



Interaction between Different Sowing Methods and Levels of Mulching on *Rainfed* Lentil

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ABSTRACT

Background: To find out the best combination of sowing method and level of mulching for growing *rainfed* lentil.

Methods: The present study was carried out under Institute of Agriculture, Visva-Bharati University, Sriniketan, West Bengal, India from 2018-19 to 2019-20 with four main plots as Spacing (S_1 -20 cm row spacing; S_2 -25 cm row spacing; S_3 -30 cm row spacing and S_4 - Broadcasting (seed rate @ 40 kg ha⁻¹)) and four sub-plot as mulching (M_0 - Without mulching; M_1 -3 t ha⁻¹ straw mulching; M_2 -4 t ha⁻¹ straw mulching and M_3 -5 t ha⁻¹ straw mulching) and replicated *trice* and experimental designed followed was split plot design (SPD).

Result: Broadcasting method is advantageous and found to be superior from the line sowing methods for lentil crop. The treatment combination of broadcasting @ 40 kg ha⁻¹ and 4 t ha⁻¹ straw mulching (M_2) showed highest seed yield (975 kg ha⁻¹) while the lowest seed yield (584 kg ha⁻¹) was recorded in control plot (M_0) with 25 cm row spacing. The crop sown by broadcasting (S_4) achieved the highest gross return (₹ 59,460 ha⁻¹), net return (₹ 39,161 ha⁻¹) and returns per rupee invested (2.93). In contrast, 20 cm row spacing incurred the highest cost of cultivation (₹ 21,022 ha⁻¹). Mulching with straw at 5 t ha⁻¹ incurred the highest cost of cultivation (₹ 21,579 ha⁻¹), while mulching at 4 t ha⁻¹ resulted in the highest gross return (₹ 55,542 ha⁻¹) and net return (₹ 32,076 ha⁻¹). From the research work it was found that the highest seed yield of 975 kg ha⁻¹ recorded in the treatment combination of broadcasting (S_4) and 4 t ha⁻¹ straw mulching (M_2) while the lowest seed yield of 584 kg ha⁻¹ recorded in control plot (M_0) with 25 cm row spacing (S_2).

Key words: Lentil, Mulching, Sowing methods, Spacing.

INTRODUCTION

India has been consistently increasing its food grain production annually and stands among the top producers globally for crops such as wheat, rice, pulses, sugarcane and cotton. Despite significant advancements in overall agricultural production, the growth rate for cereals has outpaced that of pulses over the past five decades in India. Consequently, while India is a leading producer globally, there remains a persistent deficit in pulse production, impacting dietary solutions for its population (Kumar *et al.*, 2018). Pulses constitute a crucial segment of the Indian agricultural economy, following food grains and oilseeds in terms of acreage, production volume and economic significance (Choudhary, 2013).

Pulse plants act as natural fertilizer factories, enriching soil fertility significantly. Their deep-rooted systems allow them to efficiently utilize limited moisture, surpassing many other crops, including cereals and contribute significantly to soil aeration (Srinivasarao, 2015). Even under *rainfed* conditions, pulses offer a favorable benefit-cost ratio and are adaptable in various cropping systems such as intercropping, mixed cropping and crop rotations. They enhance soil chemical and physical properties and their green pods can be consumed as vegetables while also providing nutritious fodder for livestock (Dey *et al.*, 2022). Despite these advantages, India has witnessed a decline in per capita net availability of pulses from 69.0 g day⁻¹ to 47.9 g day⁻¹ falling short of the WHO-recommended 80 g day⁻¹ (Kumar *et al.*, 2018). To combat protein-energy malnutrition, experts recommend ensuring a minimum

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availability of 50 g pulses per capita per day, alongside other protein sources (Pooniya *et al.*, 2015). Lentil is one of the world's oldest crops and stands first in the nutritional values amongst all the pulse crops (Coyne and McGee, 2013). In India, significant portions of land lie fallow after the *kharif* season rice, presenting an opportunity for expanding the cultivation of lentils in these rice fallows (Kumar *et al.*, 2020). Lentils are a key pulse crop cultivated primarily using residual soil moisture and are renowned for their rich protein content. Introducing lentil cultivation in

rice fallow areas with suitable production techniques has the potential to initiate another green revolution in economically disadvantaged regions of the country (Yadav *et al.*, 2017).

