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Effect of Rooting Media and Time of Air Layering in Guava (*Psidium guajava* L.) in West Garo Hills, Meghalaya

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Abstract The present study was conducted during December 2016 to March 2018 in the Institutional Farm of the Department of Rural Development and Agricultural Production, NEHU, Tura Campus, which lies between 25°52′ North latitude and 90°20′ East longitude. The data showed significant effect of different rooting media and time of layering on various parameters of rooting success, root characters, growth characters and field establishment. Among the eleven rooting media, it was observed that three rooting media out performed in most of the parameters recorded. The rooting media prepared by mixing equal proportions of Soil+Sawdust (T_7) ; Soil+Vermicompost + Cocopeat + Sawdust (T_{11}) and Cocopeat + Sawdust (T_{10}) were found to be the best rooting media for air layering of guava under West Garo Hills climatic condition. Among the different time of layering evaluated in the present study, it was found that the most ideal time of air layering in guava was first week of August followed by first week of June and April for air layering in guava under the agro-climatic condition of West Garo Hills.

Keywords West Garo Hills, *Psidium guajava*, Air layering, Rooting media.

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Introduction

Guava (*Psidium guajava* L.) is a potential fruit crop of Garo Hills due to its adaptability to the prevailing agro climatic conditions as well as high nutritive value. Non-availability of genuine planting material is a serious impediment in popularization of guava in Garo Hills. Vegetative propagation is considered as an effective method to produce true to type planting material. Among the different vegetative methods, air layering (also known as '*goottee*') is the commercial method practiced for propagation of guava owing to high rooting and survival of layers (80–85%) (Manna et al. 2001). The success of air-layering depends on factors like varying conditions of climate, species and varieties of the plant and environmental factors like air, temperature, humidity and mechanical treatments. Physiological condition of mother plant, age of wood, rooting media used and season during which layering is done also influence the rooting of layerings. Among the various factors, rooting media and time of layering is considered very important for the success of air layering. After extensive review of available literature published in various scientific journals, magazines, books it was observed that this crop did not receive sufficient attention from the researchers with respect to improvement of various aspects of its production technology under West Garo Hills condition. Therefore, this research program was carried out to evaluate the efficacy of different rooting media and to standardize time of air layering of guava under the agro-climatic condition of West Garo Hills, Meghalaya.

Materials and Methods

The present research program was conducted during first week of December 2016 to March 2018 in the Institutional Farm of the Department of Rural Development and Agricultural Production, NEHU, Tura Campus, which lies between 26° and 25°20′ North latitude and 90°30′ and 89°40′ East longitude. The experiment was conducted on 13 years old guava cv Sardar (Lucknow-49). A two centimeter wide ring of bark was removed at a distance of 25–30 cm from tip and the ringed area was covered with various rooting media and wrapped with transparent polythene sheet (100 gauge thickness) and then tied with jute string. The layers were removed when roots appeared on the outer surface of the rooting media. The experiment was laid down in 2 factor factorial completely randomized design with eleven treatments and five replications. Each replication included four layers making a total of 20 layers per treatment. Layering was done at bi-monthly interval for one year starting from first week of December 2016 till first week of October 2017. The data collected during the investigation was statistically analyzed by Fisher's analysis of variance (Panse and Sukhatme 1985). The following rooting media were used for the study viz. T_1=Soil (Control) ;T_2=Vermicompost ;T_3=Coco peat ; T_4 = Saw dust ; T_5=T_1 + T_2 (1 : 1 ratio) ; T_6 = T_1 + T_3 (1:1 ratio) ; T_7 = T_1 + T_4 (1:1 ratio) ; T_8=T_2+T_3 (1 : 1 ratio) ; T_9= T_2 + T_4 (1:1 ratio) ; T_{10} = T_3 + T_4 (1 : 1 ratio) ;T_{11} =T_1 + T_2 +T_3 + T_4 (1:1:1:1 ratio). Observations on rooting success, average root length and diameter, average length and diameter of longest and shortest root were recorded. Field establishment study viz. survivability of layers, number of days taken for first bud emergence, number of primary and secondary branches, length of primary and secondary branches were recorded.

