Salari, H., & Rashidi M., K. (2025). Effects of Organic and Inorganic Mulches on Soil Physico-Chemical Properties Under Temperate Conditions of Kashmir. *Journal of Natural Science Review*,3(4), 119-133. https://doi.org/10.62810/jnsr.v3i4.318
Link to this article: https://kujnsr.com/JNSR/article/view/318

Copyright © 2025 Author(s). This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License.

INTRODUCTION

The potato (Solanum tuberosum L.) is a globally vital crop, particularly in India and China, which together contribute nearly one-third of the world's potato production (FAOSTAT, 2019). While the crop boasts high productivity per unit area, it also demands substantial daily water input. Both inadequate and excessive irrigation can negatively affect its growth, yield, and quality. Optimal potato performance hinges on maintaining a proper balance between soil-air and soil-moisture in the root zone throughout the crop's developmental cycle; this depends on sound water management practices (Singh et al., 2012). Mulching practices improve soil moisture and enzyme activities in drylands, and also enhance enzyme activity related to nutrient cycling (Song et al., 2024).

Film, black/blue polythene mulches under zero tillage resulted in the highest yield and benefit–cost ratio compared to straw mulch in coastal lowlands (Mollah et al., 2025).

Moisture stress, particularly during critical stages such as stolon formation, tuber formation, and tuber development, leads to a significant decline in potato productivity (Saikia, 2011). Plastic film mulching can conserve water (Lie et al., 2004), regulate soil temperature (Hou et al., 2010; Filipovic et al., 2016), and promote plant growth (Qin et al., 2016; Fan et al., 2016). Mulching conserves soil moisture, especially during the early stages of plant growth, and significantly reduces water losses in the form of evaporation by allowing more water to be absorbed into the soil profile (Xing et al., 2012). It also improved the hydrothermal regimes of the soil, which are favorable for higher crop yields (Singh et al., 2004).

Mulching has been widely recognized as an effective agronomic practice that significantly influences soil properties, crop productivity, and resource use efficiency. Recent studies have highlighted the substantial impact of plastic film mulching on crop performance. For instance, Xu et al. (2023) reported that plastic film mulch increased potato yield by 27% and enhanced water use efficiency (WUE) by a similar 27%, while also modifying soil hydrothermal conditions by reducing cumulative temperature ≥10°C. Their findings emphasized that optimal fertilizer application, suitable planting densities, use of black-colored mulch, and ridge planting further strengthened the positive effects of mulching under temperate production systems. Similarly, Zhang et al. (2024) demonstrated that maize straw mulching combined with no-tillage practices considerably improved both grain yield and WUE compared to conventional tillage, suggesting that mulch–tillage interactions play a vital role in sustainable moisture retention.

In addition to influencing moisture and temperature dynamics, mulching also contributes to the improvement of soil chemical and physical properties. According to Xing et al. (2012), organic mulches supply substantial quantities of carbon and nitrogen upon decomposition, thereby enhancing soil fertility. Increased soil organic matter subsequently leads to improved soil porosity and structural stability, as supported by Mulumba and Lal (2008). Both organic and inorganic mulches have been shown to affect soil characteristics and crop performance. In potato production systems, different mulch types significantly alter soil temperature, moisture availability, and nutrient dynamics, thereby influencing growth and economic returns. Plastic mulches, in particular, provide multiple agronomic advantages in arid and semi-arid regions, including improved crop earliness, enhanced cleanliness, prevention of soil erosion, and conservation of soil moisture and fertility. These benefits collectively contribute to higher yields (Moreno & Moreno, 2008) and effective weed suppression (Hidayat et al., 2013).

Different types and colors, such as black, green, yellow, blue, grey, and red, of plastic mulch have optical properties that change the levels of light radiation reaching the soil, causing increases or decreases in soil temperature and moisture (Kasirajan & Ngouajio, 2012).

Organic mulches have also shown positive effects on growth, yield, and earliness, due to soil heating, however. Organic mulches must be renewed periodically to maintain their effectiveness, as they decompose over time (Iqbal et al., 2020).

Potato cultivation frequently encounters challenges related to soil moisture retention, temperature regulation, nutrient availability, and declining soil quality. Mulching is a common agronomic practice used to improve soil conditions; however, the type of mulch, whether organic or inorganic, can have varying impacts on soil properties. While organic mulches may enhance soil biological and chemical properties, Plastic mulches often influence physical conditions such as moisture and temperature (Powell et al., 2020). The objective of this research is to evaluate the effects of different organic and inorganic mulches on soil physico-chemical properties and moisture–temperature regimes under potato (*Solanum tuberosum* L.) cultivation.

METHODS AND MATERIAL

A field experiment entitled was conducted during Kharif season 2020-2021 at the Experimental Field of the Division of Vegetable Science, SKUAST-Kashmir, Shalimar. The experimental site, located 15 km from Srinagar city at an altitude of 1685 m above mean sea level (34°N latitude and 74.89°E longitude), falls under a mid- to high-altitude temperate climate characterized by hot summers and very cold winters. During the crop season, temperatures ranged from 1.85 to 16.48 °C (minimum) and 13.92 to 30.46 °C (maximum), with a total rainfall of 347.5 mm and relative humidity between 55.68 and 58.83%. The planting material used was the variety Shalimar Potato-1, a medium-maturing (115–125 days), disease-tolerant cultivar with good keeping and cooking quality. The experiment consisted of nine mulching treatments—six inorganic synthetic mulches (black, green, blue, yellow, grey and red polythene of 30-micron thickness) and three organic mulches (pine needles at 25 t ha^{-1}, rice straw at 20 t ha^{-1}, and FYM at 20 t ha^{-1})—along with an unmulched control. Prior to fertilizer and manure application, composite soil samples were collected from a 0–15 cm depth, shade-dried, sieved (2 mm), and analyzed for physico-chemical properties, revealing neutral soil pH and medium levels of available nitrogen, phosphorus and potassium.

