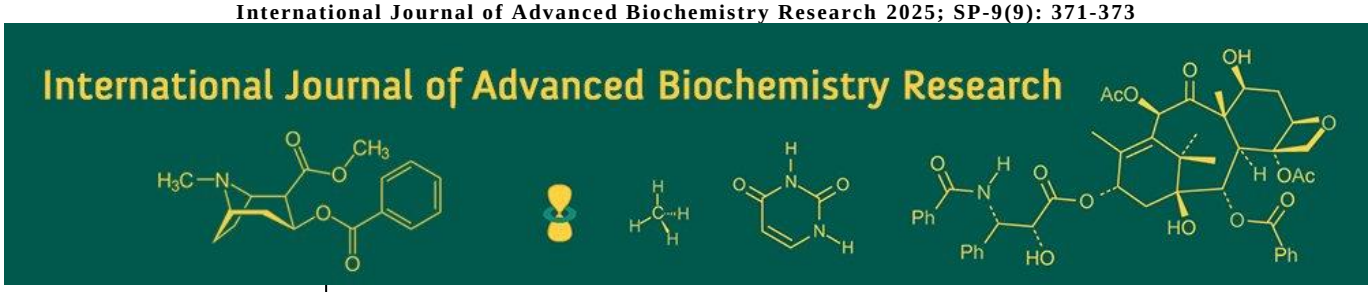

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Effects of different types of mulching on soil moisture and yield of two Indian mustard (*Brassica juncea* L.) varieties under rabi conditions in Western Uttar Pradesh

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Abstract
A field experiment was conducted at the CAE Research Farm, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh (U.P.), during the rabi season of 2023-24 to study the effect of mulching on weed suppression, soil moisture, growth, yield, and economics of two Indian mustard (*Brassica juncea* L.) cultivars (Pioneer 45S44 and Pioneer 45S46). The experiment was laid out in a factorial randomized block design with eight treatment combinations comprising three types of organic mulches—paddy straw (5 t ha^{-1}), wheat straw (5 t ha^{-1}), and sawdust (20 t ha^{-1})—along with a no-mulch control. Results revealed that mulching significantly influenced weed density, weed control efficiency, soil moisture retention, and yield parameters (siliquae plant^{-1}, seeds siliqua^{-1}, 1000-seed weight, biological yield, seed yield, and harvest index). Paddy straw mulch @ 5 t ha^{-1} outperformed other treatments, registering the highest seed yield, oil yield, and B:C ratio across both cultivars. Between the two varieties, Pioneer 45S44 showed better performance in terms of yield and economic returns compared to Pioneer 45S46. The interaction effect of mulching and varieties indicated that Pioneer 45S44 with paddy straw mulch was the most profitable treatment combination. The study underscores the role of organic mulching as a sustainable practice for weed suppression, soil moisture conservation, and yield maximization in Indian mustard cultivation under semi-arid conditions.

Keywords: Indian mustard, mulching, soil moisture, yield, economics

1. Introduction
Oilseeds play a pivotal role in Indian agriculture, contributing significantly to edible oil security and rural livelihoods. Among them, Indian mustard (*Brassica juncea* L. Czern & Coss.) is the most important rabi oilseed crop, occupying the second largest acreage after soybean and contributing substantially to India's edible oil pool (USDA, 2021-22) [12]. With about 8.8 million hectares under cultivation and an average production of 12.4 million tonnes, India ranks second globally in area and fourth in production. Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Gujarat account for over 80% of the national mustard output (MoAFW, 2019-20). Despite its importance, mustard productivity in India lags behind global averages. Among the major limiting factors, weed infestation and soil moisture deficit are particularly severe. Weeds compete with the crop for light, water, and nutrients, reducing yields by 15-30%, and sometimes causing total crop failure depending on intensity and species composition (Shekhawat *et al.*, 2012) [11]. Similarly, moisture stress is a chronic issue in rainfed mustard areas of northwestern India, particularly during February when pod filling coincides with scanty rainfall (Niwas *et al.*, 2016) [8]. Together, these constraints significantly depress mustard productivity and profitability.
Mulching has emerged as an eco-friendly, low-cost technology for improving soil moisture, reducing weed infestation, and enhancing crop growth. Mulch application modifies the soil microclimate by reducing evaporation, moderating soil temperature, suppressing weeds, and improving organic matter status (Kader *et al.*, 2017) [5]. Organic mulches such as straw, crop residues, and sawdust are readily available and environmentally sustainable alternatives to chemical herbicides, whose excessive use has raised concerns about soil degradation and

