Original Research Article

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

ABSTRACT

A field experiment was carried out at Crop Research Farm, during Rabi 2021, Department of Agronomy, SHUATS, Prayagraj (Uttar Pradesh) to study the effects of biofertilizers and potassium on the yield and economics of yellow mustard. Biofertilizers (*Azotobacter*, Phosphate-Solubilizing Bacteria) and Potassium levels (35, 40 and 45 kg/ha) were organized in a Randomized Block Design experiment. The treatment with *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + Potassium at 40 kg/ha resulted in a 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) and harvest index (22.74%). In respect to all other treatment combinations, the application of *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + Potassium at 40 kg/ha resulted in the highest gross returns (91,800.00 INR/ha), net returns (60,642.40 INR/ha) and benefit cost ratio (1.95).

Keywords: Yellow mustard, *Azotobacter*, PSB, potassium, yield, and economics.

1. INTRODUCTION

Yellow mustard is one of the most important oilseed crops, next to groundnut in importance among oil seed crops. Its oil is not only edible but also has industrial uses. In India, rapeseed and mustard crops rank second after soybeans in terms of area and yield. Mustard seed in general, consists 30-33% oil, 17-25% proteins, 8-10% fibres, 6-10% moisture and 10-12% extractable compounds. The seeds are high in nutrients, containing 38-57% erucic acid, 5-13% linoleic acid and 27% oleic acid. In addition to being rich sources of energy and carriers of fat-soluble vitamins A, D, E and K, they are also used as ingredients in meals and flavours, cosmetics and condiments, soap and detergents, lubricants and laxatives, and have medical and therapeutic use **(Chauhan *et al*. 2020)**. Mustard oil is mostly used in cooking, frying and pickle. Oil is also used to make vegetable ghee, hair oil, drugs, lubricating oil and in tanning industries The oil cake that remained after Cattle feed is made from the extraction manure. Its oil cake comprises 5.2, 1.8 and 1.2% N, P and K respectively. The green tender plant is used in vegetable preparation commonly known as "Sarsonkasaag." The entire Seed is used in the preparation of pickles and flavouring vegetable and curries.

Azotobacter is a non-symbiotic nitrogen-fixing bacteria with the ability to fix substantial amounts of atmospheric nitrogen in the rhizosphere of non-legumes. In addition to fixing nitrogen, *Azotobacter* also provides a wide range of growth-promoting compounds, such as Gibberellins, Nicotinic Acid, Vitamins of the B Group and antifungal substances. According to reports, *Azotobacter* inoculation can increase crop production by up to 25% in the absence of any amendments and by 8.75% in the presence of NPK **(Narula, 2000)**. Toria responds well to bio-fertilizers like phosphorus-solubilizing bacteria (PSB) and *Azotobacter*.

By producing growth-promoting substances, phosphate solubilizing bacteria (PSB) helps in the germination of seeds and the initial vigour of plants. Increased mineral and water uptake, root growth, vegetative growth and phosphorus fixation occur as a result of the application of PSB **(Gangwal *et al*. 2011)**. PSB makes unavailable phosphorus in soil available to plants by solubilizing it. For the growth and development of the mustard crop, potassium is the most important nutrient. In addition to N and P, it has been found that the use of K affects the productivity of seed yield and seed oil contents **(Ghosh *et al*. 1995)**. Potassium nutrition is associated to grain quality, which includes protein content. Potassium facilitates the movement of nitrogenous compounds that help fruits grow and, as a result, enhance seed production.

