Plant Archives Vol. 24, No. 2, 2024 pp. 2753-2760 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2024.v24.no.2.391

IMPACT OF VARYING SULPHUR CONCENTRATIONS AND FOLIAR APPLICATION OF LIQUID MANURE ON QUALITY ATTRIBUTES AND PROFITABILITY IN SESAME CULTIVATION

Snehil Kumar Watsh[1], A.C. Shivran[2], A.S. Chandan[3*], Manisha Kumawat[1], I. Mahamed Ashiq[4], Okram Ricky Devi[5] and Sachin Kumar Pradhan[2]

[1]Department of Agronomy, SKNAU, Jobner - 303 329, Rajasthan, India.
[2]Department of Soil Science, SKNAU, Jobner - 303 329, Rajasthan, India.
[3]Department of Crop Physiology, Assam Agricultural University, Jorhat - 785 013, Assam, India.
[4]Department of Biotechnology, University of Agricultural Sciences, Dharwad - 580 005, Karnataka, India.
[5]Department of Agronomy, Assam Agricultural University, Jorhat - 785 013, Assam, India.
*Corresponding author E-mail : chandan.a.s456@gmail.com
(Date of Receiving-16-06-2024; Date of Acceptance-19-08-2024)

ABSTRACT

During the *kharif* season 2022, a field experiment titled "Influence of Different Levels of Sulphur and Foliar Application of Liquid Manures on Sesame" was carried out at the Agronomy Farm, S.K.N. College of Agriculture, Jobner (Rajasthan), India. The experiment included sixteen treatment combinations with four levels of sulphur (0, 20, 40, and 60 kg/ha) in factor "A" and four liquid manure treatments (control, panchgavya, vermiwash, and matka khad) in factor "B", which were replicated three times in Factorial Randomised Block Design.The results demonstrated that differing sulphur levels had a substantial impact on sesame quality indices and economics. Treatment 40 kg sulphur/ha resulted in significantly higher nitrogen content in seed and stalk, as well as its uptake and sulphur content in stalk, oil and protein contents in seed, net returns, and B:C ratio of sesame, which remained at par with treatment 60 kg sulphur/ha. However, the treatment of 60 kg sulphur/ha resulted in the highest phosphorus content in seed and stalk, as well as its uptake and sulphur content in seed and its uptake. The experimental data also demonstrated that the use of liquid manures considerably improved sesame quality and economics. The application of panchgavya resulted in significantly higher nitrogen and sulphur content in seed and stalk, phosphorus content in seed, oil and protein content in seed, net returns and B:C ratio of sesame compared to control and matka khad, but remained at par with vermiwash. However, total nitrogen and sulphur uptake, as well as phosphorus concentration in stalk and its uptake, were found to be highest with two panchgavya sprays. The interaction effect of different levels of sulphur and liquid manures was also found significant with respect to seed yield, N, P and S uptake, net returns and the B:C ratio of sesame. Among all the treatment combinations, combination of 20 kg sulphur/ha along with two sprays of panchgavya at 30 and 60 DAS recorded significantly higher seed yield, net returns and B:C ratio than the rest of the treatment combinations. However, maximum amount of total N, P and S uptake was noted by the application of 60 kg sulphur/ha along with two sprays of panchgavya at 30 and 60 DAS over rest of the treatment combinations.

Key words : Sesame, Sulphur, Panchgavaya, Vermiwash, Matka khad.

Introduction

Sesamum indicum (L.) belongs to family Pedaliaceae. It is the oldest indigenous oilseed crop with the longest history of cultivation in India. It is grown on 16.27 lakh hectares in the country with a total yield of 7.8 lakh tonnes with the average productivity of 485 kg/ha (Anonymous, 2021-22a). In Rajasthan, the crop covered 2.90 lakh hectares and produced 0.77 lakh tonnes with a productivity of 265 kg/ha (Anonymous, 2021-22b).

