

## Performance of grafted brinjal cv. *Surati Ravaiya* onto *Solanum torvum* Swartz rootstock under excess moisture conditions of south Gujarat, India

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**Abstract:** *Surati Ravaiya* (SR) cultivars of brinjal have attained a pride place in south Gujarat cuisine because of their delicacy and taste but unstable and low production of these cultivars particularly during rainy season is a matter of great concern to the growers as well as lovers of brinjal in the region. High annual rainfall of more than 2000 mm mostly concentrated during monsoon in the region generally limits the production of SR brinjal by affecting plant stand and other important horticultural traits. Thus, a maiden attempt was accomplished during Kharif, 2014 and 2015 following cleft grafting of two cultivars of *Surati Ravaiya* (Pink and Purple) onto the rootstock of *Solanum torvum* having strong root system and tolerance to excess moisture stress. Interestingly, higher and significant plant survival of more than 80 per cent was achieved in both the cultivars of brinjal during individual as well in pooled analysis. Although, the traits like days to first flowering, picking, fruit length, diameter and average fruit weight remained unaffected by grafting in both the years of experimentation as well as in pooled analysis but other horticultural traits showed significant variations between grafts and non-grafts of *Surati Ravaiya*. Grafting regulated heterostyly polymorphism significantly in both types of brinjal positively exhibiting 38.04 and 43.78 percentage of long styled flowers in grafted plants of SR pink and purple, respectively with higher fruit set of 69.89 and 72.37 per cent compared to their respective non-grafts. Fruit set (%), number of fruits per plant and total number of pickings per season were observed as significant contributors to the enhanced production of grafted plants. SR pink and purple also registered low fruit infestation of 23.21 and 17.52 per cent with shoot and fruit borer compared to 34.27 and 30.60 per cent infestation in their respective counterparts. Consequently, grafted SR pink and purple outyielded their non-grafts analogues significantly with production level of 25.96 and 45.44 tonnes per ha vis-a-vis 18.56 and 32.54 tonnes per ha in pooled analysis, thereby suggesting a great improvement in survival and performance under excess moisture regime as a result of grafting onto *S. torvum* rootstock.

**Key words:** Grafting, *Solanum melongena*, *S. torvum*, excess moisture stress, horticultural traits.

### INTRODUCTION

Brinjal (*Solanum melongena* L.), also known as *aubergine* and *eggplant*, is one of the widely distributed and cultivated species of Solanaceae family. It is believed to have originated in Indo-Burma region, so varieties of brinjal display a wide range of fruit shapes and colours, ranging from oval or egg-shaped to long club-shaped and from white, yellow, green through degrees of purple

pigmentation to almost black in India. This might be probable reason to have variable choice of consumer for this crop in different regions of the country. Brinjal is an important vegetable crop of Gujarat state covering an area of 0.77 lakh ha with annual production of 13.41 lakh MT [3]. *Surati Ravaiya* (SR) cultivars of brinjal have attained a pride place in south Gujarat cuisine because of their delicacy and taste but unstable and low production

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of these cultivars particularly during rainy season is a matter of great concern to the growers as well as lovers of brinjal in the region. *Surati Ravaiya* is found to be very sensitive to excess moisture, which influences various morphological and physiological aspects of plant growth and development, thereby affecting the plant stand and ultimately yield under such situations. In south Gujarat, high rainfall during monsoon accompanied with high humidity limits the production of brinjal particularly of *Surati Ravaiya* (SR) type and leads to seasonality of crop production.

The dependency of flowering and fruiting in brinjal on various environmental factors can be understood by the fact that high humidity, temperature and heavy rains within 5 days of anthesis and insufficient light are detrimental to fruit set in brinjal [38, 39]. Genotype and environmental factors influence morphology, especially the stylar length which determines the effectiveness of fruit setting. The high relative humidity (85-90%) affect reproductive processes like anthesis, dehiscence, pollination and fertilization in vegetable plants [11]. Tendency to form different pistil flowers in brinjal is a characteristic of a particular variety [20, 21] but it also depends on other factors such as plant age [23] as well as environmental conditions [1, 38].

Therefore, overcoming excess moisture condition will have a positive impact on brinjal production. Several efforts have been made to improve excess water tolerance in brinjal but with limited commercial success. A special method of adapting plants to counteract environmental stresses is by grafting elite, commercial cultivars onto selected vigorous rootstocks [22]. Grafting is now-a-days regarded as a rapid alternative tool to the relatively slow breeding methodology aimed at increasing environmental stress tolerance of fruit vegetables [12]. Cultivation of vegetable grafts permits not only pest resistance and high yields but also ameliorates crop losses caused by adverse environmental conditions. It has also been observed that grafting brinjal on wild species affects various physiological processes of a plant which in turn provide better opportunity to survive well and perform better in adverse climatic conditions. It is a

widespread technique used especially in cucurbitaceous and solanaceous vegetables in protected cultivation [10, 26, 28].

