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EFFECT OF MULCHING ON THE GROWTH DYNAMICS AND WEED MANAGEMENT IN CLUSTER BEAN (*Cyamopsis tetragonoloba* L.)

Ram Swaroop Choudhary[1]*, Santosh Pandey[1], Surendra Kumar Meena[2], Ajay Kumar Yadav[3], Jatin[3], Deepika Yadav[3] and Rounaque Parween[4]

[1]Department of Agronomy, Institute of Agricultural Sciences, Bundelkhand University, Jhansi, Uttar Pradesh, India
[2]Directorate of Wheat Development, GOI, MA&FW, DA&FW, Gurugram-122015, Haryana, India
[3]Sri Karan Narendra Agriculture University, Jobner-303329, Rajasthan, India
[4]Chandra Shekhar Azad University of Agriculture & Technology, Kanpur–208002 (U.P.) India
*Corresponding author E-mail: ramswaroopchoudhary68@gmail.com
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ABSTRACT

Effective weed management is essential for minimizing crop–weed competition and enhancing productivity under semi-arid conditions. Mechanical weeding and mulching not only suppress weed growth but also improve soil microclimate, thereby positively influencing crop growth and yield. Keeping this in view, the present study was undertaken to evaluate the effect of different mulch-based and mechanical weed management practices on weed dynamics, crop growth and yield of cluster bean (*Cyamopsis tetragonoloba* L.). A field experiment was conducted during *Kharif* 2022 comprising ten treatments, including organic mulches (paddy and soybean straw), inorganic mulches (black and white polythene, 50 μ), their combinations, two hand weedings (15 and 30 DAS) and a weedy check. The experiment was laid out in a randomized block design with three replications. Observations on weed density, weed dry matter, growth parameters, yield attributes and yield were recorded and statistically analyzed. Two hand weedings significantly reduced weed density and weed dry matter at all growth stages and recorded the highest plant population (2.92 lakh ha^{-1}), dry matter accumulation (22.07 kg ha^{-1}), branches per plant (9.09), plant height (107.50 cm) and grain yield (1298.66 kg ha^{-1}). Black polythene mulch (50 μ) ranked next and remained statistically at par with hand weeding for several parameters. In contrast, the weedy check recorded maximum weed infestation and the lowest yield (305.67 kg ha^{-1}). The study concludes that timely mechanical weeding or black polythene mulch effectively enhances crop productivity by reducing weed competition and improving growth conditions.
***Keywords* :** *Cyamopsis tetragonoloba*, Mulching, Plant growth, Hand weeding.

Introduction

Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.], commonly known as guar, is considered one of the key commercial crops cultivated in arid and semi-arid regions. Its ability to withstand drought is attributed to a well-developed taproot system and a strong capacity for recovery under water stress conditions. Traditionally, the pods are consumed as a vegetable, while the seeds and haulms serve as valuable sources of nutritious feed and fodder for livestock. In addition, cluster bean is often grown as a green manure and cover crop. Though predominantly cultivated during the rainy season, it can also be successfully grown in the summer under irrigated conditions. As a legume, it contributes to soil fertility by fixing atmospheric nitrogen (Mezgebe *et al.*, 2022).

Cluster bean is predominantly cultivated in marginal and rainfed regions, where inadequate weed management poses a significant obstacle to realizing its full yield potential. The crop is inherently a weak competitor against weeds and, being sown during the rainy season, it is particularly vulnerable to infestation by weed species such as *Digera arvensis*, *Trianthema portulacastrum*, *Cleome viscosa*, *Dactyloctenium aegyptium*, *Physalis minima*, *Cenchrus echinatus*, *Brachiaria spp.*, *Amaranthus spp.*, *Cyperus spp.*, *Cynodon dactylon,* and *Corchorus olitorius* from the early stages of growth, owing to favourable environmental conditions that support vigorous weed proliferation (Annual Report, 2007). Weed-induced yield losses in cluster bean have been reported to be as high as 53.7% (Saxena *et al.*, 2004).

Typically, farmers rely on a single hand weeding around 25–30 DAS to manage weeds. Hand weeding remains a conventional and effective practice, with manual or mechanical weeding between 15–30 DAS being commonly recommended (Jain *et al.*, 2000; Mishra *et al.*, 2001; Randhawa *et al.*, 2002). However, frequent rainfall during the cropping season often disrupts timely weeding operations, and large-scale manual weeding becomes impractical due to high labour costs and shortages during peak weeding periods. In such situations, the use of appropriate herbicides emerges as a promising alternative, offering both effectiveness and economic feasibility.

