Indian Journal of Agronomy **60** (4): 589–593 (December 2015)

Research Paper

Effect of moisture conservation practices on productivity, profitability and moisture-use pattern of rainfed linseed (*Linum usitatissimum*)

J.P. TETARWAL[1], BALDEV RAM[2], B.S.MEENA[3] AND PRATAP SINGH[4]

Agricultural Research Station, Agriculture University, Ummedganj, Kota, Rajasthan 324 001

Received : May 2015; Revised accepted : November 2015

ABSTRACT

A field experiment was conducted during the winter (*rabi*) seasons of 2009–10 to 2011–12 at Ummedganj, Kota, Rajasthan, to find out the best moisture-conservation practices as abiotic stress management in linseed (*Linum usitatissimum* L.) for higher productivity under rainfed conditions. Straw mulch @ 10 t/ha significantly increased the growth, yield attributes, seed yield (1,037 kg/ha), oil yield (403.3 kg/ha), net returns (₹18,930/ha) and benefit: cost ratio (1.22) over rest of the moisture-conservation practices and was statistically on a par with spreading of FYM 10 t/ha as mulch. The maximum production and economic efficiency, consumptive use (215 mm), moisture-use rate (1.58 mm/day) and water-use efficiency (4.82 kg/ha-mm) were recorded with straw mulch 10 t/ha, indicating 56.2, 79.3, 28.0, 27.4 and 22.0% increase over no mulch respectively. The maximum soil moisture depletion (46.2%) was registered from top soil layer (0–15 cm) in no-mulch, while the least (42.5%) with straw mulch 10 t/ha. However, the reverse trend was observed in deeper soil layer from 16–30 and 31–45 cm, and the maximum depletion of soil moisture was recorded under straw mulch 10 t/ha (33.0 and 24.6%) followed by spreading FYM 10 t/ha as mulch (32.8 and 24.5%) and least with no-mulch (30.8 and 23.0%) respectively.

Key words **:** Linseed, Moisture conservation, Moisture-extraction pattern, Net returns, Oil content, Production efficiency, Water-use efficiency, Yield

Linseed is an important oilseed crop grown for dual purpose-seed and fibre. It is a source of complete protein, high-order linolenic acid (an essential polyunsaturated omega-3 fatty acid), complex carbohydrates, vitamins and minerals. It occupies a greater importance among oilseeds; owing to its various uses and special qualities. In India, it is grown mainly for seeds, used for extracting oil. Linseed seed is also used for its medicinal use owing to natural source of omega-3, especially for the Indian vegetarians. It is a major winter (*rabi*) season oilseed crop, next to rapeseed-mustard, of India and grown in 2.963 lakh ha with a production of 1.486 lakh tonnes and 502 kg/ha of average productivity (CSAUAT, 2013–14). In Rajasthan, the area of linseed crop is dwindling and mainly depends on rainfall pattern and duration, presently it is cultivated in 1,394 ha area and produced 1,876 tonnes with average productivity of 1,346 kg/ha (Commisionerate of Agriculture, Rajasthan 2012–13). It is mainly cultivated under limited moisture conditions of south and south-eastern parts of the state. Prasad *et al*. (1999) reported that in south-eastern Rajasthan, 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. Of late, decline of water table and shortage of available water, farmers prefers linseed cultivation. However, it is mainly grown under rainfed conditions and is prone to water stress. 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 are the best tools for enhancing crop productivity under rainfed condition. Organic mulches are poor conductor of heat that effectively reduce soil temperature and retain soil moisture for longer period (Vaidya *et al*., 1995). Keeping in view management of abiotic stress in linseed crop, a field experiment was conducted to find out suitable moisture conservation practices for enhancing production and productivity of linseed.