Results and Discussion

Analysis of variation (ANOVA) showed significant effect of different rooting media and time of layering (month) on various parameters viz. number of days taken for root emergence; percentage of successful layers ; average length and diameter of root. Interaction between rooting media and time of layering also exhibited significant effects (Table 1). Parameters like

Table 1. Analysis of variance (ANOVA) of rooting media and time of air layering on guava. *denote significance level at p=0.05 and **denotes significance level at p=0.01 ; Edf = Error degree of freedom.

		Mean sum of square				
Source	df	No. of days for rooting	Rooting percentage	Average root length	Average root diameter	Average length of longest root
Total	197	486.883	370.63	1.638	0.236	1.953
Treatment	65	1236.357^{NS}	1113.01**	3.907**	0.416^{NS}	4.482*
Rooting media (T)	10	844.421**	3729.74**	16.141**	1.249**	17.877**
Month of layering (M)	5	11248.174**	2916.96**	4.835**	0.205^{NS}	6.199**
T×M	50	313.562**	409.27**	1.367**	0.271*	1.631**
Error	132	117.823	5.07	0.521	0.147	0.708

Table 1. Continued.

		Mean sum of square				
Source	df	Average diameter of longest root	Survivability of layers after 3 month	First bud sprout	No. of primary branches after 3 months	No. of secondary branches after 3 months
Total	197	2.761	0.247	13.023	0.695	0.892
Treatment	65	4.991^{NS}	0.247^{NS}	12.866^{NS}	0.775^{NS}	0.992^{NS}
Rooting media (T)	10	4.735**	0.860**	26.64*	3.288**	3.048**
Month of layering (M)	5	8.118**	0.324^{NS}	50.74**	0.283^{NS}	1.757^{NS}
T×M	50	4.729**	0.117^{NS}	6.323^{NS}	0.321^{NS}	0.504^{NS}
Error	132	1.664	0.247	13.101	0.656	0.843

Table 2. Effect of rooting media and time of air layering on number of days taken for rooting and rooting success (%). T_1=Soil (Control) ; T_2 = Vermicompost ; T_3 = Cocopeat ; T_4 = Sawdust ; $T_5 = T_1 + T_2$ (1:1 ratio) ; $T_6 = T_1 + T_3$ (1 : 1 ratio) ; $T_7 = T_1 + T_4$ (1:1 ratio) ; $T_8 = T_2 + T_3$ (1 : 1 ratio) ; $T_9 = T_2 + T_4$ (1 :1 ratio) ; $T_{10} = T_3 + T_4$ (1 : 1 ratio) ; $T_{11} = T_1 + T_2 + T_3 + T_4$ (1:1:1:1 ratio).

Time of layering (Month)→ Rooting media (T)↓	Dec 2016		Feb 2017		Apr 2017		Jun 2017		Aug 2017		Oct 2017	
	No. of days for rooting	Rooting success	No. of days for rooting	Rooting success	No. of days for rooting	Rooting success	No. of days for rooting	Rooting success	No. of days for rooting	Rooting success	No. of days for rooting	Rooting success
T_1	98.3	40%	82.00	0%	70.33	60%	56.33	60%	66.00	80%	92.67	40%
T_2	115.3	60%	94.33	60%	73.33	80%	78.00	80%	64.33	80%	97.67	60%
T_3	125.3	60%	89.00	60%	70.33	80%	69.33	80%	69.33	80%	89.33	60%
T_4	109.3	80%	75.33	60%	83.67	80%	63.67	80%	63.33	80%	90.00	80%
T_5	124.7	60%	83.00	80%	84.00	60%	44.67	40%	46.33	60%	99.67	60%
T_6	130.0	60%	77.33	40%	79.00	80%	75.67	80%	75.00	60%	88.33	60%
T_7	76.0	80%	78.33	100%	56.33	100%	66.33	80%	60.33	100%	72.33	80%
T_8	118.7	60%	78.33	40%	100.67	60%	66.67	60%	66.67	80%	80.00	60%
T_9	129.3	60%	92.00	60%	68.00	100%	62.67	80%	66.00	60%	76.00	60%
T_{10}	106.3	60%	73.42	80%	44.33	100%	68.33	80%	64.67	80%	81.33	60%
T_{11}	104.0	100%	70.83	80%	66.33	100%	42.67	100%	57.00	100%	77.00	100%

