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Effect of Nitrogen and Sulphur Levels on Growth and Yield of Linseed (*Linum usitatissimum*) Under Rainfed Condition of Nagaland

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ABSTRACT

Background: Linseed is an annual herbaceous plant belonging to the family of Linaceae, having well developed fibrous root system with several lateral roots. It has been grown since ancient times for fibre (flax) and seed, which is rich in oil. The crop has narrow leaves and alternate with shiny yellow or light brown colored seeds. The current investigation was carried out to determine the suitable level of nitrogen and sulphur and their interaction effect on growth and yield of linseed.

Methods: A field study was conducted in the experimental site of SASRD, NU during the *rabi* season with four levels of nitrogen (0,20,40 and 60 kg ha^{-1}) and sulphur (0,20,40 and 60 kg^{-1}) under three replications following RBD, five random plants were tagged from each plot for field observation.

Conclusion: Application of 60 kg N ha^{-1} resulted in highest plant height, number of branches plant^{-1}, bolls plant^{-1}, seed (799.87 kg ha^{-1}) and stover yields (1619.87 kg ha^{-1}), similarly, incorporation of 40 kg S ha^{-1} recorded significantly higher plant height, number of branches plant^{-1}, bolls plant^{-1}, seed boll^{-1}, yield (797.54 kg ha^{-1}) and stover yields (1557.58 kg ha^{-1}). The combination of 60 kg N and 40 kg S recorded highest plant height, number of branches plant^{-1}, bolls plant^{-1}, seeds boll^{-1}, seed weight plant^{-1}, seed (840.72 kg ha^{-1}) and stover yields (1713.3 kg ha^{-1})

Key words: Economics, Linseed, Nitrogen, Sulphur, Soil nutrient status.

INTRODUCTION

Linseed is an important oilseed crop of India and grown for both seed and fibre, commonly known as flax. The oil content is about 33-44% while the protein content is 24%. The stem yields good quality of fibre having high strength, durability which are two to three times strong to those of cotton (Taylor, 2012). Linseed production is about 1.74 lakh metric tonnes covering an area of 3.2 lakh hectares with an average productivity of 544 kg ha^{-1} (FAOSTAT, 2018) while Nagaland covers an area of 259,800ha with production of 272,000 tonnes (Anonymous 2018). The reason for low yield of linseed are poor fertility, inadequate use of fertilizers and traditional crop management practises. Nagaland has good scope to enhance the production at commercial level but due to hilly terrain and topography along with lack of proper storage and postharvest handling are some of the main reasons for limitation in production in the state (Soil nutrient mapping of Nagaland, 2014). Nitrogen is the major nutrient required by plants for their better growth and development while sulphur also plays a very important role for oilseed crops and is an vital factor for increasing yield in oilseed crops and also in the formation of amino acid, synthesis of protein, chlorophyll (Singh *et al*., 2007). In this context, the present study was carried out to find out the effect of nitrogen and sulphur levels on linseed under rain fed condition of Nagaland.

MATERIALS AND METHODS

In a field experiment, linseed (var. Ruchi) was grown on a strongly acidic soil of Nagaland. The experimental farm is located at 25°45′43″N latitude and 95°53′04″N longitude under Medziphema SASRD (2017-18). The soil of the experimental plot was well drained and sandy loam in texture with pH 4.3, available N 293.08 kg ha^{-1}, P_2O_5 22.4 kg ha^{-1}, K_2O 210.3 kg ha^{-1} and S 8.50 mg kg^{-1}. The treatment comprised of 4 levels of N (0, 20, 40 and 60 kg ha^{-1}) and levels of S (0, 20, 40 and 60 kg ha^{-1}). The experiment was laid in randomized block design and replicated thrice. The sowing was done on 11th November, healthy viable seed @35 kg ha^{-1} was used for sowing in furrows with spacing of 1m was maintained. The data were recorded at 30, 60, 90 and at harvest. Recommended dose of 20 kg phosphorus ha^{-1} and 20 kg potassium ha^{-1} were applied through SSP

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and MOP. N and S were applied through urea and sulphur 90% WG respectively. Crop was raised with recommended package of practice and was harvested at maturity during the 1st of April 2017. The observations on growth and yield attributes were recorded randomly five selected plants from each plot separately. The seed and stover yield were recorded treatment wise and were separated, air dried; all parameters were analyzed by following standard statistical procedure.

