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Response of tomato (*Solanum lycopersicum*) grafted on wild brinjal (*Solanum torvum*) rootstock for growth and yield

CHANDANSHIVE A V[1], SONAVANE P N[1], GAIKWAD S D[1] and VIKASH KUMAR[2]

Mahatma Phule Krishi Vidyapeeth Rahuri, Rahuri, Maharashtra 413 722, India

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ABSTRACT

The present experiment was conducted to study the compatibility of different tomato (*Solanum lycopersicum* L.) varieties/hybrids grafted on wild brinjal (*Solanum torvum* Sw.) rootstock with an objective to study the effect of rootstock on growth, yield, graft success (%), crop duration and incidence of fusarium wilt in tomato. The study was carried out during rainy (*kharif)* season 2019 subsequently for 3 years and completed in winter (*rabi)* season 2022–23, which comprises 2 rootstocks, 3 scions in a factorial randomized block design (FRBD) with 9 treatments and 3 replications. The results were analyzed on the basis of 3 years pooled data with respect to growth and yield parameters. The grafting results showed significant increase in minimum number of days to 1st harvest (68.55), maximum fruit weight (81.04 g), number of fruit per plant (29.45), yield per plant (2.38 kg), yield per plot (85.68 kg) and yield per hectare (72.12 tonnes) over control. The graft combination of Phule Raja grafted on *Solanum torvum* showed maximum graft success (95.07%), less incidence of fusarium wilt (0.00%) with maximum crop duration of 235 days, i.e. an increase of 57 days compared to non-grafted. The benefit:cost (B:C) ratio analysis showed higher net monetary returns in grafted plants as compared to non-grafted plants. It is concluded that the grafting of Phule Raja on wild brinjal rootstock recommended for higher yield and less incidence of fusarium wilt.

Keywords: Fusarium wilt, Grafting, Rootstock, *Solanum torvum*, Tomato, Yield

Tomato (*Solanum lycopersicum* L.) is one of the most important popular vegetable crop worldwide. It is a good source of carotenoids, vitamin C and pro-vitamin A with a good antioxidant potential including lycopene, ascorbic acid, phenolics, flavonoids and vitamin E (Sen *et al.* 2018). Abiotic and biotic stresses are also significant restrictions in tomato production due to which farmers are not able to meet the demands of increasing population. For dealing with these stresses, chemical methods are also available. But chemicals may have detrimental effects not only on the consumer's health but also on the farmer himself (Sen *et al.* 2018). Hence, there is an urgent need to adopt grafting in which the union of two or more pieces of living plant tissues are forced to develop vascular connection and grow as a single plant (Edelstein *et al.* 2015). Grafting of commercial cultivars (scions) on selected tolerant rootstocks could be an advantageous method for producing tomato at suboptimal conditions (Krumbein 2013).

The main advantage of grafted plants is that they have a strong root system and are more efficient in the uptake of water and nutrients, which indirectly improves their yield (Savvas *et al.* 2010, Edelstein *et al.* 2017). Vegetable grafting has emerged as a potential and viable alternative to traditional breeding strategies for developing resistance to biotic and abiotic stresses (Schwarz *et al.* 2010, Malhotra 2017). It allows some genetic variants of specific species to be transferred and phenotype of scion are influenced by rootstock characteristics (Lee *et al.* 2010). The genetic potential of various rootstocks in vegetable crops has proven to be a better alternative to chemical sterilants for combating many soil borne diseases (Bahadur *et al.* 2015). There is limited information regarding plant growth parameters, yield and fruit quality of tomato when grafted on wild eggplant rootstock (Black *et al.* 2003). Therefore, it is important to check the response of tomato grafted on wild brinjal (*Solanum torvum* Sw.) rootstock for growth and yield. Hence, this experiment was conducted with an objective to study the compatibility of different tomato varieties/hybrids grafted on wild brinjal rootstocks for growth, yield and yield related traits with incidence of fusarium wilt.

