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Effect of Sulphur and Biofertilizers on Yield Attributes and Yield of Mustard (*Brassica juncea* L.)

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ABSTRACT: A field experiment was conducted at research farm, Vivekananda Global University, Jaipur, during the *rabi* season 2023-24 to study the "Effect of Sulphur and Biofertilizers on Yield Attributes and Yield of Mustard (*Brassica juncea* L.)". The treatment consisted of four levels of sulphur (0, 20, 40, 60 kg ha^{-1}) and four combinations of biofertilizers (control, *Azotobacter*, PSB, *Azotobacter* + PSB) there by making 16 treatments combinations replicated thrice in FRBD. Application of 60 kg S ha^{-1} significantly increased yield attributes and yields over application of 40, 20 and 0 kg S ha^{-1} and seed inoculation with PSB + *Azotobacter* significantly increased yield attributes and yields over PSB, *Azotobacter* and control.

Keywords: Sulphur, biofertilizers, *Azotobacter*, PSB, yield, yield attributes, mustard etc.

INTRODUCTION

Mustard is important *rabi* oilseeds crop of India, widely grown on large area. It occupies prominent place, next in importance to groundnut in area and production. It belongs to family Brassicaceae and has chromosome no. of 2n=36 and named as *Brassica juncea*. The oil content in mustard seeds varies from 37 to 49 per cent and its oil is utilized for human consumption for cooking and frying purposes. It is also used in the preparation of vegetable ghee, hair oils, medicines, soap making, mixtures with mineral oils for lubrication and manufacture of greases. The oil cake left after extraction is utilized as cattle feed and manure. The oil cake contains 25-30 per cent crude protein, 5 per cent nitrogen, 1.8 - 2.0 per cent phosphorus and 1.0 - 1.2 per cent potassium. Low cost of production and high yield potentials hold promise for its large-scale cultivation in the country. In India, total area under mustard 8.8 million hectares with 11.35 million tonnes production and 1290 kg ha^{-1} productivity during *rabi* 2022-23. Mustard is cool weather-loving crop, grown either as a sole crop or mixed with wheat, gram and linseed. The intercropping ratio of wheat & mustard is 9:1 and gram & mustard is 2-3: 1. The traditionally grown oilseed crop such as linseed with low yield potential even under irrigated conditions is being replaced by mustard crop. Mustard has high protein content. Besides fatty acids they also contain 1.5 % essential oil, which is of the great value in perfume industries.

Among mineral nutrition sulphur is being considered as the fourth major nutrient after nitrogen, phosphorus and potassium whose deficiency has especially been observed in soils of Rajasthan. It is essential for the formation of chlorophyll, activation of enzymes and improvement in crop growth and yield (Tondon, 1995). Crop removal is the major cause of sulphur depletion in soil. In the recent years, continuous and imbalance application of chemical fertilizers with little or no use of organic manure is leading to poor nutrient use efficiency, low yield of crop and poor physical and biological property of soil. At the same time increasing cost of production due to more and more use of costly nutrient sources is becoming unaffordable to the most of farmers. Hence, it has become imperative to search for other complementary and alternative sources of nutrients, among which use of bio-fertilizers of biological origin for integrated nutrient management in mustard is an important avenue. In this approach, microbial fertilization with *Azotobacter* as well as PSB and has been found promising to improve soil health and crop production. Bio-fertilizer such as *Azotobacter* and PSB play an important role in increasing the availability of nitrogen, phosphorus and potassium. Inoculation with *Azotobacter* will not only improve nitrogen availability in soil by biological nitrogen fixation but also ensure prolonged and adequate supply of this vital nutrient with minimum loss in light texture soil. Inoculation of seeds with *Azotobacter* culture is low-cost input in legume and has been found beneficial by many workers. Similarly, inoculation with Phosphate solubilizing bacteria (PSB) converts the unavailable form of phosphorus into soluble or available form to the plant. Microbial fertilization along with *Azotobacter* and PSB has been found promising to improve soil health and crop production. *Azotobacter* +

PSB helps to maintain soil fertility and eliminate the pollution hazards to increase the productivity. Many soil micro-organisms have capacity to solubilize mineral phosphate. The PSB helps in improving phosphate uptake in plants.

MATERIAL AND METHODS

The experiment was conducted at research farm, Vivekananda Global University, Jaipur. Jaipur is situated in South-Eastern part of Rajasthan at an altitude of 581.13 metre above mean sea level with 24º35′N latitude and 74 º42′E longitude. The region falls under Semi-Arid Eastern Plains Zone (IIIA) of Rajasthan. The soil of experimental field was loamy sand in texture, slightly alkaline in reaction (pH 8.19), low in available nitrogen (133.65 kg /ha) while medium in available phosphorus (20.54 kg /ha) and potassium status (217.87 kg /ha). The treatment consisted of four levels of sulphur (0, 20, 40, 60 kg S ha^{-1})and four combinations of biofertilizers (control, *Azotobacter*, PSB, *Azotobacter* + *PSB*) there by making 16 treatments combinations replicated thrice in FRBD. Mustard crop variety DRMRIJ 31 was used as test crop. A uniform dose of 80 kg N + 40 kg P_2O_5 + 40 kg K_2O ha^{-1} was applied. Ammonium sulphate and SSP were used as a source of nitrogen and phosphorus, respectively. The whole quantity of sulphur was applied as per treatment allocation at the time of sowing. Gypsum @250 kg ha^{-1} (18.5 % sulphur) was used as a source of sulphur and the seeds were treated with liquid biofertilizers *Azotobacter,* PSB, *Azotobacter* + PSB using 5 ml kg^{-1} through standard procedure 2-3 hours before sowing as per treatment allocation. The seeds were thoroughly mixed with biofertilizers in such a way that all the seeds were uniformly coated with a layer of biofertilizers and then seeds were allowed to dry in shade before sowing of crops. During the crop growth period various crop yield attributing characters like number of siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$, siliqua length (cm), test weight and yields like seed yield, stover yield, biological yield were taken as per schedule and requirement of investigation. Above data were statistically analysed using standard procedure of analysis of variance at 5% level of significance.

