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Effect of nitrogen phosphorus and sulphur application on yield, quality, uptake and economics of linseed (*Linun usitatissimum* L.)

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Abstract
In the current study was oriented to examine the growth, yield, quality, nutrient uptake and economics of linseed (*Linun usitatissimum* L.) under different levels of nitrogen, phosphorus and sulphur application. The investigation was done at the Instructional farm, N. M College of Agriculture, N. A. U., Navsari (Gujarat) on heavy black soil during the winter season of 2016-19. Variable involved in this study were three treatments of nitrogen (50,75and 100 kg N/ha), three levels of phosphorus (25 and 50 kg P_2O_5 /ha) and three levels of sulphur(10,20 and 40 kg S/ha) laid out in Factorial Randomized Block Design. Result revealed that individual year and pooled analysis of seed yield, stover yield were found significantly higher under the application of 100 kg N/ha (N_3) which remained at pat with 75 kg N/ha (N_2).Incase of phosphorus levels result was found statistically highest under P_2 (50 kg P_2O_5/ ha).Application of (S_3) 40 kg S/ha was statistically higher and which remained at par with (S_2) 20 kg S/ha for seed and stover yield. Treatment effect was recorded significantly not differ in case of oil content present in seed. Interaction effects of treatments was recorded non significantl effect in all the parameters. Thus based on three years field experimentation, it is concluded that better yield, quality, nutrient uptake and net return of linseed can be gained by application N_2 (75 Kg N/ha), P_2 (50 kg P_2O_5 /ha) and S_2 (20 kg S/ha)in south Gujarat.

Keywords: INM, linseed, nitrogen, phosphorus and sulphur

Introduction
Linseed is an important *rabi* oilseed crop and is cultivated primarily for oil edible as well industrial purposes. Nutritionally, linseed is the best herbal source of Omega-3 and Omega-6 fatty acids which have immense medicinal effect on human body. In India 0.017 M ha with a total production 0.09 MT and productivity 574 kg per ha (Ministry of Agriculture &farmers welfare, Govt. of India, 2018-19).

Intensive cropping with high yielding varieties is causing a marked depletion of inherent macro and micro nutrient reserves of soil including nitrogen, phosphorus and sulphur. Nitrogen is also an integral part of chlorophyll, which is the primary absorber of light energy needed for photosynthesis. Consequently besides nitrogen (N), phosphorus (P), and the deficiency of sulphur (S) is frequently reported in Indian soils. Generally adjudged the fourth major nutrient because crops in general require S slightly less than phosphorus. Sulphur is very essential nutrient for synthesis of amino acids, fatty acids, and activity of proteolytic enzymes. Its fertilization improves both yield and quality of crops if adequate supply in the field is ensured. Keeping view these in mind, the present investigation is to be proposed.

Material and Method
The present investigation carried out during *rabi* season 2016-19 at instructional farm, N.M. College of Agriculture, Navsari Agricultural University, Navsari. Soil of the experimental field was clayey in texture with low medium and high rating of available nitrogen, phosphorus and potassium. For this experiment Factorial Randomized Block Design was used with eighteen treatment combinations. Treatment details such as levels of nitrogen (N_1:50 kg N/ha, N_2:75 kg N/ha, N_3:100 kg N/ha) levels of phosphorus (P_1:25 kg P_2O_5/ha, P_2:50 kg P_2O_5/ha) and sulphur (S_1:20 kg S/ha, S_2:40 kg S/ha) with three replications. The Linseed variety local shown at 30 cm row spacing using seed rate 25 kg ha^{-1} on second week of November (2016-19) and harvested on second week of march (2016-19).

As a source of nutrients nitrogen (urea), phosphorus (Diammonium phosphate) and sulphur (elemental sulphur) are being used. Half dose of nitrogen and full dose of phosphorus was applied as basal and half dose of nitrogen applied after 30 DAS. Entire quantity of sulphur was incorporated in soil according to the treatments. The growth and yield attributing observation taken by using biometric method were recorded on randomly selected five plants in each plot and average value were utilized for analysis of data. Presence of oil content in seed (%) obtained by using the Soxhlet's apparatus.