Another sustainable approach to weed management is mulching. Mulching suppresses weed emergence while enhancing soil biological activity by improving physical and chemical soil properties. It also helps reduce the dependence on nitrogen fertilizers, moderates soil temperature, and conserves moisture factors that collectively contribute to better crop growth and increased yields. Mulching involves covering the soil around plants with organic or synthetic materials to create a more conducive microenvironment for plant development (Sheoran *et al.* 2008). Organic mulches, such as banana and palm leaves, hay, straw, grass clippings, and compost, gradually enrich the soil with nutrients as they decompose. In contrast, inorganic mulches-like red, white, and black polyethylene sheets-primarily function to reduce soil moisture loss and suppress weeds (Saxena *et al.*, 2004). Polyethylene mulch, widely adopted globally, is favoured for its ability to retain moisture, regulate soil temperature, suppress weeds, and enhance crop yield and quality, all at a relatively low cost. Nevertheless, mulching has certain drawbacks, including higher initial material costs and the need for removal and proper disposal after use.

Materials and Methods

The experiment was conducted during the *kharif* season of 2022 at Karguanji Agricultural Farm, Bundelkhand University, Jhansi, to evaluate the impact of various mulching and weeding treatments on cluster bean (var. RGC-1066). The experiment was laid out in a Randomized Block Design (RBD) with 10 treatments and three replications, comprising a total of 30 plots. The study aimed to evaluate the effect of different weed management strategies, including mulching and hand weeding, on the growth and performance of cluster bean. The ten treatments were as follows: T_1 – two hand weeding at 15 and 30 days after sowing (DAS); T_2 – black polyethylene mulch (50 micron); T_3 – white polyethylene mulch (50 micron); T_4 – paddy straw mulch; T_5 – soybean straw mulch; T_6 – paddy straw mulch + black polyethylene mulch; T_7 – paddy straw mulch + white polyethylene mulch; T_8 – soybean straw mulch + black polyethylene mulch; T_9 – soybean straw mulch + white polyethylene mulch; and T_{10} – control (no mulch or weeding). This design ensured uniform distribution of treatments and minimized experimental error, allowing effective comparison of weed management practices. Crop parameters recorded included plant population (15 DAS and at harvest), plant height (at harvest), dry matter accumulation (20, 40 DAS and harvest), and number of branches per plant (at harvest), using five randomly selected plants per plot for each observation. Analysis of variance as described by Panse and Sukhatme (1985).

Results and Discussion

Weed Parameters

Weed density and Weed Dry Matter

Weed density (narrow-leaved, broad-leaved and total weeds m^{-2}) differed significantly among treatments at 20 DAS, 40 DAS and at harvest (Table 1). At all stages, T_1: Two hand weeding (15 & 30 DAS) recorded the lowest total weed density (4.39, 6.86 and 9.13, respectively), followed by T_2: Black polythene mulch (50 μ) and T_3: White polythene mulch (50 μ), which were statistically at par but significantly superior to other treatments. The highest weed density was consistently observed under T_{10}: Control (12.93, 16.02 and 17.35, respectively). At 20 DAS, two hand weeding reduced total weed density by about 66% over control, while black and white polythene mulch reduced it by about 51%. A similar trend was maintained at 40 DAS and harvest, indicating sustained weed suppression under these treatments. Organic mulches alone (paddy straw and soybean straw) were less effective but significantly superior to control. Combined treatments (straw + polythene) showed intermediate performance. The superiority of hand weeding may be attributed to effective removal of weeds at critical stages of crop–weed competition, whereas polythene mulch acted as a physical barrier, restricting light penetration and suppressing weed emergence.

Weed dry matter (kg ha^{-1}) was significantly influenced by different weed management treatments at 20 DAS, 40 DAS and at harvest (Table 2). At all stages, T_1: Two hand weeding (15 & 30 DAS) recorded the lowest total weed dry matter (169.07, 322.70 and 674.27 kg ha^{-1}, respectively), followed by T_2: Black polythene mulch (50 μ) and T_3: White polythene mulch (50 μ). The highest weed dry matter accumulation was consistently observed under T_{10}: Control (1299.31, 1987.70 and 2951.01 kg ha^{-1}, respectively). At 20 DAS, two hand weeding reduced total weed dry matter by about 86.99% over control, while black polythene mulch reduced it by 82.66%. A similar trend was maintained at 40 DAS, where hand weeding reduced weed biomass by 83.77% compared to control. At harvest, total weed dry matter under hand weeding was reduced by about 77.15% over control, indicating sustained suppression throughout the crop growth period.

