

Performance of Linseed (*Linum usitatissimum* L.) to Fertility Levels and Seed Rates in Dryland Conditions of Eastern Uttar Pradesh

RANG LAL MEENA¹, T. K. SINGH, RAKESH KUMAR² AND PRAMOD KUMAR*

*Department of Agronomy, Institute of Agricultural Sciences
 Banaras Hindu University, Varanasi 221005, India*

¹*Division of Agronomy, IARI, New Delhi, India*

²*Division of Agronomy, ICAR-RC-NEH, Umiam, Meghalaya, India*

E-mail : pkr_ran@rediffmail.com

**Correspondence*

Abstract

A field experiment was carried out during *rabi* seasons of 2006 and 2007 to assess the performance of linseed under different fertility levels and seed rates in dry land ecosystem of eastern Uttar Pradesh. The results revealed that by increasing fertility level from F₀ (Control) to F₃ (60:30:30:30 kg N : P : K : S/ha) significantly increased all the growth and yield attributing characters viz. plant height, branches/plant, dry-matter production, capsules/plant, seeds/capsule and 1000-grain weight. The increase in yield attributes with N, P, K and S fertilizer level resulted increase in seed and straw yield. However, the marked influence of various seed rates were observed on growth and yield attributes. Increase in seed rate significantly decreased in plant height, branches/plant, and dry-matter production, capsules/plant, seeds/capsule and 1000-grain weight. Although, the increase in seed rate significantly increase in grain yield from 20—30 kg/ha but further increase, grain yield decreases but reverse in straw yield. In oil content, oil yield and protein content all these characters significantly increases with increases in fertility level but vice-versa with increasing in seed rate. Total oil yield increased with increase in seed rate upto 30 kg/ha then after decreases. The consumptive moisture was significantly increased with increase in fertility level and seed rate and it was maximum with the fertility level F₃ (N : P : K : S : 60:30:30:30 kg/ha) and S₂ (30 kg/ha) seed rate.

Key words : Linseed, Grain yield, Oil content, Protein content, Consumptive moisture use.

Linseed (*Linum usitatissimum* L.) is an important and well-known oilseed and fiber crop of India and mostly growing states are Madhya Pradesh, Maharashtra, Uttar Pradesh, Bihar, Rajasthan, Orissa, Karnataka, West Bengal, Assam, Andhra Pradesh, Himachal Pradesh, Jammu and Kashmir, punjab and Nagaland. Madhya Pradesh and Uttar Pradesh together contribute to the national linseed production to the extent of about 70%. Its seed contain 20—25% protein and 30—40% oil along with mineral elements like phosphorus. Linseed occupies a greater importance among oilseeds owing to its various uses and special qualities. It is grown mainly for seed used for extracting oil in rainfed conditions and has excellent dyeing oil used in manufacturing paints and varnishes, oilcloth, waterproof fabrics and linoleum and as edible oil in some areas. Linseed cake is a good manure and animal feed. Linseed straw produces fiber of good quality and also used in making paper and plastics

that is why it is also known as plastic crop. The reasons for low yield are poor soil fertility, inadequate use of fertilizer and traditional crop management practices. Among them the nutrient imbalance appears to be the major reason. Application of N along with adequate amount of phosphorus improved the seed yield of linseed (1). Results revealed that linseed show a great response to NPK application under the different agro-climatic conditions (2). The present study was therefore designed to evaluate the performance of different fertility levels and seed rate on growth, yield and quality of linseed cultivars under the dry-land ecosystem of eastern Uttar Pradesh.

Methods

A field experiment was carried out during *rabi* seasons of 2006 and 2007 at the agronomic research farm, Institute of Agricultural sciences, Banaras Hindu

Table 1. Effect of fertility levels and seed rates on growth, yield attributes, yield and quality on linseed under dryland conditions (pooled data of two years).