resistance development in weed populations (Diaz *et al*., 2004) [2]. Previous studies have demonstrated the benefits of mulching in cereals, vegetables, and oilseeds. In mustard, Saikia *et al*. (2014) [10] reported a 32.8% yield increase with paddy straw mulch compared to unmulched fields. Similarly, Ranjan *et al*. (2017) [9] highlighted mulching's role in enhancing soil moisture availability and weed control efficiency. However, limited information is available on the comparative efficacy of different organic mulches in Indian mustard under the climatic conditions of western Uttar Pradesh.

2. Materials and Methods

2.1 Experimental Site and Climate

The study was conducted at the CAE Research Farm, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh, Uttar Pradesh, during rabi 2023-24. The site is located at 27.88°N latitude and 78.08°E longitude at an altitude of 168 m in the North-Gangetic Plains. The climate is subtropical, characterized by hot summers and cold winters, with an average annual rainfall of 800 mm, 80% of which occurs during the southwest monsoon. During the crop season, mean maximum and minimum temperatures ranged from 15.3 °C to 31.1 °C and 5.0 °C to 15.2 °C, respectively. The soil was sandy clay loam in texture, with pH 7.32, EC 0.15 dS m^{-1}, organic carbon 0.75%, and available N, P_2O_5, K_2O, and S at 186.5, 20.3, 220.15, and 17.8 kg ha^{-1}, respectively.

2.2 Experimental Design and Treatments

The experiment was laid out in a factorial randomized block design (FRBD) with three replications. Treatments consisted of:

Mulching (4 levels)

- M1: Control (no mulch)
- M2: Paddy straw mulch @ 5 t ha^{-1}
- M3: Wheat straw mulch @ 5 t ha^{-1}
- M4: Sawdust mulch @ 20 t ha^{-1}

Varieties (2 levels):

- V1: Pioneer 45S44
- V2: Pioneer 45S46

This resulted in eight treatment combinations (T1-T8). Plot size was 3.7 × 2.5 m (net), with 45 × 15 cm spacing between rows and plants.

2.3 Crop Management

The field was prepared with one ploughing, one harrowing, and planking. A seed rate of 3 kg ha^{-1} was used, sown manually on 20th October 2023. Pre-emergence herbicide Pendimethalin 30% EC was applied within 24 hours of sowing. Mulches were applied manually after crop emergence as per treatments. Recommended doses of fertilizers (60:40:0 NPK kg ha^{-1}) were applied through urea and DAP, with sulphur supplementation. Irrigation was applied once at 30 DAS. Manual weeding was carried out along with thinning at 2 weeks after sowing. Harvesting was done on 21st March 2024 when siliquae turned brown.

3. Results

The data (Table 1) revealed significant effects of mulching practices and mustard varieties on seed yield, stover yield, oil content, protein content, and harvest index. Seed yield was markedly influenced by mulching. Among the treatments, Pioneer 45S44 with paddy straw mulch (V_1M_2) recorded the highest seed yield (1993 kg ha^{-1}), followed by V_2M_2 (1760 kg ha^{-1}), whereas the lowest yield was observed in V_2M_1 (1328 kg ha^{-1}). The superior performance of paddy straw mulch may be attributed to its effectiveness in conserving soil moisture, suppressing weeds, and improving nutrient availability, thereby promoting crop growth. Wheat straw mulch also improved yield significantly compared to control, though it remained inferior to paddy straw. Sawdust mulch (20 t ha^{-1}) exhibited intermediate yield values, likely due to its slower decomposition and lower nutrient contribution. Stover yield followed a similar trend, with the maximum recorded in V_1M_2 (6442 kg ha^{-1}) and the lowest in V_2M_1 (4588 kg ha^{-1}). Enhanced vegetative growth under straw mulches contributed to higher biomass production, which translated into increased stover yield.

