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Hijam Anju Devi
M.Sc. Research Scholar,
Department of Horticulture, Naini
Agricultural Institute, Sam
Higginbottom University of
Agriculture, Technology and
Sciences, Prayagraj, Uttar
Pradesh, India

Dr. Vijay Bahadur
Professor and HOD, Department
of Horticulture, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Dr. Annjoe V Joseph
Assistant Professor, Department of
Horticulture, Naini Agricultural
Institute, Sam Higginbottom
University of Agriculture,
Technology and Sciences,
Prayagraj, Uttar Pradesh, India

Corresponding Author:
Hijam Anju Devi
M.Sc. Research Scholar,
Department of Horticulture, Naini
Agricultural Institute, Sam
Higginbottom University of
Agriculture, Technology and
Sciences, Prayagraj, Uttar
Pradesh, India

Effect of mulching on plant growth, yield and quality of French bean (*Phaseolus vulgaris*)

Hijam Anju Devi, Vijay Bahadur and Annjoe V Joseph

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Abstract

An experiment titled “Effect of Mulching on Plant Growth, Yield and Quality of French bean (*Phaseolus vulgaris* L.) cv. Arka Suvidha” was carried out from October 2024 to January 2025 at the Central Horticulture Research Farm, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P), India. The experiment was laid out in Randomized Block Design with three replications. The findings of the study indicated the use of various mulching materials namely T₀ (control), T₁ (Paddy straw mulch), T₂ (Rice husk mulch), T₃ (Newspaper mulch), T₄ (Dry leaves mulch), T₅ (Banana leaves mulch), T₆ (Black plastic mulch), and T₇ (Transparent plastic mulch), which influenced the growth and productivity of French bean. Among the treatments, Black plastic mulch (Treatment T₆) proved to be the most effective, resulting in superior outcomes such as earlier seed germination (3.67 DAS), increased plant height at 30DAS(33.6 cm), 60DAS(42.8 cm), and 90DAS (51.2 cm), plant spread at 30DAS (31.1), 60DAS(41.8), and 90DAS (48.7), Number of leaves/plant at 30DAS (30.2), 60DAS (60) and 90DAS (87.7), pod weight (9.33g), pod length (11.91cm), pod diameter (1.48cm), and maximum no. of pods and pod yield/ha(15 t). Similarly with the economic point of view, treatment black plastic mulch resulted in maximum benefit cost ratio (3.5).

Keywords: Mulching, French bean, growth, yield and quality, black plastic mulch

1. Introduction

French bean (*Phaseolus vulgaris* L., 2n = 22), a native crop of Central and South America (Swalder *et al.*, 1992) ^[17], ranks among the oldest cultivated plants in the world. It is a leguminosae family. French bean thrives in warm climates and is sensitive to frost. Optimal growth and yield occur at an average temperature of 20-25°C. While high temperatures hinder pod development, colder conditions are not conducive to healthy vegetative growth. According to Vavilov (1950) ^[20], the crop originated in southern Mexico and Central America.

The crop is extensively grown in tropical, subtropical, and temperate climates. In India, it is mainly cultivated during the kharif season in the northern hill regions of Jammu & Kashmir, Himachal Pradesh, and Uttarakhand. It is also grown in Maharashtra, Andhra Pradesh, the Western and Eastern Ghats, and the North-Eastern Plains. In areas with mild, frost-free winters, French bean is also raised during the rabi season (Jyothi, 2017) ^[9]. French bean is nutritionally valuable, providing proteins, carbohydrates, fats, and minerals. It also contains essential vitamins like vitamin A, thiamine, riboflavin, vitamin C, and niacin (Sardana *et al.*, 2000) ^[14]. French beans are typically grown in open field conditions, which often expose the crop to erratic and extreme weather events, adversely affecting yield and quality. However, modern agricultural techniques involving controlled or semi-controlled environments have shown promise in enhancing yield and quality compared to traditional field cultivation.

Mulching is a beneficial agronomic practice that enhances soil moisture retention, improves soil structure and biological activity, and enriches soil fertility. It also helps in controlling weeds and reducing erosion. Plastic mulch combined with drip fertigation has emerged as an effective water management method, conserving soil moisture by reducing surface evaporation and thereby improving transpiration and crop yield (Agele *et al.*, 2002) ^[2]. Mulching contributes significantly to soil health by improving soil conditions, boosting microbial activity, enhancing oxygen levels around roots, regulating soil temperature, and improving porosity and water

infiltration. It also increases nutrient availability, reduces water loss through evaporation, prevents fertilizer leaching and compaction, and helps control weeds, runoff, and erosion—ultimately leading to better plant growth, yield, and quality.

