

## Effect of Fertilizer Doses on Phenological Parameters of Grafted Tomato Plants

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**ABSTRACT:** The experiment was conducted at Central Horticultural Experiment Station, ICAR- IIHR, Aiginia, Bhubaneswar, Odisha, India during *kharif* seasons of 2018 in collaboration with Odisha University of Agriculture and Technology, Bhubaneswar to study the plant height, number of branches per plant and days taken to 50 % flowering among grafted root stock and Arka Rakshak non-grafted tomato plant. As there is little information's available regarding the effect of root stock with different recommended fertilizer doses with respect to phenological parameters of the grafted tomato plants so, the experiment was conducted with cultivated Utkal Anushree and wild species *Solanum torvum* of brinjal and Arka Rakshak tomato hybrid as both scion and non-grafted control plant with 12 treatment combination (different RDFs and absolute control) following statistical design FRBD with three replications in field condition to find out better root stock with respect to vegetative and flowering parameter. The grafted *Solanum torvum* root stock recorded highest plant height (91.92 cm) and number of branches per plant (16.86) than the non-grafted Arka Rakshak tomato hybrids. Whereas non-grafted Arka Rakshak took lowest number of days (33.20 days) to 50 % flowering while the grafted root stocks of *Solanum torvum* (37.50 days) and Utkal Anushree (38.53 days) took highest number of days to 50 % flowering. *Solanum torvum* and Utkal Anushree root stock performed better at 75 % RDF as compared to 100 % RDFs, there was very little difference in plant height, number of branches and days taken to 50% flowering in comparison between 100 % and 75 % RDFs.

**Keywords:** Grafting, Rootstock, Scion, *Solanum torvum*, RDF, Phenological parameters.

### INTRODUCTION

Tomato (*Solanum lycopersicum* L.), an important Solanaceous vegetable crop grown worldwide, originated in Peru and Mexico. During the twentieth century, its cultivation spread around the world. Tomato is rich in minerals, vitamins, organic acids, and it contains potassium 268 mg, phosphorus 27 mg, ascorbic acid of 16.0-65.0 mg, 94.1 g of water, 1.0 g of protein, 0.3 g of fat, 4.0 g of carbohydrates, 0.6 g of fibres, vitamin A of 1100 I.U, vitamin B 0.20 mg, vitamin C 23 mg and total sugar content of 2.5 per cent per 100 g ripe fruit. Several processed items like paste, sauce, puree, syrup, juice, ketchup, drinks etc. are prepared on large scale from Tomato. In the present day, tomatoes have gained global recognition as an

essential vegetable, not only for their culinary appeal but also for their remarkable nutraceutical properties. Often referred to as the "Poor Man's Orange", tomatoes have cemented their position in diets worldwide due to their health benefits and nutritional value. One of the key health-promoting compounds found in tomatoes is lycopene, a potent antioxidant that has garnered significant attention from researchers and health enthusiasts alike. Lycopene plays a crucial role in maintaining heart health by reducing cholesterol levels and contributing to improved cardiovascular function. Additionally, its antioxidant properties grant it the ability to scavenge harmful free radicals within the body, potentially reducing the risk of various cancers and other chronic diseases (Watzman, 2000).

