Original Research Article

Effect of Bio-fertilizers and Phosphorus on Yield and Economics of Toria (*Brassica campestris* L.)

ABSTRACT

A field experiment was conducted during *Rabi* season of 2022 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj (U.P.) India. To study the Response of bio-fertilizers and phosphorus on growth and yield of Toria. The treatments consist of Bio-fertilizers like Azotobacter – (20g/kg seeds), PSB – (20g/kg seeds), Azotobacter – (10g/kg seeds) + PSB – (10g/kg seeds) and Phosphorus 30, 40, 50 kg/ha. There were 10 treatments each replicated thrice. The soil of experimental plot was sandy loamy in texture, nearly neutral in soil reaction (pH 7.8), low in organic carbon (0.35%) available N (163.42 kg/ha), available P (21.96 kg/ha) and available K (256.48 kg/ha). Results revealed that the higher number of siliqua (232.53 cm), higher number of seeds/siliqua (20.60), higher test weight (3.92 gm), higher grain yield (20.6 q/ha) and higher stover yield (3.70 t/ha) were significantly influenced with application of Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha. Higher gross returns (INR 1,03,828.00/ha), higher net returns (INR 74,178.00/ha) and higher B:C ratio (2.50) were also recorded in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha).

Key words: *Toria, bio-fertilizers, phosphorus, yield attributes and economics.*

INTRODUCTION

Rapeseed-mustard is India's major edible oilseed crop group and a significant source of revenue for small and marginal farmers in rainfed areas. It is India's second biggest edible oilseed after groundnut, accounting for approximately 27.8 percent of the country's oilseed industry. Rapeseed-mustard is one of the oilseed crops farmed in 26 states in the country's northern and eastern areas, with rainfed land accounting for 30% of the total. Rajasthan (47.26%), Haryana (11.73%), Madhya Pradesh (10.82%), Uttar Pradesh (9.73%), and West Bengal (6.69%) are the leading rapeseed-mustard producing states in India. With 6.32 million hectares of land under cultivation of Brassica, India is the world's largest producer, accounting for around 7.39 million tonnes of global production **(Mahanta et al., 2019).**

Toria (*Brassica campestris* L. var. toria) is an important oilseed crop farmed mostly during the Rabi season. It is an irrigated crop with a short growth season of 90-92 days. It is thought to have substantial promise as an important oilseed crop due to its shorter lifespan and tolerance to a wide range of agroclimatic areas and soil types. Growing toria in double cropping can help farmers increase their income by making greater use of the Rabi season. However, rising population and a decline in accessible land and other productive units are putting enormous strain on present agricultural and natural resources in order to fulfil expanding food demand. Farmers are employing an excessive quantity of agrochemicals to improve output in order to meet growing demand, but this is leading in degradation of soil health and loss of soil fertility.

INM is the most effective method for maximising available resources and producing crops at the lowest possible cost. Inorganic fertiliser price increases and soil degradation may also be addressed by the efficient and combined application of sufficient nutrients by inorganic and organic fertilisers **(Sindhi et al., 2018).** Biofertilizers are well-known to play a number of important roles in increasing soil fertility, crop productivity, and crop production in agriculture because they are eco-friendly, but they cannot replace chemical fertilizers because they are critical in achieving higher crop yields (Solanki et al., 2018). When phosphate solubilizing bacteria inoculants are given to various agricultural plants, they improve seed germination and plant vigour by creating growth-promoting chemicals. The use of biofertilizers improves mineral and water intake, root development, vegetative growth, and nitrogen fixation **(Solanki et al., 2018).** Azotobacter inoculants improve seed germination and plant vigour by creating growth promoting substances when applied to several nonleguminous agricultural plants **(Yadav et al., 2010).**

Phosphorus is found in many important compounds, including nucleic acids, phospholipids, and ATP. It is required for energy maintenance and transmission, genetic trait transfer, and favorable for root development, robust growth, improved yield and quality, and nodule formation in legume crops. Approximately 15-20% of applied fertilizer phosphorus is used by crops, with the remainder getting fixed in the soil and inaccessible to crop plants **(Toro, 2007)**. Thus, phosphorus availability is one of the primary issues in agricultural yield, affecting not only its actual deficit in soil but also its availability to crop plants. The only practical technique for enhancing phosphorus availability is integrated phosphorus management (IPM). IPM aids in the restoration and maintenance of soil fertility, agricultural productivity and economics also.

With these considerations in mind, the current study, named "Effect of Bio-fertilizers and Phosphorus on Growth and Yield of Toria (*Brassica campestris* L.)," was carried out during Rabi-2022 at agricultural research farm, SHUATS, Prayagraj (U.P).