	Rooting media (T)		Time of layering (M)		T × M	
	No. of days for rooting	Rooting success	No. of days for rooting	Rooting success	No. of days for rooting	Rooting success
SEd ±	3.618	0.75	2.672	0.554	8.862	1.838
$CD_{0.05}$	7.157	1.484	5.286	1.096	17.531	3.637
$CD_{0.01}$	9.457	1.961	6.984	1.448	23.165	4.805

survivability of layers after planting, number of primary and secondary branches and length of shoot did not show significant variation with respect to month of layering but rooting media had significant influence.

Data presented in Table 2 revealed that air layering of guava in the month of June and August produced early rooting which varied from 44.67 to 78 days and 46.33 to 75 days respectively, while layers done in the month of December took longest time (76 to 130 days) for rooting under the agro-climatic conditions of West Garo Hills of Meghalaya. Among the rooting media T_7 (Soil + Sawdust), T_{10} (Cocopeat + Sawdust) and T_{11} (Soil + Vermicompost +Cocopeat + Sawdust) exhibited early rooting ranging from 68.28 to 73.06 days while T_2 (vermicompost), T_3 (cocopeat), T_4 (sawdust), T_6 (soil + cocopeat), T_8 (vermicompost + cocopeat) and T_9 (vermicompost + sawdust) exhibited significant delay in rooting. Among the various treatment combinations, air layering carried out in the month of June with rooting media viz. Soil (T_1), Soil+Vermicompost (T_5), Cocopeat + Sawdust (T_{10}) and Soil+ Vermicompost+Cocopeat+Sawdust (T_{11}) exhibited early rooting time. The best rooting media for the month of August were a combination of Soil + Vermicompost (T_5) and T_{11} (Soil+Vermicompost +Cocopeat+Sawdust). Early rooting of guava layered in the month of June and July was also reported by other researchers (Manna et al. 2001). It was also reported that layers taken in the month of August exhibited early root initiation (Manga et al. 2017). Similar result was also reported by other workers (Rani et al. 2015 and Baghel et al. 2016).

Rooting success of air layering in guava was significantly influenced by rooting media and time of layering (Table 2). Rooting media made by mixing Soil + Vermicompost + Cocopeat+Sawdust in equal proportion (T_{11}) exhibited highest percentage of rooting success ranging from 80–100% followed by T_7 (Soil + Sawdust) and T_{10} (Cocopeat+Sawdust) which re-

Table 3. Effect of rooting media and time of air layering on average root length (cm) and average root diameter (cm).

Time of layering (Month)→ Rooting media (T)↓	Dec 2016		Feb 2017		Apr 2017		Jun 2017		Aug 2017		Oct 2017	
	Average root length (cm)	Average root diameter (mm)	Average root length (cm)	Average root diameter (mm)	Average root length (cm)	Average root diameter (mm)	Average root length (cm)	Average root diameter (mm)	Average root length (cm)	Average root diameter (mm)	Average root length (cm)	Average root diameter (mm)
T_1	1.66	0.86	2.60	1.26	4.09	1.54	2.64	1.03	3.84	1.46	3.19	1.52
T_2	2.11	1.42	2.01	1.29	3.56	1.80	2.78	1.58	4.13	1.16	3.13	0.96
T_3	3.70	1.64	3.54	1.73	5.44	1.92	3.92	2.17	5.36	1.99	3.83	1.69
T_4	3.86	1.53	4.33	2.12	3.16	1.52	3.62	1.42	3.86	1.21	3.86	1.21
T_5	3.26	1.80	4.85	1.74	4.80	1.63	3.29	1.68	4.29	1.69	3.79	2.19
T_6	4.03	1.53	4.71	1.46	4.77	2.23	2.30	1.45	4.96	1.54	3.96	1.54
T_7	6.00	2.01	4.49	1.47	6.17	2.13	6.18	2.26	6.83	1.92	5.22	1.90
T_8	2.88	1.49	3.68	1.80	3.51	1.78	3.23	1.59	4.39	2.28	4.39	2.28
T_9	4.44	1.65	4.27	1.58	4.91	1.63	3.04	1.79	3.67	1.06	3.75	1.94
T_{10}	5.09	1.90	5.91	1.56	6.43	2.27	5.98	1.75	5.82	2.30	5.32	2.30
T_{11}	5.93	2.44	5.74	2.15	4.32	2.02	4.41	2.51	4.33	1.76	4.33	1.54