[1]**Corresponding author Email:** jptetarwal@gmail.com
[1,2,3]Assistant Professor (Agronomy), [4]Professor (Agronomy) and Zonal Director Research, Agricultural Research Station, Ummedganj, Kota, Rajasthan 324 001

MATERIALS AND METHODS

A field experiment was conducted during 3 consecutive winter (*rabi*) seasons (2009–10 to 2011–12) at Agricultural Research Station, Ummedganj, Kota, Rajasthan, to find out the best moisture conservation practices as 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 in the soil 10 t/ha; soil mulch (hoeing) 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 clay loam, slightly alkaline (pH 8.0), low in organic carbon (0.46 %) and medium in available P (11.84 kg/ha) and available K (229.58 kg/ha). Linseed variety 'Meera' was sown in rows 30 cm × 10 cm during the second fortnight of October by adopting standard package of practices. The recommended dose of fertilizers (RDF) for rainfed linseed in south-eastern parts of Rajasthan is 30 kg N and 15 kg P_2O_5/ha was applied in all the experimental plots through urea and single super phosphate (SSP) before sowing. Total rainfall received in the crop season was 7.4, 85.9 and 3.6 mm, respectively during the respective years. Treatment number T_6 was applied only during the second year due to rainfall received before time during the first and third years.

The treatment-wise moisture-conservation practices were done in earmarked plots, i.e. soybean straw 10 t/ha (dry-weight basis) was spread uniformly over the soil surface at 30 DAS as a mulch, FYM 10 t/ha was spread as well as incorporated at 30 DAS as a mulch, soil mulch (breaking of capillaries with the help of narrow iron spade 'kudali') at 30 DAS and after first rain shower if appeared, *in-situ* weed mulching at 30 DAS (uprooting of weeds and spread between the rows and calculated their fresh biomass at the time of weeding, it was kept @ 2.8 kg/m^2 on fresh-weight basis in all the 3 replications using *ex-situ* weeds, namely *Chenopodium album, C. murale, C. arvensis* and *Cynodon dactylon* etc. The crop was harvested at physiological maturity stage in the second week of March during all the years of experimentation. The efficiency parameters related to production and economics were calculated using standard procedures. The soil moisture was determined thermo-gravimetrically using the samples collected from 0–15, 16–30 and 31–45 cm depth at different growth stages. The amount of water use by the crop under different treatments was computed by summing up the value of soil-moisture depletion from the profile during the entire crop season. The water-use efficiency (WUE) of the crop was calculated by the method (WUE=Y/ET) described by Viets (1962). The consumptive use of water by the crop under different treatments was computed as per Dastane (1972).

RESULTS AND DISCUSSION

Growth and yield attributes

Moisture-conservation practices proved superior to no moisture-conservation practices for improving growth and yield parameters of linseed under rainfed conditions (Table 1). The treatment straw mulch 10 t/ha recorded the maximum and significantly higher plant height, primary branches/plant, capsules/plant, seeds/capsule and 1,000-seed weight, remained statistically on a par with spreading of FYM 10 t/ha as mulch over rest of the moisture-conservation practices. These increased to the tune of 39.19, 59.68, 68.52, 43.54 and 22.48%, respectively, over no mulch. There were no marked variations among the mois-

Table 1. Effect of moisture-conservation practices on growth, yield attributes, yield and oil content of linseed (pooled data of 3 years)

Treatment	Plant height (cm)	Primary branches/ plant	Capsules/ plant	Seeds/ capsule	1,000-seed weight (g)	Oil content (%)	Yield (kg/ha)	
							Seed	Oil
No mulch	56.8	3.2	23.9	6.1	6.9	39.9	663	264.4
Straw mulch 10 t/ha	79.1	5.0	40.3	8.8	8.5	38.9	1037	403.3
Spreading of FYM 10 t/ha as mulch	77.3	4.7	37.5	8.4	8.4	38.9	993	386.2
Incorporation of FYM in the soil 10 t/ha	71.4	4.5	34.1	7.7	8.2	39.2	940	368.8
Soil mulch at 30 DAS	69.3	4.1	30.5	7.5	7.7	38.9	879	342.2
Soil mulch at 30 DAS + after first rain shower	71.3	4.1	31.2	7.7	7.8	39.7	877	347.8
In-situ mulch with weeds (uprooted weeds kept in between rows)	70.0	4.1	29.8	7.6	7.8	39.1	859	335.8
SEm±	1.42	0.16	1.50	0.16	0.15	0.47	25.51	11.59
CD (P=0.05)	4.08	0.45	4.31	0.45	0.44	NS	81.70	33.32