2. Materials and Methods

The present investigation entitled “Effect of mulching on Plant Growth, Yield and Quality of French bean (*Phaseolus vulgaris*) var. Arka Suvidha” in Prayagraj agro climatic conditions was conducted to identify the most suitable mulching material in terms of growth, yield, and quality of French bean. The experiment was carried out from October 2024 to January 2025 at the Horticultural Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj.

The experiment was laid out in Randomized Block Design (RBD) with three replications. The experimental plot size was 2.4m x 2m with a spacing of 60 cm x 15 cm performed on eight different mulching treatments. Observations were recorded on five random selected plants and data collected were analyzed by using ANOVA.

Table 1: Details of treatments

Notation	Treatments
T ₀	No mulch (control)
T ₁	Paddy straw mulch
T ₂	Rice husk mulch
T ₃	Newspaper mulch
T ₄	Dry leaves mulch
T ₅	Banana leaves mulch
T ₆	Black plastic mulch
T ₇	Transparent plastic mulch

3. Results and Discussion

3.1 Growth parameters

The data under various treatment combinations are presented in Table 2 which are statistically analyzed. The minimum days to germination was recorded in T₆ (3.67 days) the maximum germination period was observed in T₀ (4.53 days). The use of black mulch appeared to enhance seedling establishment by controlling the soil temperature, conserving soil moisture. These findings are consistent with those of Suresh *et al.* (2013) [16]; Tang *et al.* (2020) [18]. The minimum time to 50% flowering was recorded in T₂ (41 days) and the maximum time to 50% flowering was T₀ (46.7 days). Previous studies have also reported similar findings, where the use of mulches led to 50% flower initiation and enhanced flower production, Suresh *et al.* (2013) [16]; (Das *et al.* 2023) [7]. The earliest first picking was recorded in T₆ (54.53 days) while the maximum duration to first picking was observed

in T₀ (62.33 days). These observations are supported by finding from Chauhan *et al.* (2023) [6]. The maximum plant height was observed in the plot mulched with T₆ at 90 DAS (51.2 cm) whereas the minimum plant height were recorded in T₀ at 90 DAS (43.5 cm), where no mulch was applied. Mulching promotes plant height due to its ability to modify the soil microclimate. Similar positive impacts have been reported by Abd El-Rahman *et al.* (2018) [1]; Ramesh *et al.* (2021) [12]; Das *et al.* (2023) [7]; Ramadhani *et al.* (2024) [11]. The maximum plant spread (SN:EW) was observed in the plot mulched with T₆ at 90 DAS (48.7 cm) whereas minimum plant spread was recorded in the T₀ at 90 DAS (41.8 cm). The reflective nature of plastic mulch improves light interception at the canopy level, which supports greater lateral development. The results are consistent with previous studies by Ramdhani *et al.* (2024). The maximum number of leaves per plant was observed in plots mulched with T₆ at 90 DAS (87.7) and the minimum number of leaves per plant was recorded in T₀ at 90 DAS (70.6). The significantly lower leaf count in the control plot (no mulch) can be explained by increased moisture loss, higher weed pressure, and greater soil temperature variation. These findings align with the reports of Abd El-Rahman *et al.* (2018) [1]; Das *et al.* (2023) [7].

3.2 Yield parameters

The data on pod weight (g) of French bean as influenced by various mulch treatments are presented in Table 3 and statistical analysis showed that the observed differences were statistically significant. The maximum pod weight was observed in T₆ (9.33 g) and the minimum pod weight was recorded in T₀ (6.30 g). The observed increase in pod weight under mulch treatments is in agreement with the findings of Abd El-Rahman *et al.* (2018) [1]; Maida *et al.* (2020) [10]. The maximum pod length was recorded in mulched plot T₆ (11.91 cm) whereas the minimum pod length was observed in T₀ (10.17 cm). The length of the pod in French bean also reported by Kamal *et al.* (2010) [15]; Sahariar *et al.* (2015) [13]. The maximum pod diameter was recorded in mulched plot T₆ (1.48 cm) whereas the minimum pod diameter was observed in T₀ (0.78 cm). The beneficial effect of mulch on pod diameter is supported by the findings of Kamal *et al.* (2010) [15]; Sahariar *et al.* (2015) [13]. The maximum number of pods per plant was observed in T₆ (15.3) whereas the minimum number of pods per plant was recorded in T₀ (10.1). The findings aligns with that of Kamal *et al.* (2010) [15]; Sahariar *et al.* (2015) [13]; Ramesh *et al.* (2021) [12]. The maximum pod yield was recorded in mulched plot of T₆ (142 g) whereas the minimum yield (6 t/ha) was observed in the control T₀ (63 g). The maximum pod yield was recorded in mulched plot of T₆ (15.8 t/ha) whereas the minimum yield was observed in the control T₀ (7 t/ha). The results are consistent with the findings of Alam *et al.* (1989); Sahariar *et al.* (2015) [13].