2. MATERIALS AND METHODS

At the Crop Research Farm of the Department of Agronomy, SHUATS, Prayagraj, a field experiment was carried out during the Rabi season of 2021. The soil at the experimental site was a sandy loam with a low organic carbon content, medium availability of nitrogen, phosphorus and low in potassium. The trial was conducted using a randomized block design with nine treatments that are replicated three times. The treatments are categorized into those that include the recommended doses of nitrogen through urea and phosphorus through SSP, as well as potash through combinations of muriate of potash and biofertilizers used in accordance with the treatment's specific requirements. On October 20, 2021, the seeds were sown at a rate of 4 kg/ha. Potassium levels (35, 40 and 45 kg/ha) and biofertilizers (*Azotobacter* and PSB) are the major factors. The details of the treatment 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, T_6-PSB at 20 g/kg seed + Potassium at 45 kg/ha, T_7-*Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + Potassium at 35 kg/ha, T_8- *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + Potassium at 40 kg/ha and T_9-*Azotobacter* at

10 g/kg seed + PSB at 10 g/kg seed + Potassium at 45 kg/ha. After harvest, the yield parameters and an economic analysis of the entire trial were recorded. The parameters that affect yield, such as the number of siliqua per plant, the number of seeds per siliqua, test weight, seed yield, stover yield, and harvest index. Analysis of variance was used to statistically record and analyse these parameters. The seed yield produced per hectare was calculated and given in tonnes per hectare. Data were calculated and analysed using the **Gomez and Gomez** statistical method **(1984)**. After computing the price value of the seed yield and the total cultivation-related cost, the benefit-cost ratio was calculated.

3. RESULTS AND DISCUSSION:

3.1 Yield and Yield attributes

The yield and yield parameters of yellow mustard (Table 1) indicate that the treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) recorded significantly higher number of siliqua per plant (134.53), outperforming the other 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 10 g/kg seed + PSB at 10 g/kg seed + K at 45 kg/ha (T_9) (133.40) were statistically equivalent to the treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8). The treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) recorded significantly higher number of seeds per siliqua (31.67), outperforming all other 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 equivalent to the treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8). The treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) recorded significantly higher Test weight (3.40 g), outperforming all other treatments. However, the 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 equivalent to the treatment with *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 (T_8). The *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) treatment produced the highest seed yield (1.53 t/ha) compared to the remaining treatments. However, treatments with *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 35 kg/ha (T_7) (1.51 t/ha) and *Azotobacter* at 10 g/kg seed+ PSB at 10 g/kg seed + K at 45 kg/ha (T_9) (1.52 t/ha) were statistically equivalent to the treatment with *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8). The treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) produce the higher amount of stover (5.20 t/ha) compared to the other treatments. However, the 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 equivalent to the treatment with *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8). The maximum harvest index (22.74%) was observed 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 treatments. The significant increase in the number of siliqua and seeds per siliqua is due to an increase in Nitrogen availability by biofertilizer inoculation, which results in more siliqua lets is been produced due to increased rates of siliqua lets primordial production; similar results were found **Hadiyal *et al.* (2017)**. This could be due to *Azotobacter* inoculation asymbiotically fixes atmospheric nitrogen into soil, resulting in enhanced root development and increased nutrient availability, which results in better flowering and siliqua production and, eventually, a great impact on seed yield. There was a positive synergistic effect that resulted in improved photosynthesis by increasing water and nutrient absorption, resulting in more assimilate and enhanced plant growth, as a result of which the number of siliqua/plant and 1,000 seed weight may have increased when compared to *Azotobacter*, PSB + *Azotobacter* inoculation. **(Pramanik and Bera, 2013)** and **Patra *et al.* (2013)** reported similar findings. Potassium application promotes the formation of thick cell walls and the germination of pollen in the florets, resulting in high fertility and Siliqua formation. The findings agreed with those of **Cheema *et al*. (2012)**. Potassium may be linked to improved grain filling and, as a result, an increase in various yield-related characteristics. The results were similar to those reported by **Singh *et al.* (2017)**. Increased yield from bio-fertilizer could be due to the supply of plant hormones (auxin, cytokinin, gibberellin, etc.) by the inoculated microorganisms or by the root as a result of a reaction to microbial population. **Kalita *et al*. (2019)** observed similar result. Potassium application increases the cumulative effect of improved yield qualities such as number of siliqua per plant, number of seeds per siliqua, and test weight, as well as increased availability, absorption, and translocation of K nutrition, resulting in better seed production. The findings were in accordance with **Singh *et al.* (2017)**. *Azotobacter* and phosphate solubilizing bacteria (PSB) can help rapeseed and mustard by producing growth hormones such as IAA and gibberellins in addition to fixing ambient nitrogen to the soil and solubilizing phosphates in the soil. In this study, improved growth and development results in increased seed and biological yield. The increased supply of essential nutrients to rapeseed-mustard improved their availability, acquisition, mobilisation, and influx into plant tissues, which improved growth characteristics, yield components, and ultimately yield. These findings are in accordance with those reported by **Dutta and Singh (2002)**, **Singh and Sinsinwar (2006)** and **Tripathi *et al.*** (2010).

