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Influence of Mulch Types on Morphological and Yield Parameters of Turmeric (*Curcuma longa* L.) in Uttar Pradesh, India

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ABSTRACT- Mulching is a proven climate-smart practice for rhizomatous crops, yet comparative evaluations of organic and synthetic mulches for turmeric under subtropical conditions remain limited. This two-year field study (2020–21 and 2021–22) assessed the effects of five mulch types—black polyethylene, paddy straw, banana leaves, sugarcane leaves, and an unmulched control—on the growth, microclimate, weed suppression, and yield of turmeric (*Curcuma longa* L.) cv. *Rajendra Sonia* in Uttar Pradesh, India. Black polyethylene mulch (25 µm thickness) produced significantly greater plant height (82.5 cm), number of leaves (10.9), fresh yield (159.6 q/ha), and dry yield (81.5 q/ha), outperforming the control by 37%, 90%, 138%, and 56%, respectively. Among organic options, paddy straw mulch performed best, offering substantial improvements in moisture retention and yield, while sugarcane leaves showed reduced yield due to likely nitrogen immobilization. Soil moisture retention was highest under black polyethylene (18.2%), followed by sugarcane leaf mulch (17.4%). Weed density was lowest in black polyethylene (49.8 weeds/m²). The findings emphasize the superior agronomic efficiency of black polyethylene but highlight paddy straw as a practical, sustainable alternative.

Keywords- Turmeric, Mulching, Microclimate modification, Organic residues, Weedsuppression, Yield improvement

Introduction

Turmeric (*Curcuma longa* L.), a perennial herb of the Zingiberaceae family, holds immense significance as a culinary spice, medicinal plant, and economic crop in India, which accounts for approximately 80% of global production (Spices Board of India, 2023). In Uttar Pradesh, an emerging turmeric-growing region, productivity remains constrained by several abiotic challenges. The crop requires consistent soil moisture and warm conditions during its 8-9 month growing cycle, yet increasing water scarcity and erratic rainfall patterns threaten yield stability (Pandey et al., 2021). Furthermore, as a shallow-rooted crop, turmeric suffers significant yield losses from weed competition, particularly during the initial 4-5 months after planting (Singh et al., 2022). Conventional weed management through repeated manual weeding is labour-intensive, costly, and disturbs soil structure, exacerbating moisture loss.

Mulching has emerged as a sustainable agronomic practice to address these constraints simultaneously. By covering the soil surface, mulches moderate soil temperature, reduce evaporation, suppress weed growth, and improve water-use efficiency (Li et al., 2023). However, the choice of mulch material involves critical trade-offs between efficacy and sustainability. Black polyethylene mulch offers superior weed suppression and moisture conservation, leading to significant yield improvements in various crops (Lee et al., 2024; Sun et al., 2023). Nevertheless, its non-biodegradability raises serious environmental concerns, including soil plastic pollution and disposal challenges (Sintim et al., 2020).

Alternatively, organic mulches—such as paddy straw, sugarcane leaves, and banana leaves—provide an eco-friendly option that aligns with circular economy principles. These materials not only conserve soil moisture and suppress weeds but also enhance soil organic matter, improve structure, and promote microbial activity upon decomposition (Goyal et al., 2023). In Uttar Pradesh, where rice and sugarcane are major crops, utilizing their residues as mulch can reduce open burning and support sustainable crop management.

While previous studies have examined mulching in turmeric, a systematic comparison of black polyethylene and locally available organic materials under the specific agro-climatic conditions of Uttar Pradesh is lacking. This study therefore aims to: (1) evaluate the effects of different mulch types on morphological growth, yield, soil moisture, and weed dynamics in

turmeric; and (2) assess the viability of organic mulches as sustainable alternatives to plastic mulch. We hypothesize that although black polyethylene will show the highest performance, paddy straw mulch will serve as an effective and environmentally sound alternative for turmeric cultivation in the region.

