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Effect of Spatial Dynamics on Growth Attributes of *Toria* under Different Nutrient Levels

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ABSTRACT

Field experiment was conducted at Agronomy Research Fields, School of Agriculture, Lovely Professional University, Phagwara (Punjab) during 2021-22 to find out the effect of spacing on *toria* growth and yield at various nutrient levels for enhancing productivity. The experiments were laid out in factorial randomized block design with three replications. The treatments comprised with two spacing viz., 45 × 15 and 30 × 10 cm and four levels of fertilizers: 0, 75, 100 and 125% RDF. The planting material used in study was TL 17. Plant spacing and different nutrient levels together influenced the growth and yield of *toria*. Optimum spacing with a recommended dose of fertilizer (30 × 10 cm+100% RDF) recorded the highest plant height, fresh weight, dry weight, leaf area, CGR, RGR, number of branches than other spacing and fertilizer levels. Integration of crop geometry at 30 × 10 cm 100% RDF proved to be a better crop management alternative than 45 × 15 cm+100% RDF for sustained production of *toria* under irrigated conditions in sandy loamy soils of Punjab Region.

Key words: Fertilizers, spacing, RDF, *toria*, oil recovery yield, protein yield

INTRODUCTION

Oilseeds are a significant part of agricultural economy in India after food grain crops. *Toria*/ rapeseed belonging to Cruciferae family (*Brassica campestris* L.) occupies a prominent place. The oil and protein content in *toria* is 35-37 and 20-40%, respectively. The rapeseed-mustard group includes brown sarson, raya and *toria* crops. It is a winter (*rabi*) season crop that requires a relatively cool temperature, a fair supply of soil moisture during the growing season and a dry harvest period (Saini *et al.,* 2020). It is cultivated both under irrigated (79.2%) and rainfed (20.8%) conditions (Singh and Thenua, 2016). Highest area was recorded in Rajasthan (10.60 lakh ha) followed by Madhya Pradesh and Haryana 3.99 and 1.46 lakh ha, respectively. Production of oil seeds in 2021 was 35 million metric tonnes. In Punjab state, rapeseed was cultivated in 30.5 thousand hectares with production of 46.5 million tonnes during 2018-19 (DES– Directorate of Economics & Statistics, 2021). The main problems that are causing the low productivity of rapeseed were (i) marginal or low land holdings, (ii) poor quality of soils being used for the cultivation of oil seeds and (iii) poor knowledge about the precise application of fertilizers dose recommended by state Department of Agriculture. Proper selection of varieties and management practices will greatly influence the yield. Recommended row spacing and optimal environmental conditions can increase the yield stability. Inappropriate row spacing reduced seed yield by siliqua and hastening plant maturity (Nanjundan *et al.,* 2020). In Punjab, still there is a scrutiny of data on rapeseed yield dynamics in relation to row spacing.

Fertilizers play a key role in increasing yield. Major fertilizers that influence the yield of *toria* are N, P and S. Nitrogen increases the protein content, dry matter and yield. P and K in the presence of N will promote the flowering, siliqua setting and yield. Phosphorus results in rapid growth and earlier maturity where frost is major concern (Famda *et al.,* 2017).

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Increased root growth can be influenced by optimum supply of phosphorus. It also influences in increasing oil content and initial growth of plants. Sulphur plays a crucial role: split application increases number of pods/ plant and grain. The combined application of nitrogen, phosphorus and sulphur gives better results than using alone (Singh and Thenua, 2016). Plant geometry and plant density are the most essential yield contributing characters among numerous agronomic methods, and can be modified to get optimal yield from a unit area of land. Plant competition, thus, determines the optimal plant stand. With an increase in plant stand, competition for sunlight, moisture, light, carbon dioxide and nutrients increases. As a result, plant stand must be changed based on these characteristics in order to achieve optimal yield. Little work has been done in Punjab to assess the effects of fertilization in relation to plant spacing in relation to growth, yield and uptake of nutrients. By keeping all these points in view, a field experiment was conducted to study the effect of spacing on growth parameters of *toria* under different nutrient levels.

