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Response of Various Rooting Media on Growth of Stools and Soil Hydro Thermal Conditions (Soil Temperature and Soil Moisture) using Different Apple Clonal Rootstocks through Layering

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ABSTRACT

An experiment was conducted to observe the effect of various rooting media on the growth of stools. During the investigation programme, ten hilling materials were applied viz., Vermiculite (T1), Saw dust(T2), FYM (T3) ,Vermicompost (T4), Vermiculite + Saw dust + Pseudomonas (T5), Vermicultite + 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). The rootstocks used during the research programme consist of M-9 T337 (S1), M-27(S2), MM-106(S3), P-22(S4), MM-111(S5). The experimental results showed that maximum shoot incremental growth (67.90 cm), shoot length (120.46 cm) and leaf area (32.00 cm2) were recorded under FYM + Vermicompost + Azotobacter treatment. Maximum mean soil hydrothermal condition Viz., temperature (26.130C) was recorded under saw dust treatment. Maximum mean soil moisture content (23.44%) was recorded in under vermiculite which was significantly, higher as compared to all other hilling media however root fresh weight (8.05) and root dry weight (5.91g), were recorded with saw dust (T2). The minimum shoot incremental growth (38.83 cm), shoot length (61.62 cm), leaf area (26.90cm2), root fresh weight (4.43 g), root dry weight (2.43 g) and mean soil hydrothermal conditions viz., soil temperature and soil moisture were observed under control (only soil was used a hilling media). Among the various propagation techniques it was observed that propagation technique P2 (trench layering) had a significant effect over P1 (mound layering) with regard to average shoot length, shoot incremental growth and leaf area.

Keywords: *Clonal rootstocks, hilling media, shoot length, hilling media temperature, Leaf area, FYM + Vermicompost+ Azotobacter and saw dust.*

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INTRODUCTION

The first commercial development of clonal rootstocks began in apples to control tree vigour and incorporate resistance to the woolly apple aphid (*Eriosoma lanigerum* Hausmn.)[1] .This development took place in 1922 at the John Innes Institute in cooperation with the East Malling Research Station, UK, which led to the release of the Merton Immune and the Malling-Merton series [2].

Historically, most of the clonal apple rootstocks that we use in the Jammu and Kashmir traditionally originated in Europe [3]. Rootstock is an essential component to enhance fruit quality and productivity In Kashmir valley the apple trees, raised on seedling rootstocks are used on commercial scale. These seedling rootstocks are variable in their influence on the scion varieties due to their heterogeneous nature [3]. Poor quality, uneven packaging, marginality and fragility and low profits coupled with high production costs are forcing apple growers to improve upon efficiency and productivity. In this regard High Density Planting (HDP), which is only possible by the use of size-controlling rootstocks of homogeneous nature, can increase productivity and ensure improved efficiency [4-5]. This has stimulated interest in size-controlling clonal

Table:-1 Effect of different rooting media, propagation methods and their interaction on the average shoot length (cm) of rooted layers of different apple clonal rootstocks
(Pooled over 2017 and 2018)