Material and Methods

2.1 Experimental Site

The experiment “Effect of different types of mulches on growth and yield of turmeric (*Curcuma longa*. L.) was conducted at Prakash agricultural farm during the tow growing year 2020-21 and 2021-22 in the village Musraha at Pilibhit district of Uttar Pradesh. Spacing of rhizomes of turmeric variety Rajendra Sonia was 60x20 cm.in ridges and Randomized Block Design was used for experiment with three replications and five treatments.

2.2 Soil Characteristics

The soil was sandy loam in texture with pH 6.5, low nitrogen, medium phosphorus, and high potassium content. The field was well-drained and previously used for vegetable cultivation.

2.3 Experimental Design and Treatments

A randomized block design (RBD) was adopted with five treatments and three replications:

Treatment	Material	Thickness / Application Details
T1	Control (No mulch)	—
T2	Paddy straw mulch	5 cm uniform thickness; applied @ 6.5 t/ha
T3	Dry sugarcane leaves	5 cm; applied @ 7.8 t/ha
T4	Black polyethylene mulch	25 μ m thickness; perforated at planting holes
T5	Banana leaves	5 cm; applied @ 5.5 t/ha

Mulches were applied 30 days after planting (DAP), once sprouting was complete.

2.4 Crop Establishment

Turmeric variety 'Rajendra Sonia' was used. Rhizomes were planted at a spacing of 30 × 20 cm. Recommended dose of fertilizers was applied (N:P: K = 100:50:50 kg/ha), with half N and full P & K as basal and remaining N in two equal splits doses at 60 and 75 days.

3. Result and discussion

The application of different mulching materials significantly influenced all observed growth and yield parameters of the crop compared to the unmulched control (T1). The analysis of variance revealed that the treatment means were statistically significant, as evidenced by the critical difference (C.D.) values being lower than the differences between key treatment means. The results for each parameter are presented and discussed below.

3.1. Plant Growth Parameters

3.1.1. Plant Height

Plant height responded positively to all mulching treatments. The tallest plants were recorded under black polyethylene mulch (T₄: 82.50 cm), followed by sugarcane leaves (T₃: 77.70 cm) and paddy straw (T₂: 71.10 cm), whereas the unmulched control produced the shortest plants (T₁: 60.10 cm). The superiority of black polyethylene mulch may be attributed to its ability to maintain higher soil temperature, conserve moisture, and suppress weeds effectively, thereby enhancing vegetative growth (Gao et al., 2022; Lee et al., 2024; Sun et al., 2023). Organic mulches also improved plant height by enhancing soil structure, microbial activity, and nutrient supply. Similar findings have been reported by Li et al. (2023), Chen et al. (2023), and Zhang et al. (2021), who observed improved plant vigor and root development under organic mulching due to better soil physical and biological conditions.

3.1.2. Number of Leaves per Plant

A similar trend was observed for the number of leaves per plant, a key indicator of photosynthetic capacity. The highest number of leaves (10.97) was again found in T₄ (Black polyethylene mulch), which was significantly greater than all other treatments. This was followed by T₅ (Banana leaves mulch) at 9.87 leaves and T₂ (Paddy straw mulch) at 9.33 leaves. The control treatment (T₁) resulted in the lowest leaf count (5.77). The increase in leaf number under mulch treatments can be attributed to the improved soil hydrothermal regime, which promotes a more robust root system.

This enhances the synthesis of cytokinin in the roots, which are then translocated to the shoots, stimulating cell division and leaf initiation (Zhang et al., 2021; Ahmad et al., 2022; Ning et al., 2023). The high performance of T5 (Banana leaves) suggests it may act as a rapid-release nutrient source due to its favorable biochemical composition, facilitating quicker nutrient availability compared to other organic mulches (Kaur et al., 2020).

