

RESEARCH PAPER

Comparative Performance of Jute Non-woven Mulch, Rice Straw and Polythene Mulch in Improving Growth and Productivity of Broccoli (*Brassica oleracea* var *italica*) and Economics Thereof

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ABSTRACT

Mulching provides favourable environment for crop with multiple advantages including better crop yields. An experiment was conducted in a farmer's field at village Srichandrapur of Birbhum district, West Bengal during *rabi* season of 2022 and 2023 to study the comparative performance of jute non-woven mulch, straw and polythene mulch in improving growth and productivity of broccoli. Seven mulching treatments namely Jute non-woven mulch (250 gsm) (T₁); Jute non-woven mulch (450 gsm) (T₂); Straw mulch @ 3.5 t/ha (T₃); Straw mulch @ 4.0 t/ha (T₄); Polythene mulch (25 micron) (T₅); Polythene mulch (50 micron) (T₆) and Control- no mulch (T₇) were assigned in a randomised block design replicated thrice. Experimental findings revealed that both the Jute non-woven mulch (T₂, T₁) and Polythene mulch (50 micron) (T₆) registered higher values of growth attributing factors like plant height, leaf area, number of leaves per plant over control plot and curd fresh weight of Broccoli during both the years. All the mulching treatments significantly reduced the total weed density and total weed dry weight over no mulch. However, T₁ and T₂ were found more efficient which registered 89.24 and 90.6% lower weed density, 93.69 and 94.38% lower weed dry weight and 42.52 and 44.68% higher fresh weight of broccoli in 2022 and 2023, respectively. Though Jute non-woven mulch fetched higher gross return but net return and return per rupee invested were lower as compared to other mulch materials.

HIGHLIGHTS

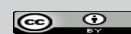
- To increase the production per unit area, the use of mulch is one of the suitable methods.
- Mulches are used to control soil temperature, safe guard plant roots from heat, prevent soil evaporation, retain soil moisture, prevent weed growth, improve water use efficiency and affect the microclimate of the soil.
- Non-woven jute mulch of 450 gsm, and non-woven jute mulch of 250 gsm was superior compared to rice straw and polythene mulches in increasing yield and growth of broccoli, suppressing weeds, increasing moisture and available N, P and K contents and microbial population of the lateritic soil.

Keywords: Broccoli, curd fresh weight, mulching, weed density, weed dry weight

Vegetables are said to be the best food for our body. Broccoli (*Brassica oleracea* var. *Italic* L.), belongs to family Brassicaceae, is a member of Cole group. It is rich in dietary fiber, minerals, vitamins and

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antioxidants that have proven health benefits (Mukherjee and Mishra, 2012). It is a store house of many phytonutrients. The crop is mainly grown during September to March after harvesting of rice. There are three classes of broccoli, *i.e.* green, purple and white, among them green type broccoli is the most popular. Sprouting broccoli contains more vitamins and minerals than those of other Cole crops. Broccoli has high nutritive value with good taste, flavour and many nutritive and health benefits. It contains carbohydrates (5.5 %), protein (3.3 %), vitamin-A (3500 IU), vitamin-C (137 mg), vitamin-B₁ (0.05 mg), vitamin-B₂ (0.12 mg), calcium (0.80 mg) and phosphorus (0.79 mg). Fresh broccoli contains 89% water, 7% carbohydrates, 3% protein and negligible fat. A 100- gram reference amount of raw broccoli provides 34 kilo calories of food energy (FDA, 2024). The demand for vegetables in the market is high and competition has forced the farmers to produce more and higher quality vegetables. The practice of applying mulch for the production of vegetables is thousands of years old. To increase the production per unit area, the use of mulch is one of the suitable methods. In the cultivation of broccoli, weed causes the serious problem. It reduces the yield, quality and increases the cost of maintenance. Weeds compete with crops for water, nutrients and light. In order to prevent the problem of weed growth, evaporation from soil surface, to protect the soil surface from the influence of unfavourable factors and to improve the growing conditions for the crop plant, the practice of mulching is beneficial. Mulching is an agricultural cropping technique that involves placing organic or synthetic materials on soil around plants to provide a more favourable environment for growth and production. Mulches influence on weed growth by blocking the daylight, which suppress their emergence and growth (Fatima and Duary, 2020; Fatima *et al.* 2021). It acts as surface barrier to check evaporation to water from soil surface.