Propagation	P1; Mound Layering					Sub Mean	P2; Trench Layering					Sub Mean	Media Mean	Rootstock Mean
Rootstock / Media	S1	S2	S3	S4	S5		S1	S2	S3	S4	S5			
T1; Vermiculite	72.25	60.44	84.66	71.96	88.61	75.58	83.07	68.20	100.57	82.49	107.44	88.35	81.97	S1=86.54
T2; Saw dust	73.64	65.34	87.62	73.96	88.61	77.83	91.81	69.05	103.31	82.57	107.78	90.90	84.37	S2=70.82
T3;FYM	86.53	67.95	89.40	83.90	99.34	85.42	95.57	74.70	105.33	99.56	108.92	96.82	91.12	S3=99.34
T4; Vermicompost	86.70	67.30	101.72	84.22	102.47	88.48	97.18	76.46	106.42	101.41	109.60	98.21	93.35	S4=84.28
T5; Vermiculite+ Saw dust+ *Pseudomonas*	75.60	68.15	87.83	75.81	94.16	80.31	92.32	70.11	103.78	82.57	108.09	91.37	85.84	S5=102.79
T6; Vermiculite+ Saw dust+ *Azotobacter*	76.74	66.88	88.30	76.63	95.69	80.85	93.74	70.88	103.78	83.79	108.43	92.12	86.49	
T7; FYM+Vermicompost+ *Pseudomonas*	86.74	69.84	104.42	84.31	105.41	90.14	100.81	82.62	119.33	101.92	110.39	103.01	96.58	
T8; FYM+Vermicompost+ *Azotobacter*	87.34	82.50	104.66	86.54	105.81	93.37	102.34	86.24	120.43	103.31	120.46	106.56	99.96	
T9;*Pseudomonas*+ *Azotobacter*+Soil	83.97	67.30	88.71	77.65	97.49	83.02	93.74	72.69	104.55	85.33	108.92	93.05	88.04	
T10; Control	68.53	61.62	81.43	66.76	85.89	72.85	82.21	68.20	98.42	80.93	104.42	86.84	79.84	
Mean	79.80	67.73	92.09	78.17	96.13	82.78	93.28	73.92	106.59	90.39	109.45	94.73	88.76	

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

C.D($p \leq 0.05$)

Media (M) : 0.74 ; M×P : 1.04
Rootstock (S) : 0.52 ; M×S : 1.6
Propagation (P): 0.33 ; P×S : 0.74
M×P×S : 2.34

rootstocks. In recent years, the demand for fruit plants has increased significantly because of the introduction of the new cultivars and re-plantation of old unproductive orchards. Therefore the present study was conducted to assess the impact of various hilling media on the growth of stools through different propagation techniques

MATERIALS AND METHODS

The present investigation was carried out at Experimental Farm SKUAST-Kashmir, The planting material for the experiment consisted of M-9 T337 (S1), M-27(S2), MM-106 (S3), P-22(S4) and MM-111 (S5) rootstocks. The planting material was imported from Holland in 2016 and planted at spacing of 90cm × 45cm. At the time of conducting present experimental studies, the age rootstock stools were one year old. During the present investigation programme two propagation techniques *viz.*, mound layering (P1) and trench layering (P2) were adopted for the multiplication of clonal rootstocks. Ten hilling materials were applied *viz.*, Vermiculite (T1), Saw dust(T2), FYM(T3) ,Vermicompost

Table :- 2 Effect of different rooting media, propagation methods and their interaction on the shoot incremental growth (cm) of rooted layers of different apple clonal rootstocks

Propagation	P1; Mound Layering					Sub Mean	P2; Trench Layering					Sub Mean	Media Mean	Rootstock Mean
Rootstock / Media	S1	S2	S3	S4	S5		S1	S2	S3	S4	S5			
T1; Vermiculite	45.00	40.50	48.00	43.17	52.5	46.66	46.17	41.33	48.67	44.33	56.67	46.60	46.43	**S1**=56.21
T2; Saw dust	46.84	42.34	48.67	45.34	55.34	49.30	50.50	42.67	52.17	47.34	63.34	49.60	49.36	**S2**=48.04
T3;FYM	59.84	47.67	60.50	59.67	67.67	59.97	62.84	51.83	64.83	56.67	72.17	60.77	60.37	**S3**=57.12
T4; Vermicompost	61.50	52.34	62.17	62.34	69.17	62.34	63.83	53.17	65.67	61.33	73.34	62.63	62.49	**S4**=53.75
T5; Vermiculite+ Saw dust+ *Pseudomonas*	52.34	43.33	54.34	46.84	57.83	52.74	53.84	43.67	56.17	50.00	66.84	52.30	52.52	**S5=65.16**
T6; Vermiculite+ Saw dust+ *Azotobacter*	52.50	45.67	54.67	50.84	61.84	54.34	58.55	46.5	60.50	50.33	68.00	55.54	54.94	
T7; FYM+Vermicompost+ *Pseudomonas*	62.67	54.50	63.84	62.17	70.84	63.74	66.67	56.34	68.67	65.33	76.50	65.57	64.65	
T8; FYM+Vermicompost+ *Azotobacter*	65.50	62.34	66.00	64.33	74.33	67.13	68.84	63.67	71.00	65.50	77.50	68.67	67.90	
T9;*Pseudomonas*+ *Azotobacter*+ Soil	55.17	46.84	58.67	54.34	64.67	57.20	58.67	47.83	63.17	53.83	71.00	57.63	57.42	
T10; Control	41.67	38.83	43.84	42.84	49.84	44.30	44.17	40.33	45.33	43.67	56.33	44.67	44.49	
Mean	54.44	47.34	55.05	53.67	62.25	55.71	57.99	48.73	59.2	53.83	68.07	56.40	56.06	

