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Graft compatibility between four Brinjal varieties (*Solanum melongena* L.) grafted on rootstock *Solanum torvum* Sw. on different dates

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Abstract
This study was conducted at All India Co-ordinated Project on vegetable crop, Department of Horticulture, MPKV, Rahuri during summer season 2019. The aim of this work was to see the graft compatibility between brinjal varieties and hybrid on rootstock *Solanum torvum* and to found the suitable time of grafting during summer season. Two open pollinated varieties (Manjari- Gota and Phule Arjun) and two F_1 hybrid (Krishna and Phule Arjun) were used as scion on rootstock *Solanum torvum* and which was grafted on four different dates (1st February, 15th February, 1st March and 15th March). The rootstock seed sown for first February grafting dates recoded minimum days to germination (24.67) and it also reported highest germination (63.00%). However, rootstock seed sown for the fifteen March grafting date reported minimum days taken to reach grafting stage (62.00). Among the varieties Phule Arjun was noted the minimum days for germination (5.33) and days taken to reach grafting stage (27.67) when sowed for fifteen March grafting date. The highest (85.67%) germination percentage was noted in Phule Arjun when sown for grafting date fifteen March. Phule Arjun took the minimum days for graft healing (3.93) and graft sprouting (9.27) when grafted on first February. While, the highest graft success (92.22%) was reported in Phule Arjun grafted on fifteen February.

Keywords: Rootstocks, scion, Solanum torvum, compatibility, brinjal

Introduction
Brinjal (*Solanum melongena* L.) belongs to the family Solanaceae. Brinjal is also known as eggplant and aubergine. It is one of the important vegetable of tropical countries, particularly India, Bangladesh, Pakistan, China, Japan, Southeast Asia, Indonesia, Thailand and Malaysia and Philippines. It is commonly grown in several countries of Africa, France, Italy, Spain, Bulgaria and U.S.A. (Swarup, 2016) [21].

In addition to India, other major brinjal producing countries are China, Turkey, Japan, Egypt, Italy, Indonesia, Iraq, Syria, Spain and Philippines. In India it grown on area of 7.36 million ha with production of 12777 MT to the global production and ranks second next to China. Brinjal covers 8.14% of total vegetable area and produces 9% of total vegetable production in India. In India it is well distributed in Orissa, Bihar, Karnataka, West Bengal, Andra Pradesh, Maharashtra and Uttar Pradesh. West Bengal rank first in production having production of 3027.75 MT and accounting 23.69% shares in production. Whereas, Maharashtra having 429.91 MT production and accounting 3.36% shares in production. (Anon, 2020) [1].

Since past decades, the primary objective of agriculture has been to increase crop yield and productivity in order to fulfill food needs of the increasing world population. As a consequence, the intensive cropping systems with limited crop rotations, adopted especially for vegetable crops both in open field and under protected cultivation, have determined a buildup of detrimental factors (biotic or abiotic) that can negatively influence yield and quality. These adverse factors caused an increase in the use of input factors (water, chemical fertilizer, pesticides, etc.) that have led to environmental and health concerns. Grafting represents a viable alternative to solve the vegetable cultivation issues related to biotic and abiotic stresses (Lee and Oda, 2003; Davis *et al.*, 2008; Savvas *et al.*, 2010; Schwarz *et al.*, 2010) [11, 3, 18, 19].

Solanum torvum is an evergreen, multi-branched shrub or small tree that can grow to 16 feet high. It is mostly used rootstock for grafting for eggplant. But its use has been limited due to lack of rapid and homogeneous synchronized seed germination.

Considering importance of *Solanum torvum* as a rootstock for eggplant grafting the present work had as objective to evaluate compatibility between brinjal variety and *Solanum torvum* and suitable time for grafting.