Experimental Site

The study was conducted at the experimental field of the Division of Vegetable Science, SKUAST-Kashmir, Shalimar, during the Kharif season of 2020–21. The site is located 15 km from Srinagar city at an altitude of 1685 m above mean sea level (34°N latitude, 74.89°E longitude). The soil at the experimental site is sandy clay loam, with an initial bulk density of 1.5 g cm^{-3}, pH of 6.63, organic carbon 0.65%, electrical conductivity 0.18 dS m^{-1}, and available nutrients of nitrogen 229.76 kg ha^{-1}, phosphorus 20.0 kg ha^{-1}, and potassium 165.2 kg ha^{-1} (Table 1). The region experiences hot summers and freezing winters, with minimum and maximum temperatures ranging from −1.47 °C to 30.75 °C. Maximum rainfall occurs during March and April, with average relative humidity ranging from 55.68% to 58.83% during the cropping season (Meteorological Observatory, Division of Agro-Metrology, SKUAST-Kashmir, 2020).

Experimental Design and Treatments

The experiment was laid out in a Randomized Complete Block Design (RCBD) with ten mulch treatments, comprising six colored polyethylene mulches (black, green, blue, yellow, grey, and red) and three organic mulches (pine needle, rice straw, and farmyard manure), each replicated three times. The Shalimar Potato-1 variety was used as the test crop. Seed tubers (25–35 g) were planted on 19 March 2020 at a spacing of 60 × 20 cm. Field preparation involved one deep plowing followed by three light plowings and harrowing to obtain a fine tilth.

Fertilizer and Crop Management

Recommended doses of fertilizers for the Desiree potato variety were applied at sowing, including farmyard manure (20–25 t ha^{-1}) and $N:P_2O_5:K_2O$ at 150:100:100 kg ha^{-1}. Due to the presence of mulches, the full dose of nitrogen was applied as a basal application at the time of sowing. All other standard agronomic practices were followed uniformly across treatments.

Data Collection

Soil samples were collected before and after the experiment to measure pH, organic carbon (%), electrical conductivity (dS m^{-1}), bulk density (g cm^{-3}), and available nutrients (N, P_2O_5, K_2O). Soil moisture content was monitored at regular intervals throughout the crop growth period. Additionally, economic returns were calculated to evaluate the cost-effectiveness of different mulching treatments.

Statistical Analysis

Collected data were subjected to analysis of variance (ANOVA), and means were compared using Duncan's Multiple Range Test (DMRT) at a 5% level of significance (Gomez & Gomez, 1984).

FINDINGS

The study revealed that both organic and inorganic mulches significantly influenced soil physical, chemical, and moisture parameters under potato cultivation. Mulching improved soil moisture retention, moderated soil temperature, and enhanced nutrient availability (N, P, K), organic carbon, and bulk density compared to un-mulched plots. Among the treatments, black and colored plastic mulches performed best in conserving soil moisture and regulating temperature, while farmyard manure and rice straw were most effective among organic mulches. Overall, mulching improved soil health and created favorable conditions for potato growth, highlighting its importance for optimizing soil properties and crop productivity under the temperate conditions of Kashmir.

Soil pH, organic carbon, electrical conductivity (EC), and bulk density were significantly influenced by different organic and inorganic mulches (Table 2). All mulching treatments reduced soil pH compared to the initial value of 6.61. Among inorganic mulches, black polyethylene mulch (T1) recorded the lowest pH (6.31), which was comparable to grey (T5), yellow, and green mulches. Among organic mulches, pine needle mulch (T7) resulted in the lowest pH (6.23), while the highest pH (6.55) was observed in the unmulched control (T10).

Soil organic carbon was highest under green polyethylene mulch (T2, 1.826%), which was comparable to other colored plastic mulches. Among organic mulches, farmyard manure mulch (T9) recorded the highest organic carbon (1.800%), followed by rice straw mulch (T8). The lowest organic carbon (0.973%) was observed in the control (T10).

Mulching also decreased soil electrical conductivity relative to the initial status (0.183 dS m^{-1}). The minimum EC (0.14 dS m^{-1}) was recorded under black polyethylene mulch (T1) and farmyard manure mulch (T9), while the highest EC (0.303 dS m^{-1}) was observed under pine needle mulch (T7), which was comparable to the control (0.302 dS m^{-1}).

Bulk density decreased under all mulching treatments compared to the initial value of 1.50 g cm^{-3}. The lowest bulk density was recorded under green polyethylene mulch (T2, 1.30 g cm^{-3}), followed by black polyethylene mulch (T1). Among organic mulches, farmyard manure mulch (T9) produced the lowest bulk density (1.32 g cm^{-3}). The highest bulk density was recorded in the unmulched control (T10, 1.43 g cm^{-3}).