DAS, Days after sowing

ture-conservation practices, viz. incorporation of FYM 10 t/ha as mulch, soil mulch at 30 DAS, soil mulch at 30 DAS + after first rain shower and *in-situ* mulch with weeds. However, they remained statistically at par with each other but significant over no mulch. It may be due to more availability of moisture during crop growth and high water retention in the root zone. Awasthi *et al.* (2011) also reported that moisture-conservation through weeding, hoeing and turning in field at 30 DAS increased the plant height, capsules/plant and 1,000-seed weight of linseed.

Seed yield

Seed yield of linseed was significantly influenced by moisture-conservation practices (Table 1). Straw mulch 10 t/ha recorded the maximum and significantly higher seed yield, being at par with spreading of FYM 10 t/ha as mulch over rest of the moisture-conservation practices. The increment in seed yield was 374 kg/ha over no-mulch. The spreading and incorporation of FYM 10 t/ha as mulch were statistically at par with each other. The per cent increase in seed yield over no-mulch was 56.41, 49.77, 41.78, 32.58, 32.28 and 29.56 with straw mulch 10 t/ha, spreading of FYM 10 t/ha as mulch, incorporation of FYM 10 t/ha as mulch, soil mulch at 30 DAS, soil mulch at 30 DAS + after first rain shower and *in-situ* mulch with weeds, respectively. The moisture-conservation practices may be provided favourable environment for movement of plant nutrients in linseed (Dubey *et al*., 1999) which increased growth and yield parameters thus enhanced seed yield.

Oil content and oil yield

Moisture-conservation practices could not influence the oil content significantly, whereas oil yield of linseed was found statistically significant (Table 1). Maximum and significantly higher oil yield was recorded with straw mulch 10 t/ha, followed by spreading of FYM 10 t/ha as mulch compared to the other moisture-conservation practices, increased to the tune of 52.53 and 46.07%, respectively, over no-mulch. The treatments, namely incorporation of FYM 10 t/ha as mulch, soil mulch at 30 DAS, soil mulch at 30 DAS + after first rain shower and *in-situ* mulch with weeds resulted in significantly higher oil yield over no-mulch but remained statistically at par with each other. Oil yield is a function of oil content and seed yield thus, increased significantly with different moisture-conservation practices. Awasthi *et al.* (2011) reported that moisture conservation practices could not influence oil content significantly.

Economics

The net return and benefit: cost ratio of the linseed was significantly influenced by moisture-conservation practices (Table 2). The mean cost of cultivation was maximum under treatment incorporation of FYM 10 t/ha followed by spreading of FYM 10 t/ha and the lowest in no-mulch treatment. Maximum and significantly higher net returns were recorded with straw mulch 10 t/ha over rest of the treatments. The increment in net return was registered to the magnitude of ₹8,370/ha or 79.3% higher over no-mulch. The next best treatments were spreading of FYM 10 t/ha as mulch and soil mulch at 30 DAS by recording 46.7 and 43.6% higher net returns over no-mulch, respectively. The benefit: cost ratio was also noticed significantly higher with straw mulch 10 t/ha over rest of the treatments and being statistically at par with soil mulch at 30 DAS. The higher monetary returns were owing to higher values of yield attributes and yield of linseed under

Table 2. Effect of moisture-conservation practices on economics, production and economic efficiency and water-use efficiency (WUE) of linseed (pooled data of 3 years)