There are different types of mulch used in the field depending on the purpose. Mulches are used to control soil temperature, safe guard plant roots from heat, prevent soil evaporation, retain soil moisture, prevent weed growth, improve water use efficiency and affect the microclimate of the soil. By creating unfavourable conditions for weed seed germination and acting as a physical barrier for emerging weeds,

mulches limit weed growth. A good mulch layer can save many hours of laborious weeding.

The present experiment was conducted with the objectives to study the comparative performance of jute non-woven mulch and straw and polythene mulch on weed control in broccoli, the effect of mulching on improving the growth and yield of broccoli and to work out the economic viability of broccoli cultivation under different mulch materials.

MATERIALS AND METHODS

The experiment was conducted in farmer's field of village Srichandrapur, Bolpur, Birbhum in the lateritic belt of West Bengal. The experimental field is located in 23°42'98" N latitude and 87°38'55" E longitude and 48 m above mean sea level. The experimental soil was clay loam with pH 6.4, low in available nitrogen and medium in available P₂O₅ and K₂O. The experiment was conducted in a randomized block design with three replications. The broccoli variety Green Magic was transplanted with a spacing of 30 × 30 cm. The plot size was 4 m × 3 m. Seven treatments comprised of Jute non-woven mulch (250 gsm), Jute non-woven mulch (450 gsm), Straw mulch @ 3.5 t/ha, Straw mulch @ 4.0 t/ha, Polythene mulch of 25 micron, Polythene mulch of 50 micron, Control- no mulch were assigned in a randomized block design with three replications. The crop was fertilized with N, P₂O₅ and K₂O at 150:100:150 kg /ha, respectively. Half of the nitrogen, full dose of P₂O₅ and K₂O were applied as basal and remaining N was applied as top dressing. Nitrogen was applied in the form of urea, P₂O₅ in the form of single super-phosphate and K₂O as muriate of potash, respectively. Three irrigations were applied. The planting of broccoli was done after final land preparation and placing of mulch materials as per treatment. The planting was done in the hole prepared in the polythene and jute unwoven mulch as per prescribed spacing. Weed count and dry weight were recorded following the standard procedure.

RESULTS AND DISCUSSION

Weed flora

The experimental field was infested with 9 weed species under grass and broad-leaved category with no sedge. Weed flora that existed in the

experimental plots during both years comprised of *Cynodon dactylon* among grasses; *Chenopodium album*, *Amaranthus viridis*, *Physalis minima*, *Solanum nigrum*, *Spilanthes acmella*, *Oxalis corniculata*, *Alternanthera philoxeroides* and self-sown mustard among broad-leaved weeds (BLW).

Weed density and dry matter accumulation at 60 days after planting

The mulch treatments had significant ($p \leq 0.05$) effect on total weed density during both the years (Table 1). The control plot recorded the highest and the treatments mulching with non-woven jute mulch of 250 gsm, non-woven jute mulch of 450 gsm and polythene mulch of 50 micron recorded lowest total weed density. The treatments polythene mulch of 25 micron, straw mulch @ 4.0 t/ha and straw mulch @ 3.5 t/ha registered 80.75%, 76.36% and 65.90% less total weed density than control in 2022 and 86.18%, 76.71% and 64.73% in the year 2023, respectively at 60 DAP (Days After Planting). Dry matter accumulation of total weeds followed almost same trend as of weed density during both the years (Table 1). The highest total weed dry weight was recorded by control plot and the lowest by mulching with non-woven jute mulch of 250 gsm, non-woven jute mulch of 450 gsm and polythene mulch of 50 micron. At 60 DAP, the treatments mulching with polythene mulch of 25 micron, straw mulch @ 4.0 t/ha and straw mulch @ 3.5 t/ha registered 84.54%, 83.12% and 72.1% lower total weed dry matter accumulation than control plot in 2022 and 89.0%, 83.3% and 72.78% in the year 2023, respectively. Manna *et al.* (2018) reported that at 60 DAP, lowest density and dry weight of grasses, sedges and broad leaved weeds were recorded by polythene mulch treatment and was statistically at par with 450 gsm non-woven jute agro-textile treatment. Accordingly, the results showed that the number of weeds was much lower in the mulched plot than in the non-mulched one because the mulches limited down light interception, which stressed the weeds that were already there and inhibited many weed species, especially those with tiny seeds from germinating. Weeds were prevented from emerging by the physical barrier that the mulches generated, but this impact was only temporary and vanished when the mulches broke down. Datta *et al.* (2005) and Subba (2015) also noted similar findings.