***Table 2**. pH, Organic carbon (%), Electrical conductivity (dsm^{-1}), and Bulk density (gcm^{-3}) in the soil after crop harvest as affected by different organic and inorganic colored polyethylene mulches*

Treatments	pH	Organic carbon (%)	Electrical conductivity (ds m^{-1})	Bulk density (g cm^{-3})
	Mean ±Sd	Mean ±Sd	Mean ±Sd	Mean ±Sd
T_1 Black Polythene Mulch	6.31±0.0058^{c}	1.823±0.011^{d}	0.140±0.0100^{a}	1.31±0.0055^{b}
T_2 Green Polythene mulch	6.33±0.0161^{cd}	1.826±0.011^{d}	0.206±0.0010^{c}	1.30±0.0060^{a}
T_3 Blue Polythene mulch	6.34±0.0095^{d}	1.800±0.010^{d}	0.203±0.006^{c}	1.32±0.0043^{c}
T_4 Yellow Polythene mulch	6.33±0.0095^{cd}	1.786±0.040^{d}	0.170±0.010^{b}	1.33±0.0043^{d}
T_5 Grey Polythene mulch	6.32±0.0119^{c}	1.792±0.007^{d}	0.154±0.001^{ab}	1.33±0.0045^{d}
T_6 Red Polythene mulch	6.34±0.0095^{d}	1.813±0.003^{d}	0.210±0.010^{c}	1.32±0.0045^{c}
T_7 Pine Needle mulch	6.23±0.0070^{a}	1.470±0.030^{b}	0.303±0.015^{d}	1.40±0.0065^{f}
T_8 Rice straw mulch	6.38±0.0015^{e}	1.650±0.045^{c}	0.157±0.0002^{b}	1.38±0.0055^{e}
T_9 Farmyard manure mulch	6.25±0.0015^{b}	1.800±0.011^{d}	0.140±0.0100^{a}	1.32±0.0045^{c}
T_{10} Control (no mulch)	6.55±0.0020^{f}	0.973±0.152^{a}	0.302±0.0130^{d}	1.43±0.0043^{g}
Initial status	6.61	0.623	0.183	1.50
CV (%)	0.117	2.48	4.00	0.39

Mean values followed by the same letters within each column do not differ significantly at $p \leq 0.05$.

The effects of different organic and inorganic mulches on soil nutrient availability (N, P_2O_5, and K_2O) are presented in Table 3. All mulching treatments significantly increased soil-available nitrogen compared to the initial status (229.76 kg ha^{-1}). Among inorganic mulches, red polyethylene mulch (T6) recorded the highest nitrogen content (301.31 kg ha^{-1}), which was comparable to black (T1), green (T2), and yellow (T4) polyethylene mulches. Among organic mulches, farmyard manure mulch (T9) exhibited the highest available nitrogen (301.0 kg ha⁻¹), statistically at par with rice straw mulch (T8). The lowest nitrogen content (255.50 kg ha⁻¹) was observed in the unmulched control (T10).

Soil-available phosphorus (P_2O_5) also varied significantly across treatments. The highest P_2O_5 (22.50 kg ha^{-1}) among inorganic mulches was recorded under black polyethylene mulch (T1), which was comparable to other colored plastic mulches. Among organic mulches, rice straw mulch (T8) recorded the highest available phosphorus (22.50 kg ha^{-1}), statistically similar to the other organic mulches. The lowest phosphorus availability (21.26 kg ha^{-1}) was observed in the control (T10), while the pre-planting soil status was 20.00 kg ha^{-1}.

Similarly, available soil potassium (K_2O) increased significantly with mulching treatments relative to the initial value (165.21 kg ha^{-1}). Black polyethylene mulch (T1) recorded the maximum K_2O (184.3 kg ha^{-1}) among inorganic mulches, comparable to other colored polyethylene mulches. Among organic mulches, farmyard manure mulch (T9) exhibited the highest potassium availability (183.10 kg ha^{-1}), statistically similar to rice straw mulch (T8). The lowest K_2O content (173.90 kg ha^{-1}) was observed in the unmulched control (T10).

Table 3. *Available Nitrogen (kg. ha^{-1}), available P2O5 (kg. ha^{-1}), and available K2O (kg. ha^{-1}) in the soil after crop harvest as affected by different organic and inorganic colored mulches*

Treatments	Available Nitrogen (kg ha^{-1})	Available P_2O_5 (kgha^{-1})	Available K_2O (kg ha^{-1})
	Mean ±Sd	Mean ±Sd	Mean ±Sd
T_1 Black Polythene Mulch	300.9±0.529^{e}	22.50±0.20^{b}	184.3±0.72^{f}
T_2 Green Polythene mulch	300.49±0.54^{de}	22.24±0.39^{b}	183.7±0.60^{ef}
T_3 Blue Polythene mulch	299.16±0.76^{cd}	22.30±0.42^{b}	182.00±0.50^{c}
T_4 Yellow Polythene mulch	300.22±0.38^{de}	22.22±0.52^{b}	183.57±0.12^{ef}
T_5 Grey Polythene mulch	298.20±1.00^{bc}	22.30±0.60^{b}	182.21±0.61^{cd}
T_6 Red Polythene mulch	301.31±1.48^{e}	22.25±0.47^{b}	183.42±0.51^{ef}
T_7 Pine Needle mulch	297.00±1.00^{b}	22.00±0.50^{ab}	180.32±0.27^{b}
T_8 Rice straw mulch	300.00±0.50^{de}	22.50±0.50^{b}	182.20±0.60^{cd}
T_9 Farmyard manure mulch	301.00±0.50^{f}	22.50±0.50^{b}	183.10±0.52^{de}
T_{10} Control (no mulch)	255.50±0.50^{a}	21.260±0.38^{a}	173.90±0.52^{a}
Initial status	229.76	20.00	165.21
CV (%)	0.245	2.12	0.274

Mean values followed by the same letters within each column do not differ significantly at $p \leq 0.05$.

