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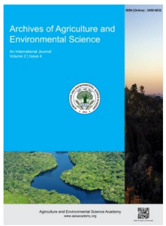

ORIGINAL RESEARCH ARTICLE

Effect of various mulching materials on different varieties of watermelon under eastern Nepal agro-climatic conditions

Dibya Raj Dhakal , Shakar Shasi Pandey* , Prakriti Kadel , Rajdip Basnet and Raj Chauhan

Gauradaha Agriculture Campus, Institute of Agriculture and Animal Science, Tribhuvan University, Nepal
*Corresponding author's E-mail: pandeysakar99@gmail.com

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ABSTRACT

Watermelon (*Citrullus lanatus*) production is often limited by soil moisture stress and low resource-use efficiency, making mulching an effective strategy for improving crop performance. This study evaluated the effects of different mulching materials on growth, yield, and fruit quality of two watermelon varieties under the agro-climatic conditions of eastern Nepal. The experiment was conducted in a two-factor factorial Randomized Complete Block Design (RCBD) with eight treatment combinations and three replications. Two varieties (Sweet Honey and Saraswati) were evaluated under three mulching materials (straw, sawdust, and black plastic mulch) along with a non-mulched control. Mulching significantly ($p<0.05$) affected plant height, number of leaves, number of branches, titratable acidity, and yield. Black plastic mulch recorded the highest plant height (3.44 m) and yield (22.35 t ha^{-1}), while straw mulch produced highest number of leaves (131.77) and branches (10.06). Among varieties, Saraswati showed higher firmness (9.03 kg cm^{-2}) and leaf number (101.51), whereas Sweet Honey produced heavier fruits (2.74 kg). Significant interaction effects were observed for leaves, branches, titratable acidity, and firmness. The highest leaf number (138.75), branch number (11.75), and firmness (9.73 kg cm^{-2}) were recorded in Sweet Honey × Straw mulch, Saraswati × Straw mulch, and Saraswati × Sawdust mulch, respectively. No significant effects were observed on pH, total soluble solids, node diameter, pulp weight, and fruit diameter. Therefore, black plastic mulch maximizes yield, while straw mulch enhances vegetative growth and provides a sustainable, low-cost alternative. Integration of suitable mulching practices with the Saraswati variety can improve watermelon productivity under eastern Nepal conditions.

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INTRODUCTION

Watermelon (*Citrullus lanatus*) is an economically important cucurbit crop widely cultivated in tropical and subtropical regions for its high water content, nutritional value, and strong market demand (Dube *et al*., 2021). In Nepal, its cultivation is increasing, particularly in the Terai region, due to favorable climatic conditions, rising consumer demand, and the availability of improved cultivars with desirable traits such as disease resistance and early maturity (Singha *et al*., 2023). Despite its economic importance, watermelon productivity is constrained by several biotic and abiotic factors, among which soil moisture deficiency and weed infestation are the most critical. The crop is highly sensitive to moisture stress due to its high water requirement during vegetative and reproductive stages (Bahari *et al*., 2012). Water deficit reduces photosynthetic activity, nutrient uptake, and assimilate accumulation, ultimately leading to reduced yield and poor fruit quality. Weed competition further intensifies resource scarcity by increasing competition for water and nutrients, thereby reducing productivity and increasing production costs (Malambane *et al*., 2023).

Mulching is an effective agronomic practice for improving soil physical properties, regulating soil temperature, suppressing weed growth, and enhancing overall crop performance. It improves soil physical properties such as infiltration and bulk density while reducing evaporation losses. Organic mulches such as straw and sawdust enhance soil organic matter, water-holding capacity, and microbial activity, whereas inorganic mulches such as black plastic reduce evaporation, suppress weeds, and improve water-use efficiency in crop production systems (Parmar *et al.*, 2013; Kumar, 2026). Consequently, mulching is widely recommended as a sustainable strategy for improving productivity under moisture-limited conditions (Elbagory *et al.*, 2025).