MATERIALS AND METHODS

The present study was carried out at Mahatma Phule Krishi Vidyapeeth Rahuri, Rahuri, Maharashtra during rainy (*kharif)* season of 2019 subsequently for 3 years completed

[1]Mahatma Phule Krishi Vidyapeeth Rahuri, Rahuri, Maharashtra; [2]Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. *Corresponding author email: aniketchandan@gmail.com

in winter (*rabi)* season of 2022–23. The experiment was laid out in a factorial randomized block design (FRBD) with 9 treatments and 3 replications with plot size of 3.60 m × 3.30 m. The grafted tomato seedlings were transplanted at recommended spacing of 90 cm × 30 cm, which accommodate 40 plants in each plot, respectively.

The seeds of both rootstocks as well as scion were sown in protrays containing sterilized cocopeat to avoid the problem of uneven germination. The seeds of rootstock were sown 4 weeks before the scion seeds. The rootstock is essential to the scion in terms of growth and development, flowering and fruiting and fruit set and improved resistance to diseases (Yun *et al.* 2023). The wild species of brinjal took 25–30 days for germination than other rootstocks (Sharma *et al.* 2019). A 4–5 weeks-old seedlings of wild eggplant were used as rootstocks, whereas 3–4 weeks-old tomato seedlings as scions.

All the recommended packages of practices were adapted to carry out the experiment. The experiment was conducted by using two wild eggplant rootstocks (*Solanum torvum* and RHRB-06), 3 scion cultivars/hybrids (Phule Raja, Phule Kesari and NS 501) and 3 non-grafted tomato plants (Phule Raja, Phule Kesari and NS 501). The B:C ratio was calculated as per the cost concept method, viz. the ratio of gross returns and total cost (Latifah *et al.* 2018).

Preparation of grafts: The seeds of both rootstocks as well as scion were sown in portrays containing sterilized cocopeat to avoid the problem of uneven germination. The seeds of rootstock were sown 4 weeks before the scion seeds. Seedlings of various ages were raised carefully as per the requirement of treatments.

Grafting: The splice method of grafting was carried out when scion and rootstock seedling attained their respective height and girth, 1.6 mm silicon grafting clips were used for grafting. Grafted plants were placed in the healing chamber to ensure high grafting success. They were kept in healing chambers with a relative humidity 85–90% and 28–32°C temperature for 10 to 12 days to allow graft union. The pro trays were irrigated daily for 25 days. The grafted seedlings were transplanted in the main plot 20 days after grafting, when the grafts were at 3–4 true leaf stage (Zhen *et al.* 2022). Grafted plants were planted to find its effect on growth and yield. The observations were recorded for rootstock, scion and grafts combination with respect to graft success, incidence of fusarium wilt, crop duration, growth, yield and related parameters on wild brinjal rootstock (Davis 2008). The results were statistically analyzed on the basis of 3 year pooled data by method of Panse and Sukhatme (1985).

Per cent of disease incidence (Fusarium wilt %):

$$\text{Per cent disease incidence (PDI)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

RESULTS AND DISCUSSION

Plant height (cm): It was observed that significant maximum plant height was recorded in grafted Phule Raja at harvest. Phule Raja grafted on *Solanum torvum* treatment recorded highest plant height (124.94 cm) among all the graft combinations, whereas the lowest plant height (65.40 cm) was recorded in Phule Kesari grafted on rootstock RHRB-06 (Fig 1). It might be due to wild brinjal rootstock is having vigorous root system and often capable of absorbing more nutrients and water efficiently than self-rooted scion plants. However, at the present location no any inverted bottleneck symptoms were observed (Hossain *et al.* 2019, Singh *et al.* 2020).

Number of branches/plant: The maximum number of branches per plant (7.89) at harvest was recorded by graft combination Phule Raja grafted on *Solanum torvum* whereas the lowest branches per plant (4.45) were observed in interaction NS-501 grafted on wild brinjal rootstock RHRB-06. The number of branches per plant is an important yield contributing factor in tomatoes (Salehi *et al.* 2009). The rootstock's vigorous root system aided scion growth, resulting in greater number of branches in grafted plants Rathod (2017) and Surve (2019).

Days to 50% flowering: The Phule Raja grafted on *Solanum torvum* recorded lowest number of days (26.00) required for 50% flowering followed by Phule Raja grafted on RHRB-06 (29.44), NS-501 grafted on *solanum torvum* (30.55). Earliness is major attribute which is measured in terms of days taken to flowering and is preferred for commercial cultivation when high yield is coupled with earliness. The result of this study indicated an earlier flowering in grafted plants than non-grafted plants (Nkansanh *et al.* 2013, Kumar *et al.* 2017).