MATERIALS AND METHODS

The experiment was conducted at Agronomy Research Farm of School of Agriculture in Lovely Professional University, Phagwara (Punjab) during *rabi* 2021-22. The nature of soil was sandy loam having medium available nitrogen, phosphorus, potassium and sulphur. The experimental site had sub-tropical climate with cool winter and hot summer. The experiment comprised eight treatments in factorial randomized block design with three replications (Table 1). After mixing the fertilizers according to the various fertilizer levels, seeds of *toria* variety TL-17 were sown in October at different spacings 45 × 15 and 30 × 10 cm between row to row and plant to plant. The crop was harvested in the month of January. At the sowing time, half dose of nitrogen and full dose of P_2O_5 and sulphur was applied. The remaining 50% of nitrogen was applied in two split doses (25% at flowering stage and 25% at pod formation stage). The different growth parameters (plant height, fresh and dry weight, leaf area, primary and secondary branches, CGR and RGR) were

Table 1. Details of the treatments

Treatment number	Treatment details
T_1	S_1 (45 x 15 cm) + F_0 (0% RDF)
T_2	S_1 (45 x 15 cm) + F_1 (75% RDF)
T_3	S_1 (45 x 15 cm) + F_2 (100% RDF)
T_4	S_1 (45 x 15 cm) + F_3 (125% RDF)
T_5	S_2 (30 × 10 cm) + F_0 (0% RDF)
T_6	S_2 (30 × 10 cm) + F_1 (75% RDF)
T_7	S_2 (30 × 10 cm) + F_2 (100% RDF)
T_8	S_2 (30 × 10 cm) + F_3 (125% RDF)

recorded at 30, 60, 90 DAS and at harvest. Plant growth parameters were recorded from five tagged plants from each plot. The differences between the mean values were estimated by generalized linear model under univariate technique with two 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.

RESULTS AND DISCUSSION

Growth and development of crop is the result of interactions of various factors like moisture, weather conditions and available nutrients in soil. In present series of experiment, growth of *toria* was measured in terms of plant height, fresh weight, dry weight, leaf area and number of primary and secondary branches. On reviewing results, it was seen that varied levels of fertilizers and spacing significantly affected the growth parameters.

Considering the spacing, plant stand of *toria* was found significant. Row spacing (30 × 10 cm) recorded more plant stand (75.54) as compared to 45 × 15 cm (Table 2). In case of fertilizer levels, plant stand recorded significant variation. Highest plant stand (70.51) was observed under F_2: 100% RDF which was followed by F_3: 125% RDF (69). A significant interaction was found between spacing and fertilizer levels in case of plant stand. *Toria* crop sown at 30 × 10 cm spacing with 100% RDF was found to record significantly highest plant stand (76) compared to all other treatments. The lowest plant stand (61) was recorded under S_1F_0: 45 × 15 cm+0% RDF. Plant stand per meter square recorded maximum in 30 × 10 cm spacing with 100% RDF that might be due to a greater number of plants per unit area and balanced supply of nutrients. Less

Table 2. Effect of spatial dynamics on growth attributes of *toria* under different nutrient levels and spacing and their interactions

Treatment			Plant height (cm)	Fresh weight (g)	Dry weight (g)	Leaf area (cm^2)	Primary branches (no.)	Secondary branches (no.)	CGR (g/day/m^2)	RGR (g/g/day)
S_1	F_0	61.1	108.90	122.22	28.33	43.26	4.8	9.33	0.59	1.43
	F_1	63.1	112.64	215.64	91.23	58.46	5.49	12.53	3.01	1.95
	F_2	65	123.24	246.79	98.37	66.57	7.03	7.33	2.65	1.9
	F_3	64	118.21	237.81	94.30	60.37	6.53	16.03	2.72	1.97
S_2	F_0	69.16	110.49	128.37	31.53	44.43	5.07	8.2	0.44	1.47
	F_1	71	117.68	200.53	91.26	45.17	5.47	10.43	2.89	1.95
	F_2	76	124.01	267.08	102.23	71.27	7.66	18.90	2.72	2.00
	F_3	74	121.33	234.24	96.12	62.20	6.00	16.56	2.71	1.97
						Mean				
S_1		63.308	115.75	205.62	78.06	57.17	5.95	13.81	2.24	1.83
S_2		75.54	118.38	207.55	80.29	55.77	6.05	13.53	2.19	1.85
F_0		65.13c	109.69d	125.29d	29.93d	43.85d	4.93c	8.77d	0.51c	1.45d
F_1		67.05b	115.16c	208.09c	91.25c	51.82c	5.45c	11.49c	2.95a	1.95c
F_2		70.51a	123.63a	256.94a	100.30a	68.92a	7.35a	18.12a	2.69b	1.99a
F_3		69b	119.77b	236.02b	95.20b	61.28b	6.26b	16.30b	2.71b	1.97b