Sesame cake can be used as manure since it contains 6.0-6.2 per cent N, 2.0-2.2 per cent P_2O_5 and 1.0-1.2 per cent K_2O (Pagal *et al.*, 2017). Nearly 73 per cent of the sesame oil is utilized for edible purposes, 14.5 per cent for domestic uses, 8.3 per cent for hydrogenation and 4.2 per cent for industrial purposes in the manufacture of paints, lubricants, perfumed oils, pharmaceuticals and insecticides. Due to its high quality, it is also known as the "poor man's substitute for ghee" (Shelke *et al*., 2014). Sesame oil is antibacterial, antiviral, antifungal and anti-oxidant. The antioxidants make the oil very resistant to oxidative rancidity and is known for its stability and quality. The high levels of unsaturated (UFA) and polyunsaturated fatty acids (PUFAs) also increase the quality of the oil for human consumption (Nupur *et al*., 2010). Sesame seed flour has a high protein content with high levels of the essential amino acids like methionine and tryptophan (about 10 to 12 per cent of oil) and has three times more calcium than milk (Doutaniya, 2018). Sesame meal-based products have also been found to be acceptable for diabetics due to their low carbohydrate and high protein content (Bigoniya *et al.*, 2012).

Despite of being such an important sesame growing state, the average productivity of sesame in Rajasthan is very low in comparison to global as well as national. Cultivation of crop on marginal and sub-marginal lands of poor fertility under rain fed condition, low rainfall, poor agronomic practices and inadequate or even no use of fertilizers are the major factors responsible for low productivity. Sulphur is important for the health and structure of soil, helping to maintain its pH and fertility (Jamal *et al*., 2010). Sulphur is also involved in the production of important plant compounds like vitamins, oils and alkaloids. Sulphur requirement is equal to that of phosphorus for oilseed crops as it is directly involved in the synthesis of oil apart from growth and development of the crop. Sulphur is required for the synthesis of amino acids like methionine (21%), cysteine (26%) and cystine (27%), which are essential constituents of protein (Tisdale *et al*., 1999). Therefore, crops of oilseeds require a higher quantity of sulphur for proper growth and development for higher yields (Salwa *et al*., 2010). It also increases the availability of other nutrients such as phosphorus, potassium and suppresses the uptake of sodium and chlorine which are toxic to plant growth and development. In general, the sufficient amount of sulphur application significantly increases crop growth and improves the quality of sesame by increasing protein and oil contents (Ahmad *et al.*, 2018).

Due to the realization of organic farming's inherent benefits (ability to sustain crop production while preserving a dynamic soil nutrient status and a safe environment), it has recently gained momentum (Lokanath and Parameshwarappa, 2006). Foliar application of fertilizers is crucial for increasing crop output and productivity since desert soils are both hungry and thirsty. The application of organic nutrients or growth regulators to seeds or roots is one alternative. These substances may support plant growth or provide disease control *via* a number of ways, such as the provision of organic nutrients or the creation of plant hormones. The panchgavya is a potent stimulator of plant development that raises the biological effectiveness of crops. In order to protect plants from diseases and to improve the nutritional value of fruits and vegetables, it is used to stimulate soil and soil microorganisms. Role of foliar application or seed soaking of panchgavya in production of many plantation crops had been well documented in India (Selvaraj, 2003). Other findings reported that liquid manure (25% herbal based kunapajala) may be an eco-friendly technique that can be used to improve seed quality and biochemical activities of wheat seeds (Devi *et al.,* 2023).

Vermiwash is a liquid bio-fertilizer can be collected through the column of activated earthworm. The primary nutrients found in vermiwash are various soluble plant nutrients like N, P, K, Ca and micronutrients. The vermiwash contains many beneficial microbes, including fungi, actinomycetes, heterotrophic bacteria, nitrogen-fixing bacteria like *Azotobacter* spp., *Agrobacterium* spp., *Rhizobium* spp. and phosphate solubilizers. Other hormone types like auxin, various amino acids, vitamins and enzyme cocktails of proteases, amylases, urease and phosphatase are also present in vermiwash (Das *et al*., 2014). Matka Khad is prepared by mixing of cow urine with cow dung, jaggery and water in a certain proportion. Matka khad is used in agricultural crops as an organic product to supply growth stimulators and various nutrients which result in higher growth and yield. Matka khad includes a higher count of azotobacter, actinomycetes and phosphate solubilizers as per it's microbial analysis (Chadha *et al*., 2012).

