Effect of Biofertilizers and Potassium on Yield and Economics of Yellow mustard (*Brassica campestris* L.)

ABSTRACT

A field experiment was conducted during *Rabi*, 2021 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The experiment was laid out in RandomizedBlock Design with the combination of Biofertilizers (*Azotobacter*, Phosphate Solubilizing Bacteria) and Potassium levels (35, 40 and 45 kg/ha). Totally there were nine treatments which were replicated thrice. The results revealed that higher number of siliqua per plant (134.53), seeds per siliqua (31.67), test weight (3.40 g), seed yield (1.53 t/ha), stover yield (5.20 t/ha), harvest index (22.74%) were recorded with the treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + Potassium at 40 kg/ha (T_8). However, the application of *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + Potassium at 40 kg/ha (T_8) also fetched maximum gross returns (91,800.00 INR/ha), net returns (60,642.40 INR/ha) and benefit cost ratio (1.95) when compared to all other treatment combinations.

Keywords: *Azotobacter, PSB*, Potassium, yield, Economics, yellow mustard.

1. INTRODUCTION

Yellow mustard is one of the most important oilseed crops and occupies a prominent place among oil seed crops being next to groundnut, its oil is not only used for edible purpose but also has industrial uses. In India rapeseed and mustard crops occupy second place after soybean inrespect area and production. Mustard seed in general, contains 30-33% oil, 17-25% proteins, 8-10% fibres, 6-10% moisture, and 10-12% extractable substances. Major mustard growing states in India are Rajasthan (40.82%), Haryana (13.33%), Madhya Pradesh (11.76%), Uttar Pradesh (11.40%) and West Bengal (8.64%) according to 2018-19 year **(Rathi *et al*. 2019)**. The seeds are highly nutritive containing 38-57% erucic acid, 5-13% linoleic acid and 27% oleic acid. They are not only rich sources of energy and carriers of fat-soluble vitamins A, D, E and K but they form the ingredients of foods and flavours, cosmetics and condiments, soap and detergents, lubricants and laxatives and also known for their medical and therapeutic use **(Chauhan *et al*. 2020).**

Azotobacter is non-symbiotic nitrogen fixing microbe having potential to fix considerable quantities of atmospheric Nitrogen in the rhizosphere of non- legumes. Besides nitrogen fixation, *Azotobacter* synthesizes various growth promoting substances such as Vitamins of B group, Nicotinic acid, Gibberellins and antifungal compounds. *Azotobacter* inoculation improves the crop productivity by 0-25 % over the control in the absence of any amendment and by 8.75% in the presence of NPK (**Narula, 2000**). Toria responds favorably to bio-fertilizers, *viz.*, *Azotobacter* and phosphorus solubilizing bacteria (PSB).

Phosphate solubilizing bacteria (PSB) promote seed germination and initial vigour of the plants by producing growth promoting substances. Application of PSB results in increased mineral and water uptake, root development, vegetative growth and nitrogen fixation (**Gangwal *et al*. 2011**). PSB solubilizes unavailable phosphorus in soil and makes it available to the plants. Potassium is most vital nutrients for the growth and development of mustard crop. Besides N and P, the use of K has been reported to influence the productivity of seed yield and seed oil contents (**Ghosh *et al.* 1995**) Potassium nutrition is associated with grain quality including protein content. Potassium stimulates the transport of nitrogenous compounds to developing fruits and thereby increase seed yield.

2. MATERIALS AND METHODS

A field experiment was conducted during *Rabi*, 2021, at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj. The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorous, and low in potassium The experiment was laid out in Randomized Block Design comprising of 9 treatments which are replicated thrice. Each treatment net plot size is 3m × 3m. The treatment are categorized as with recommended dose of nitrogen through urea and Phosphorous through SSP, in addition Potash through Muriate of Potash were applied in combinations and Bio fertilizers were applied as per the treatment details. The sowing was done on 20th October 2021 with the seed rate of 4 kg/ha. The factors used are Biofertilizers (*Azotobacter* and *PSB*) and Potassium levels (35, 40 and 45 kg/ha). The treatment details are as follows, T_1- *Azotobacter* at 20 g/kg seed + Potassium at 35 kg/ha, T_2-*Azotobacter* at 20 g/kg seed + Potassium at 40 kg/ha, T_3-*Azotobacter* at 20 g/kg seed + Potassium at 45 kg/ha, T_4- PSB at 20 g/kg seed + Potassium at 35 kg/ha, T_5-PSB at 20 g/kg seed +Potassium at 40 kg/ha, T_6-PSB at 20 g/kg seed + Potassium at 45 kg/ha, T_7-*Azotobacter* at 10g/kg seed + PSB at 10g/kg seed + Potassium at 35 kg/ha, T_8- *Azotobacter* at 10g/kg seed + PSB at 10g/kg seed + Potassium at 40 kg/ha and T_9-

Azotobacter at 10g/kg seed + PSB at 10g/kg seed + Potassium at 45 kg/ha. The crop was harvested treatment wise at harvesting (maturity stage) and after harvesting the siliqua are dried and threshing and winnowing were done. Seeds were separated from siliqua. The seed yield was calculated per ha and computed and expressed in tonnes per hectare. The data was computed and analysed by following statistical method of **Gomez and Gomez (1984)**. The benefit cost ratio was worked after price value of seed yield and total cost included in crop cultivation.

