



RESEARCH ARTICLE

Impact of sowing dates and nutrient levels on growth attributes of toria (*Brassica campestris* var. *toria*) in trans-gangetic region of Punjab

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Abstract

The present investigation was carried out at the experimental farm, School of Agriculture, Lovely Professional University, Jalandhar, Punjab during 2021-22. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with 3 dates of sowing *i.e.* D1 (1st October), D2 (15th October) and D3 (30th October) and 4 different levels of fertilizer *i.e.* 75 % RDF, 100 % RDF, 125 % RDF and 150 % RDF altogether 12 treatment combinations of dates of sowing and fertilizer levels replicated thrice. Among different temporal dynamics (sowing dates), D1 (1st October) recorded maximum values for plant height (151.20 cm), primary branches (10.33) and Secondary branches (8.91), Leaf area (64.28 cm²), Fresh weight (242.7 g), Dry weight (28.45 g), CGR (0.558 g m⁻²day⁻¹), RGR (1.39 g⁻¹g⁻¹day⁻¹). Regarding the effect of various nutrient levels, the maximum plant height (128.05cm), the number of primary and secondary branches (10.44, 8.44), Leaf area (64.67 cm²), Fresh and dry weight (253.16 g, 29.55 g), CGR (0.581 g m⁻²day⁻¹), RGR (1.42 g⁻¹g⁻¹day⁻¹) were recorded in the application of 100% RDF. The interaction of 1st DOS (1st October) × 100% RDF recorded maximum values in terms of most of the growth parameters of commercial importance. So it can be concluded that for better growth and development the toria plants should be sown on 1st October with the application of 100% RDF.

Keywords

Sustainability, nutrient levels, affordable, CGR, RGR, growth attributes

Introduction

Toria (*B. campestris* var. *toria*) is a variety of rapeseed mustards that have different characteristics and growing patterns. Area under the cultivation of Toria is about 6.86 Mha in the Rabi season (1). Toria also has a unique nutritional value with 16 kcal of energies, 3.23 g carbohydrates, 1.2 g protein, 0.2 g total fat and ample amount of different minerals and nutrients. Toria is cultivated in various parts of India because of its stiff nature, it is a tropical and subtropical crop that is grown mostly in temperate regions. Toria is also known for its fast-growing capabilities. Toria also suppresses weed growth in fields because of its growth pattern, it is mostly cultivated in Assam, Haryana, Punjab, Gujarat, Maharashtra and West Bengal (2).

The crucial reason behind the decrease in the production of toria is lesser soil productivity and the effect of numerous biotic and abiotic stresses. One of the core reasons for the low yield is that the toria is mostly grown in the mixed cropping pattern and that too without any application of essentially important nutrients like NPK and S (1). In recent studies, it has

been stated that sulphur deficiency has increased rapidly in the soil due to the use of sulphur and zinc-free fertilizers (3). Sulphur deficiency affects the yield and growth of oilseeds. Production of crops generally depends upon requisite or need-based additive supplements. The requirement for fertilizers is a major component that modifies the productivity of a crop. The crop gives improved results when we provide need-based supplements to the crop. The different required fertilizers are crucial for sustaining the plant growth, all the nutrients and micronutrients are important for crop growth but the 4 essential elements are Nitrogen, Potassium, Phosphorus and Sulphur (4). The appropriate and balanced amount of all the major nutrients (NPK and S) is crucial in increasing the productivity and quality of oilseed crops, which in the Indian context is only 935 kg ha⁻¹ in contrast with the world's 1632 kg ha⁻¹ (5). Because of the high pricing of inorganic fertilizer and lack of knowledge of soil nutrient interactions, farmers don't follow the prescribed doses of different nutrients for these high-energy-rich crops. The requirement for fertilizers is a core factor that affects the productivity of a crop. To find the appropriate nutrient levels and dates of sowing 3 different dates and 4 different nutrient levels used in the experiment.