Materials and Methods

Experimental site and location

The experiment was conducted at Agronomy Farm, S.K.N. College of Agriculture, Jobner (Rajasthan) on field number-10B during *kharif*, 2022. Geographically, Jobner is situated 45 km west of Jaipur at 26º05' N latitude and 75º28' E longitude and at an altitude of 427 metres above mean sea level. The region falls under agro-climatic zone-III A (Semi-arid Eastern Plain Zone) of Rajasthan.

Treatment details

The field experiment, comprising of 16 treatment combinations (4 sulphur levels *viz*., 0, 20, 40 and 60 kg/ha and 4 liquid manures *viz*., control, panchgavya, vermiwash and matka khad) was laid out in Factorial Randomized Block Design with three replications.

Seed and sowing

The variety RT-351 of sesame was used for sowing. The seeds were sown by kera method @ 4 kg/ha and spacing was maintained as 30 cm × 10 cm row to row and plant to plant respectively. The depth of sowing was 2 cm.

Treatment application

Before sowing, sulphur was added through gypsum fertilizer according to the treatment levels (0, 20, 40 and 60 kg/ha) in assigned plot and incorporated into soil manually. According to the treatment details, spraying of liquid manures *viz.*, panchgavya, vermiwash and matka khad @ 3 per cent, 10 per cent and 10 per cent respectively with water 600 l/ha was done twice, first at 30 DAS and second at 60 DAS by the battery-operated knapsack sprayer during the early morning and late evening time. The amount of panchgavya, vermiwash and matka khad used for spraying were 18, 60 and 60 l/ha, respectively.

Treatment evaluation

Nutrient content, uptake and quality parameters

Plant samples, at the time of harvesting of the crop were collected separately from each plot and dried in oven at constant temperature of 65 °C until they obtained constant weight. The dried samples were powdered in a grinder having stainless steel blades to avoid contamination of micronutrients.

After drying and grinding, these samples were analyzed for nitrogen, phosphorus and sulphur contents. The results were expressed as per cent nitrogen, phosphorus and sulphur on dry weight basis.

Nitrogen content and its uptake

The seed and stalk samples were analyzed for nitrogen content as per standard colorimetric method (Snell and Snell, 1949). The uptake of nitrogen by the crop was calculated using the following formula:

$$\text{N uptake (kg/ha)} = \frac{[\text{Per cent N in seed} \times \text{seed yield (kg/ha)}] + [\text{Per cent N in stalk} \times \text{stalk yield (kg/ha)}]}{100}$$

Phosphorus content and its uptake

The seed and stalk samples were analyzed for phosphorus content by Vandomolybdo phosphoric yellow colour method in sulphuric acid system (Jackson, 1973). The uptake of phosphorus by the crop was calculated using the following formula:

$$\text{P uptake (kg/ha)} = \frac{[\text{Per cent P in seed} \times \text{seed yield (kg/ha)}] + [\text{Per cent P in stalk} \times \text{stalk yield (kg/ha)}]}{100}$$

Sulphur content and its uptake

Sulphur was estimated by turbidimetric method (Tabatabai and Bremmer, 1970). The plant samples (seed and stalk) of sesame were digested in diacid mixture and barium chloride solution was used for development of turbidity. The resultant turbidity was measured on spectrophotometre at 420 nm wavelength. The sulphur content was calculated and represented in percentage. The uptake of sulphur by the crop was calculated by using the following formula:

$$\text{S uptake (kg/ha)} = \frac{[\text{Per cent S in seed} \times \text{seed yield (kg/ha)}] + [\text{Per cent S in stalk} \times \text{stalk yield (kg/ha)}]}{100}$$

Protein content (%)

The protein content of the seed was worked out by multiplying nitrogen content in the seed (%) with the factor 6.25 (A.O.A.C, 1960) and expressed as per cent protein content.

Oil content (%)

Oil content in seed was determined by Soxhlets Ether extraction method (A.O.A.C, 1960).

$$\text{Oil (\%)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Sample weight}} \times 100$$

Economic analysis

Net returns (`/ha)

To find out the most profitable treatment, comprehensive economics of different treatments were worked out in terms of net returns (`/ha) on the basis of the prevailing market rate of inputs, services and produce so that the most remunerative treatment could be recommended.

