



Effect of nitrogen and moisture conservation practices on yield, uptake, water-use efficiency and quality of linseed (*Linum usitatissimum*)*

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Received: 1 December 2009; Revised accepted: 20 January 2011

Key words: Nitrogen, Uptake, Use efficiency, Yield attributes

Linseed (*Linum usitatissimum* L.) is major winter (*rabi*) oilseed crop next to rapeseed mustard of India. Linseed is generally grown under rainfed and *utera* system of cultivation. The national productivity of linseed is only 349 kg/ha which is far below to experimental fields' yield. The linseed productivity suffers due to poor inputs and moisture management. Deficiency of nitrogen at any time during crop growth may reduce its yield. The yield of linseed can be increased by more than 100% over the prevailing practices under rainfed condition with fertilizer, weed control and plant protection and out of these fertilizer was more effective (Singh and Verma 1998). Moisture is a major factor for seedling emergence and mobilization of nitrogen from soil to plant system. These two factors are very important for increasing the productivity of linseed. The present study was carried out to evaluate the effect of nitrogen levels and moisture conservation practices on yield, uptake, water-use efficiency and quality of linseed under rainfed situation.

A field experiment was conducted for two consecutive years during *rabi* 2005 – 06 and 2006 – 07 at the Soil Conservation and Water Management farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The soil was sandy loam in texture with pH 7.5, organic carbon 0.30%, total N 0.029%, available P₂O₅ 16.5 and available K₂O 150.5 kg/ha the field had field capacity (18.4%), wilting point (6.0%), water-holding capacity (29.7%) and bulk density (1.40 Mg/m³). The experiment was constituted with 12 treatment combinations of nitrogen levels and moisture conservation practices in randomized block design and replicated thrice. The nitrogen levels were 0, 20, 40, and 60 kg/ha and moisture conservation practices were no moisture conservation practice (M₀), weeding and hoeing at 30 days after sowing (M₁) and

weeding, hoeing as well as turning in field at 30 days after sowing (M₂). Full dose of nitrogen was given treatment-wise along with a common dose of 20 kg P₂O₅ and 20 kg K₂O/ha were applied in all the experimental plots at sowing. The 'Shubhra' linseed was grown during both years. Total rainfall 20.8 and 127.0 mm were received during first and second year of experimentation, respectively. Biometric observations were recorded at the time of maturity. The nitrogen content was determined in defatted seed (cake) and straw and uptake was calculated by multiplying the content with seed and straw yields. Protein content was estimated by multiplying the N content of seed with factor 6.25. The efficiency parameters related to applied nitrogen were calculated using standard parameters. The oil content in seed was estimated with the help of NMR (Oxford model: MQA 7005). The iodine value was estimated by method described by Horowitz (1975). The soil moisture was determined thermo-gravimetrically using the samples collected from 0–25, 25–50, 50–75 and 75–100 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). Study on water use was made in one replication only where the plant stand was most uniform.

The yield-attributing characters and seed yield were significantly influenced by nitrogen levels and moisture conservation practices (Table 1). The application of nitrogen was found significantly effective for increasing the plant height, capsules/plant and 1000-seed weight. These growth attributes increased progressively with increasing nitrogen levels up to highest level of 60 kg N/ha. Each higher level of nitrogen increased these yield attributes over just preceding level significantly up to 40 kg N/ha. Application of nitrogen beyond 40 kg N/ha improved these yield parameters only marginally without any significant improvement. The capsules/plant and 1000-seed weight were increased at 40 kg/ha over without N by 63.09 and 10.30%, respectively.

*Short note

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Increase in yield components due to nitrogen application have been reported by Rana *et al.* (2000) and Badiyala and Kumar (2003). This may be ascribed to the overall improvement in plant vigour and production of sufficient photosynthates owing to higher availability of nitrogen, resulting in better yield attributes. Moisture conservation practices proved to be significantly superior to no moisture conservation practices for improving plant height, capsules/plant and 1000-seed weight. Though, weeding, hoeing and turning in the field were found significantly superior to weeding and hoeing only.

Application of nitrogen resulted in significant increase in seed yield compared to the control. The significant increase in seed yield was recorded with each increment of nitrogen levels, but seed yield at 40 kg N/ha and 60 kg N/ha was recorded statistically at par. The increased seed yield may be resultant of increased values of yield-attributing characters. On mean basis maximum increase in yield was noticed by 85% with first increment of nitrogen compared to others incremental doses. Under this investigation both moisture conservation practices were found significantly effective for enhancing the seed yield. The moisture conservation practice, ie weeding and hoeing and turning in the field were recorded seed yield by 42.25 and 9.8% higher over the no moisture conservation practice and weeding and hoeing, respectively. The findings of Nikam *et al.* (2009) confirm these results. Interaction effect of nitrogen and moisture conservation practice was not found significantly effective, though maximum seed yield was gained with 60 kg N ha + weeding and hoeing and turning in the field. The moisture conservation practices may be provided favourable environment for movement of plant nutrients.

The uptake of nitrogen by linseed was increased significantly with application of nitrogen (Table 1). The

maximum total uptake of nitrogen was recorded with 60 kg N/ha and it was statistically at par with 40 kg N/ha. These results are in conformity with the finding of Dubey *et al.* (1999). On mean basis, maximum rate of increase in uptake was noticed with 20 kg N/ha. The increase in uptake of nitrogen may be due to improvement in biomass production and seed yield which ultimately accumulated more nitrogen. This further underlined that nitrogen is an essential part of protein and higher nitrogen application resulted in higher uptake of nitrogen and ultimately converted into higher seed yield. Moisture conservation practices significantly influenced the total nitrogen uptake over no moisture conservation practice. On mean basis, the increase in nitrogen uptake was recorded by 23.3 and 44.1% with M₁ and M₂ over no moisture conservation practice, respectively.