Materials and Methods

The investigation was conducted during rabi season of 2021-22 at agricultural farms of Lovely Professional University, Phagwara, Punjab, India. The experimental site was at 31.25°N 75.7°E, an elevation of 228 m (748 ft). The climate of the site is subtropical monsoon type with an average rainfall of 600 mm and it lies under the central plain region of Punjab. The experiment was laid out in factorial RBD design with three sowing dates, D1 (1st October), D2 (15th October) and D3 (30th October), and 4 distinct fertilizer levels, 75% RDF, 100% RDF, 125% RDF and 150% RDF, 12 treatment combinations of dates of sowing and fertilizer levels were replicated 3 times. The total number of plots was 36 with plot size 5×3 m with row spacing 45 cm and plant to plant distance 10 cm. The soil of the experimental site was sandy loam in nature. The analysis of soil was done before the start of experiment to evaluate the initial status of the soil. The treatment consisted of twelve combination of planting dates and nutrient levels viz. T1 (1st DOS+75% RDF), T2 (1st DOS+100% RDF), T3 (1st DOS+125% RDF), T4 (1st DOS+150% RDF), T5 (2nd DOS+75% RDF), T6 (2nd DOS+100% RDF), T7 (2nd DOS+125% RDF), T8 (2nd DOS+150% RDF), T9 (3rd DOS+75% RDF), T10 (3rd DOS+100% RDF), T11 (3rd DOS+125% RDF), T12 (3rd DOS+150% RDF). The source of NPK and S was Urea, SSP, DAP and Gypsum respectively. The growth parameters were analysed by the analysis of variance (ANOVA).

Statistical analysis: The differences between the mean values were estimated by generalized linear model under univariate techniques with 2 factors with the SPSS 22 version software. To find out the most efficient treatment Duncan's multiple range test (DMRT) a mean separation technique was applied with probability $p < 0.05$. Fisher's LSD

test as post hoc test was used to test the significance of the variation components. The significant difference among the means were calculated based on LSD (least significant difference) at 5% level of significance.

Results and Discussion

The interaction impact of varied planting dates and fertilizer levels on the major growth characteristics of the toria crop is shown in Table 1.

Growth attributes

Plant height (cm): The interactive effect of temporal dynamics and nutrient levels were displayed in Table 1. It exhibited statistically negligible effects on the height of plants at 30, 60, 90 DAS and at harvest. However, the maximum height was recorded at 30, 60, 90 DAS and at harvest (52.66 cm, 140.16 cm, 153.00 cm and 155 cm) respectively in combination of 1st DOS (1st October) and 100% RDF. The least plant height was recorded at 30, 60, 90 DAS and at harvest (35.83 cm, 82.66 cm, 89.16 cm, 91.33 cm) respectively with interactive effect of combination of 3rd DOS (30th October) and 75% RDF level. The maximum height of the plants may be attributed because the optimum time of sowing provides a favourable environment for the growth of plants. The recommended DOS with proper nutrition by the application of 100% RDF influenced the vegetative growth which resulted in improved root growth, cell expression, elongation and multiplication in the body of a plant which may have promoted the height of the plant. Similar findings were recorded by (6, 10, 14).

Primary and secondary branches plant⁻¹: The particulars from Table 1 specifies that combined effect of planting dates and different nutrient levels exhibited negligible effects on the primary and secondary branches. An application of 100% RDF and 1st DOS results in the production of plants with the maximum primary and secondary branches (12.33 and 11.33) respectively. The minimum primary and secondary branches (6.66 and 4.66) was produced in the plant with the application of 75% RDF and 3rd DOS. The maximum number of branches per plant may be attributed due to the optimum use of nitrogen, phosphorus, potassium and sulphur from the soil which was additionally given by fertilizers. The appropriate sowing date may also influence the resource use efficiency which resulted in proper growth and formation of auxiliary buds which improves the number of branches per plant. These findings are in conformity with (7, 9, 10, 14).

Leaf area (cm²): Table 2 portrayed that interaction between dates of sowing and fertilizer levels didn't affect the leaf area of plants significantly. However, interaction effects of planting dates and fertilizer levels exhibited the maximum area of leaf (40.26 cm², 66.30 cm² and 71.60 cm²) at 30, 60 and 90 DAS in the combination of 1st DOS (1st October) and 100% RDF. Whereas the lowest leaf area (22.03 cm², 34.50 cm² and 46.93 cm²) at 30, 60 and 90 DAS was recorded in the combination of 3rd sowing date (30th October) and 75% RDF. This might be due to better intake of nutrients with the application of balanced fertilizers and

Table 1. Impact of sowing dates and nutrient levels on plant height, primary and secondary branches of Toria at different intervals