3.2. Yield Parameters

3.2.1. Fresh Yield (kg/plot) and Fresh Yield (q/ha)

Yield parameters varied significantly among treatments. Black polyethylene mulch (T₄) produced the highest fresh yield (25.83 kg/plot; 159.67 q/ha), exceeding paddy straw mulch (T₂: 17.92 kg/plot; 129.83 q/ha). Its superior performance is attributed to improved microclimate, water-use efficiency, and nutrient uptake during key growth stages (Sun et al., 2023; Zhao et al., 2020; Lee et al., 2024). In contrast, sugarcane leaves mulch (T₃) yielded less than the control (7.97 vs. 10.82 kg/plot), likely due to nitrogen immobilization from microbial decomposition of high C: N material (Chaudhary et al., 2022; Wang et al., 2021; Blanco-Canqui, 2021). Similar trends have been reported, highlighting that high-carbon mulches can temporarily limit nutrient availability and reduce yield unless supplemented with nitrogen.

3.2.2 Dry Yield (q/ha)

Dry yield followed a pattern similar to fresh yield. The highest dry yield was obtained under black polyethylene mulch (T₄: 81.57 q/ha), followed by paddy straw (T₂: 78.77 q/ha) and banana leaves (T₅: 65.40 q/ha), while the control yielded only 52.17 q/ha. The superior performance of T₄ and T₂ is attributed to improved assimilate partitioning under favorable soil conditions, allowing more photosynthates to be allocated to the economic yield (Zhao et al., 2020; Qin et al., 2022; Li et al., 2023). The lower performance of sugarcane leaves mulch (T₃) emphasizes that the effectiveness of organic mulches depends on decomposition rate and nutrient release (Chaudhary et al., 2022; Goyal et al., 2023). Similar findings have been reported, showing that fast-decomposing mulches with balanced C:N ratios enhance dry matter accumulation.

3.3 Weed Suppression

3.3.1 Weed Density (no./m²):

Mulching substantially reduced weed density at 120 DAP compared to the control (61.40 no./m²), though the level of suppression varied across materials. Black polyethylene (T₄) was the most effective (49.80 no./m²), owing to its complete light exclusion that inhibits photoblastic weed germination. Organic mulches such as dry sugarcane leaves (T₃: 51.20 no./m²) and paddy straw (T₂: 52.30 no./m²) also lowered weed emergence, with their efficacy linked to mulch thickness and persistence. Banana leaves (T₅) were least effective among mulches (56.50 no./m²), likely due to a less compact or discontinuous layer that allowed greater weed penetration. These results confirm that both physical barrier strength and mulch stability determine weed suppression efficiency (Chaudhary et al., 2022; Blanco-Canqui, 2021; Gao et al., 2022; Lee et al., 2024).

3.3.2 Weed Dry Weight (g/m²):

Weed dry weight did not fully correspond with weed density trends. Although the control recorded the highest dry weight (223.60 g/m²), differences among the mulched treatments were small and statistically non-significant, as reflected by the low C.V. (1.36%) and treatment means falling below the C.D. value (7.43). This indicates that while mulching reduced weed numbers, the few weeds that emerged in mulched plots grew to a comparable size as those in the control. Once weeds penetrated the mulch—particularly organic mulches that thin or decompose—they benefited from improved moisture and nutrient conditions created by the mulch layer (Li et al., 2023; Wang et al., 2021). In black polyethylene mulch, weeds likely emerged from planting holes or small tears, explaining the dry weight recorded.

Interpretation and Implications:

This result highlights a critical aspect of mulch-based weed management: the initial suppression is highly effective, but the longevity of control depends on the mulch's durability. Organic mulches require sufficient thickness to maintain suppression throughout the cropping season, while plastic mulches require careful installation and maintenance to prevent tears. These findings align with studies emphasizing that integrated weed management, combining mulching with other methods, may be necessary for season-long control in long-duration crops like turmeric (Sintim et al., 2020; Chen et al., 2023).

Moisture Retention (Soil moisture (%) at 90 DAP)

Mulching treatments showed clear differences in soil moisture conservation at the critical growth stage (Table 3). Black polyethylene mulch (T₄) recorded the highest moisture content (18.2%), followed by dry sugarcane leaves (T₃: 17.4%) and paddy straw (T₂: 16.9%). Banana leaves (T₅) conserved less moisture (15.7%), while the control (T₁) had the lowest (11.6%). The superior performance of T₄ is attributed to its impermeable barrier that minimizes direct evaporation (Gao et al., 2022; Sun et al., 2023). Organic mulches (T₂, T₃) also conserved significant moisture by shading the soil and disrupting capillary rise (Kader et al., 2019; Li et al., 2023), with variations linked to their thickness and density. These results explain the improved growth and yield observed under mulched treatments.