Utilizing natural fibers and natural-based polymers, such as jute, hemp, viscose, polylactic acid (PLA), and others, may improve soil health, moisture retention, and weed control while also increasing crop yield and improving crop quality. Bast fiber non-woven mulches present a strong substitute for traditional plastic mulches. These mulches are excellent at suppressing weeds because they block light, restrict photosynthesis to prevent weed development, and break down gradually when they come into touch with soil (Miao *et al.* 2013; Wortman *et al.* 2015; Tofanelli and Wortman, 2020; Liu *et al.* 2021; Kopitar *et al.* 2022).

Crop growth attributes

Plant biometric parameters including plant height 60 DAP and numbers of leaves/plant at 60 DAP were significantly ($p \leq 0.05$) influenced by mulch treatments over both the years (Table 1). During the year 2022, the treatment mulching with non-woven jute of 450 gsm attained highest plant height at 60 DAP, which was followed by the treatments mulching with non-woven jute mulch of 250 gsm, straw mulch @ 4.0 t/ha and polythene mulch of 50 micron. Among all the treatments, the treatments mulching with polythene mulch of 50 micron, straw mulch @ 3.5 t/ha and control recorded the lowest plant height in the year 2022. The treatment mulching with non-woven jute mulch of 450 gsm recorded highest plant height during 2023 at 60 DAP and was statistically at par with the treatment mulching with non-woven jute mulch of 250 gsm, polythene mulch of 25 micron, polythene mulch of 50 micron and straw mulch @ 4.05 t/ha. The control plot recorded the lowest plant height at 60 DAP in 2023. The no. of leaves/plant at 60 DAP did not vary significantly in the year 2022. The highest no. of leaves/plant was recorded by the treatment mulching with non-woven jute mulch of 450 gsm and the lowest by control plot. During the year 2023, mulching with non-woven jute mulch of 450 gsm recorded highest no. of leaves/plant and was statistically at par with the treatments mulching with non-woven jute mulch of 250 gsm and polythene mulch of 50 micron. Also, control plot recorded lowest no. of leaves/plant in the year 2023 at 60 DAP. Leaf area (cm^2)/plant at 60 DAP varied significantly during both the years. The highest leaf area (cm^2)/plant was recorded by the treatment

mulching with non-woven jute mulch of 450gsm followed by polythene mulch of 50 micron and non-woven jute mulch of 250 gsm during both the years. Mulching with non-woven jute mulch of 450gsm recorded 15.96 and 29.16% higher leaf area (cm²)/plant during the year 2022 and 2023, respectively. Also, control plot during the year 2023 recorded lowest leaf area (cm²)/plant (Table 1). Manna *et al.* (2018) found that highest average number of leaves, height of plant and curd weight of broccoli was recorded in the treatment with 350 gsm non-woven jute agro-textile mulch. The advantageous effects of improved moisture conservation, elevated organic carbon and nutrient status, and high weed control efficiency may account for the biodegradable 350gsm non-woven jute agro-textile treatment superiority over other non-woven jute agro-textile treatment thicknesses, rice straw, polythene mulch, or no mulch in the experiment. Saha *et al.* (2006) also reported similar result in high value crops like capsicum and pointed gourd in geo-textile mulched treatment plot compared to control plot.

Curd yield of broccoli

The yield of broccoli was significantly ($p \leq 0.05$) influenced by the different mulch method treatments during both the years (Table 2). The highest curd diameter (cm) was recorded by mulching with non-woven jute mulch of 450 gsm and was statistically at par with non-woven jute mulch of 250 gsm and straw mulch @4.05 t/ha during the year 2022. During the year 2023, mulching with non-woven jute mulch

of 450 gsm recorded maximum curd diameter and was statistically at par with mulching with non-woven jute mulch of 250 gsm. Control plot recorded minimum curd diameter during both the years. An increase of 30.37%, 24.65% and 22.18% was recorded by mulching with non-woven jute mulch of 450 gsm, non-woven jute mulch of 250 gsm and straw mulch @4.05 t/ha over control plot treatments in the year 2022. In addition, 35.05%, 33.36% and 26.31% increase in curd diameter was recorded by mulching with non-woven jute mulch of 450 gsm, non-woven jute mulch of 250 gsm and polythene mulch of 50 micron over control plot in 2023. The highest curd fresh weight (g) during both the years was recorded by mulching with non-woven jute mulch of 450 gsm and was statistically at par with mulching with non-woven jute mulch of 250 gsm. The above mulch treatments were also statistically at par with the polythene mulch of 25 micron and polythene mulch of 50 micron during 2023. The lowest curd fresh weight (g) of broccoli was recorded by control plot during both the years. The treatment mulching with non-woven jute mulch of 450 gsm and non-woven jute mulch of 250 gsm recorded 46.18% and 38.40% increase in curd fresh weight (g) during the year 2022 and 44.68% and 42.52% in the year 2023 over control plot treatment. Subba (2015) and Manna *et al.* (2018) opined that when it came to boosting broccoli productivity, controlling weeds, and improving moisture and nutrient availability, nonwoven jute agro-textile mulch outperformed rice straw and polythene mulches. Helaly *et al.*