Analysis of the data presented in Figure 2 indicated that mulch type had a significant influence on soil moisture content throughout the potato growth period. Among inorganic mulches, black polyethylene mulch (T1) consistently retained the highest soil moisture, followed by grey polyethylene mulch (T5). In the case of organic mulches, farmyard manure mulch (T9) maintained the maximum soil moisture compared to pine needle (T7) and rice straw mulches (T8), with rice straw mulch ranking second. The lowest soil moisture was consistently observed in the unmulched control (T10) across all growth stages.

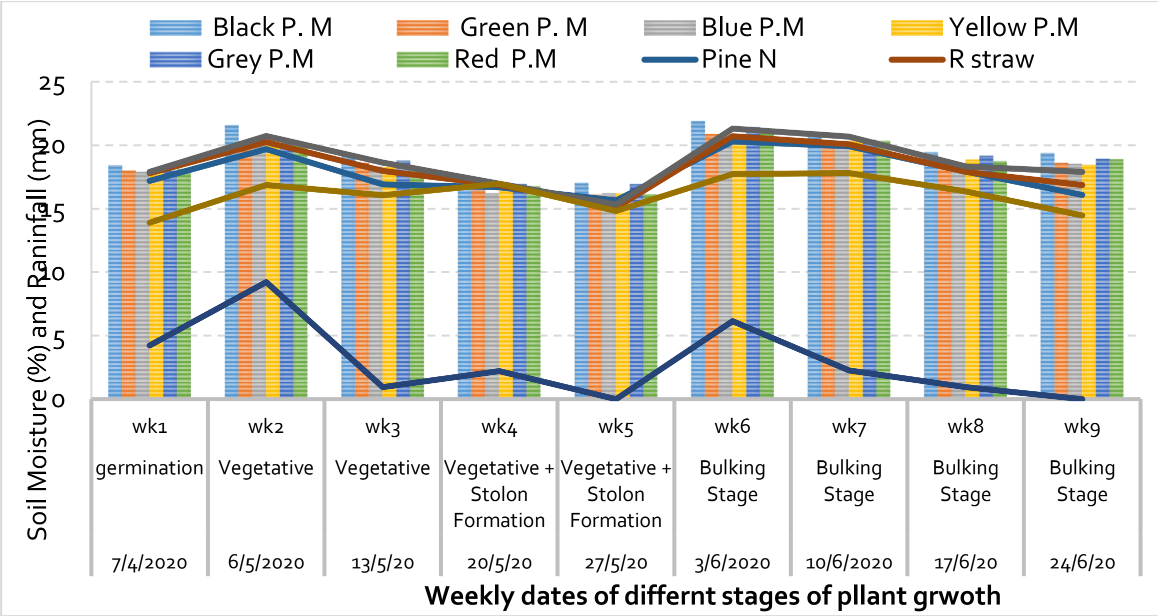

Figure. 2: *Soil moisture content (%) as affected by different organic and inorganic mulch*

The data recorded on soil temperature during different growth stages, namely germination, vegetative, stolon formation, and bulking, are presented in Figure 3. The data recorded indicate that all the mulches provided a cordial temperature at all stages of potato crop growth, compared to the control. Among the colored Plastic mulches, T_1 (black PM) maintained the soil temperature better than the other mulches. Among the organic mulches, T_9 (farmyard manure mulch) was able to maintain soil temperature more effectively than the other organic mulches. The treatment T_{10} with no mulch recorded the lowest soil temperature as compared to the mulched ones.

