Original Research Article

Effect of Moisture Conservation Practices on Productivity, Profitability and Water Use Efficiency in Rainfed Linseed (*Linum usitatissimum* L.) under Mid Hill Conditions of Himachal Pradesh

ABSTRACT

A field experiment was conducted during three consecutive years (---------) at Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya (CSK HPKV), Palampur to find out the best moisture-conservation practices in linseed grown under rainfed conditions. The experiment consisting of seven treatments related to moisture conservation was conducted in Randomized Block Design with three replications. Results of the study revealed that applying farmyard manure (FYM) at 10 t/ha, either by spreading or incorporating, and using straw mulching at the same rate significantly enhanced plant height, yield attributes, seed yield, economic returns (in term of higher gross, net returns, B C ratio), production and economic efficiency in linseed. These treatments increased seed yield by 47.4 to 55.4% compared to no mulching. The higher production and economic efficiencies achieved by said respective treatments ranged from 6.03 to 6.32 kg/ha/day and 76.12 to 74.61 Rs./ha/day, respectively. Additionally, these treatments increased oil yield by 56.8, 53.4 and 49.1 %, respectively, over no mulching, however, the increase in the oil content was not significant. Incorporation of FYM 10 t/ha was proved to be significantly best for recoding higher consumptive use and WUE over rest of the treatments.

Keywords**:** Consumptive use, FYM, linseed, moisture, oil yield, production efficiency, straw mulching, WUE

1. INTRODUCTION

Linseed has an important position in Indian economy due to its wide industrial utility. Linseed is grown in various regions around the world, major linseed growing countries are Canada, the USA, India, China, and Russia. Canada is the largest producer of flax seed in the world, representing about 40% of the world's production. India holds 5th position in the area after Russian Federation, Kazakhstan, Canada and China but ranks 6th in production after Russian Federation, Kazakhstan, Canada, China and the USA. In India, linseed is cultivated in about 19.65 million hectares with a production of 12.96 metric tonnes with a productivity of 666 kg/ha [1].

In Himachal Pradesh, it is the second most important winter oilseed crop and stands next to rapeseed-mustard in area and production. Linseed is mostly grown on marginal and sub marginal soils under conserved moisture and limited nutrient conditions with poor management practices. Early cessation of monsoon in some years adversely affects the germination and establishment of winter season rainfed crops due to inadequate soil moisture in surface layers. Moreover, growing the crop under rainfed conditions creates water stress due to uneven or erratic distribution of available rainfall. The plants are of short stature, having shallow taproot system which can draw moisture only from upper soil layers. Thus, plants are vulnerable to moisture stress during and after flowering stages. To enhance moisture-availability period and reduction in evaporation losses, appropriate agronomical moisture-conservation practices –particularly use of organic materials *viz.* crop residues/weeds, manures as mulching material are the best tools for enhancing crop productivity under rainfed condition. Organic mulches are poor

conductors of heat, which effectively reduce soil temperature and retain soil moisture for longer periods. This thermal property of organic mulches helps to maintain a cooler soil environment and prevents rapid water loss, thereby enhancing soil moisture retention [2,3,4,5]. Keeping in view the management of abiotic stress in linseed crop, this field experiment was conducted.