Treatments	Plant height (cm)	Branches/plant	Dry-matter accumulation/plant (g)	Capsule/plant	Seeds/capsule	1000-seed weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Oil content (%)	Oil yield (q/ha)	Protein content in seed (q/ha)	Protein yield (q/ha)
Fertility Levels (N:P:K:S kg/ha)												
Control	36.267	2.544	2.562	25.111	8.889	7.203	5.809	5.809	36.578	2.117	17.384	1.149
20:10:10:10	41.511	3.300	2.648	34.444	9.000	7.309	8.077	8.077	37.600	3.031	21.187	1.706
40:20:20:20	43.533	3.689	2.761	40.778	9.000	7.363	8.716	8.716	39.589	3.438	22.750	1.883
60:30:30:30	44.322	4.156	2.849	45.111	9.222	7.369	8.890	8.890	40.372	3.583	22.050	1.953
CD ($P=0.05$)	0.688	0.284	0.024	0.710	0.189	0.024	0.007	0.007	0.329	0.010	3.590	0.010
Seed Rates (kg/ha)												
20	43.308	4.008	2.754	44.250	9.167	7.415	5.809	18.614	36.578	2.117	17.384	1.149
30	41.442	3.408	2.709	36.667	9.000	7.318	8.077	21.083	37.600	3.031	21.187	1.706
40	39.475	2.850	2.652	28.167	8.917	7.201	8.716	21.757	39.589	3.438	22.750	1.883
CD ($P=0.05$)	0.596	0.246	0.021	0.615	0.163	0.021	8.890	0.015	40.372	3.583	22.050	1.953

University, Varanasi under the dryland ecosystem of Uttar Pradesh. The soil of the experimental site was sandy clay loam in texture with low nitrogen, medium in phosphorus and high in potassium availability and slightly alkaline in reaction (pH 8.2). The experimental units comprised four different fertility levels (kg/ha) N:P:K:S i.e. No fertilizer/control (F_0), 20:10:10:10 (F_1), 40:20:20:20 (F_2) and 60:30:30:30 (F_3) and three seed rates i.e., 20 (S_1), 30 (S_2) and 40 (S_3) kg/ha and were replicated thrice, laid out in randomized block design. A basal application of N, P and K were applied through the DAP, urea and MOP at the time of sowing and S was thoroughly mixed in the form of elemental sulfur 15 days before sowing at about 10 cm depth (based on treatment). A promising crop variety of linseed (Garima) was sown manually in furrow maintaining the optimum plant spacing 30 × 10 cm. However, all the other intercultural operation was done for weed management and crop requirement. Dithane M-45 at 2 kg/ha and Rogor 30 EC at 1 liter/ha were applied at the pod formation stage of crop to protect from rust and wilt attack during the vegetative periods. To assess the effects of various treatments on crop growth, yield attributes and yields of linseed, periodically observations were taken on plant height, branches/plant, dry weight/plant, capsules/plant, grain/capsule, 1,000-grain weight, grain and straw yields. Five plants were

selected randomly from each plot for recording of capsules/plant, seeds/capsule and 1,000-seed weight, whereas seed yield was calculated on plot basis and was converted into kg/ha. For the quality study in linseed oil content, oil yield, protein content and protein yield were also determined with the suitable methods in laboratory. Oil content was determined by the soxhlets extractor using petroleum ether as extractant while the protein content were determined by multiplying seed nitrogen content (%) with 6.25. However, the protein yield was worked out by multiplying the seed yield and protein per cent in seed. Soil moisture determinations were made at sowing time and at harvesting to study the consumptive use and moisture use efficiency of linseed. The crop was harvested when the stem turned yellow and capsules began to dry. After complete sun drying, threshing was done and stover yield was calculated by subtracting seed yield from bundle weight. The data collected was analyzed using Fisher's analysis of variance technique and least significant differences (LSD) test at 5% probability level to compare the treatment means.