Effect on crop growth and yield attributes (Table 1)

On the basis of pooled mean of three years (2016-2019) at harvest growth attributes such as plant height was significantly higher with N_3 and remained at pat with N_2. In case of number of branches was found non significant effect. Yield attributes like Number of capsules per plant, seed yield per plant (g) and test weight was significantly highest with N_3. Number of seed per capsule and stover yield per plant was found non significant effect. In case of phosphorus effect indicated that growth attributes like plant height and number of branches were found non significant. Number of capsules per plant and seed yield per plant were found significantly highest with the treatment P_2 (50 kg P_2O_5 /ha). Other attributes such as number of seeds per capsule, stover yield per plant and test weight were found non significant effect. In case of sulphur levels were observed non significant effect on plant height, number of branches, number of seeds per capsule and stover yield per plant and test weight. The application of S_3 was significantly higher in case of number of capsules per plant and seed yield per plant which remained at par with S_2. The interaction effects in respect of all the growth and yield attributes were failed to get the level of significance during individual as well as pooled analysis at harvest. Nitrogen, phosphorus and sulphur elements play great role for growth and development of plant. It may be due to positive effect of nitrogen and phosphorus and sulphur on growth and yield characters due to augment of cell division and cell expansion. The similar findings were also reported by Choudhary *et al*., (2016) [3], Singh *et al*., (2013) [4] and Dubey *et al*., (1997) [10].

Table 1: Growth and yield attributes at harvest of linseedas influenced by different treatment (Pooled over 3 years)

Treatment	Plant height (cm)	Number of branches	Number of capsules per plant	Number of seeds per capsule	Seed yield per plant (g)	Stover yield per plant (g)	Test weight (g)
Levels of nitrogen							
N_1	55.62	6.54	37.74	6.27	1.39	3.52	6.00
N_2	57.81	6.69	41.72	6.42	1.47	3.60	6.19
N_3	58.81	6.79	43.42	6.51	1.57	3.68	6.28
S.Em. ±	0.89	0.09	0.57	0.08	0.02	0.04	0.06
C.D. (0.05)	2.51	NS	1.60	NS	0.06	NS	0.18
Levels of phosphorus							
P_1	56.92	6.62	39.77	6.33	1.39	3.56	6.10
P_2	57.91	6.73	42.14	6.48	1.56	3.64	6.22
S.Em. ±	0.72	0.07	0.45	0.07	0.02	0.04	0.05
C.D. (0.05)	NS	NS	1.28	NS	0.05	NS	NS
Levels of sulphur							
S_1	56.87	6.57	38.81	6.20	1.39	3.53	6.07
S_2	57.22	6.68	41.27	6.48	1.50	3.60	6.18
S_3	58.16	6.77	42.79	6.53	1.55	3.67	6.23
S.Em. ±	0.88	0.09	0.55	0.09	0.02	0.04	0.06
C.D. (0.05)	NS	NS	1.56	NS	0.06	NS	NS
Interaction							
NXY S.Em. ±	1.56	1.16	0.97	0.15	0.04	0.04	0.05
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS
PXY S.Em. ±	1.27	0.13	0.79	0.12	0.03	0.07	0.09
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS
SXY S.Em. ±	1.56	0.16	0.97	0.15	0.04	0.04	0.05
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS
NXPXSXYS.Em.±	3.82	0.39	2.38	0.38	0.10	0.21	0.28
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS
C. V. %	11.54	10.33	10.10	10.43	12.29	10.17	7.91

Yield and harvest index (Table 2)

