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 ha\(^{-1}\)) 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\(_2\)O\(_5\) 22.4 kg ha\(^{-1}\), K\(_2\)O 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 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 DISCUSSIONS

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 was found to be significant. Combined application of 60 kg N and 40 kg S ha$^{-1}$ gave the highest 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 Upadhyay 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 2.81 g was recorded

| Table 1: Effect of nitrogen and sulphur on growth and yield attributes of linseed. |
|---------------------------------|-----------------|----------------|----------------|----------------|----------------|----------------|
| **Nitrogen levels (kg ha$^{-1}$)** | **Plant height (cm)** | **No. of branches** | **Shoot dry weight** | **No. of bolls plant$^{-1}$** | **No. of seeds boll$^{-1}$** | **Test weight** |
| 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 | 0.02 |
| CD(P=0.05) | 1.84 | 0.20 | 0.13 | 1.02 | 0.17 | 0.04 |

| **Sulphur levels (kg ha$^{-1}$)** | **Plant height (cm)** | **No. of branches** | **Shoot dry weight** | **No. of bolls plant$^{-1}$** | **No. of seeds boll$^{-1}$** | **Test weight** |
|---------------------------------|-----------------|----------------|----------------|----------------|----------------|----------------|
| 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 |
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Application of up to 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 4.10 g 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 40 kg S ha\(^{-1}\) gave maximum yield (797.54 kg 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 40 kg S ha\(^{-1}\) gave maximum yield (797.54 kg 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 40 kg S ha\(^{-1}\) gave maximum yield (797.54 kg 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 40 kg S ha\(^{-1}\) gave maximum yield (797.54 kg 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 40 kg S ha\(^{-1}\) gave maximum yield (797.54 kg 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 40 kg S ha\(^{-1}\) gave maximum yield (797.54 kg ha\(^{-1}\)). Levels of nitrogen and sulphur had no significant effect on test weight.

### 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\(_2\)O\(_5\) (kg ha\(^{-1}\)) | Available S (mg kg\(^{-1}\)) |
|-----------|----------------------------|-------------------------------|-----------------------------|-----------------------------------|-----------------------------|
| Nitrogen  |                            |                               |                             |                                   |                             |
| 0         | 709.83                     | 1408.93                       | 295.94                      | 11.66                             |
| 20        | 720.07                     | 1403.24                       | 303.11                      | 12.23                             |
| 40        | 763.79                     | 1444.33                       | 308.99                      | 12.51                             |
| 60        | 799.87                     | 1619.07                       | 326.50                      | 12.81                             |
| SE±       | 21.80                      | 32.71                         | 5.16                        | 0.19                              |
| CD (P=0.05) | 62.96                   | 111.79                        | 14.89                       | 0.56                              |
| Sulphur   |                            |                               |                             |                                   |                             |
| 0         | 702.19                     | 1317.58                       |                             |                                   |
| 20        | 721.19                     | 1371.58                       |                             |                                   |
| 40        | 797.54                     | 1557.58                       |                             |                                   |
| 60        | 772.81                     | 1534.47                       |                             |                                   |
| SE±       | 21.80                      | 32.71                         |                             |                                   |
| CD (P=0.05) | 62.96                  | 111.79                        |                             |                                   |

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

|          | S0   | S1   | S2   | S3   |
|----------|------|------|------|------|
| N0       | 9.40 | 12.67| 10.63| 11.63|
| N1       | 11.60| 10.07| 11.33| 12.07| (30 DAS) SE±0.47 |
| N2       | 10.83| 12.07| 12.27| 13.73| CD(P=0.05) 1.35 |
| N3       | 12.80| 14.47| 15.67| 12.57|
| N0       | 20.33| 22.90| 23.03| 24.07|
| N1       | 21.13| 25.57| 23.23| 25.40| (60DAS) SE±0.80 |
| N2       | 23.37| 24.30| 28.27| 24.47| CD(P=0.05) 2.32 |
| N3       | 28.63| 29.17| 30.97| 30.63|
| N0       | 38.63| 40.90| 39.50| 41.17|
| N1       | 41.87| 39.13| 42.47| 39.40| (90DAS) SE±0.81 |
| N2       | 40.47| 41.27| 41.87| 44.03| CD(P=0.05) 2.35 |
| N3       | 44.50| 45.27| 49.43| 44.93|
| N0       | 40.30| 42.50| 41.10| 43.70|
| N1       | 42.67| 41.80| 43.80| 41.80| (at harvest) SE±1.27 |
| N2       | 43.60| 42.63| 44.35| 44.62| CD(P=0.05) 3.68 |
| N3       | 44.80| 46.12| 53.07| 46.23|

with the application of 60 kg N and 40 kg S ha\(^{-1}\) respectively. Application of up to 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 4.10 g 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 40 kg 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
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### Table 4: Interaction effect of N and S on number of branches.

