AATCC Review

Received: 10 June, 2022
Revised: August 26, 2022
Accepted: September 12, 2022

http://aatcc.peerjournals.net/

Research Article Open Access

Performance of Various Apple Clonal Rootstocks under Temperate Environment using Different Rooting Media and Propagation Techniques

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Abstract

The present study was conducted at the experimental field of Division of Fruit Science, SKUAST-Kashmir, Srinagar on one year old rootstock of various types viz., M9-T337 (S1), M-27(S2), MM-106(S3), P-22(S4), MM-111(S5) by applying ten hilling materials viz., Vermiculite (T1), Saw dust (T2), FYM (T3),Vermicompost (T4), Vermiculite + Saw dust + Pseudomonas (T5), + Saw dust + Azotobacter (T6), FYM + Vermicompost + Pseudomonas (T7), FYM + Vermicompost+ Azotobacter (T8), Pseudomonas+ Azotobacter+ Soil (T9), Control(T10) (only soil was used as a hilling material) and two propagation techniques viz., mound and trench layering. During this study maximum root length (12.90 cm), root number (7.50), root initiation points (4.71), root fresh weight (8.05) and root dry weight (5.93 g) were recorded with saw dust (T2) hilling material. Moreover, propagation technique P2 (trench layering) showed significant effect over P1 (mound layering) in terms of root length, root number per layer and root initiation points. Therefore, above findings will play an important role in augmenting the quality planting production through various multiplication techniques.

Keywords: *Apple, Clonal rootstocks, hilling media, rooted layers, Root length and Saw dust*

Introduction

Apple (*Malus* × *domestica* Borkh.) is the most important fruit crop of J&K, besides plays an important role in the nutritional security of the country [1]. Jammu and Kashmir produces approximately 18 lakh metric tonnes of apple which is about 70 per cent of the production of the apples in India with a productivity of about 11.42 MT/ha [2] which is very low in comparison to New Zealand (56 MT/ha) and Chile (50MT/ha).This gap could be bridged by creating high density orchards [3], through the use of various clonal root stocks *viz.,* M-9, M-27, MM-111, MM-106, Merton-793 and P-22. Nowadays, Clonal rootstocks showed an important role in fruit industry to maintain the genetic make-up and thus, produce rootstocks of homogeneous nature [4]. Presently apple growers are focussing on the production of high quality apple in order to increase their high income return which has been plagued due to poor quality, uneven packaging in conventional orcharding [5]. Due to the introduction of the High Density Plantation (HDP), new cultivars, area expansion and re-plantation of old unproductive orchards, the demand for growing these HDP plants has been increased significantly [6]. In this regard, SKUAST-Kashmir has introduced various clonal rootstocks (M9-T337, M-27, MM-106, P-22, MM-111 and Merton-793) from Holland which is under evaluation. So in order to produce maximum number of daughter stocks from the mother stocks, the present experiment was evaluated by using different types of hilling media along with the best propagation technique.

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DOI: https://doi.org/10.51470/AATCCReview.2022.10.01.02

Table 1. Details of treatments for the growth of various apple clonal rootstocks

Treatment	Media	Ratio
T1	Vermiculite	100%
T2	Saw dust	100%
T3	FYM	100%
T4	Vermicompost	100%
T5	Vermiculite+ Saw dust+ *Pseudomonas*	1:1
T6	Vermiculite + Saw dust +*Azotobacter*	1:1
T7	FYM + Vermicompost + *Pseudomonas*	1:1
T8	FYM + Vermicompost+ *Azotobacter*	-
T9	*Pseudomonas*+*Azotobacter* + Soil	100%
T10	Control (soil as a hilling media)	-

Table 2. Influence of various hilling media, propagation methods and their interaction on average root length (cm) of daughter stocks from the motherstock.