Mulching significantly influenced quality parameters. The highest oil content (43.2%) was observed in V_1M_4 (sawdust mulch), while the lowest (39.2%) was in V_2M_4. This suggests that organic mulches can improve microclimatic conditions favourable for oil biosynthesis. Protein content showed marginal variation across treatments, ranging between 20.02% (V_2M_1) and 21.88% (V_1M_2). The superior protein content under paddy straw mulch may be attributed to enhanced nutrient uptake and better moisture conservation. Harvest index (HI) varied from 22.13% (V_2M_4) to 23.42% (V_2M_2). Mulched plots consistently recorded higher HI than control, indicating better partitioning of assimilates towards seed yield under favourable soil conditions created by mulching.

4. Discussion

The results clearly establish that mulching improved productivity and quality of Indian mustard. Paddy straw mulch was most effective, enhancing both seed and stover yields, along with oil and protein content. These findings align with Saikia *et al*. (2014) [10], who reported a 32.8% yield increase in mustard with straw mulch, and Ranjan *et al*. (2017) [9], who highlighted mulching's role in conserving soil moisture and enhancing water use efficiency. The better performance of Pioneer 45S44 over Pioneer 45S46 can be attributed to its higher genetic potential and better adaptability under mulched conditions. The improvement in oil and protein content under mulched treatments corroborates the reports of Ahmed *et al*. (2013) [1], who observed that organic mulches enhance soil organic matter and nutrient availability, thereby improving seed quality. Thus, straw-based mulching, particularly paddy straw, emerges as a sustainable practice to enhance yield and profitability of mustard cultivation under semi-arid conditions.

Table 1: Effect of different types of mulches on yield (kg/ha) and quality parameters in Indian Mustard

Treatment	Seed Yield (kg/ha)	Stover Yield (kg/ha)	Oil Content (%)	Protein Content (%)	Harvest Index (%)
V_1M_1	1339	4572	41.4	21.19	22.65
V_1M_2	1993	6442	41.6	21.28	23.08
V_1M_3	1756	5860	42.7	21.56	23.05
V_1M_4	1695	5597	43.2	21.08	22.90
V_2M_1	1328	4588	40.2	20.02	22.44
V_2M_2	1760	5753	40.2	21.01	23.42
V_2M_3	1533	5338	39.9	20.09	22.31
V_2M_4	1473	5010	39.2	20.02	22.13
S.Em.±(V*)	14.78	34.54	0.31	0.18	0.16
S.Em.±(M*)	20.90	48.85	0.44	0.26	0.22
S.Em.±(VM)	29.56	69.09	0.63	0.37	0.32
CD at 5% (V*)	44.84	104.78	0.96	0.56	0.49
CD at 5% (M*)	63.42	148.18	1.36	0.79	0.69
CD at 5% (VM)	89.69	209.56	1.92	1.12	0.98

V*-Varieties; M*-Mulches

5. Conclusion

The study revealed that mulching significantly enhanced the growth, yield, and quality of Indian mustard compared to unmulched control. Among the treatments, paddy straw mulch @ 5 t ha^{-1} with Pioneer 45S44 variety recorded the highest seed and stover yields, oil and protein content, and harvest index, proving to be the most effective and profitable combination. Wheat straw mulch also improved performance over the control, while sawdust showed moderate effects. The positive impact of mulching was mainly due to improved soil moisture conservation, weed suppression, and better nutrient utilization. Overall, the results suggest that adopting organic mulching, particularly paddy straw, along with suitable mustard varieties, offers a sustainable and eco-friendly strategy to increase productivity and profitability in mustard cultivation under semi-arid conditions.

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