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

C.D(p≤0.05)

Media (M) : 0.63 ; M×P :0.90

Rootstock (S) : 0.45 ; M×S :1.4

Propagation (P): 0.28 ; P×S :0.63

M×P×S : 2.02

(T4), Vermiculite+ Saw dust+ *Pseudomonas* (T5), Vermicultite + 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).

Shoot incremental growth of rooted layers (cm).

In this case twenty uniform and healthy stools were randomly selected in each replication and the length of each shoot was measured at beginning and end of growing season between the point of next growth initiation to the tip of shoot. The length of these shoots were measured with a measuring scale after the cessation of growth and expressed in centimeter.The leaf area (cm^2) were recorded during first week of October when leaves were fully developed. Twenty five leaves collected at random from each of the ten marked stool shoots and the total leaves were measured with the help of Leaf Area Meter (LI-COR Model-3100) and then reading was averaged in cm^2. The data on shoot length (cm) were recorded at the end of growing season when the cessation of growth had taken place. Five stool shoots were selected from each replication under each treatment to obtain the linear growth, which was measured with the help of measuring scale. The total linear growth

Table:-3 Effect of different rooting media, propagation methods and their interaction on the average leaf area (cm^2) of different apple clonal rootstocks
(Pooled over 2017 and 2018).

Propagation	P1; Mound Layering					Sub Mean	P2; Trench Layering					Sub Mean	Media Mean	Rootstock Mean
Rootstock / Media	S1	S2	S3	S4	S5		S1	S2	S3	S4	S5			
T1; Vermiculite	26.11	24.41	26.51	25.35	28.38	26.15	27.12	26.41	28.93	27.01	28.26	27.54	27.12	**S1**=28.54
T2; Saw dust	26.53	25.14	26.75	26.00	29.48	26.78	27.36	26.62	29.11	27.41	29.70	28.05	27.36	**S2**=26.72
T3;FYM	29.45	26.54	30.03	28.07	31.47	29.11	30.12	28.00	29.92	29.07	30.60	29.55	30.12	**S3**=29.03
T4; Vermicompost	30.06	26.61	30.44	29.33	31.95	29.68	30.56	28.23	29.93	29.38	30.73	29.78	30.56	**S4**=28.01
T5; Vermiculite+ Saw dust+ *Pseudomonas*	26.68	25.75	27.83	26.59	29.57	27.28	27.75	26.95	29.21	27.54	30.24	28.35	27.75	**S5=30.33**
T6; Vermiculite+ Saw dust+ *Azotobacter*	26.93	26.35	28.07	26.65	30.48	27.70	28.50	27.65	29.74	28.56	30.28	28.95	28.50	
T7; FYM+Vermicompost+ *Pseudomonas*	30.68	26.72	30.79	30.09	**32.19**	30.09	30.01	28.47	30.70	29.65	31.47	30.07	30.01	
T8; FYM+Vermicompost+ *Azotobacter*	31.10	27.30	31.41	30.60	32.47	30.58	30.71	29.44	**31.32**	30.49	**32.00**	30.80	30.71	
T9;*Pseudomonas*+ *Azotobacter*+Soil	27.78	26.43	28.34	26.73	30.89	28.03	29.52	27.81	29.76	28.64	30.50	29.26	29.52	
T10; Control	25.46	25.24	26.23	24.35	27.74	25.80	26.90	25.24	28.11	26.24	28.13	26.93	26.90	
Mean	28.17	25.96	28.55	27.53	30.46	28.13	28.92	27.49	29.52	28.48	30.21	28.93	28.92	