	Rooting media (T)		Time of layering (M)		T × M	
	Average root length (cm)	Average root diameter (cm)	Average root length (cm)	Average root diameter (cm)	Average root length (cm)	Average root diameter (cm)
SEd ±	0.24	0.128	0.177	0.094	0.589	0.313
$CD_{0.05}$	0.476	0.253	0.351	NS	1.166	0.247
$CD_{0.01}$	0.629	0.334	0.464	NS	1.541	NS

corded 60–100% of rooting, while, T_1 (Soil)showed lowest rooting success (0–80%). The treatment combination of soil and sawdust (T_7) exhibited best result in the month of February, April, June and August followed by T_9 (vermicompost+sawdust) in the month of June ; T_{10} (Cocopeat + Sawdust) in the month of April and T_{11} (oil+vermicompost+cocopeat+sawdust) in the month of February and April. However, T_1 (Soil) performed the least in most of the months, especially December, February and October. Higher rooting success in the month of August was also reported by different researchers from different parts of the country (Manga et al. 2017, Rani et al. 2015, Rymbai and Reddy 2010). June and July months were also reported to be the most suitable months for air layering in guava for getting maximum rooting success (Manga et al. 2017). Similarly month of June was found to bear better rooting success in other study also (Urmi et al. 2016).

Table 3 shows that layers made with a mixture of T_7 (Soil+Sawdust and T_{10} (cocopeat+sawdust) recorded highest average length of root ranging from 4.49 cm to 6.83 cm and 5.09 cm to 6.93 cm respectively, followed by T_{11} (soil+vermicompost+cocopeat +sawdust). Rooting media viz. T_1 (soil) and T_2 (vermicompost) recorded shortest average length of roots of 1.66 cm to 4.09 cm and 2.01 cm to 4.13 cm respectively. Layering carried out in the month of April and August recorded longest average root while, layers taken in October and December recorded shortest average root length. Among the interaction effect, soil and sawdust (T_7) in the month of April, August and December, followed by cocopeat and sawdust (T_{10}) in the month of February, April, June and August a mixture of soil+vermicompost+ cocopeat+sawdust (T_{11}) in the month of February and December were found to be the best combination with respect to average root length. Similarly, longest roots

Table 4. Effect of rooting media and time of air layering on longest root length (cm) and longest root diameter (mm).

Time of layering (Month)→ Rooting media (T)↓	Dec 2016		Feb 2017		Apr 2017		Jun 2017		Aug 2017		Oct 2017	
	Longest root length	Longest root diameter	Longest root length	Longest root diameter	Longest root length	Longest root diameter	Longest root length	Longest root diameter	Longest root length	Longest root diameter	Longest root length	Longest root diameter
T_1	3.35	1.19	3.60	1.62	5.20	1.71	4.00	1.28	5.55	1.32	3.70	1.82
T_2	4.10	2.10	2.65	2.13	3.85	2.06	4.65	1.14	5.75	2.00	3.70	2.23
T_3	4.70	2.30	4.60	1.78	6.75	1.31	6.35	3.40	6.50	1.66	5.80	1.36
T_4	5.00	1.95	6.00	2.36	4.20	2.16	4.95	1.80	5.90	0.81	5.50	0.81
T_5	5.25	1.84	6.75	2.19	6.25	1.92	4.95	0.89	5.85	1.28	5.40	1.28
T_6	5.20	2.70	5.65	1.45	4.40	2.62	5.60	2.77	6.00	1.47	5.00	1.47
T_7	8.25	2.69	6.15	1.28	7.00	1.75	8.45	3.34	8.05	2.22	6.03	2.32
T_8	4.75	2.30	4.35	1.90	5.15	0.88	5.25	2.32	5.75	1.72	4.89	1.64
T_9	5.70	2.20	6.35	2.37	7.65	1.62	4.95	9.21	6.20	1.49	5.20	1.24
T_{10}	6.75	1.07	6.90	1.65	7.25	2.64	6.65	1.35	6.90	2.04	5.40	1.76
T_{11}	6.85	2.56	6.75	2.71	7.00	2.26	7.40	2.70	6.90	1.42	4.93	1.41