An appraisal of data in Table 2 indicated that in individual year treatment N_3 (100 kg N/ha) produced significantly higher grain yield and stover yield which remain at par with N_2 (75 kg N/ha). In case of pooled mean of three years grain yield and straw yield were significantly higher (861 kg/ha and 1862 kg/ha) where in respect of harvest index did not differ significantly. During three years of experimentation treatment P_2 gave significantly highest grain yield and straw yield. Pooled analysis data on grain and straw yield was found significantly highest with P_2 (50 kg P_2O_5/ha). Harvest index was found non significant effect. The result of experiment indicated that during all the individual years as well as pooled result on grain and straw yield (865 kg/ha and 1863 kg/ha) were found significantly higher with S_3 (40 kg S/ha) which remain at par with S_2 (20 kg S/ha). The interaction effects in respect of nitrogen phosphorus and sulphur levels did not reach the level of significance in respect of grain yield and straw yield during individual years and pooled analysis. Harvest index during the individual year of experimentation and pooled analysis did not found significant. The probable reason might be balanced fertilization increased photosynthetic efficiency and enhanced the yield of the crop. The results are in conformity with findings of Singh *et al*., (2013) [4] Dohat *et al*., (2017) [5]. and Dubey *et al*., (1997) [10],

Table 2: Seed yields, stover yields and harvest index of linseed as influenced by different treatment

Treatment	Seed yield (kg/ha)				Stover yield kg/ha)				Harvest Index			
	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled
Levels of nitrogen												
N_1	853	542	840	745	1922	1229	1689	1614	30.78	30.74	33.30	31.61
N_2	941	612	947	833	2154	1372	1890	1805	30.46	30.84	33.41	31.57
N_3	994	621	969	861	2203	1432	1953	1862	31.05	30.41	33.25	34.58
SEm±	23.86	16.67	23.49	12.40	51.06	43.26	61.43	29.83	0.36	0.80	0.30	0.30
CD (0.05)	68.62	47.96	67.58	34.80	146.84	124.43	176.67	83.75	NS	NS	NS	NS
Levels of phosphorus												
P_1	868	561	879	769	1948	1287	1765	1667	30.81	30.50	33.34	31.55
P_2	991	623	958	857	2238	1401	1923	1854	30.72	30.82	33.30	31.61
SEm±	19.48	13.61	19.20	10.28	41.69	35.32	50.15	25.02	0.29	0.65	0.24	0.25
CD (0.05)	56.03	39.16	55.22	28.76	119.90	101.60	144.25	70.28	NS	NS	NS	NS
Levels of sulphur												
S_1	839	538	851	743	1899	1230	1751	1613	30.65	30.46	33.34	31.49
S_2	955	598	943	832	2158	1366	1889	1805	30.72	30.51	33.35	31.53
S_3	995	639	962	865	2221	1436	1947	1863	30.92	31.00	33.27	31.73
SEm±	23.86	16.67	23.49	12.40	51.06	43.26	61.43	29.83	0.36	0.80	0.30	0.30
CD (0.05)	68.62	47.96	67.58	34.80	146.84	124.43	176.67	84.17	NS	NS	NS	NS
Interaction												
NXY S.Em.±	-	-	-	21.60	-	-	-	52.45	-	-	-	0.53
C.D. (0.05)	-	-	-	NS	-	-	-	NS	-	-	-	NS
PXY S.Em.±	-	-	-	17.63	-	-	-	42.82	-	-	-	0.44
C.D. (0.05)	-	-	-	NS	-	-	-	NS	-	-	-	NS
SXY S.Em.±	-	-	-	21.60	-	-	-	52.45	-	-	-	0.53
C.D. (0.05)	-	-	-	NS	-	-	-	NS	-	-	-	NS
NXPXSXY S.Em.±	-	-	-	52.91	-	-	-	128.47	-	-	-	1.32
C.D. (0.05)	-	-	-	NS	-	-	-	NS	-	-	-	NS
CV%	10.89	11.95	10.85	11.27	10.35	13.66	14.13	12.64	-	-	-	-