Net returns (`/ha) = Gross return (`/ha) – Total cost of cultivation (`/ha)

Benefit cost (B:C) ratio

Benefit cost ratio for each treatment was calculated to ascertain the economic viability of the treatment using the formula:

$$\text{B:C} = \frac{\text{Net returns (`/ha)}}{\text{Total cost of cultivation (`/ha)}}$$

Results and Discussion

Nutrient content, uptake and quality parameters

Sulphur levels

The N, P and S content in the seed and stalk as well

Table 1 : Effect of sulphur fertilization and foliar application of liquid manures on N, P and S content in seed and stalk of sesame.

Treatment	Nutrient content in seed (%)			Nutrient content in stalk (%)		
	N	P	S	N	P	S
Sulphur levels (kg/ha)						
Control	2.30	0.49	0.169	1.01	0.15	0.127
20	2.72	0.59	0.195	1.17	0.20	0.145
40	3.02	0.64	0.216	1.27	0.22	0.162
60	3.10	0.68	0.232	1.30	0.24	0.167
SEm±	0.03	0.008	0.003	0.01	0.003	0.002
CD (P=0.05)	0.09	0.024	0.009	0.04	0.008	0.006
Liquid manures						
Control	2.43	0.46	0.178	1.00	0.17	0.119
Panchgavya	2.97	0.66	0.222	1.31	0.22	0.169
Vermiwash	2.91	0.65	0.214	1.28	0.21	0.164
Matka khad	2.84	0.63	0.198	1.15	0.20	0.150
SEm±	0.03	0.008	0.003	0.01	0.003	0.002
CD (P=0.05)	0.09	0.024	0.009	0.04	0.008	0.006
Interaction	NS	NS	NS	NS	NS	NS
CV (%)	4.02	4.86	5.60	4.22	4.80	4.91

Table 2 : Effect of sulphur fertilization and foliar application of liquid manures on N, P and S uptake of sesame.

Treatment	Total nutrient uptake (kg/ha)			Yield (q/ha)	
	N	P	S	Seed	Stalk
Sulphur levels (kg/ha)					
Control	32.10	5.70	3.35	5.75	18.45
20	43.38	8.35	4.41	6.85	20.87
40	52.58	10.10	5.42	7.57	22.93
60	54.76	11.08	5.75	7.80	23.29
SEm±	0.77	0.17	0.09	0.15	0.65
CD (P=0.05)	2.23	0.50	0.27	0.42	1.89
Liquid manures					
Control	33.09	6.06	3.27	5.92	18.39
Panchgavya	54.32	10.62	5.76	7.76	23.52
Vermiwash	51.36	9.87	5.40	7.46	22.79
Matka khad	44.04	8.67	4.51	6.84	20.84
SEm±	0.77	0.17	0.09	0.15	0.65
CD (P=0.05)	2.23	0.50	0.27	0.42	1.89
Interaction	Sig.	Sig.	Sig.	Sig.	NS
CV (%)	5.85	6.87	6.93	7.27	10.60

as their overall absorption by sesame were increased when varying doses of sulphur were applied. The information in the Table 1 showed that the significantly higher amount of N in sesame seed and stalk, and S in the stalk were found when 40 kg of sulphur/ha was applied. Application of 60 kg sulphur/ha resulted in the highest P content in seed and stalk, its uptake, S content in seed and its uptake by the crop (Table 2). The improved nutritional environment in the rhizosphere and the plant system, that resulted in greater translocation of N, P and S to reproductive parts, which ultimately increased the content of these nutrients in seed and stalk, appears to be a result of the positive influence of sulphur fertilisation on nutrient content in crop. Improved metabolic activity at the cellular level and improved food availability in the root zone may have boosted the uptake of nutrients and their accumulation in various plant parts.

