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# Influence of clonal rootstocks on fruit quality of exotic apple varieties under ambient storage conditions

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## ABSTRACT

*Clonal rootstocks have been used by the fruit growers in scientifically advanced countries for better management and quality fruit production. Investigation was carried out to study the effect of clonal rootstocks on storage behavior on two exotic apple (Vance Delicious and Silver Spur) varieties grafted on three clonal rootstocks (M-9, M-4, MM-106) planted in the experimental orchard of Division of Fruit Science, SKUAST-Kashmir, Shalimar campus, Srinagar. The experiment was laid out in Randomized Block Design with four replications having two plants in each replication. Thirty fruits from each cultivar were stored under ambient conditions for 90 days and observations on quality parameters were taken at 15 days intervals. Results revealed that trees on dwarfing rootstock M-9 stood best in terms of minimum physiological loss in weight, spoilage, and acidity whereas maximum TSS and fruit firmness were recorded in semi-dwarfing rootstock MM-106. Among cultivars, Silver Spur registered a minimum physiological loss in weight, spoilage, acidity and maximum total soluble solids and fruit firmness as compared to Vance Delicious. From the present study, it was concluded that under ambient conditions fruits of Silver Spur grafted on M-9 clonal rootstock performed best.*

***Keywords:*** *clonal, rootstocks, fruit, quality, exotic, apple, ambient, storage*

## INTRODUCTION

Apple is a temperate fruit and its cultivation is concentrated in areas where the environment is particularly favourable however chill apple cultivars are also grown in plains of the Northern part of the country [1]. In India apple is grown in Jammu and Kashmir, Himachal Pradesh, Uttarakhand and few areas of the Northeastern states. The apple is the most ubiquitous of temperate fruits and has been cultivated in Europe and Asia from antiquity. Apple can be grown at an altitude of 1,500-2,700 amsl which requires 1,000-1,500 hours of annual chilling [2]. Apples may be eaten off the tree or stored for a longer period. Apples can be processed into sauce, slices, or juice and are favored for pastries, cakes tarts, and pies. The juice can be consumed fresh, either natural or filtered, fermented into alcoholic beverages such as cider or wine, distilled into brandy, or transformed into vinegar [3]. The productivity of apple in scientifically advanced countries is 50-60 MT/ha but in Jammu and Kashmir, it is only 11.24 MT/ha [4]. One of the main reasons of this low productivity is the uneven and unpredictable yields registered by the use of incompatible varieties, seedling rootstocks and low-density orchards. Apple trees grown on seedling rootstock often tend to develop into large and vigorous trees making its management difficult. There is more competition between vegetative growth and fruit production within these trees and their internal self-shading makes them more vulnerable to various diseases.

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In fact apple industry of Jammu and Kashmir is yet to come to its full strength so it has become imperative to go for high-density plantation for which change in rootstock from vigorous to size-controlling rootstock is a prerequisite. The development of high-density system with the use of dwarfing rootstocks also provides a faster return on investment although the initial costs tend to be somewhat on the higher side. Clonal rootstocks have been used by fruit growers in scientifically advanced countries for better management and quality fruit production [5], [6].

Further in Jammu and Kashmir, apple acreage is dominated by a major proportion of Red Delicious variety. In spite of the consistent increase in area under apple, the production has not proportionally increased. The need of the hour is to upgrade the varietal status of apple through the use of spur varieties and colour mutants for better productivity and marketability. Hence the clonal rootstocks in combination with specific scion varieties offer great potential to improves productivity, quality and shelf life of apple. Keeping in view the above-mentioned facts, the present investigation was carried out to study the effect of rootstocks on the storability of apple varieties grafted on clonal rootstocks under temperate conditions.

## MATERIALS AND METHODS

The present study was carried out on three-year-old plants of two exotic apple (Vance Delicious and Silver Spur) varieties grafted on three clonal rootstocks (M-9, M-4, MM-106) planted in the experimental orchard of the Division of Fruit Science, SKUAST-Kashmir, Shalimar campus, Srinagar during 2015-2016. The experiment was laid out in Randomized Block Design with four replications having two plants in each replication. Freshly harvested fruits were stored for 90 days under ambient conditions and observations were recorded after every 15 days interval on physiological loss in weight (%), spoilage (%), TSS ($^{o}$B), acidity (%), TSS/acid ratio and fruit firmness (lb/inch$^{2}$).