*Solanum torvum* Swartz, a native of western tropics and India, exhibits resistance to a wide range of soil pathogens such as *Verticillium dahliae*, *Ralstonia solanacearum*, *Fusarium oxysporum* and root-knot-nematodes [4, 5, 14] as well as being tolerant to abiotic stresses [35] and is frequently used for eggplant grafting [5, 8, 19, 37].

Looking into the importance of this crop and scope to ensure stability in production during rainy season of this region, the present investigation was planned to study the performance of *Surati Ravaiya* type brinjal upon grafting onto the rootstock of *Solanum torvum* Swartz.

## MATERIALS AND METHODS

The study was undertaken during *Kharif*, 2014 and 2015 at Regional Horticultural Research Station, Navsari Agricultural University, Navsari (Gujarat), which is located at a latitude of 20°57'N and longitude of 72°54'E with an altitude of 12 m amsl and characterized by high humid climate with high annual rainfall of more than 2000 mm mostly concentrated during monsoon.

*Solanum torvum* Swartz was used as rootstock for scions of *Surati Ravaiya* pink and purple cultivar. *Solanum torvum* is a highly vigorous relative of eggplant but its poor, irregular and erratic germination due to long dormancy in seeds [13, 14] limits practicability as rootstock. Therefore, seeds of rootstock were subjected to a protocol for enhancing seed germination [32] and sown 30 days prior to cultivars in plug trays filled with cocopeat to get compatible size of scion and stock. Grafted plantlets in both the cultivars were produced by cleft grafting under naturally ventilated polyhouse and further put under high humid conditions created under polyethylene tunnel. The whole experiment was arranged in 4 treatments consisting of grafted plants of both the cultivars and their non-grafted counterparts and assigned a plot size of 5.4 x 3.6 m per treatment with a spacing of 90 x 60 cm and 5 replicates in RBD representing 36 plants in each treatment. The recommended dose of fertilizers at

the rate of 100 kg N: 50 kg P: 50 kg K was applied to the crop, of which whole dose of P, K and ½ of N was given at time of planting. The remaining N was further split into 2 parts and applied at 30 and 60 days of planting.

The data on various parameters *viz.*, plant survival (%), days to first flowering, picking, heterostyly polymorphism, fruit set (%), fruit length (cm), fruit diameter (cm), plant height (cm), stem diameter (cm), number of fruits per plant, total number of pickings, average fruit weight (g), marketable yield and fruit infestation with shoot and fruit borer were recorded and the mean values were subjected to statistical analysis as per [29].

## RESULTS

### Influence on plant survival and vigour

The results of present study indicated a significant increase in survival percentage of Surati Ravaiya pink and purple over the years up to the level of 96.94 and 97.50, respectively having 21.60 and 13.22 percent more plant stand compared to their non-grafted counterparts. The mean plant height among different treatments was observed higher in grafted SR pink as well in grafted SR purple. However, grafted plants in both the types of brinjal didn't express significant increase in all the years of study as well as in pooled analysis except grafted SR pink which was significantly taller than non-grafted SR pink. Both the cultivars responded differently over the years to stem diameter upon grafting. Although, grafted plants in these cultivars presented higher stem diameter, but significantly higher stem diameter of 1.82 cm was shown by only grafted SR purple compared to normal plants of SR pink (Table 1).

### Influence on reproductive parameters

Grafting of SR pink onto the rootstock of *Solanum torvum* didn't make any significant effect on days to first flowering as well as picking during all the years of experimentation and pooled analysis except grafted plants of SR pink expressed significant advantage (37.80 days) over non-grafted plants (42.00 days) for early flowering. However, grafted

plants of SR purple showed significant differences for days to first flowering and had earliness in flowering by more than 5 days compared to its non-grafted counterpart. Earliness of flowering in grafted plants didn't corresponded to early picking in 2014 and 2015, but pooled analysis expressed early pickings in grafted plants by more than 5 days (Table 2).