Table 2: Effect of different mulching on growth parameters of French bean

Sl. No.	Symbol	Treatments	Days to germination	Days to 50% flowering	Days to 1 st picking	Plant height (cm)			Plant spread (cm) (SN: EW)			No. of leaves/plant		
						30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
1.	T ₀	No mulch (control)	4.53	46.7	62.3	24.5	34.8	43.5	261.9	36.8	41.8	18.7	44.6	70.6
2.	T ₁	Paddy straw mulch	3.73	43.1	56.8	27.1	37.8	45.8	28.0	39.0	43.4	26.7	54.6	79.9
3.	T ₂	Rice husk mulch	3.80	41.0	55.23	32.9	42.6	50.8	30.1	40.4	46.1	27.1	58.8	86.6
4.	T ₃	Newspaper mulch	3.93	46.7	57.2	32.1	42.2	50.3	29.8	39.5	44.2	28.8	50	80.0
5.	T ₄	Dry leaves mulch	4.00	45.5	58.5	30.7	40.2	48.4	27.6	37.7	42.7	25.0	48.8	77.4
6.	T ₅	Banana leaves mulch	4.07	42.2	56.6	31.3	41.9	49.0	29.8	39.6	45.5	27.2	57.8	84.4
7.	T ₆	Black plastic mulch	3.67	42.5	54.53	33.6	42.8	51.2	31.1	41.8	48.7	30.2	60	87.7
8.	T ₇	Transparent plastic mulch	3.73	45.8	57.7	30.8	40.0	49.4	29.6	39.1	45.5	23.8	55.4	80.7
F test			S	S	S	S	S	S	S	S	S	2.99	5.42	4.30
SE.d (+)			0.1	0.573	0.904	2.06	1.19	1.56	0.66	1.307	1.75	2.76	11.63	9.23
C.D(0.05)			0.3	1.229	1.940	4.43	2.56	3.35	1.42	2.804	3.77	14.00	12.36	6.51
C.V.			5.3	1.591	1.931	8.34	3.63	3.94	2.78	4.082	4.81	2.99	5.42	4.30

Table 3: Effect of different mulching on yield parameters of French bean

Sl.no.	Symbol	Treatments	Pod weight (g)	Pod length (cm)	Pod diameter (cm)	No. of pods/plant	Pod yield/plant (g)	Pod yield/hectare (t)
1.	T ₀	No mulch (control)	62.3	10.17	0.8	10.1	63.3	7.0
2.	T ₁	Paddy straw mulch	56.8	11.90	1.0	14.7	127.3	14.1
3.	T ₂	Rice husk mulch	55.23	11.61	1.2	15.0	138.0	14.5
4.	T ₃	Newspaper mulch	57.2	10.99	0.9	14.2	120.3	13.3
5.	T ₄	Dry leaves mulch	58.5	10.79	0.8	11.7	82.3	9.2
6.	T ₅	Banana leaves mulch	56.6	11.31	0.9	13.0	106.0	11.7
7.	T ₆	Black plastic mulch	54.53	12.08	1.5	15.3	142.0	15.8
8.	T ₇	Transparent plastic mulch	57.7	10.81	1.0	14.0	121.7	13.1
F test			S	S	S	S	S	S
SE.d (+)			0.534	0.39	0.13	0.28	8.53	0.85
C.D(0.05)			1.146	0.84	0.28	0.61	18.30	1.83
C.V.			7.974	4.31	16.04	2.58	9.28	8.40

3.3 Quality parameters

Total Soluble Solids (°Brix)

The data on TSS (°Brix) following the application of different treatment combinations are presented in Table 4 and statistical analysis indicated that the observed differences were statistically significant. The significantly highest TSS content was observed in T₂ (6.17°Brix) followed by T₁ (5.63°Brix), while the lowest was recorded in T₀ (5.07°Brix). Das *et al.* (2023) ^[7]; Abd El-Rahman *et al.* (2018) ^[1].

Table 4: Effect of different mulching on quality of French bean

Sl.no.	Symbol	Treatments	Total Soluble Solid (°Brix)
1.	T ₀	No mulch (control)	5.07
2.	T ₁	Paddy straw mulch	5.63
3.	T ₂	Rice husk mulch	6.17
4.	T ₃	Newspaper mulch	5.43
5.	T ₄	Dry leaves mulch	5.23
6.	T ₅	Banana leaves mulch	5.50
7.	T ₆	Black plastic mulch	5.17
8.	T ₇	Transparent plastic mulch	5.20
F test			S
SE.d (+)			0.052
C.D(0.05)			0.112
C.V.			1.181