In India, tomatoes are grown in an area of 0.805 million hectares with a production of 19.69 million tonnes, and the productivity is 24.4t/ha. The area and production of Tomato in Odisha is 0.091 million hectare and 1.311 million tonnes respectively with a productivity of 14.4t/ha (Horticultural Statistics at a Glance 2017). Lower productivity of tomato in Odisha is mostly encountered by poor management practices and major biotic and abiotic stresses. Similarly, one of the most important critical inputs which seriously affect the growth and yield of tomato crop is fertilizer, particularly N, P and K. Nitrogen promotes vegetative growth, flower and fruit set but excess of nitrogen delays maturity and decreases fruit size. High level of phosphorus throughout root zone is essential for rapid root development and good utilization of water and other nutrients by plant. Phosphorous has pronounced effect on the flowering. Phosphorous in combination with N and K improves peel colour, taste, hardness and vitamin C content and hastens maturity. Potassium tends to increase fruit size, fruit quality and rectifies many disorders. Additionally, it contributes to reducing the occurrence of irregularly shaped fruits. Moreover, potassium is essential in the process of pigmentation for tomato fruits. Gradually the availability of fertilizers is decreasing that makes them more costly. So, fertilizers such as Nitrogen, Phosphorus and Potassium should be applied adequately as per the requirement of the crop. It should be neither too much nor too less. Providing excessive amounts of certain nutrients may lead to imbalances, which can have negative effects on the plant's growth and development. By following recommended fertilizer doses, we can avoid nutrient imbalances and maintain a healthy nutrient profile for the grafted tomato plant. Grafted tomato plants have been shown to have higher shoot and root biomass, greater chlorophyll content, and improved photosynthesis compared to non-grafted plants. (Abdelmageed and Gruda 2009). Limited information is currently available about the recommended fertilizer doses and their impact on grafted tomato plants, as well as the specific fertilizer doses that lead to better growth and flowering in these grafted plants. In India, special Odisha condition there is an urgent need to determine the recommended fertilizer dose that performs better in terms of phenology for both grafted and non-grafted tomato plants. Considering these factors an experiment was designed with objective to identify best recommended fertilizers dose with root stocks among grafted and non-grafted tomato plants.

## MATERIALS AND METHODS

The experiment was conducted at Central Horticultural Experiment Station, ICAR- IIHR, Aiginia, Bhubaneswar, Odisha, India during *rabi* seasons of 2019-20 and 2020-21 in collaboration with Department of Vegetable Science, Odisha University of Agriculture and Technology, Bhubaneswar. The site is located at 20°15' N latitude, 85°053' E longitude and 25.5 m above mean sea level. The experiment was conducted with two root stocks and Arka Rakshak tomato hybrid as both scion and non-grafted control plant following

statistical design FRBD with three replications in field condition to find out better root stock. The 12 treatment combinations were

- R<sub>1</sub>D<sub>1</sub>-*Solanum torvum* with 50% RDF
- R<sub>1</sub>D<sub>2</sub>-*Solanum torvum* with 75% RDF
- R<sub>1</sub>D<sub>3</sub>-*Solanum torvum* with 100% RDF
- R<sub>1</sub>D<sub>4</sub>-*Solanum torvum* control
- R<sub>2</sub>D<sub>1</sub>-Utkal Anushree with 50% RDF
- R<sub>2</sub>D<sub>2</sub>-Utkal Anushree with 75% RDF
- R<sub>2</sub>D<sub>3</sub>-Utkal Anushree with 100% RDF
- R<sub>2</sub>D<sub>4</sub>-Utkal Anushree control
- R<sub>3</sub>D<sub>1</sub>-Arka Rakshak with 50% RDF
- R<sub>3</sub>D<sub>2</sub>-Arka Rakshak with 75% RDF
- R<sub>3</sub>D<sub>3</sub>-Arka Rakshak with 100% RDF
- R<sub>3</sub>D<sub>4</sub>-Arka Rakshak control

Recommended dose of fertilizer in Arka Rakshak F<sub>1</sub> hybrids was 175-150-175 kg NPK/ha and cleft method of grafting was followed for this experiment. The data on phenological and flowering characters were averaged, tabulated, and statistically analysed using factorial randomized block design as suggested by Gomez and Gomez (1984).

## RESULTS AND DISCUSSION

### A. Plant height

The data recorded on plant height of tomato plant at 90 days after transplanting was significantly influenced by the root stock in both the year 2019-20 and 2020-21. The maximum plant height was recorded in R<sub>1</sub>-*Solanum torvum* (91.06 cm and 92.78 cm) root stock in both the year which was significantly higher than R<sub>2</sub>-Utkal Anushree (82.54 cm and 85.30 cm) and R<sub>3</sub>-Arka Rakshak non-grafted. The minimum plant height was observed in R<sub>3</sub>-Arka Rakshak non-grafted (74.14 cm and 75.94 cm) in both the year of study. The perusal of data revealed that plant height of tomato was significantly influenced by the different recommended dose of fertiliser. In both the year 2019-20 and 2020-21 the maximum plant height was recorded in D<sub>3</sub> (100 % RDF) (89.94 cm and 92.28 cm) and minimum plant height (68.26 cm and 71.28 cm) was observed in D<sub>4</sub> (Control).