Grafting regulated heterostyly polymorphism positively and significantly in both the cultivars of brinjal. The overall percentage of long styled flowers was observed to be higher in grafted SR pink to the level of 38.04, while much higher percentage of such flowers (43.78) was noticed in grafted SR purple (Table 2). Consequently, the presence of higher per cent of medium styled flowers in non-grafts was observed, which was at par with grafts of SR pink in 2014 and 2015. But, results of pooled analysis showed significantly higher number of medium styled flowers (54.04%) in non-grafts compared to grafts (51.16%) in SR pink. Likewise, normal plants of SR purple expressed significantly higher percentage of such flowers in all the year of experimentation and pooled analysis. Such trend of significant increase in undesirable styly level *i.e.* pseudo short and true short styled was observed in normal plants of both the cultivars in all the years of experimentation (Table 3). Therefore, positive effect of grafting on heterostyly polymorphism was corresponded to fruit set percentage in both the cultivars under study. Grafted plants of SR pink and purple showed an overall fruit set of 69.89 per cent and 72.37 per cent, respectively compared to their respective non-grafts (62.46 and 64.31%) [Table 4].

### Influence on yield components and yield

It is evident from Tables 4 and 5 that there existed significant differences among grafts and non-grafts for all yield components and yield except average fruit weight, which showed significant differences only in pooled analysis but with at par performance in grafts versus non-grafts of both cultivars. It is evident from *per se* performance of all the treatments that grafted plants recorded higher average values for fruit length and diameter in both the cultivars except in SR purple. However, variations between grafted versus non-grafted plants were observed to

be non-significant. Grafted plants of SR pink produced significantly higher number of fruits with average value of 19.01 in comparison to non-grafts (13.62). The grafted plants of SR purple also showed similar trend producing 35.31 fruits compared to 25.90 fruits in non-grafts. Grafting also exerted significant effect on crop duration resulting into higher number of pickings. Grafted plants of SR pink had overall 32 pickings compared to non-grafted ones (24.20), while grafts of SR purple showed even more number of pickings (36.20) in comparison to 27.20 pickings in normal plants of this cultivar. Although, grafting both the cultivars on wild rootstock made no significant effect on average fruit weight in first and second year of experimentation, but presence of significant differences among treatments in pooled analysis didn't make any significant change in fruit weight between grafts and non-grafts of each cultivar. Marketable yield per plant and hectare differed significantly over the years between grafted and non-grafted plants of both the cultivars. Averaging over the years, marketable yield was 1403.91 g per plant and 25.96 tonnes per ha in grafted plants of SR pink compared to 1003.49 g and 18.56 in non-grafted plants. Whereas, grafted plants of SR purple produced 2482.68 g yield per plant and 45.44 tonnes per ha in comparison to 1762.37 g and 32.54 tonnes in non-grafts (Table 6).

#### **Influence on incidence of brinjal shoot and fruit borer**

The tolerance of grafted plants was indicated by significantly less fruit infestation by brinjal shoot and fruit borer. The overall fruit infestation of 23.21 percent was observed in grafted plants of SR pink compared to 34.27 per cent, while grafted SR purple recorded 17.52 per cent infestation in contrast to 30.63 in normal plants of the cultivar (Table 6).

#### **DISCUSSION**

The percentage of plant survival in grafted plants of both the cultivars in high intense rains during monsoon at Navsari expresses the suitability of *Solanum torvum* as rootstock to perform well under such conditions. A high moisture situation in the soil causes oxygen starvation and is often associated

with so many soil borne problems like wilts, root knot nematodes etc. The vigorous root system of *Solanum torvum* and resistance to soil diseases or pests, tolerance to abiotic stress, selective absorption of available soil nutrients confer a high degree of vigour to the scion [9, 22, 33]. [16] have also suggested that improved nutrient uptake in grafted seedlings increases photosynthesis under weak sunlight conditions and such conditions generally prevails during rainy season under south Gujarat conditions.

Grafting increased plant height but not to a significant level except in one cultivar. Although, grafting had positive impact on plant vigour indicators like plant height and stem diameter, but was specific to Surati Ravaiya pink in case of plant height and Surati Ravaiya purple for stem diameter. Thus, it reveals that vigour of rootstock is important in conferring scion vigour [6, 18]. [40] have also suggested that vigorous root system of rootstock is often capable of absorbing nutrients more efficiently than scion roots. [24, 31] have also indicated that the effect of grafting on plant height differed regarding the combination of rootstock/eggplants varieties used.

Both the cultivars responded differently to days to first flowering and picking upon grafting onto *Solanum torvum* rootstock. Surati Ravaiya pink had very little impact on these parameters more precisely on days to first picking, whereas Surati Ravaiya purple responded positively for earliness upon grafting. Thus, such a variable response of these cultivars for earliness suggests the specificity of rootstock to cultivars influencing various physiological processes to enhance the reproductive ability of the crop [5].