At random ten fruits from each replication and treatment were weighed, labeled, and kept separate from other fruits at harvest. The initial weight of fruits was recorded at harvest and thus physiological loss in weight (PLW) at different interval periods under study was worked out as per given formula

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Weight at 'x' days of storage}}{\text{Initial weight}} \times 100$$

Spoilage per cent of stored fruits was calculated on the basis of number of fruits that had spoiled out of total stored fruits during storage using following formula

$$\text{Rotting (\%)} = \frac{\text{Number of rotten fruits at 'x' days of storage}}{\text{Total number of stored fruits}} \times 100$$

Fruit firmness was determined with the help of a digital Effegi pressure tester plunger and expressed in lb/inch$^2$. Total soluble solids (%), acidity (%) and TSS/acid ratio was determined as per the standard procedures [7]. Data generated from these investigations were appropriately computed, tabulated and statistically analyzed as per the procedure given by Snedecor and Cochran [8]. The level of significance was tested for different variables at 5 per cent level of significance.

## RESULTS AND DISCUSSION

Clonal rootstocks and varieties of apple exerted a significant effect on physiological loss in weight and spoilage percentage of fruit (Table 1). A significant loss in physiological weight of fruit was observed during 90 days of storage and minimum physiological loss in weight after 15, 30, 45, 60, 75 and 90 days of ambient storage was recorded in dwarfing clonal rootstock M.9 (2.6, 3.6, 6.4, 9.2, 13.6 and 19.0%, respectively) whereas maximum physiological loss in weight was registered by semi-dwarfing rootstock MM-106 after 15, 30, 45, 60, 75 and 90 days of storage under ambient conditions with a value of 3.7, 5.0, 7.6, 10.5, 14.1 and 23.5 per cent, respectively. Among varieties minimum physiological loss in weight was recorded in Silver Spur with a value of 2.7, 3.9, 6.5, 8.9, 12.4 and 19.2 per cent after storage of 15, 30, 45, 60, 75, and 90 days, respectively under ambient conditions whereas maximum physiological loss in weight was recorded in Vance Delicious apple (3.6, 4.3, 7.8, 10.5, 15.3 and 23.8%, respectively).M-9 clonal rootstock (1.11, 4.99, 9.16, 12.49, 17.33 and 22.44 %) registered minimum spoilage percentage after 15, 30, 45, 60, 75 and 90 days of storage under ambient conditions however maximum spoilage percentage after 15, 30, 45, 60, 75 and 90 days of ambient storage was observed in semi-dwarfing rootstock MM-106 with a value of 2.25, 11.66, 17.49, 19.83, 22.49 and 25.00 %). Highest spoilage percentage was recorded in Vance Delicious (1.87, 8.88, 13.33, 16.21, 20.99 and 25.72 %) while as lowest spoilage percentage was noticed in Silver Spur (1.53, 7.77, 11.66, 14.88, 17.77 and 21.55%).

Interaction studies between clonal rootstocks and varieties showed non-significant results for physiological loss in weight and spoilage percentage. Water losses through skin evapotranspiration are the main cause of fruit weight loss and to some extent, respiration also contributes in water losses and it is also well known that stored fruit loose weight as the storage period prolongs. Maximum physiological loss in fruit weight in MM106 in the present study may be attributed to the inhibition of insoluble protopectin into water-soluble pectin by fruits of trees grafted on MM-106 which results in delayed softening of fruits. Small fruits have more percentage of cell wall material and, therefore; have more firmness than larger fruits. This might be due to the slow loss of water resulting in shrinkage and softening as well as decreased respiration rate and solubile enzymatic activity [9]. Similar results with respect to loss in fruit weight during storage period while working on Red Chief apple grafted on MM-106 and MM-111 clonal rootstocks [10].