Propagation	**P1; Mound Layering**						**P2; Trench Layering**							
Rootstock / Media	**S1**	**S2**	**S3**	**S4**	**S5**	**Sub mean**	**S1**	**S2**	**S3**	**S4**	**S5**	**Sub mean**	**Media mean**	**Root stock mean**
T1	10.50	10.17	10.84	10.25	12.17	10.79	11.50	11.17	11.84	11.25	13.17	11.79	11.29	S1=10.39
T2	12.39	11.67	12.52	11.84	13.59	12.40	13.39	12.67	13.52	12.84	14.59	13.40	12.90	S2=9.85
T3	9.50	9.34	10.54	9.40	11.17	9.99	10.50	10.34	10.58	10.40	12.17	10.80	10.39	S3=10.79
T4	10.08	10.00	10.83	9.84	11.83	10.52	11.08	10.84	11.83	11.00	12.83	11.52	11.02	S4=10.09
T5	11.84	10.70	12.17	10.84	12.78	11.67	12.84	11.70	13.17	11.84	13.78	12.67	12.17	S5=11.68
T6	10.80	10.50	11.50	10.67	12.50	11.19	11.80	11.50	12.50	11.67	13.50	12.19	11.69	
T7	9.30	8.50	9.58	8.67	10.67	9.34	10.30	9.50	10.54	9.67	11.67	10.34	9.84	
T8	8.67	8.17	9.20	8.50	9.50	8.81	9.67	9.17	10.20	9.50	10.50	9.81	9.31	
T9	8.17	7.34	9.17	8.17	9.34	8.44	9.17	8.34	10.17	9.17	10.34	9.44	8.94	
T10	7.08	6.84	7.83	7.00	8.20	7.56	8.78	7.84	8.83	8.08	9.20	8.56	8.06	
Mean	9.89	9.35	10.34	9.59	11.18	10.07	10.89	10.35	11.24	10.59	12.18	11.05	10.56	

S1; M-9T337 S2; M-27 S3; MM-106 S4; P-22 S5; MM-111

C.D($p \leq 0.05$)

Media (M)	:	0.52	;	M×P	:	0.73		
Rootstock (S)	:	0.36	;	M×S	:	1.16		
Propagation (P)	:	NS	;	P×S	:	M×P×S	: 0.59	

Material and Methods

The present experiment was conducted during 2016-2017 and 2017-2018 at Apple orchard nursery SKUAST-Kashmir. The rootstocks used during the experimental research consist of M9-T337, MM-106, M-27, P-22 and MM-111 and were one year old at the time of planting. These rootstocks were planted at a distance of 90 cm × 45 cm. The one year old mother stocks were headed back to the soil line during first week of March. After 25 days emerging shoots were mounded up with hilling media. The hilling media was subsequently applied at 45 days intervals amounting to the total of 5kg per plant up to the growing season (October). During the experimental trial ten hilling materials were applied *viz.*, Vermiculite (T1), saw dust (T2), FYM (T3), Vermicompost (T4), Vermiculite + Sawdust + *Pseudomonas* (T5), vermiculite + Saw dust + *Azotobacter* (T6), FYM + Vermicompost + *Pseudomonas* (T7), FYM + Vermicompost + *Azotobacter* (T8), *pseudomonas* + *Azotobacter* + Soil (T9), Control (T10) (only soil was used as a hilling material). These mother stools were managed routinely. For the multiplication of these rootstocks two propagation methods were employed. The details of the treatment combinations are tabulated in the Table 1 which was replicated thrice in RBD (randomized block design). In this experiment root

Table 3. Influence of various hilling media, propagation methods and their interaction on average root number per layer of daughter stock from the mother stock

Propagation	P1; Mound Layering					Sub	P2; Trench Layering							
Rootstock / Media	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Sub mean	Media mean	Root stock mean
T1	6.25	5.30	6.38	5.26	7.47	6.13	7.30	6.34	7.72	6.26	8.51	7.23	6.68	S1=6.48
T2	6.90	5.56	7.38	6.82	8.22	6.98	7.95	6.60	8.42	7.92	9.24	8.03	7.50	S2=5.45
T3	6.18	5.20	6.28	5.10	7.26	6.00	7.20	6.22	7.35	6.20	8.27	7.05	6.53	S3=6.86
T4	6.20	5.28	6.30	5.20	7.40	6.08	7.25	6.30	7.43	6.30	8.43	7.14	6.61	S4=5.94
T5	6.60	5.45	6.99	6.01	7.93	6.60	7.63	6.47	8.10	7.08	8.97	7.65	7.12	S5=7.75
T6	6.48	5.39	6.67	5.87	7.50	6.38	7.52	6.42	7.72	6.93	8.54	7.43	6.90	
T7	5.81	4.48	6.27	5.08	7.17	5.76	6.87	5.37	7.26	6.10	8.21	6.76	6.26	
T8	5.19	4.35	6.21	5.05	6.50	5.46	6.27	5.30	7.25	6.09	7.54	6.49	5.98	
T9	5.10	4.28	6.01	4.90	6.45	5.35	6.21	5.52	6.62	5.96	7.50	6.36	5.86	
T10 Control	4.80	4.07	5.01	4.78	6.43	5.02	5.85	5.07	6.06	5.82	7.42	6.04	5.53	
Mean	5.95	4.94	6.34	5.41	7.24	5.98	7.01	5.96	7.39	6.47	8.27	7.02	6.50	