Material and Methods

Present investigation was conducted at the farm of All India Co-ordinated Research Project on vegetable crops, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri. The experiment conducted in summer 2019. Seeds of rootstock sowed one month before the scion seeds. To overcome the problem of uneven germination, the rootstock seeds sown in 102 cells pro-trays containing sterilized coco-peat. The rootstock seedling took 60 to 65 days and scion seedlings were ready for grafting in 25-30 days after sowing. Four cultivated varieties i.e. Manjari Gota, Phule Harit, Krishna (F_1) and Phule Arjun (F_1) were grafted onto *Solanum torvum* rootstock by using cleft grafting method. This is the most commonly method used for solanaceous crops. With a razor blade, rootstocks were cut below the cotyledon and a longitudinal cut was made 1.5 cm. Scions were pruned to 1-3 leaves and the lower stem was cut into a tapered wedge to place inside the depth cut of the rootstock. After insertion, graft unions were joined with silicon clip to improve stability, reduce chance of infection and ensure vascular contact. For grafting used 17 to 19 mm stem girth seedlings of both scion and rootstocks. Grafting were carried out in the morning and evening hours in mist chambers made up with transparent polythene of 100 micron thickness. After grafting seedlings were immediately placed in grafting chamber for nine days. Grafting chamber were covered with black polythene for two days and seedlings were placed in dark. This process was carried out to ensure high grafting success. Maintain relative humidity of 85-95% for five days to allow the graft union to heal, then light was gradually increased and relative humidity was decreased. Then the seedlings were transferred to the normal nursery where healing process was allowed for one weeks before they were transplanted. Before the transplanting seedlings were grown under natural light conditions for two to three days. During the whole crop cycle, air temperature and relative humidity inside the graft chamber was recorded daily presented in table 1. Ten seedling were selected and tagged from each replication and observation were recorded given below.

A) Rootstock and scion parameters

1. Days taken for germination

The observation was recorded at every day by visual observation and average days taken for germination were expressed.

2. Days taken to reach grafting stage

Observation was recorded based on seedling height, number of leaves and days required to reach correct stage of grafting.

3. Germination percentage

Hundred seed were sown in pro-trays containing coco-peat. The observation was recorded by counting emergence of seedling by visual observation and it is expressed in percentage (%).

$$\text{Germination (\%)} = \frac{n}{N} \times 100$$

Where, n = number of seeds germinated, N: total number of seed sown in each experiment.

B) Observation of grafted plant

1. Days taken for graft healing

The observation was recorded after three days of grafting by removing the grafting clips and average days were noted.

2. Days taken to sprouting

The observation was recorded at everyday by visual observation and the number of sprouted seedlings were counted and average days were expressed.

3. Days taken to attain transplanting

The observation was recorded by counting day required for transplanting from grafting and mean days required for days taken to attain transplanting was worked out.

4. Graft success

Graft success was recorded at five, ten and fifteen days after grafting and on the day transplanting, seven, fourteen and thirty day after transplanting based on wilting of the grafts at healing region. It is calculated by number of plants died to the total number plants multiplied by hundred and it is expressed in percentage (%).

Statistical analysis

The experiment was conducted in two Factorial Randomized Block Design (FRBD). 5×4 FRBD consisting of five treatments (one rootstocks R0: *Solanum torvum* and four varieties V_1: Manjari Gota, V_2: Phule Harit, V_3: Krishna and V_4: Phule Arjun) and four sowing dates (rootstock seed was sown 60 days before the grafting dates and scion seed sown 1 month before grafting date). 4×4 FRBD consists of four grafting dates (D_1: 1st February, D_2: 15th February, D_3: 1st March and D_4: 15th March) and four scion varieties (V_1: Manjari Gota, V_2: Phule Harit, V_3: Krishna and V_4: Phule Arjun) which were replicated tree times.The data obtained during experiment were analyzed as per the statistical methods prescribed by Panse and Sukhatme (1985) to obtain valid conclusion.

Results and Discussion

Rootstock and scion parameters

The mean data pertaining on effect of different dates of sowing on days taken to germination, germination percentage and days taken to reach grafting stage in brinjal varieties and rootstock depicted in Table 2. Significantly lowest days taken for germination (10.20), days taken to reach grafting stage (35.80) and highest germination percentage (74.33%) was recorded in seed sown for fifteen March (D_4) grafting date. Whereas, highest days for germination (12.73) and days taken to reach grafting stage (40.93) was noted in seed sown for fifteen February (D_2) grafting date. The lowest germination percentage (69.67%) was noted in seed sown for first February (D_1) grafting date. Among the variety V_4: Phule Arjun noted minimum days for germination (6.33), days taken to reach grafting stage (29.25) and highest germination (83.92%). However, highest days taken for germination (9.00) and lowest germination percentage (65.75%) was noted in variety Phule Harit. However, variety Manjari Gota took highest days taken to reach grafting stage (33.33). The interaction effect of date and rootstock recorded significantly