Treatment	Economics			Production efficiency (kg/ha/day)*	Economic efficiency (₹/ha/day)	Consumptive use (mm)	WUE (kg/ha-mm)	Moisture-use rate (mm/day)
	Cost of cultivation ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio					
No mulch	11.42	10.56	0.92	4.88	77.63	168	3.95	1.24
Straw mulch 10 t/ha	15.48	18.93	1.22	7.62	139.16	215	4.82	1.58
Spreading of FYM 10 t/ha as mulch	17.48	15.49	0.88	7.30	113.88	208	4.77	1.53
Incorporation of FYM in the soil 10 t/ha	18.55	12.64	0.68	6.91	92.92	202	4.65	1.49
Soil mulch at 30 days after sowing (DAS)	14.08	15.16	1.07	6.46	111.43	193	4.55	1.42
Soil mulch at 30 DAS+after first rain shower	15.08	14.01	0.94	6.45	103.01	195	4.50	1.43
In-situ mulch with weeds (uprooted weeds kept in between rows)	14.08	14.35	1.02	6.31	105.54	188	4.57	1.38
SEm±	-	0.88	0.09	0.12	4.01	-	-	-
CD (P=0.05)	-	2.52	0.27	0.34	11.51	-	-	-

Sale Price: Linseed: ₹30/kg (2009–10, 2010–11) and ₹40/kg (2011–12), *Mean crop duration: 136 days these treatments. Moisture conservation through weeding, hoeing and turning in field at 30 DAS fetched higher net returns in linseed (Awasthi *et al.,* 2011).

Production and economic efficiency

Application of straw mulch 10 t/ha recorded the highest production efficiency over rest of the moisture-conservation practices and it increased to 56.15% over no-mulch, remained a par with spreading of FYM 10 t/ha as mulch. The maximum and significantly higher economic efficiency was also observed with straw mulch 10 t/ha, increased to the magnitude of 79.26% over no-mulch (Table 2). The next best treatment was spreading of FYM 10 t/ha as mulch by recording ₹113.88/ha/day economic efficiency, significantly higher over incorporation of FYM 10 t/ha and no-mulch but at par with rest of the treatments. This might be due to higher seed yield owing to increased production and economic efficiencies. The results confirm the findings of Tetarwal *et al.* (2013) in Indian mustard.

Moisture-use pattern

The higher consumptive water use, water-use efficiency and moisture-use rate were observed under straw mulch 10 t/ha to the magnitude of 27.98, 22.03 and 27.42% over no-mulch, respectively (Table 2). The next best practice was spreading of FYM 10 t/ha as mulch. This might be due to the increased availability of soil moisture and water-holding capacity under these treatments, ultimately enhanced the crop growth. Awasthi *et al.* (2011) also reported that weeding, hoeing and turning in field had highest water-use efficiency as compared to no moisture-conservation practice in linseed.

Soil-moisture extraction pattern was markedly influenced by different moisture-conservation practices in linseed grown under rainfed conditions (Fig 1). Maximum soil-moisture depletion was registered from top soil layer (0 –15 cm) in no-mulch, while, the least with straw mulch 10 t/ha (M_1). It might be due to slow canopy development which exposed soil surface to solar radiation leading to higher evaporation from top layer in no-mulch treatment. However, the reverse trend was observed in deeper soil layer from 16–30 cm and 31–45 cm and the maximum depletion of soil moisture was recorded under straw mulch 10 t/ha (32.94 and 24.60%) followed by spreading of FYM 10 t/ha as mulch (32.82 and 24.48%) and least with no-mulch (30.77 and 23.02%), respectively. This was due to higher moisture availability in the deeper soil layers under different moisture-conservation treatments compared to no-mulch under rainfed conditions. Thus plants can absorb more moisture from deeper layers during later stages of crop growth. These results corroborate the findings of Tetarwal *et al*. (2013) in Indian mustard.