C. D. (P=0.05)	C. D.	S. Em	C. D.	S. Em	C. D.	S. Em	C. D.	S. Em	C. D.	S. Em	C. D.	S. Em	C. D.	S. Em	C. D.	S. Em	C. D.	S. Em
S	0.86	0.27	0.89	0.29	NS	1.07	0.87	0.28	0.66	0.21	NS	0.16	NS	0.32	NS	0.02	0.008	0.003
F	1.16	0.38	1.26	0.41	4.64	1.51	1.23	0.40	0.94	0.30	0.72	0.23	1.39	0.45	0.11	0.03	0.012	0.004
S × F	1.651	0.54	Sig.*	0.58	Sig*	2.14	Sig*	0.57	Sig*	0.43	NS	0.33	NS	0.64	NS	0.05	0.017	0.005

S_1 = 45 × 15 cm, S_2 = 30 × 10 cm, F_0 = 0% RDF, F_1 = 75% RDF, F_2 = 100% RDF, F_3 = 125% RDF, Sig* = Significant, NS = Non-significant, S = Spacing, F = Fertilizer, S × F = Spacing × Fertilizer interaction.

plant stand was recorded in 45 × 15 cm and 0% RDF due to more spacing and no fertilization. These results are in conformity with the findings of Daisy *et al.* (2015).

Plant height is direct catalogue to evaluate growth and vigour of the plant. The maximum plant height (118.38 cm) was recorded in spacing of 30 × 10 cm (Table 2; Fig. 1). At different fertilizer levels, the maximum plant height was noted in 100% RDF (128.63 cm) followed by the 125% RDF. This might be due to optimum dose of fertilizers which encouraged carbohydrates synthesis and resulted in taller plants. Lowest plant height was recorded in F_0: 0% RDF that might be due to lack of nutrients in soil, plant did not get the proper nutrition.The interaction was found to be significant in different spacing and fertilizer levels. The increased plant height under 30 × 10 cm+100% RDF could be due to the competition for light and recommended dose of fertilizers joined together favoured higher plant height. These results were supported by Singh and Thenua (2016).

Number of primary and secondary branches was mostly benefitted under different spacing (Table 2; Figs. 2 and 3). The maximum advantage to individual plants was observed under 45 cm spacing but overall number of primary branches was found to be highest

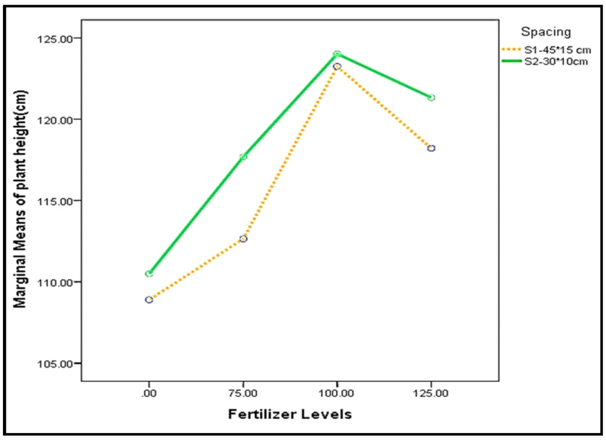

Fig. 1. Effect of spatial dynamics on plant height (cm) in *toria* under different nutrient levels.

