

Response of Different Rootstock and Scion Combinations on the Success of Grafting in Apple (*Malus x domestica*)

Priyanka Malasi¹, Nidhika Thakur² and Chetanchidambar N. Mangalore^{3*}

¹Manmohan Uniyal, Dobhalwal, Dehradun – 248001, Uttarakhand, India

²Department of Fruit Science, College of Horticulture, V. C. S. G. Uttarakhand University of Horticulture and Forestry, Bharsar, Uttarakhand, India

³Dr. Y S R Horticulture University, Venkataramannagudem, Tadepalligudem, West Godavari – 534101, Andhra Pradesh, India

*Corresponding author

ABSTRACT

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Grafting, Combinations, Graft success, Rootstocks, Scion diameter.

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Apple is the leading fruit in the temperate regions of the world due its major share in the production of temperate fruit crops. Heterozygosity is the major problem for the production of true-to-type plants which leads to the production of propagule through vegetative means. Grafting is the one of the major artificial vegetative means of propagation. But the graft incompatibility and many other things lead to the failure of grafted plants. So in this experiment we used the scion wood of three apple cultivars (Vance Delicious, Gold Spur and Oregon Spur) which were Tung grafted on rootstocks M-793, M-7 and MM-111 in a series of different combination. The maximum graft height (92.40 cm), scion diameter (1.12cm), rootstock diameter (1.26), number of leaves per graft (105.07), root length (25.34 cm) and root diameter (1.21 cm) were observed in the rootstock and scion combination of Vance Delicious and M-793. The minimum days taken to bud sprout (10.58) and maximum % survival were observed in Oregon Spur and MM-111. It concludes that the combination between Vance delicious and M - 793 is the best for cultivation and other improvement program.

Introduction

‘An apple a day keeps the doctor away’ which means apple is full of every nutrient which is required to human body. Apple (*Malus x domestica* Borkh.) is an important temperate fruit crop belongs to the family Rosaceae (Kheiralipour *et al.*, 2008). Apple has been cultivated in the various parts of the world since 4000 BC. Asia Minor, Central Asia, Himalayan regions of India, Pakistan and Western China is believed as the centre of origin of apple (Muzher *et al.*, 2007).

In India, most of the apple crop is under cultivation in Jammu and Kashmir, Himachal Pradesh and hilly regions of Uttarakhand. It contains different proportion of nutrients like carbohydrates, vitamins, minerals, sugars, fat, protein, and dietary fibre.

It also contains the mineral nutrients like calcium, magnesium, phosphorus, potassium, iron and zinc in a different proportion (Fereneand and Estrada, 2008).

Apple is a cross pollinated crop due to the presence of sporophytic self-incompatibility which leads to the heterozygosity in its progenies due to segregation of chromosomes. It is the main reason for not getting the true-to-type progenies and there is a high degree of variation in the plant characters of seedling plants of apple crop. To overcome this problem, vegetative propagation is the best option in many perennial fruit crops. In vegetative propagation there are two types. One is natural vegetative propagation and second is artificial vegetative propagation. Among all the artificial vegetative propagation, grafting is considered as a superior method due to its high percentage of success, adaptability, survival capacity and true-to-type plants. In a grafted plant there are two parts. Scion is the above part of the graft union helps in the all plant metabolic activities. Rootstock is below part of graft union which having its own root system for the uptake of the nutrients from the soil.

Rootstock plays major role in growth pattern, tree size, drought tolerance, adoptability in different soil and climatic conditions, winter hardiness, bearing age and total yield plus quality of fruits (Herrera, 2002, Jaskani *et al.*, 2006). Scion and stock interaction is a well-documented fact. Rootstock plus scion cultivars interact with each other as well as soil and climatic conditions of the prevailing area (Kosina, 2009). The interaction between scion and stock exhibits many interesting and valuable manifestations. February to March is the best period for getting higher success in the tongue grafting in apple cultivars under hill conditions of Uttarakhand which is a state of India.