The interaction effect between root stock and fertilizer doses had significant influence with respect to plant height. Among all the treatment combination *Solanum torvum* with 100 % RDF recorded highest plant height of (100.40 cm and 103.07 cm) which was at par with treatment combination *Solanum torvum* with 75 % RDF (97.27 cm and 98.87 cm) in the year 2019-20 and 2021-22 respectively. Similarly minimum plant height was noticed in R<sub>3</sub>D<sub>4</sub>-non-grafted Arka Rakshak control (64.07 and 65.77 cm) in both the years of study.

From pooled data it was observed that highest plant height of 91.92 cm was recorded in *Solanum torvum* root stock and lowest plant height 75.04 cm in non-grafted Arka Rakshak. Pooled data also recorded maximum plant height (91.11 cm) in D<sub>3</sub> (100 % RDF) and minimum plant height observed in D<sub>4</sub>(Control). In interaction effect pooled maximum plant height was recorded in R<sub>1</sub>D<sub>3</sub>-*Solanum torvum* with 100 % RDF (101.73 cm) followed by R<sub>1</sub>D<sub>2</sub>-*Solanum torvum* with 75 % RDF (98.07 cm) and minimum plant height was

recorded in R<sub>3</sub>D<sub>4</sub>-non-grafted Arka Rakshak control (64.92 cm). The pooled interaction of root stock and fertiliser doses with year found non-significant. Similar results were reported by other researchers Khah *et al.* (2006) reported that under open field condition, the grafted tomato plants recorded the highest plant height (95.88 cm), which was significantly greater than the non-grafted control plant (70.32 cm). The rootstock's vigorous root system is often capable of absorbing water and nutrients more efficiently than scion roots and serves as a good supplier of endogenous plant hormones (Lee,1994). Gisbert *et al.* (2011) reported that the vigorous root system of the rootstock enhances the ability to absorb water and nutrients compared to the non-grafted plants while serving as a better supplier of endogenous plant hormones. Results are similar with findings of Leonardi and Giuffrida (2006) who stated significant increase in plant height was recorded in grafted tomato and egg plant when compared to non-grafted plant.

#### B. Number of branches per plant

The recorded mean data on number of branches per plant of tomato plant at 90 days after transplanting presented in the Table 2. Significant difference was observed among the all the treatments and number of branches per plant was significantly influenced by the root stock in both the year 2019-20 and 2020-21. Significantly highest number of branches per plant was recorded in R<sub>1</sub>-*Solanum torvum* (16.71 and 17.01) root stock in both the years which was significantly higher than R<sub>2</sub> -Utkal Anushree (15.87 and 16.12) root stock. The lowest number of branches per plant was recorded in R<sub>3</sub> -Arka Rakshak non-grafted (14.45 and 14.79) in both the year of experiment.

In both the year 2019-20 and 2020-21 the maximum number of branches per plant was recorded in D<sub>3</sub> (100 % RDF) (17.14 and 17.50) and minimum number of branches per plant (15.67 and 15.98) was observed in D<sub>4</sub> (Control).

The interaction effect between root stock and fertilizer doses had significant influence with reference to number of branches per plant. In 2019-20 among the all-treatments combination R<sub>1</sub>D<sub>3</sub>-*Solanum torvum* with 100 % RDF recorded highest number of branches per plant of 18.27. In 2020-21 R<sub>1</sub>D<sub>3</sub>-*Solanum torvum* with 100 % RDF also recorded significantly highest number of branches per plant of 18.51 and at par with treatment R<sub>1</sub>D<sub>2</sub>-*Solanum torvum* with 75% RDF (18.19). Similarly minimum number of branches per plant was noticed in R<sub>3</sub>D<sub>4</sub>-non-grafted Arka Rakshak control (11.93 and 12.27) in both the year of experiment.

