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EFFECT OF SULPHUR ON GROWTH, YIELD AND QUALITY PARAMETERS OF LINSEED (*Linum usitatissium* L.)

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ABSTRACT

The present investigation entitled "Effect of sulphur on growth, yield and quality of linseed (*Linum usitatissium* L.)" was conducted at Department of Agronomy farm, College of Agriculture, Nagpur during *rabi* season of year 2017-18 in randomized block design with three replications. The treatments included T_1- RDF (60:30:00 NPK kg ha^{-1}), T_2- RDF + 15 kg S ha^{-1} through gypsum, T_3- RDF + 20 kg S ha^{-1} through gypsum, T_4- RDF + 25 kg S ha^{-1} through gypsum,T_5- RDF + 15 kg S ha^{-1} through bensulf, T_6- RDF + 20 kg S ha^{-1} through bensulf,T_7- RDF + 25 kg S ha^{-1} through bensulf and T_8- No fertilizer (control). The results of the study indicated that application of RDF + 25 kg S ha^{-1} through bensulf recorded higher growth, yield attributing and quality parameters viz., plant height, number of branches plant^{-1}, number of days to 50% flowering, dry matter plant^{-1}, seed and straw yield (kg ha^{-1}), protein per cent and oil per cent.

(Key words: Linseed, sulphur, growth ,yield and quality)

INTRODUCTION

Linseed (*Linum usitatissimum* L.) is one of the oldest *rabi* oilseed crop under cultivation. It belongs to the family *Linaceae* and is native to Mediterranean region and Southwest Asia. The Genus *Linum* has over 200 species of which *Linum usitatissimum* (L.) is the only widely cultivated economically important species. It has somatic chromosome number 2n=30 and varies from 16 to 86 in other species. It is an annual plant grown during *rabi* season in India. Two morphologically distinct cultivated species of linseed are recognized, namely flax and linseed. The flax type is commercially grown for the extraction of fiber, whereas the linseed is meant for the extraction of oil from seed. It is the third largest natural fibre crop and one of the five major oilseed crops in the world.

Linseed (*Linum usitatissimum* L.) is a pristine crop cultivated since ages getting its mention in *Vedas* and *manusmriti.* At present it is widely cultivated in Asia, Europe, America and Africa for oil. Each and every part of plant is endowed with some quality. It's medicinal and nutraceutical properties have paved the way for its diversified uses and value addition in various forms. Its seed comprises of complete protein (rich in eight essential amino acids), higher order linolenic acid (an essential poly unsaturated Omega-3 fatty acid) highest in plant kingdom, complex carbohydrates, vitamins and minerals. A recent advance in neuro-biology has established that it is the best herbal source of Omega-3 (57%) and Omega-6 fatty acid (8%) which helps in regulating the nervous system. It also have a property of lowering down the cholesterol level in mammals. Lignin present in oil has anti-carcinogenic effect. The lustrous fiber of Linseed (Flax) coupled with strength, durability; blending quality with natural and artificial fibers has made its fiber an essential raw material for high value linen industry.

India contributes about 10.81 per cent and 5.3 per cent to world area and production respectively. The major linseed growing states of country are Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Maharashtra, Bihar, Orissa, Jharkhand, West Bengal, Nagaland and Assam, accounting for about 97% of total area of nation. In Maharashtra it is cultivated on an area of 14.2 thousand ha with the production of 3.4 thousand tones and having productivity of 239 kg ha^{-1} and in Vidarbha region, it is grown on area of 9.3 thousand ha with the productionof 1.7 thousand tones and having productivity of 180 kg ha^{-1} (Anonymous, 2016). The present production of oilseed is not sufficient to meet demand for consumption and also for industrial use. Considered the above facts present investigation was undertaken to study the response of sulphur on growth, yield and quality parameters of linseed.

MATERIALS AND METHODS

The present investigation entitled "Effect of sulphur on growth, yield and quality of linseed (*Linum usitatissium* L.)" was conducted at Department of Agronomy farm, College of Agriculture, Nagpur during *rabi* season of year 2017-18. The soil was clayey in nature with

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pH 7.9 indicating slightly alkaline in reaction, low in available nitrogen; medium in available phosphorus and very high in available potassium.