Results and Discussion

Effect of Fertility Levels

Table 1 shows that all the growth attributes such

as plant height, primary branches/plant, dry weight/plant exhibited significant response in normal course of investigation. The increased dose of fertility from F_1 (20 kg N, 10 kg P, 10 kg K and 10 kg S)/ha to F_3 (60 kg N, 30 kg P, 30 kg K and 30 kg S)/ha significantly increase all the growth attribute characters than control. However, the higher doses of fertility levels accelerated better growth and proportionately brought about higher production of linseed. Increased availability of NPKS in soil brought about vigorous vegetative growth of the plants that developed to their full potential not only in the plant height, leaf area and size but also in the rate of photosynthesis. The increased photosynthetic capacity of foliage at higher dose of nutrient application might have resulted in increased synthesis of photosynthates as compared to lower dose. Inadequacy of photosynthesis with the resultant lower production of carbohydrates at lower dose of (NPKS) application is possible. The crop growth is generally measured in terms of dry matter accumulation, which is the function of morphological characters of plants. Hence, significantly maximum plant height and branches/plant were recorded at the highest level of fertility application. This might be possible because NPKS enhances the cell division, cell multiplication and tissue differentiation, which ultimately increase the plant height and branching in plant. These results are in close agreement with the findings of Dubey and Khan (3). However, the NPKS application enhanced higher dry matter accumulation in plants at all the stages (Table 1). Nitrogen and sulfur application greatly influences chlorophyll synthesis, carbohydrate and protein metabolism and finally results in improvement of growth characters contributing to higher dry matter accumulation in plants (4). It is possible that at higher levels of NPKS application, vigorous plant growth might have produced more photosynthates. Efficient partitioning of accumulated photosynthates, which resulted, enhanced yield attributes that ultimately increased the seed yield. The application of NPKS might exert flower initiation and seeds/capsules in by increasing the rate of photosynthesis and transport of source to sink sites. Therefore, supply of NPKS must be adequate at reproductive phase in order to obtain maximum yield. Lack of NPKS at flower initiation stage reduces potential seed number and test weight, which are determined at this stage. There were reduced test weight

and seeds/capsule at lower rates of NPKS applications (Table 1) and increase in capsule/plant and seed/capsule with increasing the fertility levels resulting to enhanced cell division, cell elongation and tissue differentiation. The increase in yield attributing characters of linseed with the application of NPKS has been reported by Khare et al. (4). The favorable effect of NPKS application on yield attributing characters viz., capsules/plant, seeds/capsule, 1,000-seed weight and seed yield/plant finally contributed to seed yield. Seed yield/ha increased significantly upto 60 kg N, 30 kg P, 30 kg K and 30 kg S. These results corroborate the findings of Singh et al. (5). However, the higher stover yield was recorded at higher rates of NPKS application. This could be attributed to the increased plant height, branching and dry matter accumulation with increasing levels of NPKS application. This indicates that both seed and stover utilized the applied NPKS at almost the same level of efficiency. Similar results have been reported by Jaggi et al. (6). Although, the application of NPKS caused favorable improvement in seed oil content as well as oil yield. It may be inferred that oil content increased significantly due to NPKS application over control, oil content in seed was maximum with fertility level F_3 (60 kg N, 30 kg P, 30 kg K and 30 kg S)/ha. Similar results have been reported by Bodiya et al. (7). Hence, the improvement in seed oil content with increasing rate of NPKS application might be due to the role of sulfur in the formation of acetyl Co-A, a precursor compound for synthesis of long chain fatty acids. Increased oil content accompanied with higher seed yield at higher levels of sulfur application ultimately enhanced the oil yield. Increasing the fertility levels from F_0 (control/no fertilizer) to F_3 (60 kg N, 30 kg P, 30 kg K, 30 kg S)/ha correspond to influence seed protein content. The fertility levels F_1 , F_2 and F_3 gave significantly higher protein content than control and at par to each other. The nitrogen is the component of all the amino acids and S is the component of cysteine, cystine, and methionine. So, their availability increased plant resulting in higher protein content in seeds that result in higher protein yield. These findings are in agreement with those of Chaubey and Dwivedi (8).

Effect of Seed Rates

The seed rate has profound influence on the cul-

Table 2. Effect of fertility levels and seed rates on soil moisture use and moisture use efficiency on linseed (pooled data of two years).