3.4 Soil parameters

The data on different soil parameters after harvesting of different treatment combinations are presented in Table 5 and statistical analysis showed that the observed differences were statistically non-significant. The maximum soil pH was observed in T₀ (7.57) while the minimum was recorded in T₁ (7.22). The data support the conclusions of earlier studies Billeaud *et al.* (1989) ^[4]; Broschat, T.K. (2007) ^[5]; Alharbi A. (2017) ^[3]. The maximum soil organic carbon content was observed in T₄ (0.49) and the minimum was recorded in T₀ (0.39). These findings are consistent with those of Das *et al.* (2017) ^[8]; Tejada *et al.* (2007) ^[19]. The data on soil nutrient content (available NPK) before sowing and after harvesting showed that the maximum retention of available NPK before sowing was observed in N-T₂ (294 kg/ha):P- T₂(24.8 kg/ha): K-T₇(190.3 kg/ha) while the minimum was recorded in N-T₇ (270.5 kg/ha): P-T₀(12.5 kg/ha):K-T₂(154.6 kg/ha). The maximum retention of available NPK after harvesting was observed in N-T₅ (215.2 kg/ha):P- T₅(24.2 kg/ha): K-T₅(174.8 kg/ha) while the minimum was recorded in N-T₀ (198 kg/ha): P-T₀(10 kg/ha):K-T₀(134.7 kg/ha). Overall mulch has a positive effect on soil nutrient these findings align with previous research of Alharbi A. (2017) ^[3]; Das *et al.* (2017) ^[8]; Ayyar (2018); Ramesh *et al.* (2021) ^[12].

Table 5: Effect of different mulching on soil fertility of French bean

Sl.no.	Symbol	Treatments	Soil pH	Soil organic carbon(%)	Soil NPK (kg/ha) (before sowing)			Soil NPK (kg/ha) (after harvesting)		
					Soil N	Soil P	Soil K	Soil N	Soil P	Soil K
1.	T ₀	No mulch (control)	7.57	0.39	275.7	12.5	160.2	198.0	10.0	134.7
2.	T ₁	Paddy straw mulch	7.22	0.48	286.8	19.8	167.3	204.6	20.3	170.5
3.	T ₂	Rice husk mulch	7.36	0.46	294.0	24.8	154.6	201.1	18.2	158.2
4.	T ₃	Newspaper mulch	7.43	0.44	271.8	15.7	177.3	205.3	16.9	173.5
5.	T ₄	Dry leaves mulch	7.31	0.49	278.8	22.7	184	210.6	19.0	165.5
6.	T ₅	Banana leaves mulch	7.29	0.47	290.4	14.2	174.3	215.2	24.2	174.8
7.	T ₆	Black plastic mulch	7.42	0.43	288.3	21.9	179.6	189.7	15.5	152.6
8.	T ₇	Transparent plastic mulch	7.51	0.42	270.5	18.2	190.3	197.9	14.3	145.5
F test			NS	NS	NS	S	NS	NS	S	S
SE.d (±)			0.311	0.033	11.38	1.36	9.40	8.080	1.38	8.58
C.D(0.05)			0.667	0.0724	24.41	2.93	20.17	17.329	2.95	18.40
C.V.			5.160	9.270	4.94	8.93	6.63	4.88	9.74	6.59

3.5 Effect of different mulching on economics of French bean

The economic analysis of French bean was carried out for three months, presented in Table 6, showed that the maximum Cost of Cultivation (Rs. 135284), Gross return (Rs. 474000), Net return

(Rs. 338716), and Benefit Cost ratio (3.5) was observed in Black plastic mulch and minimum Cost of Cultivation (Rs. 115284), Gross return (Rs. 210000), Net return (Rs. 94752), and Benefit Cost ratio (1.8) in no mulch.

Table 6: Effect of different mulching on economics of French bean

Symbol	Treatments	Total cost of cultivation (INR/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit cost ratio
T ₀	No mulch (control)	115284	210000	94752	1.8
T ₁	Paddy straw mulch	124784	420000	295216	3.36
T ₂	Rice husk mulch	126484	435000	334166	3.43
T ₃	Newspaper mulch	123784	399000	275216	3.2
T ₄	Dry leaves mulch	116784	276000	159216	2.3
T ₅	Banana leaves mulch	124784	351000	226216	2.8
T ₆	Black plastic mulch	135284	474000	338716	3.5
T ₇	Transparent plastic mulch	130784	393000	262252	3.0

Conclusion

Based on the present investigation, it is concluded that the cultivation of French bean with different mulching materials found as the best option for higher productivity in which the treatment T₆ (Black plastic mulch) showed the best results in terms of growth, yield, quality and B:C ratio followed by treatment T₂ (Rice husk mulch).

Hence, the treatment T₆ (Black plastic mulch) was best suited for the farmers in terms of growth, yield, quality and net returns.

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