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Effect of biofertilizers and sulphur on yield, yield attributes and economics of yellow mustard (*Sinapis alba*)

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Abstract
A field experiment was carried out at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P) in *Rabi* 2020 to study the Effect of Biofertilizers and Sulphur on Growth and Yield of Yellow Mustard (*Sinapis alba*). It was consisting of combination of three levels of biofertilizer PSB, Azotobacter, VAM and three Sulphur levels (15 kg S/ha, 30 kg S/ha and 45 kg S/ha). The experiment was laid out in Randomized Block Design with nine treatments each replicated thrice. The experiment results revealed that the growth parameters such as yield attributes *viz*., number of siliqua/plant (133.92), number of seeds/siliquae (33.80) and test weight (3.63 g) at harvest, significantly recorded in treatment T_3 with the application of PSB+45 kg S/ha. However seed yield (1.80 t/ha), stover yield (3.36 t/ha), gross returns (117000.00 INR/ha), net returns (79573.58 INR/ha) and B:C ratio (2.12) was significantly recorded in the treatment of T_3 which is PSB+45 kg S/ha among all treatments.

Keywords: Mustard, biofertilizers, sulphur, siliquae, seed yield and economics

Introduction
Rapeseed-mustard crops are important for the Indian economy, since India imports large quantities of edible oils despite having the largest area of cultivated oilseeds in the world. Oil seeds play an important role in Indian Agriculture and industries. Besides, immense value in our diet, oils and fats are used in cosmetics, soaps, lubricants, paints and varnish industries and their medicinal and therapeutic value. The requirement of vegetable oils and fats will be much higher in coming years in view of ever increasing population (Kumar *et al.*, 2016) [3].

In India, it is mainly cultivated in sub-tropical climate, but recent stats prove that it thrives well in dry and cool climate. It requires the temperature from 10^0 to 25^0 C. The crop is highly susceptible to the frost conditions and it requires the rainfall of 625- 1000 mm annual rainfall for its proper growth. It can be cultivated in light to heavy loamy soils with 6-7.5 pH because of its deep root system. In the tropics, it is normally mixed cropped with gram, wheat and lentils mostly in the *rabi* seasons (Chauhan *et al.*, 2020) [10].

Sulphur is a secondary plant nutrient which plays a significant role in increasing production specially in oil seed crops. Rapeseed-mustard crops are particularly sensitive to sulphur deficiency mainly due to the fact that S plays an important role in the chemical composition of seed and increases the percentage of oil content of seed. Sulphur increases the oil content and gives pungency to oil as it forms certain disulphide linkages. (Khan *et al.*, 2002). Oilseed crops require more Sulphur than cereals as their oil storage organs are mostly proteins, rich in S. Deficiency of Sulphur is known to hamper N metabolism in plants as well as synthesis of S-containing amino acids and thus exerts adverse effects on both seed and oil yield.

Biofertilizer are known to play a number of vital roles in soil fertility, crop productivity and production in agriculture as they are eco- friendly but cannot at any cost replaces chemical fertilizers that are indispensable for getting maximum crop yields. They supplement chemical fertilizers for meeting the integrated nutrient demand of the crops. Application of biofertilizers results in increased mineral and water uptake, root development, vegetative growth and nitrogen fixation (Solanki *et al.*, 2018) [8]. Bio-fertilizers offer an economically attractive and ecologically sound means of reducing external inputs and improving quality and quantity of crop. They contain microorganisms which are capable of mobilizing nutrient elements from unavailable form to available form through different biological processes (Hadiyal *et al.*, 2017) [1].

Phosphate solubilizing bacteria inoculants when applied to many crop plants, promote seed

germination and initial vigor of plants by producing growth promoting substances. Application of biofertilizers results in increased mineral and water uptake, root development, vegetative growth and nitrogen-fixation (Solanki *et al.*, 2018) [8].

