Original Research Article

Influence of Bio-fertilizers and Phosphorus on Growth and Yield 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 plant height (124.54 cm), higher plant dry weight (25.01 g/plant), higher number of branches 11.71), higher number of siliqua (232.53 cm), higher 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.

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

INTRODUCTION

Rapeseed (Brassica campestris var. toria), also known as raya, rai, or lahi, is an important oilseed crop in India that belongs to the Brassica group of oilseeds. It is India's second most significant edible oilseed crop after peanuts, accounting for roughly 30% of total oilseed production. In India, Indian mustard is used as a spice or condiment in the preparation, seasoning, and stuffing of a variety of meals and pickles. The yield potential of this crop may be investigated using agronomic approaches. The oil is used in cooking and frying for human consumption throughout northern India. The entire seed is used as a condiment in pickling and to spice curries and vegetables. Mustard oil is also used in the production of vegetable ghee, hair oil, medications, soaps, lubricating oil, and tanning products. The oil content of mustard seeds ranges between 37 and 49% **(Bhowmik et al., 2014).**

Oilseeds are energy-rich crops, however they are largely cultivated in India under energy-stressed conditions. One of the most prominent reasons for low oilseed yield is a lack of or ineffective usage of plant nutrients. Oilseeds have a high nutritional need, which must be met in sufficient amount for increased yields. Chemical fertilizer application to soil, in addition to being costly, frequently results in an imbalance in soil nutrient supplies. Due to the increasing prices and huge demand supply gap of chemical fertilizers', there is a great need to adopt a realistic alternative, namely, biofertilizer, for soil fertility restoration and mustard productivity increase. It responds exceptionally well to artificial fertilizers', particularly nitrogen and phosphorus.

Mustard grows well in the presence of bio-fertilizers such as azotobacter and phosphorus solubilizing being (PSB) (**Vyas et al., 2003**). Because of the rising cost of fertilisers and their negative impacts on soil health, there is a need to specialise in integrated nutrient supply systems that will boost crop output while lowering cultivation costs. Biofertilizers have been shown to increase the yield of Indian mustard **(Suneja et al., 2001),** owing to improved N nutrition via N2 fixation, increased nutrient availability and uptake, and the production of growth hormones such as indole ethanoic acid, gibberellins, and so on.

There might be a variety of reasons for India's low mustard yield, but poor soil fertility and inefficient use of fertiliser nutrients, particularly phosphorus, appear to be the most crucial **(Premi and Kumar, 2004).** As a structural component of cell constituents and metabolically active molecules such as chloroplasts, mitochondria, phyton, nucleic acid, protein, flavin nucleotides, and many enzymes, phosphorus is essential. Phosphorus affects plant vitality and root development. It also promotes the growth of nitrogen-fixing bacteria, pod formation, and pod maturation.

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

Growth parameters:

PLANT HEIGHT - the significantly higher plant height (124.54 cm) was observed in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha) 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 application of Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) resulted in considerably increased plant height (124.54 cm), which may have encouraged the plants to assimilate more nutrients and water, resulting in improved plant growth. Improved plant growth by Azotobacter sp. and PSB may be ascribed to a variety of processes, including growth hormone synthesis, improved root efficiency, and increased phosphorus availability. comparable findings with **Vessey (2003).** Furthermore, plant height was increased by applying 50 kg/ha of phosphate. This might be because the enhanced phosphorus supply aided in early root initiation and establishment of the crop, resulting in higher growth characteristics **(Gangwal et al., 2011).**

Number of branches - the significantly higher number of branches/plant (11.71) was observed in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha) 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 use of bio-fertilizers resulted in a considerably larger number of branches/plant (11.71), which aids in the release of growth stimulating compounds, resulting in enhanced root development, water transportation, nutrient absorption, and breakdown. The current findings are also consistent with those of **Mahboobeh and Jahanfar (2012).** Phosphorous also plays an important function as a structural component of cell constituents and metabolically active molecules such as chloroplasts, mitochondria, phyton, nucleic acid, protein, flavin nucleotides, and many enzymes. Phosphorus affects plant vigour and root development. It also promotes the growth of nitrogen-fixing bacteria, pod formation, and pod maturation **(Tisdale et al., 1984).**

Dry weight/plant- the significantly higher Plant dry weight (25.01 gm) was observed in treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha) 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 seed treatment resulted in considerably greater plant dry weight (25.01 gm), and total dry matter assimilation improved as a result of increased plant height due to adequate N and other nutrient inputs in the soil. Taller plants have more possibilities to make and store photosynthates, therefore they produce more dry matter, which leads to increased dry weight. It was also shown that the use of chemical fertilizers in conjunction with seed treatment increased the height and dry matter content of mustard plants **(Singh and Pal 2011; Tripathi et al., 2010).** Furthermore, phosphorus application altered photosynthesis, protein and phospholipid production, and other plant metabolic activities favorably. Comparable outcomes were also obtained **Singh and Thenua (2016).**

Crop growth rate - the significantly higher Crop growth rate (10.5 $g/m^2/day$) was observed in treatment-1 (Azotobacter - (20g/kg seeds) + Phosphorus - 30kg/ha) However, treatment-9 (Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha) was found to be statistically at par with treatment- 1 (Azotobacter - (20g/kg seeds) + Phosphorus - 30kg/ha).

The use of bio-fertilizers resulted in considerably greater crop growth rates. When phosphorus-solubilizing bacteria inoculants are given to various agricultural plants, they improve seed germination and plant vigour by creating growth-promoting chemicals. Biofertilizers improve 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 boosting substances when applied to several non-leguminous agricultural plants **(Yadav et al., 2010).**

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.

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)** 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).**

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 growth parameters of Toria.

S. No.	Treatment combinations	Plant height	Number of branches	Plant Dry Weight	Crop growth rate
1.	Azotobacter - (20g/kg seeds) + Phosphorus - 30kg/ha	115.86	9.02	21.02	11.8
2.	Azotobacter - (20g/kg seeds) + Phosphorus - 40kg/ha	117.51	9.41	21.39	12.9
3.	Azotobacter - (20g/kg seeds) + Phosphorus - 50kg/ha	118.79	9.87	22.00	11.9
4.	PSB - (20g/kg seeds) + Phosphorus - 30kg/ha	119.15	10.15	21.92	13.0
5.	PSB - (20g/kg seeds) + Phosphorus - 40kg/ha	120.28	10.41	22.91	12.7
6.	PSB - (20g/kg seeds) + Phosphorus - 50kg/ha	122.04	11.15	23.27	13.2
7.	Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 30kg/ha	121.07	11.45	22.51	13.2
8.	Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 40kg/ha	123.10	11.31	24.22	13.2
9.	Azotobacter - (10g/kg seeds) + PSB - (10g/kg seeds) + Phosphorus - 50kg/ha	124.54	11.71	25.01	13.2
10.	Control	116.84	9.35	18.63	11.1
	F test	S	S	S	S
	SE m (±)	0.55	0.18	0.28	0.38
	CD (P=0.05)	1.64	0.53	0.84	1.12

Table 2. 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	--

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