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Effect of Levels and Sources of Sulphur on Nutrient Uptake, Economics and Post-Harvest Soil Nutrient Concentration of Sesamum (*Sesamum indicum* L.)

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Abstract

A field experiment was conducted at the experimental farm, Department of Agronomy, SASRD, Nagaland University to study sesamum on nutrient uptake, economics and nutrient concentration on post-harvest soil as affected by different levels and sources sulphur. The experiment was laid out in randomized block design (RBD) with three replications. There were ten treatments *viz*., T_1 (control), T_2 (10 kg gypsum ha^{-1}), T_3 (20 kg gypsum ha^{-1}), T_4 (30 kg gypsum ha^{-1}), T_5 (40 kg gypsum ha^{-1}), T_6 (control), T_7 (10 kg elemental sulphur ha^{-1}), T_8 (20 kg elemental sulphur ha^{-1}), T_9 (30 kg elemental sulphur ha^{-1}) and T_{10} (40 kg elemental sulphur ha^{-1}). The total Nitrogen (70.72 kg ha^{-1}), Phosphorus (7.91 kg ha^{-1}), Potassium (28.52 kg ha^{-1}) and Sulphur (6.05 kg ha^{-1}) uptake by the plant was recorded highest with 40 kg elemental sulphur ha^{-1}. Treatment T_{10} recorded the highest net return as well as B:C ratio (%) with Rs. 24,130.40 ha^{-1} and 1.21 respectively, while T_1 and T_6 recorded the lowest net return and were statistically at par. The available soil Nitrogen (435.53 kg ha^{-1}) after harvest was recorded highest in T_1 (control). The available soil Phosphorus (48.75 kg ha^{-1}) and Potassium (214.27 kg ha^{-1}) was recorded highest in T_1 (control) and available soil Sulphur (22.15 kg ha^{-1}) was recorded highest in T_{10}.

1. Introduction

Sesamum (*Sesamum indicum* L.) is believed to be one of the most ancient crops cultivated by humans. Sesamum seed has higher oil (46-64%) and protein (25%) content. They are a good source of different minerals like Mg, Ca, Fe, vitamin B_1, *etc*. as well as a good source of both monounsaturated fats and dietary fibres. The average yield of sesamum in India is very low (436 kg ha^{-1}) when compared to other countries in the world (535 kg ha^{-1}) (Anonymous, 2016). The main reasons behind this low productivity are its cultivation in marginal and sub marginal lands mainly under rainfed conditions under little or poor management, low and sub-optimal input conditions. This indicates the scope and importance of adopting better management practices including optimum and balanced fertilization in order to achieve higher productivity.

Sulphur is an important component of plant amino acids, vitamins, enzyme structures and proteins which influence the productivity, quality and total oil content. Oilseed crops are especially sensitive to sulphur deficiency because their demand for sulphur is quite high and produce seeds with a high yield of protein with relatively large quantities of sulphur containing amino acids (Zhao *et al*., 1997). Among all the sulphur supplying sources, gypsum and elemental sulphur are most abundantly used in sulphur deficient soils. Hence, this study is attempted to improve the production of sesamum crop through optimum supply of sulphur in Nagaland state.

2. Materials and Methods

The soil texture was found to be clayey loam which was acidic in reaction (4.94). It was found to be high in organic carbon content (1.38%), low in available sulphur content (14.03 kg ha^{-1}) low in available nitrogen content (225.79 kg ha^{-1}), high in available phosphorus content (28.24 kg ha^{-1}) and medium in available potassium content (173.6 kg ha^{-1}). There were 10 treatment combinations with three replications. Two sources of sulphur (Gypsum and Elemental sulphur), four levels of sulphur (10, 20, 30 and 40 kg ha^{-1}) and two control treatment were used. The recommended dose of N, P and K fertilizer *i.e*., 30 kg ha^{-1} Urea, 60 kg ha^{-1} SSP and 30 kg ha^{-1} MOP was applied as a single basal dose followed by the treatments. The seeds were sown on 19th of July, 2019. The seeds were pre- treated with Bavistin @ 2 g kg^{-1} of seed and sown manually in lines and then covered them with soil to make it favourable for germination. Seed were sown at the rate of 4 kg ha^{-1}. The soil samples were collected from the post-harvest soil in

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order to evaluate the nutrient status. Cost of cultivation was cultivated on per hectare basis for each treatment by taking into consideration the cost in different operations separately for each treatment. Gross return was estimated considering the monetary value of the economic produce of different treatments based on the prevailing market prices ha^{-1}. Net return for each treatment was estimated by subtracting the total cost of cultivation from gross return. B:C Ratio was calculated by the following formula.