Days to first harvest: The Phule Raja grafted on *Solanum torvum* recorded the lowest number of days (68.55) for first harvest, whereas the highest number of days (74.67) was recorded in the graft combination of NS-501 on RHRB-06. However, the first harvesting was done on an average 73 days after transplanting (Kumar *et al.* 2016, Soe *et al.* 2018).

Average fruit weight (g): The Phule Raja grafted on *Solanum torvum* produced significantly higher fruit weight (81.04 g), whereas the lowest weight of fruit (66.54 g) was observed in graft combination Phule Kesari grafted on RHRB-06 (Table 1). However, other grafts also showed the significantly highest average fruit weight than self-rooted plants (Ahmed 2014, Kumar *et al.* 2017, Kumar *et al.* 2018, Yun *et al.* 2023).

Polar/equatorial diameter (cm): The Phule Raja grafted on *Solanum torvum* showed maximum polar diameter (6.98 cm) and equatorial diameter (6.41cm), whereas minimum polar diameter (4.91 cm) was recorded in Phule Kesari grafted on RHRB-06 (Fig 2). Whereas, minimum equatorial diameter (4.83 cm) was observed in graft combinations of Phule Kesari grafted on RHRB-06 and NS-501 grafted on RHRB-06 (Table 1). The tomato grafted on eggplant rootstock had maximum fruit diameter compared to non-grafted tomato plants (Kumar *et al.* 2017, Soe *et al.* 2018, Hossain *et al.* 2019)

Fruit shape: The graft combination Phule Raja grafted on *Solanum torvum* reported that due to vigorous rootstock grafted plants usually showed increased uptake of water and

Table 1 Mean performance of tomato grafted on wild brinjal rootstock (3 years pooled data)

Rootstock	Scion	Graft success (%)	Plant height (cm)	Days to 50% flowering	No. of branch-es/plant	Polar diameter (cm)	Equatorial diameter (cm)	Av. Fruit weight (g)	No. of fruit/ plant	Yield/ plant (kg)	Yield/ plot (kg)	Yield (t/ha)	Pericarp thickness (mm)	Days to Ist harvest	Crop duration (days)	Fusarium wilt (PDI %)	Fruit shape	B:C ratio
Solanum torvum	Phule Raja	95.07 (77.17)	124.94	26.00 (30.65)	7.89 (2.89)	6.98	6.41	81.04	29.45 (5.47)	2.38	85.68	72.12	7.67	68.55 (8.30)	235.00 (15.35)	0.00 (4.05)	Oval round	2.13
	Phule Kesari	86.07 (68.09)	72.17	31.58 (34.30)	5.54 (2.45)	5.89	5.13	69.07	25.64 (5.11)	1.77	63.74	53.65	6.41	74.33 (8.65)	196.33 (14.03)	3.32 (10.50)	Oval	1.58
	NS-501	88.41 (70.09)	83.17	30.55 (33.61)	5.45 (2.43)	6.69	6.18	79.09	24.44 (4.99)	1.92	69.27	58.31	5.87	72.55 (8.54)	205.00 (14.34)	0.00 (4.05)	Round	1.72
RHRB-06	Phule Raja	94.05 (75.88)	107.00	29.44 (32.83)	4.55 (2.24)	6.20	5.83	72.01	22.60 (5.30)	1.65	59.43	50.02	6.48	73.00 (8.57)	178.33 (13.37)	0.06 (4.05)	Oval round	1.48
	Phule Kesari	93.80 (75.63)	65.40	32.22 (34.57)	5.56 (2.44)	4.91	4.83	66.54	22.97 (4.51)	1.52	54.95	46.26	6.21	73.67 (8.61)	193.33 (13.92)	1.64 (7.35)	Oval	1.37
	NS-501	92.15 (73.74)	78.40	32.11 (34.50)	4.45 (2.21)	5.15	6.06	68.22	25.04 (5.11)	1.70	61.47	51.73	5.84	74.67 (8.66)	184.00 (13.58)	2.50 (9.09)	Round	1.53
C_1 (Without grafting)	Phule Raja	--	98.72	30.00 (33.21)	4.83 (2.69)	5.31	5.82	75.16	22.08 (5.19)	1.65	59.74	50.02	6.78	73.66 (9.08)	190.00 (14.28)	2.45 (9.01)	Round	1.95
C_2 (Without grafting)	Phule Kesari	--	82.13	27.67 (31.74)	4.63 (2.65)	6.75	5.08	68.90	22.15 (5.20)	1.52	54.94	46.26	9.61	74.33 (9.12)	181.33 (13.96)	4.16 (11.77)	Oval	1.79
C_3 (Without grafting)	NS-501	--	77.23	27.36 (31.54)	5.36 (2.81)	5.37	6.34	73.22	23.32 (5.32)	1.70	61.46	51.74	6.28	73.31 (9.06)	184.11 (14.06)	3.24 (10.37)	Round	1.98
CD (P=0.05)		1.47	2.97	2.64	0.33	0.15	0.18	2.15	0.143	0.13	3.60	4.34	0.59	0.101	2.70	0.049	--	--