Another important determinant of watermelon productivity is varietal selection, as different cultivars vary in growth behavior, yield potential, and fruit quality due to genetic differences (Elbagory *et al.*, 2025). Therefore, evaluating varietal performance under different mulching conditions is essential for identifying suitable combinations for higher productivity and better resource-use efficiency (Dube *et al.*, 2021). Although several studies have reported the beneficial effects of mulching on watermelon growth and yield, information on the combined effects of different mulching materials and watermelon varieties under the agro-climatic conditions of eastern Nepal remains limited (Singh *et al.*, 2019; Singha *et al.*, 2023). Most available studies have evaluated either mulching materials or varietal performance independently, with limited emphasis on their interaction effects. This restricts the development of location-specific recommendations for farmers in Nepal.

Therefore, the present study addresses this gap by evaluating the effects of organic (straw and sawdust) and inorganic (black plastic) mulching materials in combination with two commonly cultivated watermelon varieties under the agro-climatic conditions of eastern Nepal. The study aims to assess their effects on growth, yield, and fruit quality and to identify the most suitable mulch and variety combination for enhancing watermelon productivity under field conditions in Jhapa, Nepal.

MATERIALS AND METHODS

Study area

The field experiment was conducted at the Horticulture Farm of Gauradaha Agriculture Campus, Institute of Agriculture and Animal Science (IAAS), Tribhuvan University, Jhapa, Nepal (26° 33'30.4'' N, 87°43'04.3'' E) at an altitude of 79 m above sea level. The experimental site lies in the subtropical agro-climatic zone of eastern Nepal and receives an average annual rainfall of 250-300 cm, most of which occurs during the monsoon season. During the study period, the average temperature and rainfall were 26.36°C and 6.21 mm, respectively.

Experimental design and treatment factors

The experiment was arranged in a two-factor factorial Randomized Complete Block Design (RCBD) with three replications. The study consisted of eight treatment combinations derived from four mulching materials and two watermelon varieties.

Factor A: Mulching materials:

- M_1: No mulch (control)
- M_2: Straw mulch
- M_3: Sawdust mulch
- M_4 Black plastic mulch

Factor B: Watermelon varieties:

- V_1: Sweet Honey
- V_2: Saraswati

The resulting treatment combinations were:

T_1: Saraswati + Control
T_2: Saraswati + Sawdust
T_3: Saraswati + Straw
T_4: Saraswati + Black plastic mulch
T_5: Sweet Honey + Control
T_6: Sweet Honey + Sawdust
T_7: Sweet Honey + Straw
T_8: Sweet Honey + Black plastic mulch

Planting materials and crop establishment

The watermelon varieties Sweet Honey and Saraswati were selected based on their popularity among growers in eastern Nepal. The seed lots had 95% genetic purity, 98% physical purity, and 60% germination percentage. Seeds were sown in polyethylene bags containing a mixture of soil, sand, and well-decomposed cow dung in a 1:1:1 ratio during the first week of February. Healthy seedlings at the 3-5 leaf stage were transplanted to the main field during the first week of March. Each experimental plot measured 10 m × 5 m and contained 16 plants arranged in four rows. Plants were spaced at 2.0 m × 1.0 m. A spacing of 1 m was maintained between adjacent plots and replications. Border plants were excluded from data collection.

Crop management practices

The field was thoroughly ploughed and leveled before transplanting. Farmyard manure and inorganic fertilizers were applied at the rate of 500 g FYM per pit, along with 60 g urea, 60 g diammonium phosphate (DAP), and 20 g muriate of potash (MOP) per pit. Irrigation and intercultural operations were carried out following standard recommended practices for cucurbit cultivation.

Data collection

Meteorological data: Weather data, including temperature and rainfall, were obtained from the meteorological station of Gauradaha Agriculture Campus throughout the experimental period.

Growth parameters: Growth observations included vine length (m), vine diameter (cm), number of leaves per plant, and number of branches per plant. Data were recorded from randomly selected sample plants in each plot at 30 and 60 days after transplanting (DAT).

Yield parameters: Yield attributes recorded included fruit weight (kg), equatorial diameter (cm), transverse diameter (cm), and fruit yield (t ha^{-1}). Total fruit yield per plot was converted into yield per hectare.

Quality parameters: Fruit quality was assessed by measuring total soluble solids (TSS), fruit pulp weight, pH, firmness, and titratable acidity. Total soluble solids were determined using a hand refractometer and expressed as °Brix following standard procedures described by AOAC (2019). Fruit juice pH was measured using a digital pH meter. Titratable acidity was determined by titration against 0.01 N sodium hydroxide (NaOH) solution following AOAC (2019) methods and expressed as percentage acidity.