Table 1: Effect of treatments on growth attributes of broccoli and total weed density and dry weight at 60 DAP

Treatments	Plant height (cm) at 60 DAP		No. of leaves/ plant at 60 DAP		Leaf area (cm ²)/plant at 60 DAP		Total weed density (No./m ²) at 60 DAP		Total weed dry wt. (g/m ²) at 60 DAP	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T ₁	57.4	59.0	13.5	14.9	5093.8	3887.7	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
T ₂	62.0	59.2	13.7	15.0	5536.5	4137.8	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)	0.71 (0.0)
T ₃	56.4	56.1	13.4	13.4	4907.4	3758.9	2.25 (4.56)	2.68 (6.67)	3.14 (9.40)	3.44 (11.30)
T ₄	57.3	57.0	13.5	13.1	5068.9	3794.4	1.56 (1.95)	1.77 (2.65)	1.90 (3.13)	2.11 (3.96)
T ₅	57.3	58.6	13.1	14.1	4911.1	3846.8	1.27 (1.12)	1.05 (0.61)	1.74 (2.53)	1.39 (1.42)
T ₆	56.4	57.9	13.3	14.4	5186.2	4002.2	0.71 (0.00)	0.71 (0.00)	0.71 (0.0)	0.71 (0.0)
T ₇	56.4	53.1	12.5	12.8	4774.3	3203.4	6.60 (43.12)	7.60 (57.32)	11.26 (126.43)	12.64 (159.17)
SEm±	1.53	0.90	0.39	0.26	33.64	16.3	0.05	0.06	0.15	0.17
CD(P=0.05)	4.23	2.52	NS	0.73	94.2	45.2	0.14	0.18	0.43	0.49

T₁: Jute non-woven mulch (250 gsm); T₂: Jute non-woven mulch (450 gsm); T₃: Straw mulch @ 3.5 t/ha; T₄: Straw mulch @ 4.0 t/ha; T₅: Polythene mulch (25 micron); T₆: Polythene mulch (50 micron); T₇: Control- No mulch.

Table 2: Effect of treatments on stalk height, curd diameter and curd weight of broccoli

Treatments	Stalk height (cm)		Curd diameter (cm)		Curd fresh weight (g)	
	2022	2023	2022	2023	2022	2023
T ₁ : Jute non-woven mulch (250 gsm)	21.79	20.12	12.64	12.67	426.7	423.3
T ₂ : Jute non-woven mulch (450 gsm)	21.21	22.31	13.22	12.83	450.7	429.7
T ₃ : Straw mulch @ 3.5 t/ha	21.75	20.67	11.81	11.67	394.4	352.0
T ₄ : Straw mulch @ 4.0 t/ha	21.42	20.24	12.39	11.83	398.4	355.0
T ₅ : Polythene mulch (25 micron)	21.94	21.34	11.42	11.83	376.8	384.0
T ₆ : Polythene mulch (50 micron)	22.33	21.64	11.56	12.00	380.5	394.0
T ₇ : Control- No mulch	20.94	19.87	10.14	9.50	308.3	297.0
SEm±	0.71	0.68	0.49	0.25	16.02	16.6
CD (P=0.05)	NS	NS	1.37	0.72	44.85	46.5

(2017) delineated that mulching minimizes crop weed competition and retains soil moisture and temperature below the surface, which ultimately encourages early plant growth and horticultural maturity in vegetables. Manna *et al.* (2022) also reported significantly higher productivity of broccoli over rice straw and black polythene mulch. High porosity, high permeability, high carbon to nitrogen (C/N) ratio, high water absorbing power (~ 500%), and an environmentally friendly, biodegradable material composed of 83% cellulose, 12.5% lignin, 1.1% fat and wax, and 1.8% nitrogenous matter are some of non-woven jute agro-textile mulch characteristics that may be the likely cause of its superior efficacy when compared to other materials. Additionally, a greater production and growth of broccoli were observed in the non-woven jute agro-textile mulch-treated plot compared to others due to favourable soil environmental conditions, such as appropriate temperature, humidity, and aeration for microorganisms and plant roots.