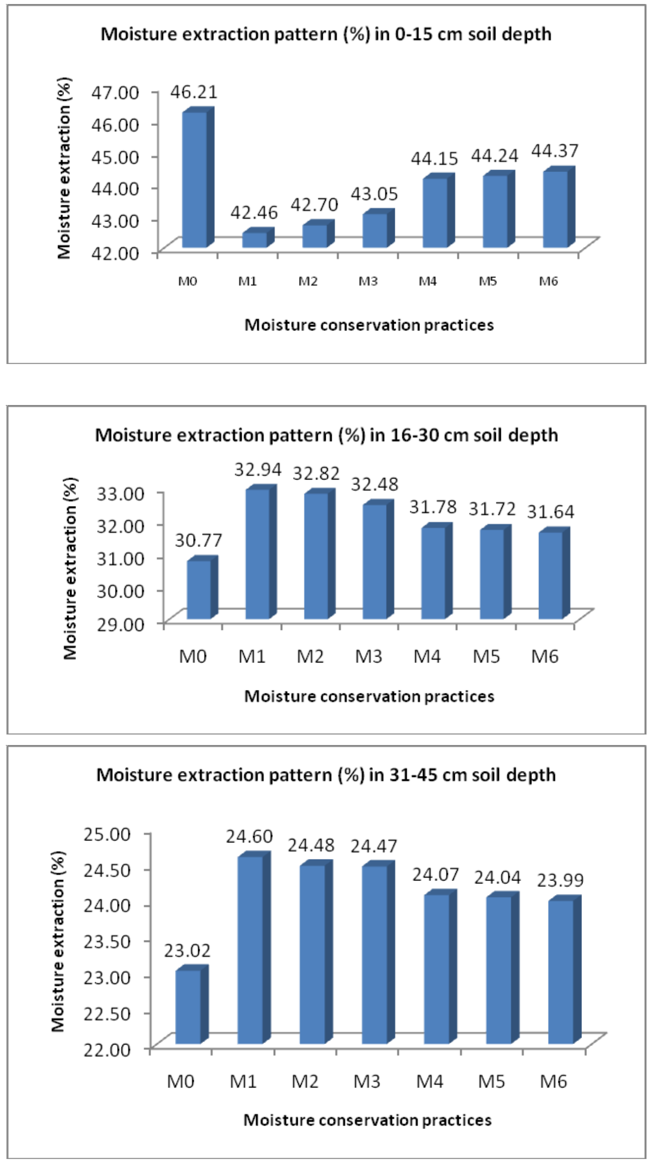

Fig. 1. Moisture extraction pattern (%) in different soil depths (M_0, No mulch; M_1, Straw mulch 10t/ha; M_2, Spreading FYM 10t/ha as mulch; M_3, Incorporation FYM in soil 10t/ha; M_4, Soil mulch at 30 DAS; M_5, Soil mulch at 30 DAS + after first rain shower; and M_6: *In situ* mulch with weeds)

Nutrient status in soil

Moisture-conservation practices in linseed significantly influenced the nutrient status in soil under rainfed conditions (Table 3). The organic carbon was significantly higher under treatment straw mulch 10 t/ha over rest of the moisture-conservation practices and was statistically on a par with incorporation of FYM 10 t/ha as mulch; the increase being 44.74% over no-mulch. The net gain in organic carbon over initial soil status was being 19.56% under straw mulch 10 t/ha and 15.22% under incorporation of FYM 10 t/ha. Application of straw mulch 10 t/ha

Table 3. Effect of moisture-conservation practices on nutrient status in soil after linseed harvest (pooled data of 3 years)

Treatment	Available nutrient status in soil			
	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
No mulch	0.38	252.4	10.1	215.1
Straw mulch 10 t/ha	0.55	288.7	14.2	242.8
Spreading of FYM 10 t/ha as mulch	0.50	276.3	13.0	232.6
Incorporation of FYM in the soil 10 t/ha	0.53	279.8	13.6	237.2
Soil mulch at 30days after sowing (DAS)	0.41	257.8	10.8	224.8
Soil mulch at 30 DAS+after first rain shower	0.42	262.2	11.1	225.4
In-situ mulch with weeds (uprooted weeds kept in between rows)	0.46	268.5	12.2	229.3
SEm±	0.009	3.60	0.21	3.05
CD (P=0.05)	0.028	11.10	0.64	9.40