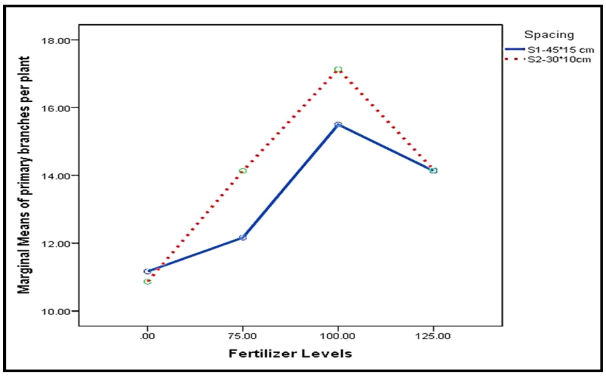

Fig. 2. Effect of spatial dynamics on primary branches in *toria* under different nutrient levels.

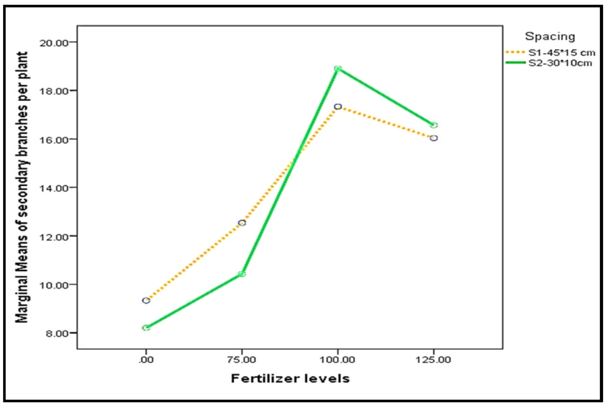

Fig. 3. Effect of spatial dynamics on secondary branches in *toria* under different nutrient levels.

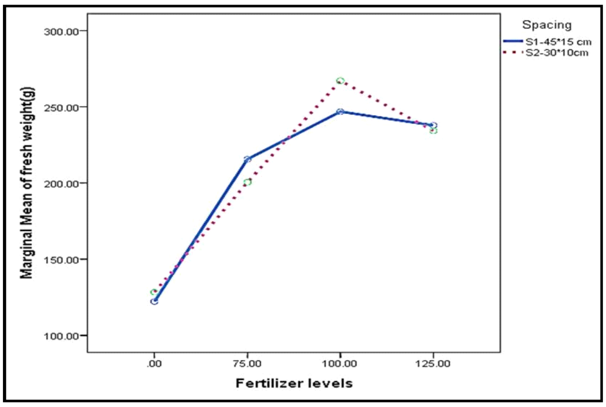

Fig. 4. Effect of spatial dynamics on fresh weight (g) in *toria* under different nutrient levels.

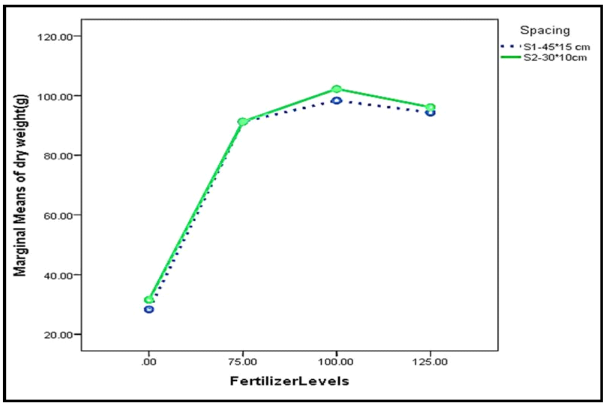

Fig. 5. Effect of spatial dynamics on dry weight (g) in *toria* under different nutrient levels.

