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Influence of bio-fertilizers and growth regulators for enhancing yield and yield attributes of Indian mustard (*Brassica juncea* L.) grown under rainfed condition

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ABSTRACT

A field study was conducted during *Rabi* season of two consecutive years 2019 and 2020 in Crop Research Farm at Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India to determine the role of biofertilizer and growth regulators on production of Indian mustard (*Brassica juncea* L.). For the yield and yield parameter *viz.,* seed yield (1.943 and 2.034 t/ha), stover yield (6.747 and 6.964), harvest index (22.31 and 22.56 %) and test weight (3.38 and 3.47 g) significantly higher were recorded during the years 2019-20 and 2020-21 in treatment combination B_4 (PSB + VAM + Azotobacter), respectively. Among the growth regulators results revealed that is significantly higher recorded the seed yield (1.842 and 1.978 t/ha) and stover yield (6.768 and 6.954 t/ha) during the years 2019-20 and 2020-21, respectively in the treatment G_1 [Gibberellic acid 50 ppm (0.05 g/l)].

Key words: *Mustard, Biofertilizer, Growth regulators, Yield and Test weight*

Introduction

Mustard (*Brassica juncea* L.) is an important *Rabi* season oilseed crop, belongs to family Cruciferae and genus *Brassica.* Mustard seed is the world's second leading source of vegetable oil, after soybean (Nasri *et al.* 2008). There is an ever-increasing demand of edible oil in the country and the local production can meet up only one third of the requirement. Every year, it needs to import oil and oilseeds to meet up the deficit. Climatic change may be the major cause for yield reduction in winter crops. Temperature is increasing day by day which hampers the growth of rapeseed - mustard and reduced yield (Alam *et al.* 2014).

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).

In our present investigation, phosphate solubilizing bacteria (PSB) and Azotobacter are used as biofertilizer. PSB secrete some organic acids which can solubilize P from insoluble and fixed forms to plant available forms, whereas Azotobacter can convert atmospheric N_2 into plant available form of N in

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the soil (Mondal *et al.,* 2015).

Mustard is generally, affect by irrigation water. The mustard is the crop that has fewer requirements of the water (Aujla *et al.,* 2005). To alleviate the harmful effect of drought stress, bioregulators may be used to change the different metabolic and physiological activities of the plant for increasing the yield of mustard crop (Meena *et al.,* 2013) and (Singh and Meena, 2019).

The recent research findings indicate the use of bio-regulators for increasing productivity (Hayat and Ahmad, 2007). These bio -regulators acts as chemical catalyst in the plant and improve physiology and reproductive efficiency in the plant. These bio-regulators possibly improve the sucrose transport and increase dry matter partitioning for grain production (Dadhich *et al.,* 2015).

Materials and Methods

Study area description

The field experiment was conducted on the crop Indian mustard during the *rabi* season 2019-20 and 2020-21 at Crop Research Farm, SHUATS, Department of Agronomy, Naini Agricultural Institute, Prayagraj, Uttar Pradesh, India. The experimental site has sub humid climate and is located at 25^0 39 42" N latitude, $81^0$6756" E longitude and 98 m altitude above the mean sea level (MSL).This area is situated on the right side of the Yamuna River.

Experimental design and analysis

The experiment consisted of two factors, biofertilizers and growth regulators with water spray, there were 16 treatments each being replicated thrice and laid down in Split Plot Design with three replications. The data of two years were pooled and statistically analysed using analysis of variance (ANOVA) for Split Plot Design. The experimental data were analyzed statistically by applying the technique of analysis of variance prescribed for the design to test and conclusions were drawn at 5% probability levels.

Crop husbandry

Seed yield (t ha^{-1}); The siliquae harvested from the net plot were weighted and expressed in t ha^{-1}. *Stover yield (t ha^{-1});* after harvesting of siliquae, the left-over plants were harvested to the base from net plot was weighed and expressed in t ha^{-1}. *Harvest Index;* Harvest index was obtained by dividing the economic yield (grain) by biological yield (grain + straw). It was calculated for each of the plot and was represented in percentage. The following formula was used (Donald, 1962).

Harvest Index (%): Economic yield (g)/Biological yield (g) x 100

Test weight (g); the 1000 seeds from five mustard plants were obtained immediately after harvest, weighed and the average weight was expressed in g.