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

C.D($p \leq 0.05$)

Media (M)	:	0.54	;	M×P	:	0.77
Rootstock (S)	:	0.38	;	M×S	:	1.20
Propagation (P)	:	0.24	;	P×S	:	0.54
M×P×S	:	1.70				

was measured from ground level to the tip of the stool shoot, and was expressed in centimetre per stool shoot. Soil hydro thermal conditions viz., Soil temperature (°C) and soil moisture (%) of experimental area was recorded at depth of 15-30cm with the help of soil thermometer and soil moisture meter. First reading was taken on 15th, April and subsequent readings at 60 days intervals. Final reading was recorded at the end of growing season. The data presented is pooled data of two years (2016-2017 and 2017-2018) was statistically analyzed as per standard method [6]. Statistical analyses were done by using Assex Software (Statistix PC Dos Version 2.0 NH Analytical Software).

RESULTS AND DISCUSSION

The data on growth of rooted layers viz., shoot length, shoot incremental growth, leaf area, root fresh weight and root dry weight and soil hydrothermal conditions viz., soil temperature and soil moisture attained by different apple clonal rootstocks and as affected by different rooting media and two propagation techniques are presented in Table -1, 2 3, 4 and 5 and 6. It is clear from the data that all the rootstocks differed significantly among themselves in respect of average shoot length. MM-111 attained the maximum shoot length (102.79 cm) followed

Table 4: Effect of different rooting media, propagation methods and their interaction on root fresh weight (g) of rooted layers of different apple clonal rootstocks (pooled over 2017 and 2018)

Propagation / Rootstock / Media	P1; Mound Layering					Sub Mean	P2; Trench Layering					Sub Mean	Media Mean	Root-stock Mean
	S1	S2	S3	S4	S5		S1	S2	S3	S4	S5			
M1; Vermiculite	6.39	4.36	6.76	5.43	7.28	6.04	7.35	5.32	7.71	6.38	8.23	7.00	6.52	S1=6.48
M2; Saw dust	8.45	4.91	9.06	5.57	9.87	7.57	9.40	5.88	10.00	6.52	10.82	8.52	8.05	S2=4.42
M3;FYM	6.11	3.72	6.32	5.22	6.34	5.54	7.07	4.68	7.28	6.18	7.34	6.51	6.03	S3=6.85
M4; Vermicom-post	6.15	4.20	6.64	5.38	6.78	5.83	7.10	5.16	7.60	6.33	7.74	6.79	6.31	S4=5.52
M5; Vermiculite+ Saw dust+ *Pseu-domonas*	8.25	4.68	8.44	5.51	8.78	7.13	9.20	5.64	9.40	6.47	9.71	8.08	7.61	S5=7.54
M6; Vermiculite+ Saw dust+ *Azoto-bacter*	6.97	4.44	7.28	5.45	8.69	6.57	7.92	5.40	8.21	6.40	9.65	7.52	7.04	
M7; FYM+Vermi-compost+ *Pseu-domonas*	5.50	3.71	5.64	4.59	6.20	5.13	6.45	4.67	6.64	5.54	7.14	6.09	5.61	
M8; FYM+Vermi-compost+ *Azotobacter*	4.50	3.53	4.82	4.17	5.89	4.58	5.45	4.48	5.80	5.13	6.82	5.54	5.06	
M9;*Pseudomo-nas*+ *Azotobacter*+ Soil	4.38	2.98	4.60	4.10	5.41	4.28	5.32	3.91	5.55	5.05	6.32	5.23	4.76	
M10; Control	3.37	2.91	4.17	3. 10	5.38	3.96	4.32	3.88	5.13	4. 05	6.30	4.91	4.43	
Mean	6.01	3.94	6.37	5.05	7.06	5.69	6.96	4.90	7.33	6.00	8.01	6.64	6.16	