The firmness of the stored fruits were significantly influenced by clonal rootstocks and varieties (Table 3) and highest firmness after 0, 15, 30,45,60,75 and 90 days of ambient storage conditions was recorded in semi-dwarfing rootstock MM-106 (18.05, 15.87, 13.62, 12.91, 13.47, 11.13 and 11.00 lb/inch$^2$) whereas lowest firmness was found in dwarfing rootstock M-9 (17.08, 13.33, 11.82, 12.43, 11.10, 11.00 and 10.42 lb/inch$^2$). Highest firmness was recorded in Silver Spur (18.21, 15.53, 13.76, 12.74, 12.10, 11.74 and 11.13 lb/inch$^2$). While as lowest firmness was noticed in Vance Delicious (16.70, 13.83, 11.85, 12.49, 11.13, 10.58 and 10.19 lb/inch$^2$). Interaction between clonal rootstock and variety showed a non-significant effect on fruit firmness. The present study revealed that plants grafted on MM-106 clonal rootstock had significantly higher fruit firmness when compared with MM-111 and M-9 clonal rootstocks during storage under ambient conditions. This can be attributed to the inhibition of insoluble protopectin into water-soluble pectin by fruits of trees grafted on MM-106 which results in delayed softening of fruits. Small fruits have a higher percentage of cell wall material therefore; more firmer than larger fruits. Our findings are backed up by Tsipouridis and Thomidis [11], Cantin *et al.* [12] and Tareen *et al.* [13] who reported that fruit firmness was significantly influenced by scion-rootstock combinations.

A significant effect of clonal rootstocks and varieties was observed on fruit quality (TSS, acidity and TSS/acid ratio) parameters. Maximum total soluble solids was recorded in semi-dwarfing clonal rootstock MM-106 (12.72, 13.06, 13.33, 13.66, 14.90, 16.22 and 17.50°B) after 0, 15, 30,45,60,75 and 90 days of storage under ambient condition however minimum total soluble solids was found in dwarfing rootstock M-9 (11.58, 12.06, 12.92, 12.83, 14.50, 15.74 and 17.15°B).Highest total soluble solid was recorded in Silver Spur (13.36, 13.42, 13.55, 13.61, 15.21, 16.41 and 17.9°B) whereas lowest total soluble solid was observed in Vance Delicious (11.19, 11.50, 12.82, 13.05, 14.21, 15.61 and 16.71°B) after 0, 15, 30,45,60,75 and 90 days of storage under ambient condition (Table 3). Soluble solid content is one of the main quality attributes that contribute towards fruit acceptability. It is well known that the soluble solids content of fruit increases during storage due to insoluble starch conversion into soluble solids [14]. In other words, soluble solids content changes are directly correlated with hydrolytic changes in the starch concentration in harvested fruits and these changes cause starch conversion into sugars, which are vital index for the ripening process. Jimenez *et al.* [15] in cherry and Tareen *et al.* [13] in peach have described that fruit total soluble solid content was influenced significantly by different rootstocks.

Among the studied rootstocks, minimum acidity was observed in dwarfing rootstock M-9 (0.74, 0.71, 0.61, 0.50, 0.50, 0.42 and 0.27%) after 0, 15, 30,45,60,75 and 90 days of storage under ambient conditions whereas maximum acidity was recorded in semi-dwarfing rootstock MM-106 (0.85, 0.77, 0.65, 0.84, 0.64, 0.56 and 0.58%). Cv. Silver Spur scored minimum acidity values (0.79, 0.70, 0.61, 0.57, 0.53, 0.51, and 0.42%) after storage of 0, 15, 30,45,60,75, and 90 days, respectively under ambient storage conditions however maximum acidity was noticed in Vance Delicious (0.83, 0.79, 0.66, 0.60, 0.58, 0.54 and 0.46%).

Fruits with higher levels of titrable acidity showed better performance in terms of intact quality. This can be because of decreased transformation of insoluble starch into soluble solids. Present results are in agreement with Ozdemir *et al.* [10]. TSS/acid ratio of the stored fruits were significantly influenced by both clonal rootstocks and varieties (Fig 1) and maximum TSS/acid ratio after 0, 15, 30, 45, 60, 75 and 90 days of ambient storage conditions were recorded in semi-dwarfing rootstock M-9 (15.64, 16.98, 21.18, 25.66, 29.00, 37.47 and 63.51) whereas minimum TSS/acid ratio was found in dwarfing rootstock MM-106 (14.96, 16.96, 20.50, 16.26, 23.28, 28.96 and 36.45). Among studied varieties, maximum TSS/acid ratio was recorded in Silver Spur (16.91, 19.17, 22.21, 23.87, 28.69, 32.17 and 42.64) whereas Vance Delicious (13.48, 14.55, 19.42, 21.75, 24.50, 28.90 and 36.32) registered minimum TSS/acid ratio after 0, 15, 30, 45, 60, 75 and 90 days of storage under ambient conditions. Non-significant results were observed between interaction studies of clonal rootstock and variety for TSS, acidity and TSS acid ratio.

