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Graft compatibility among three muskmelon varieties (*Cucumis melo* L.) grafted on pumpkin, bottle gourd and sponge gourd in summer season 2022

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Abstract
This study was conducted at All India Co-ordinated Project on a vegetable crop, Department of Horticulture, MPKV, Rahuri during the summer season 2022. This work aimed to see the graft compatibility among Muskmelon varieties on rootstocks of Pumpkin, Bottle gourd, and Sponge gourd in the summer season. Three muskmelon varieties Sagar 60, Dhruvi, and Vijay were used as scions and were grafted on rootstocks of Pumpkin (Arka Chandan, Arka Suryamukhi), Bottle gourd (Arka Bahar, Samrat) and Sponge gourd (Phule Komal, Phule Prajakta). The scion seed is sown 22 -25 days before the rootstock and dates are recorded for days to germination, days to graftable size, and diameter of scion and rootstock. It was observed that early healing (4.67) and the highest (96.66%) graft success (%) was observed in Sagar 60 (90.00%) grafted on Phule Prajakta, and minimum days to attain transplanting was noted with Sagar 60 grafted on Samrat (11.27).

Keywords: Muskmelon, scion, pumpkin, bottle gourd, sponge gourd, rootstocks, compatibility

Introduction
Muskmelon (*Cucumis melo* L.) is a popular and important vegetable crop that is grown as a "Dessert crop" throughout the world (Verma *et al*., 2017) [19]. It grows well in all the tropical and subtropical areas of the world but prefers a hot climate (Parle, M. and Singh, K. 2011) [11]. In India, it is popular in the states of Uttar Pradesh, Punjab, Rajasthan, and Madhya Pradesh, particularly in the North, West, and Central regions. Musk melon (2n=24) is a member of the Cucurbitaceae (cucurbit) family (Schaefer *et al*., 2009, Priyanka *et al*., 2015) [16, 12]. Kharbooza (Hindi), Kaling (Sanskrit), and Velapalam (Malayalam) are some of the local names for muskmelon. *Cucumis melo* is a big polymorphic taxon that includes a wide range of botanical and horticultural variations or groups. Musk melon was first described by Linne in the year 1753 in the species planetarium. The family Cucurbitaceae is represented by some 130 genera and 800 species (Benjamin *et al*., 2021) [2]. Melon plants have long trailing vines with shallow loaned circular leaves and are either monoecious or andromonoecious annuals (Verma *et al*., 2017, Benjamin *et al*., 2021) [19, 2]. Musk melon flowers are yellow, and male and female flowers grow on the same plant. Musk melon is high in vitamins and minerals. Fruits are low in nutritional value, especially in terms of protein. Cantaloupe has a high concentration of -carotene, a provitamin A pigment found in yellow and orange-skinned melons (Priyanka *et al*., 2015) [12]. It has significant medicinal value and acts as an anti-cancer, anti-diabetic, and anti-microbial agent. (Danish *et al*., 2020, Ali *et al*., 2020) [3, 1].

For decades, the primary goal of agriculture has been to increase crop yield and productivity to meet the food needs of the world's growing population. As a result, intensive cropping systems with limited crop rotations, particularly for vegetable crops grown in open fields and under protected cultivation, have resulted in the accumulation of harmful factors (biotic or abiotic) that can reduce yield and quality. These negative factors increased the use of input factors (water, chemical fertilizer, pesticides, etc.), resulting in environmental and health concerns. Grafting is a viable option for addressing biotic and abiotic stress issues in vegetable cultivation. (Lee and Oda, 2003; Davis *et al*., 2008; Savvas *et al*., 2010; Schwarz *et al*., 2010) [9, 4, 15, 17]. Considering the importance of Pumpkin, Bottle gourd and Sponge gourd as rootstock for muskmelon grafting the present work had as its objective to evaluate compatibility among muskmelon scion varieties and rootstocks.