Statistical analysis

The recorded data were entered into Microsoft Excel 2019 and analyzed using R Studio version 4.4.0 with appropriate statistical packages. Analysis of variance (ANOVA) for a factorial RCBD was performed following Gomez & Gomez (1984). Treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

This section presents the effects of different mulching materials, watermelon varieties, and their interactions on growth, yield, and quality parameters (Tables 1-5).

Plant height

Mulching significantly influenced plant height at both 30 and 60 days after transplanting (DAT). Black plastic mulch produced the tallest plants (2.06 m and 3.44 m), followed by straw and sawdust mulch, while the control recorded the lowest values (1.09 m and 2.30 m) (Table 1). The superior plant growth under black plastic mulch may be attributed to improved soil moisture conservation, favorable soil temperature, and reduced weed competition, which together enhance vegetative development. Similar findings on soil warming and improved root-zone conditions under plastic mulch have been reported in previous studies, where improved canopy development was associated with better water-use efficiency. In addition, improved microclimatic conditions under plastic mulch may have contributed to enhanced photosynthetic efficiency, as plastic mulch can modify the soil-plant environment (Regmi *et al.*, 2021).

Number of leaves

Mulching significantly influenced the number of leaves at both observation stages (Table 1). At 30 DAT, black plastic mulch produced the highest number of leaves (56.29), whereas straw mulch recorded the highest number at 60 DAT (131.77). Saraswati produced more leaves than Sweet Honey, and the highest leaf number (138.75) was observed in the Sweet Honey × Straw mulch combination. The increased leaf production under mulching may be associated with improved moisture availability and nutrient uptake, which enhance photosynthetic activity and vegetative growth. Similar findings have been reported by Parmar *et al.* (2013), Reddy *et al.* (2017), and Vijay *et al.* (2012).

Table 1. Effects of different varieties and mulches on number of leaves at different time interval.

Variety	Number of leaves	
	At 30 DAT	At 60 DAT
Control	15.46^{d}	75.96^{c}
Sawdust	34.18^{c}	68.61^{d}
Straw	48.49^{b}	131.77^{a}
Black Plastic Mulching	56.29^{a}	119.62^{b}
F-value	***	***
LSD	4.63	4.29
Sweet Honey	36.88^{b}	96.47^{b}
Saraswati	40.33^{a}	101.51^{a}
F-value	*	**
LSD	3.28	3.03
Sweet Honey × Control	14.17	76.05^{d}
Sweet Honey × Sawdust	33.52	55.64^{e}
Sweet Honey × Straw	46.64	138.75^{a}
Sweet Honey × Black Plastic Mulching	53.17	115.42^{c}
Saraswati × Control		
Saraswati × Sawdust	16.75	75.86^{d}
Saraswati × Straw	34.83	81.58^{d}
Saraswati × Black Plastic Mulching	50.33	124.78^{b}
	59.42	124.83^{b}
F-value	NS	***
LSD	6.56	6.07
Mean	38.61	98.99
CV	9.69	3.50

CV: coefficient of variation, DAT: Days after Transplantation, LSD: Least Significant Difference, *: 5% level of significance, **: 1% level of significance, ***: 0.1% level of significance, NS: Non significance, same letter signifies no significant difference between treatments while different letter signifies significant difference between treatments.

Table 2. Effects of different varieties and mulches on number of branches at different time interval.

Mulching	Number of branches	
	At 30 DAT	At 60 DAT
Control	2.22^{b}	3.69^{c}
Sawdust	5.68^{a}	7.93^{b}
Straw	7.00^{a}	10.06^{a}
Black Plastic Mulching	6.79^{a}	8.04^{b}
F-value	***	***
LSD	1.92	1.32
Sweet Honey	5.01	6.98
Saraswati	5.83	7.88
F-value	NS	NS
LSD	1.36	0.93
Sweet Honey × Control	1.94	2.79^{c}
Sweet Honey × Sawdust	5.11	8.44^{b}
Sweet Honey × Straw	6.00	8.36^{b}
Sweet Honey × Black Plastic Mulching	7.00	8.33^{b}
Saraswati × Control	2.50	4.58^{c}
Saraswati × Sawdust	6.25	7.42^{b}
Saraswati × Straw	8.00	11.75^{a}
Saraswati × Black Plastic Mulching	6.58	7.75^{b}
F-value	NS	**
LSD	2.72	1.87
Mean	5.42	7.43
CV	28.65	14.27

CV: coefficient of variation, DAT: Days after Transplantation, LSD: Least Significant Difference, **: 1% level of significance, ***: 0.1% level of significance, NS: Non significance, same letter signifies no significant difference between treatments while different letter signifies significant difference between treatments.