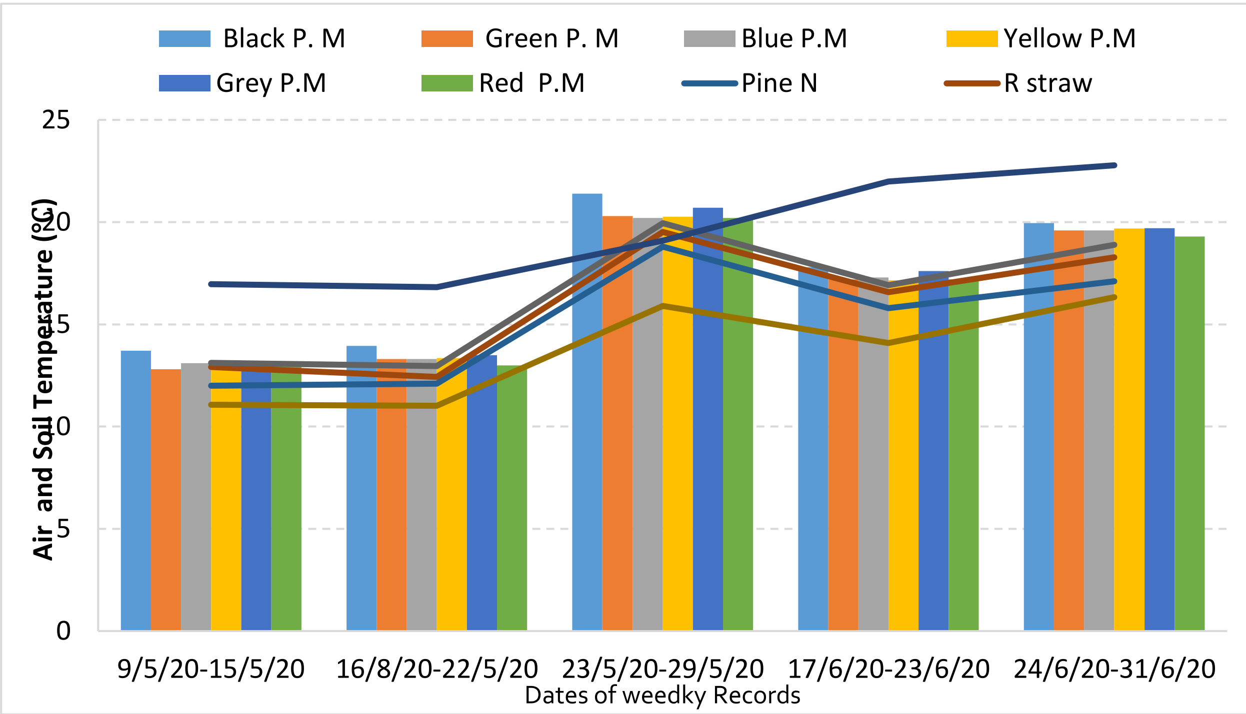

Figure 3. *Soil temperature (°C) as affected by different organic and inorganic Polythene mulches*

DISCUSSION

The ideal soil pH for potatoes is slightly acidic, between 6.0 and 6.5. During the study, it was found that the use of mulching has significantly influenced the soil pH compared to the initial soil pH. Pine needle mulch (T_7) was able to make the soil more acidic as compared to other organic and colored plastic mulches. This could be attributed to the fact that pine needles release acid during the decomposition process, thereby providing the ideal pH condition for the crops. Various researchers have also reported that organic mulches can reduce the soil pH by forming organic acids during the decomposition of plant-derived materials (Wang et al., 2021; Zhao et al., 2022). These results also correlate with the findings of Kumar *et al*. (2023).

Soil organic carbon plays a significant role with respect to many chemical and physical processes in soil environments, which provides a primary source of nutrients for plants, aids in the aggregation of particles, develops soil structure, increases water storage capacity, and provides a habitat for soil biota. The study revealed significant differences in soil organic carbon compared to the initial organic carbon of the soil. Plastic mulches have increased the organic carbon of the soil among the treatments as compared to the un-mulched treatment. Similarly, in the case of organic mulches, T_9 (farmyard manure mulch) has increased the organic carbon content compared to the rest of the organic mulches. Since the life of microorganisms is directly influenced by soil temperature, mulching provides a congenial environment for maximum microbial activity, leading to the decomposition of organic matter in the soil and an increase in soil organic carbon. The results are in agreement with the findings of (Sabri et al., 2018; Singh et al., 2022; Chen et al., 2023).

Electrical conductivity is the measure of the amount of salt in the soil. For optimum plant growth, EC should be ideal, as high or low EC is not desirable. High EC hinders nutrient uptake by increasing the osmotic pressure of the nutrient solution. Likewise, low EC also affects plant growth and yield. So, EC is considered an important indicator of soil health. The study revealed significant differences in EC among the treatments compared to the initial EC of the soil. Black PM (T_1) has reduced the EC as compared to the un-mulched treatment. The reason for this can be attributed to the fact that mulching reduces soil water evaporation, thereby reducing salt accumulation in the soil. These results align with the findings of Pakdel *et al*. (2013). Hild and Morgan (1993) also reported that mulching reduces the accumulation of salts in the soil, and so EC gets reduced. Among the organic mulches, Farmyard manure mulch (T9) resulted in a reduction in EC compared to the other two mulches. This can be attributed to the fact that FYM mulch helps maintain soil moisture by reducing water evaporation from the soil. Thus, reduces the accumulation of salts in soil, leading to a low EC of soil.

Density of the soil refers to the mass per unit volume of soil. The denser the soil, the less permeable is. The study revealed significant differences in soil bulk density compared to the initial bulk density of the soil. Plastic mulches have resulted in a reduction of bulk density compared to unmulched cases. In the case of organic mulches, T9 (farmyard manure mulch) has decreased the bulk density of the soil compared to the rest of the organic mulches, unmulched, and the initial status. The probable reason for this might be the high amount of organic carbon produced by the activities of microorganisms during the decomposition of organic materials, which leads to a lower soil density and ultimately increases the soil's porosity. Secondly, mulch materials create the optimum temperature in the soil, which provides a suitable condition for the growth of soil microorganisms. As a result, microorganisms accelerate the decomposition process of organic matter, which leads to the production of organic carbon. The results are in agreement with those of Orji and Eke (2018), who reported that bulk density values were reduced compared to the control. (Sabri et al., 2018; Singh et al., 2022; Chen et al., 2023) also support our findings.