	Rooting media (T)		Time of layering (M)		T × M	
	Longest root length	Longest root diameter	Longest root length	Longest root diameter	Longest root length	Longest root diameter
SEd ±	0.28	0.43	0.207	0.317	1.053	0.687
$CD_{0.05}$	0.555	0.85	0.409	0.628	2.083	1.359
$CD_{0.01}$	0.733	0.123	0.541	0.83	2.753	1.796

were obtained from layers taken during the month of June and July (Manga et al. 2017).

The rooting media viz. T_3 (cocopeat), T_7 (Soil+Sawdust), T_8 (vermicompost+cocopeat), T_{10} (Cocopeat+Sawdust) and T_{11} (soil+vermicompost +cocopeat+sawdust) recorded highest average root diameter, while T_1 (soil), T_2 (vermicompost) and T_4 (sawdust) recorded lowest average root diameter (Table 3). The average root diameter ranged between 1.93 to 1.73 mm in T_3 during different months of layering. Time of layering (month) did not show significant effect. Among the interaction effect, cocopeat when used as the rooting media in the month of April, June and August showed best result with respect to average root diameter while only soil (T_1) as a rooting media showed lowest average diameter.

Average length of longest root (Table 4) did not vary significantly with respect to rooting media, time of layering and its interaction. However, the average length of longest root of T_7 (Soil+Sawdust) ranged between 6.03 cm to 8.45 cm taken during different months. The layers recorded longest roots during the month of June (5.5 to 8.05 cm) followed by April (3.85 to 7.65 cm). Average diameter of longest roots exhibited significant variation in response to rooting media and time of layering (Table 4). Thickest roots were recorded in layers where cocopeat (T_3), was used as rooting media followed by T_{11} (soil + vermicompost+ cocopeat + sawdust), T_{10} (Cocopeat + Sawdust) and T_5 while, T_2 (vermicompost), T_4 (sawdust), T_6 (soil + cocopeat), and T_8 (vermicompost + cocopeat) recorded thinnest root. Layers taken in the month of April and August recorded thickest root diameter ranging from 0.95 to 2.96 mm and 0.36 to 2.63 mm respectively. Combined effect also exhibited significant variations with respect to diameter of short-

Table 5. Effect of rooting media and time of air layering on number of days taken for first bud sprout and percentage of layers survived after 3 month (MAP).T_1=Soil (Control) ; T_2=Vermicompost ;T_3 = Cocopeat ; T_4 = Sawdust ; T_5 = T_1+ T_2 (1:1 ratio) ; T_6= T_1 + T_3 (1 : 1 ratio) ; T_7 = T_1 + T_4 (1:1 ratio) ; T_8 = T_2 + T_3 (1 : 1 ratio) ; T_9 = T_2 + T_4 (1 :1 ratio) ; T_{10} = T_3 + T_4 (1:1 ratio); T_{11} = T_1 + T_2 + T_3 + T_4 (1:1:1:1 ratio).

Time of layering (Month)→ Rooting media (T)↓	Dec 2016		Feb 2017		Apr 2017		Jun 2017		Aug 2017		Oct 2017	
	No. of days for first bud sprout	% of layers survived 3 MAP	No. of days for first bud sprout	% of layers survived 3 MAP	No. of days for first bud sprout	% of layers survived 3 MAP	No. of days for first bud sprout	% of layers survived 3 MAP	No. of days for first bud sprout	% of layers survived 3 MAP	No. of days for first bud sprout	% of layers survived 3 MAP
T_1	9	0.00	8	0.00	5	0.33	6	0.33	7	0.67	13	0.33
T_2	7	0.33	6	0.33	5.5	0.67	5	0.67	6	0.67	7.5	0.33
T_3	6	0.33	7	0.33	5	0.33	5	0.33	5	0.33	5	0.00
T_4	5.5	0.67	5	0.33	4.5	0.67	4	0.33	5.5	0.67	7	0.67
T_5	7	0.33	10	0.67	6	0.00	5	0.00	8	0.33	10	0.33
T_6	10	0.00	7	0.00	5	0.00	6	0.33	7	0.33	7	0.33
T_7	5	0.67	4.5	0.67	5	1.00	4	0.67	6	1.00	7	0.67
T_8	11	0.00	9	0.00	4	0.33	5	0.33	7	0.33	10	0.33
T_9	10	0.33	9	0.33	4.5	0.67	5	0.33	7	0.33	13	0.33
T_{10}	8	0.33	6.5	0.67	5	1.00	5.5	0.67	5.5	0.67	9	0.67
T_{11}	6.5	1.00	5.5	0.67	5	0.67	6	1.00	5	1.00	8	0.67