Materials used for grafting

The basic requirements used in this study were, Rootstock and scion material, Greenhouse, Protrays, Cocopeat, Sharp Blade, Grafting Clips, Supporting sticks, and Healing Chamber. The experimental material consists of six rootstocks of Pumpkin (Arka Chandan, Arka Suryamukhi), Bottle gourd (Arka Bahar, Samrat), and Sponge gourd (Phule Komal, Phule prajakta) obtained from the Indian Institute of Horticulture Research, Mahatma Phule Krishi Vidyapeeth and Three Scions *viz*., Sagar 60, Dhruvi and Vijay obtained from Sagar Biotech Pvt. Ltd. This experiment was conducted at All India Co-ordinated Project on Vegetable Crop, Department of Horticulture, MPKV, Rahuri, Maharashtra. The experiment was conducted in Summer in 2022. Seeds of scion are sowed 20-25 days before the rootstock seeds. The scion (Sagar 60, Dhruvi and Vijay) seeds sown in 102 cells protrays and rootstock (Arka Chandan, Arka Suryamukhi, Arka Bahar, Samrat, Phule Komal, and Phule Prajakta) seed sown 70 cells protrays containing sterilized coco-peat. The rootstock seedlings took 7-10 days to attain the graftable stage. To synchronize of scion and rootstock graftable stage, we went for prior sowing of the scion. Results were presented in table 1.

Method and procedure single cotyledonary of grafting in Muskmelon

Three hybrid scions Sagar 60, Dhruvi, and Vijay were grafted on Pumpkin, Bottle gourd, and Sponge gourd by using the Single cotyledonary grafting method. This is the most common method used for cucurbitaceous crops. It is also called one cotyledon grafting/ slant grafting/ spice grafting. This procedure was performed manually. This method is suitable when scion and rootstock are of a similar stem diameter size. The rootstocks should be grafted when rootstocks were at the cotyledonary stage and the scion was about the first true leaf stage. With a razor blade, the rootstock seedling was cut at a slant from the base of the one cotyledon to 0.8-1.0cm below the other cotyledon, one cotyledon and the growing tip was removed in rootstocks. The length of cut on the muskmelon scion seedling should match that of the rootstock and should be at a 35° to 45° angle. The muskmelon scion was attached to the rootstock and fixed tightly by a grafting clip and it was supported with sticks to protect the grafted seedling.

Grafting was carried out in the morning and evening hours in mist chambers made up of transparent polythene of 100-micron thickness. After grafting seedlings were immediately placed in a grafting chamber for 5 to 7 days. The grafting chamber was covered with black polythene for two days and seedlings were placed in the dark. This process was carried out to ensure high grafting success. Maintain a relative humidity of 85-95% for five days to allow the graft union to heal, then the light was gradually increased and relative humidity was decreased. Then the seedlings were transferred to the normal nursery where the healing process was allowed for almost one week before they were transplanted. Before the transplanting seedlings were grown under natural light conditions for two to three days. The observations were presented in table 2.

A. Rootstock and Scion parameter

1. Days taken for Germination

The observation was recorded at everyday by visual observation and date on which seedling emerged was noted, average days taken for germination were calculated.

2. Days taken to reach grafting stage

Seedlings were selected randomly from each replication and observation was recorded based on seedling diameter, number of leaves and days required to reach correct stage of grafting *i.e.,* the seedling diameter of 2.39 to 2.45 mm for scion, for rootstock 2.47 to 2.70 mm and two to true leaves stage for scion and single cotyledon stage for rootstock.

3. Diameter of scion at time of grafting

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

4. Diameter of rootstock at time of grafting

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

5. Number of leaves on scion at time of grafting

At the time of grafting, leaves on the scion seedlings were counted replication wise.

6. Number of leaves on rootstock at time of grafting

At the time of grafting, leaves on the root stock seedlings were counted replication wise.

B. 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 average days it took to heal the graft union were noted.

2. Graft Success (%)

Grafting success was recorded on 15 days after grafting (DAG). 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.

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

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.

Statistical Analysis

The data obtained during the experiment were analyzed as per the statistical methods prescribed by Panse and Sukhatme (1995) [10] 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 about different dates of sowing on days to germination, days to reach the grafting stage, and diameter of scion and rootstock in Muskmelon are depicted in Table 1. The scion and rootstock showed significant differences for days to germination, days to reach the grafting stage and non-significant differences for the diameter of the scion and rootstock in the Summer 2022 season.

In scion, Sagar 60 (S_1) taken a minimum number of days to germination in Summer (7.43). Whereas, Vijay (S_3) took the maximum number of days to germinate in Summer (9.29). In rootstock, Phule Komal (R_5) showed a minimum number of days to germination in Summer (6.00). Whereas, a maximum (7.75) number of days was observed in Arka Chandan (R_1) in Summer.

In crop production, seed germination is an important criterion. Cucurbits are summer crops. 20-25°C is the ideal temperature for germination and growth. If the temperature falls below 18°C, the seed does not germinate. The temperature had a significant impact on seed germination. In this study, we looked at how temperature fluctuations during summer affected the germination of Muskmelon, Pumpkin, Bottle gourd, and Sponge gourd. In the summer, higher mean temperatures promote cucurbit germination than lower temperatures in the *Kharif* season. This result is in line with Gisbert *et al*. (2011) [6], Rathod (2017) [13], and Kumar *et al*. (2016) [8].