*Figures in parentheses arcsine transformed values

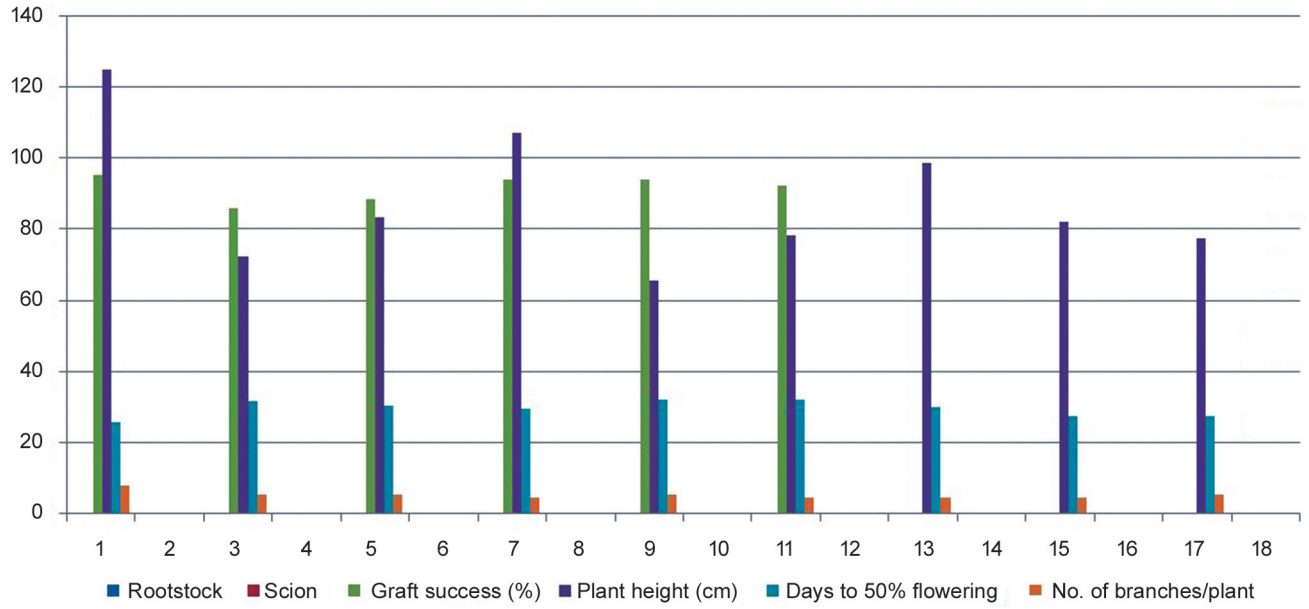

Fig 1 Effect of grafting of tomato on brinjal rootstock for growth characters.

minerals when compared to self-rooted plants but does not affect the shape of fruit as it was controlled by genotype of scion but not of the rootstock (Turhan *et al.* 2011, Negi 2016, Surve 2019).