Weed density and weed dry matter were significantly influenced by different weed management treatments at 20 DAS, 40 DAS and at harvest (Table 1 and 2). At all growth stages, T_1: Two hand weeding (15 & 30 DAS) recorded the lowest weed density as well as minimum weed dry matter accumulation, followed by T_2: Black polythene mulch (50 μ) and T_3: White polythene mulch (50 μ). The highest weed density and biomass were consistently observed under T_{10}: Control, indicating severe and uninterrupted weed growth throughout the crop period. Two hand weeding reduced total weed density by about 66% at 20 DAS and nearly 47% at harvest over control. Similarly, weed dry matter was drastically reduced under this treatment, with reductions of about 87% at 20 DAS, 84% at 40 DAS and 77% at harvest compared to control. Black polythene mulch also proved highly effective, consistently recording significantly lower weed density and dry matter than other mulching treatments. In contrast, sole organic mulches (paddy straw and soybean straw) were comparatively less effective, though still significantly superior to control. Combined treatments (straw + polythene mulch) showed intermediate performance. The consistent superiority of hand weeding may be attributed to timely and effective removal of weeds at critical stages of crop–weed competition, thereby preventing further weed proliferation and biomass accumulation. Polythene mulch likely acted as a physical barrier, restricting light penetration and suppressing weed germination and growth, which ultimately reduced weed density and dry matter. Lower weed biomass under these treatments reflects reduced competition for essential resources such as nutrients, moisture and light. These findings are in conformity with the reports of Rajak and Prasad (2017), Dheer and Yadav (2021) and Mezgebe *et al.* (2022), who also observed significant reductions in weed density and dry matter under mechanical weeding and plastic mulching treatments. Overall, the results clearly indicate that two hand weedings, followed by black polythene mulch, were most effective in minimizing weed population and biomass, thereby improving overall weed control efficiency throughout the crop growth period.

Crop growth parameters

Crop growth parameters *viz*., plant population at harvest, dry matter accumulation, number of branches per plant and plant height were significantly influenced by different weed management treatments (Table 3 and figure 1). The highest plant population at harvest was recorded under T_1: Two hand weeding (15 & 30 DAS) (2.92 lakh ha^{-1}), which was statistically at par with T_2: Black polythene mulch (50 μ) and T_3: White polythene mulch (50 μ) but significantly superior to control (2.09 lakh ha^{-1}). The higher plant stand under these treatments may be attributed to reduced crop–weed competition, resulting in better plant survival up to harvest. Dry matter accumulation at 40 DAS and at harvest was also significantly higher under two hand weeding (8.08 and 22.07 kg ha^{-1}, respectively), followed by black polythene mulch and white polythene mulch. At harvest, hand weeding recorded about 127% higher dry matter over control (9.69 kg ha^{-1}). The marked increase in biomass under effective weed control treatments indicates improved resource utilization and enhanced photosynthetic activity due to minimal weed interference. Similarly, the maximum number of branches per plant (9.09) and plant height (107.50 cm) were recorded under two hand weeding, which were statistically comparable with black polythene mulch and superior to other treatments. In contrast, control recorded the lowest branches (5.09) and plant height (84.55 cm), reflecting severe competition stress. The improvement in branching (about 78% increase over control) and plant height under weed-free treatments suggests better nutrient uptake, moisture availability and light interception.

Among mulching treatments, black polythene mulch proved more effective than white polythene mulch and straw mulches alone, while combined treatments showed intermediate response. Sole straw mulches were less effective but still significantly superior to control. These results are in conformity with the findings of Yadav and Mundra (2017), Dheer and Yadav (2021) and Mezgebe *et al.* (2022), Choudhary *et al.* (2022), who reported enhanced plant growth attributes under effective mechanical weeding and plastic mulching due to reduced crop–weed competition and improved microclimatic conditions. Overall, the results clearly indicate that two hand weedings followed by black polythene mulch significantly improved crop growth parameters by minimizing weed competition and promoting better vegetative development.