In scion, Sagar 60 (S_1) showed minimum days (19.00) to reach the graftable stage in the Summer season. Whereas, Vijay (S_3) took a maximum number (21.80) days to reach the graftable stage. In rootstock, Samrat (R_4) showed minimum days (9.50) to reach the graftable stage in Summer. Whereas, the maximum number of days to reach the graftable stage (11.00) was observed in Arka Chandan (R_1).

In scion, Sagar 60 (S_1) showed a maximum diameter in Summer (2.45 mm). While Vijay (S_3) showed a minimum diameter in Summer (2.39 mm). In rootstock, Arka Suryamukhi (R_2) showed maximum diameter in the Summer (2.70 mm) season. Whereas, Phule Prajakta (R_6) showed a minimum diameter (2.47 mm).

The diameter of rootstock and scion at the collar region is an important parameter that decides graft union combination and further decides the health and growth of graft in the field. The survival rate and graft union formation were inversely related to hypocotyl diameter differences between the scion and rootstock. The number of vascular bundles did not affect survival, but it did affect the growth rate of grafted melon plants in general (Yetisir and Sari, 2004; Davis *et al*., 2008) [20, 4]. These observations were recorded at the time of grafting.

Number of leaves on scion and rootstock at time of grafting

The number of leaves on the scion and rootstock at the time of grafting was two true leaf stages in the scion and a single cotyledonary stage in the rootstock. These observations were recorded at the time of the grafting stage. Due to the increase in the age of seedlings, the number of leaves on both rootstock and scion was also increased.

B. Observations of Grafted Plant

The observation of grafted plants was recorded in Summer. The observation of grafted plants was recorded after grafting and before the transplanting.

Days aken for graft healing

The mean data about the effect of muskmelon scion varieties grafted on different rootstocks on days taken to graft healing is presented in Table 2.

The rootstock and scion varieties showed significant differences in days taken for graft healing in the Summer season. In the Summer season, the rootstock Arka Bahar (R_3) taken a minimum of days (4.89) for graft healing. While the rootstock Arka Chandan (R_1) took the maximum number of days (6.18) for graft healing. In scion, Vijay (S_3) recorded the minimum number of days (5.34) for graft healing in Summer. Whereas, Dhruvi (S_2) took a maximum number of days (5.70) for graft healing.

The interaction effect of rootstock and scion showed a significant difference in days taken for graft healing in the Summer season. In Summer season interaction R_6S_1 were recorded minimum days (4.67) for graft healing and which was at par with R_3S_3 (4.73), R_3S_2 (4.80), R_4S_1 (4.87), R_5S_1 (4.93) and R_4S_3 (5.00). Whereas, R_1S_1 were recorded maximum days (6.53) for graft healing.

Graft Success (%)

The mean data about the effect of muskmelon scion varieties grafted on different rootstocks on days taken to graft success (%) is presented in Table 2.

The rootstock and scion varieties showed significant differences in graft success (%) in the Summer season. In the Summer season, the rootstock Phule Prajakta (R_6) was recorded highest (95.03%) for graft success. While the lowest was recorded in (R_1) Arka Chandan (83.92%) in Summer. The scion Sagar 60 (S_1) was noted highest (92.76%) graft success in the Summer season. While the lowest graft success (90.06%) was recorded in Vijay (S_3).

The interaction effect of rootstock and scion showed a significant difference in graft success in the Summer season. In summer season interaction R_6S_1 was recoded highest (96.66 %) graft success and which were at par with R_5S_2 (94.67 %), R_6S_2 (95.00 %), R_3S_2 (95.00 %), R_5S_1 (95.11 %). Whereas, lowest graft success (81.66 %) was noted in interaction R_1S_2.

Grafting success depends on several factors that include graft union and graft compatibility, the combination of scion and rootstock (Kawaguchi *et al*., 2008) [7], 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) [4]. 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) [18].

Days to attain transplanting

The mean data about the effect of muskmelon scion varieties grafted on different rootstocks for days taken to attain transplanting is presented in Table 2.

The rootstock and scion varieties showed significant

differences for days to attain transplanting in Summer season. In Summer season, the rootstock Arka Bahar (R_3) was taken minimum days (11.51) to attain transplanting. While, maximum days were recorded in (R_2) Arka Suryamukhi (13.00). In scion, Sagar 60 (S_1) was noted lowest (11.91) days to attain transplanting in summer season. While, highest days to attain transplanting (12.73) was recorded in Dhruvi (S_2).