under 30 cm spacing (6.05). It is clear that benefit occurred to individual plant under 45 cm spacing was not sufficient to compensate the benefit occurring due to a greater number of plants under 30 cm row spacing. This result is in accordance with Adhikari *et al.* (2021) and Shafi and Farooq (2021). In case of primary and secondary branches, it is interesting to observe that where no fertilizer was applied, plants were of poor branching. In different fertilizer levels, 100% RDF gave more number of primary branches (7.35) and it was followed by 125% RDF (6.26). However, in case of secondary branches, it will elucidate that with the application of increasing rates of fertilizers, number of secondary branches was significantly improved and this enhancement was quite appreciable up to 100% RDF. At 125% RDF neither primary nor the secondary branches/plant were increased. These results are in line with the findings of Famda *et al.* (2017). In interactions S_2-F_2: 30 × 10 cm+100% RDF gave more number of secondary branches (18.90), though the data were statistically non-significant.

Dry weight is considered as an index for enhancing photosynthetic efficiency in plants. Fresh weight and dry matter production can be observed as the net photosynthetic transformation of intercepted radiation which is related to canopy development. In current study, *toria* sown at spacing of 30 × 10 cm gained more fresh (207.55 g) and dry weight (80.29 g) as compared to 45 × 15 cm that was due to more incidence of photosynthetic active radiation (PAR) and radiation use efficiency (RUE) (Table 2; Figs. 4 and 5). *Toria,* being a very proficient crop in the utilization of light, resulted in more weight of the plant. These results are in conformity with the findings of Hussain *et al.* (2020). Different fertilizer levels showed great influence on dry weight. Maximum dry weight was recorded in 100% RDF (100.30 g) that might be due to more photosynthetic area, good interception of sunlight and the presence of a greater number of leaves. The interaction between spacing, fertilizers were found significant among different treatments and spacing levels. This could be attributed due to closer spacing acquiring a greater number of plants per unit area with more nutrient uptake and enhanced dry matter of the plant. These results are in conformity with the findings of Famda *et al.* (2017).

Leaf area is a direct measure of the plant growth. It is an important source in synthesizing photo assimilation and as an indicator of dry matter accumulation and crop yield. Enhancement in leaf area resulted in improved utilization of solar energy. Higher leaf area at all stages of experimentation was observed under 30 × 10 cm compared to wider spacing of 45 × 15 cm (Fig. 6). Maximum leaf area (55.17 cm^2) recorded under closer spacing 30 × 10 cm might be due to increased plant stand per unit area. These results are in accordance with the findings of Bazzaz *et al.* (2020). The fertilizer level 100% RDF (68.92 cm^2) gave more leaf area than any other fertilizer level. Significant interaction was found at 30 and 90 DAS among spacing and fertilizer levels on leaf area. *Toria* sown at 30 × 10 cm spacing with 100% RDF recorded highest leaf area (71.27 cm^2) as compared to other combinations. Optimum/balanced fertilization could be attributed to its favourable effects on cell enlargement including photosynthetic capacity of plants. These results are in conformity with the findings of Dubey *et al.* (2021).

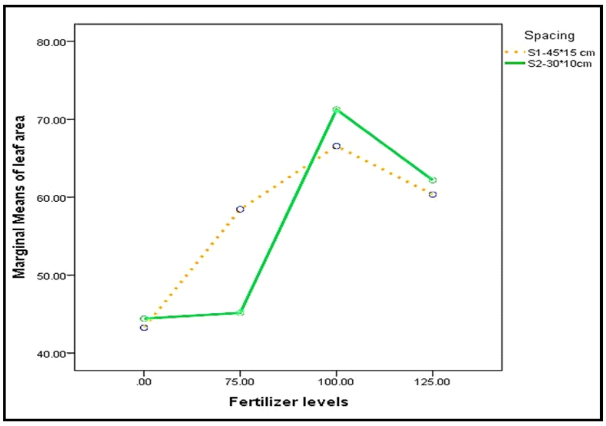

Fig. 6. Effect of spatial dynamics on leaf area (cm^2) in *toria* under different nutrient levels.