S1; M9-T337 S2; M-27 S3; MM-106 S4; P-22 S5; MM-111

C.D ($p \leq 0.05$)

Media (M)	:	0.18	;	M×P	:	0.26
Rootstock (S)	:	0.13	;	M×S	:	0.41
Propagation (P)	:	0.83	;	P×S	:	0.18

M×P×S : 0.59

Table 4. Influence of various hilling media, propagation methods and their interaction on root initiation points of daughter stock from the mother stock.

Propagation	P1; Mound Layering					Sub	P2; Trench Layering							
Rootstock / Media	S1	S2	S3	S4	S5	Mean	S1	S2	S3	S4	S5	Sub Mean	Media Mean	Root-stock Mean
T1	3.60	3.15	4.18	3.50	4.60	3.81	4.49	3.50	4.68	4.10	5.54	4.46	4.13	S1=3.71
T2	4.30	3.34	4.45	4.50	4.98	4.31	5.19	4.20	5.41	4.83	5.94	5.11	4.71	S2=2.95
T3	3.15	3.07	3.72	3.00	4.25	3.44	4.04	3.00	4.34	4.03	5.28	4.14	3.79	S3=3.93
T4	3.23	3.10	3.88	3.34	4.43	3.60	4.12	3.17	4.38	4.05	5.39	4.22	3.91	S4=3.43
T5	4.20	3.25	4.42	4.17	4.80	4.17	5.09	4.00	5.14	4.34	5.76	4.87	4.52	S5=4.69
T6	3.84	3.18	4.38	3.83	4.75	4.00	4.83	3.67	4.84	4.30	5.71	4.67	4.33	
T7	3.11	2.78	3.21	2.34	4.20	3.13	4.00	3.00	4.17	3.74	5.21	4.02	3.58	
T8	3.10	2.56	3.10	2.17	4.18	3.02	3.99	2.67	4.00	3.52	5.14	3.86	3.44	
T9	2.88	1.67	2.89	2.00	3.32	2.55	3.44	2.34	3.70	3.30	5.14	3.58	3.07	
T10	1.36	1.17	1.43	1.26	2.98	1.62	2.14	2.00	2.70	2.30	4.02	2.62	2.12	
Mean	3.28	2.73	3.56	3.01	4.25	3.36	4.14	3.19	4.30	3.85	5.31	4.16	3.76	

S1; M9-T337 S2;M-27 S3; MM-106 S4; P-22 S5; MM-111

C.D($p \leq 0.05$)

Media (M)	:	0.36	;	M×P	:	NS
Rootstock (S)	:	NS	;	M×S	:	NS
Propagation (P)	:	NS	;	P×S	:	0.36
				M×P×S	:	NS

Table 5:- Influence of various hilling media, propagation methods and their interaction on root fresh weight (g) of daughter stocks from the mother stock