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

C.D ($p \leq 0.05$)

Media (M) : 0.38 ; 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

by MM-106 (99.34) whereas, M-27 produced minimum least shoot length (70.82cm). The effect of different rooting media on shoot length was also found to be significant. The stools of different clonal rootstocks with FYM+ vemicompost + *Azotobacter* as hilling medium produced more shoot length (99.96 cm) followed by 96.58cm with FYM+ vemicompost + *Pseudomonas* as hilling medium and the least shoot length (79.84 cm) was observed in control (when only soil was used as hilling material).Interaction between rooting media, propagation methods and rootstocks were also found to be significant. The maximum shoot length (120.46 cm) was recorded in MM-111 (S_5) with FYM+ vermicompost+ *Azotobacter* as hilling medium followed by MM-106 (120.43 cm) when they were propagated through trench layering. The least shoot length (61.62 cm) was recorded in M-27 (S_2) with soil as hilling media when it was propagated through mound layering. Further it was observed that propagation technique P_2 (trench layering) had a significant advantage over P_1 (mound layering) with a value of 94.73 cm as compared to 82.78 cm with regard to average shoot length.

Among the different rooting media maximum shoot incremental growth (67.90 cm) was recorded with FYM+Vermicompost+*Azotobacter* as a hilling material and the least shoot incremental growth (44.49 cm) was recorded in control. The perusal of the data shows that among the different rootstocks maximum shoot incremental growth (65.14 cm) was found in MM-111 followed by

Table 5: Effect of different rooting media, propagation methods and their interaction on root dry weight (g) of different apple clonal rootstocks (pooled over 2017 and 2018)

Propagation	P1; Mound Layering					Sub Mean	P2; Trench Layering					Sub Mean	Media Mean	Rootstock Mean
Rootstock / Media	S1	S2	S3	S4	S5		S1	S2	S3	S4	S5			
T1; Vermiculite	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; Saw dust	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;FYM	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; Vermicompost	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; Vermiculite+ Saw dust+ *Pseudomonas*	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; Vermiculite+ Saw dust+ *Azotobacter*	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; FYM+Vermicompost+ *Pseudomonas*	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; FYM+Vermicompost+ *Azotobacter*	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;*Pseudomonas*+ *Azotobacter*+ Soil	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; Control	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

MM-106 (57.12 cm) whereas, the minimum shoot incremental growth (48.03 cm) was recorded in M-27. Interaction between hilling material, rootstocks and propagation methods were also found to be significant. The maximum shoot incremental growth was found in MM-111(77.50 cm) with FYM+Vermicompost+ *Azotobacter* as hilling medium and under trench layering while as minimum shoot incremental growth (38.83 cm) was recorded in control. Further it was observed that propagation technique P_2 (trench layering) had a significant effect over P_1 (mound layering) in terms of shoot incremental growth 56.40 cm as compared to 55.71 cm

The perusal of the data shows that all the rooting media significantly increased the leaf area of different apple clonal rootstocks. However, maximum leaf area (30.71 cm^2) was recorded with FYM+Vermicompost+*Azotobacter* as hilling material and the minimum leaf area (26.90 cm^2) was recorded in control. Among the various rootstocks, the maximum leaf area (30.33 cm^2) was found in MM-111 which was significantly higher than M-27 (26.72 cm^2). Interaction between rooting media, rootstocks and propagation techniques were also found to be significant. The maximum leaf area was found in MM-111 (32.00 cm^2) with FYM+ Vermicompost+ *Azotobacter* as hilling material under trench layering followed by 31.47 cm^2 with FYM+ Vermicompost+ *Pseudomonas* as hilling material. In the present study it was also observed

Table 5:- Effect of different rooting media, propagation methods and their interaction effect on the soil hydro thermal condition viz, soil temperature (^{0}C) of rooted layers (15-30 cm depth) of different apple clonal rootstocks (pooled over 2017 and 2018)