lowest days for germination (24.67) and highest germination percentage (63.00%) was recoded in *Solanum torvum* sown for first February grafting date (D_1R_0) and lowest days taken to reach grafting stage (62.00) was reported when *Solanum torvum* seed sown for fifteen March grafting date (D_4R_0). While, highest days taken to germination (29.67) and lowest germination percentage (52.00%) was reported when *Solanum torvum* seed was sown for fifteen February grafting date (D_2R_0) and the highest days taken to reach grafting stage (72.33) was reported in *Solanum torvum* seed sown for first February grafting date (D_1R_0). The interaction effect of date and variety showed significantly lowest days taken for germination (5.33), days taken to reach grafting stage (27.67) and highest germination percentage (85.67%) was noted in variety Phule Arjun sown for date fifteen March (D_4V_4). While, the highest days taken for germination (11.00) and lowest germination percentage (63.00) was reported in variety Phule Harit sown for first February grafting date (D_1V_2) and variety Manjari Gota sown for first February grafting date (D_1V_1) took highest days for reach grafting stage (36.00).

Seed germination is an important criteria in crop production. Brinjal is a warm-season crop. The optimum temperature for brinjal seed germination ranges from 22-30°C. In the present investigation rootstocks and scion seed sowed at different dates and observed that temperature was critical factor which affect the germination. Temperature played an important role in germination of seed. At very high temperature and low temperature the rate of germination was strictly prohibited and caused cell and embryos death. Seedling establishment rate was also reduced (Rajatha *et al.*, 2018) [15].

Solanum torvum took maximum days for germination this may be due to species character. It is a wild species which may be having hard seed coat and prolonged seed dormancy that may result in erratic, poor and late germination. The rootstock *Solanum torvum* is wild in nature and seed germination is an important concern when using materials of wild species or exotic species as rootstock. Seeds of a number of wild Solanum species are known to emerge slowly and about 30 days can be needed to attain germination with percentage rates that vary between 15% and 50% in *S. insanum* L. *S. torvum S. integrifolium*, *S. surattense*, *S. khasianum*, *S. sanitwongsei* and in hybrids of *S. melongena* x *S. integrifolium* (Ibrahim *et al.*, 2001). This results is in line with Gisbert *et al.*, (2011) [4] and Rathod (2017) [16]. In addition to Kumar *et al.*, (2016) [9] also revealed that *Solanum torvum* Swartz is a highly vigorous relative of eggplant but its poor, irregular and erratic germination due to long dormancy in seeds limits practicability as rootstock. Fasted germination was showed in variety Phule Arjun obviously resulted in minimum number of days to reach the grafting stage.

Grafted plant Parameters

The mean data pertaining on effect of different dates of grafting on days taken to graft healing (DTGH), Days taken to sprouting (DTS), days taken to transplanting (DTT) and graft success (%) in brinjal varieties depicted in Table 3. Significantly lowest days taken for graft healing (4.54) and sprouting (9.83) was reported on first February (D_1) grafted plant. Fifteen February (D_2) grafted plant was reported lowest days for transplanting (20.14) and highest graft success (90.00%). While, highest days taken for graft healing (5.57), sprouting (10.93) and lowest graft success (78.89%) was reported in D_4: fifteen March grafted plant and first March (D_3) grafted plant took highest days for transplanting (21.83). Among the four varieties Phule Arjun (V_4) showed significantly lowest days for graft healing (4.39), sprouting (10.10), transplanting (20.15) and it was also recoded highest graft success (88.06%). However, highest days for graft healing (5.94), sprouting (10.96) and transplanting (22.08) was repoted in variety Manjari Gota (V_1) and lowest grafting success was reported in (79.17%) variety Phule Harit (V_2). The interaction effect of dates of grafting and variety showed significant difference for days taken for graft healing, days taken for graft sprouting and grafting success. The lowest days taken for graft healing (3.93) and sprouting (9.27) was reported in variety Phule Arjun grafted on first February (D_1V_4) and highest grafting success (92.22%) was reported in Phule Arjun grafted on fifteen February (D_2V_4). Whereas, highest days taken for graft healing (6.35) and graft sprouting (11.37) was noted in variety Manjari Gota grafted on first March (D_3V_1). However, Phule Harit grafted on fifteen March ($D_4V_{2)}$ was recorded lowest graft success (73.33%).