Nitrogen is highly mobile in soil and is subject to several losses, including denitrification, volatile losses, and nitrate losses through percolating water. During the study, it was found that the soil's nitrogen content improved after crop harvest compared to its initial status. Red PM (T_6) resulted in the highest available nitrogen of the soil as compared to other plastic mulches. This could be attributed to the fact that global solar radiation transmittance is highest in red-colored mulch (Amare & Desta, 2021) compared to other colors, which may have significantly increased soil temperature. Several researchers report that nitrification has a distinct optimum temperature between 25 °C and 35°C (Mu et al., 2023). Hence, the favorable microclimatic conditions of mulched soil increase the number and efficiency of the nitrifying soil micro-organisms, resulting in more available nitrogen (Sokombela et al., 2025; Long et al., 2022; Pakdel et al., 2013).

Results showed that soil K is significantly affected by the mulching process. In the case of plastic mulches, maximum available potassium was recorded by T_1 (black PM), which was superior among the rest of the plastic mulches. In the case of organic mulches, T_9 (farmyard manure mulch) recorded the maximum available potassium followed by T_8 (rice straw mulch). With respect to the availability of phosphorus, it was higher in the mulched than the unmulched treatment. In the case of plastic mulches, the maximum available phosphorus was recorded by T1 (black PM), which was comparable to the rest of the plastic mulches. In case of organic mulches, T_9 (farmyard manure mulch) recorded maximum available phosphorus, which was at par with T_8 (rice straw mulch) but was significantly superior compared to un-mulched plots. Similar results were obtained by Li et al. (2023), who noted that potassium and phosphorus availability increased under mulched treatment compared to no mulch treatment.

Furthermore, the presence of mulch causes adjustments in soil temperature and maintains soil moisture, which helps improve the availability of phosphorus in soil. Another possibility could be the organic acids produced during the decomposition of soil organic matter complexes, thereby helping in the solubilization of native P and reducing P sorption (Sokombela et al., 2025).

Since mulches formed a physical barrier, limited soil water, and prevented percolation losses, the moisture in the surface layer of the soil, up to 15 cm, has increased. The moisture conservation abilities of mulches have been reported by (Goel et al., 2019; Mulumba & Lal, 2008; Xing et al., 2012). This role could be associated with reduced soil evaporation, enhanced soil water infiltration, and redistribution of soil moisture. Furthermore, the variation in the color of plastic mulches affects the transmittance, absorbance, and reflectance of both short-wave and long-wave radiations. The higher the reflection, the lower the temperature and loss of water. These important characteristics of plastic mulches make it efficient in conserving water and protecting against water loss (Wang et al., 2024).

The application of black PM increases the average soil temperature by 3.68 °C compared to bare soil or a non-mulched plot. This might be due to the greater solar radiation transmittance of black plastic mulches compared with other plastic mulches. These findings are in agreement with field studies conducted by Li et al. (2023) and Moursy *et al*. (2015). Similarly, applying farmyard manure mulch increased average soil temperature by 2.68 °C as compared to a non-mulched plot. The findings are in agreement with those of many other field studies, including those by (Li et al., 2018; Simsek, 2017; Xing et al., 2012). The warmer soil temperature can hasten seedling emergence and growth, allowing for the achievement of the desired population at an earlier growth stage, which in turn maximizes the absorption of solar radiation and enhances yield (Li *et al*., 2018).

Furthermore, the soil temperature under rice straw mulch was lower during the warmer part of the season and higher during the colder, later part of the season. This might be because rice straw \reduces the solar energy reaching the soil and, as a result, reduces temperature increase because it has a higher albedo and lower thermal conductivity. Similar findings have been reported by many other studies, including those by (Xu et al., 2023; Yi et al., 2014).

CONCLUSION

The organic and inorganic (polyethylene) mulches exhibited a significant influence on all soil parameters and economic production. Soil physical properties like pH, EC, organic carbon, and bulk density were improved significantly by the use of different mulches as compared to the initial status. However, among the mulches, it shows less significance. The use of mulches significantly improved nutrient availability as compared to the control. Black PM showed a significant increase in available N, P, and K, and was found to be comparable to rice straw mulch in terms of improving nutrient availability. For harvesting a sustainable, economic, and high-quality yield in potatoes, and based on both gross and net returns, a grower can adopt the black and red PM for inorganic and Farm Yard Manure mulch for organic mulching.

AUTHORS CONTRIBUTIONS

Zahedullah Zahed conceptualized and supervised the experiments, while Hikmatullah Hikmat conducted the fieldwork and data collection. Hamid Salari and Mohammad Khalid Rashidi performed data analysis and manuscript preparation.

ACKNOWLEDGEMENTS

The authors sincerely thank the Division of Vegetable Science, SKUAST-Kashmir for providing the necessary facilities and support to carry out this research.

FUNDING INFORMATION

This study did not receive any external funding.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest related to this study.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding authors upon reasonable request.

REFERENCES

Amare, G., & Desta, B. (2021). Coloured plastic mulches: Impact on soil properties and crop productivity. Chemical and Biological Technologies in Agriculture, 8(1), 1–9. https://doi.org/10.1186/s40538-020-00201-8

Anonymous. (2019). Food and Agriculture Organization Statistics (FAOSTAT) data.