Materials and Methods

The experiment was conducted during *Rabi* of 2022, Crop Research Farm, Department of Agronomy, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology And Sciences, Prayagraj, Uttar Pradesh. Which is located at 25.24' 42'' N latitude, 81.50' 56" E longitude and 98m altitude above the mean sea level (SL). The experiment was conducted in Randomized Block Design with 10 treatments each replicated thrice. The plot size of each treatment was 3m x 3m. The factors are Bio-fertilizers Azotobacter – (20g/kg seeds), PSB – (20g/kg seeds), Azotobacter – (10g/kg seeds) + PSB – (10g/kg seeds) and Phosphorus 30, 40, 50 kg/ha. The Toria crop was sown on 15 Sept 2022. Harvesting was done by taking 1m^2 area from each plot. And from it five plants were randomly selected for recording growth and yield parameters. The treatment details are as follows, T_1 -(Azotobacter - (20g/kg seeds) + Phosphorus - 30kg/ha), T_2 -(Azotobacter - (20g/kg seeds) + Phosphorus - 40kg/ha), T_3 – (Azotobacter - (20g/kg seeds) + Phosphorus - 50kg/ha), T_4 -(PSB - (20g/kg seeds) + Phosphorus - 30kg/ha), T_5 -(PSB - (20g/kg seeds) + Phosphorus - 40kg/ha), T_6 -(PSB - (20g/kg seeds) + Phosphorus - 50kg/ha), T_7 -(Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 30kg/ha), T_8 -(Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 40kg/ha), T_9 -(Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus – 50 kg/ha), and Control Plot. The observations were recorded for plant height, dry weight, Crop growth rate, number of siliqua/plant, number of seeds/siliqua, test weight, see yield and stover yield. The data was subjected to statistical analysis by analysis of variance method **(Gomez and Gomez, 1976).**

Results and Discussion

YIELD ATTRIBUTES:

Number of siliqua/plant

The significant higher number of siliquae/plant (232.53) was observed in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 40kg/ha) was found to be statistically at par with treatment- 9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha).

The significant higher number of siliquae/plant (232.53) was observed with seed treatment of Azotobacter along with PSB, there was to be a positive synergistic effect that caused to improve photosynthesis by increasing water and nutrient absorption and thus leading to more assimilate and improving plant growth, as result number of siliquae/plant similar results reported by **(Pramanik and Bera, 2013)** and alongside, with the application of phosphorus. Phosphorus intake increases net CO_2 fixation with enhanced photosynthesis rate, resulting in more photosynthates to generate more pods per plant in mustard **(Badsra and Chaudhary 2001).** Phosphorus treatment raised the number of siliquae/plants in mustard considerably **(Premi and Kumar 2004).**

Number of seeds/siliqua

The significant higher number of seeds/siliquae (20.60) was observed in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 40kg/ha) was found to be statistically at par with treatment- 9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha).

Seed inoculation resulted in a significantly increased number of seeds/siliquae (20.60). This might be owing to the use of bio fertilizers' such as PSB, Azotobacter, and synthetic fertilizers', which were responsible for increasing seed production in siliqua. These findings and comparable discoveries of the number of seeds per siliqua were also found by scientists called **Vijayeswarudu et al. (2021),** and phosphorus treatment may also lead to a rise in the number of seeds per siliquae. Phosphorus levels cause the synthesis and deposition of seed reserves (starch, lipid, protein, and phytin), resulting in a larger number of seeds/siliqua **(Jat et al., 2000).**

Test weight (gm)

The significant higher test weight (3.92 gm) was observed in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 40kg/ha) was found to be statistically at par with treatment- 9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha).

A substantial increase in test weight (3.92 gm) was found. The combination of chemical fertilisers and biofertilizers increases the availability of plant nutrients, resulting in a more robust seed and higher seed weight **(Tripathi et al., 2010).** and the findings showed that raising phosphorus levels up to 50 Kg phosphorus led in a considerable increase in dry matter buildup, phosphorus absorption, yield parameters pods per plant, seed per pod, 1000 seed weight and seed yield **(Kumar and Sharma, 2005).**

Seed Yield (t/ha)

The significant higher seed yield (20.57 q/ha) was observed in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 40kg/ha) was found to be statistically at par with treatment- 9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha).