3.2 Economics

As shown in Table 2, different treatments had a significant effect on the gross returns, net returns, and benefit cost ratio. The treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) produced the highest gross return (91,800.00 INR/ha), followed by *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 45 kg/ha (T_9) (91,200.00 INR/ha), whereas lowest gross return was observed with *Azotobacter* at 20 g/kg seed + K at 35 kg/ha (T_1) (77,400.00 INR/ha). The treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) produced the highest net return (60,642.40 INR/ha), 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 lowest net return was observed with *Azotobacter* at 20 g/kg seed + K at 35 kg/ha (T_1) (46,325.50 INR/ha). The treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha (T_8) produced the highest benefit-cost ratio (1.95), followed by *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed+ K at 45 kg/ha (T_9) (1.92), whereas *Azotobacter* at 20 g/kg seed + K at 35 kg/ha (T_1) produced the lowest benefit-cost ratio (1.49).

Table 1. Effect of Biofertilizers and Potassium on yield attributes of yellow mustard.

T. No.	Treatment Combinations	No. of siliqua/plant	No. of Seeds/siliqua	Test weight (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
T_1	*Azotobacter* at 20 g/kg seed + K at 35 kg/ha	125.80	29.27	2.63	1.29	4.52	22.29
T_2	*Azotobacter* at 20 g/kg seed + K at 40 kg/ha	127.20	29.87	2.83	1.39	5.06	21.57
T_3	*Azotobacter* at 20 g/kg seed+ K at 45 kg/ha	126.87	29.87	2.77	1.36	5.02	21.32
T_4	PSB at 20 g/kg seed+ K at 35 kg/ha	129.27	30.00	2.87	1.40	4.22	21.58
T_5	PSB at 20 g/kg seed+ K at 40 kg/ha	131.80	30.20	3.07	1.48	4.39	22.03
T_6	PSB at 20 g/kg seed+ K at 45 kg/ha	130.80	30.80	2.97	1.42	4.34	21.84
T_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
T_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
T_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 of yellow mustard

T. No.	Treatment Combinations	Cost of Cultivation (INR/ha)	Gross returns (INR/ha)	Net Return (INR/ha)	B:C ratio
T_1	*Azotobacter* at 20 g/kg seed + K at 35 kg/ha	31,074.50	77,400.00	46,325.50	1.49
T_2	*Azotobacter* at 20 g/kg seed+ K at 40 kg/ha	31,157.60	83,400.00	52,242.40	1.68
T_3	*Azotobacter* at 20 g/kg seed+ K at 45 kg/ha	31,240.90	81,600.00	50,359.10	1.61
T_4	PSB at 20 g/kg seed+ K at 35 kg/ha	31,074.50	84,000.00	52,925.50	1.70
T_5	PSB at 20 g/kg seed+ K at 40 kg/ha	31,157.60	88,800.00	57,642.40	1.85
T_6	PSB at 20 g/kg seed+ K at 45 kg/ha	31,240.90	85,200.00	53,959.10	1.73
T_7	*Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed+ K at 35 kg/ha	31,074.50	90,600.00	59,525.50	1.92
T_8	*Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed+ K at 40 kg/ha	31,157.60	91,800.00	60,642.40	1.95
T_9	*Azotobacter* at 10 g/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

The application of treatment *Azotobacter* at 10 g/kg seed + PSB at 10 g/kg seed + K at 40 kg/ha resulted in significantly higher seed yield (1.53 t/ha), higher gross returns (91,800 INR/ha), net returns (60,642.40 INR/ha) and benefit cost ratio (1.95 INR/ha) as compared to other treatments and was found to be more productive and cost effective.