Chen, L., Zhang, H., & Li, X. (2023). Effects of organic carbon additions on soil bulk density and fertility in agricultural soils. Agriculture, Ecosystems & Environment, 345, 108586. https://doi.org/10.1016/j.agee.2023.108586

Fan, Y. Q., Ding, R. S., Kang, S. Z., Hao, X. M., Du, T. S., Tong, L., & Li, S. E. (2016). Plastic mulch decreases available energy and evapotranspiration and improves yield and water use efficiency in an irrigated maize cropland. Agricultural Water Management. https://doi.org/10.1016/j.agwat.2016.08.019

Filipovic, V., Romic, D., Romic, M., Borosić, J., Filipovic, L., Mallmann, F. J. K., & Robinson, D. A. (2016). Plastic mulch and nitrogen fertigation in growing vegetables modify soil temperature, water and nitrate dynamics: Experimental results and a modeling study. Agricultural Water Management, 176, 100–110. https://doi.org/10.1016/j.agwat.2016.04.020

Goel, L. V. S., & Sharma, R. K. (2019). Investigation on effectiveness of wheat and rice straw mulches on moisture retention in potato crop (Solanum tuberosum L.). International Journal of Recycling of Organic Waste in Agriculture, 8(1), 345–356. Link

Hidayat, H., Hassan, G., Khan, I., Khan, M., & Khan, I. A. (2013). Effect of different mulches and herbicides on potato and associated weeds. Pakistan Journal of Weed Science Research, 19(2), 191–200. Link

Hild, A. L., & Morgan, D. L. (1993). Mulch effects on crown growth of five southwestern shrub species. Journal of Environmental Horticulture, 11(1), 41-43. Link

Hou, X. Y., Wang, F. X., Han, J. J., Kang, S. Z., & Feng, S. Y. (2010). Duration of plastic mulch for potato growth under drip irrigation in an arid region of Northwest China. Agricultural and Forest Meteorology, 150, 115–121. https://doi.org/10.1016/j.agrformet.2009.09.007

Iqbal, R., Raza, M. A. S., Valipour, M., Saleem, M. F., Zaheer, M. S., Ahmad, S., ... & Nazar, M. A. (2020). Potential agricultural and environmental benefits of mulches—a review. Bulletin of the National Research Centre, 44(1), 75. https://doi.org/10.1186/s42269-020-00308-3

Kasirajan, S., & Ngouajio, M. (2012). Polyethylene and biodegradable mulches for agricultural applications: A review. Agronomy for Sustainable Development, 32(2), 501–529. https://doi.org/10.1007/s13593-011-0068-3

Kumar, R., Singh, A., & Sharma, P. (2023). Role of organic mulching in soil pH modification and nutrient availability in horticultural crops. Horticultural Science, 50(1), 112–121. https://doi.org/10.17221/34/2023-HORTSCI

Li, Q., Li, H., Zhang, L., Zhang, S., & Chen, Y. (2018). Mulching improves yield and water-use efficiency of potato cropping in China: A meta-analysis. Field Crops Research, 221, 50–60. https://doi.org/10.1016/j.fcr.2018.02.017

Li, Q., Zhou, X., Xu, W., & Yang, Q. (2023). Effect of long term biodegradable film mulch on soil physicochemical and microbial properties. Science of the Total Environment, 809(Pt 1), 151039. https://doi.org/10.1016/j.scitotenv.2021.151039

Li, X., Zhou, J., & others. (2023). Mulching improves the soil hydrothermal environment, soil aggregate content, and potato yield in dry farmland. Agronomy, 14(11), 2470. https://doi.org/10.3390/agronomy14112470

Lie, F. M., Wang, J., Xu, J. Z., & Xu, H. L. (2004). Productivity and soil response to plastic film mulching duration for spring wheat on entisols in the semiarid Loess Plateau of China. Soil & Tillage Research, 78, 9–20. https://doi.org/10.1016/j.still.2003.12.009

Long, H., Li, X., Liu, X. E., Jiang, X. J., & others. (2022). Plastic mulch stimulates nitrogen mineralization in urea-amended soils in a semiarid environment. Agronomy Journal, 107(3), 921–930. Link

Moreno, M. M., & Moreno, A. (2008). Effect of different biodegradable and polyethylene mulches on soil properties and production in a tomato crop. Scientia Horticulturae, 116(3), 256–263. https://doi.org/10.1016/j.scienta.2008.01.007

Moursy, S. A. (2015). Polyethylene and rice straw as soil mulching: Reflection of soil mulch type on soil temperature, soil-borne diseases, plant growth and yield of tomato. Global Journal of Advance Research, 2(10), 1497–1519. Link

Mu, X., Gao, H., Li, H., Gao, F., Zhang, Y., & Ye, L. (2023). Effect of different mulch types on soil environment, water and fertilizer use efficiency, and yield of cabbage. Applied Sciences, 13(7), 4622. https://doi.org/10.3390/app13074622

Mulumba, L. N., & Lal, R. (2008). Mulching effects on selected soil physical properties. Soil & Tillage Research, 98(1), 106–111. https://doi.org/10.1016/j.still.2007.11.004

Mollah, M. A. K., Uddin, M. K., Kasim, S., Zaibon, S., & Mostafizur, M. Potential Organic Mulches For Sustainable Agricultural Production And Improving Soil Environment. International Journal of Environmental Sciences, 11(8), 2025. https://www.researchgate.net/profile/Md-Khalid-8/publication/397739025_Potential_Organic_Mulches_For_Sustainable_Agricultural_Production_And_Improving_Soil_Environment

Pakdel, P., Tehranifar, A., Nemati, H., Lakzian, A., & Kharrazi, M. (2013). Effect of different mulching materials on soil properties under semi-arid conditions in northeastern Iran. Wudpecker Journal of Agricultural Research, 2(3), 80–85. https://link.springer.com/article/10.1007/s12517-022-10040-6