Crop Yield Parameters

Yield attributes and yield were significantly influenced by different weed management treatments (Table 4 and figure 2). The highest number of pods per plant was recorded under T_1: Two hand weeding (15 & 30 DAS) (50.39), which was significantly superior to all other treatments, followed by T_2: Black polythene mulch (50 µ) (42.96) and T_3: White polythene mulch (50 µ) (41.25). Control recorded the lowest number of pods (20.63). The increase in pods per plant under two hand weeding was about 144% over control, indicating effective reduction in crop–weed competition. Test weight did not vary significantly among most weed management treatments, as differences were within the CD value. However, the highest test weight (25.91 g) was observed under two hand weeding, while the lowest was recorded under control (21.53 g), suggesting better grain development under weed-free conditions. Grain yield was markedly higher under two hand weeding (1298.66 kg ha^{-1}), which was statistically at par with black polythene mulch (1182.65 kg ha^{-1}) but significantly superior to other treatments. Compared to control (305.67 kg ha^{-1}), two hand weeding recorded about 325% higher grain yield. Similar trends were observed in haulm yield and biological yield, with maximum values under two hand weeding (2656.95 and 3955.61 kg ha^{-1}, respectively). Harvest index was also significantly influenced by treatments. The highest harvest index was recorded under soybean straw mulch + black polythene mulch (33.69%), which was statistically at par with most treatments except control (29.02%) and paddy straw mulch + black polythene mulch (30.58%). The relatively lower harvest index under control indicates poor partitioning of assimilates towards economic yield due to severe weed competition.

The higher yield and yield attributes under two hand weeding and black polythene mulch can be attributed to effective weed suppression, resulting in better nutrient uptake, improved photosynthetic efficiency and enhanced assimilate partitioning towards reproductive structures. These findings are in agreement with the reports of Yadav and Mundra (2017), Dheer and Yadav (2021) and Mezgebe *et al.* (2022), who also observed significant improvement in yield attributes and grain yield under efficient mechanical weeding and plastic mulching practices. Overall, the results clearly indicate that two hand weedings, followed by black polythene mulch, were most effective in enhancing yield attributes and maximizing grain yield by minimizing crop–weed competition throughout the crop growth period.

Conclusion

The results of the present investigation clearly demonstrate that effective weed management significantly improved weed control, crop growth and yield parameters. Among all treatments, two hand weedings at 15 and 30 DAS proved most effective in reducing weed density and weed dry matter throughout the crop growth period. This treatment also recorded the highest plant population, dry matter accumulation, number of branches, plant height and yield attributes, ultimately resulting in maximum grain, haulm and biological yield. Black polythene mulch was the next best treatment and remained statistically at par with hand weeding for several growth and yield parameters. In contrast, the weedy check recorded the highest weed infestation and the lowest crop performance, highlighting the severe impact of unchecked weed competition. Overall, timely mechanical weeding or the use of black polythene mulch can be recommended as efficient weed management practices for enhancing crop productivity under similar agro-climatic conditions.

Table 1: Effect of mulches on weed density in cluster bean

Treatments	Weed density (No. m^{-2})								
	20 DAS			40 DAS			At harvest		
	Narrow -leaved	Broad -leaved	Total weeds	Narrow -leaved	Broad -leaved	Total weeds	Narrow -leaved	Broad -leaved	Total weeds
T_1 Two hand weeding (15 & 30 DAS)	3.33 (10.63)	2.94 (8.20)	4.39 (18.83)	4.31 (18.12)	5.39 (28.51)	6.86 (46.82)	6.78 (46.00)	6.13 (37.15)	9.13 (83.15)
T_2 Black polythene mulch (50 µ)	4.60 (20.67)	4.33 (18.23)	6.27 (38.90)	5.97 (35.21)	6.35 (39.81)	8.69 (75.02)	7.08 (49.65)	7.16 (50.91)	10.05 (100.57)
T_3 White polythene mulch (50 µ)	4.67 (21.33)	4.40 (18.90)	6.38 (6.38)	6.07 (36.35)	6.36 (39.92)	8.76 (76.27)	7.39 (54.09)	7.53 (56.29)	10.53 (110.38)
T_4 Paddy straw mulch	7.16 (50.71)	6.98 (48.27)	9.97 (40.23)	9.32 (86.38)	8.87 (78.31)	12.85 (164.69)	9.62 (91.98)	9.89 (97.28)	13.77 (189.26)