Initial values: Organic carbon 0.46%; available N 263.1 kg/ha; available P 11.84 kg/ha; available K 229.58 kg/ha

recorded the maximum values of available N, P and K, per cent increase being 9.73 for N, 19.93 for P and 5.76 for K over initial soil fertility. This might be due to the effect of organic mulches that improved the nitrogen, phosphorus and potassium dynamics of soil during the crop growth. Tetarwal *et al.,* (2013) reported that moisture conservation through straw mulch 4 t/ha + kaolin 6% spray recorded the maximum nutrient-use efficiency, nutrient-harvest index and net positive balance of N, P and S in soil in rainfed mustard. Rajput (2012) also reported that moisture conservation through PMA + kaolin foliar spray recorded higher N uptake and soil N status after harvest of mustard crop.

Thus, linseed can be successfully grown under rainfed conditions by use of straw mulch 10 t/ha and harvest higher productivity, profitability and water-use efficiency.

REFERENCES

Awasthi, U.D., Dubey, S.D. and Shripal. 2011. Effect of nitrogen and moisture-conservation practices on yield, uptake, water-use efficiency and quality of linseed (*Linum usitatissimum*). *Indian Journal of Agricultural Sciences* **81**(4): 383–85.

CSAUAT, 2013–14. All India Coordinated Research Project on Linseed. *Annual Report 2013–14*. Project Coordinating Unit (linseed), Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. p. 257.

Commissionerate of Agriculture, Rajasthan. 2012–13. *Rajasthan Agricultural Statistics at a Glance*. Commissionerate of Agriculture, Jaipur, Rajasthan. p. 88.

Dastane, N.G. 1972. *A Practical Manual for Water Use Research in Agriculture*. 120 pp. Navbharat Prakashan, Poona, Maharashtra.

Dubey, S.D., Shukla, P. and Chandra, R. 1999. Effect of nitrogen, phosphorus and sulphur application on their content and uptake in linseed. *Journal of Oilseeds Research* **16**(1): 43–47.

Prasad, S.N., Singh, R. and Rao, D.H. 1999. Effect of pre-sowing irrigation and soil mulch on yield attributes, yield and water-use of chickpea (*Cicer arietinum*), linseed (*Linum usitatissimum*) and Indian mustard (*Brassica juncea*). *Indian Journal of Agricultural Sciences* **69**(6): 424–26.

Rajput, A.L. 2012. Effect of plant density, N levels and moisture conservation practices on the performance of Indian mustard (*Brassica juncea*) and available N status of soil. *Indian Journal of Agronomy* **57**(2): 171–75.

Tetarwal, J.P., Ram, Baldev and Raiger, P.R. 2013. Yield, nutrient balance and water use efficiency as influenced by moisture conservation practices and sulphur sources of Indian mustard under rainfed conditions. *Indian Journal of Fertilizers* **9**(7): 58–64.

Tetarwal, J.P., Ram, Baldev, Meena, D.S. and Tomar, S.S. 2013. Effect of moisture conservation and sulphur sources on productivity and water use efficiency of Indian mustard (*Brassica juncea*) under rainfed conditions. *Indian Journal of Agronomy* **58**(2): 231–36.

Vaidya, V.B, Varshneya, M.C., Bote, N.L. and Naidu, T.R.V. 1995. Estimation of thermal efficiency and apparent reflectivity of mulches using soil temperature. *Journal of Maharashtra Agricultural Universities* **20**(3): 341–44.

Viets, F.G. 1962. Fertilizer and efficient use of water. *Advances of Agronomy* **14**: 231–61.