Despite India's significant share in global pulse cultivation, there has been a 16% decline in lentil production (Dey *et al.*, 2023), necessitating enhanced research efforts to meet domestic demand. India's projected demand for pulses in 2023-24 is being met by importing 47.38 lakh tonnes of pulses, which is a 90% increase from the previous year. Lentil is typically cultivated as a *rainfed* crop during the *rabi* season, given the lack of rainfall in Indian winters and the financial constraints of small and marginal farmers who cannot afford irrigation. While line sowing has shown better results in field experiments, broadcasting remains popular among Indian farmers. Lentil, particularly during the seedling stage, faces competition from various grasses such as *Cynodon dactylon*, *Cyperus rotundus* and weed species such as *Chenopodium album*, *Vicia sativa* commonly found in agricultural fields (Pala, 2019). So weed control before planting and early in the growing seasons is critical and needs two manual weeding besides the pre emergence application of herbicide. Since it is grown in *rabi* season, less humid environments, the crop is relatively free from major diseases. It has the characteristic of being resistant to drought and of early maturity (Mishra *et al.*, 2018).

Different researches had been conducted in the past and are being conducted presently to resolve the different troubles related to its production techniques. Generally pulse crops are cultivated in rows of wider spacing (30 cm) as most of them having spreading type habit but in case of lentil, there is less number of branches and the length of the branches are small as compared to the other pulse crops. So wider spacing (30 cm) may not be effective in case of lentil. So, line sowing with different spacing distances along with broadcasting method may be tested to find out optimum one. As irrigation resources of West Bengal are very limited, winter crops like lentil is mostly cultivated under *rainfed* situation with the help of conserved residual soil moisture, so to conserve that residual soil moisture different mulching techniques can be adopted along with proper utilization of rice fallow area (Marwein and Ray, 2019). There are different mulching materials like stubble mulching, soil mulching, saw-dust mulching and plastic mulching which are tested in different experiments but among them paddy straw mulching is mostly followed and found to be effective as it is commonly available mulch materials during *rabi* season.

MATERIALS AND METHODS

The field experiment was conducted during *rabi* season at Institute of Agriculture, Visva-Bharati University, Sriniketan, West Bengal, India from 2018-19 to 2019-20. The experiment is arranged in a Split-Plot Design (SPD) comprising four main plots and four sub-plots, replicated three times.

The soil of the experimental field was sandy loam in texture with medium acidic in reaction (pH 5.17), low in salt content (0.30 dsm^{-1}), medium in soil organic carbon (0.47%), low in available nitrogen ($205.82 \text{ kg N ha}^{-1}$), medium in available phosphorus ($42.53 \text{ kg P}_2\text{O}_5 \text{ ha}^{-1}$) and medium in available potassium ($131.42 \text{ kg K}_2\text{O ha}^{-1}$). The weekly average maximum and minimum temperature during the crop season (November to February) ranged from 31.27°C to 24.33°C and 15.85°C to 8.15°C . The total rainfall received throughout the cropping period was about 4.93 mm in 2018-19.

Growth attributes of lentil

Observations on growth attributes like plant height (cm), dry matter, yield, harvest index of lentil were recorded by following scientific methods (Dey *et al.*, 2023). The other observation like consumptive use (CU), consumptive use efficiency (CUE), cost of cultivation, gross Return, net return and benefit cost ratio are also taken.

Statistical analysis

The data obtained from the study were statistically analyzed using a Split Plot Design (SPD) and the Analysis of Variance (ANOVA) technique. Pooled data were generated from the experiment by averaging the data from 2018-19 and 2019-20. The significance of differences between treatment means was tested using an appropriate critical difference (CD) value at a 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Plant height

The results indicated that plant height was significantly influenced by spacing throughout the crop growing season, except at 60 days after sowing (DAS). Plant height gradually increased up to maturity. At 30 DAS, the shortest plant height (15.02 cm) was recorded under 20 cm row spacing (S_1 treatment), while the tallest (15.90 cm) was recorded under broadcasting (S_4 treatment), which was statistically similar to the 20 cm row spacing (S_1) (Table 1).