Propagation	P1; Mound Layering						P2; Trench Layering							
Rootstock / Media	S1	S2	S3	S4	S5	Sub mean	S1	S2	S3	S4	S5	Sub mean	Media Mean	Rootstock Mean
T1	10.50	10.17	10.84	10.25	12.17	10.79	11.50	11.17	11.84	11.25	13.17	11.79	11.29	S1=10.39
T2	12.39	11.67	12.52	11.84	13.59	12.40	13.39	12.67	13.52	12.84	14.59	13.40	12.90	S2=9.85
T3	9.50	9.34	10.54	9.40	11.17	9.99	10.50	10.34	10.58	10.40	12.17	10.80	10.39	S3=10.79
T4	10.08	10.00	10.83	9.84	11.83	10.52	11.08	10.84	11.83	11.00	12.83	11.52	11.02	S4=10.09
T5	11.84	10.70	12.17	10.84	12.78	11.67	12.84	11.70	13.17	11.84	13.78	12.67	12.17	S5=11.68
T6	10.80	10.50	11.50	10.67	12.50	11.19	11.80	11.50	12.50	11.67	13.50	12.19	11.69	
T7	9.30	8.50	9.58	8.67	10.67	9.34	10.30	9.50	10.54	9.67	11.67	10.34	9.84	
T8	8.67	8.17	9.20	8.50	9.50	8.81	9.67	9.17	10.20	9.50	10.50	9.81	9.31	
T9	8.17	7.34	9.17	8.17	9.34	8.44	9.17	8.34	10.17	9.17	10.34	9.44	8.94	
T10	7.08	6.84	7.83	7.00	8.20	7.56	8.78	7.84	8.83	8.08	9.20	8.56	8.06	
Mean	9.89	9.35	10.34	9.59	11.18	10.07	10.89	10.35	11.24	10.59	12.18	11.05	10.56	

S1; M9-T337 S2; M-27 S3; MM-106 S4; P-22 S5; MM-106

C.D ($p \leq 0.05$)

Media (M)	:	0.38	;	M×P	:	0.73
Rootstock (S)	:	0.26	;	M×S	:	0.85
Propagation (P)	:	0.17	;	P×S	:	0.38
				M×P×S	:	1.20

Table 6. Influence of various hilling media, propagation methods and their interaction on dry root weight (g) of daughter stocks from the mother stocks

Propagation	P1; Mound Layering						P2; Trench Layering							
Rootstock / Media	S1	S2	S3	S4	S5	Sub Mean	S1	S2	S3	S4	S5	Sub Mean	Media Mean	Rootstock Mean
T1	4.29	3.45	4.64	3.67	5.09	4.23	4.52	3.58	4.64	3.85	4.73	4.26	4.25	S1=4.08
T2	6.31	3.78	6.15	6.10	7.38	5.94	5.26	4.85	6.56	6.02	6.86	5.91	5.93	S2=3.39
T3	4.05	3.32	3.71	3.56	4.28	3.78	3.98	3.52	4.39	3.73	4.55	4.03	3.91	S3=4.28
T4	4.07	3.43	4.28	3.65	4.35	3.96	4.45	3.54	4.49	3.85	4.63	4.19	4.07	S4=3.86
T5	5.58	3.71	6.01	4.79	6.43	5.30	5.33	4.01	5.86	5.21	6.31	5.34	5.32	S5=4.37
T6	4.73	3.62	5.32	3.77	6.07	4.70	4.88	3.62	5.09	3.85	5.74	4.64	4.67	
T7	2.75	2.66	3.60	3.46	4.18	3.33	4.20	3.38	3.62	3.46	4.32	3.80	3.56	
T8	2.50	2.45	2.88	2.48	3.44	2.75	3.30	2.75	3.31	3.39	3.42	3.23	2.99	
T9	2.45	2.34	2.82	2.31	3.42	2.67	3.09	2.70	3.25	2.83	3.36	3.05	2.86	
T10	2.00	1.89	2.45	1.90	3.17	2.35	2.56	1.74	3.13	2.05	3.30	2.50	2.43	
Mean	3.94	3.07	4.13	3.79	4.55	3.90	4.27	3.37	4.40	3.82	4.64	4.10	4.00	

S1; M-9 T337 S2; M-27 S3; MM-106 S4; P-22 S5; MM-111

C.D($p \leq 0.05$)

Media (M)	:	0.16	;	M×P	:	0.23
Rootstock (S)	:	0.11	;	M×S	:	0.37
Propagation (P)	:	0.17	;	P×S	:	0.52
				M×P×S	:	0.50

number per layer, root length, root initiation points, root fresh weight and root dry weight were measured [7]. The statistical significance of the data was carried out using OPSTAT [8].