Table 3. Effects of different varieties and mulches on firmness, fruit weight and pulp weight.

Mulching	Firmness (kg cm^{-2})	Fruit weight (kg)	Pulp weight (kg)
Control	8.65	2.77	2.08
Sawdust	7.92	2.49	1.88
Straw	8.63	2.38	1.68
Black Plastic Mulching	7.58	2.33	1.78
F-value	NS	NS	NS
LSD	1.10	0.38	0.44
Sweet Honey	7.35^{b}	2.74^{a}	1.93
Saraswati	9.03^{a}	2.24^{b}	1.78
F-value	***	**	NS
LSD	0.78	0.27	0.31
Sweet Honey × Control	8.03^{ab}	3.18	2.33
Sweet Honey × Sawdust	6.10^{c}	2.84	2.00
Sweet Honey × Straw	8.40^{ab}	2.50	1.65
Sweet Honey × Black Plastic Mulching	6.90^{bc}	2.44	1.75
Saraswati × Control	9.27^{a}	2.36	1.83
Saraswati × Sawdust	9.73^{a}	2.15	1.76
Saraswati × Straw	8.87^{a}	2.26	1.71
Saraswati × Black Plastic Mulching	8.27^{ab}	2.21	1.82
F-value	*	NS	NS
LSD	1.56	0.54	0.61
Mean	8.20	2.49	1.85
CV	10.86	12.47	18.96

CV: coefficient of variation, DAT: Days after Transplantation, LSD: Least Significant Difference, *: 5% level of significance, **: 1% level of significance, ***: 0.1% level of significance, NS: Non significance, same letter signifies no significant difference between treatments while different letter signifies significant difference between treatments.

Number of branches

Mulching significantly affected the number of branches (Table 2). Straw mulch produced the highest number of branches at both 30 DAT (7.00) and 60 DAT (10.06), while the control recorded the lowest values. The highest branch number (11.75) was observed in the Saraswati × Straw mulch combination. Improved moisture retention and favorable soil conditions under straw mulch likely contributed to enhanced branching and plant vigor. Similar results have been reported in cucurbit crops where organic mulches improved vegetative branching due to better soil biological activity and reduced evaporative loss (Singh *et al.*, 2019).

Table 4. Effects of different varieties and mulches on pH, titratable acidity and diameter of nodes.

Mulching	pH	Titratable acidity (%)	Diameter of nodes (cm)
Control	6.57	0.23[a]	0.61
Sawdust	6.20	0.19[ab]	0.56
Straw	6.30	0.16[b]	0.59
Black Plastic Mulching	6.25	0.17[b]	0.69
F-value	NS	*	NS
LSD	1.08	0.05	0.24
Sweet Honey	6.38	0.18	0.66
Saraswati	6.28	0.19	0.57
F-value	NS	NS	NS
LSD	0.76	0.03	0.17
Sweet Honey × Control	6.13	0.25	0.68
Sweet Honey × Sawdust	6.53	0.16	0.57
Sweet Honey × Straw	6.77	0.17	0.59
Sweet Honey × Black Plastic Mulching	6.10	0.15	0.81
Saraswati × Control	7.00	0.20	0.54
Saraswati × Sawdust	5.87	0.21	0.56
Saraswati × Straw	5.83	0.15	0.60
Saraswati × Black Plastic Mulching	6.40	0.18	0.58
F-value	NS	NS	NS
LSD	1.53	0.07	0.34
Mean	6.33	0.18	0.62
CV	13.77	20.46	31.14

CV: coefficient of variation, DAT: Days after Transplantation, LSD: Least Significant Difference, *: 5% level of significance, NS: Non significance, same letter signifies no significant difference between treatments while different letter signifies significant difference between treatments.

Table 5. Effects of different varieties and mulches on yield and TSS.