Further analysis revealed that plant height did not show significant responses to sowing methods during later growth stages. However, at 60 DAS, plant height increased with row spacing (30 cm) method of sowing, possibly higher Plant height may be due to the cause of appropriate aeration, moistness, sunlight, availability of nutrients, weeds control and good conditions of root interception (Ahmadi *et al.*, 2021).

The result showed that the height of the plant with mulching significantly higher as compared to control during entire growth period. At 30 days after sowing (DAS), a significant variation was observed in plant height by various level of mulching (3, 4, 5 t ha^{-1}). The control plot exhibited the lowest plant height (13.325 cm), while the highest plant height was recorded with 5 t ha^{-1} mulching (16.167 cm), followed by 3 t ha^{-1} mulching (15.575 cm). By 60 days after

sowing (DAS), the tallest plants (26.275 cm) were observed in the 5 t ha⁻¹ mulching treatment, followed by 4 t ha⁻¹ mulching (20.95 cm), with the shortest plants in the control plot (22.267 cm). By 90 DAS, the highest plant height (30.538 cm) was again observed in the 5 t ha⁻¹ mulching treatment, while the lowest was in the control plot (25.017 cm). Except at 30 DAS, the highest mulching level (5 t ha⁻¹) showed statistically similar results to the 4 t ha⁻¹ mulching.

These findings suggest that the higher plant heights observed with mulching treatments may be attributed to the moisture retention provided by mulch, supporting the growth and development of the crop compared to the control plot (Devi *et al.*, 2021).

Dry matter accumulation (g m⁻²)

At 60 DAS, the lowest dry matter accumulation (100.05 g m⁻²) was recorded at 20 cm row spacing whereas the broadcasted plots (treatment S₄) recorded the highest (141.49 g m⁻²) dry matter accumulation which was at par with the treatment S₃ (30 cm spacing). However, the data of 90 DAS, depicted that the highest dry matter (201.63 g m⁻²) was observed with broadcasting (treatment S₄) and the lowest value (162.57 g m⁻²) was observed under 20 cm row spacing (treatment S₁) (Table 2).

The highest dry matter production recorded at treatment S₄ (broadcasting) was due to less competition faced by the plants and second highest dry matter production recorded at the treatment S₃ (30 cm row spacing) may be due to the optimum line spacing for the crop. Thus, it is clear that spacing is mandatory for crop growth and accumulation of dry matter in crop plant.

Mulching treatment showed significant effect on dry matter accumulation throughout the growing period where 4t ha⁻¹ straw mulching gave the highest dry matter accumulation over the control plot probably due to the higher moisture conservation in mulched plots which helped in better growth and development. M₃ (5 t ha⁻¹ straw mulching) and M₂ (3 t ha⁻¹ straw mulching) treatment results were statistically at par.

At 60 days after sowing (DAS) and 90 DAS, the 4 t ha⁻¹ straw mulching treatment exhibited the highest dry matter accumulation compared to the control plot. This could be attributed to the enhanced moisture retention in the mulched plots, which facilitated improved growth and development (Sharma *et al.*, 2010).

The interaction effect between sowing methods and mulching was found significant at 60 DAS. At 60 DAS, the highest dry matter accumulation (166.67 g m⁻²) was recorded in treatment combination of broadcasting (S₄) with 4 t ha⁻¹ straw mulching (M₂). The lowest dry matter accumulation (86.09 g m⁻²) was recorded under 20 cm row spacing (S₁) and 4 t ha⁻¹ mulching (M₂) combination (Table 2.1).

Seed yield (kg ha⁻¹)

Spacing significantly influenced the seed yield of lentils. The crop in the broadcasted treatment (S₄) achieved the highest seed yield at 915 kg ha⁻¹, which was statistically

similar to the yields from treatments with 20 cm row spacing and 25 cm row spacing (treatment S₂), producing 677 kg ha⁻¹ (Table 3) (Ngangom *et al.*, 2020).