The Experiment was laid out in Randomised Block Design with eight treatments viz., T_1- RDF (60:30:00 NPK kg ha^{-1}),T_2- RDF + 15 Kg S ha^{-1} through gypsum, T_3- RDF + 20 kg S ha^{-1} through gypsum,T_4- RDF + 25 kg S ha^{-1} through gypsum,T_5- RDF + 15 kg S ha^{-1} through bensulf,T_6 - RDF + 20 kg S ha^{-1} through bensulf,T_7- RDF + 25 kg S ha^{-1} through bensulf,T_8- no fertilizer (control), replicated thrice.

The crop variety PKV- NL- 260 was used with gross plot size of 3.6 m ×5.0 m and net plot size of 2.4 m × 3.0 m. As per the treatment, the quantity of sulphur and fertilizer required $plot^{-1}$was calculated. Nitrogen was applied as per treatments in two splits i.e.$^1/_2$at sowing,$^1/_2$ at 30 DAS.Full dose of phosphorus and potassium were applied at sowing. In order to represent the plot, five plants of linseed from each net plot were selected randomly, labeled properly. The growth attributing characters *viz.,*plant height, number of branches $plant^{-1}$ and were recorded at 30,60,90 DAS and at harvest and dry matter accumulation $plant^{-1}$ was recorded at harvest, yield and quality parameters *viz.,* seed and straw yield (kg ha^{-1}), protein and oil content were also recorded at harvest. Seed protein was estimated by Kjeldahl method as suggested by Johan G. C. T. Kjeldahl. Similarly oil content in seed was estimated by Soxhlet apparatus method suggested by Franz von Soxhlet.

RESULTS AND DISCUSSION

Effect of sulphur on crop growth

Plant height

The data pertaining to mean plant height as influenced by different treatments are presented in table1.Data from table 1 indicated that integrated use of sulphur and nutrient management treatments significantly influenced the plant height at all growth stages.

At 30, 60, 90 DAS, treatment RDF + 25 kg S ha^{-1} through bensulf (T_7),recorded significantly higher plant height over application of RDF (60:30:00 NPK kg ha^{-1})(T_1), RDF + 15 Kg S ha^{-1} through gypsum(T_2), RDF + 20 kg S ha^{-1} through gypsum(T_3), RDF + 15 kg S ha^{-1} through bensulf(T_5), No fertilizer (control) (T_8) treatments. However, it was found at par with RDF + 25 kg S ha^{-1} through gypsum (T_4) and RDF + 20 kg S ha^{-1} through bensulf (T_6).Maximum plant height (68.36 cm) was recorded with RDF + 25 kg S ha^{-1} through bensulf(T_7) while minimum plant height (32.00 cm) was recorded in no fertilizer (control)(T_8).

Lawania *et al.* (2015) reported that application of sulphur with increasing level up to 40 kg ha^{-1} increased plant height over control in linseed. Similarly Jagtap (2003) reported that application of sulphur with increasing level up to 30 kg ha^{-1}significantly enhanced of plant height over control in linseed.

Number of branches $plant^{-1}$

The data pertaining to mean number of branches $plant^{-1}$ as influenced by different treatments are presented in table1.Data from table 1 indicated that integrated use of sulphur and nutrient management treatments significantly influenced the number of branches $plant^{-1}$ at all growth stages.

At 45, 60, 90 DAS and at harvest number of branches $plant^{-1}$ was significantly influenced with RDF + 25 kg S ha^{-1} through bensulf (T_7). However, it was found at par with treatment RDF + 25 kg S ha^{-1} through gypsum (T_4) and RDF + 20 kg S ha^{-1} through bensulf (T_6).When compared with no fertilizer (control). This might be due to use of recommended dose of fertilizers and availability of sulphur.

Mishra and Gaur (2013) reported that application of sulphur with increasing level up to 40 kg ha^{-1} increased number of branches $plant^{-1}$ over control in linseed. Similarly Singh *et al*.(2013) reported that application of sulphur with increasing level up to 40 kg ha^{-1}significantly enhanced number of branches $plant^{-1}$ over control in linseed.

Dry matter accumulation $plant^{-1}$

The data pertaining to dry matter production $plant^{-1}$ showed that the effect of different sources and levels of sulphur were significantly superior over control. While in case of sulphur levels, the dry matter production $plant^{-1}$ significantly increased with the increase in sulphur levels.