Materials and Methods

The present examination was carried out during *Rabi* 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj, UP, which is located at 25.28ºN latitude, 81.54ºE longitude and 98 m altitude above the mean sea level. Super goldy variety used for sowing yellow mustard. The experiment laid out in Randomized Block Design which consisting of nine treatments with T1: PSB +15 kg S/ha, T2: PSB +30kg S/ha, T3: PSB+45 kg S/ha, T4: Azotobacter +15 kg S/ha, T5: Azotobacter +30kg S/ha, T6: Azotobacter +45 kg S/ha, T7: VAM +15 kg S/ha, T8: VAM +30kg S/ha, T9: VAM + 45 kg S/ha were replicated thrice.

The experimental site was uniform in topography and sandy loam in texture, nearly neutral in soil reaction (P^H 7.1), low in Organic carbon (0.38%), medium available N (225 kg ha^{-1}), higher available P (19.50 kg ha^{-1}) and medium available K (213.7 kg ha^{-1}). Nutrient sources were Urea, DAP, MOP to fulfill the necessity of Nitrogen, phosphorous and potassium. Gypsum used to fulfill the requirement of sulphur. The application of fertilizers were applied as basal at the time of sowing. Nitrogen applied as split dose half as basal dose remaining as top dressing. In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded those parameters are growth parameters, plant height, branches per plant and plant dry weight are recorded. The yield parameters like siliquae per plant, seeds per siliquae, grain yield, test weight (1000 seeds), stover yield and harvest index were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984).

Results

Yield attributes

Data in table 1 revealed that T_3 PSB + Sulphur at 45 kg/ha resulted in significantly higher number of siliquae per plant (133.92), number of seeds per siliquae (33.80) and test weight (3.63 g). However, T_3 and T_9 which were statistically at par with PSB + Sulphur at 45 kg/ha.

Table 1: Effect of Bio-fertilizers and Sulphur on yield attributes of Yellow Mustard

S. No	Treatments	Siliquae/plant	Seeds/Siliquae	Test weight (g)
1.	PSB +15 kg S/ha	125.17	29.13	2.93
2.	PSB +30kg S/ha	128.79	31.74	3.04
3.	PSB+45 kg S/ha	133.92	33.80	3.63
4.	Azotobacter +15 kg S/ha	125.30	30.21	3.03
5.	Azotobacter +30kg S/ha	128.53	31.81	3.14
6.	Azotobacter +45 kg S/ha	133.23	32.89	3.34
7.	VAM +15 kg S/ha	125.90	30.33	3.10
8.	VAM +30kg S/ha	128.78	32.36	3.29
9.	VAM + 45 kg S/ha	133.27	32.98	3.45
F- test		S	S	S
S. EM (±)		0.78	0.41	0.08
C. D. (P = 0.05)		2.34	1.24	0.23

Yield and Yield attributes

Data in table 2 revealed that Application of PSB + Sulphur at 45 kg/ha resulted maximum seed yield (1.80 t/ha), stover yield (3.36 t/ha) which are recorded maximum with T_3 which was significantly higher. However, T_3 and T_9 which were statistically at par with PSB + Sulphur at 45 kg/ha.

Table 2: Effect of Bio-fertilizers and Sulphur Yield and Yield attributes Yellow Mustard

S. No	Treatments	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
1.	PSB +15 kg S/ha	1.16	2.47	44.07
2.	PSB +30kg S/ha	1.36	2.84	32.38
3.	PSB+45 kg S/ha	1.80	3.36	34.88
4.	Azotobacter +15 kg S/ha	1.38	2.59	34.76
5.	Azotobacter +30kg S/ha	1.43	2.85	33.41
6.	Azotobacter +45 kg S/ha	1.71	3.23	34.61
7.	VAM +15 kg S/ha	1.48	2.68	35.57
8.	VAM +30kg S/ha	1.64	2.87	36.36
9.	VAM + 45 kg S/ha	1.76	3.29	34.85
F- test		S	S	S
S. EM (±)		0.02	0.06	0.13
C. D. (P = 0.05)		0.07	0.19	0.39

Economics

Data in table 3 tabulated Experimental results revealed that application of PSB + Sulphur at 45 kg/ha recorded higher gross returns (117000.00 INR) net returns (79573.58 INR) and benefit: cost ratio (2.12) and minimum gross returns (75400.00 INR), minimum net returns (41233.58 INR) and minimum benefit: cost ratio (1.20) were recorded with the treatment of PSB +15 kg S/ha.

