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Influence of NPK, S and variety on growth, yield and quality of irrigated linseed (*Linum usitatissimum*)

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Linseed (*Linum usitatissimum* L.) is one of the important oilseed crops in India and stands next to rapeseed-mustard in winter season oilseeds with respect to area and production. Of the two technical oil bearing crops, viz. linseed and castor, linseed accounts for about 60%. Linseed, due to its high iodine value are quick drying property is valued for its industrial applications. Its importance is further increased owing to its demand as functional food due to the presence of Omega-3 factor in its oil. The cultivation of linseed is restricted mostly to marginal and submarginal lands under limited supply of fertilizer and irrigation, resulting in low crop yield. Among the agro-techniques that can increase its productivity, judicious application of nutrients, particularly the nitrogen, phosphorus, potash and sulphur play the important role. The studies have demonstrated the essentiality of sulphur nutrition and interaction between S and NPK in optimizing seed and oil yield in oilseeds (Pali and Tripathi 2000). In the recent past, the studies on nutritional requirement of linseed has been restricted mainly under rainfed condition but it has been well documented that the crop responds well to applied fertilizers under irrigated conditions (Kushuwaha *et al*. 2006). With increase in irrigated area in most parts of the country including eastern Uttar Pradesh, it becomes imperative to work out the response of linseed to N, P, K and S application under irrigated condition. The proper selection of genotype is equally important in realizing the high yield of linseed. Therefore, in view of the above facts, the present investigation was carried out to study the effect of NPK, sulphur and variety on growth, yield and quality of irrigated linseed varieties.

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The field experiment was conducted during winter (*rabi*) season (November-March) of 2009-10 at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh (25°18´ N latitude, 83°36´ E longitude and an altitude of 128.93 meters from mean sea level in the centre of North-Gangetic Alluvial Plain) under subtropical climate. The soil of the experimental field was sandy clay loam in texture having pH (1:2.5) 7.6, organic carbon 0.34 %. It was low in available nitrogen (209 kg/ha) and medium in available phosphorus (21.3 kg/ha), potassium (194.3 kg/ha) and sulphur (17.2 kg/ha). The experiment was laid out in split plot design assigning three NPK levels (60-30-30, 90-45-45 and 120-60-60 kg NPK/ha) to main plots and six combinations of three sulphur levels (0, 20 and 40 kg S/ha) and two varieties (Garima and Shekhar) to the sub-plots. The whole field was divided into three blocks each representing a replication.

Half the dose of nitrogen and full doses of phosphorus and potash (as per treatment) was applied as basal and remaining dose of nitrogen was top dressed after the irrigation at flowering stage. The entire quantity of sulphur was incorporated uniformly in accordance with treatments into the soil before sowing. The oil content in seed was estimated with the help of Soxhlet's apparatus using petroleum ether as extractant (Sankaran 1966). The iodine value was estimated by method described by Horowitz (1975). The weekly mean maximum and minimum temperature during the experimentation ranged from 15.1 to 40.2 ºC and 7.1 to 21.1 ºC, respectively.

Increasing levels of NPK application up to highest level resulted in improved growth and yield attributing characters (Table 1). However, 120-60-60 and 90-45-45 kg NPK/ha did not differ significantly with respect to growth and yield parameters. Application of 90-45-45 kg NPK/ha significantly improved the growth and yield attributing characters over 60-30-30 kg NPK/ha and the percentage increase in dry matter accumulation, capsules/plant, seeds/capsule and 1000-

seed weight were 8.6, 20.3, 3.1 and 8.2% under 90-45-45 kg NPK compared to 60-30-30 kg NPK/ha, respectively. However, incremental levels of NPK significantly delayed maturity of the crop. This might be due to prolonged vegetative phase of crop under higher supply of nitrogen. Dordas (2010) also reported similar results. The seed and stover yield improved correspondly with increasing NPK levels up to highest level. However, the highest and medium levels remained statistically at par. Application of 90-45-45 kg NPK/ha recorded 19.8 and 17.3 per cent higher seed and stover yield, respectively over 60-30-30 kg NPK/ha. The increase in seed yield with increasing NP levels has also been reported by Tanwar *et al*. (2011). The seed oil content and oil yield was significantly influenced by different levels of NPK. The highest oil content was observed with lowest dose of NPK level while progressive increase in oil yield was obtained with successive increment of NPK up to the highest level, but increment beyond 90-45-45 kg NPK/ha was not significant. The reduction in oil content at higher supply of nitrogen appears to be due to conversion of more carbohydrate into protein and thus the amount of synthesized carbohydrates left for conversion into fats are relatively low as compared to other nitrogen treated plants. Singh *et al*. (2010) reported similar results. Seed yield appeared to be directly related with oil yield. Sune *et al*. (2006) also obtained higher oil recovery with increasing levels of phosphorus and sulphur application. The iodine value which decides the degree of unsaturation was significantly decreased with increasing levels of NPK from 60-30-30 to 120-60-60 kg/ha. Similar result was observed by Awasthi *et al*. (2011). The graded application of NPK levels consistently increased removal of NPK and S by the crop (seed + stover) to an extent statistically significant. However, medium and highest levels of NPK remained statistically at par with each other in respect to removal of NPK and S.

