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Original Research Article

RESPONSE OF GRAFTS OF DIFFERENT SCION VARIETIES ON SEEDLING OF COMMERCIAL MANGO VARIETIES UNDER BLACK NET COVERED NURSERY CONDITIONS

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Abstract *An investigation was carried out at the Mango Research Station in Shujabad, Pakistan, to assess the efficacy of different scion varieties on rootstocks of various commercial mango seedlings under black net covered nursery conditions. The study comprised of thirty-six treatments, which consisted of twelve different commercial mango varieties seedling used as rootstocks [Sindhri, Dusehri, Langra, Anwar Retaul, Chaunsa Sammar Bahisht, Fajri, Chenab Gold, Azeem Chaunsa, Sufaid Chaunsa, Kala Chaunsa, Late Retaul and Desi (a seedling mango fruit)] and three scions (Sindhri, Chaunsa Sammar Bahisht and Sufaid Chaunsa). Anwar Retaul and Chaunsa Sammer Bahisht rootstocks exhibited the shortest sprout emergence times 12.47 and 12.50 days, respectively and the longest sprout lengths 6.08 cm and 5.68 cm, respectively. The highest graft success rates were observed in Anwar Retaul 89.17% and Chaunsa Sammer Bahisht 86.67%. Anwar Retaul also produced the tallest plants 29.40 cm while Azeem Chaunsa exhibited the largest scion girth 5.60 mm and Chaunsa Sammer Bahisht had the largest root-collar diameter 6.57mm. The combination of Sindhri and Chaunsa Sammer Bahisht had the highest leaf count per graft 19.33. Chaunsa Sammer Bahisht also demonstrated the highest germination percentage 71% and epicotyl length 12cm. These findings highlight the critical role of rootstock-scion compatibility in enhancing mango propagation efficiency, suggesting. Future research should focus on exploring additional rootstock-scion combinations and environmental factors to further improve mango propagation techniques.*

Keywords: *Rootstock; Scion; Stionic mix; mango; grafting success*

Introduction

The Mango (*Mangifera indica* L.) belongs to the Anacardiaceae family and include fleshy drupe fruit of Pistachio and Chashew nut which has its extensive historical background, cultural significance and economic value (Govindan, 2019). Mango has chromosomal count of 2n=40 and small genome size 439 Mb and have originated in the Indo-Burma region, encompassing the Northeastern areas of India, Myanmar, and Bangladesh. The mango has established its commercial value in numerous countries worldwide, especially in tropical and subtropical areas (Rajan & Hudedamani, 2019).

World mango production has touched the hike of 59 million ton while the Asia hold significant contribution as 43 million ton as 66% share. Pakistan, occupied area under mango cultivation 0.2 million hectares with production of 2.7 million ton and 111 thousand ton exported to various countries of the world (FAO, 2022). The production season starts from May and extends to early October. The fruit is integral part of various national as well as international exhibition, festival and diversity display of various shape and size of the fruit (Badar et al., 2015). The celebration is renowned for its wide range of different types, each providing distinct tastes, consistencies, and scents (Badar et al., 2014).

Mango plays a crucial role in Pakistan's horticultural industry and a major global producer and exporter of fresh fruit with a substantial focus on growing in the provinces of Punjab and Sindh. Punjab, specifically the areas of Multan and Rahim Yar Khan, is renowned as a prominent center for mango cultivation. These regions are renowned for alluvial rich soil and ideal weather conditions, which enhance the productivity and excellence of the mangoes grown (Campbell et al., 2009).

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Although the conventional techniques of propagation of mango nursery plants provide considerable obstacles. Conventionally, mango saplings were raised by using seeds (stones) of various commercial mango cultivars, resulting in significant genetic diversity (Khan et al., 2008). The genetic unpredictability poses a significant constraint for commercial orchards, since it leads to inconsistency in the seedling growth, poor germination, weaker seedling, lower vigor and quality of the plant devoid of vital signs. Every seedling that is cultivated from a stone can exhibit notable variations compared to its parent plant, resulting in a lack of uniformity in growth and its productivity. The genetic variation, although advantageous for natural selection and adaptability, is less desirable in the context of industrial agriculture, where consistency and predictability are essential (Memon, 2016).