From the Pooled data it was observed that *Solanum torvum* root stocks recorded highest number of branches per plant (16.86) and lowest number of branches per plant (14.62) in non-grafted Arka Rakshak. Maximum number of branches per plant (17.32) was recorded in D<sub>3</sub> (100 % RDF) and minimum number of branches per plant (12.75) was observed in D<sub>4</sub>(Control). In pooled interaction effect maximum number of branches per plant was recorded in R<sub>1</sub>D<sub>3</sub>-*Solanum torvum* with 100 % RDF (18.39) followed by R<sub>1</sub>D<sub>2</sub>-*Solanum torvum* with 75 % RDF (17.99) and

minimum number of branches per plant was recorded in R<sub>3</sub>D<sub>4</sub>-non-grafted Arka Rakshak (Control) (12.10). The pooled interaction of root stock and fertiliser doses with year found non-significant.

*Solanum torvum* root stock recorded highest number of branches per plant (16.86) when grafted with Arka Rakshak tomato F<sub>1</sub> hybrid than the non-grafted Arka Rakshak plant (14.62). This might be due to deep robust root system, allowing for better nutrient absorption and distribution throughout the plant. This increased nutrient availability can stimulate vegetative growth, resulting in a higher number of branches. The vigorous root system of the rootstock enhanced better growth of scion which resulted in a greater number of branches in grafted plants (Mohammed *et al.*, 2009). Plants with vigorous root system might have produced more cytokinins into the ascending xylem sap resulting in increased yield due to growth promotion (Aloni *et al.*, 2010). In a reduced nutrient environment, the *Solanum torvum* grafts showed the most vigorous growth with higher biomass (Cassaniti *et al.*, 2011). The 100 % RDFs showed similar results with that of 75 % RDFs. Similar results were also observed by Davis *et al.* (2008) and Ganpatrao (2021).

#### C. Days taken to 50 % flowering

The results regarding days taken to 50 % flowering indicated significant difference among the all the treatments and days taken to 50 % flowering was significantly influenced by the root stock in both the year 2019-20 and 2020-21. R<sub>3</sub>-non-grafted Arka Rakshak took lowest days to produce 50 % flowering than grafted R<sub>1</sub>-*Solanum torvum* (42.17 and 41.73 days) and R<sub>2</sub>-Utkal Anushree root stocks (43.60 and 42.61) in the year 2019-20 and 2020-21 respectively.

The perusal of data revealed that days taken to 50 % flowering of tomato was significantly influenced by the different recommended dose of fertiliser. In both the year 2019-20 and 2020-21 the days taken to 50% flowering D<sub>4</sub> (Control) recorded lowest days to flowering (36.63 and 36.19 days) and Highest days were taken by D<sub>1</sub>(50% RDF) (42.92 and 42.60 days).

The interaction effect of root stock and fertilizer doses had significant influence with days taken to 50% flowering. In 2019-20 and 2020-21 among the all-treatments combination R<sub>3</sub>D<sub>4</sub>-Arka Rakshak non-grafted control recorded lowest days (33.53 and 32.87days) to days taken to 50% flowering which was followed by R<sub>1</sub>D<sub>4</sub>-*Solanum torvum* control and R<sub>2</sub>D<sub>4</sub>-Utkal Anushree control.

