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Graft compatibility between watermelon grafted on pumpkin, bottle gourd and sponge gourd rootstock in summer season 2022

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Abstract
This study was conducted at All India Co-ordinated Project on vegetable crops, Department of Horticulture, MPKV, Rahuri during the summer season, 2022. This work aimed to see the graft compatibility between hybrids of watermelon and different rootstocks. The three hybrids of watermelon were used as scion. Varieties of pumpkin (Arka Chandan, Arka Suryamukhi); bottle gourd (Arka Bahar, Samrat) and Sponge gourd (Phule Prajakta, Phule Komal) were used as rootstocks. In scion, Commercial Hybrid S_3 recorded a minimum number of days to germination (9.43) and days to reach the grafting stage (9.43). In rootstock, Pumpkin recorded the minimum number of days to germination (6.00) and days to reach the grafting stage. The minimum number of days to graft healing (4.67) and days to transplanting (17.00) was recorded in Phule Komal grafted with scion Commercial Hybrid S_1. Graft Success was recorded highest (96.67%) in rootstock Phule Komal when grafted on Commercial Hybrid S_2.

Keywords: Watermelon, scion, rootstock, pumpkin, sponge gourd, sponge gourd, graft compatibility

Introduction
Watermelon (*Citrullus lanatus* (Thunb.) Matsum and Nakai) is a warm-season annual crop belonging to the family Cucurbitaceae having chromosome number 2x = 22. It is grown in tropical and Mediterranean regions of the world and is believed to have originated from the Kalhari Desert of Africa (Simmonds, 1979) [21]. Globally it is grown in an area of 3 million hectares with a production of 100 million tons (Anon. 2019) [1]. After China and Turkey India is the third-largest grower of watermelon. India contributes 123 thousand ha area with production of 3461 thousand MT (Anon. 2021-2022) [3]. In India, Maharashtra is sixth in number with an area of 4.85 thousand hectares with 109.19 thousand MT of production (Anon. 2020-2021) [2].

Grafting of watermelon was first introduced in the 1920s and by 1998, in Korea, Japan and Taiwan, 95% of watermelon and melon plants were grafted onto resistant rootstocks, resulting in up to 200% higher yields in comparison with self-rooted plants (Lee and Oda, 2003) [13]. Rootstocks that are commonly used for grafting watermelon are *Cucurbita moschata*, *Cucurbita maxima*, *Cucurbita pepo*, *Benincasa hispida*, *Lagenaria siceraria*, *Citrullus lanatus*, *Cucumis metuliferus*, *Luffa spp.* as well as hybrids of squash species *C. moschata* × *C. maxima* (Lee, 1994) [12].

Grafting vegetables helps in the management of biotic and abiotic stresses, increases yield, extends the harvest period, manipulates sex expression and improves fruit quality. Vegetable grafting reduces the agrochemical dependence on vegetable production (Rivard *et al.*, 2008) [20]. Compatibility is higher in intraspecific rootstock/ scion grafting than with interspecific grafting (Black *et al*., 2003) [4]. Thus, owing to the beneficial effects incurred by grafting on different rootstocks, the present experiment was planned to check the graft compatibility of watermelon with different rootstocks.

Material and Methods
The 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 was conducted in the summer 2022. Watermelon (scion) varieties seeds were sown 15 days earlier than the rootstocks seeds i.e. Pumpkin (varieties- Arka Chandan, Arka Suryamukhi), Bottle gourd (var.- Arka Bahar, Samrat) and Sponge gourd (var.- Phule Prajakta, Phule Komal). A single cotyledon method of grafting was used.

Rootstock was given cut at 60^0 angle with razor blade in such a way that one cotyledon remains and one is removed. Seedling of scion was given cut at 60^0 angle below the cotyledons. These two cut surfaces were hold together with the help of grafting clip to ensure proper vascular binding. After grafting seedlings were placed in grafting chamber for healing. Relative humidity of 85-95% and temperature 28-32 ^oC was maintained to allow the graft union to heal. The observations were recorded as given below.

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

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

3. Girth of scion and rootstock at time of grafting

The replication wise stem diameter of rootstock was measured by using of digital Vernier Caliper Scale at the time of grafting.

A) Observation of grafted plant

1. Days taken for graft healing

Grafted plants were selected randomly from each replication. The observation was recorded after 5 days of grafting by removing the grafting clips and the average days it took to heal the graft union were noted.

Graft Success (%)

Grafting success was calculated for each graft combination. Complete break down at the graft area and differences in stem diameter between scion and rootstock followed by scion wilting was considered as unsuccessful ones and the scion which remained green was also taken as successful graft after15 days of grafting.