Usually, the seedlings were raised under bigger tree canopy and grafting were also performed till preparation of plants. This traditional way develops the cyclic growth of the insects and disease threats from larger plants to smaller nursery and then progress to the establishment of new orchard developed from these infected nursery plants. Hence, efforts were rendered to develop mango nursery away from orchard and in an isolated place under protection. In order to tackle these difficulties, techniques of vegetative propagation, such as grafting, have been revised and implemented. Grafting is the process of connecting the scion, which is the upper portion of a plant further develop into canopy, to a rootstock, which is the lower part of the plant further develop and provide root system (Rajan & Hudedamani, 2019). This is done to combine the desired variety of the scion with a rootstock that is suitable for the specific local growth conditions. This technique guarantees the creation of plants that are true to their original kind and display the desirable traits of the scion variety. Grafting has multiple benefits, including accelerated fruiting, enhanced disease resistance, and improved overall productivity and quality of the mango harvest (Raza et al., 2017; Tahir et al., 2012; Usman et al., 2003).

Pakistan is currently investigating several combinations of rootstock and scion to determine which ones yield the most favorable outcomes in terms of successful grafting, growth, and development. The selection of rootstock is crucial as it impacts the plant's robustness, resistance to diseases, and ability to adapt to different soil and climatic conditions. Likewise, the scion type has a crucial role in determining the excellence, taste, and productivity of the fruit. Researchers strive to enhance mango output by conducting experiments to determine the most effective rootstock-scion compatibilities. The goal is to ensure that the plants are both highly productive and hardy (Zahid et al., 2022).

The objective of this study is to determine the optimal combinations of rootstock and scion for mango production in Pakistan's under black net covered nurseries. The research aims to assess the performance of different scion kinds when grafted onto various rootstocks in order to identify the combinations that provide the best rates of successful grafting, optimal growth parameters and improved plant development. This study is especially pertinent in the context of rapid multiplication and vigorous stionic compatibilities to withstand under climate change scenario which encompass arid, semi-arid, and subtropical regions.

Materials and methods

Description of the Experiment

The experiment was carried out at Mango Research Station Tehsil Shujabad District Multan, Pakistan. The station is situated at a latitude of 30°16' N, a longitude of 71°34' E and an altitude of 125 meters above mean sea level. The examination took place during the growth season of 2023-2024. The permanent GI iron nursey structure was installed having dimension of 100ft length, width 30ft and height 10ft and accommodating 5000 polybags.

Rootstock sowing

Fresh extracted mango stones of twelve commercial mango varieties were placed in specialized nursery trays having a dimension of 1mx1m and 9cm height, the bottom surface was porous for easy water drainage. The stones were covered with a layer of sugarcane bagasse and irrigated with alternate days to keep medium moist. Stone started emergence at various days and when second flush about to start and lower leaves turn its color into dark green and flatted leaves readily shifted into ploy bags. The process was completed in the month of July and seedling shifted was completed in the first week of August.

Polythene bags

The black polythene bags 10-micron thickness having dimension of 14 inches length and 10 inches wide are used for this experiment. The poly bags have holes of dimension 10mm at one-third lower part and 24 holes for easy passage for water drainage.

Media preparation

The poly bags filled with growing media contain thoroughly mixed sugarcane bagasse, river silt and coconut coir with a ratio of 65.30.05 v/v basis.

Treatment plan

The study included of thirty-six treatments, which included twelve different rootstocks [Sindhri, Dusehri, Langra, Anwar Retaul, Chaunsa Sammar Bahisht, Fajri, Chenab Gold, Azeem Chaunsa, Sufaid

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Chaunsa, Kala Chaunsa, Late Retaul and Desi (stone extracted from fruit of seedling mango tree)].

Scion collection

The young vigorous mango tree of three cultivars as Sindhri, Chaunsa Sammar Bahisht and Sufaid Chaunsa was selected for clipping of scion. The scion was clipped as terminal twig, with mature green hard leaves having age from three- to four-month-old with no signs of insect, disease or other blemishes. The terminal tip of scions is treated with 2% solution of thiophanate methyl containing 5ppm GA_3 in order to avoid malformation and quick sprouting.

Grafting Technique

Wedge grafting was performed on the rootstock seedling which attained compatible girth onto scion. After insertion of wedge into rootstock and firmly joined the cambium of both rootstock and scion, it was tied with a transparent plastic sheet.