## CONCLUSION

From the present investigation, it was concluded 1that among cultivars Silver Spur performed better in terms of minimum physiological loss in weight, spoilage and acidity along with maximum fruit firmness and TSS as compared to Vance Delicious. Dwarfing rootstock M-9 gave the best results and offered minimum physiological loss in weight, spoilage, and acidity however maximum firmness and total soluble solids fruit were registered in MM-106 clonal rootstocks during storage under ambient conditions.

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**Author contribution:** Shiekh Amir Mushtaq, Aroosa Khalil: Data curation, Investigation; Amit Kumar: Writing – original draft. Aroosa Khalil, Amit Kumar: Formal analysis; Project administration; Methodology. Nowsheen Nazir, Safura Nabi: Conceptualization; Supervision. Nowsheen Nazir: Visualization.

**Ethical guidelines:** Ethics approval was not required for this research work.

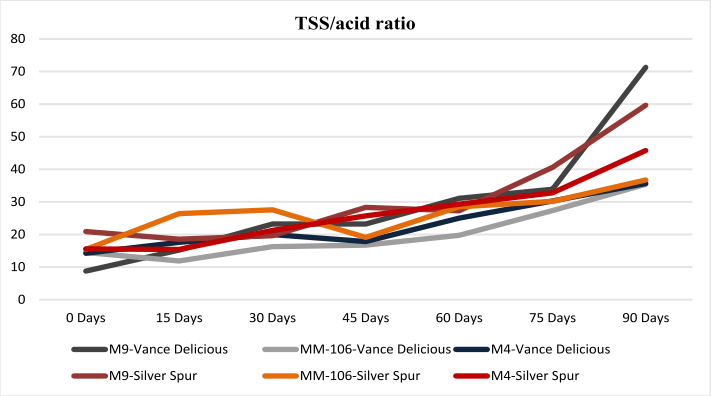


***Fig 1 Effect of rootstocks on TSS/acid ratio of apple varieties during ambient storage***

***Table 1 Effect of rootstocks on physiological loss in weight (%) of apple varieties during storage***

| Rootstock / Variety | 15 days | | | | 30 days | | | | 45 days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean |
| Vance Delicious | 3.7 | 3.4 | 3.6 | 3.6 | 3.9 | 4.9 | 4.0 | 4.3 | 7.6 | 7.4 | 8.6 | 7.8 |
| Silver Spur | 1.4 | 3.9 | 2.7 | 2.7 | 3.3 | 5.1 | 3.5 | 3.9 | 5.2 | 7.8 | 6.4 | 6.5 |
| Mean | 2.6 | 3.7 | 3.1 | | 3.6 | 5.0 | 3.7 | | 6.4 | 7.6 | 7.5 | |
| $CD_{0.05}$ | | | | | | | | | | | | |
| Rootstock | | 0.20 | | | | 0.40 | | | | 0.87 | | |
| Variety | | 0.35 | | | | 0.10 | | | | 0.80 | | |
| R x V | | NS | | | | NS | | | | NS | | |

***Contd……..***

| Rootstock / Variety | 60 days | | | | 75 days | | | | 90 days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean |
| Vance Delicious | 10.4 | 10.7 | 10.5 | 10.5 | 14.8 | 15.6 | 15.4 | 15.3 | 18.8 | 27.4 | 25.3 | 23.8 |
| Silver Spur | 8.1 | 10.4 | 8.3 | 8.9 | 12.4 | 12.6 | 12.2 | 12.4 | 19.3 | 19.7 | 18.8 | 19.2 |
| Mean | 9.2 | 10.5 | 9.4 | | 13.6 | 14.1 | 13.8 | | 19.0 | 23.5 | 22.0 | |
| $CD_{0.05}$ | | | | | | | | | | | | |
| Rootstock | | 0.20 | | | | 0.01 | | | | 1.20 | | |
| Variety | | 0.33 | | | | 0.95 | | | | 1.60 | | |
| R x V | | NS | | | | NS | | | | NS | | |