In present experiment studies were carried out to estimate the best combination of scion and rootstock for the future recommendation of Uttarakhand hill condition. This investigation

was undertaken with the objectives to study the vegetative characters of the rootstock and scion combinations, to study the per cent survival of different rootstock and scion combinations and to evaluate best rootstock and scion combination for apple.

Materials and Methods

In this experiment various rootstocks and scion woods were used in apple to get the desired plant quality. M-793 is the vigorous rootstock, resistant to wooly aphid, collar-rot and early recommended for hilly areas. M-7 It is a semi dwarfing rootstock, resistant to collar rot, fire blight and induces the early production of fruits. MM-111 is the cross between M-793 and Northern Spy. It is a vigorous stock, tolerant to drought condition and gives first bearing in 5 to 7 years of planting.

The scion woods which is used in this experiment were Vance Delicious is an outstanding variety and is in great demand by fruit growers. Skin is solid red and it mature in second week of August. Oregan Spur is a bud sport of Delicious group of apple. The trees are small sized but with large number of spur bearing branches. Gold Spur is bud sport of Golden Delicious and bears fruits similar to Golden Delicious in shape and colour but it matures early.

The experiment was laid out in Randomized Complete Block Design (RCBD) consist of 9 treatments *viz.*, T₁= M-793 + Vance Delicious, T₂= M-7 + Vance Delicious, T₃= MM-111 + Vance, T₄ = M-793 + Gold Spur, T₅ = M-7 + Gold Spur, T₆ = MM-111 + Gold Spur, T₇ = M-793 + Gold Spur, T₈ = M-7 + Oregan Spur and T₉ = MM-111 + Oregan Spur with three replication. The data on days taken to bud sprout from the date of grafting was recorded. Graft height, number of leaves per graft, leaf area, root length root diameter percent

survival and percent mortality were recorded in an interval of one month for a period of six months.

Results and Discussion

In the present experiment the graft combination of MM-111 rootstock which is grafted with Oregon Spur showed the minimum days (10.58) taken for the initiation of the early vegetative buds (Table 1). Among all the rootstock and scion combinations, the highest diameter of the rootstock was observed when the Vance Delicious scion wood was grafted on M-793 rootstock. The diameter observed in this combination was 1.26 cm as recorded in table 1. When Vance Delicious scion wood was grafted on M-793 rootstock, it records the highest scion diameter of 1.09 cm (Table 1).

It is evident from the data presented in table 1 that the different rootstock and scion combinations had significant influence on increase in graft height. The maximum graft height (92.40 cm) was recorded with the treatment combination of M-793 of Vance Delicious.

The data presented in table 1 showed that the different combinations of rootstock and scion had significant influence on the number of branches. The maximum average number of branches (15.33) was recorded with the treatment M-793 and Vance Delicious. The numbers of leaves (Table 1) were significantly affected rootstock and scion combinations. The maximum numbers of leaves per graft (105.07) were recorded with the treatment combination of M-793 and Vance Delicious.

According to the table 2 the maximum average leaf area (15.58 cm²) was recorded with the treatment combination of Gold Spur and MM-111 which may be due to the influence of the different rootstock interaction

on the leaf character of the scion as shown in table 2. The maximum root diameter (1.21 cm) was observed in the rootstock and scion combination of Vance Delicious and rootstock M-793 because the photosynthetic activity of scion had very much influence on the diameter of the roots of the rootstock which is presented in table 2. Length of the root was maximum (25.34 cm) in the rootstock and scion combination of Vance Delicious and rootstock M-793 which shows that this combination has good influence on the meristematic growth of the root as shown in table 2.

The data on percent survival in table 2 reveals that the effect of different rootstocks and scion combination was non-significant on the survival percent on apple plants.

The maximum survival percent (93.33%) was recorded with the MM-111 and Oregon Spur combination. The research on effective combination of rootstock and scion was given the highest mortality percentage (20.00%) obtained under the combination of Gold spur and M-7 (Table 2).