It has been well established that heterostyly polymorphism is an an important phenomenon deciding extent of fruit set in brinjal [15, 21, 30]. among various stylar levels in brinjal, long styled flowers shows high pollination as well as fruit set efficiency followed by medium styled flowers and so on [7, 36]. The presence of higher percentage of long styled flowers followed by medium styled flowers in grafted plants of both the cultivars reflects the ability of rootstock to bring changes in

heterostyly. It is also supported by the findings of earlier workers [27, 41] who stated that initiation of morphogenic changes in scions by grafting induce changes on leaves, flowers and fruits due to genetic changes highlighting its potential in genetic improvement .

The major yield contributing traits observed in grafted plants of both the cultivars were production of higher number of fruits per plant and enhancement of cropping period to take more number of harvests from these plants compared to non-grafted plants. This was also corroborated with the findings of [25, 34]. Hormonal signalling in rootstock-scion interactions might have a greater

impact on flowering and fruit setting [2]. This increase in yield can also be related to higher vigorous growth of grafted plants and such response has also been observed by [24] while studying the grafting effect of inter-specific tomato rootstock on tomato. In addition to observed yield contributing traits in the study, less fruit infestation in grafted plants of brinjal by brinjal shoot and fruit borer also confer to contribute towards yielding ability of grafted plants. Other contributing traits like fruit length and diameter remained unaffected by grafting, similar kind of response was also observed in eggplant cv. Epic upon grafting onto the rootstocks of *Solanum lycopersicum* x *S. habrochaites* and *S. aethiopicum* by [17].

**Table 1**  
Response of *Surati ravaiya* type brinjal to plant survival and vigour upon grafting onto *Solanum torvum*

Treatment	Plant survival (%)			Pl. height (cm)			Stem dia. (cm)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>Non-grafted SR pink</b>	80.56 (63.87)	78.89 (62.72)	79.72 (63.30)	71.67	77.71	74.69	1.76	1.79	1.77
<b>Grafted SR pink</b>	97.22 (81.39)	96.67 (79.56)	96.94 (80.47)	78.80	84.12	81.46	1.86	1.89	1.88
<b>Non-grafted SR purple</b>	86.67 (68.74)	85.56 (67.90)	86.11 (68.32)	78.95	83.15	81.05	1.62	1.65	1.63
<b>Grafted SR purple</b>	97.78 (83.21)	97.22 (81.39)	97.50 (82.30)	83.79	87.64	85.71	1.80	1.83	1.82
S.E.m ±	1.75	1.49	1.09	2.70	2.72	1.81	0.05	0.06	0.04
C.D. <sub>(0.05)</sub>	5.39	4.59	3.15	NS	NS	5.27	0.17	NS	0.11
C.V. (%)	5.26	4.57	4.93	7.72	7.31	7.51	6.86	7.36	7.12

(Values in parenthesis are arc sign transformed)

**Table 2**  
Response of *Surati ravaiya* type brinjal to reproductive parameters upon grafting onto *Solanum torvum*

Treatment	Days to first flowering			Days to first picking			Long styled (%)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>Non-grafted SR pink</b>	40.60	43.40	42.00	61.80	65.60	63.70	26.68	27.33	27.01
<b>Grafted SR pink</b>	36.40	39.20	37.80	57.80	61.60	59.70	37.72	38.37	38.04
<b>Non-grafted SR purple</b>	37.40	40.40	38.90	57.00	61.00	59.00	28.75	29.60	29.18
<b>Grafted SR purple</b>	32.20	35.20	33.70	51.40	55.40	53.40	43.35	44.20	43.78
S.E.m ±	1.50	1.56	1.02	2.11	2.19	1.43	1.42	1.50	0.97
C.D. <sub>(0.05)</sub>	4.62	4.81	2.96	6.50	6.74	4.16	4.38	4.63	2.83
C.V. (%)	9.14	8.83	8.98	8.27	8.03	8.15	9.31	9.62	9.47

**Table 3**  
**Response of Surati ravaiya type brinjal to reproductive parameters upon grafting onto**  
*Solanum torvum*