At harvest, treatment RDF + 25 kg S ha^{-1} through bensulf. (T_7) recorded significantly higher dry matter over application of RDF (60:30:00 NPK kg ha^{-1})(T_1), RDF + 15 Kg S ha^{-1} through gypsum(T_2), RDF + 20 kg S ha^{-1} through gypsum(T_3), RDF + 15 kg S ha^{-1} through bensulf(T_5), No fertilizer (control) (T_8) treatments.However, it was found at par with RDF + 25 kg S ha^{-1} through gypsum (T_4) and RDF + 20 kg S ha^{-1} through bensulf (T_6).

Days to 50 per cent flowering

The data pertaining to mean days to 50 % as influenced by different treatments are presented in table 1.Treatment RDF + 25 kg S ha^{-1} through bensulf. (T_7) required numerically more number of days to attained 50 per cent flowering (65.33 days) than T_1- RDF (60:30:00 NPK kg ha^{-1}), T_2- RDF + 15 Kg S ha^{-1} through gypsum, T_3- RDF + 20 kg S ha^{-1} through gypsum, T_4- RDF + 25 kg S ha^{-1} through gypsum,T_5- RDF + 15 kg S ha^{-1} through bensulf, T_6 - RDF + 20 kg S ha^{-1} through bensulf and T_8- No fertilizer (control) in descending manner. However, lowest number of days required (57.00 days) to attained 50 per cent flowering at treatment T_8 (control).

Effect on yield

Grain yield (kg ha^{-1})

The data presented in table 1 revealed that seed yield kg ha^{-1} of linseed was influenced significantly due to different integrated nutrient and sulphur management treatments. RDF + 25 kg S ha^{-1} through bensulf (T_7) found statistically higher in seed yield over application of RDF (60:30:00 NPK kg ha^{-1})(T_1), RDF + 15 Kg S ha^{-1} through gypsum(T_2), RDF + 20 kg S ha^{-1} through gypsum(T_3), RDF + 15 kg S ha^{-1} through bensulf(T_5), No fertilizer (control) (T_8) treatments and was found at par with withRDF + 25 kg S

Table 1. Effect of sulphur on growth, yield and quality parameters of linseed

Treatments	Plant height (cm)				Number of branches Plant^{-1}				Dry matter plant^{-1}	Days to 50 per cent flowering	Grain Yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Protain (%)	Oil (%)
	30 DAS	60 DAS	90 DAS	at harvest	30 DAS	60 DAS	90 DAS	at harvest	at harvest (g)		at harvest	at harvest	at harvest	at harvest
T_1- RDF (60:30:00 NPK kg ha^{-1})	20.73	38.26	46.00	46.21	1.70	2.60	3.33	3.33	4.94	59.33	731	1404	17.90	34.56
T_2- RDF + 15 kg S ha^{-1} through gypsum.	24.13	44.33	55.50	55.70	2.60	3.16	3.86	3.86	5.55	62.16	800	1569	18.10	35.84
T_3- RDF + 20 kg S ha^{-1} through gypsum	27.00	45.40	56.40	56.60	2.79	3.53	4.10	4.10	6.04	62.33	827	1678	18.40	36.58
T_4- RDF + 25 kg S ha^{-1} through gypsum.	29.00	53.43	63.23	63.40	3.33	4.53	5.10	5.10	8.23	64.50	991	2261	21.00	40.81
T_5- RDF + 15 kg S ha^{-1} through bensulf.	27.60	47.40	56.56	56.60	2.98	3.84	4.36	4.36	6.45	62.66	867	1924	18.60	37.08
T_6- RDF + 20 kg S ha^{-1} through bensulf.	28.85	52.87	62.86	62.87	3.26	4.50	4.90	4.90	7.90	63.75	988	2290	20.35	39.39
T_7- RDF + 25 kg S ha^{-1} through bensulf	32.90	56.18	68.26	68.36	3.64	5.08	5.33	5.33	8.68	65.33	1038	2355	21.58	41.35
T_8- No fertilizer (control).	14.65	28.90	32.00	32.00	1.20	1.33	2.33	2.33	3.83	57.00	498	892	17.40	31.41
S E (m) ±	1.67	2.76	3.62	3.69	0.18	0.22	0.29	0.29	0.25	2.09	17	37	0.90	1.13
C D at 5%	4.88	8.20	11.39	11.10	0.53	0.61	0.87	0.87	0.74	-	51	107	2.78	3.37

ha^{-1} through gypsum (T_4) and RDF + 20 kg S ha^{-1} through bensulf (T_6).