Table 3: Oil content, nutrient content (seed and stover) of linseed as influenced by different treatment

Treatment	Oil content in seed (%)	Nutrient content in seed (%)				Nutrient content in stover (%)			
		N	P_2O_5	K_2O	S	N	P_2O_5	K_2O	S
Levels of nitrogen									
N_1	37.27	2.15	0.79	2.63	0.14	0.71	0.30	1.76	0.07
N_2	37.85	2.24	0.82	2.67	0.15	0.72	0.31	1.84	0.07
N_3	38.20	2.29	0.84	2.78	0.15	0.75	0.33	1.89	0.08
SEm±	0.38	0.04	0.01	0.04	0.002	0.01	0.01	0.04	0.002
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of phosphorus									
P_1	37.43	2.19	0.80	2.64	0.14	0.71	0.30	1.81	0.07
P_2	38.12	2.25	0.82	2.74	0.15	0.73	0.32	1.84	0.08
SEm±	0.31	0.04	0.01	0.04	0.002	0.01	0.01	0.04	0.002
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Levels of sulphur									
S_1	37.20	2.16	0.79	2.62	0.14	0.70	0.30	1.77	0.07
S_2	37.87	2.23	0.81	2.69	0.15	0.73	0.31	1.82	0.07
S_3	38.25	2.27	0.83	2.75	0.15	0.74	0.32	1.88	0.08
SEm±	0.38	0.04	0.01	0.04	0.002	0.01	0.01	0.04	0.002
C.D.(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction									
NXY S.Em.±	0.66	0.07	0.03	0.05	0.004	0.02	0.005	0.06	0.005
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
PXY S.Em.±	0.54	0.06	0.02	0.04	0.003	0.01	0.003	0.05	0.002
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
SXY S.Em.±	0.66	0.07	0.03	0.05	0.004	0.02	0.005	0.06	0.005
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
NXPXSXY S.Em.±	1.63	0.16	0.12	0.09	0.006	0.006	0.012	0.11	0.006
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	7.50	7.79	7.23	7.05	6.91	7.11	9.31	8.45	10.34

Nutrient content and uptake by seed and stover

On the basis of pooled analysis, significantly not differ N,P,K,S content in seed and stover and also oil content in seed. In case of uptake of N and S by seed and stover were found significantly higher with treatment N_3 which remain at par with N_2 where in case of P and K uptake by seed and stover were found non significant effect. In case of the N,P,K,S content in seed and stover in linseed were found non significant effect. Table 4 indicated that pooled data of nutrient uptake of N,K,S in seed and N,P,K,S by stover was

fond significantly highest with treatment P_2. Phosphorus uptake by seed was found statistically at par P_2 with P_1.The pooled data showed that nutrient content of N,P,K,S in seed and stover of linseed werefound non significant effect. In case of N, P uptake by linseed seed and N, P, K, S stover were observed significantly higher with S_3 and remain at par with S_2.The result of nutrients uptake of K and S by seed were found significantly highest with S_3 treatment. The interaction effects was found non significant effect. This might be due to the favorable effect of nutrients on growth and yield attributes and ultimate increased the nutrient uptake. The results are corroborate the findings of Sune *et al*.,(2006) [11], Patel Urvina N (2015) [8] Awasthi *et al*.,(2011) [2] and Tiwari *et al*.,(2018) [12].

Table 4: Nutrient uptake (seed and stover) of linseed as influenced by different treatment