Similarly, mulching applications also had a significant effect on lentil seed yield. The highest yield of 854 kg ha⁻¹ was obtained from plots with 4 t ha⁻¹ of straw mulching, which was statistically comparable to the yield from plots with 3 t ha⁻¹ of straw mulching. These yields were significantly higher than those from the control treatment (736 kg ha⁻¹) and treatments with 5 t ha⁻¹ of straw mulching

Table 1: Effect of spacing and mulching on plant height of *rainfed* lentil at different growth stages.

Treatments	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
Spacing			
S ₁ - 20 cm row spacing	15.02	23.77	27.59
S ₂ - 25 cm row spacing	15.06	24.14	27.64
S ₃ - 30 cm row spacing	15.90	25.23	28.20
S ₄ - Broadcasting (Seed rate @ 40 kg ha ⁻¹)	15.15	24.26	28.02
SEm (±)	0.18	0.30	0.36
CD (p=0.05)	0.64	NS	NS
Mulching			
M ₀ - Without mulching	14.33	22.27	25.02
M ₁ - 3 t ha ⁻¹ straw mulching	15.58	23.98	27.35
M ₂ - 4 t ha ⁻¹ straw mulching	15.06	24.88	28.56
M ₃ - 5 t ha ⁻¹ straw mulching	16.17	26.28	30.54
SEm(±)	0.28	0.34	0.31
CD (p=0.05)	0.81	0.99	0.91

Table 2: Effect of spacing and mulching on dry matter accumulation of *rainfed* lentil at different growth stages.

Treatments	Dry matter accumulation (g m ⁻²)		
	30 DAS	60 DAS	90 DAS
Spacing			
S ₁ - 20 cm row spacing	38.02	100.05	162.57
S ₂ - 25 cm row spacing	39.70	103.07	183.96
S ₃ - 30 cm row spacing	40.95	124.58	177.15
S ₄ - Broadcasting (Seed rate @ 40 kg ha ⁻¹)	41.65	141.49	201.63
SEm (±)	1.02	1.73	1.50
CD (p=0.05)	NS	6.00	5.19
CV(%)	8.88	5.12	2.87
Mulching			
M ₀ - Without mulching	35.67	113.74	166.30
M ₁ - 3 t ha ⁻¹ straw mulching	39.54	115.47	180.16
M ₂ - 4 t ha ⁻¹ straw mulching	44.74	123.3	192.10
M ₃ - 5 t ha ⁻¹ straw mulching	40.36	116.61	186.75
SEm(±)	1.12	2.20	2.82
CD (p=0.05)	3.28	6.59	8.23
CV(%)	9.72	6.67	5.39

(818 kg ha⁻¹). This improvement is likely attributed to higher plant population at harvest, increased test weight and more seeds per pod in the mulched plots compared to the control plot (Ghosh *et al.*, 2006; Devi *et al.*, 2021).

The interaction effect of sowing methods and mulching on seed yield was found significant (Table 2.1). The highest seed yield (975 kg ha⁻¹) was recorded in the treatment combination of broadcasting (S₄) and 4 t ha⁻¹ straw

mulching (M₂) while the lowest seed yield (584 kg ha⁻¹) was recorded in control plot (M₀) with 25 cm row spacing (S₂) (Table 3.1).

Harvest index (%)

The spacing treatment did not significantly affect the harvest index (%) of lentils. However, the crop sown with a spacing of 30 cm recorded the highest harvest index.

Table 2.1: Interaction effect of sowing methods and mulching on dry matter accumulation of rainfed lentil at 60 Days after sowing.

