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Growth and Yield of Toria (*Brassica campestris* var. *toria*) under various Integrated Nutrient Management Schedules in Trans-Gangetic Plains of Punjab

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ABSTRACT: Increasing crop yield is essential in the current context of a growing population and a relatively stable amount of farmland. To achieve this goal, chemical fertilizers are often over-applied to high-yielding cultivars, which not only reduces agricultural net profit but also negatively impacts soil quality and human health. The aim of the present study was to assess potential solutions, such as the INM method, to this difficulty. The research experiment was carried out during *Rabi* season of 2021-22 at the agriculture farm of Lovely Professional University, Phagwara, Punjab. TL-17 variety of toria with nitrogen and phosphorus doses of 100%, 75%, and 50% RDF along with FYM at a dose of 5t/ha, vermicompost dose of 2t/ha, boron, zinc, and *Azotobacter* was evaluated for various parameters at 30, 60 and 90 days. The present research study defined the effect of growth and yield of toria (*Brassica campestris* var. *toria*) under various integrated nutrient management schedules in the trans-Gangetic plains of Punjab. The experiment consists of eight treatments and three replications and was set up in a Randomized Block Design (RBD). The study revealed that the treatment 75% RDF + FYM (5t/ha) + *Azotobacter* (40g/kg seed treatment) reported significantly higher plant height (58.33, 120.66 and 148.41cm), leaf count (7.94,42.83 and 17.82), No. of branches (6.67 and 9.23), dry weight (1.76, 6.76 and 48.24g), siliqua length (7.23 cm), No. of siliqua (284), No. of seeds/siliqua (13.38), test weight (4.68g), seed yield (1772.82kg/ha) and stover yield (3009.75 kg/ha) compared to all other treatment combinations. The outcomes achieved may provide a better way to reach the desired level of productivity, profitability, and sustainability.

Keywords: Recommend Dose of Fertilizer, Integrated Nutrient Management, Farm Yard Manure.

INTRODUCTION

Oilseeds are the second-most significant crop after cereals for the agricultural economy. They supply vital fatty acids and are also used to make cattle feed and are popular in pharma, biofuel and oleochemical industries. Currently, oilseed production in India is 1.04 percent higher than in 2008-09 (Kumar and Tiwari 2020). In India, rapeseed and mustard are the 2nd most valuable edible oilseed crops in India. Toria (*Brassica campestris* var. toria) is a short-duration crop used as a catch crop in the tarai region of UP, Assam and Odisha. *Brassica* crops are grown in a rainfed, resource-poor environment. Small and marginal farmers with minimal resources can grow toria in these locations. Rapeseed-mustard contributes greatly to small and marginal farmers' livelihoods as they rely heavily on it, especially in rainfed areas (Kumar *et al.*, 2015). India is the biggest producer in the world, with 6.32 million hectares of land used to grow Brassica, which accounts for about 7.39 million tonnes of total world production (*Mahanta et al*., 2019).

With a continuously growing population, edible oil demand is soaring too. In order to maintain productivity as well as sustainability, integrated nutrient management (INM) can be a very effective approach. INM combines inorganic and organic fertilizers to maintain soil fertility without reducing crop output. It involves a judicious blend of organic and inorganic nutrition coupled with biofertilizers. INM was not practiced earlier as no one understood its significance also the crop nutrient loss was minimal cause of subsistence farming practiced by the farmers (Sharma *et al*., 2022). Chemical fertilizer efficiency can be improved with organic manure. It minimizes nutrient loss from inorganic fertilizers by improving the soil's Physico-chemical characteristics, which replenishes biological activity in the soil (Kumarswamy, 2001). Vermicompost is effective organic manure for establishing beneficial soil bacteria and increasing nitrogen-fixing microorganisms. FYM is a broken-down mixture that can be used as a soil conditioner. It contains animal waste, urine, trash, and leftover roughage or feed. *Azotobacter* improves crop growth

rate (CGR) by adding nitrogen to the soil. Zinc and Boron are two of the most essential micronutrients. Zinc helps in producing chlorophyll which eventually leads to the proper growth and development of plant whereas, Boron helps in the transportation of sugar as well as cell division in plants.