The interaction effect of rootstock and scion showed a significant difference for transplanting in Summer season. In summer season interaction R_4S_1 was noted lowest (11.27) days to attain transplanting and which were at par with R_3S_1 (11.33), R_4S_3 (11.33), R_3S_3 (11.53), R_3S_2 (11.67) and R_5S_1 (11.80). While, interaction R_2S_2 was recoded highest (13.53) days for transplanting.

The height of the plant has been influenced by the rootstocks, leading to higher plant growth in grafted plants. The rootstocks Arka Chandan and Arka Suryamukhi took the maximum number of days to graft healing and sprouting so they were taken somewhat more days to attain transplanting when compared to Arka Bahar and Samrat. The findings are following those obtained by Gisbert *et al*. (2011) [6], Kumar *et al.* (2017) [8], Gheorghita *et al*. (2017) [5], and Sabatino *et al*. (2019) [14].

Table 1: Days to germination, days to reach grafting stage and diameter of scion and rootstock

Crop name	Scion	Days to germination	Days to graftable stage	Diameter (mm)
Muskmelon	Sagar 60	7.43	19	2.45
	Dhruvi	8.14	21.4	2.41
	vijay	9.29	21.8	2.39
	S.Em(±)	0.19	0.32	0.05
	CD (5%)	0.58	0.99	NS
Rootstock				
Pumpkin	Arka Chandan	7.75	11	2.67
	Arka Suryamukhi	7	10.5	2.70
Bottle gourd	Arka Bahar	6.75	10	2.52
	Samrat	6.5	9.5	2.50
Sponge gourd	Phule Komal	6	9.75	2.49
	Phule Prajakta	6.25	10	2.47
	S.Em (±)	0.30	0.30	0.04
	CD (5%)	0.90	0.92	NS

Table 2: Effect of grafting on Days to graft healing (DTGH), Graft success (%) and Days attain to transplanting (DATP)

Rootstock			
Treatments	**DTGH**	**Graft success (%)**	**DATP**
R_1 (AC)	6.18	83.92	12.80
R_2 (AS)	6.11	90.55	13.00
R_3 (AB)	4.89	93.48	11.51
R_4 (S)	5.04	92.37	11.62
R_5 (PK)	5.27	94.33	12.20
R_6 (PP)	5.47	95.03	12.49
S.Em (±)	0.08	0.44	0.12
CD 5%	0.24	1.25	0.33
Scion			
S_1 (S60)	5.43	92.76	11.91
S_2 (D)	5.70	91.33	12.73
S_3 (V)	5.34	90.76	12.21
S.Em (±)	0.06	0.31	0.08
CD 5%	0.17	0.88	0.24
Interaction (RXS)			
R_1S_1 (AC+S60)	6.53	85.11	12.53
R_1S_2 (AC+D)	6.40	81.66	13.47
R_1S_3 (AC+V)	5.60	85.00	12.53
R_2S_1 (AS+S60)	6.47	93.33	12.80
R_2S_2 (AS+D)	6.33	90.00	13.53
R_2S_3 (AS+V)	5.53	88.33	12.67
R_3S_1 (AB+S60)	5.13	93.66	11.33
R_3S_2 (AB+D)	4.80	95.00	11.67
R_3S_3 (AB+V)	4.73	91.77	11.53
R_4S_1 (S+S60)	4.87	92.66	11.27
R_4S_2 (S+D)	5.27	91.66	12.40
R_4S_3 (S+V)	5.00	92.77	11.33
R_5S_1 (PK+S60)	4.93	95.11	11.80
R_5S_2 (PK+D)	5.40	94.67	12.33
R_5S_3 (PK+V)	5.47	93.22	12.47
R_6S_1 (PP+S60)	4.67	96.66	11.73
R_6S_2 (PP+D)	6.00	95.00	13.00
R_6S_3 (PP+V)	5.73	93.44	12.73
S.Em (±)	0.14	0.75	0.20
CD 5%	0.41	2.17	0.58

Conclusion

From this study, it was concluded that Pumpkin, Bottle gourd, and Sponge gourd were more compatible with Sagar 60, Dhruvi, and Vijay. It was reported that significantly lowest days for graft healing, graft success (%), and days to attain transplanting were observed with rootstocks of Bottle gourd and Sponge gourd when compared with Pumpkin.

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