Seed inoculation with Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) resulted in significantly greater seed production (2.06 t/ha). This might be attributable to a large improvement in total plant growth as a result of higher photosynthetic rate. With these levels of bio-fertilizers, greater availability of photosynthates, metabolites, and nutrients to form reproductive structures appears to have resulted in an increase in the number of siliquae per plant and the number of seeds per siliqua. Crop yield is a consequence of multiple yield components and the complimentary interplay of the crop's vegetative and reproductive development. The current findings are similar to those published by **Yadav et al. (2010).** Along with the application of phosphorus, positive outcomes have been obtained. This might be attributed to a considerable increase in P availability and absorption, which led in profuse nodulation and increased symbiotic N fixation, which has a beneficial influence on photosynthesis and yield ha-1. **Gabhane et al. (2016)** and **Patel**

et al. (2017) both reported on phosphorus response.

Stover Yield (t/ha)

The significant higher stover yield (3.70 t/ha) was observed in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha), which was significantly superior over rest of the treatments. However, treatment-8 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 40kg/ha) was found to be statistically at par with treatment- 9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha).

Bio-fertilizer inoculation resulted in significantly greater stover yield production (3.70 t/ha). Increases in yield attributes and yield through bio-fertilizer could be attributed to the supply of more plant hormones (auxin, cytokinin, gibberellin, and so on) by the microorganisms inoculated or by the root as a result of microbial population reaction. Similar results were obtained by **Kalita et al., (2019).**

ECONOMIC ANLYSIS

Gross Returns

Highest gross return (103828.00 INR/ha) was obtained in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha) as compared to other treatments.

Net Returns

Net return (74178.00 INR /ha) was found to be highest in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha) as compared to other treatments.

Benefit Cost Ration

Benefit Cost ratio (2.50) was found to be highest in treatment-9 with (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha) as compared to other treatments.

CONCLUSION

It is concluded that application of Azotobacter and PSB along with application of Phosphorus-50 kg/ha was recorded highest seed yield, benefit cost ratio in Toria crop.

Fig 1. Field investigation

Table 1. Influence of Bio-fertilizers and Phosphorus on yield attributes of Toria.

S.No.	Treatment combinations	No. of. Siliquae/plant	No. of. seeds/siliquae	Test weight(gm)	Seed yield(t/ha)	Stover yield (t/ha)	Harvest Index (%)
1.	Azotobacter - (20g/kg seeds) + Phosphorus - 30kg/ha	177.70	16.92	3.37	14.37	2.67	34.96
2.	Azotobacter - (20g/kg seeds) + Phosphorus - 40kg/ha	189.80	17.58	3.49	15.53	2.79	35.79
3.	Azotobacter - (20g/kg seeds) + Phosphorus - 50kg/ha	197.98	18.86	3.61	16.10	2.91	35.61
4.	PSB - (20g/kg seeds) + Phosphorus - 30kg/ha	199.87	18.32	3.58	15.80	3.10	33.72
5.	PSB - (20g/kg seeds) + Phosphorus - 40kg/ha	212.18	18.82	3.61	16.47	3.18	34.10
6.	PSB - (20g/kg seeds) + Phosphorus - 50kg/ha	219.61	19.19	3.70	17.97	3.33	35.04
7.	Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 30kg/ha	214.50	18.77	3.68	16.83	3.44	32.83
8.	Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 40kg/ha	225.75	19.91	3.78	19.10	3.64	34.39
9.	Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha	232.53	20.60	3.92	20.57	3.70	35.72
10.	CONTROL	186.84	17.85	3.22	14.63	2.65	35.62
	F test	S	S	S	S	S	NS
	S. Em(±)	2.40	0.19	0.11	0.57	0.05	0.79
	CD (P=0.05)	7.13	0.56	0.33	1.71	0.14	--

Table .2 Influence of Bio-fertilizers and Phosphorus on economics of Toria.

S. No.	Treatment combinations	Cost of cultivation	Gross return	Net return	Benefit-cost ratio
1.	Azotobacter - (20g/kg seeds) + Phosphorus - 30kg/ha	28,270	72,518	44,248	1.56
2.	Azotobacter - (20g/kg seeds) + Phosphorus - 40kg/ha	28,960	78,426	49,466	1.70
3.	Azotobacter - (20g/kg seeds) + Phosphorus - 50kg/ha	29,650	81,305	51,655	1.74
4.	PSB - (20g/kg seeds) + Phosphorus - 30kg/ha	28,270	79,790	51,520	1.82
5.	PSB - (20g/kg seeds) + Phosphorus - 40kg/ha	28,960	83,123	54,163	1.87
6.	PSB - (20g/kg seeds) + Phosphorus - 50kg/ha	29,650	90,698	61,048	2.05
7.	Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 30kg/ha	28,270	84991	56,721	2.00
8.	Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 40kg/ha	28,960	96,455	67,495	2.33
9.	Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha	29,650	1,03,828	74,178	2.50
10.	Control	28,960	73,730	44,770	1.54

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