Economics of broccoli as influenced by different treatments

In both the years, the cost of cultivation (₹/ha) was recorded highest in mulching with non-woven jute mulch of 450 gsm, and was followed by non-woven jute mulch of 250 gsm and the least in control plot (Table 3 and 4). Among the different mulching treatments, the highest gross return (₹/ha) was fetched by the treatments mulching with non-woven jute mulch of 450 gsm, and non-woven jute mulch of 250 gsm during both the years. The lowest gross return was recorded by control plot during both the years. The highest net return and return per rupee

invested was recorded in case of mulching with polythene mulch of 25 micron and was followed by mulching with polythene mulch of 50 micron. Net return was found lower in control plot treatment. The treatments mulching with non-woven jute mulch of 450 gsm and non-woven jute mulch of 250 gsm fetched lowest return per rupee invested among various mulching treatments. Mulch improved the cauliflower crops' output and yield characteristics (Salim *et al.* 2008). Organic mulch materials are mostly used in field conditions as it can increase the overall performance of crop plants and also brings improvement in soil conditions. However, Jute non-woven mulches could potentially minimize water runoff, improve infiltration capacity of soil, prevent weed population and perform as hindrance in evapotranspiration and has also some other positive environmental effects such as temperature regulation of soil, minimum nutrient losses, slow down soil erosion and improved physical conditions of soil.

Efficacy of the jute non-woven mulching treatments over others

The results of the field study indicated that non-woven jute mulch of 450 gsm, and non-woven jute mulch of 250 gsm was superior compared to rice straw and polythene mulches in increasing yield and growth of broccoli, suppressing weeds, increasing moisture and available N, P and K contents and microbial population of the lateritic soil. The characteristics of non-woven jute mulch of 450 gsm, and non-woven jute mulch of 250 gsm like high porosity, high permeability, high carbon to nitrogen (C/N) ratio, high water absorbing power

Table 3: Economics of broccoli cultivation under different treatments in 2022

Treatments	Cost of cultivation (₹/ha)	Gross Return (₹/ha)	Net Return (₹/ha)	Return per rupee invested
T ₁	614500	1650000	1035500	2.69
T ₂	814500	1650000	835500	2.03
T ₃	167000	1210000	1043000	7.25
T ₄	174500	1210000	1035500	6.93
T ₅	164500	1320000	1155500	8.02
T ₆	174500	1320000	1145500	7.56
T ₇	114500	888000	773500	7.76

T₁: Jute non-woven mulch (250 gsm); T₂: Jute non-woven mulch (450 gsm); T₃: Straw mulch @ 3.5 t/ha; T₄: Straw mulch @ 4.0 t/ha; T₅: Polythene mulch (25 micron); T₆: Polythene mulch (50 micron); T₇: Control- No mulch.

Table 4: Economics of broccoli cultivation under different treatments in 2023

Treatments	Cost of cultivation (₹/ha)	Gross Return (₹/ha)	Net Return (₹/ha)	Return per rupee invested
T ₁	625950	1650000	1024050	2.64
T ₂	825950	1650000	824050	2.00
T ₃	183700	1210000	1026300	6.59
T ₄	191950	1210000	1018050	6.30
T ₅	180950	1320000	1139050	7.29
T ₆	191950	1320000	1128050	6.88
T ₇	125950	888000	762050	7.05

T₁: Jute non-woven mulch (250 gsm); T₂: Jute non-woven mulch (450 gsm); T₃: Straw mulch @ 3.5 t/ha; T₄: Straw mulch @ 4.0 t/ha; T₅: Polythene mulch (25 micron); T₆: Polythene mulch (50 micron); T₇: Control- No mulch.

(~ 500%) and eco-friendly, biodegradable material made up of 83% cellulose, 12.5% lignin, 1.1% fat and wax and 1.8% nitrogenous matter might be the probable reason for showing the higher efficacy compared to others. Besides, due to favourable soil environmental condition like suitable temperature, humidity and aeration for microbes in non-woven jute mulch of 450 gsm, and non-woven jute mulch of 250 gsm treated plot over others, higher yield and growth of broccoli was recorded. Consequently, enhancement of soil health by increasing organic C, available nutrient content and microbial population of post-harvest soil was also revealed in non-woven jute mulch treated plots of 450 gsm, and non-woven jute mulch of 250 gsm. Similar opinion was also reported by Subba (2015).

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