RESULTS AND DISCUSSION

Effect of nitrogen and sulphur on growth attributes

The growth attributes of linseed as influenced by N and S levels were recorded at 30, 60, 90 days after sowing and at harvest (Table 1). It was indicated that plant height increased at 30,60,90 DAS and harvest and recorded maximum at 60 kg N ha^{-1} (13.88, 29.85, 46.55 and 48.18 cm respectively. The increased in plant height with increase in the rate of N may be attributed to enhance vegetative growth, similarly results was also recorded by Sharief *et al*. (2005). Plant height was also significantly influenced by S levels, maximum height was observed 12.63, 26.38, 43.32 and 44.85 cm at 30, 60, 90 DAS and at harvest, respectively at highest S level. These findings were corroborated with the findings of Misra *et al*. (2013) and Minz *et al*. (2017), while the interaction effect of N and S were found to be significant. Combined application of 60 kg N and 40 kg S ha^{-1} gave the highest plant height of 15.67, 30.97, 49.93 and 50.73cm respectively at successive stages of growth (Table 3). The fact that nitrogen being a structural constituent of protein seems to be an essential for cell division and cell expansion too. Further, cell division and cell expansion are the prime characteristics of dynamics for increase in height and number of branches. Maximum number of branches were found with the application of 40 kg S ha^{-1}, these findings was in agreement with the findings of Banerjee *et al*. (2001). Sulphur is the constituent of a number of amino acids which are essential for the growth and development of plant tissues. Maximum branches $plant^{-1}$ was recorded (Table 4) with the combined application of 60kg N and 40 kg S ha^{-1} in all stages of observation as 1.77, 4.83, 9.05 and 9.27 respectively, similar findings at also reported by Dwidevi *et al*. (2001).

Effect of nitrogen and sulphur on yield attributes

The increasing N levels had significant differences on number of bolls $plant^{-1}$. The highest number of bolls $plant^{-1}$ was recorded with application of 60kg N ha^{-1} (64.35). Similar result was noticed by Khajini *et al*. (2012). Variation on number of boll $plant^{-1}$ due to the interaction of N and S was found to be significant (Table 5). Combined use of 60 kg N and 40 kg S ha^{-1} gave the higher number of capsules $plant^{-1}$ (67.56) as compared to the remaining treatments. The result was in agreement with the findings of Singh (2001). Under N levels, application of 60 kg ha^{-1} recorded the highest number of seed $boll^{-1}$ (9.37). The increase in yield attributes results due to proper and balanced supply of nutrients. Maximum number of seed $boll^{-1}$ (9.13) was recorded at 40 kg S ha^{-1} as compared to other doses of S. Dutta and Patra (2005); Singh *et al*. (2008) recorded similar results. Combination of 60 kg N and 40 kg S gave superior number of seeds $boll^{-1}$ (9.91) (Table 6), similar results was also obtained by Upadyay *et al*. (2012). Among the nitrogen levels, maximum seed weight was recorded at 60 kg N ha^{-1}. Lawania *et al*. (2015) revealed that seed weight $plant^{-1}$ increased significantly with the application of 50 kg N ha^{-1} as compared to all other treatments. Increasing levels of nitrogen and sulphur significantly increased the seed weight. The maximum seed weight 2.80 and 2.81g was recorded

Table 1: Effect of nitrogen and sulphur on growth and yield attributes of linseed.

Treatment	Plant height (cm)	No. of branches	Shoot dry weight	No. of bolls $plant^{-1}$	No. of seeds $boll^{-1}$	Test weight
Nitrogen levels (kg ha^{-1})						
0	41.90	7.75	8.38	57.42	8.76	2.49
20	42.54	7.86	8.53	55.38	8.62	2.35
40	43.80	7.80	8.96	56.08	8.59	2.69
60	47.56	8.80	9.27	64.35	9.37	3.45
SEm±	0.64	0.07	0.05	0.35	0.06	0.0 2
CD (P=0.05)	1.84	0.20	0.13	1.02	0.17	0.0 4
Sulphur levels (kg ha^{-1})						
0	42.84	7.87	8.67	56.07	8.62	2.52
20	43.28	7.83	8.77	57.58	8.74	2.56
40	45.58	8.40	8.86	61.05	9.13	2.80
60	44.09	8.11	8.84	58.52	8.84	2.81
SEm±	0.64	0.07	0.05	0.35	0.06	0.02
CD (P=0.05)	1.84	0.20	0.13	1.02	0.17	0.04

Table 2: Effect of nitrogen and sulphur levels on seed yield, stover yield, available nitrogen, phosphorus and sulphur.