	15^{th} April						15^{th} June						
Treatment	S1	S2	S3	S4	S5	Submean	S1	S2	S3	S4	S5	Submean	
T1	17.86	17.49	17.75	17.50	17.87	17.69	25.48	25.46	25.77	24.51	25.00	17.69	
T2	17.83	18.38	18.8	18.63	18.94	18.71	26.04	26.98	26.39	26.01	**26.13**	18.71	
T3	17.68	17.13	17.01	17.65	17.38	17.37	25.44	25.01	25.56	25.26	25.01	17.37	
T4	17.94	17.4	17.79	17.65	17.60	17.67	25.96	25.66	25.89	25.48	25.72	17.67	
T5	17.68	17.38	17.07	17.95	17.52	17.52	24.64	24.55	25.36	25.99	25.65	17.52	
T6	17.69	17.9	17.71	17.56	17.22	17.61	24.59	24.59	25.79	25.58	25.63	17.61	
T7	17.90	17.35	17.7	17.71	17.08	17.34	25.23	24.61	25.18	25.36	25.05	17.34	
T8	16.81	16.81	16.37	16.96	16.44	16.27	23.83	23.41	24.92	24.82	24.44	16.50	
T9	16.88	16.88	15.34	16.22	16.03	16.16	23.04	22.84	24.51	24.63	24.80	16.16	
T10	15.27	15.27	16.37	14.31	15.04	15.09	20.55	20.48	23.87	22.41	23.41	15.21	
Mean	16.65	16.65	16.41	16.43	16.51	16.41	23.78	23.65	24.62	24.30	24.38	16.48	
	15^{th} August						15^{th} October						
Treatment	S1	S2	S3	S4	S5	Submean	S1	S2	S3	S4	S5	Submea	Rootstock mean
T1	26.66	26.56	26.50	26.51	26.05	26.46	22.58	22.03	22.51	22.66	23.38	22.43	22.90
T2	27.94	27.76	27.02	27.01	27.53	26.45	23.94	23.48	23.01	23.86	24.05	23.47	22.73
T3	26.47	26.36	26.66	26.26	26.73	26.50	22.44	22.77	22.26	22.50	23.25	22.44	23.00
T4	26.97	26.61	26.49	26.48	26.08	26.53	22.55	22.38	22.48	22.61	23.03	22.41	22.96
T5	26.56	26.17	26.84	26.99	26.35	26.58	22.39	22.95	22.99	22.77	23.62	22.74	21.75
T6	26.55	26.48	26.56	26.58	26.74	26.58	22.52	22.61	22.58	21.62	23.33	22.53	
T7	26.81	26.04	26.57	26.36	26.70	26.50	22.24	22.86	22.36	22.53	23.80	22.56	
T8	26.57	26.12	26.52	26.82	26.35	26.48	22.47	22.14	22.82	22.12	23.99	22.51	
T9	26.70	26.44	26.27	26.63	26.23	26.45	22.42	22.29	22.63	22.11	23.98	22.49	
T10	25.46	25.03	25.27	25.41	25.34	25.30	21.42	21.92	21.41	21.53	22.39	21.53	
Mean	26.66	26.35	26.47	26.50	26.41	26.48	22.49	22.54	22.50	22.53	23.48	22.51	

C.D (p ≤ o.o5)
Days (D) 0.21
Stock (S) 0.18
Media (M) 0.26
Propagation (P) NS

that propagation technique P_2 (trench layering) had a significant effect over P_1 (mound layering) in terms of leaf area 28.93 cm^2 as compared to 28.13 cm ^{2}.

It is clear from the data that rootstocks, propagation techniques as well as rooting media had a significant effect on average root fresh weight and root dry weight presented in table-4, 5. Both MM-111 (S5) and MM-106 (S3) attained significantly maximum root fresh weight and dry weight per layer (7.54, 5.91 g and 6.85, 4.28 respectively) than M-27(S2), which attained the minimum root fresh weight (4.42 g). The rootstocks mounded with Saw dust produced maximum root fresh weight (8.05 g) and the minimum root fresh weight (4.43 g) was recorded in control (only soil is used for hilling material). MM-111(S5) earthed-up with saw dust under trench layering produced maximum root fresh weight (10.82 g) in comparison to all other treatment combinations. However, minimum root fresh weight (2.91g) was found in M-27(S2) with soil as a hilling material It was observed that propagation technique P_2 had a significant effect over P_1 with a value of 6.64 g as compared to 5.69 g.