Powell, S. M., McPhee, J. E., Dean, G., Hinton, S., Sparrow, L. A., Wilson, C. R., & Tegg, R. S. (2020). Managing soil health and crop productivity in potato: A challenging test system. Soil Research, 58(8), 697–712. https://doi.org/10.1071/SR20155

Qin, S. J., Li, S. E., Kang, S. Z., Du, T. S., Tong, L., & Ding, R. S. (2016). Can drip irrigation under film mulch reduce crop evapotranspiration and save water under sufficient irrigation conditions? Agricultural Water Management, 177, 128–137. https://doi.org/10.1016/j.agwat.2016.06.022

Sabri, N. S. A., Zakaria, Z., Mohamad, S. E., Jaafar, A. B., & Hara, H. (2018). Importance of soil temperature for the growth of temperate crops under a tropical climate and functional role of soil microbial diversity. Microbes and Environment, 33, 144–150. https://doi.org/10.1264/jsme2.ME17159

Saikia, M. (2011). Effect of irrigation and mulching on growth, yield and water-use efficiency of potato in Assam. Potato Journal, 38(1), 81–83. https://www.cabidigitallibrary.org/doi/full/10.5555/20113286073

Simsek, U. E. (2017). Effect of mulching on soil moisture and some soil characteristics. Feb-Fresenius Environmental Bulletin, 26(8), 7437–7444. https://d1wqtxts1xzle7.cloudfront.net/55747261/HMinGreenAlgae2.pdf

Singh, N., Sood, M. C., & Upadhyay, N. C. (2004). Effect of tillage practices and mulch on potato (Solanum tuberosum) under drip, sprinkler and furrow method of irrigation. In Proceedings of National Symposium on RCAP (pp. 194–195). PAU, Ludhiana. https://www.researchgate.net/profile/Abdelmonnem-Kahlel-2/publication/329130007_Pages_252-258

Singh, N., Sood, M. C., Trehan, S. P., Lal, S. S., & Singh, S. P. (2012). Influence of irrigation and mulch on growth, yield and economics of potato. Annals of Horticulture, 5(1), 41–46. https://www.cabidigitallibrary.org/doi/full/10.5555/20123315244

Singh, R., Kumar, P., & Sharma, S. (2022). Influence of organic amendments on soil bulk density and carbon sequestration. Journal of Environmental Quality, 51(4), 862–870. https://doi.org/10.2134/jeq2022.03.0112

Sokombela, A., Ndhlala, A. R., Bopape Mabapa, M. P., Eiasu, B. K., Mpai, S., & Nyambo, P. (2025). Colored plastic mulch impacts on soil properties, weed density and vegetable crop productivity: A meta-analysis. Scientific Reports, 15(1). https://doi.org/10.1038/s41598-025-17237

Song, W., Han, F., Bao, Z., Chai, Y., Wang, L., Huang, C., Cheng, H., & Chang, L. (2024). Mulching practices improve soil moisture and enzyme activity in drylands, increasing potato yield. Agronomy, 14(5), 1077. https://doi.org/10.3390/agronomy14051077

Wang, L., Song, S., Zeng, D., Gong, H., Li, H., & Qiu, X. (2024). Soil quality and eggplant productivity in response to different mulching strategies under conservation tillage in organic greenhouse production. Frontiers in Agronomy, 6, 1603762. https://doi.org/10.3389/fagro.2025.1603762

Wang, Y., Zhang, Z., & Li, H. (2021). Effects of organic mulches on soil acidity and nutrient dynamics in temperate cropping systems. Soil Science and Plant Nutrition, 67(4), 512–521. https://doi.org/10.1080/00380768.2021.1889476

Xing, Z., Toner, P., Chow, L., Rees, H. W., Li, S., & Meng, F. (2012). Effects of hay mulch on soil properties and potato tuber yield under irrigation and non-irrigation in New Brunswick, Canada. Journal of Irrigation and Drainage Engineering, 138(8), 703–714. https://doi.org/10.1061/(ASCE)IR.1943-4774.0000482

Xu, J., Li, Y., Wang, S., & Zhang, H. (2023). Effects of plastic film mulching on potato yield and water use efficiency: A meta-analysis in Northwest China. Water, 15(7), 2279. https://doi.org/10.3390/w15072279

Xu, Z., Wallach, R., Song, J., & Mao, X. (2023). Effect of plastic film colours and perforations on energy distribution, soil temperature, and evaporation. Agronomy, 13(3), 926. https://doi.org/10.3390/agronomy13030926

Yi, L., Wang, J., Liu, D., Li, Z., & Zhang, G. (2014). Straw mulching reduces the harmful effects of extreme hydrological and temperature conditions in citrus orchards. PLOS ONE, 9(1), e87094. https://doi.org/10.1371/journal.pone.0087094

Zhang, L., Chen, Y., Wang, Q., & Liu, M. (2024). Effects of mechanized no-tillage planting combined with maize straw mulching on yield and water use efficiency in arid Northwest China. Preprints. https://doi.org/10.20944/preprints202407.0619.v1

Zhao, X., Chen, J., & Liu, Y. (2022). Influence of organic mulching on soil chemical properties and crop growth. Agriculture, 12(3), 401. https://doi.org/10.3390/agriculture12030401