Crop growth rate (CGR) is an indicator of dry matter accumulation per unit area, in per unit time. The highest CGR was recorded in the spacing of 45 × 15 cm (2.24 g/day/m^2) followed by 30 × 10 cm (2.24) spacing (Figs. 7 and 8). Various fertilizer levels had shown a remarkable differentiation of CGR and maximum was recorded in the F_1: 75% RDF (2.95) and lowest CGR in F_0: 0% RDF. In interaction, S_2F_1 had more CGR (2.89) than other interactions and the data were statistically significant. It could be due to more photosynthetic output per unit area per unit time which resulted in more leaf area by better distribution of light in the canopy, higher absorption of nutrients and low competition in betweens plants. This is in conformity with the findings of Bazzaz *et al.* (2020). The highest RGR was recorded in the spacing of 45 × 15 cm (1.85)

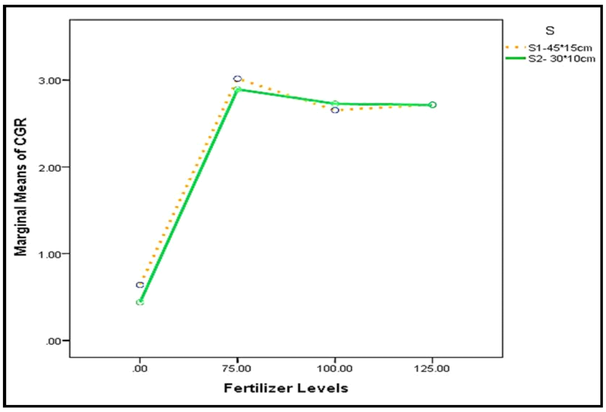

Fig. 7. Effect of spatial dynamics on CGR (g/m^2/day) in *toria* under different nutrient levels.

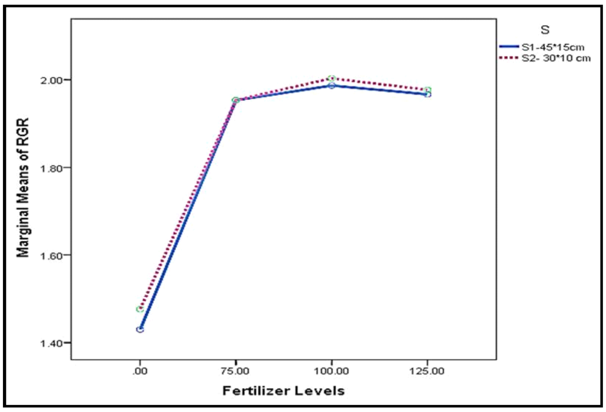

Fig. 8. Effect of spatial dynamics on RGR (g/g/day) in *toria* under different nutrient levels.

followed by 30 × 10 cm (1.83) spacing. Various fertilizer levels had shown a remarkable differentiation of RGR and maximum was recorded in the F_2: 100% RDF (1.99 g/g/day) and lowest RGR in F_0: 0% RDF. In interaction, S_2F_2: 30 × 10 cm+100% RDF had more RGR (2.00) than other interactions and the data were statistically significant. That might be due to increased availability of resources, canopy closure at later stages leading to more interruption of photosynthetic active radiations (PAR) and increased plant growth causing higher RGR. The lowest RGR recorded under 45 × 15 cm might be due to translocation of more assimilates from source to sink. The results are in conformity with the findings of Nega and Woldes (2018). CGR and RGR were significantly enhanced by fertilizer levels at all stages of growth and compared to unfertilized plots. The increase in CGR and RGR by application of 100% RDF (F_2) was mainly due to more leaf area and dry weight of plant. Bolaji *et al.* (2021) confirmed that increased rate of fertilizers up to 100% RDF enhanced CGR and RGR.

CONCLUSION

Toria planted at 30 × 10 cm was found to be optimum for higher crop productivity and economic returns. 100% RDF was the suitable fertilizer management strategy for sustainable production of *toria*. Integration of crop geometry at 30 × 10 cm plus 100% RDF proved to be a better crop management alternative than 45 × 15 cm+100% RDF for sustained production of *toria* under irrigated conditions. Based upon above results, one can conclude that *toria* should be sown at 30 × 10 cm spacing with 100% RDF for getting most profitable yield of *toria* in sandy loam soils of Punjab region.

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