***Table 2 Effect of rootstocks on spoilage percentage of apple varieties during storage***

| Rootstock / Variety | 15 days | | | | 30 days | | | | 45 days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean |
| Vance Delicious | 1.23 | 2.60 | 1.80 | 1.87 | 6.66 | 8.33 | 11.66 | 8.88 | 10.00 | 18.33 | 11.66 | 13.33 |
| Silver Spur | 1.00 | 1.90 | 1.70 | 1.53 | 3.33 | 15.00 | 5.00 | 7.77 | 8.33 | 16.66 | 10.00 | 11.66 |
| Mean | 1.11 | 2.25 | 1.75 | | 4.99 | 11.66 | 8.33 | | 9.16 | 17.49 | 10.83 | |
| $CD_{0.05}$ | | | | | | | | | | | | |
| Rootstock | | 0.80 | | | | 1.33 | | | | 2.66 | | |
| Variety | | 0.10 | | | | 0.27 | | | | 0.30 | | |
| R x V | | NS | | | | NS | | | | NS | | |

***Contd……..***

| Rootstock / Variety | 60 days | | | | 75 days | | | | 90 days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean |
| Vance Delicious | 13.33 | 21.66 | 13.66 | 16.21 | 19.66 | 23.33 | 20.99 | 20.99 | 25.23 | 26.00 | 25.94 | 25.72 |
| Silver Spur | 11.66 | 18.00 | 15.00 | 14.88 | 15.00 | 21.66 | 16.66 | 17.77 | 19.66 | 24.00 | 21.00 | 21.55 |
| Mean | 12.49 | 19.83 | 13.33 | | 17.33 | 22.49 | 18.33 | | 22.44 | 25.00 | 23.47 | |
| $CD_{0.05}$ | | | | | | | | | | | | |
| Rootstock | | 1.10 | | | | 2.60 | | | | 0.94 | | |
| Variety | | 0.33 | | | | 1.91 | | | | 1.12 | | |
| R x V | | NS | | | | NS | | | | NS | | |

***Table 3 Effect of rootstocks on total soluble solids (%) of apple varieties during storage***

| Rootstock / Variety | 0 days | | | | 15 days | | | | 30 days | | | | 45 days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean |
| Vance Delicious | 10.19 | 11.57 | 11.82 | 11.19 | 11.12 | 12.12 | 11.27 | 11.50 | 12.30 | 13.17 | 13.00 | 12.82 | 12.07 | 13.72 | 13.37 | 13.05 |
| Silver Spur | 12.98 | 13.87 | 13.25 | 13.36 | 13.00 | 14.00 | 13.26 | 13.42 | 13.55 | 13.50 | 13.60 | 13.55 | 13.60 | 16.61 | 13.63 | 13.61 |
| Mean | 11.58 | 12.72 | 12.53 | | 12.06 | 13.06 | 12.26 | | 12.92 | 13.33 | 13.30 | | 12.83 | 13.66 | 13.49 | |
| $CD_{0.05}$ | | | | | | | | | | | | | | | | |
| Rootstock | | 0.14 | | | | 0.30 | | | | 0.15 | | | | 0.75 | | |
| Variety | | 0.36 | | | | 0.55 | | | | 0.25 | | | | 0.10 | | |
| R x V | | NS | | | | NS | | | | NS | | | | NS | | |

***Contd……..***

| Rootstock / Variety | 60 days | | | | 75 days | | | | 90 days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean |
| Vance Delicious | 14.00 | 14.40 | 14.25 | 14.21 | 15.25 | 15.85 | 15.75 | 15.61 | 16.40 | 17.00 | 16.75 | 16.71 |
| Silver Spur | 15.00 | 15.40 | 15.25 | 15.21 | 16.23 | 16.60 | 16.40 | 16.41 | 17.90 | 18.00 | 17.85 | 17.91 |
| Mean | 14.50 | 14.90 | 14.75 | | 15.74 | 16.22 | 16.07 | | 17.15 | 17.50 | 17.30 | |
| $CD_{0.05}$ | | | | | | | | | | | | |
| Rootstock | | 0.10 | | | | 0.21 | | | | 0.15 | | |
| Variety | | 0.50 | | | | 0.60 | | | | 1.00 | | |
| R x V | | NS | | | | NS | | | | NS | | |