Pooled data revealed that non-grafted Arka Rakshak took lowest days (33.20 days) to days taken to 50 % flowering while the grafted root stocks of *Solanum torvum* (37.50 days) and Utkal Anushree (38.53 days) taken highest days for 50 % flowering. Among fertilisers doses it is also recorded that the D<sub>4</sub>(control) took minimum days of 36.41 days than the D<sub>3</sub> (100 % RDF), D<sub>2</sub> (75% RDF) and D<sub>1</sub> (50 % RDF). In pooled interaction effect R<sub>3</sub>D<sub>4</sub>-non-grafted Arka Rakshak took minimum days (33.20 days) and R<sub>2</sub>D<sub>1</sub>-Utkal Anushree with 50% RDF taken maximum 46.82 days to 50 % flowering. Among *Solanum torvum* and Utkal Anushree root stocks *Solanum torvum* is earlier in flowering than

Utkal Anushree root stocks when grafted with Arka Rakshak tomato. The pooled interaction of root stock and fertiliser doses with year found non-significant. In this research it was revealed that non-grafted Arka Rakshak took lowest days (33.20 days) to days taken to 50% flowering while the grafted root stocks of *Solanum torvum* (37.50 days) and Utkal Anushree (38.53 days) took highest number of days for 50 % flowering. Comparable effect of delayed flowering in grafted plants of eggplant and tomato was reported by Moncada *et al.* (2013) and Musa *et al.* (2020). The concluding phenomenon is attributable to the stress experienced by these plants following the grafting operation Khah *et al.* (2006). In pooled interaction effect non-grafted Arka Rakshak took minimum days (33.20 days) and Utkal Anushree with 50% RDF took maximum 46.82 days to 50 %

flowering. Non-fertilized plants may experience stress due to the absence of nutrients in vegetative growth stage and this stress might have helped to entered reproductive growth leading to earlier flowering. Among *Solanum torvum* and Utkal Anushree root stocks *Solanum torvum* was earlier in flowering than Utkal Anushree root stocks when grafted with Arka Rakshak tomato. Khah *et al.* (2006) reported non-grafted tomato plants were earlier in flowering than grafted tomato plants. Similar trend of delayed flowering in grafted plants were also reported by Matsuzoe *et al.* (1990); Ali *et al.* (1994) in egg plant and Rashid *et al.* (2004) they noticed that grafted tomato plants with *Solanum torvum* took about 10 days more time for flowering (66 days) than non- grafted plants (54 days).

**Table 1: Plant height of Arka Rakshak (tomato) as affected by *Solanum* rootstocks and Arka Rakshak non-grafted at different RDFs.**

Fertilizer dose	R <sub>1</sub> ( <i>Solanum torvum</i> )			R <sub>2</sub> (Utkal Anushree)			R <sub>3</sub> (Arka Rakshak)			Mean		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
D <sub>1</sub> (50% RDF)	92.82	93.72	93.27	85.53	86.30	85.91	75.07	76.90	75.98	84.47	85.64	85.06
D <sub>2</sub> (75% RDF)	97.27	98.87	98.07	87.32	89.45	88.38	78.40	80.20	79.30	87.66	89.51	88.58
D <sub>3</sub> (100% RDF)	100.40	103.07	101.73	90.40	92.87	91.63	79.03	80.90	79.97	89.94	92.28	91.11
D <sub>4</sub> (Control)	73.77	75.47	74.62	66.93	72.60	69.77	64.07	65.77	64.92	68.26	71.28	69.77
Mean	91.06	92.78	91.92	82.54	85.30	83.92	74.14	75.94	75.04	82.58	84.68	83.63
	R			D			R*D					
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	Y*R	Y*D	Y*R*D
SE(m) ±	0.65	0.67	0.45	0.75	0.77	0.52	1.3	1.34	0.89	0.63	0.73	1.26
C.D(0.05)	1.9	1.96	1.27	2.2	2.26	1.47	3.81	3.92	2.54	NS	NS	3.59

**Table 2: Number of branches of Arka Rakshak (tomato) as affected by *Solanum* rootstocks and Arka Rakshak non-grafted at different RDFs.**