Observations and Parameters

Observations were recorded for the following parameters:

- **Days to Sprout Grafts:** Measured at 15, 30, and 45 days after grafting (DAG).
- **Sprout Length:** Measured in centimeters at 15, 30, and 45 DAG.
- **Graft Success Percentage:** Evaluated at 15, 30, and 45 DAG.
- **Height of Grafted Plant:** Measured in centimetres at 15, 30, and 45 DAG.
- **Scion Girth:** Measured in millimeters at 30, 60, and 90 DAG.
- **Root-Collar Diameter:** Measured in millimeters at 30, 60, and 90 DAG.
- **Number of Leaves per Graft:** Counted at 30, 60, and 90 DAG.
- **Stone weight:** The weight of the individual stones was calculated by using electric balance.
- **Emergence days:** The germination of stone was calculated as day of sowing till emergence of the epicotyl from growing medium
- **Germination %:** The germination percentage of the seedling were calculated total number of stones sown and total emergence of the seedling and percentage was calculated by the formula.
- **Epicotyl length:** The length of stone till the first expanded leaf was calculated with the help of scale.
- **Vigor:** The emerged seedling vigor was calculated depending upon their strength and health of the seedling and marked as signs +, ++ and +++ on apparent basis.

Quantitative analysis of data using statistical methods.

The study utilized a factorial randomized full block design with three replications containing twelve rootstocks versus three scions. The means were compared by using LSD test and the interpretations were based on the guidelines provided by Panse and Sukhatme (1967).

Results

Number of Days Taken for Sprout Emergence

Anwar Retaul (12.47 days) and Chaunsa Sammer Bahisht (12.50 days) exhibited the shortest duration for sprout emergence among the various rootstocks. While, longest duration for sprout emergence was exhibited by Dusehri (18.07) followed by Late Retaul (17.30) and Sindhri (17.00) as represented in table 1. The variation in performance can be ascribed to the innate vigor of the rootstocks and the genetic compatibility between the scion and rootstock.

Length of the sprout

The rootstock Anwar Retaul had the longest sprout length at 45 DAG, measuring 6.08 cm followed by Chaunsa Sammer Bahisht (5.68) and Kala Chaunsa (5.50). The excellent fusion of grafts and strong vascular activity in these varieties certainly influenced these outcomes (table 1).

Table 1. Effect of different mango rootstocks and scion combinations on days for sprout emergence, sprout length, and graft success

Treatment	Days for Emergence of Sprouts (45 DAG)	Sprout Length (45 DAG)	Graft Success (%)
Sindhri	17.00c	5.18d	85.55b
Dusehri	18.07d	4.70g	76.67d
Langra	16.37g	5.14d	80.83c
Anwar Retaul	12.47g	6.08a	89.17a
Chaunsa Sammer Bahisht	12.50g	5.68b	86.67a
Fajri	13.20h	5.26d	76.67d
Chenab Gold	16.50e	4.90f	78.50c
Azeem Chaunsa	14.70f	5.30d	81.00b
Sufaid Chaunsa	15.60e	5.40c	84.00b
Kala Chaunsa	16.80d	5.50c	83.50b
Late Retaul	17.30c	4.80f	77.00c
Desi	15.00f	5.25d	82.00b

Successful graft

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The rootstock Anwar Retaul demonstrated a graft success rate of 89.17%, while the variety Chaunsa Sammer Bahisht exhibited a graft success rate of 86.67%, both of which were the highest among the tested varieties (table 1). The success rates were significantly influenced by the environmental circumstances, including temperature and humidity, as well as the genetic compatibility of the rootstock-scion combination.

Plant's Vertical Measurement

The plants that reached the greatest height at 45 days after grafting (DAG) were found in the Anwar Retaul rootstock (table 2), measuring 29.40 cm followed by Chaunsa Sammer Bahisht (28.25 cm) and Langra (27.45 cm). This can be attributed to the strong growth characteristics and effective absorption of nutrients enabled by the harmonious combination of the rootstock and scion.

Scion Girth

The Chaunsa Sammer Bahisht rootstock exhibited the largest scion girth, measuring 5.67 mm. The heightened vascular cambium activity resulting from the compatibility between the rootstock and scion is likely responsible for the observed increase in girth (table 2).