Sulphur fertilization at 20 kg S/ha being at par with 40 kg S/ha increased plant height, primary and secondary branches/plant, dry matter accumulation, capsules/plant, seeds/capsule, 1000-seed weight over unfertilized linseed. Favourable effects of S application on growth and yield attributes were reflected on the seed and stover yield. The application of 20 kg S/ha increased seed and stover yield by 18.7 and 10.6% over no sulphur, respectively. Further increase in S level did not produce perceptible increase in seed and stover yield. The improvement in yield might be due to better translocation of photosynthates leading to more number of capsules/plant, seeds/capsule and 1000-seed weight. Sulphur fertilization markedly increased oil content at 20 kg S/ha. Further increase of this nutrient did not cause appreciable variation in oil content. The magnitude of increase at 20 kg S/ha over the control was 4.4%. The results of the present investigation corroborate the findings of Singh *et al*. (2006). Increasing levels of sulphur from 0 to 20 kg/ha significantly increased removal of NPK and S by linseed (seed and stover). Further increase in sulphur level up to 40 kg did bring statistically at par with 20 kg S/ha in respect of the nutrient removal. The increase in removal of the nutrients under S application might be the outcome of increase contents of these nutrients in seed and stover coupled with increased seed and stover yield/ha. Similarly, sulphur application showed significant influence on iodine value. Application of sulphur at 40 kg S/ha gave significantly lower value of iodine as compared to the control. Dwivedi and Chaubey (1995) observed decreased iodine values with increasing phosphorus and sulphur levels in linseed var. Garima. Application of sulphur at 40 kg/ha being at par with 20 kg/ ha gave significantly higher removal of NPK and S as compared to the control.

Among the two linseed varieties Shekhar produced significantly higher plant height, primary and secondary branches/plant and dry matter accumulation/plant over Garima. The marked variation in growth could be ascribed on account of their genetic capabilities to exploit available resources for their growth and development. Linseed variety Shekhar took more number of days to maturity (121.1 days) as compared to Garima (117.4 days). Significantly higher number of capsules/plant, seeds/capsule and 1000-seed weight of Shekhar than Garima resulted in lucidly higher seed and stover yield in Shekhar by 18.9 and 13.0%, respectively than Garima. The maximum seed yield (16.52 q/ha) was observed with the treatment combination of 90, 45, 45 kg NPK, 20 kg S/ ha and Shekhar variety which also exhibited maximum net return (` 18570/ha) and output input ratio (2.04) (Table 2).

SUMMARY

A field experiment was conducted at the Banaras Hindu University, Varanasi during winter (*rabi*) season of 2009–10 to evaluate the performance of linseed (*Linum usitatissimum* L.) varieties as influenced by NPK and S levels under irrigated condition in a sandy clay loam soil. The treatment involved three levels of NPK (60, 30, 30; 90, 45, 45 and 120, 60, 60 kg NPK/ha) in main plots and combinations of three sulphur levels (0, 20 and 40 kg S/ha) and two varieties (Garima and Shekhar) in sub plots replicated in thrice under split plot design. Results revealed that application of 90-45-45 kg NPK/ha significantly increased growth parameters, such as plant height, primary and secondary branches/plant and dry matter accumulation, yield attributes and seed yield over 60-30-30 kg NPK/ha. The maximum oil content and minimum iodine value were recorded under 60-30-30 kg and 120-60-60 kg NPK/ha, respectively. The plant height, dry matter accumulation, capsules/plant 1000-seed weight, seed yield, oil content, removal of NPK significantly increased up to the application of 40 kg S/ha. Linseed variety Shekhar gave the highest values of growth parameters, yield attributes, yield and removal of the nutrients than Garima. Shekhar also registered maximum net return (₹ 18 570/ha) and output input ratio (2.04) when fertilized with 60-30-30 kg NPK

along with 20 kg S/ha.

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