T_5 Soybean straw mulch	7.33 (53.33)	7.17 (50.90)	10.23 (98.98)	9.55 (90.85)	9.19 (83.95)	13.24 (174.80)	9.88 (97.16)	10.47 (109.30)	14.38 (206.47)
T_6 Paddy straw mulch + Black polythene mulch (50 μ)	5.33 (27.93)	5.10 (25.50)	7.34 (104.23)	6.93 (47.58)	7.28 (52.51)	10.03 (100.09)	7.78 (60.05)	7.88 (61.57)	11.05 (121.62)
T_7 Paddy straw mulch +White polythene mulch (50 μ)	6.10 (36.71)	5.89 (34.27)	8.45 (70.98)	7.94 (62.53)	8.22 (67.23)	11.41 (129.76)	8.69 (74.94)	8.64 (74.21)	12.23 (149.15)
T_8 Soybean straw mulch + Black polythene mulch (50 μ)	5.53 (30.04)	5.30 (27.61)	7.63 (57.65)	7.19 (51.18)	7.38 (53.98)	10.28 (105.16)	7.95 (62.75)	7.96 (62.82)	11.23 (125.57)
T_9 Soybean straw mulch +White polythene mulch (50 μ)	6.29 (39.04)	6.09 (36.61)	8.73 (75.65)	8.19 (66.51)	8.62 (73.76)	11.86 (140.27)	8.81 (77.15)	9.07 (81.91)	12.63 (159.05)
T_{10} Control	9.23 (84.67)	9.09 (82.23)	12.93 (166.90)	12.03 (144.21)	10.61 (112.00)	16.02 (256.21)	11.81 (139.25)	12.73 (161.65)	17.35 (300.90)
S.E. m. (±)	0.105	0.107	0.150	0.137	0.121	0.144	0.208	0.175	0.205
C.D. (P = 0.05)	0.312	0.317	0.446	0.406	0.361	0.427	0.619	0.519	0.609

*Data subjected to $\sqrt{X+0.5}$ transformation and figures in parenthesis are original weed count m^{-2}

Table 2: Effect of mulches on weed dry matter in cluster bean

Treatments	Weed dry matter (kg/ha)								
	20 DAS			40 DAS			At harvest		
	Narrow -leaved	Broad -leaved	Total weeds	Narrow -leaved	Broad -leaved	Total weeds	Narrow -leaved	Broad -leaved	Total weeds
T_1 Two hand weeding (15 & 30 DAS)	72.67	96.40	169.07	133.60	189.10	322.70	347.67	326.60	674.27
T_2 Black polythene mulch (50 μ)	95.76	129.54	225.30	183.62	218.50	402.12	388.00	357.37	745.37
T_3 White polythene mulch (50 μ)	107.94	140.60	248.54	219.20	235.57	454.77	462.33	398.53	860.87
T_4 Paddy straw mulch	176.30	262.27	438.57	406.60	409.23	815.83	788.67	643.40	1432.07
T_5 Soybean straw mulch	187.93	270.33	458.27	439.72	442.60	882.32	834.51	726.87	1561.37
T_6 Paddy straw mulch + Black polythene mulch (50 μ)	125.86	161.40	287.26	240.94	265.30	506.24	517.46	442.57	960.03
T_7 Paddy straw mulch +White polythene mulch (50 μ)	154.33	218.27	372.60	307.07	333.30	640.37	639.95	497.80	1137.75
T_8 Soybean straw mulch + Black polythene mulch (50 μ)	133.92	196.27	330.19	257.80	284.63	542.44	531.81	473.30	1005.11
T_9 Soybean straw mulch + White polythene mulch (50 μ)	158.43	239.30	397.73	346.25	361.93	708.18	703.67	557.30	1260.97
T_{10} Control	530.94	768.37	1299.31	887.91	1099.79	1987.70	1603.55	1347.46	2951.01
S.E. m. (±)	14.63	16.577	22.96	7.58	33.37	34.68	111.89	22.63	110.76
C.D. (P = 0.05)	43.46	49.253	68.22	22.51	99.14	103.05	332.45	67.25	329.080

Table 3: Effect of mulches on plant population, dry matter accumulation, plant height and branches per plant of cluster bean