REFERENCES

Cheema, M.A., Wahid, M.A., Sattar, A., Rasul, F., Saleem, M.F. (2012). Influence of different levels of potassium on growth, yield and quality of canola (*Brassica napus* L.) cultivars. *Pakistan Journal of Agricultural Science*. **49**(2): 163-168.

Dutta, S. and Singh, M. S. (2002). Effect of Azotobacter on yield and oil content of rapeseed mustard varieties under Manipur condition. *Indian Journal of Hill Farming*. **15**(2); 44-46.

Gangwal, T.V., Patel, M.V. and Jadav, N.J. (2011). Effect of phosphorus, sulphur and phosphate solubilising bacteria on yield, nutrient uptake and soil fertility after harvest of mustard. *Indian Journal of Fertilizer*. **7**: 32-40.

Ghosh, S.K., Pal, S., Mukhopadhyay, A.K. (1995). Split application of potassium to maximize its efficiency on yield of high yielding rice. *American Journal of Plant Sciences*. **39**: 259-261.

Gomez, K.A and Gomez, A.A. (1984). Statistical Procedures for Agriculture Research. *2nd ed. John Wiley and Sons*. New York, USA. 680p.

Hadiyal, J.G., Kachhadiya, S.P., Ichchhuda, P.K., Kalsaria, R.N. (2017). Response of Indian mustard (*Brassica juncea* L.) to different levels of organic manures and bio-fertilizers. *Journal of Pharmacognosy and Phytochemistry*. **6**(4): 873-875.

Kalita N, Bhuyan S, Maibangsa S and Saud R.K. (2019). Effect of Biofertilizer Seed Treatment on Growth, Yield and Economics of Toria (*Brassica campestris* L.) under Rainfed Condition in Hill Zone of Assam. *Current Agriculture Research Journal*. **7**(3) 332-336.

Narula, N. (2000). Azotobacter as an organism. (*In:*) Azotobacter in Sustainable Agriculture. C*BS Publishers and Distributors*. New Delhi: 1-12.

Patra, P., Pati, B.K., Ghosh, G.K., Mura, S.S., Saha, A. (2013). Effect of Biofertilizers and Sulphur on Growth, Yield, and Oil Content of Hybrid Sunflower (*Helianthus annuus*. L) In a Typical Lateritic Soil. *Open Access Scientific Reports* **2**(1).

Pramanik, K., Bera, A.K. (2013). Effect of biofertilizers and phytohormone on growth, productivity and quality of sunflower (*Helianthus annuus*. L) *Journal of Crop and Weed*. **9**(2):122-127.

Singh, R., Sinsinwar, B.S. (2006). Effect of integrated nutrient management on growth, yield, oil content and nutrient uptake of Indian mustard (*Brassica juncea*). *Indian Journal of Agricultural Sciences*. **76**(5), 322-324.

Singh, J.P., Bhardwaj, K.K., Tomar, D. (2017). Effect of Potassium Application on Yield of and Nutrient Uptake by Mustard. *Indian Journal of Fertilisers*. **13**(8): 68-72.

Tripathi, M.K., Chaturvedi, S., Shukla, D.K., Mahapatra. (2010). Yield performance and quality in Indian mustard (*Brassica juncea*) as affected by integrated nutrient management. *Indian Journal of Agronomy*. **55** (2), 138-142.

Zalak Y. Chauhan, D. K. Patel and Komal Bhabhor. (2020). Effect of Nitrogen, Phosphorus and Sulphur on Yield, Nutrient Uptake and Soil Fertility after Harvest of Mustard (*Brassica juncea* L.). *International Journal of Current Microbiology and Applied sciences*. **9**(6): 3506-3512.

Balasu Janaki, Rajesh Singh and Thakur Indu. (2022). Effect of biofertilizers and potassium on growth and yield of yellow mustard (Brassica campestris L.). The Pharma Innovation Journal 2022; 11(7): 3033-3036