2. MATERIALS AND METHODS

A field experiment was conducted during three consecutive (please add years) *rabi* seasons at Research Farm of Linseed Unit, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya (CSK HPKV) ~~CSK HPKV~~ Palampur to find out the best moisture conservation practices to combat abiotic stress management in linseed crop for higher productivity under rainfed conditions. The experiment comprising 7 treatments *viz.* no mulch; straw mulch 10 t/ha; spreading of FYM 10 t/ha as mulch; incorporation of FYM 10 t/ha in the soil; soil mulch at 30 days after sowing (DAS); soil mulch at 30 DAS + after first rain shower and *in-situ* mulch with weeds was carried out in a randomized block design with 3 replications. The soil was silty clay, acidic (pH 5.4) with medium in available nitrogen, phosphorus and potassium. Linseed variety 'Himani' was sown at a row distance of 23 cm using seed rate of 40 kg/ha during the first fortnight of October by adopting standard package of practices. The treatment-wise moisture-conservation practices were done in earmarked plots. Soil mulching was done by breaking of capillaries with the help of wheel hoe at 30 DAS and after first rain shower if appeared, *in-situ* weed mulching at 30 DAS was done by uprooting of weeds and spreading in between the rows. Plant height, yield attributes were recorded from the selected five plants in each net plot. After maturity, the crop was harvested from the net plot area, sun dried, threshed with wooden mallet and the seed yield obtained was expressed in kg/ha. Economics of the treatments was computed based on prevalent market prices. The efficiency parameters related to production and economics were calculated using standard procedures. The water-use efficiency (WUE) of the crop was calculated by the method (WUE=Y/ET) described by Smith and Allen [6]. The consumptive use of water by the crop under different treatments was computed as per Johnson [7].

3. RESULTS AND DISCUSSION

3.1 Plant height: On pooled basis, all the moisture conservation treatments had recorded more plant height than no mulch. Spreading or incorporation of FYM 10 t/ha and straw mulching 10 t/ha being at par with each other had recorded significantly more plant height over rest of all treatments. Johnson et al. [8] also reported more plant height with straw mulching applied @ 10 t/ha [9]. All these treatments significantly delayed the appearance of 75% flowering by 2-3 days and maturity by 3-4 days over no mulch (Table 1).

3.2 Yield attributes: Pooled data presented in Table-1 revealed that all yield attributes were significantly influenced by different treatments. Spreading or incorporating FYM 10 t/ha and straw mulching 10 t/ha behaved statistically similar to each other in recording significantly higher yield attributes *viz.* final plant stand, number of primary branches/plant, capsules/plant, seeds/capsule and 1000-seed weight. Smith et al. [9] also found mulching with straw 10t/ha as the best treatment in this regard. Hand weeding but no removal of weeded plants from the field also behaved statistically similar to these treatments in influencing number of primary branches/plant. Sharma and Gupta [10] also found that among various moisture conservation practices, weeding, hoeing and turning in the field at 30 days after sowing was most effective for recording higher yield attributes and seed yield of linseed. Among different moisture conservation practices, soil mulching at 30 DAS was found least effective in increasing different yield attributes.

3.3 Seed yield: Significantly higher yield attributes contributed to obtaining significantly higher seed yield by statistically alike treatments of spreading or incorporation of FYM 10 t/ha and straw mulching 10 t/ha as is evident from the Table-1. The percent increase in seed yield by these treatments ranged from 47.4 to 55.4% over no mulching. Soil mulching at 30 DAS and thereafter receiving the first rain shower and hand weeding, but no removal of weeded plants from the field, remained at par with each other and had 217.4 and 201.7 kg/ha higher production than no mulching. The results are in direct conformity with Tetarwal et al. [11]. Similarly, Sharma et al. [12] and Gupta et al. [13] also reported significantly higher seed yields of linseed with *in situ* hand weeding and straw mulching, respectively. Patel et al. [14], has also confirmed the effectiveness of organic mulching techniques in improving crop yields. Yadev et al. [15] also found the superiority of application of organic residue mulch @ 4 t/ha on soil surface in between the crop rows at 20 days after sowing over dust mulch and farmer´s practice in linseed.

Significantly lower yield was obtained in no mulched plots. This was due to the fact that absence of mulch might have caused a rapid loss of water from soil surface to prevailing dry micro environment. Consequently moisture deficit in the rhizosphere might have hindered uptake and the utilization of nutrients by the crop and thereby reduced seed yield. All the treatments except soil mulching at 30 DAS significantly have higher harvest index over no mulch treatment.