The compatibility between MM-111 and Oregon Spur is much more for the early formation of callus tissue between scion and the rootstock due to high activity of interacted vascular tissues of this scion and rootstock combinations. Similar result were obtained by Muzalfar and Ajay (2011) who conducted the experiment on effect of scion defoliation and stock leaf retention on the grafting success and survivability of Lime. The similar observation was made by these two scientists.

When the scion is highly compatible with rootstock, there is an increased physiological and metabolic activity was observed in the scion which leads to higher uptake and accumulation of nutrients in the rootstock. This may be the probable reason for the increase in the diameter of the rootstock.

Table.1 Data on days taken to bud sprout, rootstock diameter, scion diameter, graft height, no. of branches, no. of leaves per graft of different rootstock and scion combinations of apple

Treatments	Days taken to bud sprout ± SE	Rootstock diameter (cm) ± SE	Scion diameter (cm) ± SE	Graft height (cm) ± SE	No. of branches ± SE	No. of leaves per graft ± SE
T ₁ (Vance Delicious + M-793)	13.41 ± 0.58	1.26 ± 0.005	1.09 ± 0.02	92.40 ± 1.10	15.33* ± 0.33	84.56 ± 1.62
T ₂ (Vance Delicious+M-7)	15.50 ± 0.11	1.20 ± 0.02	0.94 ± 0.04	74.44 ± 1.53	7.33 ± 0.33	70.22 ± 1.93
T ₃ (Vance Delicious + M-111)	18.38 ± 0.11	1.21 ± 0.028	0.73 ± 0.09	75.67 ± 1.52	8.67 ± 0.33	67.82 ± 1.86
T ₄ (Gold Spur +M-793)	12.37 ± 0.12	1.23 ± 0.02	0.76 ± 0.01	81.55 ± 1.56	10.00* ± 0.57	71.14 ± 2.08
T ₅ (Gold Spur +M-7)	13.61 ± 0.16	1.21 ± 0.01	0.89 ± 0.03	71.63 ± 2.06	7.00 ± 0.01	67.22 ± 1.58
T ₆ (Gold Spur + MM-793)	14.51 ± 0.98	1.14 ± 0.03	0.78 ± 0.07	77.43 ± 3.42	7.67 ± 0.88	67.50 ± 8.67
T ₇ (Oregon Spur + M-793)	15.33 ± 0.01	1.22 ± 0.037	0.90 ± 0.01	74.56 ± 0.72	8.67 ± 0.66	66.18 ± 3.52
T ₈ (Oregon Spur + M-7)	14.51 ± 0.01	1.14 ± 0.045	0.81 ± 0.01	73.48 ± 2.10	9.67* ± 0.66	68.85 ± 1.31
T ₉ (Oregon Spur + M-111)	10.85 ± 0.12	1.22 ± 0.01	0.85 ± 0.08	85.78 ± 2.45	12.00* ± 0.57	80.60 ± 1.57
SE(d)	0.21	0.03	0.08	2.41	0.80	4.66
CD _{0.05}	0.44	0.07	0.16	5.10	1.70	9.88

Table.2 Data on Leaf area, Root length, Root diameter, Survival percentage and Mortality percentage of different root stock and scion combinations of apple