Also, the application of 40 kg sulphur/ha resulted in significantly greater oil and protein content in seed compared to the control and 20 kg sulphur/ha, but was statistically equivalent to 60 kg sulphur/ha (Fig. 1). The two basic components of protein are nitrogen and sulphur and increase in their availability increased the utilization of nitrogen for the synthesis of protein. It is a constituent of three amino acids *viz.*, methionine (21% S), cysteine (26% S) and cystine (27% S), which are the building blocks of protein. Protein production requires the proper structure, which sulphur gives in the form of di-sulphide chains, helping to boost the protein content. Due to the helpful environment that sulphur application created, the rise in oil content caused by sulphur fertilisation may be the result of better nutrient availability. Given that sulphur is a crucial component of oil, the increasing availability of sulphur may have had a positive impact on the synthesis of the vital metabolism that accounts for the larger oil content. Sulphur is also known to be involved in primary fatty acid conversion. Similar findings also have been

Table 3 : Interactive effect of sulphur fertilization and foliar application of liquid manures on N, P and S uptake of sesame.

Treatment	N uptake				P uptake				S uptake			
	Liquid manures				Liquid manures				Liquid manures			
Sulphur levels (kg/ha)	Control	Panchgavya	Vermiwash	Matka khad	Control	Panchgavya	Vermiwash	Matka khad	Control	Panchgavya	Vermiwash	Matka khad
Control	24.71	37.35	36.07	30.25	4.41	6.67	6.18	5.55	2.34	3.97	3.71	3.39
20	30.05	53.56	50.33	39.60	20	5.33	10.51	9.87	2.88	5.38	5.25	4.14
40	36.87	61.96	58.88	52.62	40	6.78	12.13	11.17	3.75	6.53	6.27	5.11
60	40.75	64.42	60.15	53.71	60	7.72	13.17	12.28	4.13	7.15	6.36	5.39
SEm±			1.51				0.35				0.19	
CD (P=0.05)			4.53				1.02				0.56	

reported in sesame by Shilpi *et al*. (2014), Mamatha *et al*. (2017) and Paul *et al*. (2019).

Liquid manures

The foliar application of several liquid manures improved N, P and S content in the seed and stalk as well as their overall uptake in sesame. According to the data in the Table 1 matka khad and control treatments were not as effective at enhancing the N, P and S contents of sesame seeds and stalks as panchgavya when applied topically. However, effect of vermiwash was statistically equal to panchgavya in terms of nitrogen and sulphur content in seed and stalk and phosphorus content in seed. Four nitrogen atoms are bonded in each chlorophyll structure, which is a component of the nitrogen content in leaves (Devi *et al.*, 2024). The increased supply of N, P and S in reproductive structures like seed and stalk is thought to be the cause of liquid manures beneficial effects on crop nutritional content. The uptake of nutrients and their accumulation in different plant sections may have been improved by the increased availability of nutrients combined with higher metabolic activity at the cellular level. Similar research findings were reported by Munji *et al*. (2010) in sesame and Choudhary *et al.* (2017) in black gram. It was also reported that seeds invigorated with 25% kunapajala showed higher germination percentage which might be resulted from the activity of microbes and growth promoters like GA_3 and IAA in liquid concoction (Devi *et al*., 2022).

With the foliar application of panchgavya, which was noticeably superior to control and matka khad but remained at par with vermiwash, the maximum protein content in seed was recorded (Fig. 1). Since nitrogen is a key ingredient in the amino acids, the protein content in seeds really represents the nitrogen content in seed. Vermiwash and matka khad closely following panchgavya, recorded considerably more oil content than control (Fig. 1). The application of different liquid manures gave the crop an adequate supply of nutrients and enhanced the crop's quality characteristics. Waghmode *et al*. (2015) in maize, Choudhary *et al*. (2017) in black gram, and Shariff *et al*. (2017) in green gram all reported similar findings.

Economics

Sulphur levels

The most profitable level of sulphur application in sesame was discovered to be at the rate of 40 kg/ha. It generated net returns of ₹ 49698/ha, representing increase of 54.0 and 17.6 per cent over the control and 20 kg/ha, respectively. A resilient B:C ratio of 1.88 was also recorded across all levels (Table 4). As the overall cost