3.4 Economics: On pooled basis, incorporation, spreading of FYM 10 t/ha and straw mulching 10 t/ha being at par with each other had recorded significantly higher gross, net returns and BC ratio over rest of the treatments. There was increase of Rs. 10435, 9953 and 8945/ha for gross returns, Rs. 6442, 6323 and 6671/ha for net returns and 0.22, 0.24 and 0.38 in BC ratio by these respective treatments as compared to no mulching. Hand weeding but no removal of weeded plants from the field was also equally good to these said treatments in obtaining higher BC ratio of 0.96 (Table-2).

Although cost of cultivation involved in these treatments is more but due to significantly higher production of produce, higher returns were obtained by these respective treatments as compared to rest of the treatments and resulted in higher BC ratio. The higher monetary returns were owing to higher values of yield attributes and yield of linseed under these treatments. Similarly, significantly higher net returns and BC ratio was also reported with straw mulching and in situ weeding [16,17].

3.5 Production and economic efficiency: Pooled data presented in Table-2 revealed that the application of straw mulch 10 t/ha, incorporation and spreading of FYM 10 t/ha being at par with each other were significantly superior over rest of the treatments for having higher production (6.03 to 6.32 kg/ha/day) and economic efficiency (76.12 to 74.61 Rs./ha/day). The magnitude of increase of production efficiency ranged from 2.16 kg/ha/day with incorporation of FYM 10 t/ha to 1.87 kg/ha/day with straw mulching 10 t/ha as compared to no mulch treatment, while, it was 33.48 Rs/ha/day with straw mulching 10 t/ha to 31.91 Rs/ha/day with spreading of FYM 10 t/ha in case of economic efficiency. These results are in close conformity with the finds of Patel et al. [18].

Similar findings were reported by Doe et al. [19], who found that straw mulching significantly improved soil moisture retention and crop yield, leading to an increase in production efficiency. Furthermore, research by Smith and Kumar [20] supports these results, indicating that organic mulching practices enhanced soil fertility and boost crop performance, thereby improved both production and economic efficiencies. Lee et al. [21] observed that incorporating FYM significantly increased soil organic matter content, which contributed to better crop yields and higher economic returns. Johnson et al. [22] also demonstrated that straw mulching and FYM application improved soil structure and nutrient availability, resulting in enhanced productivity.

3.6 Water use efficiency: Incorporation of FYM 10 t/ha was proved to be significantly best for recoding higher consumptive use and WUE over rest of the treatments and respective increase was 3.4 and 4.5% over unmulched plots. Spreading of FYM 10 t/ha and straw mulching 10 t/ha also behaved statistically similar to it for recording significantly higher water use efficiency. However, in respect of higher consumptive use, spreading of FYM 10 t/ha and straw mulching 10 t/ha were at par to each other (Table-3). This might be due to the increased availability of soil moisture and water holding capacity under these treatments, which ultimately enhanced the crop growth [23, 24, -25].

3.7 Oil content and yield: The data presented in Table 3 revealed that although different moisture conservation practices failed to influence oil content of linseed significantly, but had higher oil content than no mulching. Straw mulching 10 t/ha had recorded higher oil content of 34.05% followed by soil mulching at 30 DAS and after first rain shower (34.0 %) and incorporation of FYM 10 t/ha (33.9%), which was 1.34, 1.16 and 1.01 % more than no mulch treatment, respectively. Awasthi et al. [26] also reported that moisture conservation practices could not influence oil content significantly. Similar findings were also reported by Kumar et al. [27] and Singh et al. [28], who noted that while moisture conservation methods improved other crop parameters, their effect on oil content remained negligible.

Since oil yield is a function of oil content and seed yield, all moisture-conservation practices were significantly superior over no mulch. Incorporation and spreading of FYM 10 t/ha being at par with straw mulching 10 t/ha had recorded significantly higher oil yield over rest of the treatments. The respective increase in oil yield due to these treatments was 56.8, 53.4 and 49.1%, respectively over no mulching.