$$\text{Benefit Cost (B:C) Ratio} = \frac{\text{Net Return}}{\text{Cost of cultivation}}$$

3. Results and Discussion

3.1 Nutrient Uptake

As shown in Table 1, highest nitrogen uptake by seed was recorded in T_{10} (48.48 kg ha^{-1}) which was statistically at par (47.63 kg ha^{-1}) with T_9 (control). The minimum nitrogen uptake was recorded in T_6 (24.85 kg ha^{-1}). Nitrogen uptake by stover showed significant differences due to different levels and sources of sulphur treatment. T_{10} recorded higher N uptake (22.24 kg ha^{-1}). The lowest N uptake (11.76 kg ha^{-1}) was recorded in T_1. This was in close conformity with Dayanand *et al*. (2010). Phosphorus uptake by seed was recorded highest in T_{10} (4.65) which was found at par with T_9 (4.36) and T_1 recorded the lowest P uptake [2.78]. T_{10} recorded higher P uptake (3.26 kg ha^{-1}). The lowest P uptake (1.94 kg ha^{-1}) was recorded in T_1 which was at par with T_6 (2.00 kg ha^{-1}). The highest potassium uptake by seed (9.28 kg ha^{-1}) was recorded in T_{10} while the lowest (3.14 kg ha^{-1}) was observed in T_1 which was statistically at par (3.70) with T_6 (control). T_{10} recorded higher K uptake (19.24 kg ha^{-1}). The lowest K uptake (13.30 kg ha^{-1}) was recorded in T_1 (control). It was observed that both sources and levels of sulphur influenced K uptake significantly. The highest sulphur uptake (3.16 kg ha^{-1}) was recorded in T_{10}. However, the lowest (1.62 kg ha^{-1}) was recorded in T_1 (control) which was at par with T_6 (control) [1.88 kg ha^{-1}]. The elemental sulphur source and its increased level must have a significant influence on the uptake of N, P, K and S by the seed. The maximum sulphur uptake by stover (2.89 kg ha^{-1}) was recorded in T_{10} while the lowest sulphur uptake was recorded in T_1 (1.50 kg ha^{-1}) which was at par with T_6 (control) [1.72 kg ha^{-1}]. The application of sulphur has resulted in higher uptake by the stover (Vaijapuri *et al*., 2003). The total plant uptake of N and S was recorded highest in T_{10} (40 kg elemental sulphur ha^{-1}) while total K uptake was recorded highest in T_{10} (40 kg elemental sulphur ha^{-1}) which was at par with T_9 (30 kg elemental sulphur ha^{-1}). The sources and levels of sulphur were not found to have any significant influence on total uptake of P by sesamum.

Table 1: Effect of sources and levels of sulphur on plant nutrient uptake of N, P, K and S (kg ha^{-1}) in seed and stover of Sesamum

Treatments	Nutrient uptake in seed				Nutrient uptake in stover				Total plant nutrient uptake			
	N	P	K	S	N	P	K	S	N	P	K	S
Sources												
S1: Gypsum	33.30	3.57	5.16	2.39	16.81	2.67	16.36	2.17	50.10	6.25	21.53	4.56
S2: Elemental Sulphur	40.44	3.90	6.36	2.63	17.76	2.73	16.92	2.37	58.21	6.63	23.28	5.00
SEm±	0.13	0.02	0.04	0.01	0.06	0.04	0.08	0.01	0.10	0.07	0.05	0.02
CD (p=0.05)	0.81	0.14	0.24	0.07	0.36	NS	0.47	0.09	0.59	NS	0.31	0.14
Levels												
L0: 0 kg ha^{-1}	27.29	2.85	3.42	1.75	11.97	1.97	13.86	1.61	39.26	4.82	17.28	3.36
L1: 10 kg ha^{-1}	33.48	3.51	4.41	2.41	15.96	2.44	15.42	2.16	49.44	5.95	19.83	4.57
L2: 20 kg ha^{-1}	36.68	3.71	5.03	2.57	17.13	2.92	16.73	2.28	53.82	6.63	21.75	4.85
L3: 30 kg ha^{-1}	41.74	4.17	7.74	2.79	19.99	2.96	18.14	2.54	61.73	7.13	25.88	5.32
L4: 40 kg ha^{-1}	45.17	4.44	8.22	3.03	21.37	3.21	19.05	2.75	66.54	7.65	27.26	5.79
SEm±	0.50	0.03	0.10	0.01	0.15	0.05	0.11	0.02	0.49	0.07	0.16	0.02
CD (p=0.05)	1.50	0.09	0.29	0.03	0.44	0.15	0.34	0.06	1.46	0.20	0.48	0.07

