J. Agric. Res. Technol., 47 (1) : 012-017 (2022) https://doi.org/10.56228/JART.2022.47103

Effect of Sulphur on Linseed Cultivars Under Rain Fed Condition

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(Received : 12.05.2021 Accepted : 06.06.2021)

Abstract

A field experiment was conducted on the Dryland Farming Research Station, Zonal Agriculture Research Station, Solapur for the five consecutive years (*Rabi*) from 2016-17 to 2020-21 to study the effect of sulphur on linseed cultivars under rainfed condition. Application of recommended dose $N:P_2O_5:K_2O$ (25:50:0) kg ha^{-1} with FYM 2.51 ha^{-1} + 40 kg ha^{-1} sulphur recorded significantly higher grain and straw yield of linseed (4.76 and 8.80 q ha^{-1}) highest gross monetary return, net monetary returns and BC ratio (25794, 8990 and 1.57), respectively. However, the effect of different Interaction among the parameters tested were found to be non-significant.

Key words : Linseed, Gain yield, straw yield, sulphur, GMR, NMR, BC ratio

Linseed (*Linum usitatissimum* L.) is an oil seed and fiber crop and locally known as jawas or flexseeds. Linseed have nutritional characteristics and are rich source of omega-3 fatty acid: - linolenic acid (ALA), short chain polyunsaturated fatty acid (PUFA), soluble and insoluble fibers, proteins and array of antioxidants (Ivanova *et al*. 2011). Seed contain 33-47% oil which is used for both edible and industrial purpose (paint, varnishes, printing ink and soaps etc.). Most of the world oilseed production occurs in the semi -arid tropics where the average yield is low. Also most of the oilseeds, being drought tolerant in nature, suffer from sulphur deficiency resulting in low yield. Growing these energy rich oilseed crops under rainfed situation, low fertility and vagaries of weather conditions are the main reason for low productivity (Singh, 1999).

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India is the second largest (21.21%) linseed growing country in the world after Canada and production wise it ranks fourth (8.20%) in the world after Canada (40.51%). Among the Rabi oil seed crop, linseed occupy the second position i.e. next to rapeseed- mustard in areas as well as production. It cultivated on about 4.36 lakh ha with the contribution of 1.67 lakh tones to the annual oilseed production of the country (Diwan *et al.* 2019). In Maharashtra, linseed is grown on 68.0 thousand ha. With productivity of 279 kg ha^{-1} which is well below the national average (Anonymous, 2010) Sulphur ranks 13th in terms of abundance in the earth's crust and is the fourth major plant nutrient after N, P and K (Kanwar and Mudahar, 1986). Among the fertilizer elements, sulphur requirement of oil seed is quite high as compared to other crop (Srivastava *et al*. 2000). Sulphur is not mobile in the plant, so a continuous supply of sulphur is needed from emergence to crop maturity A deficiency of sulphur at any stage of growth can result in reduced yields, Sulphur play an important role in the formation of amino acids, synthesis of proteins, chlorophyll and oil (Singh

and Singh 2007). Most of the world oilseed production occurs in the semi-arid tropics suffer from sulphur deficiency resulting in low yield. Sulphur fertilization influences the composition of the oil. Amongst the nutrients, sulphur deficiency is widespread in Indian soil due to wide gap between removal of sulphur and its addition in the soil. The continuous use of S-free fertilizers resulted in the depletion of S from the soil reserves. Sulphur deficiency tends to adversely affect the growth and yield of oil seed crops to the extent of 10-30 percent due to its poor nourishment. The high yielding genotypes are coming forward which require variable quantity of sulphur due to their variable genetic makeup (Upadhyay, 2012). Sulphur deficiency can be corrected by application of sulphur containing fertilizers viz gypsum, ammonium sulphate and single super phosphate etc. Elemental sulphur fertilizers are granular with 90 to 99 per cent sulphur in the elemental form and cannot be directly used by plants. It must first be converted to sulphate-sulphur (S04-2-S) by soil microorganisms

Keeping in view the importance of sulphur for oilseed, a field experiment was under taken to study the effect of sulphur on linseed cultivars under rainfed condition.