Treatment	Medium styled (%)			Pseudo Short styled (%)			True short styled (%)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>Non-grafted SR pink</b>	54.60	53.48	54.04	10.47	10.35	10.41	8.25	8.83	8.54
<b>Grafted SR pink</b>	51.72	50.60	51.16	4.84	4.73	4.79	5.72	6.30	6.01
<b>Non-grafted SR purple</b>	54.06	52.74	53.40	10.20	10.29	10.24	6.99	7.37	7.18
<b>Grafted SR purple</b>	46.86	45.54	46.20	6.40	6.48	6.44	3.39	3.78	3.59
S.E.m $\pm$	1.34	1.41	0.92	0.41	0.49	0.30	0.48	0.56	0.35
C.D. <sub>(0.05)</sub>	4.14	4.36	2.67	1.26	1.51	0.87	1.49	1.74	1.02
C.V. (%)	5.80	6.25	6.02	11.49	13.72	12.66	17.72	19.19	18.54

**Table 4**  
**Response of Surati ravaiya type brinjal to fruit set and yield contributing traits upon grafting onto**  
*Solanum torvum*

Treatment	Fruit set (%)			Fruit length (cm)			Fruit dia. (cm)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>Non-grafted SR pink</b>	63.25 (7.95)	61.66 (7.85)	62.46 (7.90)	8.31	8.05	8.18	7.78	7.56	7.67
<b>Grafted SR pink</b>	70.78 (8.41)	69.01 (8.30)	69.89 (8.36)	8.38	8.14	8.26	7.82	7.62	7.72
<b>Non-grafted SR purple</b>	64.96 (8.05)	63.66 (7.97)	64.31 (8.01)	6.91	6.73	6.82	6.15	6.00	6.08
<b>Grafted SR purple</b>	73.11 (8.55)	71.64 (8.46)	72.37 (8.50)	6.83	6.71	6.77	6.17	6.01	6.09
S.E.m $\pm$	0.15	0.15	0.10	0.26	0.26	0.17	0.25	0.24	0.16
C.D. <sub>(0.05)</sub>	0.46	0.46	0.29	0.79	0.81	0.50	0.79	0.73	0.48
C.V. (%)	4.06	4.05	4.06	7.53	7.96	7.75	8.16	7.85	8.01

(Values in parenthesis are square root transformed)

**Table 5**  
**Response of Surati ravaiya type brinjal to yield contributing traits upon grafting onto**  
*Solanum torvum*

Treatment	No. of fruits per plant			Total no. of pickings			Av. fruit wt. (g)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>Non-grafted SR pink</b>	14.28	12.96	13.62	24.60	23.80	24.20	73.28	73.43	73.35
<b>Grafted SR pink</b>	19.60	18.42	19.01	32.40	31.60	32.00	74.06	73.06	73.56
<b>Non-grafted SR purple</b>	26.76	25.04	25.90	27.60	26.80	27.20	68.13	69.02	68.57
<b>Grafted SR purple</b>	36.26	34.36	35.31	36.60	35.80	36.20	69.15	69.83	69.49
S.E.m $\pm$	1.71	1.70	1.14	1.17	1.29	0.82	1.79	1.89	1.24
C.D. <sub>(0.05)</sub>	5.26	5.25	3.30	3.59	3.98	2.38	NS	NS	3.59
C.V. (%)	15.75	16.79	16.25	8.61	9.79	9.20	5.64	5.92	5.78

**Table 6**  
**Response of Surati ravaiya type brinjal to fruit infestation and marketable yield upon grafting onto *Solanum torvum***

Treatment	Fruit infestation (%)			Marketable Yield per plant (g)			Marketable Yield per ha (t)		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
<b>Non-grafted SR pink</b>	32.66 (5.71)	35.88 (5.99)	34.27 (5.85)	1054.76	952.22	1003.49	19.51	17.60	18.56
<b>Grafted SR pink</b>	23.60 (4.84)	22.82 (4.78)	23.21 (4.81)	1460.34	1347.47	1403.91	26.98	24.93	25.96
<b>Non-grafted SR purple</b>	30.83 (5.55)	30.37 (5.51)	30.60 (5.53)	1809.86	1714.88	1762.37	33.42	31.67	32.54
<b>Grafted SR purple</b>	16.06 (4.01)	18.97 (4.36)	17.52 (4.18)	2547.33	2418.03	2482.68	46.41	44.46	45.44
S.E.m ±	0.13	0.06	0.08	103.91	109.35	71.15	1.84	1.93	1.26
C.D. (0.05)	0.40	0.19	0.22	320.21	336.98	206.49	5.66	5.94	3.65
C.V. (%)	5.82	2.73	4.51	13.52	15.21	14.34	13.01	14.53	13.75

(Values in parenthesis are square root transformed)

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