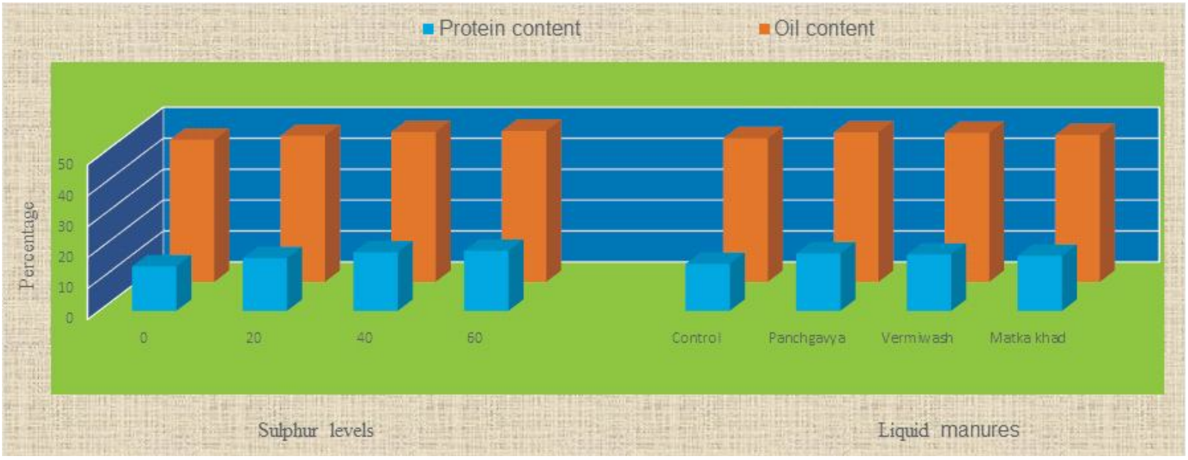

Fig. 1 : Effect of sulphur fertilization and foliar application of liquid manures on protein and oil content in seed of sesame.

Table 4 : Interactive effect of sulphur fertilization and foliar application of liquid manures on net returns and of B-C ratio sesame.

Treatment	Net returns				B-C ratio			
	Liquid manures				Liquid manures			
Sulphur levels (kg/ha)	**Control**	**Panchgavya**	**Vermiwash**	**Matka khad**	**Control**	**Panchgavya**	**Vermiwash**	**Matka khad**
Control	31824	36382	34010	26832	1.45	1.36	1.27	1.05
20	32758	53855	47136	35272	1.45	1.97	1.72	1.35
40	38889	54970	52667	52267	1.68	1.98	1.89	1.96
60	41967	55043	53811	53511	1.77	1.94	1.89	1.96
SEm±	2936.2				0.11			
CD (P=0.05)	8612.1				0.33			

of cultivation, including treatment costs, is subtracted from the gross returns, which is computed by multiplying the seed yield by their sale prices. This might be primarily because the treatment resulted in increased seed yields, which came at a relatively lower additional cost of sulphur. The results are in close conformity with the findings of Shah *et al.* (2013), Mamatha *et al*. (2017), Parmar *et al*. (2018) and Yadav *et al.* (2020) in sesame.

Liquid manures

The data in Table 4 clearly shows that compared to the control, foliar treatment of various liquid manures significantly increased net returns and the B:C ratio in sesame. In comparison to control and matka khad, two sprays of panchgavya recorded the higher net returns (` 50063/ha) and B:C (1.81) ratio, whereas vermiwash was close behind. The sole explanation for the better net returns and benefit cost ratio may be the minimal investment and favourable economic yield. The findings of Patil *et al*. (2012) in chick pea and Gowtham chand *et al*. (2020) in french bean are very similar to the results.

Interaction effects of sulphur levels and liquid manures on sesame

Interaction effect of sulphur levels and liquid manures on seed yield, total N, P and S uptake, net returns and B:C ratio were found significant (Table 3). Among all the treatment combinations, the combination of 20 kg sulphur/ha along with two sprays of panchgavya at 30 and 60 DAS recorded significantly higher seed yield, net returns and B:C. The maximum amount of total N, P and S uptake was noted by the application of 60 kg sulphur/ha along with two sprays of panchgavya at 30 and 60 DAS. Synergistic interaction between sulphur and liquid manures may be due to the fact that liquid manure comprises a combination of organic matter, macro and micro nutrients, and advantageous microbes. It improves the availability and uptake of nutrients by plants when applied. Sulphur, on the other hand, is a macro nutrient and is especially important for the production of proteins and enzymes. The synergistic effect of liquid manures and sulphur might be due to increased microbial interactions that improve nutrient transformation, organic matter breakdown and overall soil fertility, which may facilitate greater nutrient uptake. Superior crop quality and adherence to sustainable farming practices collectively contribute to increased yields and reduced input costs resulting in favourable economic outcomes.