MATERIALS AND METHODS

During the *Rabi* season of 2021-22, an experiment was carried out at Agriculture Farm, School of Agriculture, Lovely Professional University, Phagwara, Punjab with the objective of studying growth and yield of Toria (*Brassica campestris* var. *toria*) under various integrated nutrient management schedules in trans-Gangetic plains of India on sandy loam soils. The experimental site was situated at an altitude of 234m above mean sea level at 31.2560° N latitude and 75.7051° E longitude, respectively. The experiment was laid out in Randomized Block Design (RBD) in three replications with eight treatments *viz.*, T_1: Control, T_2: 100% RDF(N: P 63: 20kg/ha), T_3: 75% RDF + VC (2t/ha), T_4: 75% RDF + FYM (5 t/ha), T_5: 75% RDF + VC (2t/ha) + *Azotobacter* (40g/kg seed treatment), T_6: 75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment), T_7: 50% RDF + VC (2t/ha) + *Azotobacter* (40g/kg seed treatment)+ Zn (0.5% foliar) + B (0.5% foliar), T_8: 50% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) + Zn (0.5% foliar) + B (0.5% foliar). Nitrogen and phosphorus were applied through urea and SSP with a half dose of N and a full dose of P at the time of sowing and the remaining half dose of N with first irrigation. Vermicompost and FYM, as per the treatments were added one week prior to sowing during land preparation and were properly mixed into the soil while planking. Boron (0.5% foliar) and Zinc (0.5% foliar) were applied through foliar application. Seeds were treated with *Azotobacter* before sowing. Observations were taken from 5 randomly chosen plants from each plot in each replication. Significant findings were later determined using statistical analysis done at the level of 5% probability.

RESULTS AND DISCUSSION

A. Effect of integrated nutrient management on growth attributes of toria

Plant height. Growth parameters of toria (TL-17) were significantly affected by different treatments as shown in the Table 1 and 2.75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) (T_6) recorded significantly maximum height at 30,60 and 90 days after sowing (58.33, 120.66 and 148.41cm, respectively) which stayed at par with 50% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) + Zn (0.5% foliar) + B (0.5% foliar) (T_8) and 75% RDF + FYM (5 t/ha) (T_4). This increase in plant height is attributed to the N, P and K applied in the soil through 75% RDF and FYM as the integration of both these sources together prolonged the availability of nutrients to the plants. Treating the seeds with *Azotobacter* helps in fixing the atmospheric nitrogen which makes more nitrogen available for the plant, thus influencing the plant height in a positive way (Bijarnia *et al*., 2017).

Table 1: Effect of INM on growth attributes of toria.

Treatments		Plant height (cm)			Leaf count per plant		
		30DAS	60DAS	90DAS	30DAS	60DAS	90DAS
T_1	Control	43.70	84.77	105.87	5.98	23.44	11.89
T_2	100% RDF	45.91	96.89	116.92	6.75	27.83	15.29
T_3	75% RDF + VC (2t/ha)	54.20	102.32	127.53	6.92	32.09	12.09
T_4	75% RDF + FYM (5 t/ha)	57.14	114.89	137.55	7.27	33.46	15.49
T_5	75% RDF + VC (2t/ha) + *Azotobacter* (40g/kg seed treatment)	53.70	104.90	129.59	6.94	36.94	14.99
T_6	75% RDF + FYM (5t/ha) + *Azotobacter* (40g/kg seed treatment)	58.33	120.66	148.41	7.94	42.83	17.82
T_7	50% RDF + VC (2t/ha) + *Azotobacter* (40g/kg seed treatment)+ Zn (0.5% foliar)+ B (0.5% foliar)	48.36	99.34	122.25	6.29	32.72	12.02
T_8	50% RDF + FYM (5t/ha) + *Azotobacter* (40g/kg seed treatment)+ Zn (0.5% foliar)+ B (0.5% foliar)	56.10	112.76	136.08	7.16	33.63	13.15
SEm ±		3.27	4.86	6.03	0.32	1.86	0.75
CD (P=0.05)		9.93	14.74	18.29	0.97	5.65	2.28

Leaf count. As evident from Table 1, significantly higher leaf count (7.94, 42.83 and 17.82) at 30,60 and 90 days after sowing were observed in 75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) (T_6). However, at 30 DAS, treatments 75% RDF + FYM (5 t/ha) (T_4) and 50% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) + Zn (0.5% foliar)+ B (0.5% foliar) (T_8) recorded leaf count (7.27 and 7.16cm) which is at par with T_6. Application of N directly influences the vegetative growth of the plant. FYM improves the soil's physio-chemical condition, creating a favourable environment that promotes the absorption of nutrients and boosts macro as well as micronutrients which eventually increases the nutrients available for the plants. FYM along with *Azotobacter* enhances the nutrient availability for the plants which eventually leads to higher leaf count as well as vegetative growth. These results are in agreement with the findings of Tripathi *et al*. (2010).