3. RESULTS AND DISCUSSION:

3.1 **Effect on the yield of yellow mustard:** The Yield and Yield parameters of yellow mustard were tabulated in Table 2 shows that Maximum number of Siliqua/plant (134.53) were recorded with the treatment *Azotobacter* at 10g/kg seed + PSB at 10 g/kg seed+ K at 40 kg/ha (T_8) which was superior over rest of all treatments.However, treatments with Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 35 kg/ha (T_7) (132.80) and Azotobacter at 10g/kg seed + PSB at 10 g/kg seed + K at 45 kg/ha (T_9) (133.40) were statistically at par with treatment Azotobacter at 10g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8). Maximum Number of seeds/siliqua (31.67) were recorded with the treatment Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) which was superior over rest of all treatments.However, treatments with PSB at 20 g/kg seed+ K at 45 kg/ha (T_6) (30.80) and Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 45 kg/ha (T_9) (31.20) were statistically at par with treatment Azotobacter at 10 g/kgseed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8). Maximum Test weight (3.40 g) was recorded with the treatment Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) which was superior over rest of all treatments. However, treatments with Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 35 kg/ha (T_7) (3.27 g) and Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 45 kg/ha (T_9) (3.33 g) were statistically at par with the treatment Azotobacter at 10 g/kg seed+ PSB at 10 g/kg seed + K at 40 kg/ha (T_8). Seed yield (1.53 t/ha) was recorded significantly highest with treatment Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) which was superior over rest of all treatments. However, treatments with *Azotobacter* at 10g/kg seed+ PSB at 10 g/kg seed + K at 35 kg/ha (T_7) (1.51 t/ha) and *Azotobacter* at 10g/kg seed+ PSB at 10 g/kg seed + K at 45 kg/ha (T_9) (1.52 t/ha) were statistically at par with treatment Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8). Stover yield (5.20 t/ha) was recorded significantly highest with treatment Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) which was superior over rest of all treatments. However, treatments with *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 35 kg/ha (T_7) (4.98 t/ha) and *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 45 kg/ha (T_9) (5.18 t/ha) were statistically at par with treatment Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8). Harvest index (22.74 %) was recorded highest with the treatment Azotobacter at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) and there was no significant difference among the treatments. The significant increase in number of siliqua and grains/siliqua is due to increase in the availability of Nitrogen through bio fertilizer inoculation by which more siliqua lets are produced due to increased rates of siliqua lets primordial production, similar results were found **Hadiyal *et al*. (2017).** This might be due to the fact that *Azotobacter* inoculation fixed atmospheric nitrogen into soil asymbiotically results into better root development and more nutrient availability, resulted in better flowering and siliqua formation and ultimately beneficial effect on seed yield. There were to be a positive synergistic effect that caused to improving photosynthesis by increasing water and nutrients absorption and thus leading to more assimilate and improving plant growth, as result number of siliquae/plant and 1,000 seed weight may have increased as compared with *Azotobacter*, PSB + *Azotobacter* inoculation. Similar result was reported by **(Pramanik and Bera, 2013) and Patra *et al*. 2013.** Potassium application enhances the development of strong cell walls and improves germination of pollen in the florets which leads to high fertility and Siliqua formation. The results were in accordance with **Cheema *et al.* (2012).** Potassium might be attributed to better filling of grains and thus, an increase in different yield attributing characters. The results were found to be similar with **Singh *et al.* (2017).** Increase in yield through bio-fertilizer might be attributed to supply of more plant hormones (auxin, cytokinin, gibberellin etc.) by the microorganisms inoculated or by theroot resulting from reaction to microbial population similar results were obtained by **Kalita *et al.*, (2019).** Potassium application stimulates the cumulative effect of improvement in yield attributes viz., number of siliqua per plant, no of seeds per siliqua and test weight and also increased availability, absorption, and translocation of K nutrient which helped in higher seed yield. The results were in accordance with **Singh *et al.* (2017).** *Azotobacter* and phosphate solubilizing bacteria (PSB) beside fixing ambient nitrogen to the soil and solubilize phosphates in the soil, can benefit rapeseed and mustard by producing growth hormones viz., IAA and gibberellins also. Increased seed and biological yield are the resultant effect of better growth and development in this study.