Conclusion

Based on the results of one-year experimentation, it may be concluded that the application of different levels of sulphur and liquid manures provides an additive effect in increasing the quality parameters and economics of sesame. Application of 20 kg sulphur per ha with two sprays of panchgavya at 30 and 60 DAS produced significantly higher nutrient uptake and B:C ratios of sesame; hence, it is more desirable and profitable for farmers.

References

A.O.A.C. (1960). *Official method of analysis*. 18th Edition, Association of Official Agricultural Chemists, Washington.

Ahmad, J., Ahmad F., Iqbal S., Shah S.M.A., Ali M., Abbas M.W., Nawaz H., Mehmood Z., Ali B. and Ali S. (2018). Growth and oil yield of sesame as influenced by sulphur and nitrogen. *J. Agricult. Res*., **3(7)**, 000187.

Anonymous (2021-2022a). *Fourth Advance Estimates of Production of Food grains*. Directorate of Economics and Statistics, Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India, New Delhi.

Anonymous (2021-2022b). Final estimates of area, production and yield of crops in respect of Rajasthan state/U.T. Directorate of Economics and Statistics, Jaipur, Rajasthan.

Bigoniya, P., Nishad R. and Singh C.S. (2012). Preventive effect of sesame seed cake on hyperglycaemia and obesity against high fructose-diet induced type 2 diabetes in rats. *Food Chem*., **133(4)**, 1355-1361.

Chadha, S., Rameshwar A., Saini J.P. and Paul Y.S. (2012). Sustainable livelihood option for small and marginal farmers. *Indian J. Traditional Knowledge*, **11(3)**, 480-486.

Choudhary, G.L., Sharma S.K., Choudhary S., Singh K.P., Kaushik M.K. and Bazaya B.R. (2017). Effect of panchagavya on quality, nutrient content and nutrient uptake of organic black gram [*Vigna mungo* (L.) Hepper]. *J. Pharmacog. Phyto-chem*., **6(5)**, 1572-1575.

Das, S.K., Avasthe R.K. and Gopi R. (2014). Vermiwash: use in organic agriculture for improved crop production. *Popular Kheti*, **2(4)**, 45-46.

Devi, O.R., Halder R., Pandey S.T., Verma O. and Chaturvedi P. (2022). Effect of seed priming with liquid organic on germination, seedling development and enzymatic activity of wheat (*Triticum aestivum* L.).

Devi, O.R., Verma O., Laishram B., Raj A., Singh S. and Gaurav K. (2023). Influence of Seed Invigoration with Organic Kunapajala on Seed Quality and Biochemical Activity in Late Sown Wheat. *Int. J. Environ. Clim. Change*, **13(9)**, 900-906.

Devi, O.R., Harish B.M., Doggalli G., Laishram B., Verma O., Sharma A. and Ojha N. (2024). Effect of liquid fermented organic manure concoctions and their foliar spray under different dose of nutrients on chlorophyll content of late sown wheat. *Plant Archives*, **24(1)**, 1244-1248.

Doutaniya, R.K. (2018). Intercropping of sesame (*Sesamum indicum* L.) with mungbean (*Vigna radiata* L. Wilczek) under different levels of sulphur. *M.Sc. Thesis*, Department of Agronomy, O.P.J.S. University, Churu, Rajasthan.

Gowthamchand, N.J., Ganapathi and Soumya T.M. (2020). Effect of bulky manures and fermented liquid organics on growth, yield, nutrient uptake and economics of french bean [*Phaseolus vulgaris* (L.)] under rainfed condition. *Int. J. Agricult., Environ. Biotechnol.*, **13(1)**, 51-58.

Jackson, M.L. (1973). *Soil Chemical Analysis*. Prentice Hall of India Private Limited New Delhi. pp. 498.

Jamal, A., Moon Y.S. and Abdin M.Z. (2010). Sulphur-A general overview and interaction with nitrogen. *Austr. J. Crop Sci*., **4**, 523-329.