Fertilizer dose	R <sub>1</sub> ( <i>Solanum torvum</i> )			R <sub>2</sub> (Utkal Anushree)			R <sub>3</sub> (Arka Rakshak)			Mean		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
D <sub>1</sub> (50% RDF)	17.43	17.76	17.60	16.57	16.84	16.71	14.28	14.75	14.52	16.09	16.45	16.27
D <sub>2</sub> (75% RDF)	17.80	18.19	17.99	16.89	17.19	17.04	15.77	15.92	15.85	16.82	17.10	16.96
D <sub>3</sub> (100% RDF)	18.27	18.51	18.39	17.34	17.75	17.55	15.80	16.23	16.01	17.14	17.50	17.32
D <sub>4</sub> (Control)	13.33	13.60	13.47	12.67	12.70	12.68	11.93	12.27	12.10	12.64	12.86	12.75
Mean	16.71	17.01	16.86	15.87	16.12	15.99	14.45	14.79	14.62	15.67	15.98	15.82
	R			D			R*D					
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	Y*R	Y*D	Y*R*D
SE(m)±	0.06	0.09	0.05	0.07	0.10	0.06	0.13	0.18	0.11	0.07	0.09	0.15
C.D(0.05)	0.19	0.27	0.15	0.21	0.31	0.17	0.37	0.53	0.30	NS	NS	0.43

**Table 3: Days taken to 50 % flowering of Arka Rakshak (tomato) as affected by *Solanum* rootstocks and Arka Rakshak non-grafted at different RDFs.**

Fertilizer dose	R <sub>1</sub> ( <i>Solanum torvum</i> )			R <sub>2</sub> (Utkal Anushree)			R <sub>3</sub> (Arka Rakshak)			Mean		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
D <sub>1</sub> (50% RDF)	45.52	45.33	45.43	46.97	46.67	46.82	36.27	35.80	36.03	42.92	42.60	42.76
D <sub>2</sub> (75% RDF)	43.23	42.33	42.78	44.67	42.90	43.78	34.83	34.67	34.75	40.91	39.97	40.44
D <sub>3</sub> (100% RDF)	42.27	41.93	42.10	44.07	42.50	43.28	34.67	34.33	34.50	40.33	39.59	39.96
D <sub>4</sub> (Control)	37.67	37.33	37.50	38.70	38.37	38.53	33.53	32.87	33.20	36.63	36.19	36.41
Mean	42.17	41.73	41.95	43.60	42.61	43.10	34.83	34.42	34.62	40.20	39.59	39.89
	R			D			R*D					
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	Y*R	Y*D	Y*R*D
SE(m) ±	0.31	0.31	0.21	0.35	0.36	0.24	0.61	0.63	0.42	0.3	0.34	0.59
C.D(0.05)	0.89	0.92	0.6	1.03	1.06	0.69	1.79	1.84	1.19	NS	NS	1.68



## CONCLUSIONS

The grafted *Solanum torvum* and Utkal Anushree root stock recorded highest plant height and number of branches per plant than the non-grafted Arka Rakshak tomato hybrids. Among recommended fertiliser doses 100 % RDF performed highest plant height and was at par with 75% RDF. Whereas, non-grafted Arka Rakshak took lowest days (33.20 days) to 50% flowering while the grafted root stocks of *Solanum torvum* (37.50 days) and Utkal Anushree (38.53 days) took highest number of days for 50 % flowering. However, the non-fertilized plants may experience stress due to the absence of nutrients in vegetative growth stage and this stress might have helped them to enter reproductive growth phase leading to earlier flowering. Among *Solanum torvum* and Utkal Anushree root stocks *Solanum torvum* is earlier in flowering than Utkal Anushree root stocks when grafted with Arka Rakshak tomato. *Solanum torvum* and Utkal Anushree root stocks performed better at 75 % RDF compared to 100 % RDFs., there was very little difference in plant height, number of branches and days taken to reach 50% flowering between 100 % and 75 % RDFs. This led to the conclusion that *Solanum torvum* with 75 % can be recommended for commercial cultivation, but its yield potential should be assessed. However, since *Solanum torvum* is a wild rootstock and availability of seeds may be a problem, in that case, Utkal Anushree, released by OUAT, can be recommended with 75% RDF for better vegetative growth of tomatoes.

## FUTURE SCOPE

The Utkal Anushree root stock's yield performance and reaction to root knot nematode and bacterial wilt incidence and quality parameters should be assessed at 75% recommended doses of fertilizers.

**Conflict of Interest.** None.

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