Pericarp thickness (mm): The Phule Raja grafted on *Solanum torvum* recorded maximum pericarp thickness (7.67 mm), whereas NS-501 grafted on RHRB-06 recorded minimum pericarp thickness (5.84 mm). The pericarp thickness is a major contributing trait to determine fruit firmness (Chandanshive *et al.* 2019, Negi 2016, Kumar *et al.* 2018, Sharma 2019).

Number of fruit per plant: The Phule Raja grafted on *Solanum torvum* recorded maximum fruits per plant (29.45) [Ibrahim 2014], whereas minimum number of fruits per plant

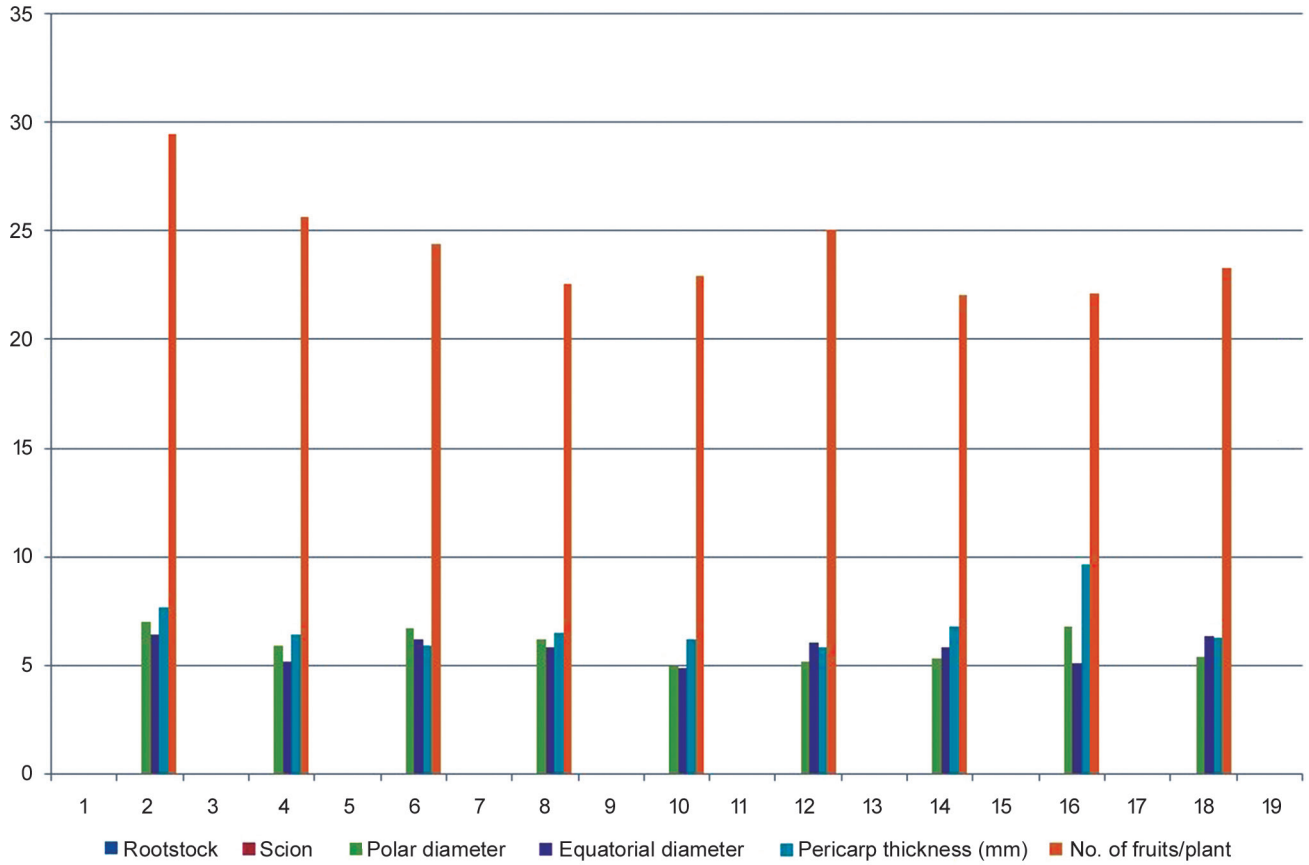

Fig 2 Effect of grafting of tomato on brinjal rootstock for growth characters.