Root-Collar Diameter refers to the measurement of the diameter of a tree's trunk at the base, where the roots meet the trunk.

The Chaunsa Sammer Bahisht rootstock had the biggest root-collar diameter, measuring 6.57 mm, followed closely by the Azeem Chaunsa with a diameter of 6.55 mm. While Late Retaul showed minimum values (6.40) among all rootstocks (table 2).

Leaf count per graft

The combination of Sindhri and Chaunsa Sammer Bahisht exhibited the highest number of leaves per graft (19.33) indicating the robust growth and superior photosynthetic efficiency of this combination. While, the combination Kala Chaunsa + Sufaid Chaunsa exhibited the lowest number of leaves per graft (16) as represented in table 3.

Stone weight

Maximum stone weight was observed in Sufaid Chaunsa (72g) followed by Sindhri (70 g) and Chaunsa Sammer Bahisht (68 g). While, lowest stone weight was exhibited by Langra (30g) followed by Dusehri (32g) and Anwar Retaul (32g) as presented in table 4.

Germination days

Among all the rootstocks under study, Langra showed maximum days to germination (19) (table 4). Sufaid Chaunsa showed minimum days to germination (16) followed by Anwar Retaul, Chaunsa Sammer Bahisht, Azeem Chaunsa and Desi (which all showed 17 days to germination).

Table 2. Effect of different mango rootstocks and scion combinations on height of grafted plant, scion girth, and root collar diameter

Treatment	Height of Grafted Plant (45 DAG)	Scion Girth (mm) (90 DAG)	Root Collar Diameter (mm) (90 DAG)
Sindhri	26.22d	5.57b	6.50
Dusehri	25.95e	5.54b	6.46
Langra	27.45c	5.53b	6.49
Anwar Retaul	29.40a	5.59b	6.47
Chaunsa Sammer Bahisht	28.25b	5.67a	6.57
Fajri	27.00c	5.50b	6.45
Chenab Gold	26.50d	5.45c	6.42
Azeem Chaunsa	27.20c	5.60b	6.55
Sufaid Chaunsa	27.10c	5.52b	6.50
Kala Chaunsa	26.80d	5.49c	6.44
Late Retaul	26.70d	5.46c	6.40
Desi	27.30c	5.55b	6.53

Germination %

In terms of germination %, Chaunsa Sammer Bahisht showed maximum values (71%) followed by Sindhri (70%) and Sufaid Chaunsa (68%). Least values of germination % were observed in Dusehri and Late Retaul (50) (table 4).

Epicotyl length

Chaunsa Sammer Bahisht showed highest lengths of epicotyls measuring 12 cm among all the varieties under study followed by Sufaid Chaunsa (11 cm), Sindhri (10cm). lowest values for this parameter were observed in Langra (5cm), Dusehri (6cm), Anwar Retaul (6cm) and Late Retaul (6cm) (table 4).

Vigor

The results revealed that seedling of the mango varieties like Sindhri, Chaunsa Sammer Bahisht were found maximum seedling germination as well as vigor indexed as most suitable for sowing of nursery while Azeem Chaunsa, Sufaid Chaunsa and Kala Chaunsa seedling had vigor index as less suitable due to having late varieties and late availability of the seeds for the sowing of nursery plants (table 4).

Discussion

Studying the relationships between rootstocks and scions in specific climatic conditions will offer valuable knowledge for mango cultivators in Pakistan (Zahid *et al.*, 2022). It will aid in choosing the most

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appropriate combinations for various regions, hence improving the overall efficiency and profitability of mango orchards (Santhi *et al.*, 2020).

The experiment conducted at the Mango Research Station in Shujabad, Pakistan, yielded valuable findings regarding the performance of several combinations of mango rootstocks and scions in the specific climatic circumstances of the region. Out of the different rootstocks that were assessed, Anwar Retaul and Chaunsa Sammer Bahisht exhibited exceptional outcomes in terms of graft success, growth, and development. Anwar Retaul exhibited the highest percentage of successful grafting, specifically at 89.17 %, with Chaunsa Sammer Bahisht and Sindhri closely trailing after. The high success rate demonstrates a robust compatibility and adaptability to the climate of Shujabad.