Treatment	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available S (mg kg^{-1})
Nitrogen levels (kg ha^{-1})					
0	709.83	1408.93	295.94	25.12	11.66
20	720.07	1403.24	303.11	25.29	12.23
40	763.79	1444.33	308.99	25.65	12.51
60	799.87	1619.07	326.50	26.95	12.81
SEm±	21.80	32.71	5.16	0.19	0.15
CD (P=0.05)	62.96	111.79	14.89	0.56	0.42
Sulphur levels (kg ha^{-1})					
0	702.19	1317.58			
20	721.19	1371.58			
40	797.54	1557.58			
60	772.81	1534.47			
SEm±	21.80	32.71			
CD (P=0.05)	62.961	11.79			

Table 3: Interaction effect of N and S on plant height.

	S_0	S_1	S_2	S_3		
N_0	9.40	12.67	10.63	11.63	(30 DAS)	SEm±0.47
N_1	11.60	10.07	11.33	12.07		CD(P=0.05)
N_2	10.83	12.07	12.27	13.73		1.35
N_3	12.80	14.47	15.67	12.57		
N_0	20.33	22.90	23.03	24.07	(60 DAS)	SEm±0.80
N_2	21.13	25.57	23.23	25.40		CD(P=0.05)
N_3	23.37	24.30	28.27	24.47		2.32
N_1	28.63	29.17	30.97	30.63		
N_0	38.63	40.90	39.50	41.17	(90 DAS)	SEm±0.81
N_1	41.87	39.13	42.47	39.40		CD(P=0.05)
N_2	40.47	41.27	41.87	44.03		2.35
N_3	44.50	45.27	49.43	44.93		
N_0	40.30	42.50	41.10	43.70	(At harvest)	SEm±1.27
N_1	42.67	41.80	43.80	41.80		CD(P=0.05)
N_2	43.60	42.63	44.35	44.62		3.68
N_3	44.80	46.12	53.07	46.23		

with the application of 60 kg N and 40 kg S ha^{-1} respectively. Application of upto 40 kg S significantly increased seed weight (Lawania *et al*. 2015). Interaction effects of nitrogen and sulphur on seed weight were observed to be significant. The highest seed weight was 4.10g was recorded when 60 kg N was applied with 40 kg S ha^{-1}. Levels of nitrogen and sulphur had no significant effect on test weight. Maximum seed yield was recorded with application of 60 kg N ha^{-1} (799.87 kg ha^{-1}), Lawania *et al*. (2015) showed positive yield responses to nitrogen up to 60 kg ha^{-1}. Amongst S levels, application of 40kg S ha^{-1} gave maximum yield (797.54 kg ha^{-1}), while the lowest yield was associated with control. The increase in yield attributes on addition of sulphur might be due to its deficiency in the experimental soil. The crop received 40 ppm sulphur might have been helped in terms of vigorous root growth, formation of chlorophyll, resulting in higher photosynthesis similar results were reported by Singh and Sharma (1996). Combination of 60 kg N with 40 kg S ha^{-1} gave the highest yield (840.72 kg ha^{-1}) in comparison with other treatment; the results were in accordance with Jaggi *et al*. (1993). Among the nitrogen levels, maximum stover yield was recorded (1619.87 kg ha^{-1}) at 60 kg N ha^{-1}, the results corroborate with the findings of Patil (2016). Sulphur levels also showed significant effect on stover yield. Application of 40 kg S recorded highest stover yield (1557.58 kg ha^{-1}). The results were similar with Chaudhary *et al*. (2016). Combination of 60 kg N and 40 kg S ha^{-1} provided maximum stover yield (1713.30 kg ha^{-1}) in

Table 4: Interaction effect of N and S on number of branches.

	S_0	S_1	S_2	S_3		
N_0	1.27	1.33	1.47	1.47	(30 DAS)	SEm±0.07
N_1	1.17	1.20	1.57	1.60		CD(P=0.05)
N_2	1.53	1.60	1.57	1.53		0.21
N_3	1.53	1.53	1.77	1.57		
N_0	3.47	3.79	4.00	4.37	(60 DAS)	SEm±0.08
N_1	3.99	3.67	4.10	4.27		CD(P=0.05)
N_2	3.83	4.13	4.30	4.33		0.23
N_3	4.43	4.53	4.83	4.23		
N_0	7.00	6.97	8.00	7.77	(90 DAS)	SEm±0.10
N_1	8.27	7.17	8.20	7.12		CD(P=0.05)
N_2	7.13	7.63	7.77	8.17		0.29
N_3	8.36	8.60	9.05	8.63		
N_0	7.24	7.30	8.20	8.24	(At harvest)	SEm±0.14
N_1	8.38	7.55	8.20	7.32		CD(P=0.05)
N_2	7.34	7.82	7.93	8.10		0.40
N_3	8.51	8.63	9.27	8.79		

Table 5: Interaction of N and S on number of bolls plant^{-1}, no. of seeds boll^{-1}, seed yield and stover yield.