It is further evident from the data that rootstocks had a significant effect on root dry weight of rooted layers. MM-111 (S5) produced the maximum root dry weight (4.37g) followed by MM-106 (4.28g). However, M-27(S2) produced the minimum root dry weight (3.39 g). Maximum root dry weight (6.86 g) was found in MM-111 (S5) with saw dust as rooting media under trench layering and the minimum root dry weight (3.07g) was observed

Table-6 Effect of different rooting media, propagation methods and their interaction effect on the media moisture (%) of rooted layers (15-30cm depth) of different apple clonal rootstocks (pooled over 2017 and 2018)

	15th April						15th June						
Treatment	S1	S2	S3	S4	S5	Submean	S1	S2	S3	S4	S5	Submean	
T1	28.38	28.10	27.76	27.87	28.11	25.67	25.61	26.51	23.79	24.85	25.28	24.28	
T2	26.85	26.94	26.76	26.85	26.95	23.77	24.30	24.77	25.50	24.33	24.53	23.11	
T3	27.00	27.00	28.06	26.17	27.07	24.07	24.25	23.82	24.14	24.44	24.14	23.31	
T4	27.09	27.09	26.99	27.42	27.19	24.27	24.14	24.08	24.01	23.84	24.07	23.14	
T5	27.19	27.30	27.34	27.23	27.24	24.17	23.85	24.10	24.14	24.40	24.13	23.01	
T6	27.12	27.11	27.06	27.40	27.17	24.20	23.89	24.25	24.00	24.15	24.10	23.09	
T7	27.97	27.02	26.92	27.00	26.98	23.95	24.13	23.90	23.78	23.61	23.87	23.12	
T8	26.17	27.05	26.98	26.87	26.79	23.66	23.58	24.04	24.19	24.01	23.89	23.29	
T9	26.81	26.55	26.83	26.84	26.80	24.05	23.93	23.69	23.91	23.81	23.88	23.23	
T10	25.82	25.28	27.03	25.80	25.95	22.80	22.99	23.20	23.20	23.19	23.07	22.26	
Mean	26.94	26.94	28.17	26.94	27.02	24.06	24.07	24.23	24.07	24.06	24.10	23.18	
	15th August					15th October							
S1	S2	S3	S4	S5	sub-mean	S1	S2	S3	S4	S5	Submea	Median mean	Root stock mean
24.12	24.47	23.06	22.53	23.69	17.83	16.44	16.34	16.33	16.33	16.66	23.44	23.44	19.39
22.81	23.25	24.41	24.26	23.57	16.68	16.41	16.34	16.33	16.33	16.42	22.87	22.87	23.58
23.07	23.39	23.12	23.06	23.19	16.56	16.40	16.33	16.33	16.33	16.39	22.70	22.70	23.66
22.91	23.32	23.07	22.80	23.05	16.80	16.36	16.33	16.33	16.33	16.43	22.68	22.68	22.68
23.08	23.23	22.95	23.11	23.07	16.74	16.32	16.33	16.33	16.33	16.41	22.71	22.71	22.57
22.88	22.73	23.07	22.93	23.94	16.35	16.32	16.33	16.33	16.33	16.33	22.63	22.63	
23.15	23.00	22.91	23.07	23.05	16.26	16.33	16.33	16.33	16.33	16.31	22.55	22.55	
23.10	22.97	23.35	23.10	23.16	16.78	16.28	16.33	16.33	16.33	16.41	22.56	22.56	
22.86	22.97	23.35	22.67	23.01	16.30	16.28	16.34	16.33	16.33	16.32	22.50	22.50	
21.64	22.05	22.12	22.03	22.02	15.38	16.37	16.33	16.33	16.33	16.15	21.80	23.80	
22.96	23.14	23.14	22.95	23.07	16.57	16.35	16.33	16.33	16.33	16.38		23.44	

in M-27 (S2) under mound layering. Further it was observed that propagation technique P_2 (trench layering) had a significant effect over P_1 (mound layering) in terms of root dry weight 4.10 g as compared to 3.90 g.