In the commercial nurseries, the grafted seedlings are usually placed in specially constructed tunnels within which the temperature is maintained at 24°C and relative humidity 100% (Nobuoka *et al.*, 1997) [13]. In present investigation the optimum temperature and high humidity was recorded on first and fifteen February (D_1 and D_2) in grafting chamber. Might be due to better union of vascular tissues at the graft union takes place. Rathod (2017) [16] was reported similar results in brinjal. The variety Phule Arjun grafted on first and fifteen February reported minimum days for graft healing and sprouting because of early graft union and it might be due to the favorable temperature and humidity. Hence obviously it took minimum number of days for transplanting and gives highest graft success.

Grafting success depends on several factors that include graft union and graft compatibility, combination of scion and rootstock (Kawaguchi *et al.*, 2008) [7], Seedling age, post grafting management, size of scion and rootstock, cultural condition, grafting method, tissue and structure differences, physiological and biochemical characteristics, growing stage of rootstock and scion, phytohormone and the environment which play a major role (Davis *et al.*, 2008) [3]. The success of grafting is also dependent upon the weather conditions and it varies from region to region within a season. The seasonal influence could be ascribed to the influence of prevailing temperature and humidity (Tamilselvi, 2015). Eggplant is grafted mainly by cleft or tube grafting techniques (Lee, 1994; Bletsos *et al.*, 2003; Miguel *et al.*, 2007) [10, 2, 12]. Successful grafting (compatibility between scion and rootstock) was due to cell division in the scion and rootstock at the graft union (dedifferentiation and dedifferentiation of the callus tissue), followed by rapid connection between the vascular bundles of the scion and rootstock and subsequent secondary growth of the scion (Shehata *et al.*, 2000) [20]. Among the four eggplant varieties hybrid (Phule Arjun and Krishna) form early callus and better compatibility than varieties (Manjari Gota and Phule Harit). The findings are in accordance with those obtained by Gisbert *et al.*, (2011) [4], Kumar *et al.* (2017) [8], Hoza *et al.* (2017) [5], and Sabatino *et al.*, (2019) [17] in eggplant.

Table 1: Temperature and humidity recorded in grafting chamber

1st February					15th February				
Days	Temperature		Humidity		Days	Temperature		Humidity	
	Max	Min	Max	Min		Max	Min	Max	Min
1	24.4	11.1	99	80	1	27.5	11.1	99	70
2	23.4	10.6	99	79	2	29.4	10.6	99	75
3	24.4	12.4	99	75	3	32	12.4	99	70
4	23.5	14.7	98	59	4	32.2	14.7	99	50
5	25.2	14.9	97	50	5	32.3	14.9	99	45
6	30.4	17	94	51	6	32.7	17	99	51
7	29.3	19.4	98	77	7	33.8	19.4	97	44
8	26.3	16.8	96	54	8	35.1	16.8	94	54
9	30.1	17.7	95	47	9	34.1	17.7	92	47
Mean	26.33	14.96	97.22	63.56	Mean	32.12	14.96	97.44	56.22
1st March					15th March				
1	31.2	13.8	99	70	1	30.5	18.6	99	70
2	31.6	13.8	99	73	2	30.8	18.8	95	68
3	31.6	14.8	99	75	3	31.4	18.8	96	75
4	29.3	15.2	98	53	4	34.6	18.1	95	46
5	31.8	16.2	99	43	5	34.3	17.2	88	41
6	32.2	16.6	98	42	6	34.6	18.8	88	40
7	34.6	16.7	97	37	7	35	19	87	38
8	34.9	20.1	94	30	8	35.1	20	84	30
9	34.9	16.2	95	28	9	35.6	20.5	82	28
Mean	32.46	15.93	97.56	50.11	Mean	33.54	18.87	90.44	48.44

Table 2: Effect of date and rootstock or varieties on days taken to germination (DTG), germination percentage (GP) and days taken to reach grafting stage (DTRGS).