Table 3: Effect of Bio-fertilizers and Sulphur on economics of Yellow Mustard

S. No	Treatments	Cost of Cultivation (INR/ha)	Gross return (INR/ha)	Net Return (INR/ha)	B:C ratio
1.	PSB +15 kg S/ha	34166.42	75400.00	41233.58	1.20
2.	PSB +30kg S/ha	35846.42	88400.00	52553.58	1.46
3.	PSB+45 kg S/ha	37526.42	117000.00	79573.58	2.12
4.	Azotobacter +15 kg S/ha	34246.42	89700.00	55453.58	1.61
5.	Azotobacter +30kg S/ha	35926.42	92950.00	57023.58	1.58
6.	Azotobacter +45 kg S/ha	37606.42	111150.00	73543.58	1.95
7.	VAM +15 kg S/ha	34326.42	96200.00	61873.58	1.80
8.	VAM +30kg S/ha	36006.42	106600.00	70593.58	1.96
9.	VAM + 45 kg S/ha	38050.42	114400.00	76349.58	2.00

Discussion

Number of siliquae/plant, number of seeds/siliquae, dry weight accumulation, test weight and seed yield with the application of Sulphur 30 kg/ha Yogesh *et al.,* (2009) [9]. increasing levels of Sulphur up to 60kg/ha significantly enhances siliquae/plant, seeds/siliquae and test weight Similarly increased Sulphur content manifested the lucid effect on seed and straw yield and increased significantly up to 30kg S/ha Singh *et al.,* (2010) [7]. an experiment in Agra concluded that application of Sulphur 60kg S/ha increased the seed yield by 75.1% over no Sulphur. Higher oil content was recorded under 60kg S/ha (39.14 to 42.58%). The increase in oil content under influence of S addition seems to be due to increased S content in seed, which has a significant role in overall biosynthesis of oil Jagpal *et al*., (2012). seed and straw yield increased significantly with increasing levels of sulphur up to highest levels of sulphur @ 60 Kg S/ha. Application of 20, 40 and 60 Kg S/ha increased the seed yield over the Control (T_0) by 13.9, 28.1 and 28.4% respectively Kumar and Trivedi (2012). the maximum net returns of (Rs 9,176 /ha) and benefit cost ratio of (1.49) with 60 Kg S per hectare, whereas the highest benefit cost ratio was obtained with 40Kg S ha-1 Rana and Rana (2004) [5]. In Rajasthan observed that 74.86 Kg sulphur per hectare resulted net income and benefit cost ratio of Rs 15,799 and 2.69 respectively during the first year. In second year Rs 18,193 and 2.87 net income and benefit cost ratio (B:C) respectively in mustard Singh and Meena (2005) [6]. Found that the highest net returns (Rs.37200/ha) and B:C ratio (2.64) was recorded highest in the treatment *Azotobacter* + *PSB* and 100% RDF compared to other treatments Meena *et al.,* (2013) [4]. Reported that application of *Azotobacter* spp. + *PSB* spp. (each @ 10 ml/kg seed) found the highest net returns of 86629 Rs/ha and B: C ratio 3.40 over control (no inoculation) Hadiyal *et al*., (2017) [1]. in their experiment found that economics of cultivation in terms of net return of Rs.17605 & Rs. 17205 and B: C of 2.07 & 2.11 were considerably higher in treatment of Azotobacter + PSB + 50% NPK + FYM and Azotobacter + PSB + 75% NPK + FYM In which biofertilizer seed treatment was done as compared to recommended NPK (Rs. 14160 and 1.93, respectively) Kalita *et al.,* (2019) [2].

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