Treatments	Plant population (lakh/ha)	Dry matter accumulation (kg/ha)		Branches (plant^{-1})	Plant height (cm)
	At harvest	40 DAS	At harvest	At harvest	
T_1 Two hand weeding (15 & 30 DAS)	2.92	8.08	22.07	9.09	107.50
T_2 Black polythene mulch (50 μ)	2.86	7.03	21.52	8.78	102.82
T_3 White polythene mulch (50 μ)	2.81	6.94	20.84	8.46	100.02
T_4 Paddy straw mulch	2.69	5.81	18.88	6.58	91.41
T_5 Soybean straw mulch	2.70	5.70	18.21	6.41	90.08
T_6 Paddy straw mulch + Black polythene mulch (50 μ)	2.64	6.92	20.83	8.40	98.99
T_7 Paddy straw mulch +White polythene mulch (50 μ)	2.74	6.85	20.23	7.09	93.12

T_8 Soybean straw mulch + Black polythene mulch (50 μ)	2.49	6.89	20.31	7.19	95.48
T_9 Soybean straw mulch +White polythene mulch (50 μ)	2.79	6.85	19.10	6.87	92.34
T_{10} Control	2.09	4.04	9.69	5.09	84.55
S.E. m. (±)	0.09	0.22	0.79	0.26	3.95
C.D. (P = 0.05)	0.26	0.66	2.34	0.77	11.75

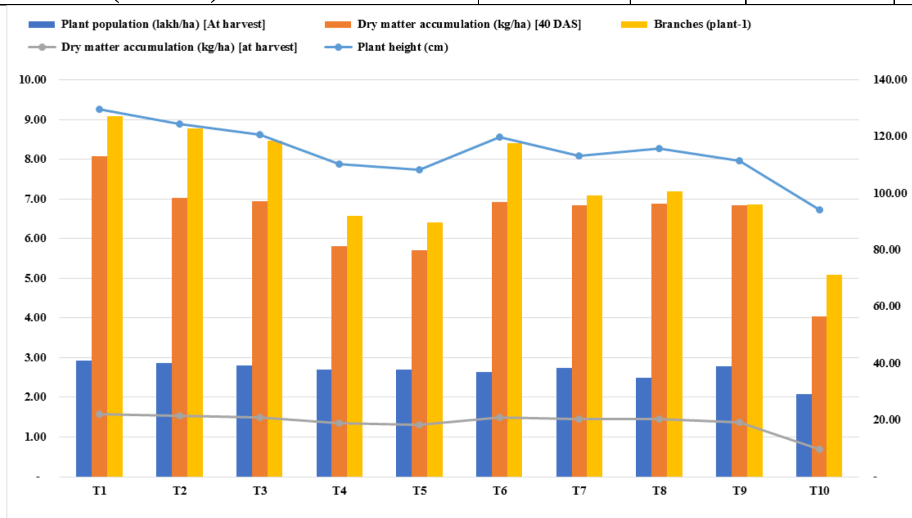

Fig. 1: Effect of mulches on plant population, dry matter accumulation, plant height and branches per plant of cluster bean

Table 4: Effect of mulches on yield parameters of cluster bean

Treatments	No of pods per plant	Test weight (g)	Grain Yield (Kg/ha)	Halum Yield (Kg/ha)	Biological Yield (Kg/ha)	Harvest Index (%)
T_1 Two hand weeding (15 & 30 DAS)	50.39	25.91	1298.66	2656.95	3955.61	32.72
T_2 Black polythene mulch (50 μ)	42.96	25.13	1182.65	2443.52	3626.17	32.44
T_3 White polythene mulch (50 μ)	41.25	24.33	1095.46	2260.03	3355.49	32.29
T_4 Paddy straw mulch	29.13	22.86	989.76	2023.67	3013.43	33.10
T_5 Soybean straw mulch	27.59	22.20	898.37	1881.32	2779.69	33.68
T_6 Paddy straw mulch + Black polythene mulch (50 μ)	39.78	23.89	826.00	1746.33	2572.33	30.58
T_7 Paddy straw mulch +White polythene mulch (50 μ)	34.04	23.34	793.04	1704.94	2497.98	32.19
T_8 Soybean straw mulch + Black polythene mulch (50 μ)	37.62	23.88	679.90	1564.67	2244.57	33.69
T_9 Soybean straw mulch +White polythene mulch (50 μ)	31.87	23.11	665.97	1528.69	2194.66	32.73
T_{10} Control	20.63	21.53	305.67	603.68	909.35	29.02
S.E. m. (±)	0.67	0.65	98.95	200.76	249.38	0.68
C.D. (P = 0.05)	1.93	2.01	294.01	596.49	740.95	1.97

Fig. 2: Effect of mulches on yield parameters of cluster bean

Conflict of Interest: The authors declare no conflict of interest.

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