Treatment details	Plant height 30DAS (cm)		Plant height 60DAS (cm)		Plant height 90DAS (cm)		Plant height At Harvest (cm)		Primary branches (60DAS)		Primary branches (90DAS)		Secondary branches (90DAS)	
D₁	F1	41.16	133.50	141.83	143.50	6.66	8.00	7.67						
	F2	52.66	140.16	153.00	155.00	8.66	12.33	11.33						
	F3	51.00	138.83	149.83	151.66	8.00	11.00	8.34						
	F4	52.00	139.50	152.66	154.66	7.66	10.00	8.33						
D₂	F1	39.33	118.16	121.83	123.66	5.33	9.00	6.33						
	F2	46.16	127.33	129.83	132.00	7.66	11.33	8.66						
	F3	43.16	123.66	127.33	129.16	6.66	9.33	8.00						
	F4	43.66	126.00	127.83	129.83	7.33	10.00	7.66						
D₃	F1	35.83	82.66	89.16	91.33	5.33	6.66	4.66						
	F2	41.50	88.00	95.33	97.16	6.33	7.66	5.33						
	F3	40.83	87.16	94.66	96.66	5.66	7.00	5.00						
	F4	39.50	86.33	91.16	93.33	4.33	7.33	4.64						
Mean Table														
D₁	49.20 ^a		138.00 ^a		149.33 ^a		151.20 ^a		7.75a		10.33a		8.91a	
D₂	43.08 ^b		123.79 ^b		126.70 ^b		128.66 ^b		6.75b		9.91a		7.66b	
D₃	39.41 ^c		86.04 ^c		92.58 ^c		94.62 ^c		5.41c		7.16b		4.91c	
F1	38.77 ^b		111.44 ^b		117.61 ^b		119.50 ^b		5.77b		7.88c		6.22b	
F2	46.77 ^a		118.50 ^a		126.05 ^a		128.05 ^a		7.55a		10.44a		8.44a	
F3	45.00 ^a		116.55 ^a		123.94 ^a		125.83 ^a		6.77ab		9.11b		7.11b	
F4	45.05 ^a		117.27 ^a		123.88 ^a		125.94 ^a		6.44ab		9.11b		6.88b	
CD at 5%	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)
D	2.156	0.730	2.760	0.935	2.894	0.980	2.872	0.973	0.808	0.274	0.889	0.301	0.935	0.317
F	2.489	0.843	3.187	1.080	3.342	1.132	3.316	1.123	0.933	0.316	1.027	0.348	1.080	0.366
DXF	NS	1.460	NS	1.870	NS	1.961	NS	1.946	NS	0.547	NS	0.602	NS	0.634

Note: D₁= 1st date of sowing, D₂= 2nd date of sowing, D₃= 3rd date of sowing, F1= 75% RDF, F2= 100 % RDF, F3=125% RDF, F4=150% RDF

optimum growth degree days which resulted in the expansion of leaf, improved chlorophyll and better photosynthetic activities which might be the reason for maximum area of leaf under 1st DOS and 100% RDF. Similar results were recorded by (8, 12, 13).

Fresh weight (g): Interaction of dates of sowing and fertilizer levels produced maximum fresh weight (14.53 g, 77.66 g, 272.33 g, 283.00 g) at 30, 60, 90 and at harvest in the combination of 1st DOS (1st October) and 100% RDF. However, the least fresh weight (8.83 g) and (61.33 g) at 30 and 60 DAS recorded in 3rd DOS (30th October) with 75% RDF, (189.00 g) at 90 DAS in 3rd DOS (30th October) with 125% RDF, (192.33 g) at harvest in 3rd DOS (30th October) with 75% RDF (Table 3). An increase in the fresh weight may be due to the increment in carbohydrates, amino acids, proteins and other physiological parameters, especially in the presence of an ample amount of nutrition and favourable environmental conditions. A similar finding was recorded by (7, 9, 10).