***Table 4 Effect of rootstocks on acidity (%) of apple varieties during storage***

| Rootstock / Variety | 0 days | | | | 15 days | | | | 30 days | | | | 45 days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean |
| Vance Delicious | 0.86 | 0.80 | 0.83 | 0.83 | 0.73 | 1.02 | 0.64 | 0.79 | 0.53 | 0.81 | 0.65 | 0.66 | 0.52 | 0.82 | 0.75 | 0.60 |
| Silver Spur | 0.62 | 0.90 | 0.85 | 0.79 | 0.70 | 0.53 | 0.86 | 0.70 | 0.69 | 0.49 | 0.64 | 0.61 | 0.48 | 0.87 | 0.53 | 0.57 |
| Mean | 0.74 | 0.85 | 0.84 | | 0.71 | 0.77 | 0.75 | | 0.61 | 0.65 | 0.64 | | 0.50 | 0.84 | 0.64 | |
| $CD_{0.05}$ | | | | | | | | | | | | | | | | |
| Rootstock | | NS | | | | 0.03 | | | | 0.002 | | | | 0.28 | | |
| Variety | | NS | | | | 0.02 | | | | 0.01 | | | | 0.01 | | |
| R x V | | NS | | | | NS | | | | NS | | | | NS | | |

***Contd……..***

| Rootstock / Variety | 60 days | | | | 75 days | | | | 90 days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean |
| Vance Delicious | 0.45 | 0.73 | 0.57 | 0.58 | 0.45 | 0.58 | 0.52 | 0.54 | 0.23 | 0.48 | 0.47 | 0.46 |
| Silver Spur | 0.55 | 0.54 | 0.52 | 0.53 | 0.40 | 0.55 | 0.50 | 0.51 | 0.30 | 0.49 | 0.39 | 0.42 |
| Mean | 0.50 | 0.64 | 0.54 | | 0.42 | 0.56 | 0.51 | | 0.27 | 0.48 | 0.43 | |
| $CD_{0.05}$ | | | | | | | | | | | | |
| Rootstock | | 0.06 | | | | 0.04 | | | | 0.12 | | |
| Variety | | 0.02 | | | | 0.001 | | | | 0.002 | | |
| R x V | | NS | | | | NS | | | | NS | | |

***Table 5 Effect of rootstocks on firmness (lb/inch2) of apple varieties during storage***

| Rootstock / Variety | 0 days | | | | 15 days | | | | 30 days | | | | 45 days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean |
| Vance Delicious | 17.21 | 16.23 | 16.66 | 16.70 | 10.76 | 17.83 | 12.90 | 13.83 | 11.02 | 11.87 | 12.67 | 11.85 | 11.46 | 13.47 | 12.53 | 12.49 |
| Silver Spur | 18.89 | 17.92 | 17.82 | 18.21 | 15.91 | 13.91 | 16.76 | 15.53 | 12.62 | 15.37 | 13.30 | 13.76 | 13.40 | 12.35 | 12.50 | 12.74 |
| Mean | 18.05 | 17.08 | 17.24 | | 13.33 | 15.87 | 14.83 | | 11.82 | 13.62 | 12.98 | | 12.43 | 12.91 | 12.51 | |
| $CD_{0.05}$ | | | | | | | | | | | | | | | | |
| Rootstock | | 0.89 | | | | 0.65 | | | | 0.25 | | | | 0.05 | | |
| Variety | | 0.75 | | | | 1.00 | | | | 0.10 | | | | 0.15 | | |
| R x V | | NS | | | | NS | | | | NS | | | | NS | | |

***Contd……..***

| Rootstock / Variety | 60 days | | | | 75 days | | | | 90 days | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean | M9 | MM-106 | M4 | Mean |
| Vance Delicious | 8.15 | 13.49 | 11.76 | 11.13 | 11.00 | 10.30 | 10.45 | 10.58 | 10.00 | 10.45 | 10.12 | 10.19 |
| Silver Spur | 12.06 | 13.45 | 10.79 | 12.10 | 11.00 | 12.32 | 11.90 | 11.74 | 10.85 | 11.55 | 11.00 | 11.13 |
| Mean | 10.10 | 13.47 | 11.27 | | 11.00 | 11.31 | 11.17 | | 10.42 | 11.00 | 10.56 | |
| $CD_{0.05}$ | | | | | | | | | | | | |
| Rootstock | | 0.20 | | | | 0.70 | | | | 0.20 | | |
| Variety | | 1.05 | | | | 0.08 | | | | 0.10 | | |
| R x V | | NS | | | | NS | | | | NS | | |

