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Effect of sulphur and thiourea on growth and yield of mustard (*Brassica juncea* L.)

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Abstract
A field experiment was carried out during the *rabi* season of 2024-25 at the Agricultural Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur (Rajasthan), to evaluate the "Effect of Sulphur and Thiourea on Growth and Yield of Mustard (*Brassica juncea* L.)". The study was conducted using a factorial randomized block design with three replications. The experiment comprised four sulphur levels (0, 15, 30 and 45 kg ha^{-1}) and four thiourea foliar spray concentrations (0, 250, 500 and 750 ppm). The mustard variety Giriraj (DRMRIJ 31) was used for the investigation.
The findings indicated that application of sulphur at 30 kg ha^{-1} significantly enhanced plant height, dry matter accumulation (80 DAS and at harvest), chlorophyll content, number of siliquae per plant, number of seeds per siliqua, seed yield, stover yield and biological yield when compared with the control and the 15 kg ha^{-1} sulphur level.
The results also revealed that foliar application of thiourea at 500 ppm, closely followed by 750 ppm, significantly improved plant height, dry matter accumulation (80 DAS and at harvest), chlorophyll content, number of siliquae per plant, number of seeds per siliqua, seed yield, stover yield and biological yield.

Keywords: Mustard, sulphur, thiourea, growth, yield attributes, productivity

1. Introduction
Indian mustard [*Brassica juncea* (L.) Czern. & Coss], a member of the family Brassicaceae with chromosome number 2n = 36, is an important edible oilseed crop widely cultivated across northern and western India. The seed contains 37-49% oil, predominantly used for cooking and frying purposes. Mustard oil also serves as a condiment in food preparations such as pickles, spices, and traditional dishes. Young leaves are consumed as a leafy vegetable. Mustard cake, a by-product after oil extraction, contains about 25-30% crude protein and appreciable levels of nitrogen, sulphur, and potassium, making it valuable as livestock feed.
India stands as the world's third-largest producer of rapeseed-mustard after China and Canada, contributing around 11% to global production. Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, Gujarat, Punjab, and Bihar account for the majority of the cultivated area. Nationally, mustard covers about 95.77 lakh ha, producing approximately 13 million tonnes with an average productivity of 1443 kg ha^{-1} (Anonymous, 2023-24). Rajasthan alone contributes 40.50 lakh ha area with 6.2 million tonnes production and a productivity of 1500 kg ha^{-1}.
Sulphur is a vital macronutrient required for optimal plant growth. Deficiency of sulphur is now widespread in semi-arid soils of Rajasthan, particularly in districts such as Jodhpur, Udaipur, and Jaipur. Sulphur improves nodulation in legumes, enhances nitrogen metabolism, and indirectly aids chlorophyll formation. It also plays a role in improving tolerance to drought and cold through disulphide linkages. Sandy soils with low organic matter content are especially prone to sulphur depletion due to leaching losses. For example, Bikaner soils contain only 8-9.5 ppm S, with approximately 65% area deficient.
Thiourea, a sulphydryl-containing compound (Jocely, 1972), possesses one -SH group along with $-NH_2$ groups and contains 42.1% sulphur and 36.8% nitrogen. External application of thiourea functions as a growth promoter by influencing key physiological processes, photosynthetic efficiency, and nutrient assimilation. It modifies plant metabolism and enhances tolerance to abiotic stresses.

2. Materials and Methods

The experiment was carried out during the *rabi* season of 2024-25 at the Research Farm, School of Agriculture, Suresh Gyan Vihar University, Jaipur, located in agro-climatic zone IIIA (Semi-Arid Eastern Plain Zone) at 26°48'35" N latitude, 75°51'44" E longitude, and an elevation of 432 m.

A factorial randomized block design with three replications was used. Treatments included four sulphur levels (0, 15, 30, and 45 kg ha^{-1}) and four thiourea spray concentrations (0, 250, 500, and 750 ppm). Mustard variety Giriraj (DRMRIJ) was sown on 29 October 2024 at 30 × 10 cm spacing using 5 kg ha^{-1} seed rate by *kera* method.

Soil samples from 0-15 cm depth were collected before sowing, shade-dried, powdered, and analyzed. The soil was loamy sand with 0.22% organic carbon, 136.74 kg N ha^{-1}, 20.09 kg P_2O_5 ha^{-1}, and 237.34 kg K_2O ha^{-1}. Total rainfall during the crop period was 19 mm.