Table 1: Effect of treatments on growth, yield attributes and yield of linseed (Pooled data of three years)

Sl. No.	Treatments	Plant height at harvest (cm)	Days to flower initiation	Days taken to 75% maturity	Primary branches/ plant	Capsules/ plant	Seeds/ capsules	1000-seed wt. (g)	Seed yield (kg/ha)	HI (%)
1.	No Mulching	54.6	133.68	192.55	5.07	23.0	6.67	4.85	799.00	27.30
2.	Straw mulching @ 10 t/ha	62.1	136.12	195.78	6.00	31.0	8.09	5.44	1177.86	29.23
3.	Spreading FYM @ 10 t/ha as mulch	64.3	136.43	195.67	6.00	31.9	8.13	5.49	1221.05	29.99
4.	Incorporation of FYM in the soil @ 10 t/ha	63.4	137.21	196.88	6.07	32.3	8.29	5.23	1241.26	29.51
5.	Soil mulching at 30 DAS	59.6	133.54	193.68	5.53	27.2	7.49	5.13	949.79	28.12
6.	Soil mulching at 30 DAS and thereafter receiving first rain shower	60.7	134.32	193.45	5.67	27.5	7.71	5.22	1016.40	28.88
7.	Hand weeding but no removal of weeded plants from the field	60.5	134.68	193.45	5.80	27.8	7.82	5.28	1000.73	28.85
	CD (P=0.05)	**2.3**	**1.41**	**0.98**	**0.35**	**2.49**	**0.36**		**112.24**	**1.55**

Table 2: Effect of treatments on economics and –production & economic efficiency (Pooled data three years)

Sl. No.	Treatment	GMR (Rs/ha)	NMR (Rs./ha)	BC ratio	Production efficacy (kg/ha/day)	Economic efficiency (Rs./ha/day)
1.	No Mulching	18878	8195	0.77	4.16	42.64
2.	Straw mulching @ 10 t/ha	27823	14866	1.15	6.03	76.12
3.	Spreading FYM @ 10 t/ha as mulch	28831	14518	1.01	6.26	74.55
4.	Incorporation of FYM in the soil @ 10 t/ha	29313	14637	0.99	6.32	74.61
5.	Soil mulching at 30 DAS	22402	10496	0.88	4.92	54.51
6.	Soil mulching at 30 DAS and thereafter receiving first rain shower	24042	11501	0.91	5.27	59.64
7.	Hand weeding but no removal of weeded plants from the field	23635	11558	0.96	5.18	59.91
	CD at 5%	**2568**	**2633**	**0.20**	0.59	**13.72**

Table 3: Effect of treatments on water use efficiency, consumptive use and quality of linseed (Pooled data of three years)

Sl. No.	Treatment	WUE (kg/ha-mm)	Consumptive use (mm)	Oil content (%)	Oil yield (kg/ha)
1.	No Mulching	1.53	530	33.60	268.97
2.	Straw mulching @ 10 t/ha	2.22	542	34.05	401.10
3.	Spreading FYM @ 10 t/ha as mulch	2.30	543	33.73	412.48
4.	Incorporation of FYM in the soil @ 10 t/ha	2.32	548	33.94	421.84
5.	Soil mulching at 30 DAS	1.82	533	33.63	320.68
6.	Soil mulching at 30 DAS and thereafter receiving first rain shower	1.97	531	33.99	344.52
7.	Hand weeding but no removal of weeded plants from the field	1.92	531	33.82	339.26
	CD at 5%	**0.25**	**4.0**	**NS**	**40.93**

4. CONCLUSION

The study concluded that depending upon the availability of organic material, farmyard manure (FYM) 10 t/ha can be applied either through incorporation or spreading and straw mulching @ 10 t/ha can also be

used for getting significantly higher productivity and profitability in linseed grown under rainfed conditions of Himachal Pradesh.

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