The incremental doses of nitrogen markedly decreased the nitrogen-use efficiency compared with preceding level of nitrogen. The moisture conservation practices markedly increased the nitrogen-use efficiency and it was obtained maximum with weeding, hoeing and turning in the field. The physiological nitrogen-use efficiency was recorded maximum with N₂₀ and it was recorded minimum with N₆₀. This argues that degree of uptake of nitrogen reduced with increased levels of nitrogen. This may be due to loss of nitrogen in soil in different ways with increasing doses of nitrogen, though total uptake is more.

The data reveal that total water-use efficiency improved due to application of nitrogen levels, maximum water use and water-use efficiency were recorded with 60 kg N/ha and it was lowest with control (Table 2). Application of nitrogen promoted plant growth and crop canopy which might be due to utilization of more soil moisture and nutrients by crop, resulting increase in total water use which reflected their response by producing more seed yield and higher WUE.

Table 1 Yield, yield attributes, nitrogen uptake and efficiencies of linseed as affected by different nitrogen levels and moisture conservation practices (mean data of 2005–06 and 2006–07)

Treatment	Seed yield (tonnes/ha)	Plant height (cm)	Capsules/plant	1000-seed weight (g)	Total N uptake (kg/ha)	Nitrogen-use efficiency	Physiological N-use efficiency
N ₀	0.37	49.38	31.62	6.67	10.72		
N ₂₀	0.67	52.44	46.42	6.93	22.97	15.65	25.09
N ₄₀	0.82	55.15	51.57	7.39	29.41	11.26	24.07
N ₆₀	0.85	56.95	54.09	7.54	32.61	7.95	21.81
CD (P=0.05)	0.11	1.98	2.63	0.31	4.17		
No moisture conservation practice	0.54	51.88	43.70	7.10	19.30	9.33	14.95
Weeding and hoeing at 30 DAS	0.71	53.67	46.64	7.14	23.79	11.55	24.65
Weeding, hoeing and turning in field at 30 DAS	0.77	54.61	49.24	7.20	27.81	13.99	38.40
CD (P=0.05)	0.05	0.83	2.28	0.03	2.98		

DAS, Days after sowing

Table 2 Effect of nitrogen levels and moisture conservation practices on water-use, water-use efficiencies, net returns, oil content, iodine value and protein content of linseed (mean data of 2005–06 and 2006–07)

Treatment	Water-use (mm)	WUE (kg seed/ha mm water)	Net returns (₹/ha)	Oil content (%)	Iodine value	Protein in seed (%)
N ₀	228.8	1.67	1 816	40.27	186.91	15.96
N ₂₀	231.4	3.04	3 372	43.20	180.18	17.25
N ₄₀	233.1	3.58	5 595	41.69	176.01	19.50
N ₆₀	234.3	3.76	6 251	41.51	172.78	20.67
CD (P=0.05)	–	–	690.1	1.42	3.38	1.74
No moisture conservation practice	234.0	2.43	1 772	41.54	178.16	18.19
Weeding and hoeing at 30 DAS	232.3	3.14	3 486	41.62	179.12	18.32
Weeding, hoeing and turning in field at 30 DAS	229.4	3.48	4 788	41.84	180.24	18.53
CD (P=0.05)			855.4	NS	NS	NS

DAS, Days after sowing; WUE, water-use efficiency

Maximum water use were recorded under control, followed by M₁ and M₂. Weeding, hoeing and turning in the field had the highest water use efficiency as compared to other treatments. This might be due to the fact that moisture conservation practices reduced the weeds and evaporation losses and ultimately reduced the total water use by the crop and resulting in higher seed, straw yield and water-use efficiency. The highest net return was observed with 60 kgN/ha which was at par with 40 kg N/ha, followed by 20 kgN/ha (Table 2). However, weeding, hoeing and turning in the field fetched the significantly highest mean net returns of ₹ 4 788/ha, followed by weeding and hoeing (₹ 3 486/ha) and no moisture conservation practice (₹ 1 772/ha).

The oil content in linseed was increased due to nitrogen only up to 20 kgN/ha, thereafter it was decreased (Table 2). The moisture conservation practices could not influence the oil content significantly. However, maximum oil content was recorded with weeding, hoeing and turning in the field. The iodine value which decides the degree of unsaturation was significantly decreased with increased dose of nitrogen from N₀ to N₆₀. The moisture conservation practices could not influence the iodine value. The protein content in seed was recorded higher with higher doses of nitrogen and it was improved significantly up to 40 kg N. The negative association between oil and protein content was observed as protein content was increased with decrease in oil content. Similar association between oil and protein content was observed by Mandal *et al.* (2010).

SUMMARY

A study undertaken during winter (*rabi*) seasons of 2005–06 and 2006–07 at Kanpur to assess the effect of nitrogen levels and moisture conservation practices on linseed (*Linum usitatissimum* L.). Increasing nitrogen levels up to 40 kg/ha gave significantly taller plants, more yield attributes

(capsules/plant and 1000-seed weight) and N uptake, which consequently improved the seed yield and net returns. Increasing nitrogen levels reduced nitrogen-use efficiency (NUE) and physiological NUE progressively but improved the water-use efficiency. Among moisture conservation practices weeding, hoeing and turning in the field at 30 days after sowing was most effective for higher yield attributes, seed yield net returns and N uptake. However, moisture conservation practices could not affect, oil content, iodine value and protein content markedly.

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