| N  | S0   | S1   | S2   | S3   |
|----|------|------|------|------|
| N0 | 1.27 | 1.33 | 1.47 | 1.47 |
| N1 | 1.17 | 1.20 | 1.57 | 1.60 |
| N2 | 1.53 | 1.60 | 1.57 | 1.53 |
| N3 | 3.47 | 3.79 | 4.00 | 4.37 |
| N1 | 3.99 | 3.67 | 4.10 | 4.27 |
| N2 | 3.83 | 4.13 | 4.30 | 4.33 |
| N3 | 4.43 | 4.53 | 4.83 | 4.23 |
| N0 | 7.00 | 6.97 | 8.00 | 7.77 |
| N1 | 8.27 | 7.17 | 8.20 | 7.12 |
| N2 | 7.13 | 7.63 | 7.77 | 8.17 |
| N3 | 8.36 | 8.60 | 9.05 | 8.63 |
| N0 | 7.24 | 7.30 | 8.20 | 8.24 |
| N1 | 8.38 | 7.55 | 8.20 | 7.32 |
| N2 | 7.34 | 7.82 | 7.93 | 8.10 |
| N3 | 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.

| N  | S0   | S1   | S2   | S3   |
|----|------|------|------|------|
| N0 | 52.40| 57.50| 60.42| 59.34|
| N1 | 57.83| 51.46| 59.31| 52.91|
| N2 | 53.57| 56.70| 56.91| 57.15|
| N3 | 60.49| 64.66| 67.56| 64.76|
| N0 | 8.30 | 8.75 | 9.03 | 8.96 |
| N1 | 8.79 | 8.52 | 8.82 | 8.35 |
| N2 | 8.32 | 8.58 | 8.76 | 8.71 |
| N3 | 9.08 | 9.12 | 9.91 | 9.36 |
| N0 | 541.93| 737.86| 808.66| 750.87|
| N1 | 712.57| 705.33| 713.86| 748.50|
| N2 | 53.57| 56.70| 56.91| 57.15|
| N3 | 60.49| 64.66| 67.56| 64.76|
| N0 | 8.30 | 8.75 | 9.03 | 8.96 |
| N1 | 8.79 | 8.52 | 8.82 | 8.35 |
| N2 | 8.32 | 8.58 | 8.76 | 8.71 |
| N3 | 9.08 | 9.12 | 9.91 | 9.36 |
| N0 | 541.93| 737.86| 808.66| 750.87|
| N1 | 712.57| 705.33| 713.86| 748.50|
| N2 | 53.57| 56.70| 56.91| 57.15|
| N3 | 60.49| 64.66| 67.56| 64.76|
| N0 | 8.30 | 8.75 | 9.03 | 8.96 |
| N1 | 8.79 | 8.52 | 8.82 | 8.35 |
| N2 | 8.32 | 8.58 | 8.76 | 8.71 |
| N3 | 9.08 | 9.12 | 9.91 | 9.36 |
| N0 | 541.93| 737.86| 808.66| 750.87|
| N1 | 712.57| 705.33| 713.86| 748.50|
| N2 | 53.57| 56.70| 56.91| 57.15|
| N3 | 60.49| 64.66| 67.56| 64.76|
| N0 | 8.30 | 8.75 | 9.03 | 8.96 |
| N1 | 8.79 | 8.52 | 8.82 | 8.35 |
| N2 | 8.32 | 8.58 | 8.76 | 8.71 |
| N3 | 9.08 | 9.12 | 9.91 | 9.36 |

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 60 kg 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$_{0}$S$_{0}$ `73524.6 and net return `53417.1. The highest BC ratio was 2.90 noted to be under N$_{60}$S$_{0}$ treatment, followed by N$_{40}$S$_{0}$ (2.90).
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### 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 |
|------------|------------------|----------------|------------------|
| N₀S₀      | 73524.6          | 53417.1        | 2.65             |
| N₀S₂₀     | 78613.2          | 57173.7        | 2.66             |
| N₀S₄₀     | 79625.6          | 56854.1        | 2.49             |
| N₀S₆₀     | 80494.8          | 53496.3        | 2.23             |
| N₂₀S₀     | 81685.4          | 60925.85       | 2.93             |
| N₂₀S₂₀    | 82648.3          | 60556.45       | 2.74             |
| N₂₀S₄₀    | 81644.2          | 58220.65       | 2.48             |
| N₂₀S₆₀    | 81646           | 56890.45       | 2.29             |
| N₄₀S₀     | 83521           | 62109.25       | 2.90             |
| N₄₀S₂₀    | 75010.06         | 55757.31       | 2.45             |
| N₄₀S₄₀    | 86074.8          | 61999.05       | 2.57             |
| N₄₀S₆₀    | 84261.7          | 58853.95       | 2.31             |
| N₆₀S₀     | 84669.4          | 62605.35       | 2.83             |
| N₆₀S₂₀    | 84751.8          | 61355.85       | 2.62             |
| N₆₀S₄₀    | 86893           | 62165.05       | 2.51             |
| N₆₀S₆₀    | 83736.1          | 57676.15       | 2.21             |

Urea @ `15 kg⁻¹, SSP @ `15 kg⁻¹, MOP @ `15 kg⁻¹
Price of grain @ `50
FYM @500t⁻¹
Labour charge @ `300 day⁻¹

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