Dry weight (g): The values recorded for dry weight were presented in Table 3 and it specifies that interaction between DOS (dates of sowing) and fertilizer levels showed a significant difference (0.239) at 30 DAS but at all the other growth stages it had exhibited negligible effects on the dry weight of plants. The association effects of dates of sowing and fertilizer levels resulted in the maximum dry weight (1.67 g, 11.83 g, 30.33 g and 33.16 g) at 30, 60, 90 DAS and at harvest in the combination of 1st DOS (1st October) with 100 and RDF. However, the minimum dry weight of plants (.893 g, 7.16 g, 17.00 g and 19.83 g) at 30, 60, 90 DAS and at harvest was reported in the interaction of 3rd DOS with 75% RDF. The difference in dry weight between different sowing dates and nutrient dosages may be attributed to their different growing periods; the crop sown on the first sowing date receives the optimum time and temperature for growth and development, which may help the plant achieve its maximum potential growth, which directly influences the fresh

Table 2. Impact of sowing dates and nutrient levels on leaf area, CGR and RGR of Toria at different intervals

Treatment details		Leaf area 30DAS (cm ²)		Leaf area 60DAS (cm ²)		Leaf area 90DAS (cm ²)		CGR (60DAS) g day ⁻¹ m ⁻²		CGR (90DAS) g day ⁻¹ m ⁻²		RGR (60DAS) g g ⁻¹ day ⁻¹		RGR (90DAS) g g ⁻¹ day ⁻¹	
D₁	F1	27.76		43.46		53.3		0.254		0.572		0.927		1.38	
	F2	40.26		66.30		71.60		0.339		0.617		1.064		1.46	
	F3	37.93		57.23		64.70		0.242		0.539		0.936		1.37	
	F4	37.46		58.76		67.53		0.265		0.506		0.957		1.35	
D₂	F1	25.83		38.10		51.13		0.219		0.389		0.867		1.25	
	F2	34.36		55.90		65.30		0.300		0.578		1.008		1.42	
	F3	30.76		45.76		57.30		0.247		0.571		0.925		1.39	
	F4	30.16		44.86		54.83		0.260		0.378		0.947		1.28	
D₃	F1	22.03		34.50		46.93		0.209		0.328		0.856		1.20	
	F2	32.03		45.43		57.13		0.236		0.550		0.907		1.37	
	F3	30.86		42.43		53.70		0.222		0.333		0.884		1.22	
	F4	28.00		43.03		55.60		0.241		0.379		0.910		1.26	
Mean Table															
D₁		35.85a		56.44a		64.28a		0.275a		0.558a		0.971a		1.39a	
D₂		30.28b		46.15b		57.14b		0.256ab		0.479ab		0.937a		1.33b	
D₃		28.23b		41.35b		53.34b		0.227b		0.397b		0.889b		1.26c	
F1		25.21b		38.68c		50.45c		0.227b		0.430b		0.883c		1.28b	
F2		35.55a		55.87a		64.67a		0.292a		0.581a		0.993a		1.42a	
F3		33.18a		48.47b		58.56b		0.237b		0.481ab		0.915b		1.33b	
F4		31.87a		48.88b		59.32b		0.256b		0.421b		0.938c		1.30b	
CD at 5%		CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)
D		3.436	1.164	4.490	1.521	4.321	1.464	0.030	0.010	0.92	0.031	0.048	0.016	0.055	0.019
F		3.967	1.344	5.184	1.756	4.989	1.690	0.035	0.012	0.107	0.036	0.055	0.019	0.064	0.022
DXF		NS	2.328	NS	3.042	NS	2.928	NS	0.020	NS	0.063	NS	0.032	NS	0.037

Table 3. Impact of sowing dates and nutrient levels on fresh and dry weight (g) of toria plants at different intervals