	Rooting media (T)		Time of layering (M)		T × M	
	No. of days for first bud sprout	% of layers survived 3 MAP	No.of days for first bud sprout	% of layers survived 3 MAP	No. of days for first bud sprout	% of layers survived 3 MAP
SEd±	1.206	0.165	0.841	0.122	2.955	0.406
$CD_{0.05}$	2.386	0.328	1.762	NS	NS	0.803
$CD_{0.01}$	3.153	0.433	2.329	NS	NS	NS

est root. The best result was found in combination of T_2 (vermicompost) taken in the month of June, T_3 (cocopeat) taken in the month of April, June and August.

Field survivability of layers is an important criterion to assess the efficacy of any propagation method. Data presented in Table 5 revealed that highest field survivability of layers recorded after 1st and 3rd month of planting was found in rooting media viz. T_7 (soil +sawdust), and T_{11} (soil+vermicompost+cocopeat+ sawdust) where the percentage of survivability varied from 67% to 100% during different months of layering, while T_1 (soil), T_3 (cocopeat), T_5 (soil+vermicompost), T_6 (soil+cocopeat), T_8 (vermicompost+ cocopeat), and T_9 (vermicompost+ sawdust) recorded poor survivability (0–67%). Highest percentage of survivability were recorded in the month of April, June and August, while October, December, and February showed lowest percentage of survivability. Interaction effect did not show significant variation. Highest survivability of layers taken in the month of June was also reported several scientists (Manga et al. 2017, Rymbai and Reddy 2010, Urmi et al. 2016). This may be attributed to availability of rainfall. Field establishment of guava layers prepared in the month of January and February were reported to be significantly poor (Manga et al. 2017).

Emergence of axillary bud is the first sign of successful establishment of layers. Emergence of bud significantly varied between 4 to 13 days as influenced by rooting media and time of layering. The rooting media viz. T_4 (sawdust), T_7 (soil+sawdust), and T_{11} (soil+vermicompost+cocopeat+sawdust) recorded lowest time for bud sprout while, T_1 (soil), T_2

(vermicompost) and T_9 (vermicompost+sawdust) exhibited relatively slow bud emergence. Fastest bud sprout was observed in layers carried out in the month of April (4.5 to 5.5 days) followed by June (4 to 6 days) and August (5 to 8 days) while layers taken in the month of December and October exhibited very slow bud emergence (Table 5). Similar finding was reported by Rymbai et al. (2012) and Rani et al. (2015). Manga et al. (2017) also reported maximum number of sprouts (8.25) in layers taken in the month of August which corroborates with the present observation.

Conclusion

Out of the eleven rooting media studied, it was observed that three rooting media out performed in most of the parameters recorded. The rooting media prepared by mixing equal proportions of Soil+ Sawdust (T_7) ; Soil +Vermicompost+Cocopeat+ Sawdust (T_{11}) and Cocopeat+Sawdust (T_{10}) were found to be the best rooting media for air layering of guava under West Garo Hills climatic condition. Among the different time of layering evaluated, it was found that the most ideal time of air layering in guava was the month of August followed by June and April, while the month of February and December were found to be relatively in appropriate time for air layering in guava under the agro-climatic condition of Garo Hills. The results of interaction effect revealed that, a mixture of soil+sawdust (T_7) may be used to obtain successful layers during the drier month of February. This finding opens up new possibility of air layering in guava during the off season by selecting the right kind of rooting media. Further research in this direction may pave way to time / month specific rooting media for successful layering of guava.

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