Results and Discussion

Effect of biofertilizer

The data of both the year (Table 2) revealed that seed significantly higher (1.943 t/ha at 2019-20 and 2.034 t/ha at 2020-21) and stover yield (6.747 t/ha at 2019-20 and 6.964 t/ha at 2020-21), respectively were recorded organic fertilized by biofertilizer treatment combination B_4(PSB + VAM + Azotobacter). Significantly the higher harvest index (22.31 % at 2019-20 and 22.56 % at 2020-21) also recorded is similar treatment combination. It might be due to inoculation of PSB solubilization of inorganic in-

Table 1. Description of treatment with symbol

Plots	Symbol
Biofertilizers (Main plots)	
Azotobacter	B_1
Phosphate Solubilizing Bacteria + Azotobacter	B_2
Vesicular Arbuscular Mycorrhiza + Azotobacter	B_3
Phosphate Solubilizing Bacteria + Vesicular Arbuscular Mycorrhiza + Azotobacter	B_4
Growth regulators (Sub plots)	
Water Spray	G_0
Gibberellic acid 50 ppm (0.05 g/L)	G_1
Salicyclic acid 100 ppm (0.01 g/L)	G_2
Indole acetic acid 50 ppm (0.05 g/L)	G_3

soluble phosphates by microorganisms helped in production of organic acids, chelating oxoacids from sugars, and exchange responses in growth environment, the results were found to similar with (Kumar *et al.*, 2016).

From the observations test weight (3.38 and 3.47 g at 2019-20 and 2020-21) and length of siliquae (6.88 and 6.89 g at 2019-20 and 2020-21) wererecorded significant and maximum in treatment B_4 (PSB + VAM + Azotobacter), respectively. Increase in yield attributes and yield through bio-fertilizer might be attributed to supply of more plant hormones (auxin, cytokinin, gibberellin etc.) by the microorganisms inoculated or by the root resulting from reaction to microbial population similar results were obtained by (Kalita *et al.*, 2019) and (Vijayeswarudu and Singh, 2021). Other reason application of bio-fertilizers helps in secretion of growth promoting substances, which lead to better root development, transportation of water, uptake and decomposition of nutrients. The present results are also in agreement with the finding of Mahboobeh and Jahanfar (2012), Premi *et al.* (2012); Meena *et al.* (2014) and Hadiyal *et al.*, 2017.

Significantly lower seed yield (1.649 t/ha at 2019-20 and 1.768 t/ha at 2020-21) and stover yield (6.596 t/ha at 2019-20 and 6.794 t/ha at 2020-21) respectively, was observed with B_1 (Azotobacter).

Effect of growth regulators

The observation on seed yield (Table 2) revealed that among the growth regulator plots from the treatment G_1 [Gibberellic acid 50 ppm (0.05 g/l)] recorded the significantly higher (1.842 t/ha at 2019-20 and 1.978 t/ha at 2020-21) and stover yield (6.768 t/ha at 2019-20 and 6.954 t/ha at 2020-21), respectively. However, non-significant harvest index and length of siliquae were recorded during first year of experiment. The result on test weight showed that treatments G_1 [Gibberellic acid 50 ppm (0.05 g/l)] recorded significant and maximum test weight (3.32 and 3.44 g at 2019-20 and 2020-21) compared to other growth regulators. The significantly higher harvest index (22.12%) and length of siliquae (6.77 cm) during second year of experiment were recorded for the treatment G_1, however it was statistically at par with all growth regulators except water spray, respectively. It might due to Gibberellic acid increased the translocation of assimilates to the reproductive organ which resulted in the increased length of siliquae and yield production. The plant growth regulators like gibberellic acid might be in-

Table 1. Crop productivity as influenced by biofertilizer and growth regulators on Indian mustard (*Brassica juncea* L.)

Treatments	Seed yield (t/ha)		Stover yield (t/ha)		Harvest Index (%)		Test weight (g)		Length of siliquae (cm)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Biofertilizer										
B_1: Azotobacter	1.649 b	1.768 b	6.596 a	6.794 a	19.98 b	20.59 b	2.98 b	3.10 c	6.47 c	6.54 c
B_2: PSB + Azotobacter	1.818 a	1.941 a	6.702 a	6.873 a	21.35 a	22.04 a	3.24 a	3.29 b	6.70 b	6.78 b
B_3: VAM + Azotobacter	1.723 b	1.848 b	6.588 a	6.856 a	20.71 a	21.18 a	3.28 a	3.43 a	6.50 c	6.56 c
B_4: PSB + VAM + Azotobacter	1.943 a	2.034 a	6.747 a	6.964 a	22.31 a	22.56 a	3.38 a	3.47 a	6.88 a	6.89 a
F-test	S	S	S	S	S	S	S	S	S	S
SEm±	0.046	0.032	0.106	0.104	0.49	0.43	0.11	0.02	0.05	0.02
CD (P = 0.05)	0.161	0.111	0.366	0.358	1.69	1.48	0.39	0.08	0.17	0.06
CV (%)	4.794	1.318	2.926	2.421	4.26	4.40	6.43	1.55	1.35	0.60
Growth Regulators										
G_0: Water Spray	1.658 b	1.728 b	6.418 b	6.729 b	20.47	20.37 b	2.97 b	3.11 c	6.51	6.52 b
G_1: Gibberellic acid 50 ppm (0.05 g/l)	1.842 a	1.978 a	6.768 a	6.954 a	21.33	22.12 a	3.32 a	3.44 a	6.71	6.77 a
G_2: Salicyclic acid 100 ppm (0.01 g/l)	1.808 a	1.938 a	6.698 a	6.941 a	21.26	21.81 a	3.30 a	3.38 b	6.68	6.74 a
G_3: Indole acetic acid 50 ppm (0.05 g/l)	1.825 a	1.947 a	6.748 a	6.864 a	21.30	22.07 a	3.29 a	3.36 b	6.66	6.74 a
F-test	S	S	S	S	NS	S	S	S	NS	S
SEm±	0.045	0.049	0.072	0.061	0.46	0.46	0.08	0.02	0.06	0.05
CD (P = 0.05)	0.127	0.140	0.206	0.173	1.30	1.31	0.21	0.05	0.18	0.14
CV (%)	4.617	2.014	1.997	1.425	3.98	4.73	4.32	1.05	1.72	1.79