Treatment details		Fresh 30DAS (gm)		60DAS (gm)		90DAS (gm)		At Harvest (gm)		Dry 30DAS (gm)		60DAS (gm)		90DAS (gm)		At Harvest (gm)	
D₁	F1	9.50		66.66		197.00		202.83		0.88		8.50		25.66		27.16	
	F2	14.53		77.66		272.33		283.00		1.67		11.83		30.33		33.16	
	F3	13.83		71.66		240.16		243.83		1.55		8.83		25.00		27.66	
	F4	13.66		73.00		236.66		241.50		1.21		9.16		24.33		25.83	
D₂	F1	9.50		63.00		190.16		192.83		0.77		7.33		19.00		20.66	
	F2	14.00		72.00		249.83		253.33		1.34		10.33		27.66		29.00	
	F3	12.00		66.33		232.00		234.50		1.10		8.50		25.66		27.00	
	F4	13.83		68.33		212.33		214.66		1.19		9.00		20.33		21.83	
D₃	F1	8.83		61.33		189.66		192.33		0.89		7.16		17.00		19.83	
	F2	13.50		67.66		221.00		223.16		1.07		8.16		24.66		26.50	
	F3	10.33		65.33		189.00		193.16		1.00		7.66		17.66		20.16	
	F4	9.83		64.00		192.00		195.66		0.74		8.00		19.33		20.66	
Mean Table																	
D₁		12.88a		72.25a		236.54a		242.79a		1.33a		9.58a		26.33a		28.45a	
D₂		12.33a		67.41b		221.08b		223.83b		1.10b		8.79a		23.16b		24.62b	
D₃		10.62b		64.58c		197.91c		201.08c		0.92c		7.75b		19.66c		21.79c	
F1		9.27c		63.66c		192.27c		196.00c		0.85d		7.66c		20.94b		22.55b	
F2		14.01a		72.44a		247.72a		253.16a		1.36a		10.11a		27.55a		29.55a	
F3		12.05b		67.77b		220.38b		223.83b		1.21b		8.33bc		22.77b		24.94b	
F4		12.44b		68.44b		213.66b		217.27b		1.04c		8.72b		21.33b		22.77b	
CD at 5%		CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)	CD	SE(m)
D		1.005	0.340	1.527	0.517	13.999	4.743	14.331	4.855	0.120	0.041	0.885	0.300	2.940	1.023	2.881	0.976
F		1.160	0.393	1.763	0.597	16.165	5.476	16.547	5.606	0.138	0.047	1.021	0.346	3.395	1.181	3.327	1.127
DXF		NS	0.681	3.461	1.035	NS	9.485	NS	9.710	0.239	0.081	NS	0.599	NS	2.046	NS	1.952

weight and dry weight (7, 11, 12) had comparable findings.

CGR (g day⁻¹m⁻²): The interaction between dates of sowing

and fertilizers levels manifested a negligible impact on CGR (crop growth rate) which is displayed in Table 2. However, the maximum crop growth rate (0.339 day⁻¹m⁻²) at 60 DAS was observed in the combination of 1st DOS (15th Octo-

ber) with 100% RDF. Similarly, at 90 DAS the highest crop growth ($0.617 \text{ day}^{-1}\text{m}^{-2}$) was observed in the combination of 1st DOS (1st October) and 100% RDF. Whereas, the minimum crop growth ($0.209 \text{ day}^{-1}\text{m}^{-2}$) at 60 DAS was observed in the combination of 3rd DOS (30th October) with 75% RDF and at 90 DAS the lowest crop growth rate ($0.328 \text{ day}^{-1}\text{m}^{-2}$) was observed in the combination of 3rd DOS (30th October) with 75% RDF. The high nutrient availability and ideal plant growth environment caused the growth characteristics to increase quickly, which raised plant dry matter and other metrics that could affect the CGR. These outcomes were like the results of (7, 9).

RGR ($\text{g g}^{-1}\text{day}^{-1}$): The data from Table 2 specifies that interaction between fertilizers levels and dates of sowing had manifested a negligible influence on the RGR (relative growth rate) of plants. However, interactive effects of dates fertilizer levels and dates of sowing produced the highest relative growth rate ($0.1.064$ and $1.46 \text{ g g}^{-1}\text{day}^{-1}$) in the combined application of 100% RDF with 1st DOS (1st October). While the least RGR (0.856 and $1.20 \text{ g g}^{-1}\text{day}^{-1}$) at 60 and 90 DAS was observed in the combined application of 75% RDF and 3rd DOS (30th October). The effect of temporal dynamics and nutrient levels affects the productivity of crops, the optimum date of sowing is the most vital agronomic factor which influences the growth pattern of crops which might affect the CGR and RGR of toria. Similar results were seen in the research of (7, 9, 13, 14).

Conclusion

The interaction between 1st DOS (1st October)×100% RDF was reported to be the best treatment in the research. It performed well in all the growth attributes. Hence, it can be concluded that for better growth and development. The toria plants should be sown on 1st October with the application of 100% RDF.

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Authors contributions

All the authors wrote, reviewed and approved the final version of the manuscript equally.

Compliance with ethical standards

Conflict of interest: The authors declare no conflict of interest.

Ethical issues : None.

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