With the increment in supply of essential nutrient to rapeseed-mustard, their availability, acquisition, mobilization and influx into the plant tissues increased and thus improved growth attributes, yield components and finally yield. These results are in agreement with the findings of **Dutta and Singh (2002), Singh and Sinsinwar (2006); Tripathi et al. (2010).**

3.2 **Economic analysis of yellow mustard:** Gross returns, Net returns and Benefit cost ratio were significantly influenced due to different treatments were present in Table 2 Shows that Maximum Gross Returns (91,800.00 INR/ha) was observed with treatment *Azotobacter* at 10 g/kg seed+ PSB at 10 g/kg seed+ K at 40 kg/ha (T_8) followed by *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 45 kg/ha (T_9) (91200.00 INR/ha) whereas minimum gross returns was observed with Azotobacter at 20 g/kg seed + K at 35 kg/ha (T_1) (77,400.00 INR/ha). Maximum Net Returns (60,642.40 INR/ha) was observed with treatment *Azotobacter* at 10g/kg seed+ PSB at 10 g/kg seed+ K at 40 kg/ha (T_8) followed by *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed+ K at 45 kg/ha (T_9) (59,959.10 INR/ha) whereas minimum net returns was observed with Azotobacter at 20 g/kg seed + K at 35 kg/ha (T_1) (46,325.50 INR/ha). Higher Benefit cost Ratio (1.95) was observed with treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed+ K at 40 kg/ha (T_8) over the rest of the treatments followed by *Azotobacter* at 10g/kg seed + PSB at 10 g/kg seed+ K at 45 kg/ha (T_9) (1.92) whereas lower Benefit cost ratio (1.49) was observed with treatment Azotobacter at 20 g/kg seed + K at 30 kg/ha (T_1)

Table No 1. Effect of Biofertilizers and Potassium on yield attributes in yellow mustard.

S. No.	Treatment Combinations	No. of siliqua/plant	No. of Seeds/siliqua	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1.	*Azotobacter* at 20 g/kg seed + K at 35 kg/ha	125.80	29.27	2.63	1.29	4.52	22.29
2.	*Azotobacter* at 20 g/kg seed + K at 40 kg/ha	127.20	29.87	2.83	1.39	5.06	21.57
3.	*Azotobacter* at 20 g/kg seed+ K at 45 kg/ha	126.87	29.87	2.77	1.36	5.02	21.32
4.	PSB at 20 g/kg seed+ K at 35 kg/ha	129.27	30.00	2.87	1.40	4.22	21.58
5.	PSB at 20 g/kg seed+ K at 40 kg/ha	131.80	30.20	3.07	1.48	4.39	22.03
6.	PSB at 20 g/kg seed+ K at 45 kg/ha	130.80	30.80	2.97	1.42	4.34	21.84
7.	*Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 35 kg/ha	132.80	30.27	3.27	1.51	4.98	22.10
8.	*Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha	134.53	31.67	3.40	1.53	5.20	22.74
9.	*Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 45 kg/ha	133.40	31.20	3.33	1.52	5.18	21.75
	F-Test	S	S	S	S	S	NS
	SEm (±)	0.67	0.31	0.06	0.01	0.14	0.55
	CD (P=0.05)	2.02	0.92	0.17	0.03	0.42	--

Table 2. Effect of Biofertilizers and Potassium on Economics in yellow mustard

S No.	Treatment Combinations	Cost of Cultivation	Gross returns	Net Return	B:C ratio
1.	*Azotobacter* at 20g/kg seed + K at 35 kg/ha	31,074.50	77,400.00	46,325.50	1.49
2.	*Azotobacter* at 20g/kg seed+ K at 40 kg/ha	31,157.60	83,400.00	52,242.40	1.68
3.	*Azotobacter* at 20g/kg seed+ K at 45 kg/ha	31,240.90	81,600.00	50,359.10	1.61
4.	PSB at 20 g/kg seed+ K at 35 kg/ha	31,074.50	84,000.00	52,925.50	1.70
5.	PSB at 20 g/kg seed+ K at 40 kg/ha	31,157.60	88,800.00	57,642.40	1.85
6.	PSB at 20 g/kg seed+ K at 45 kg/ha	31,240.90	85,200.00	53,959.10	1.73
7.	*Azotobacter* at 10g/kg seed + PSB at 10 g/kg seed+ K at 35 kg/ha	31,074.50	90,600.00	59,525.50	1.92
8.	*Azotobacter* at 10g/kg seed+ PSB at 10 g/kg seed+ K at 40 kg/ha	31,157.60	91,800.00	60,642.40	1.95
9.	*Azotobacter* at 10g/kg seed + PSB at 10 g/kg seed+ K at 45 kg/ha	31,240.90	91,200.00	59,959.10	1.92

*Data was not subjected to statistical analysis.

4. CONCLUSION

It is concluded that application of treatment *Azotobacter* at 10g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha was recorded significantly higher seed yield (1.53 t/ha) and found to be more productive and also economically feasible.

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