	S_0	S_1	S_2	S_3		
N_0	52.40	57.50	60.42	59.34	(No. of bolls plant^{-1})	SEm±0.71
N_1	57.83	51.46	59.31	52.91		CD(P=0.05)
N_2	53.57	56.70	56.91	57.15		2.05
N_3	60.49	64.66	67.56	64.76		
N_0	8.30	8.75	9.03	8.96	(No. of seeds boll^{-1})	SEm±0.11
N_1	8.79	8.52	8.82	8.35		CD(P=0.05)
N_2	8.32	8.58	8.76	8.71		0.33
N_3	9.08	9.12	9.91	9.36		
N_0	541.93	737.86	808.66	750.87	(Seed yield)	SEm±43.60
N_1	712.57	705.33	713.86	748.50		CD(P=0.05)
N_2	815.05	641.09	826.93	772.10		125.92
N_3	739.21	799.80	840.72	819.77		
N_0	1038.77	1288.83	1528.30	1646.50	(Stover yield)	SEm±72.04
N_1	1453.40	1335.60	1521.53	1302.43		CD(P=0.05)
N_2	1281.20	1413.80	1467.20	1615.10		208.07
N_3	1579.63	1609.50	1713.30	1573.83		

comparison to others treatments, this result was in accordance with the findings of Jaggi *et al*. (1993).

Available soil NPKS (kg ha^{-1})

A critical study of the data on available nitrogen in the soil revealed significant variation due to nitrogen levels. Available N in the soil increased with increasing levels of nitrogen from 0 to 60 (326.50 kg ha^{-1}), the present findings were similar with the findings of Gudeta *et al*. (2017), the N accumulation in seed and straw of the crop to some extent may be responsible for such a decline in nitrogen content in the soil. Moreover, N losses through leaching, denitrification and volatilization are also important for the decline, application of nitrogen from 0-60 kg ha^{-1} proved significant increase in the content of soil sulphur. The highest value of 12.81 mg kg^{-1} of soil was recorded with the application of 60kg N ha^{-1}, against the initial available soil sulphur content of 8.50 mg kg^{-1} (Table 2). The available sulphur content of soil after harvest of linseed increased with the increasing levels of sulphur from control (8.93 mg kg^{-1}) to 60 kg S ha^{-1} (18.76 mg kg^{-1}). Similar results was also observed by Gudeta *et al*. (2017).

Economic analysis

The maximum gross return was observed under treatment $N_{60}S_{40}$ as ₹86893, while net return was ₹62605.35 under $N_{60}S_0$ respectively (Table 6), while treatment recorded least gross return was under treatment N_0S_0 ₹73524.6 and net return ₹53417.1. The highest BC ratio was 2.90 noted to be under $N_{20}S_0$ treatment, followed by $N_{40}S_0$ (2.90).

Table 6: Effect of nitrogen and sulphur levels on gross return, net return and BC ratio of linseed.

Treatments	Gross return (₹)	Net return (₹)	Benefit cost ratio
N_0S_0	73524.6	53417.1	2.65
N_0S_{20}	78613.2	57173.7	2.66
N_0S_{40}	79625.6	56854.1	2.49
N_0S_{60}	78049.8	53946.3	2.23
$N_{20}S_0$	81685.4	60925.85	2.93
$N_{20}S_{20}$	82648.3	60556.45	2.74
$N_{20}S_{40}$	81644.2	58220.65	2.48
$N_{20}S_{60}$	81646	56890.45	2.29
$N_{40}S_0$	83521	62109.25	2.90
$N_{40}S_{20}$	78501.06	55757.31	2.45
$N_{40}S_{40}$	86074.8	61999.05	2.57
$N_{40}S_{60}$	84261.7	58853.95	2.31
$N_{60}S_0$	84669.4	62605.35	2.83
$N_{60}S_{20}$	84751.8	61355.85	2.62
$N_{60}S_{40}$	86893	62165.05	2.51
$N_{60}S_{60}$	83736.1	57676.15	2.21

Urea @ ₹15kg^{-1}, SSP @ ₹15 kg^{-1}, MOP @ ₹15 kg^{-1}.

Price of grain @ ₹50.

FYM @ 500 t^{-1}.

Labour charge @ ₹300 day^{-1}.

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