The required quantities of fertilizers and thiourea were applied as per the treatment schedule. Hoeing and weeding were performed at 30 DAS, and plant protection measures were adopted as needed. At maturity, yield was recorded from the net plot area after excluding border rows. The collected data on growth, yield, and economics were analyzed using the method suggested by Panse and Sukhatme.

3. Results and Discussion

3.1 Effect of Sulphur

Sulphur application significantly influenced the growth of mustard. Application of 30 kg S ha^{-1} resulted in noticeably higher plant height, dry matter accumulation, and chlorophyll content at 80 DAS and harvest compared to control and 15 kg S ha^{-1}. These values remained statistically comparable with 45 kg S ha^{-1} (Table 1).

Enhanced growth under higher sulphur supply may be attributed to improved meristematic activity and increased synthesis of sulphur-containing amino acids, which promote cell division, elongation, and tissue development. Adequate sulphur availability also supports chlorophyll formation and photosynthetic activity, leading to greater biomass production. Similar observations were reported by Piri *et al.* (2011) [7], Singh *et al.* (2016), and Singh *et al.* (2021) [11].

Yield attributes such as siliquae per meter row length and seeds per siliqua, along with seed, stover, and biological yields, were significantly higher with 30 kg S ha^{-1} than with lower levels, and were statistically at par with 45 kg S ha^{-1} (Table 2). Improvement in yield may result from better nutrient uptake and enhanced structural strength such as xylem and fibre development. These findings align with studies by Rai *et al.* (2014) [8], Kour *et al.* (2014) [5], and Rajput *et al.* (2018) [9].

3.2 Effect of Thiourea Sprays

Thiourea sprays exerted a marked influence on mustard growth. Foliar application of 500 ppm thiourea significantly increased plant height, dry matter accumulation, and chlorophyll content over control and 250 ppm, while being statistically at par with 750 ppm (Table 1).

Enhanced growth could be due to improved nutrient availability and increased photosynthetic activity induced by thiourea. Previous studies by Meena & Sharma (2005) [6] and Singh & Singh (2017) [10] reported similar improvements. Thiourea is known to stimulate dark CO_2 fixation (Hernandez-Nistel *et al.*, 1983) [4], contributing to better photosynthetic efficiency and increased production of auxiliary buds.

Yield traits such as siliquae per metre row length, seeds per siliqua, and seed, stover and biological yields were also significantly improved with 500 ppm thiourea, comparable to 750 ppm (Table 2). This enhancement may be due to better source-sink translocation, improved stomatal behaviour, stress mitigation, and enhanced floral development. These results are in agreement with Gupta *et al.* (2017a) [2] and Gurjar *et al.* (2022a) [3].

Table 1: Effect of sulphur and thiourea sprays on growth attributes of mustard.

Treatments	Plant height (cm)		Dry matter accumulation per metre row length (g)		Chlorophyll content
	50 DAS	At Harvest	50 DAS	At Harvest	
Sulphur levels (kg ha^{-1})					
Control	148.5	156.0	125.18	188.91	2.85
S 15 kg ha^{-1}	157.4	168.5	146.14	220.70	2.94
S 30 kg ha^{-1}	165.3	179.6	161.76	252.40	2.99
S 45 kg ha^{-1}	171.4	184.9	169.65	261.07	3.01
S.Em ±	3.0	4.6	4.14	7.37	0.01
CD (p=0.05)	8.7	13.3	11.94	21.28	0.03
Thiourea spray					
Control	149.7	155.7	129.28	190.01	2.82
Thiourea @ 250 ppm	157.9	169.6	145.80	232.04	2.93
Thiourea @ 500 ppm	166.4	178.3	156.36	245.51	3.01
Thiourea @ 750 ppm	168.5	185.4	171.29	255.53	3.03
S.Em ±	3.0	4.6	4.14	7.37	0.01
CD (p=0.05)	8.7	13.3	11.94	21.28	0.03

4. Conclusion

From the findings of the study, it is evident that sulphur application at 30 kg ha^{-1} is optimal for achieving higher seed, stover, and biological yields of mustard under semi-arid conditions. Likewise, foliar application of thiourea at 500 ppm or 750 ppm significantly enhanced yield performance over lower concentrations.

Therefore, the combination of 30 kg S ha^{-1} with thiourea spray at 500 ppm (or 750 ppm) can be recommended for achieving higher productivity and profitability of mustard in the semi-arid regions of Rajasthan.

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