(22.60) were recorded in the graft combination of Phule Raja grafted on RHRB-06. The total number of fruits per plant increased by grafting than non-grafted plants (Turhan *et al.* 2011, Kumar *et al.* 2018, Sharma *et al.* 2019).

Yield per plant (kg): The highest yield was recorded by Phule Raja grafted on *Solanum torvum* per plant (2.38 kg), whereas lowest yield per plant (1.52 kg) was observed in interaction effect of Phule Kesari grafted on rootstock RHRB-06 (Table 1). Tomato hybrid Phule Raja grafted on *Solanum torvum* reported significantly highest yield per plant (Ibrahim *et al.* 2014, Zhen *et al.* 2022).

Yield per plot (kg): The treatments showed significant difference for yield per plot in graft combination of Phule Raja grafted on *Solanum torvum* recorded maximum yield per plot (85.68 kg), whereas minimum yield per plot (54.95 kg) was observed in Phule Kesari grafted on RHRB-06 (Fig 3) (Kumar *et al.* 2017, Sabatino *et al.* 2020).

Yield per hectare (tonnes): The significant differences for yield per hectare (tonnes) were recorded in graft combination of Phule Raja grafted on *Solanum torvum* highest yield per hectare (72.12 tonnes/ha), whereas lowest yield per hectare (46.26 tonnes/ha) was recorded in Phule Kesari grafted on RHRB-06. Grafted tomato on wild eggplant rootstock had maximum yield per hectare than non-grafted plants due to wild brinjal rootstock (*Solanum torvum)* having good root systems ensuring more plant height and vigorous growth, which absorbs more water and nutrients. The scions selected for grafting study are popular varieties/hybrids of the locality. The higher yield in the grafting might be due to the vigorous root system in the wild rootstock that resulted in improved fruit quantity and quality. The grafting of tomato on *Solanum torvum* rootstocks was highly compatible and showed 95% grafting success (Kumar *et al.* 2018, Singh *et al.* 2020). This might be due to the deep root system in rootstocks, which can uptake excessive amounts of water and nutrients resulting in increased production of endogenous hormones than self-rooted plants (Soe *et al.* 2018, Sharma *et al.* 2019, Yun *et al.* 2023).

Graft success (%)

The results revealed that there was considerable variation between the grafts success range of 86.07–95.07%. The highest graft success (95.07%) was observed in Phule Raja grafted on *Solanum torvum,* which was at par with graft combination treatment Phule Raja grafted on RHRB-06 (94.05%) followed by graft combination Phule Kesari grafted on RHRB-06 (93.80%) followed by graft combination NS-501 grafted on RHRB-06 (92.15%). The minimum grafting success (86.07%) was noted in Phule Kesari grafted on *Solanum torvum*.

Significantly highest graft success was recorded in graft combination Phule Raja grafted on *Solanum torvum* which might be due to better graft union and favourable conditions provided in the healing chamber (Nkansanh *et al.* 2013, Kumar *et al.* 2018, Soe *et al.* 2018). The results revealed that the grafting of tomato on wild brinjal *Solanum torvum* rootstock was highly compatible.

Crop duration (days): The crop duration influences the viable resistance activities among the progeny, which helps to induce resistance against low and high temperature, influencing higher yield and growth character. Grafting is a viable proposition that revitalizes modern vegetable production in challenging environments. The graft