The perusal of data (Table-6) reveals that average media temperature at 15-30 cm depth was significantly influenced under all the hilling media. Maximum mean media temperature (28.05^{0}C) was recorded under saw dust treatment followed by Vermiculite+ Saw dust+ *Azotobacter* (27.87^{0}C). The minimum media temperature (17.27^{0}C) was recorded in control (when only soil was used as hilling media).The media temperature at 0-15cm depth also varied significantly during different months and maximum mean media temperature was recorded during the month of August. The minimum media temperature was observed on 15th April. In general, the media temperature showed an increased trend during the whole growing season except in the month of October where the media temperature decreases. Maintenance of relatively higher media temperature under saw dust is attributed to its ability to create insulation over the soil surface, thereby restricting the temperature inversion and negative heat flux from the soil. The results of the present study are in agreement with the findings of [7] Wherein they studied the effect of mulch on successive crop yields and soil carbon in Tonga and found increased soil temperature under saw dust. The effect of media temperature on the propagation techniques *viz*., mound layering and trench layering were found non-significant.

Perusal of Table-2 reveals that all the hilling media significantly influenced the media moisture content at 15-30 cm depth in various rootstocks throughout the growing season. Maximum mean media moisture content (29.54%) was recorded in under vermiculite which was significantly, higher as compared to all other hilling media. The minimum media moisture content (19.47%) was recorded under control (when only soil was used a hilling media).

The media moisture content at 15-30cm cm depth also varied significantly during different months and maximum mean soil moisture content (28.54%) was recorded on 15th June and the minimum (%) on 15thApril. The increase in media moisture in vermiculite is attributed due to retention of higher water holding capacity because of its swelling properties and light dark in colour [8], wherein they studied the Influence of nursery soil amendments on water relations, root architectural development, and field performance of Douglas-fir transplants and found increased soil moisture under vermiculite. The effect of media temperature on the propagation techniques viz., mound layering and trench layering were found non-significant.

The increase in shoot length and shoot incremental growth might be due to the fact that FYM+Vemicompost+*Azotobacter* directly added organic carbon, improved soil physical and chemical properties, improved soil health, soil ecology and soil environment supplying essential micronutrients, and build soil micro flora which are involved in nitrogen fixation and recycling pathways of other minerals beside maintenance of humic substances in soil [9]. The high amount of nitrogen due to more organic matter tends to increase the vegetative growth [10].

The increase in leaf area might be due to the fact that the plant cells grow in size by cell enlargement which in turn requires water [11]. Turgidity of cells helps in extension growth. Thus, plant growth and further development is intimately linked to the water status of the plant. As the water content of the plant decreases, cells shrink and the turgor pressure against cell walls reflexes, results in reduction in the leaf area [11]. Increase in Leaf area is a function of cell multiplication and cell enlargement. Nitrogen forms a major source for cell division and cell enlargement and is the main component of chlorophyll, proteins and nucleic acid [12].

The increase in leaf area under FYM+Vermicompost+*Azotobacter* might be due to adequate N which might has led to higher metabolic activity resulting in higher production of carbohydrates and phytohormones [13]. *Azotobacter* helps in increasing the biological nitrogen fixation which is required for strong vegetative growth. Vermicompost is rich source of nitrogen, which is the direct component for the synthesis of proteins in plants, thus the increase in nitrogen supply accelerates synthesis of amino acids which may directly result in excessive growth and development of cells which might have indirectly exhibited increased leaf area. [14-15].

The increase in root characters/ traits in saw dust may be attributed to continuous increase in media temperature during the period of investigation leading to an increase in metabolic activity of root cells and the development of lateral roots which in turn improves root growth and other rooting characters [16]. Low soil temperature results in reduced tissue nutrient concentrations and as such decreases root growth [17].

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