Treatments	Dry matter accumulation (g m ⁻²)				
Mulching Sowing methods	Without mulching	3 t ha ⁻¹ straw mulching	4 t ha ⁻¹ straw mulching	5 t ha ⁻¹ straw mulching	Mean
S ₁ - 20 cm row spacing	92.56	128.67	86.09	92.91	100.056
S ₂ - 25 cm row spacing	100.37	63.90	120.70	127.33	103.076
S ₃ - 30 cm row spacing	107.10	102.67	157.50	131.09	124.587
S ₄ - Broadcasting (Seed rate @ 40 kg ha ⁻¹)	154.97	129.23	166.67	115.13	141.498
Mean	113.749	115.475	123.377	116.616	117.304
	S.Em (±)		C.D. (P=0.05%)		
Sowing methods within mulching		4.278			12.867
Mulching within spacing		4.516			13.180

Table 3: Effect of spacing and mulching on seed yields of *rainfed* lentil.

Treatments	Seed yield (kg ha ⁻¹)	Harvest index (%)
Spacing		
S ₁ - 20 cm row spacing	730	33.07
S ₂ - 25 cm row spacing	677	32.01
S ₃ - 30 cm row spacing	838	33.83
S ₄ - Broadcasting (Seed rate @ 40 kg ha ⁻¹)	915	33.11
SEm (±)	25.34	0.83
CD (p=0.05)	87.69	NS
Mulching		
M ₀ - Without mulching	736	32.27
M ₁ - 3 t ha ⁻¹ straw mulching	751	32.61
M ₂ - 4 t ha ⁻¹ straw mulching	854	33.92
M ₃ - 5 t ha ⁻¹ straw mulching	818	33.21
SEm(±)	22.88	0.39
CD (p=0.05)	66.80	1.15

Table 3.1: Interaction effect of sowing methods and mulching on seed yield of *rainfed* lentil.

Treatments	Dry matter accumulation (g m ⁻²)				
Mulching	Without mulching	3 t ha ⁻¹ straw mulching	4 t ha ⁻¹ straw mulching	5 t ha ⁻¹ straw mulching	Mean
Sowing methods					
S ₁ - 20 cm row spacing	668	638	847	766	730
S ₂ - 25 cm row spacing	584	727	743	654	677
S ₃ - 30 cm row spacing	851	690	853	960	838
S ₄ - Broadcasting (seed rate @ 40 kg ha ⁻¹)	839	952	975	893	915
Mean	736	751	854	818	790
	S.Em (±)			C.D. (P=0.05%)	
Sowing methods within mulching		47.054			144.720
Mulching within spacing		45.778			133.604

In contrast, mulching had a significant effect on the harvest index of lentils. The highest harvest index (33.93%) was observed in crops grown with 4 t ha⁻¹ of straw mulching, which was statistically similar to the harvest indexes from plots with 3 t ha⁻¹ and 5 t ha⁻¹ of straw mulching. These values were significantly higher than the harvest index observed in the control plot, attributed to the increased biomass production facilitated by the mulching treatments (Murade *et al.*, 2014; Sharma *et al.*, 2014 and Singh *et al.*, 2015).

Consumptive use (cm)

The consumptive use of water by the lentil crop was calculated based solely on soil moisture contribution and effective rainfall, excluding any contribution from

groundwater due to its depth below the effective root zone. Results presented in Table 4 indicate that consumptive water use by the crop was highest in the 30 cm row spaced plots and lowest in the broadcasting sowing plots.

In contrast, the crop grown without mulching (control plot) exhibited the highest consumptive water use, likely due to greater soil moisture loss through evaporation and transpiration from the field. Consumptive water use was lowest in plots mulched at 5 t ha⁻¹.

Consumptive use efficiency (kg ha⁻¹ cm⁻¹)

Spacing significantly affected consumptive use efficiency, with the broadcasted plot (treatment S₄) achieving the highest efficiency (46.53 kg ha⁻¹ cm⁻¹), while the crop in 30 cm row spacing (treatment S₂) exhibited the lowest efficiency (32.46 kg ha⁻¹ cm⁻¹).

Similarly, mulching had a significant impact on consumptive use efficiency (Sudeshna and Saren, 2013). The highest efficiency (42.60 kg ha⁻¹ cm⁻¹) was observed in crops mulched with 5 t ha⁻¹ of straw, which was significantly greater than that of the control plot (33.80 kg ha⁻¹ cm⁻¹). This improvement can be attributed to increased crop yield and reduced soil moisture losses, resulting in lower consumptive water use in the mulched plots compared to the control plot (Bandyopadhyay *et al.*, 2018).