Maximum seed yield ha^{-1}(1038 kg) was recorded in RDF + 25 kg S ha^{-1} through bensulf (T_7), while minimum seed yield ha^{-1} (498 kg ha^{-1}) recorded in treatment T_8 with no fertilizer (control). Higher seed yield might be due to the cumulative favorable effect of the higher number of effective capsules $plant^{-1}$ and seed yield $plant^{-1}$ due to greater availability of nutrients and plant metabolism which in turn produced higher seed yield.

Kumar *et al.* (2009) stated that application of sulphur significantly increased the seed yield $ha^{-1}$of linseed with the increased level of sulphur from 0 to 45 kg ha^{-1}.Similarly Ghosh et *al.* (2000) reported that application of sulphur 30 kg ha^{-1} increased seed yield ha^{-1} over control in linseed.

Straw yield (kg ha^{-1})

The data presented in table 1 revealed that straw yield (kg ha^{-1}) of linseed was influenced significantly due to different integrated fertilizer and sulphur management treatments. The straw yield ha^{-1} was significantly higher with RDF + 25 kg S ha^{-1} through bensulf (T_7) and found higher straw yield over application of RDF (60:30:00 NPK kg ha^{-1})(T_1), RDF + 15 Kg S ha^{-1} through gypsum(T_2), RDF + 20 kg S ha^{-1} through gypsum(T_3), RDF + 15 kg S ha^{-1} through bensulf(T_5), No fertilizer (control) (T_8) treatments and was found at par with RDF + 25 kg S ha^{-1} through gypsum (T_4), and RDF + 20 kg S ha^{-1} through bensulf(T_6).Maximum straw yield (2358 kg ha^{-1}) was recorded in treatment with RDF + 25 kg S ha^{-1} through bensulf (T_7),while minimum straw yield (892 kg ha^{-1}) was recorded in treatment T_8 with no fertilizer (control).

Lawania *et al*.(2015) reported that application of sulphur with increasing level up to 40 kg ha^{-1} increased straw yield kg ha^{-1} over control in linseed.SimilarlyPandey and Ali (2012) reported that seed and stover yield of linseed increased significantly when sulphur was applied through ammonium sulphate compared to the other sources of sulphur up to 40 kg ha^{-1}.

Effect on quality

Protein per cent

Data presented in table 1 are indicated that the protein content (%) of grain was significantly influenced by different treatments. The protein was significantly higher with RDF + 25 kg S ha^{-1} through bensulf (T_7) and was found at par with RDF + 25 kg S ha^{-1} through gypsum (T_4) and RDF + 25 kg S ha^{-1} through bensulf (T_6).

Maximum protein (21.6 %) was recorded in treatment RDF + 25 kg S ha^{-1} through bensulf (T_7),while minimum protein (17.3%) was recorded in no fertilizer (control) T_8.

Singh and Singh (2007) reported that each successive increase in the level of sulphur up to 60 kg ha^{-1} significantly increased the oil content of the crop by 36.7% over control.

Oil per cent

Data related to oil content are presented in table 1. The oil content (%) of seed was significantly influenced by different treatments. The oil (%) was significantly higher with RDF + 25 kg S ha^{-1} through bensulf (T_7) and was found at par with RDF + 25 kg S ha^{-1} through gypsum (T_4) and RDF + 25 kg S ha^{-1} through bensulf (T_6). Maximum oil (41.38 %) was recorded in treatment RDF + 25 kg S ha^{-1} through bensulf (T_7),while minimum oil (31.39%) was recorded in treatment no fertilizer (control) T_8. This might be due to sulphur plays key role in formation of glucosides, which on hydrolysis produces higher oil content as well as oil yield (kg ha^{-1}).

Jagtap *et al.* (2003) reported that the oil content in linseed significantly increases with increasing level of sulphur up to 30 kg ha^{-1}.

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