Materials and Methods

The field experiment was conducted on the Dryland Farming Research Station, Zonal Agriculture Research Station, Solapur for the five consecutive years (*Rabi*) from 2016-17 to 2020-21 The experiment was laid out in Factorial Randomized Block Design (FRBD) with 12 treatment combination with net plot size 3.60 x 2.40 m^2. The GRDF 25:50:00 kg N. P_2O_5, K_2O with FYM 2.5 t ha^{-1} was applied in all treatments. The three main treatments (varieties) and four sub main treatments (sulphur levels) replicated three times. The main treatments are V_1 : NL-97. V_1 : PKV NL 260 and V_3 - Padimini and items are different sulphur levels i.e. S_1 - O kg ha^{-1}, S_2 - 20 kg ha^{-1}, S_3 - 30 kg ha^{-1} and S_4 - 40 kg ha^{-1} Sulphur was applied through elemental sulphur with FYM 2.5 ton 15 days before sowing and pre sowing *in-situ* moisture conservation through compart-mental bunding (3.60 x 3.60 m) followed by linseed sowing and flatbed preparation. Seeds was treated with Bavistin @ 1.5 g kg^{-1} of seed before sowing to control seed born disease. Soil pH was measured in 1:2 soil water suspensions where 10 gm of soil was taken and stirred intermittently for 30 minutes with 20 ml of water and measured with pH meter (McLean. 1982). The electrical conductivity was measured in 1:2 soil water suspensions using conductivity meter (Rhondes, 1982) N, P and K content of crop residues were analyzed by standard procedures outline by Jackson(1973). Organic carbon by (Walkley and Black, 1934) Available N (Subbaiah and Asija, 1956); Available P_20_5, (Olsen *et al*., 1954) and Available K_2O (Knudsen und Peterson, 1982). Sulpher (Singh *et al.* 1988). The data obtained in respect of the observations was statistically analyzed by Panse and Sukhatme (1985)

Results and Discussion

Growth characters : The pooled data of effect of different varieties and sulphur levels showed significant effect on growth characters was presented in Table 1. As regarding the varieties, treatment V_1 ie. NL-97 recorded maximum plant population (1,64,014 plants ha^{-1}) than rest of the treatments with significantly higher plant height, No. of branches $plant^{-1}$ and No. of capsules $plant^{-1}$ (42.09, 5.41 and 50.34) respectively.

For different sulphur levels, the treatment S_4 i.e. 40 kg sulphur ha^{-1} recorded maximum plant population (172819) ha^{-1} whereas minimum plant population in the treatment S_1 i.e. 0 kg sulphur (151969) ha^{-1}. Treatment S_4 i.e. 40 kg sulphur ha^{-1} also recorded significantly higher

plant height, No. of branches plant^{-1} and No. of capsules plant^{-1} (41.91, 6.09 and 50.72) respectively which was at par with treatment S_3 i.e 30 kg sulphur ha^{-1}. These findings was in agreement with the findings of Banerjee *et al*. (2001). Cell division and cell expansion are the prime characteristics of dynamics for increasing in height and number of branches. Sulphur is the constituents of a number of amino acids which are essential for the growth and development of plant tissues (Virosanoo Solo *et al*. 2021). The number of capsules plant^{-1} were increased significantly with increasing sulphur levels. This might be because of better growth of plant due to more availability of sulphur and which was in agreement with Patil *et al*. (2018). The interaction effect between effect of varieties and sulphur levels was found non-significant. Higher dose of sulphur was responsible for increased leaf area and chlorophyll content of leaves causing higher photosynthesis and assimilation, metabolic activities which were responsible for overall improvement in vigour and yield attributes and finally seed yield (Chaubey and Dwivedi, 1995. Upadhyay *et al*., 2012). Sulphur is mainly responsible for enhancing the reproductive growth and the production of reproductive tissues (inflorescence and capsules) (Grath and Zhao, 1996).