Economics of lentil production

The cost of cultivation and returns were determined based on the prevailing market prices of inputs and outputs during the experimental period in local markets. The crop sown by broadcasting (S₄) achieved the highest gross return (₹ 59,460 ha⁻¹), net return (₹ 39,161 ha⁻¹) and returns per rupee invested (2.93). In contrast, 20 cm row spacing incurred the highest cost of cultivation (₹ 21,022 ha⁻¹) (Table 5).

The application of mulching significantly influenced the economics of lentil production. Mulching with straw at 5 t ha⁻¹ incurred the highest cost of cultivation (₹ 21,579 ha⁻¹),

Table 4: Effect of spacing and mulching on consumptive use and consumptive use efficiency of rainfed lentil.

Treatments	Consumptive use (cm)	Consumptive use efficiency (kg ha ⁻¹ cm ⁻¹)
Spacing		
S ₁ - 20 cm row spacing	20.50	35.80
S ₂ - 25 cm row spacing	20.75	32.46
S ₃ - 30 cm row spacing	20.91	40.84
S ₄ - Broadcasting (Seed rate @ 40 kg ha ⁻¹)	19.75	46.53
SEm (±)	-	1.37
CD (p=0.05)	-	4.74
Mulching		
M ₀ - Without mulching	21.91	33.80
M ₁ - 3 t ha ⁻¹ straw mulching	20.70	36.76
M ₂ - 4 t ha ⁻¹ straw mulching	20.00	42.46
M ₃ - 5 t ha ⁻¹ straw mulching	19.29	42.60
SEm(±)	-	1.31
CD (p=0.05)	-	3.83

Table 5: Effect of spacing and mulching on economics of rainfed lentil cultivation.

Treatments	Cost of cultivation (₹ ha ⁻¹)	Gross return (₹ ha ⁻¹)	Net return (₹ ha ⁻¹)	Return per rupees invested
Spacing				
S ₁ - 20 cm row spacing	21022	47450	26428	2.257
S ₂ - 25 cm row spacing	20882	43998	23115	2.106
S ₃ - 30 cm row spacing	20666	54502	33836	2.640
S ₄ - Broadcasting (Seed rate @ 40 kg ha ⁻¹)	20299	59460	39161	2.932
SEm (±)	-	1647.38	1693.97	0.08
CD (p=0.05)	-	5700.05	5861.266	0.29
Mulching				
M ₀ - Without mulching	19124	47814	28691	2.507
M ₁ - 3 t ha ⁻¹ straw mulching	20876	48847	27971	2.348
M ₂ - 4 t ha ⁻¹ straw mulching	21290	55542	34252	2.614
M ₃ - 5 t ha ⁻¹ straw mulching	21579	53206	31626	2.47
SEm(±)	-	1487.79	1507.516	0.07
CD (p=0.05)	-	4342.12	4399.681	NS

while mulching at 4 t ha⁻¹ resulted in the highest gross return (₹ 55,542 ha⁻¹) and net return (₹ 32,076 ha⁻¹). However, mulching at 4 t ha⁻¹ also recorded the highest returns per rupee invested (2.614), which was statistically comparable to mulching at 5 t ha⁻¹ (2.47) (Kar *et al.*, 2013).

CONCLUSION

Broadcasting method is advantageous and found to be superior over the line sowing methods for lentil crop. The highest seed yield (975 kg ha⁻¹) was recorded in the treatment combination of broadcasting (S₄) and 4 t ha⁻¹ straw mulching (M₂). In terms of economics mulching at 4 t ha⁻¹ resulted in the highest gross return (₹ 55,542 ha⁻¹) and net return (₹ 32,076 ha⁻¹) and highest returns per rupee invested (2.614).

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Research content

The content of the research is not published anywhere else.

Ethical approval

There are no ethical issues for the present research work.

Data availability

The data and materials described in the manuscript may be made available on request basis to any scientist wishing to use for non-commercial purpose.

Conflict of interest

The authors declare that there is no conflict of interest.

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