Note: NS = Non-significant at 5% level of significance

3.2 Economics

It is evident from Table 2 that the highest cost of cultivation was recorded in T_5 (Rs. 24,810.00 ha^{-1}) followed by T_4 (Rs. 23,110.00 ha^{-1}). T_1 and T_6 (control) recorded the lowest cost of cultivation (Rs. 18,010.00 ha^{-1}). The highest gross return (Rs. 44,060.00) was recorded from T_{10} followed by T_9 (Rs. 38,118.57). The highest net return (Rs. 24,130.40 ha^{-1}) and benefit-cost (B:C) ratio (1.21) was obtained in T_{10} (40 kg elemental sulphur ha^{-1}) while lowest benefit-cost ratio was obtained in T_2 with 0.17 and T_1 and T_6 (control) recorded the lowest net return of Rs. 3,741.32 ha^{-1} and Rs. 4,737.12 ha^{-1} respectively.

Table 2: Effect of sources and levels of sulphur on the economics of sesamum during the study

Treatments	Cost of cultivation (Rs.)	Gross return (Rs.)	Net return (Rs.)	B:C Ratio
S1L0	18010.00	21751.32	3741.32	0.21
S1L1	19710.00	23081.54	3371.54	0.17
S1L2	21410.00	31135.67	9725.67	0.45
S1L3	23110.00	33442.28	10332.28	0.45
S1L4	24810.00	36996.22	12186.22	0.49
S2L0	18010.00	22747.12	4737.12	0.26
S2L1	18490.00	32297.00	13807.00	0.75
S2L2	18970.00	35125.89	16155.89	0.85
S2L3	19450.00	38118.57	18668.57	0.96
S2L4	19930.00	44060.40	24130.40	1.21

3.3 Available Nutrient Status of Post-Harvest Soil

It was observed from Table 3 that the pH and organic carbon content of the soil was not significantly affected by sources of sulphur. The highest available soil nitrogen after crop harvest was recorded in T_6 (435.53 kg ha^{-1}) and the lowest value was recorded in T_{10} (232.06 kg ha^{-1}). The data also showed that the available nitrogen in the soil was lesser with the increased application of elemental sulphur as compared to gypsum. The highest available soil P is recorded in T_6 (control) which was at par with T_1 (control) and the least available soil P was recorded in T_{10} (27.69 kg ha^{-1}). It is evident that significantly highest available soil K (214.27 kg ha^{-1}) was recorded in T_6 and the lowest available soil K was recorded in T_{10} (92.40 kg ha^{-1}). It was observed that the highest available soil S (22.15 kg ha^{-1}) was recorded in T_{10} and the lowest available soil S was recorded in T_1 (11.82 kg ha^{-1}). Since, elemental sulphur have higher concentration of sulphur and are subjected to lesser leaching losses, they tends to accumulate in the soil in higher amounts as compared to other sources of sulphur, while releasing S into the soil solution at a slower rate. Therefore, higher available soil sulphur after crop harvest was observed at T_{10} (elemental sulphur @ 40 kg ha^{-1}). Similar result was also obtained by Raja *et al*. (2007).

Table 3: Effect of sources and levels of sulphur on soil pH, organic carbon (%) and available N, P and K (kg ha^{-1}) in the soil after harvest of sesamum

Treatments	Soil pH	Organic carbon (%)	Available nutrients in the soil after harvest (kg ha^{-1})			
			N	P	K	S
Sources						
S1: Gypsum	5.81	1.41	318.24	37.87	146.86	14.76
S2: Elemental Sulphur	5.45	1.47	294.78	35.95	128.42	17.74
SEm±	0.08	0.03	3.80	0.14	1.22	0.09
CD (p=0.05)	NS	NS	23.15	0.83	7.44	0.52
Levels						
L0: 0 kg ha^{-1}	5.53	1.09	405.93	47.88	197.29	11.08
L1: 10 kg ha^{-1}	5.87	1.38	320.69	41.07	164.64	13.85
L2: 20 kg ha^{-1}	5.72	1.46	304.19	37.15	135.42	16.80
L3: 30 kg ha^{-1}	5.53	1.59	260.29	30.15	108.26	18.94
L4: 40 kg ha^{-1}	5.50	1.68	241.47	28.32	82.60	20.59
SEm±	0.14	0.02	2.95	0.43	3.03	0.27
CD (p=0.05)	NS	0.06	8.85	1.30	9.08	0.81

Note: NS = Non-significant at 5% level of significance

4. Conclusion

Elemental sulphur @ 40 kg ha^{-1} is a better source of sulphur in addition to recommended dose of fertilizers as compared to gypsum for improving the productivity of sesamum as well as higher nutrient uptake and nutrient availability under rainfed condition of Nagaland.

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