Number of branches. Among all the treatments, 75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) (T_6) recorded significantly higher number of branches in toria (6.67 and 9.23) at 60 and 90 days after sowing as shown in Table 2. Application of 75% RDF + FYM @ 5t/ha along with biofertilizer (*Azotobacter*) increases the nutrients available for the plants which eventually influences the vegetative growth. Similar

results were given by Kalita *et al.* (2019); Kashved *et al.*(2010)

Dry weight accumulation. 75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) (T_6) recorded the maximum dry weight (1.76, 6.76 and 48.24g) at 30, 60 and 90 days after sowing as shown in Table 2. Treatments with 75% RDF + FYM (5 t/ha) (T_4) and 50% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) + Zn (0.5% foliar) + B (0.5% foliar) (T_8) was also statistically at par with T_6. As a result of increased plant height due to sufficient N and other nutrient supplies in the soil, total dry matter assimilation improved as well. This is because taller plants have greater opportunities to create and store photosynthates, they produce more dry matter which eventually leads to more dry weight. It was also seen that the application of chemical fertilizers alongside FYM, Zn, and seed treatment had positive effects on the height and dry matter content of mustard plants (Singh and Pal 2011; Tripathi *et al.,* 2010).

Table 2: Effect of INM on growth attributes of toria.

Treatments		No. of branches per plant		Dry weight accumulation (g)		
		60DAS	90DAS	30DAS	60DAS	90DAS
T_1	Control	2.80	6.80	0.83	4.60	32.60
T_2	100% RDF	4.13	7.84	0.84	5.42	37.01
T_3	75% RDF + VC (2t/ha)	4.67	7.10	0.85	5.33	33.53
T_4	75% RDF + FYM (5 t/ha)	5.40	8.13	1.12	5.89	42.73
T_5	75% RDF + VC (2t/ha) + *Azotobacter* (40g/kg seed treatment)	4.93	7.93	0.87	5.61	39.16
T_6	75% RDF + FYM (5t/ha) + *Azotobacter* (40g/kg seed treatment)	6.67	9.23	1.76	6.76	48.24
T_7	50% RDF + VC (2t/ha) + *Azotobacter* (40g/kg seed treatment) + Zn (0.5% foliar) + B (0.5% foliar)	4.60	6.80	0.75	4.66	34.53
T_8	50% RDF + FYM (5t/ha) + *Azotobacter* (40g/kg seed treatment) + Zn (0.5% foliar)+ B (0.5% foliar)	5.20	7.50	1.70	6.09	41.29
SEm ±		0.31	0.36	0.07	0.36	2.48
CD (P=0.05)		0.95	1.10	0.21	1.08	7.52

B. Effect of integrated nutrient management on yield attributes and yield of toria

Number of siliqua. Significantly higher number of siliqua per plant in toria (284) was observed under 75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) (T_6) (Table 3). FYM application with chemical fertilizers and *Azotobacter* improved the soil's physio-chemical condition, provided favourable conditions, and stimulated the uptake of nutrients and almost continuous supply of N, P, K, and S with micronutrients distributed over the entire crop, which resulted in better plant vigor, as well as a greater ability to produce a higher yield at the critical growth period (Mohapatra and Dixit 2010; Tripathi *et al*. 2010).

Siliqua length. Among all the treatments, 75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) (T_6) recorded the highest siliqua length (7.23 cm) at harvest. However, the treatment 75% RDF + FYM (5 t/ha) (T_4), 100% RDF (T_2) and 50% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment)+ Zn (0.5% foliar) + B (0.5% foliar) (T_8) remained statistically at par with T_6 by recording siliqua length of around 6.83, 6.57 and 6.69cm, respectively (Table 3). A combination of FYM, chemical fertilizers, and biofertilizers may have resulted in fast cell multiplication and cell elongation because of the enhanced and longer availability of nutrients which might have influenced the length of the siliqua. Similar results were given by Tripathi *et al*. (2010).

Number of seeds per siliqua. As shown in Table 3, treatment 75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) (T_6) recorded highest seeds/siliqua (13.38) which is statistically at par with 75% RDF + FYM (5 t/ha) (T_4) (12.98). As these treatments improved cell division and tissue development, the number of seeds per siliqua also have risen. Increased seeds per siliqua also arise from higher growth and more photosynthesis as a result of enough nutrients in the crop. Similar findings were reported by Mandal and Sinha (2002); Tripathi *et al.* (2010).