RESULTS AND DISCUSSION

A. Effect of sulphur

It is evident from the results application of sulphur up to 60 kg ha^{-1} significantly improved number of siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$, siliqua length (cm) and test weight which is over to the application of 40, 20 and 0 kg S ha^{-1}. The highest number of siliquae $plant^{-1}$ (300.2), number of seeds $siliqua^{-1}$ (10.7), siliqua length (5.9 cm) and test weight (3.70 g) over observed with application of 60 kg S ha^{-1}. The highest seed yield, stover yield and biological yield was 1781.6 kg ha^{-1}, 4772.6 kg ha^{-1} and 6467.2 kg ha^{-1} found due to application of 60 kg S ha^{-1} over 40, 20 and 0 kg S ha^{-1}, respectively. All above mentioned yield attributes and yields were recorded to be lowest with 0 kg S ha^{-1}. It is accounted that sulphur plays a vital role in improving vegetative structure thereby photosynthesis, strong sink strength through development of reproductive structure and formation of assimilates to fill economically important sink. Thus the sulphur increases the metabolic uses of sulphur in plants which seems to have to endorsed meristematic activies ensuing in higher apical growth and increase of photosynthetic surface. The similar results were also found by Kumar *et al.* (2018); Hadiyal *et al.* (2017); Solanki *et al.* (2018); Nandan and Bhatnagar (2022).

Table 1: Effect of sulphur and biofertilizers on yield attributes of mustard.

Treatment	Yield attributes			
	Number of siliquae /plants	Number of seeds /siliqua	Siliqua length (cm)	Test weight (g)
Sulphur (kg /ha)				
0	260.8	9.3	5.2	3.34
20	266.2	9.9	5.6	3.31
40	269.5	10.5	5.8	3.59
60	300.2	10.7	5.9	3.70
SEm+	**4.057**	**0.157**	**0.081**	**0.117**
CD (P=0.05)	**11.55**	**0.45**	**0.23**	**NS**
Biofertilizers				
Control	260.7	9.5	5.3	3.27
Azotobacter	274.1	10.1	5.6	3.50
PSB	276.5	10.4	5.8	3.58
Azotobacter + PSB	285.4	10.5	5.8	3.59
SEm+	**4.057**	**0.157**	**0.081**	**0.117**
CD (P=0.05)	**11.55**	**0.45**	**0.23**	**NS**
Interaction				
SEm+	**8.114**	**0.314**	**0.163**	**0.234**
CD at 5%	**NS**	**NS**	**NS**	**NS**

B. Effect of biofertilizers

It was observed that the inoculation of seeds with *Azotobacter* + PSB were significantly enhance the yield attributes *viz.,* number of siliquae $plant^{-1}$, number of seeds $siliqua^{-1}$, siliqua length (cm) and test weight which is over to the inoculation of seeds with *PSB*, *Azotobacter* and control. The highest number of siliquae $plant^{-1}$ (285.4), number of seeds $siliqua^{-1}$ (10.5), siliqua length (5.8 cm) and test weight (3.59 g) over PSB, *Azotobacter* and the above yield attributes were

found lowest at control treatment. The maximum seed yield, stover yield and biological yield was recorded with the seed inoculation of *Azotobacter* + PSB was found over to PSB, *Azotobacter* and control, respectively. This improvement ultimately manifested in production of higher seed yield, stover yield and biological yield by (7.34, 7.10, 32.44%), (2.94, 3.88, 10.42%) and (1.38, 8.51, 13.66%), respectively. Further results indicated that the significant increase in yield attributes and yields is due to increase in the availability of nitrogen through bio fertilizer inoculation by which more spikelet's are formed to produce spikelets primordial production and supplying of more plant hormones by the microorganisms inoculated or by the root resulting from reaction to microbial population. Similar finding were obtained by Hadiyal *et al.* (2017); Beenish *et al.* (2018); Reddy and Singh (2018); Kalita *et al.* (2019).

Table 2: Effect of sulphur and biofertilizers on yields of mustard.

Treatment	Yield (kg /ha)		
	Seed yield	Stover yield	Biological yield
Sulphur (kg /ha)			
0	1346.4	3971.7	5331.5
20	1578.6	4029.2	5730.9
40	1655.9	4654.4	6008.6
60	1781.6	4772.6	6467.2
SEm±	**24.141**	**76.037**	**86.088**
CD (P=0.05)	**68.72**	**216.45**	**245.06**
Biofertilizers			
Control	1326.9	4110.6	5467.4
Azotobacter	1641.1	4369.4	5727.0
PSB	1637.1	4409.1	6129.5
Azotobacter + PSB	1757.3	4538.8	6214.2
SEm±	**24.141**	**76.037**	**86.088**
CD (P=0.05)	**68.72**	**216.45**	**245.06**
Interaction			
SEm±	**48.281**	**152.075**	**172.176**
CD at 5%	**NS**	**NS**	**NS**

CONCLUSIONS

On the basis of present study, it is concluded that the mustard crop with the application 60 kg sulphur ha^{-1} and *Azotobacter* + PSB resulting significantly higher yield attributes and yields.

FUTURE SCOPE

Future research is required to examine the effects of the suggested combination on soil health, nutrient input loss reduction, soil fertility enhancement, and fertilizer nutrient saving.

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Conflict of Interest. None.

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