Treatments	Moisture (mm) on weight basis in (0—90 cm soil profile)		Depletion (mm)	Effective rainfall (mm)	Consumptive use (mm)	Moisture use efficiency (kg/ha/ mm)
	At sowing	At harvest				
Fertility Levels						
Control	280.6	192.3	88.3	99.8	188.1	3.08
20:10:10:10	280.6	181.5	99.1	99.8	198.9	4.05
40:20:20:20	280.6	178.7	101.9	99.8	201.7	4.31
60:30:30:30	280.6	176.4	104.2	99.8	204.0	4.35
Seed Rates (kg/ha)						
20	280.6	190.4	90.2	99.8	190.0	3.91
30	280.6	182.5	98.1	99.8	197.9	4.11
40	280.6	175.4	105.2	99.8	205	3.93

tivation of field crops including oilseeds. To obtain maximum yield, optimum plant population is the prerequisite that can be maintained only by sowing appropriate seed rate. Plants, in general demonstrate remarkable adaptability in growth and development to variability in environmental conditions, particularly to plant density factor. This factor is directly related to the phenomenon of competition involved by the plant population for nutrient, moisture, air and light. This is an important constituent for determining the extent of growth, development and finally the yield of a crop. However, the marked affect of seed rate was observed on the plant height of linseed at all growth stages onward. Significantly shorter plants were observed with increasing seed rates upto 40 kg/ha. So, all the growth attributing characters of linseed affected adversely with increasing seed rates. As a result of lower plant population at 20 kg seed rate, the individual plant could have utilized more soil moisture, nutrients and solar radiations and hence there growth and development were better leading to higher dry matter accumulation. The greater competition for solar radiation at higher plant density due to increased mutual shading, the photosynthetic activity of leaves might have adversely affected there by reducing almost all the growth attributes of linseed. Both primary and secondary branches/plant were markedly

reduced with increasing plant population. This could be ascribed to less availability of space for horizontal growth at higher plant densities. Increased production of primary and secondary branches/plant at lower seed rates led to the production of higher capsules/plant (Table 1). The lowest plant density at 20 kg seed rate also significantly bolder seeds than 30 and 40 kg seed/ha. It was further observed that seeds/capsule though declined with increasing seed rate from 20 to 40 kg/ha accordingly, the seed yield/plant followed the trend of capsules/plant and test weight. However, the seed yield (q/ha), which is the function of seed yield/plant and plant population was found to increase significantly between 20 and 30 kg seed rate but decline thereafter. Whereas, due to increasing plant density and biomass production the stover yield increased correspondingly with increasing seed rate but the difference between 30 and 40 kg seed rate was not significant. These results are in conformity with the finding of Jain et al. (9). Profound decrease in seed oil content of linseed was noticed with increasing seed rates from 20 to 40 kg/ha. These findings are in close conformity with findings of Kumar and Shastri (10). Oil yield, which is the product of seed yield and seed oil content was found to increase significantly between 20 and 30 kg seed rate. However, beyond 30 kg seed/ha it declined at highest seed rate. On the contrary, seed protein content at 20 kg seed rate was significantly higher than 30 and 40 kg seed rates, because of the higher seed yield of linseed at 30 kg seed rate. The protein yield at this seed rate was significantly higher than 20 kg seed/ha and it also showed distinct superiority over 40 kg seed rate (Table 1).

Soil Moisture Use and Moisture Use Efficiency (MUE)

Availability of soil moisture to plant is the most important factor that governs crop yield under dry-land condition. Therefore, a slight variation in soil moisture and rainfall may result into success or failure of the crop. In the present investigation the total water use by the crop was associated with the moisture availability in the root zone (Table 2). However, the high stored soil moisture at sowing and winter rains (99.8 mm) at capsule formation stage to maturity increase consumptive use of water due to increased availability of soil moisture to plant as has also been

reported by Rathore and Singh (11) but the reverse was true in water use efficiency. The crop complete its major part of life cycle in dry condition and at pod formation to maturity received (99.8 mm) rains that adversely affect the crop which resulted poor yield and reduce MUE of the crop. The moisture use efficiency increase with increase in fertility levels and it was maximum in F_3 i.e. NPKS : 60:30:30:30 kg/ha. The fertility levels increase MUE due to their adequate supply of nutrient to plant. The increase in the seed rate resulted increase in WUE due to competition among plants for space and for sunlight, and it was found to be maximum at 30 kg seed rate, then it starts decreasing.

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