Treatments	Leaf area (cm) ± SE	Root length (cm) ± SE	Root diameter(cm) ± SE	Survival percentage(%) ± SE
T ₁ (Vance delicious + M-793)	12.33 ± 0.40	25.27 ± 0.03	124 ± 0.008	86.67 ± 3.33
T ₂ (Vance delicious + M-7)	13.60 ± 0.36	18.20 ± 0.05	1.14± 0.033	83.33 ± 3.33
T ₃ (Vance delicious + MM-111)	11.48 ± 0.48	22.50 ± 0.11	1.11± 0.05	86.67 ± 3.33
T ₄ (Gold spur + M- M793)	12.32 ± 0.24	17.40 ± 0.11	1.09 ± 0.14	83.33 ± 3.33
T ₅ (Gold spur + M-7)	12.54 ± 0.25	14.42 ± 0.50	1.12 ± 0.09	80.00 ± 5.77
T ₆ (Gold spur + MM -111)	15.58 ± 0.12	20.37 ± 0.20	1.19 ± 0.71	90.33 ± 3.33
T ₇ (Oregon spur + M-793)	13.35 ± 0.18	21.47 ± 0.20	1.10 ± 0.71	90.33 ± 0.00
T ₈ (Oregon spur + M-7)	14.56 ± 0.15	23.47 ± 0.16	1.15 ± 0.14	86.67 ± 3.33

This result also agreements with the results obtained by Angelini *et al.*, 1986 who observed in their experiment on Vegetative growth and yield of pear cultivars on Quince BA29 and seedling rootstocks. They also recorded similar results in their experiment.

When the scion and rootstocks were highly compatible, after the formation of vascular tissues between scion and rootstock there is an increased metabolic activity had observed in the leaves which leads to accumulation of food in the stem of scion wood. This result was accordant with the findings of Rana and Bhatia (2004) which was supported by the findings of Bhatia and Kumar (2009) and in their research work on rootstock and scion combination of different rootstock and scions.

The treatment combination between M-793 and Vance Delicious had shown the highest graft height. The probable reason may be the highly vigorous character of the rootstock which shows high influence on the vigor of the scion. Another reason for greater height of grafts in the present study might be that the grafts sprouted earlier and received fairly long period of favorable weather for vegetative growth (Singh and Ananda, 2005) which was confirmed by the findings of Nauriyal and Kanwar (1969).

The higher number of branches may be due to the influence of internal plant hormone present in the stem of the scion wood which is also influenced by the activity of the rootstock. Similar result were obtained by Wertheimand Webster (2005) who reported that the IAA levels in inter-stock and rootstock trunk may bereduced, which may lead to more cytokinin production at nodes of inter-stock and rootstock trunk. Therefore, higher cytokinin could be synthesized at higher levels in longer trunk. Consequently, higher cytokinin amounts transported to scion may promote lateral bud growth. In fact,

thenumber of lateral shoot increased. The number of leaves increased in the combination of M-793 and Vance Delicious. It may be due to the increase in the photosynthetic rate due to high rootstock and scion combination. And the same reason is also whole stood for the increase in the area of the leaves. Similar result are obtained by Rana and Bhatia (2004) in their experiment on performance of Vance Delicious apple on different semi dwarfing rootstocks in Kullu valleywhich was supported by the findings of Marini *et al.*, (2000); Autio and Karupa (2001); Tworkosi and Millar (2007); Domozetor (2009) and Kosina (2010).

The root diameter and root length got highly influence by combination of M-793 and Vance Delicious. This may be due to the early formation of callus in the graft union region. The early formation of the callus leads to the early formation of the vascular tissues. It leads the early beginning of the metabolic activity in the leaves. To supply the required amount of nutrients, root grows to the deeper layer of the soil to uptake the required nutrients. This leads to the increase in the length and the diameter of the roots. This result was similar with the findings of Chandel and Chauhan (1992) where the interaction study between scion and rootstock was observed to be significant and supported by Kaurand Mahi (2006).

The highest percent survival is observed in MM-111 and Oregan Spur combination. This may be due to the compatibility interaction between scion and the rootstock. The callus formation between this rootstock and scion was highly active with the formation of vascular tissues. This was agreements with the results obtained by Chandel*et.al* (1992) in their experiment conducted on Drought resistance of Starking Delicious apple plants on biomas, root growth and photosynthetic efficiency of apple also supported by the

findings of the Muzalfar and Ajay (2011). The tables 1 and 2 concludes that the scion and rootstock combination of Vance delicious and M - 793 given the best result in the most of the parameters which summarizes that this combination was the best for cultivation and other crop improvement program.

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