In addition, Anwar Retaul had the quickest sprout emergence, with an average of 12.47 days, and yielded the longest sprouts, measuring 6.08 cm at 45 days after grafting (DAG). The grafted plants on Anwar Retaul exhibited the greatest height. Similar results were also observed by (Nikam, 2021).

Chaunsa Sammer Bahisht also exhibited the most substantial scion growth, with an average girth of 5.60 mm, suggesting strong and vigorous development. The combination of Sindhri and Chaunsa Sammer Bahisht exhibited the maximum leaf yield, with 19.33 leaves per graft at 90 days after grafting (DAG). The combination of Anwar Retaul and Chaunsa Sammer Bahisht proved to be the most efficient coupling when considering various factors.

The data on germination and seedling vigor further support the superiority of certain rootstocks. Chaunsa Sammer Bahisht exhibited the highest germination percentage (71%) and the greatest epicotyl length (12 cm), indicating its potential for vigorous growth and development. Sindhri also showed high germination rates and significant seedling vigor. These results suggest that Chaunsa Sammer Bahisht and Sindhri are the most suitable varieties for mango propagation under the conditions studied.

These findings are especially beneficial for mango cultivators in Shujabad and comparable areas. Similar results were also obtained by (Ajal & Kizito, 2012; Kumar *et al.*, 2006; Rathore *et al.*, 2023). By choosing the most advantageous combinations, such as Anwar Retaul and Chaunsa, one can greatly improve the production, uniformity, growth, and economic efficiency of an orchard (Abbasi *et al.*).

The study highlights the significance of continuous research on mango grafting methods and the compatibility between rootstock and scion to enhance production, quality, and resistance against pests and diseases. Continuing this research is crucial to bolster the sustainable expansion and efficiency of mango plantations in Pakistan and other locations that produce mangoes.

Conclusion

The study at the Mango Research Station in Shujabad, Pakistan, demonstrated that Anwar Retaul rootstock consistently outperformed others in terms of rapid sprout emergence, sprout length, successful grafting rate, plant height, and leaf count per graft. Chaunsa Sammer Bahisht scion exhibited quick sprouting, significant sprout length, and high grafting success rates across different rootstocks, with optimal results observed when grafted onto Anwar Retaul.

Table 3. effect of different mango rootstocks and scion combinations on number of leaves per graft (90 DAG)

Rootstocks	Sindhri	Chaunsa Sammar Bahisht	Sufaid Chaunsa	Mean
Sindhri	18.33a	19.33a	17.23e	18.30a
Dusehri	17.70c	18.40b	17.33d	17.81b
Langra	17.10d	18.00c	16.80f	17.30c
Anwar Retaul	16.50f	17.80c	16.20g	16.83d
Chaunsa Sammer Bahisht	16.80e	17.50d	16.60f	16.97c
Fajri	17.20d	17.90c	16.70f	17.27c
Chenab Gold	16.70f	17.20e	16.10g	16.67d
Azeem Chaunsa	17.00e	17.60d	16.50f	17.03c
Sufaid Chaunsa	17.30d	18.10b	17.00e	17.47b
Kala Chaunsa	16.40g	17.00e	16.00g	16.47d
Late Retaul	17.50c	18.20b	17.10e	17.60b
Desi	17.00e	18.00c	16.90e	17.30c

***Note**: The letters (a, b, c, etc.) next to the values indicate significant differences between the means as determined by statistical analysis*

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Table 4. Impact of germination and seedling strength of various rootstock seedlings utilized for commercial application

Rootstocks	Stone weight (g)	Germination Days	Germination %	Epicotyl Length (cm)	Vigor
Sindhri	70	18	70	10	+++
Dusehri	32	18	50	06	+
Langra	30	19	52	05	+
Anwar Retaul	32	17	62	06	+
Chaunsa Sammer Bahisht	68	17	71	12	+++
Fajri	62	18	60	07	+
Chenab Gold	42	18	59	08	+
Azeem Chaunsa	35	17	60	07	++
Sufaid Chaunsa	72	16	68	11	++
Kala Chaunsa	55	18	67	08	++
Late Retaul	33	18	50	06	+
Desi	33	17	58	07	+

+++ most suitable, ++ less suitable, + not suitable

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Declaration

Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

The study was approved by authors.

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Conflict of Interest

There is no conflict of interest among the authors regarding this case study.

Authors Contribution

All authors contributed equally.