The percentage of success was recorded by the formula number of successful grafts.

$$\text{Graft success percentage} = \frac{\text{Number of successful grafts}}{\text{Total number of plants grafted}} \text{ x } 100$$

Days to attain transplanting stage

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

Statistical Analysis

The data obtained during the experiment were analyzed as per the statistical methods prescribed by Panse and Sukhatme (1995) [16] to obtain valid conclusions. The treatments were compared using the critical difference at a 5% level of significance.

Results and Discussion

A. Rootstock and scion parameters

Days to germination, days to reach grafting stage and diameter of scion and rootstock

The mean data pertaining to days taken to germination, days to reach the grafting stage and diameter of scion and rootstock are depicted in Table 1. In scion, Commercial Hybrid S_3 has taken a minimum number of days to germination (9.43) and days to reach grafting stage (22.29). Whereas, Commercial Hybrid S_2 has taken maximum number of days 10.00 to germination. The maximum number days to reach the grafting stage (24.29) was recorded in scion Commercial Hybrid S_1.

In rootstock, Arka Chandan reported the minimum number of days to germination (6.00) and minimum number of days to reach the grafting stage (9.50). Whereas, Phule Prajakta taken maximum number of days to germination (8.00). The maximum number of days to attain the grafting stage was reported in Phule Komal (11.75).

The diameter of rootstock and scion at a collar region is an important parameter that decides graft union combination and further decides health and growth of the graft on field. The scion showed non-significant difference for the diameter. The maximum diameter was recorded in Commercial Hybrid S_3 (2.34 mm) and minimum (2.16 mm) in Commercial Hybrid S_2. Whereas, rootstock recorded maximum diameter of 2.69 mm in Arka Suryamukhi. The minimum diameter was recorded in Phule Prajakta (2.12 mm).

B. Observation of grafted plant

The observation of grafted plant was recorded after grafting and before the transplanting.

1. Days taken for graft healing

The mean data pertaining to effect of grafting on days taken for graft healing of grafted plants is depicted in Table 2. The rootstock and scion varieties showed significant differences in days taken for graft healing. The rootstock Phule Komal (R_6) has taken a minimum number of days (5.11) for graft healing. While, the rootstock Arka Suryamukhi (R_2) recorded maximum number of days (9.11) for graft healing.

In scion, Commercial Hybrid S_1 recorded minimum number of days (6.78) for graft healing and Commercial Hybrid S_3 has taken maximum number of days (7.56) for graft healing.

The interaction, effect of rootstock and scion showed a significant difference in all the treatments for days taken to graft healing. The minimum number of days (4.67) recorded in the interaction of R_6S_1 (Commercial Hybrid S_1 grafted on Phule Komal) and R_6S_2 (Commercial Hybrid S_2 grafted on Phule Komal) which was at par with interactions R_5S_3 (5.33). Whereas, R_2S_3 (Commercial Hybrid S_3 grafted on Arka Suryamukhi) recorded maximum number of days (10.00) to graft healing.

Days required for graft healing depends on stage of rootstock and scion as well as prevailing atmospheric conditions. According to findings, changes occur during the formation of graft union include the death of cell layers at graft interface, cohesion of scion and rootstock, proliferation of callus cells at the graft interface, and vascular differentiation across the graft interface to establish vascular connectivity. Similar results were given by Fernandez-Garcia *et al.* (2004) [8], Martinez-Ballesta *et al.* (2010) [6], Dhivya (2013) [14], Rahmatian *et al.* (2014) [19], Surve *et al.* (2019) [22], Hossain *et al.* (2019) [9].

2. Graft Success (%)

The mean data pertaining to effect of grafting on the percent of graft success of grafted plants is depicted in Table 2. The rootstock and scion showed significant differences for graft success. The rootstock Phule Komal (R_6) has recorded the

highest (95.56%) graft success. While, the lowest was recorded in Arka Suryamukhi (83.00%).

The scion, Commercial Hybrid S_3 has noted the highest (91.33%) graft success and the lowest graft success (88.39%) was recorded in Commercial Hybrid S_1.

The interaction, effect of rootstock and scion showed a significant difference for graft success for all the treatments. Interaction R_6S_2 (Commercial Hybrid S_2 grafted on Phule Komal) has recorded the highest (96.67%) graft success which was at par with interactions R_6S_3 (96.33), R_5S_3 (96.00), R_6S_1 (95.33) and R_5S_2 (95.00). Whereas, the lowest graft success (79.67%) was noted in interaction R_2S_1 (Commercial Hybrid S_1 grafted on Arka Suryamukhi).

The results obtained agree with Rahman *et al.* (2002) [18], Yetisir and Sari (2003) [25], Hsiu-fung and Yung-fu (2013) [10], El-Sayed *et al.* (2015) [7] and Pawar (2021) [17].