Treatment	Oil content in seed (%)	Nutrient uptake by seed (kg/ha)				Nutrient uptake by stover (kg/ha)			
		N	P_2O_5	K_2O	S	N	P_2O_5	K_2O	S
Levels of nitrogen									
N_1	37.27	18.44	6.76	22.60	1.20	13.58	5.87	33.93	1.41
N_2	37.85	21.12	7.68	25.16	1.39	15.67	6.65	39.70	1.60
N_3	38.20	22.82	8.38	27.64	1.45	16.52	7.23	41.62	1.71
SEm±	0.38	0.69	0.21	0.70	0.04	0.43	0.22	1.08	0.05
C.D.(0.05)	NS	1.94	0.59	1.99	0.12	1.21	0.55	3.05	0.13
Levels of phosphorus									
P_1	37.43	19.18	8.03	23.05	1.24	13.93	5.98	35.50	1.46
P_2	38.12	22.39	8.17	27.21	1.44	16.57	7.11	41.33	1.69
SEm±	0.31	0.69	0.21	0.70	0.04	0.43	0.22	1.08	0.05
C.D.(0.05)	NS	1.94	0.59	1.99	0.12	1.21	0.55	3.05	0.13
Levels of sulphur									
S_1	37.20	18.26	6.69	22.16	1.18	13.41	5.79	33.90	1.61
S_2	37.87	21.48	7.81	25.84	1.38	15.82	6.70	39.44	1.61
S_3	38.25	22.63	8.30	27.39	1.46	16.53	7.24	41.90	1.69
SEm±	0.38	0.69	0.21	0.70	0.04	0.43	0.22	1.08	0.05
C.D.(0.05)	NS	1.94	0.59	1.99	0.12	1.21	0.55	3.05	0.13
Interaction									
NXY S.Em.±	0.66	1.22	0.59	1.28	0.08	0.98	0.80	2.20	0.15
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
PXY S.Em.±	0.54	1.10	0.40	1.13	0.07	0.78	0.64	0.13	0.12
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
SXY S.Em.±	0.66	1.22	0.59	1.28	0.08	0.98	0.80	2.20	0.15
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
NXPXSXY S.Em.±	1.63	2.60	1.98	2.56	1.27	2.80	2.30	5.60	0.56
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	7.50	14.00	11.77	11.84	13.67	11.94	12.65	11.88	12.29

Economics

The data presented in Table 5 in respect to cost of cultivation, gross monetary return, net monetary return and benefit cost ratio was not analyzed statistically and inference are drawn on average values. The maximum gross monetary returns (Rs.60291/ha), net monetary returns(Rs.30760/ha) and B:C ratio (1.87) recorded by N_3 but in case of seed yield of linseed N_3 was statistically at par with N_2. Treatment P_2 (50 kg P_2O_5/ha) recorded higher gross monetary returns (Rs.59990/ha), net monetary returns (Rs.30036/ha) and B:C ratio (0.92) over P1 (25 kg/ha).seed yield was significantly highest with treatment P_2.Application of 40 kg S/ha was recorded maximum gross monetary returns (Rs.60550/ha), net monetary returns(Rs.31577/ha) and B:C ratio (1.02) over lower levels. Seed yield of linseed was significantly higher with S_3 and remain at par with S_2.

Table 5: Economics of linseed as influenced by different treatment

Treatment	Yield (kg/ha) seed	Cost of cultivation(Rs./ha)	Gross Monetary Return(Rs./ha)	Net Monetary Return(Rs./ha)	B:C ratio
Nitrogen levels					
N_1	745	28970	52170	23200	0.80
N_2	833	29125	58330	29205	1.00
N_3	861	29531	60291	30760	1.04
Phosphorus levels					
P_1	769	28434	53830	25407	0.89
P_2	857	29806	59990	30184	1.01
Sulphur levels					
S_1	743	27314	52010	24696	0.90
S_2	832	28735	58240	29505	1.02
S_3	865	31577	60550	28973	0.91

Selling Price: Linseed seed - 70 Rs./kg

Cost of Input: Linseed 160Rs./kg, Urea-5.7 Rs./kg, DAP - 27.17 Rs./kg, Elemental sulphur-135 Rs./kg

Conclusion

From the above results, it can be concluded that cultivation of linseed during *rabi* season fertilized with (75:50:20 NPS kg/ha) for getting higher yield, quality, nutrient uptake and net return as compared to other treatment combinations.

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