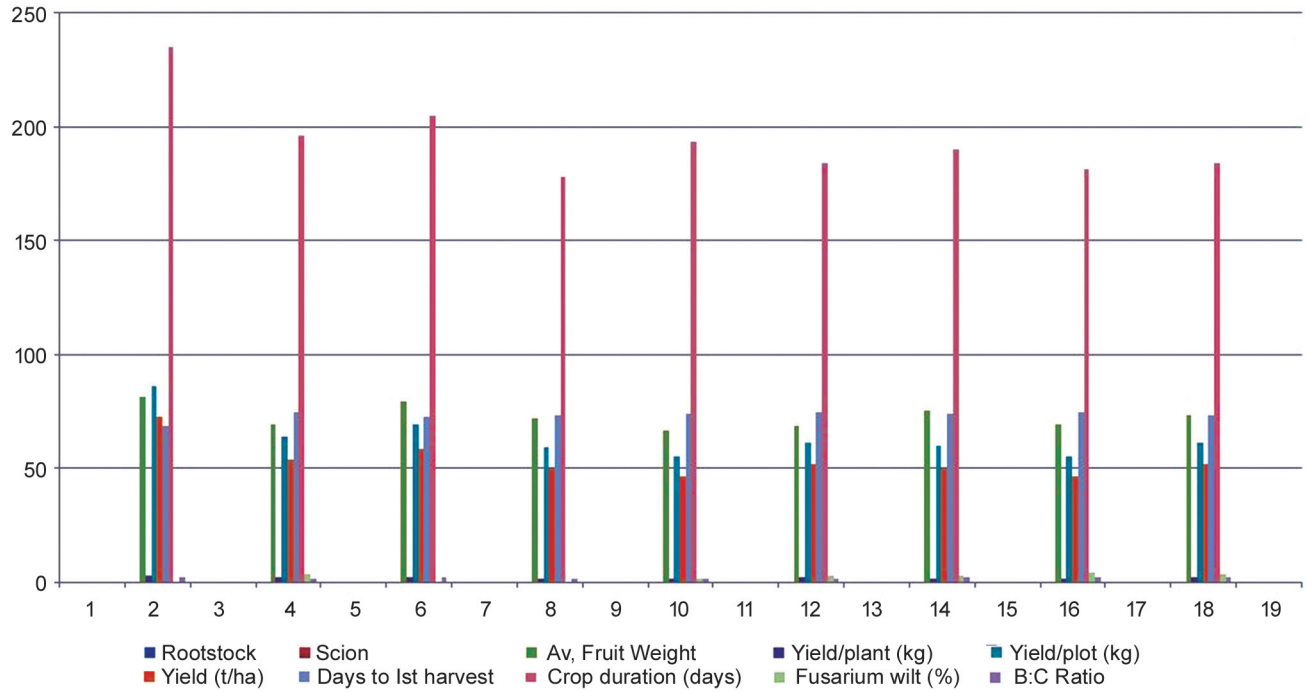

Fig 3 Effect of grafting of tomato on brinjal rootstock for yield, related traits, crop duration and per cent disease incidence (%).

combination, Phule Raja grafted on wild brinjal rootstock *solanum torvum* required maximum number of days for survival, i.e. (235.00 days) whereas, the lowest days (178.33) were required by the graft combination Phule Raja grafted on wild brinjal rootstock RHRB-06. The study revealed that the graft combination Phule Raja grafted on *Solanum torvum* extended the harvesting of the crop by 57 days as compared to control without grafting (Gousset *et al.* 2005, Rathod 2017, Kumar *et al.* 2017).

Benefit-cost ratio: The benefit-cost (B:C) ratio for grafted tomato was 2.13 in comparison to 1.37 for non-grafted tomato.

Per cent disease incidence (Fusarium wilt): The mean data pertaining to the effect of wild brinjal rootstock on tomato showed significant differences for incidence of fusarium wilt. In a graft combination Phule Raja grafted on *solanum torvum*, recorded 0.00% disease incidence (PDI). Among the different graft combinations, NS-501 grafted on RHRB-06 exhibited maximum percent disease incidence (PDI) of 2.50%, which was more susceptible to Fusarium wilt than other graft combinations. It indicated the resistance capacity of *Solanum torvum* rootstock against fusarium wilt disease. The *Solanum torvum* rootstock conferred resistance to *Fusarium oxysporum* f. sp. *Lycopersici* limit fusarium wilt disease in scions (Gousset *et al.* 2005, Kumar *et al.* 2017, Sen *et al.* 2018, Singh *et al.* 2020).

The present study revealed that grafting of Phule Raja tomato hybrid on wild brinjal rootstock *Solanum torvum* significantly increased the maximum crop duration, better growth, higher graft success, tomato fruit yield and more net monetary returns. Therefore, using this wild eggplant rootstock in tomato for exploiting the yield potential and better growth ability with higher graft compatibility would be a potential tool for growing tomatoes and to avoid fusarium wilt incidence.

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