Yield characters and economics : The pooled data of effect of varieties and sulphur levels on yield contributing characters and economics showed significant effect and presented in Table 2. As regarding the verities, treatment V_1 i.e. NL-97 recorded significantly higher thousand seed weight, grain and straw yield (6.08 gm., 4.53 and 8.44 q ha^{-1}) respectively than all other treatments. The treatment V_2 i.e. PKV NL 260 recorded significantly lower grain and straw yield (4.14 and 7.17 q ha^{-1}) respectively.

For sulphur levels, treatment S_4 i.e. 40 kg ha sulphur recorded significantly higher thousand seed weight, grain and straw yield (5.83 gm, 4.77 and 8.80 q ha^{-1}) respectively than all other treatments. The treatment S, i.e. 0 kg ha sulphur recorded significantly lower thousand seed weight, grain and straw yield (5.49 gm, 3.56 and 6.68 q ha^{-1}). This might be because of better growth of plant due to availability of sulphur leading to increased number of capsules plant as seed yield directly related to the growth and yield attributes. Higher straw yield might be due to increased growth and yield parameters resulting into more dry matter accumulation plant. Similar results were also reported by Patil *et al*. (2018) and Sune *et al*., (2006). Substantial yield increases can be obtained by applying sulphur fertilizer to crops having sulphur demand that cannot be satisfied by soil sulphur supply Seed yield and stover yield increased significantly with increasing levels of sulphur due to proper partitioning of photosynthesis from source to sink (Singh *et al*. 2017). The increased in yield

Table 1. Effect of sulphur on morphological characters of linseed as affected by different treatments during (pooled mean 2016-17 to 2020-21)

Treatment	Plant population ha^{-1}	Plant height (cm)	No. of branches plant^{-1}	No. of cap. plant^{-1}
Main plot Treatment				
V_1 : NL-97	164014	42.09	5.41	50.34
V_2 : PKV NL 260	161837	38.88	4.85	43.84
V_3 : Padmini	160314	40.27	5.05	43.08
SE±	5902	0.70	0.27	1.68
CD 5%	N.S.	2.19	0.83	5.24
Sub plot Treatment				
S_1 : 0 kg ha^{-1}	151969	38.26	4.35	40.29
S_1 : 20 kg ha^{-1}	160110	39.54	4.60	42.14
S_1 : 30 kg ha^{-1}	163943	40.59	5.18	45.68
S_1 : 40 kg ha^{-1}	172819	41.91	6.09	50.72
SE±	7207	0.98	0.27	1.98
CD 5%	N.S.	2.75	1.00	5.92
Interaction				
SE±	5984	1.70	0.67	3.92
CD 5%	N.S.	N.S.	N.S.	N.S.

of linseed crop may be attributed to improve yield attributes (Basumatary *et al*., 2019). The interaction effect between effect of varieties and sulphur levels was found non-significant.

Table 2. Effect of sulphur on yield and economics of linseed as affected by different treatments during (pooled mean 2016-17 to 2020-21)

Treatment	Thousand seed weight (gm)	Crop Yield (q ha^{-1})		Economies (Rs. ha^{-1})		
		Grain	Straw	GMR	NMR	B:C ratio
Main plot Treatment						
V_1 : NL-97	6.08	4.53	8.44	24590.2	9821	1.65
V_2 : PKV NL 260	5.45	4.14	7.17	22311.0	7542	1.49
V_3 : Padmini	5.27	4.20	7.27	22691.6	7923	1.52
SE±	0.08	0.08	0.36	208.3	511	0.04
CD 5%	0.24	0.26	0.92	649.8	1500	0.12
Sub plot Treatment						
S_1 : 0 kg ha^{-1}	5.49	3.56	6.68	21601.2	7658	1.54
S_1 : 20 kg ha^{-1}	5.58	3.81	7.28	22592.6	7501	1.49
S_1 : 30 kg ha^{-1}	5.71	4.17	7.56	23352.0	7174	1.46
S_1 : 40 kg ha^{-1}	5.83	4.77	8.80	25794.8	8990	1.57
SE±	0.11	0.09	0.31	206.6	324	0.02
CD 5%	0.35	0.28	0.99	612.8	1010	0.06
Interaction						
SE±	0.18	0.74	0.55	1226.5	788	0.18
CD 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 3. Effect of sulphur on soil properties as affected by different treatments during (pooled mean 2016-17 to 2020-21)