Results and Discussions

it is indicated from the data depicted in table-1 that various hilling media applied during the experimental trial significantly increased root number per layer however maximum root number (7.50) was recorded with saw dust, Vermiculite+ Saw dust+ *Pseudomonas* (7.12) as hilling medium. Among the various rootstocks, maximum root number per layer (7.75) was recorded in MM-111 and less root number per layer (5.45) was recorded in M-27.Interaction between rooting media, rootstocks and propagation methods was found to be significant. The maximum root number per layer was found in MM-111 (8.97) with Vermiculite+ Saw dust+ *Pseudomonas* as hilling media under trench layering whereas, less root number per layer (4.07) was recorded in M-27 (S2) with soil as hilling media under mound layering. Further it was studied that propagation technique P_2 (trench layering) showed significant effect over P_1 (mound layering) in terms of root number per layer 7.02 as compared to 5.98.

The different rooting media as well as various propagation techniques showed significant effect on the average root length per layer (Table-2). Both MM-111(S5) and MM-106 (S3) showed maximum root length (11.68 and 10.79 cm respectively) per layer, however M-27 (S2) attained the lowest root length per layer (9.85cm). Among the different rooting media the rootstocks mounded with saw dust produced maximum root length (12.90 cm). Interaction between different rooting media, rootstocks and propagation methods were also found to be significant. MM-111 with saw dust as hilling media under trench layering produced maximum root length per layer (14.59 cm) in comparison to all other treatment combinations. However, minimum root length (6.84 cm) was recorded in M-27 with soil as a hilling material under mound layering.

The data revealed to root initiation points affected by different hilling media and propagation techniques presented in Table-3. The data indicated that maximum root initiation points (4.71) were recorded with saw dust as rooting media. The minimum root initiation points (2.12) were observed in control. Interaction between rooting media, rootstocks and propagation methods were found non-significant. Among the different clonal rootstocks maximum root initiation points were found in MM-111 (4.69) followed by MM-106 (3.93) and the minimum root initiation points (2.95) were found in M-27.The effect of two propagation techniques *viz*., mound and trench layering for the production of root initiation points were found to be non-significant.

The data depicted from table 4 and 5 showed that that all the hilling media showed a significant effect on the root fresh (8.05 g) and root dry weight (5.93 g). The maximum root fresh and root dry weight were found maximum under saw dust as a hilling media. During the course of experimental research the interaction between various rootstocks, propagation techniques and different hilling media were found significant.

The increase in root characters/ traits in saw dust may be attributed to be due to excellent aeration, good drainage of water, better water holding capacity better root penetration [9]. Optimum media temperature under saw dust as hilling media increased soil flora and fauna thus improving soil fertility status [10]. Continuous increase in media temperature during the period of investigation results in maximum number of root primordial cells beside activity of root initials which leads to the formation of fibrous roots [11]. The lower media temperature under the soil leads to the reduction and proliferation of the secondary roots [12]. It was also found that the influence of the different rooting media on the growth of root traits is due increase in aeration and greater oxygen diffusion [13-16]. It has also been reported that the effect of various organic hilling media on the various clonal root stocks (M9, M26, P60 and MM106) in Poland during 1996-2000 [17]. It has also been opined that the effect of rooting of Kiwi hardwood cuttings in saw dust, sand and observed that saw dust as good hilling media as compared to sand [18]. They also observed that saw dust showed maximum root initiation points in Kiwi hard wood cutting as compared to other organic substrate. It has also observed that root zone temperature affects root initiation of stem cuttings in plants. Maximum number of root initiation points leads to reduction in the mortality of the plants and if during the transportation few root initiation points are damaged the plant will still survive [19]. So it clearly from the results and discussion that application of various hilling media results in the growth of root traits. Further it is concluded that saw dust results in maximum growth of root length, root number per layer, root fresh, root dry weight and root

initiation points

Author's contribution

Conceptualization and designing of the research experiment (Sheikh Mehraj, A.H. Pandit), Data collection and analysis (Sheikh Mehraj, Mohammed Tauseef Ali, Nowsheen Nazir), Preparation of the manuscript (Shaziya Hassan and S.A Wani),

Declaration

The authors do not have any conflict of interest.

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