Test weight. Significantly higher test weight (4.68 g) was observed at 75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) (T_6) which is statistically at par with 75% RDF + FYM (5 t/ha) (T_4) (4.34). It is due to the result of combining FYM with chemical fertilizers and biofertilizers, that the availability of plant nutrients rises, leading to a more robust seed and an increased seed weight (Chauhan *et al*., 1995; Tripathi *et al.,* 2010).

Seed yield. According to the findings shown in Table 3, a significantly higher seed yield (1772.82 kg/ha) of toria was observed under75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) (T_6).Due to the combined effect of FYM, chemical fertilizers, and biofertilizers, the highest seed production was achieved. Since FYM releases its nutrients slowly, there is less nitrogen loss and more efficient uptake occurs over time. Growth and yield metrics such as plant height, number of primary and secondary branches, siliquae, length of siliqua, number of seeds per siliqua, and seed weight were all improved as a result of better nutrient utilization. Another factor contributing to the increased yields was the capacity of *Azotobacter* to fix nitrogen. Similar findings were reported by Chauhan *et al*. (1995); Mandal and Sinha (2002); Chand (2007); Triphati *et al*. (2010).

Stover yield. Among different integrated nutrient management treatments, 75% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment)(T_6)recorded highest stover yield (3009.75 kg/ha) which is statistically at par with 100% RDF (T_2), 75% RDF + FYM (5 t/ha) (T_4), 75% RDF + VC (2t/ha) +

Azotobacter (40g/kg seed treatment) (T_5) and 50% RDF + FYM (5 t/ha) + *Azotobacter* (40g/kg seed treatment) + Zn (0.5% foliar)+ B (0.5% foliar) (T_8) showing stover yield of 2686.81, 2771.76, 2651.77 and 2623.78 kg/ha, respectively. The stover yields were boosted by the use of FYM, biofertilizers, and chemical fertilizers. Soil Physico-chemical qualities and microbial populations were enhanced, which resulted in increased crop growth and productivity as a result of fixing atmospheric nitrogen and providing micronutrients favourable to crop growth. Higher fertility enhanced plant height, leaf area, and dry matter per plant, which boosted stover output. These findings are in confirmation with Singh and Pal (2011).

Harvest index. Different treatments failed to show any significant effect on harvest index of toria. One possible explanation for this is that there has been a proportional rise in the yield of both seeds and stover.

Table 3: Effect of INM on Yield attributes and Yield of Toria.

Treatments		Siliqua length (cm)	No. of siliqua	No. of seeds/siliqua	Test weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
T_1	Control	5.24	108	7.54	3.60	828.75	1709.27	32.84
T_2	100% RDF	6.57	237	11.59	4.07	1526.60	2686.81	36.20
T_3	75% RDF + VC (2t/ha)	5.80	195	11.06	3.72	1350.51	2498.04	35.11
T_4	75% RDF + FYM (5 t/ha)	6.83	252	12.98	4.34	1562.00	2771.76	36.00
T_5	75% RDF + VC (2t/ha) + *Azotobacter* (40g/kg seed treatment)	6.07	210	11.35	4.10	1520.74	2651.77	36.65
T_6	75% RDF + FYM (5t/ha) + *Azotobacter* (40g/kg seed treatment)	7.23	284	13.38	4.68	1772.82	3009.75	37.15
T_7	50% RDF + VC (2t/ha) + *Azotobacter* (40g/kg seed treatment) + Zn (0.5% foliar) + B (0.5% foliar)	5.61	184	10.13	3.86	1306.86	2574.52	33.64
T_8	50% RDF + FYM (5t/ha) + *Azotobacter* (40g/kg seed treatment) + Zn (0.5% foliar)+ B (0.5% foliar)	6.69	198	11.12	4.02	1411.39	2623.78	34.95
SEm ±		0.38	9.99	0.56	0.19	69.21	133.61	1.63
CD (P=0.05)		1.15	30.30	1.71	0.57	209.91	405.26	NS

CONCLUSION

Based on the above findings, it can be concluded that using 75 % of RDF from chemical fertilizers along with FYM at a dose of 5t/ha in combination with *Azotobacter* improved growth and productivity in toria crops grown in the trans-Gangetic plains of Punjab.

FUTURE SCOPE

In order to increase productivity and profitability without endangering human and environmental health, the results of the current investigation would serve as a baseline for future research studies on integrated nutrient management as a successful alternative to excessive chemical fertilizer use issues in the trans-Gangetic plains of India. Other organic nutrient sources, including green manures, green leaf manuring, oil cakes, etc., and the application of different nutrients through foliar spray were not studied in this experiment but should be studied before conclusive

recommendations can be made to farmers to maximize profits while minimizing chemical use in soil.

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Conflict of Interest. None.

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