Lokanath, H.M. and Parameshwarappa K.G. (2006). Effect of organics on the productivity of spanish bunch groundnut under rainfed farming situation. (In): *Proceedings of* 18th *World Congress of Soil Science*. Philadelphia, Pannsylvania, USA, pp. 62-63.

Mamatha, K., Sagar G.E.C.V., Narayana P.L. and Padmaja G. (2017). Physiological growth, quality and economics of sesame [*Sesamum indicum* (L.)] as influenced by application of sulphur with use of farmyard manure. *Int. J. Chem. Stud*., **5(4)**, 2121-2125.

Munji, R., Babalad H.B., Prasanna, Kumara B.H. and Pushpa V. (2010). Effect of organics and fermented organics on yield, soil available N, P_2O_5, K_2O Kg/ha and microbial count in sesame. *An Asian J. Soil Sci.*, **5(2)**, 379-385.

Nupur, M., Kangila V.B. and Srivastava P.S. (2010). Variation in fatty acid composition in Indian germplasm of sesame. *J. Amer. Oil Chemists' Soc*., **87(11)**, 1263-1269.

Pagal, A.K., Singh A.P., Behera S. and Meher C. (2017). Effect of different level of sulphur and phosphorus on growth and yield attributes of sesamum. *Int. J. Curr. Microbiol. Appl. Sci*., **6(11)**, 3278-3285.

Parmar, N.N., Patel A.P. and Choudhary M. (2018). Effect of sources and level of sulphur on growth yield and quality of summer sesame under south Gujarat condition [*Sesamum indicum* (L.)]. *Int. J. Curr. Microbiol. Appl. Sci*., **7(2)**, 2600-2605.

Patil, S.V., Halikatti S.I., Hiremath S.M., Babalad H.B., Sreenivasa M.N., Hebsur N.S. and Somanagouda G. (2012). Effect of organics on growth and yield of chickpea [*Cicer arietinum* (L.)] in vertisols. *Karnataka J. Agricult. Sci*., **25(3)**, 326-331.

Paul, S.K., Khatun M.M. and Sarkar M.A.R. (2019). Effect of sulphur on the seed yield and oil content of sesame [*Sesamum indicum* (L.)] Seed yield and oil content of sesame. *J. Bangl. Agricult. Univ*., **17(1)**, 33–38.

Salwa, A.I.E., Mohsen M.A. and Behary S.S. (2010). Amelioration productivity of sandy soil by using amino acid, sulphur and micronutrients for sesame production. *Amer. J. Sci*., **6**, 250-257.

Selvaraj, N. (2003). Report of work done on organic farming at horticulture research station, Tamil Nadu Agriculture University, Ooty, India 2-5.

Shah, M.A., Manaf A., Hussain M., Farooq S. and Hye M. Zu (2013). Sulphur fertilization improves the sesame productivity and economics return under rainfed condition. *Int. J. Agricult. Biol*., **15**, 1301-1306.

Shariff, A.F., Sajjan A.S., Babalad H.B., Nagaraj L.B. and Palankar S.G. (2017). Effect of organics on seed yield and quality of green gram [*Vigna radiata* (L.)]. *Legume Research*, **40(2)**, 388-392.

Shelke, R.I., Kalegore N.K. and Wayase K.P. (2014). Effect of levels of phosphorus and sulphur on growth, yield and quality of sesame [*Sesamum indicum* (L.)]. *World J. Agricult. Sci*., **10(3)**, 108-111.

Shilpi, S., Nuruzzaman Md., Akhter F., Islam M.N. and Sutradher G.N. (2014). Response of nitrogen and sulphur on the oil content of sesame and nutrient status of Soil. *Int. J. Bio-Resource Stress Manage*., **5(1)**, 041-046.

Snell, P.D. and Snell G.T. (1949). *Colorimetric methods of analysis*. 3rd Edn. Vol. II D. Van Nostrand Co. Inc., New York.

Tabatabai, M.A. and Bremner J.M. (1970). An alkaline oxidation method for determination of total sulphur in soils. *Soil Sci. Soc. America J*., **34(1)**, 62-65.

Tisdale, P.P., Poongothai S., Savithri R.K. and Bijujoseph O.P. (1999). Influence of gypsum and green leaf manure application on rice. *J. Indian Soc. Soil Sci*., **47(1)**, 96-99.