Treatment	Observation of rootstock and scion		
Date	DTG	GP	DTRGS
D_1: 1st February	11.73	71.00	40.93
D_2: 15th February	12.73	69.67	39.00
D_3: 1st March	11.27	71.73	37.00
D_4: 15th March	10.20	74.33	35.80
S.Em. ±	0.23	0.55	0.26
CD at 5%	0.65	1.58	0.75
Variety and Rootstock			
R0*: Solanum torvum*	26.27	58.17	66.42
V_1: Manjari Gota	8.83	67.83	33.33
V_2: Phule Harit	9.00	65.75	31.50
V_3: Krishna	6.58	82.75	30.42
V_4: Phule Arjun	6.33	83.92	29.25
S.Em. ±	0.25	0.61	0.29
CD at 5%	0.72	1.77	0.83
Interaction			
D_1R_0	24.67	63.00	72.33
D_1V_1	10.00	65.33	36.00
D_1V_2	11.00	63.00	33.67
D_1V_3	6.67	81.33	32.33
D_1V_4	6.33	82.33	30.33
D_2R_0	29.67	52.00	68.00
D_2V_1	9.33	66.67	34.00
D_2V_2	9.67	64.33	32.00
D_2V_3	7.67	82.33	31.00
D_2V_4	7.33	83.00	30.00
D_3R_0	26.33	56.33	63.33
D_3V_1	9.00	68.33	32.33
D_3V_2	8.00	67.00	30.67
D_3V_3	6.67	82.33	29.67
D_3V_4	6.33	84.67	29.00
D_4R_0	26.00	61.33	62.00
D_4V_1	7.00	71.00	31.00
D_4V_2	7.33	68.67	29.67
D_4V_3	5.33	85.00	28.67
D_4V_4	5.33	85.67	27.67
S.Em. ±	0.50	1.23	0.58
CD at 5%	1.45	3.53	1.67

Table 3: Effect of date and varieties on days taken to graft healing (DTGH), days taken to sprouting (DTS), days taken to transplanting (DTT) and graft success (%).

Treatment	Observation of grafted plant			
Date	**DTGH**	**DTS**	**DTT**	**Graft Success (%)**
D_1: 1st February	4.54	9.83	20.86	85.28
D_2: 15th February	5.04	10.45	20.14	90.00
D_3: 1st March	5.35	10.76	21.83	81.94
D_4: 15th March	5.57	10.93	21.36	78.89
S.Em. ±	0.07	0.07	0.14	0.44
CD at 5%	0.19	0.20	0.39	1.28
Variety				
V_1: Manjari Gota	5.94	10.96	22.08	81.94
V_2: Phule Harit	5.73	10.75	21.54	79.17
V_3: Krishna	4.45	10.16	20.41	86.94
V_4: Phule Arjun	4.39	10.10	20.15	88.06
S.Em. ±	0.07	0.07	0.14	0.44
CD at 5%	0.19	0.20	0.39	1.28
Interaction				
D_1V_1	5.20	10.40	21.90	81.11
D_1V_2	4.93	10.20	21.00	80.00
D_1V_3	4.10	9.43	20.40	88.89
D_1V_4	3.93	9.27	20.13	91.11
D_2V_1	5.90	10.90	21.17	90.00
D_2V_2	5.77	10.73	20.60	86.67
D_2V_3	4.28	10.13	19.63	91.11
D_2V_4	4.20	10.03	19.17	92.22
D_3V_1	6.35	11.37	22.84	80.00
D_3V_2	6.17	11.10	22.35	76.67
D_3V_3	4.40	10.40	21.17	85.56
D_3V_4	4.50	10.17	20.95	85.56
D_4V_1	6.30	11.17	22.43	76.67
D_4V_2	6.03	10.97	22.20	73.33
D_4V_3	5.00	10.67	20.43	82.22
D_4V_4	4.93	10.93	20.37	83.33
S.Em. ±	0.13	0.14	0.37	0.89
CD at 5%	0.38	0.39	NS	2.56

Conclusion

From this study it is concluded that *Solanum torvum* was more compatible with var. Phule Arjun when grafted on first and fifteen February. It was reported significantly lowest days for graft healing, graft sprouting and highest graft success. The variety Phule Arjun also took the minimum days for germination, days taken to reach grafting stage and highest germination percentage when sown for the fifteen March grafting date.

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