Treatment	pH	EC (dsm^2)	OC (%)	Available Nutrients (Kg ha^{-1})			Available sulphur (ppm)
				N	P	K	
Main plot Treatment							
V_1 : NL-97	7.82	0.22	0.45	166.90	18.55	648	6.94
V_2 : PKV NL 260	7.81	0.21	0.46	168.15	18.58	649	7.42
V_3 : Padmini	7.80	0.21	0.46	167.95	18.85	649	7.01
SE±	0.007	0.002	0.002	0.90	0.27	0.517	0.047
CD 5%	N.S.	0.006	N.S.	N.S.	0.78	N.S.	0.133
Sub plot Treatment							
S_1 : 0 kg ha^{-1}	7.82	0.23	0.45	165.40	18.99	648.33	6.03
S_1 : 20 kg ha^{-1}	7.80	0.25	0.47	169.86	18.61	650.73	7.21
S_1 : 30 kg ha^{-1}	7.80	0.25	0.46	169.40	19.05	649.86	7.44
S_1 : 40 kg ha^{-1}	7.82	0.24	0.47	166.00	19.28	647.60	7.81
SE±	0.008	0.002	0.002	1.04	0.31	0.597	0.054
CD 5%	0.023	N.S.	N.S.	2.99	N.S.	1.708	0.154
Interaction							
SE±	0.014	0.004	0.004	1.81	0.55	1.035	0.093
CD 5%	N.S.	N.S.	0.012	5.19	N.S.	2.95	N.S.

Economics : The effect of different variety treatment V_1 i.e. NL-97 showed significant effect on GMR, NMR and B:C ratio (24590, 9821 Rs. ha^{-1} and 1.65) respectively over rest of the treatment. As regarding the sulphur levels, treatment S_4 i.e.40 kg sulphur ha^{-1} recorded significantly higher GMR, NMR and B:C ratio (25794, 8890 Rs. ha^{-1} and 1.57) respectively over rest of the treatments. The interaction effect between effect of varieties and sulphur levels was on yield characters and economics was found non-significant.

Soil Properties : The data regarding pooled mean of soil pH , EC, Organic carbon, Available N, P and K content and sulphur content are reported in Table 3 revealed that the soil pH was found to be non-significant due to different varieties and sulphur levels and its interaction. The data regarding EC was found significant due to varieties but non-significant to sulphur levels and its interaction. The organic carbon content was found non-significant for varieties and sulphur levels but its interactions were found significant. The available N content for varieties was non-significant. However sulphur levels S_2 i.e. 20 kg ha^{-1} with RDF showed significantly higher available N (169.86 kg ha^{-1}) over the rest of the treatment. However it was at par with S_3 and S_4 treatment (169.40 and 166 kg ha^{-1}). The data regarding available phosphorus found significant due to varieties but non-significant sulphur levels and its interaction. As regards to potassium varieties should non-significant. However S_2 levels showed higher available potassium (650.73 kg ha^{-1}) over the rest of sulphur levels. However its interactions was found significant.

The pooled data regarding effect of varieties and sulphur levels on available sulphur showed significant difference but its interaction were non-significant. The 40 kg sulphur recorded significantly higher soil available sulphur (7.81 ppm) after the harvest over the rest of sulphur levels. Simillar results was also observed by Virosanuo Solo *et al*. (2021) and Gudeta *et al.* (2017).

Conclusion

Application of recommended dose $N:P_2O_5:K_2O$ (25:50:0) kg ha^{-1} with FYM 2.5 ton ha^{-1} + 40 kg ha^{-1} sulphur recorded significantly higher grain and straw yield of linseed (4.76 and 8.80 q ha^{-1}) highest gross monetary return, net monetary returns and B:C ratio (25794, 8990 Rs. ha^{-1} and 1.56), respectively.

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