Table 3: Interaction effect of biofertilizers and growth regulators on seed yield, stover yield and harvest index of Indian mustard (*Brassica juncea* L.)

Treatment combination	Seed yield (t/ha)					Stover yield (t/ha)					Harvest Index(%)				
						2019-20									
	G_0	G_1	G_2	G_3	Mean	G_0	G_1	G_2	G_3	Mean	G_0	G_1	G_2	G_3	Mean
B_1	1.433	1.633	1.740	1.790	1.649	6.207	6.677	6.940	6.560	6.596	18.73	19.66	20.08	21.44	19.98
B_2	1.867	1.787	1.870	1.750	1.818	6.333	6.683	6.923	6.867	6.702	22.71	21.12	21.25	20.33	21.35
B_3	1.623	1.787	1.687	1.793	1.723	6.540	6.743	6.367	6.700	6.588	19.88	20.87	20.97	21.13	20.71
B_4	1.710	2.160	1.933	1.967	1.943	6.593	6.967	6.560	6.867	6.747	20.54	23.67	22.76	22.29	22.31
Mean	1.658	1.842	1.808	1.825	1.783	6.418	6.768	6.698	6.748	6.658	20.47	21.33	21.26	21.30	21.09
F-test	S	S	S												
SEm±	0.089	0.144	0.91												
CD (P=0.05)	0.255	0.411	2.59												
						2020-21									
	G_0	G_1	G_2	G_3	Mean	G_0	G_1	G_2	G_3	Mean	G_0	G_1	G_2	G_3	Mean
B_1	1.533	1.873	1.867	1.797	1.768	6.439	6.963	6.948	6.827	6.794	19.19	21.20	21.16	20.79	20.59
B_2	1.943	1.903	1.993	1.923	1.941	7.031	6.833	6.922	6.707	6.873	21.64	21.85	22.35	22.32	22.04
B_3	1.700	1.867	1.893	1.933	1.848	6.839	6.890	6.839	6.857	6.856	19.80	21.30	21.64	21.98	21.18
B_4	1.737	2.267	2.000	2.133	2.034	6.607	7.131	7.053	7.064	6.964	20.84	24.12	22.10	23.20	22.56
Mean	1.728	1.978	1.938	1.947	1.898	6.729	6.954	6.941	6.864	6.872	20.37	22.12	21.81	22.07	21.59
F-test	S	S	S												
SEm±	0.098	0.122	0.92												
CD (P=0.05)	0.279	0.347	2.62												

Note: *Biofertilizer*: B_1: Azotobacter, B_2: PSB + Azotobacter, B_3: VAM + Azotobacter, B_4: PSB + VAM + Azotobacter, *Growth Regulators*: G_0: Water Spray, G_1: Gibberellic acid 50 ppm, G_2: Salicyclic acid 100 ppm, G_3: Indole acetic acid 50 ppm

volved in formation of seeds in the pods and their optimum nourishments have resulted in a smaller number of aborted seeds and thus maximized the survival of fertile seeds/pod in mustard resulted that more yield (Akter *et al.*, 2007).

Interaction effect of biofertilizer and growth regulators (B x G)

The available yield and yield attributes (Table 2) after harvest of mustard was significantly influenced for biofertilizer and growth regulators interaction (Table 3). Application of (PSB + VAM + Azotobacter) along with gibberellic acid 50 ppm (0.05 g/l)] reported significantly higher seed yield (2.160 and 2.267 t/ha at 2019-20 and 2020-21), stover yield (6.967 and 7.131 t/ha at 2019-20 and 2020-21) and harvest index (23.67 and 24.12 % at 2019-20 and 2020-21), respectively. The P solubilizers on the other hand transforms fixed and insoluble forms of P into soluble forms and increase the availability of phosphorus. Similar results were also obtained by Khanday and Ali (2012).

Conclusion

It may be concluded that sources of biofertilizers with higher combination in presence of biofertilizer like phosphate solubilizing biofertilizers (PSB) and Vesicular Arbuscular Mycorrhizae (VAM) with azotobacter have pronounced influenced on seed yield, stover yield, harvest index, test weight and length of siliquae. Thus, application of gibberellic acid 50 ppm (0.05 g/l) more beneficial over the growth regulators and water spray. The results confirmed the positive role of Gibberellic acid in increased yield attributes even direct effect on crop productivity and increases in crop yields as compare to other growth regulators.

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