PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 10(1): 261–265
https://doi.org/10.14719/pst.2061

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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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OPEN ACCESS

ARTICLE HISTORY

Received: 14 August 2022
Accepted: 29 October 2022

Available online
Version 1.0 : 23 December 2022
Version 2.0 : 01 January 2023

Check for updates

Additional information

Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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Indexing: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS etc.
See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting

CITE THIS ARTICLE

Jaiswal A, Jaswal A, Singh A. Impact of sowing dates and nutrient levels on growth attributes of toria (*Brassica campestris* var. *toria*) in trans-gangetic region of Punjab. Plant Science Today. 2023; 10(1): 261–265. https://doi.org/10.14719/pst.2061

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 cm^2), Fresh weight (242.7 g), Dry weight (28.45 g), CGR (0.558 g $m^{-2}day^{-1}$), RGR (1.39 $g^{-1} g^{-1}day^{-1}$). 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 cm^2), Fresh and dry weight (253.16 g, 29.55 g), CGR (0.581 g $m^{-2}day^{-1}$), RGR (1.42 $g^{-1} g^{-1}day^{-1}$) 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 $kgha^{-1}$ (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 31.25^0N 75.7^0E, 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 (cm^2): 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 cm^2, 66.30 cm^2 and 71.60 cm^2) at 30, 60 and 90 DAS in the combination of 1st DOS (1st October) and 100% RDF. Whereas the lowest leaf area (22.03 cm^2, 34.50 cm^2 and 46.93 cm^2) 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)
D_1	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
D_2	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
D_3	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								
D_1		49.20^{a}	138.00^{a}	149.33^{a}	151.20^{a}	7.75a	10.33a	8.91a
D_2		43.08^{b}	123.79^{b}	126.70^{b}	128.66^{b}	6.75b	9.91a	7.66b
D_3		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	0973	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: D_1= 1st date of sowing, D_2= 2nd date of sowing, D_3= 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 (cm²)	Leaf area 60DAS (cm²)	Leaf area 90DAS (cm²)	CGR (60DAS) $g\ day^{-1}m^{-2}$	CGR (90DAS) $g\ day^{-1}m^{-2}$	RGR (60DAS) $g\ g^{-1}day^{-1}$	RGR (90DAS) $g\ g^{-1}day^{-1}$
D_1	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
D_2	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
D_3	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								
D_1		35.85a	56.44a	64.28a	0.275a	0.558a	0.971a	1.39a
D_2		30.28b	46.15b	57.14b	0.256ab	0.479ab	0.937a	1.33b
D_3		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)
D_1	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
D_2	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
D_3	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									
D_1		12.88a	72.25a	236.54a	242.79a	1.33a	9.58a	26.33a	28.45a
D_2		12.33a	67.41b	221.08b	223.83b	1.10b	8.79a	23.16b	24.62b
D_3		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 ($g\ day^{-1}m^{-2}$): 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 $day^{-1}m^{-2}$) at 60 DAS was observed in the combination of 1st DOS (15th October) with 100% RDF. Similarly, at 90 DAS the highest crop growth (0.617 $day^{-1}m^{-2}$) was observed in the combination of 1st DOS (1st October) and 100% RDF. Whereas, the minimum crop growth (0.209 $day^{-1}m^{-2}$) 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 $day^{-1}m^{-2}$) 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 (g $g^{-1}day^{-1}$): 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 g $g^{-1}day^{-1}$) in the combined application of 100% RDF with 1st DOS (1st October). While the least RGR (0.856 and 1.20 g $g^{-1}day^{-1}$) 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.

Acknowledgements

All the faculty members of Lovely Professional University, School of Agriculture, Department of Agronomy including all the field helpers.

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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