Summary Table

Parameter	Best Treatment	Trend Summary
Plant height & leaves	Black polyethylene	Greatest improvement; organic mulches moderate gains
Fresh & dry yield	Black polyethylene	Highest yield; paddy straw best among organics
Weed suppression	Black polyethylene	Strongest reduction in weed density
Soil moisture	Black polyethylene	Highest retention; organics provide moderate gain

Conclusion

Black polyethylene mulch significantly improved turmeric growth, physiological performance, and yield due to superior microclimatic modification and weed suppression. However, its environmental concerns—non-biodegradability and soil plastic accumulation—limit long-term sustainability. Among organic mulches, paddy straw emerged as the most effective and sustainable option, providing high yields, good moisture conservation, and eco-friendly residue recycling benefits. Banana leaves also showed potential as a low-cost biodegradable material.

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(Table: 1. Effect of different types of mulches on growth and yield of turmeric)

Treatment	Plant Height		No. of leaves per plant		Fresh Yield(kg/plot)		Fresh Yield (q./ha)		Dry yield (q/ha)	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.	Mean	S.E.
T1: Control (No mulch)	60.100	0.152	5.767	0.088	10.817	0.060	58.333	0.291	52.167	0.203
T2: Paddy straw mulch	71.100	0.321	9.333	0.120	17.917	0.088	129.833	0.178	78.767	0.145
T3: Dry Sugarcane leaves	77.700	0.264	8.067	0.088	7.967	0.060	92.500	0.839	59.733	0.202
T4: Black polyethylene mulch (25 microns)	82.500	0.321	10.967	0.145	25.833	0.159	159.667	0.490	81.567	0.434
T5: Banana leaves	73.400	0.265	9.867	0.145	16.600	0.104	128.367	0.317	65.400	0.231
Mean	72.967		8.800		15.827		113.740		67.527	
C.D.	0.288		0.099		0.139		0.864		0.369	
SE(m)	0.087		0.030		0.042		0.261		0.111	
SE(d)	0.123		0.042		0.059		0.369		0.158	
C.V.	0.206		0.586		0.459		0.397		0.286	

(Table: 2. Effect of different types of mulches on Weed Suppression of turmeric field)

Treatment	Weed Density (no./m ²)	Weed Dry Weight (g/m ²) at 120 DAP
T ₁ : Control (No mulch)	61.40	223.60
T ₂ : Paddy straw mulch	52.30	218.40
T ₃ : Dry Sugarcane leaves	51.20	221.10
T ₄ : Black polyethylene mulch (25 microns)	49.80	219.30
T ₅ : Banana leaves	56.50	215.60
Mean	54.24	219.60
S. D	4.72	2.99

S. E	2.72	1.73
C.V. (%)	8.70	1.36
C.D. (5% level)	11.72	7.43

(Table: 3. Effect of different types of mulches on Soil Moisture Retention of turmeric field)

Treatment	Moisture Content (%)
T ₁ : Control (No mulch)	11.6
T ₂ : Paddy straw mulch	16.9
T ₃ : Dry Sugarcane leaves	17.4
T ₄ : Black polyethylene mulch (25 microns)	18.2
T ₅ : Banana leaves	15.7
Mean	15.96%
S. D	2.60
S. E	1.16
C.V	16.29%
C.D(5%)	4.55

Table: 4. Key Observations

Parameter	Best Treatment (T ₄ - Black Polyethylene)	% Increase over Control
Plant Height	82.5 cm	+37%
Number of Leaves	10.96 leaves/plant	+90%
Fresh Yield	25.83 kg/plot	+138%
Dry Yield	81.56 q/ha	+56%
Soil Moisture	18.2%	+56%
Weed Suppression	49.8 weeds/m ² (lowest density)	-19%

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Fig.1. Effect of different types of mulches on growth and yield of turmeric