Grafting success depends on several factors that include graft union and graft compatibility, combination of scion and rootstock (Kawaguchi *et al.*, 2008) [11], Seedling age, post grafting management, size of scion and rootstock, culture 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) [5]. 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 and Pugalendhi, 2017) [24].

3. Days to attain transplanting

The mean data pertaining to effect of grafting on days to attain transplanting stage in grafted plants is depicted in Table 2. The rootstock and scion showed significant difference for days to attain transplanting. The rootstock Phule Komal (R_6) has taken minimum number of days (18.00) to attain the transplanting stage. While, maximum days were recorded in Arka Suryamukhi (21.78).

In scion, Commercial Hybrid S_1 has noted the minimum (19.39) number of days to attain transplanting. While, the maximum number of days to attain transplanting (20.56) was recorded in Commercial Hybrid S_3.

The interaction effect of rootstock and scion showed a significant difference for days to transplanting of grafted plants for all treatments. In interaction, R_6S_1 (Commercial Hybrid S_1 grafted on Phule Komal) has recorded the minimum (17.00) number of days for transplanting which was at par with interactions R_6S_2 (17.67) and R_5S_1 (18.33). While, R_2S_3 (Commercial Hybrid S_3 grafted on Arka Suryamukhi) has taken maximum (23.33) number of days for transplanting of grafted plants. The results are similar to Hossain *et al.* (2019) [9] and Maurya *et al.* (2019) [15].

Table 1: Number of days taken to germination, days taken to reach grafting stage and Diameter(mm) of scion rootstock.

Crop Name	Scion	Days to germination	Days to grafting	Diameter (mm)
Watermelon	Commercial Hybrid S_1	9.89	24.29	2.21
	Commercial Hybrid S_2	10.00	23.14	2.16
	Commercial Hybrid S_3	9.43	22.29	2.34
	S. Em (±)	0.13	0.32	0.06
	CD (5%)	0.39	0.98	NS
Rootstock				
Pumpkin	Arka Chandan (R_1)	6.00	9.50	2.51
	Arka Suryamukhi (R_2)	6.25	9.75	2.69
Bottle Gourd	Arka Bahar (R_3)	6.75	10.25	2.38
	Samrat (R_4)	7.00	10.75	2.41
Sponge Gourd	Phule Prajakta (R_5)	8.00	11.25	2.24
	Phule Komal (R_6)	7.75	11.75	2.12
	S.Em (±)	0.31	0.26	0.06
	CD (5%)	0.93	0.80	0.18

Table 2: Number of days required to graft healing, days to transplanting from grafting and graft success (%).

Treatments	Days to graft healing	Days to transplanting	Graft Success (%)
Rootstock			
R_1 (AC)	9.00	21.56	83.67
R_2 (AS)	9.11	21.78	83.00
R_3 (AB)	7.00	19.67	91.67
R_4 (S)	7.22	20.22	91.44
R_5 (PP)	5.89	18.89	95.44
R_6 (PK)	5.11	18.00	95.56
S.Em. (±)	0.24	0.27	0.45
CD 5%	0.72	0.81	1.35
Scion			
S_1	6.78	19.39	88.39
S_2	7.33	20.11	90.67
S_3	7.56	20.56	91.33
S.Em. (±)	0.17	0.19	0.32
CD 5%	0.51	0.56	0.96
Interaction (R*S)			
R_1S_1	8.33	20.33	80.67
R_1S_2	9.67	22.00	84.33

R_1S_3	9.00	22.33	86.00
R_2S_1	8.33	21.00	79.67
R_2S_2	8.67	21.00	84.33
R_2S_3	10.00	23.33	85.00
R_3S_1	7.00	19.33	90.00
R_3S_2	6.67	20.00	92.67
R_3S_3	7.33	19.67	92.33
R_4S_1	6.33	20.33	90.67
R_4S_2	8.00	20.67	91.00
R_4S_3	7.33	19.67	92.67
R_5S_1	6.00	18.33	94.00
R_5S_2	6.33	19.33	95.00
R_5S_3	5.33	19.00	96.00
R_6S_1	4.67	17.00	95.33
R_6S_2	4.67	17.67	96.67
R_6S_3	6.00	19.33	96.33
S.Em. (±)	0.42	0.47	0.77
CD 5%	1.25	1.40	2.31

Conclusion

From this study, it is concluded that Phule Komal (Sponge gourd) is more compatible compared to other rootstocks with scions. Whereas, Phule Komal recorded minimum number of days to graft healing, days to reach transplanting stage and highest graft success (%) when grafted with scion Commercial Hybrid S_1 and Commercial Hybrid S_2.

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