## References


1. Salama, A.M., Ezzat, A., El-Ramady, H., Alam-Eldein, S.M., Okba, S., Elmenofy, H.M., Hassan, I.F.,Illés, A. and Holb, I.J. 2021. Temperate fruit trees under Climate Change: Challenges for dormancy and chilling requirements in Warm Winter Regions. *Horticulturae* 7: 86. https://doi.org/10.3390/horticulturae7040086

2. Dolker, T., Kumar, D., Chandel, J.S., Angmo, S., Chaurasia, O.P. and Stobdan, T. 2021. Phenological and Pomological characteristics of native Apple (*Malus x domestica* Borkh.) Cultivars of Trans-Himalayan Ladakh, India. *Defence Life Science Journal* 6(1): 63-68

3. Abdualrahman, M.A.Y. 2015. Comparative study between local and imported Apple (*Malus domestica*) fruits and their uses in Juice Production. *Science International* 3(2): 69-72

4. Anonymous, 2022. District-wise area and production under major horticultural crops in J & K UT during the year 2021-2022. Directorate of Horticulture, Kashmir.

5. Kumar, A., Rathore, J.P., Iqbal, U., Sharma, A., Nagar, P.K. and Mir, M.M. 2021. Rootstocks of Stone Fruit Crops. *In:* Mir, M.M., Iqbal, U. and Mir S.A. (eds.). *Production Technology of Stone Fruits*.Springer, Singapore.pp 131-169

6. Bashir, A. Ganai, N.A., Qayoom, S. and Yousuf, M.W. 2023. Influence of clonal rootstocks on major morphological characteristics of some exotic Apple cultivars in Northern Himalayas of Kashmir valley. *Biological Forum – An International Journal* 15(8): 58-64.

7. AOAC. 2012. Official and Tentative Methods of Analysis, 15th edn. Benajmin Franklin Station, Association of the Official Analytical Chemists, Washington, DC, USA

8. Snedecor, G.W. and Cochran, W.G. 1994.Statistical Methods, 5th edn. Iowa State University Press, Ames, Iowa, USA.

9. Lufu, R., Ambaw, A. and Opara, U.L. 2020. Water loss of fresh fruit: Influencing pre-harvest, harvest and postharvest factors. *Scientia Horticulturae* 272(102): 109519

10. Ozdemir, A.E., Dundar, O. and Ozkaya, O. 2005. Effects of Some Rootstock on Cold Storage of Red Chief Apples. *Acta Horticulturae* 682: 709-714.

11. Tsipouridis, C. and Thomidis, T. 2005. Effect of 14 peach rootstocks on the yield, fruit quality, mortality, girth expansion and resistance to frost damages of May Crest peach variety and their susceptibility on *Phytophthora citrophthora*. *Scientia Horticulturae* 103: 421-428.

12. Cantin, C.M., Pinochet, J., Gogorcena, Y. and Moreno, M.A. 2010. Fruit quality and yield of 'Van' and 'Stark Hardy Giant' sweet cherry cultivars as influenced by grafting on different rootstocks. *Scientia Horticulturae* 123: 329-335

13. Tareen, M.N., Wang, X., Ali, I., Bibi, Y., Fiaz, S., Shahzad, R., Ahmed, W. and Qayyum, A. 2022. Influence of Scion/Rootstock reciprocal effects on post-harvest and metabolomics regulation in stored peaches. *Saudi Journal of Biological Sciences* 29: 427-435

14. Rooban, R., Shanmugam, M., Venkatesan, T. and Tamilmani, C. 2016. Physiochemical changes during different stages of fruit ripening of climacteric fruit of mango (*Mangifera indica* L.) and non-climacteric of fruit cashew apple (*Anacardium occidentale* L.). *Journal of Applied and Advanced Research* 1(2): 53-58

15. Jimenez, S., Garın, A., Gogorcena, Y., Betran, J.A. and Moreno, M.A. 2004. Flower and foliar analysis for prognosis of sweet cherry nutrition: influence of different rootstocks. *Journal of Plant Nutrition* 27: 701–712