Mulching	Yield (ton ha^{-1})	TSS (°Brix)
Control	13.21[b]	4.28
Sawdust	13.36[b]	5.29
Straw	18.24[a]	3.68
Black Plastic Mulching	22.35[a]	4.73
F-value	**	NS
LSD	4.53	1.97
Sweet Honey	17.75	4.32
Saraswati	15.84	4.67
F-value	NS	NS
LSD	3.20	1.40
Sweet Honey × Control	15.53	5.40
Sweet Honey × Sawdust	16.25	4.75
Sweet Honey × Straw	18.83	2.67
Sweet Honey × Black Plastic Mulching	20.40	4.47
Saraswati × Control	10.91	3.17
Saraswati × Sawdust	10.49	5.83
Saraswati × Straw	17.66	4.70
Saraswati × Black Plastic Mulching	24.31	5.00
F-value	NS	NS
LSD	6.40	2.79
Mean	16.80	4.50
CV	21.77	35.45

CV: coefficient of variation, DAT: Days after Transplantation, LSD: Least Significant Difference, **: 1% level of significance, NS: Non significance, same letter signifies no significant difference between treatments while different letter signifies significant difference between treatments

Firmness, fruit weight, and pulp weight

Varietal differences significantly influenced fruit firmness and fruit weight, while mulching had no significant effect on these parameters (Table 3). Saraswati recorded higher firmness (9.03 kg cm^{-2}), whereas Sweet Honey produced heavier fruits (2.74 kg). The highest firmness (9.73 kg cm^{-2}) was observed in the Saraswati × Sawdust mulch treatment. These differences are attributed to genetic variation between varieties. Mulching had no significant effect on fruit weight or pulp weight, which is consistent with findings where fruit size is mainly controlled by genotype rather than mulch type (Díaz-Pérez, 2022).

pH, titratable acidity, and node diameter

As presented in Table 4, mulching significantly affected titratable acidity, with the highest acidity recorded in the control treatment (0.23%) and the lowest under straw mulch (0.16%). Reduced acidity under mulched conditions may be due to improved fruit maturation and sugar accumulation. However, pH and node diameter were not significantly affected by mulching, variety, or their interaction.

Yield and TSS

Table 5 shows that mulching significantly influenced yield. Black plastic mulch produced the highest yield (22.35 t ha^{-1}), followed by straw mulch (18.24 t ha^{-1}), whereas the control recorded the lowest yield (13.21 t ha^{-1}). Variety and interaction effects were non-significant for yield and TSS. Yield improvement under black plastic mulch may be attributed to improved soil moisture conservation, enhanced soil temperature regulation, and effective weed suppression, which collectively promote better plant growth and fruit development. Similar results were reported by Singh *et al.* (2019), who observed increased yield in watermelon under plastic mulch due to improved hydrothermal soil conditions.

Fruit diameter

Equatorial and transverse fruit diameters were not significantly affected by mulching, variety, or their interaction. This indicates that fruit size was relatively stable across treatments and was less responsive to mulching practices under the present experimental conditions.

Conclusion

The present study demonstrated that mulching significantly influenced growth, yield, and fruit quality attributes of watermelon. Among the mulching materials, black plastic mulch produced the highest plant height and fruit yield, while straw mulch resulted in the highest number of leaves and branches. Among the varieties, Saraswati performed better in terms of leaf number and fruit firmness, whereas Sweet Honey produced heavier fruits. Significant interaction effects were observed for leaf number, branch number, and firmness, with the Saraswati × Straw mulch combination showing superior performance for some growth attributes. Overall, both black plastic and straw mulches improved watermelon performance compared to the control treatment. While black plastic mulch was most effective in maximizing yield, straw mulch provided favorable growth performance and may be a more sustainable and cost-effective option for smallholder farmers due to its availability, biodegradability, and environmental friendliness.

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DECLARATIONS

Authors contribution statement: Conceptualization: S.S.P., D.R.D., P.K., R.B., and R.C.; Methodology: D.R.D. and S.S.P.: Software and validation: S.S.P., D.R.D., R.B., and R.C.; Investigation: D.R.D., P.K., R.B., and R.C.; Data curation: D.R.D.; Writing-original draft preparation: D.R.D. and P.K.; Writing-review and editing: D.R.D., P.K., and S.S.P.; Supervision: S.S.P. All authors have read and agreed to the published version of the manuscript.

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