SKUAST Journal of Research 27(4): 579-587; (2025)
(*DOI No. 10.5958/2349-297X.2025.00069.8*); NASS rating: 4.88

Research Paper

Rooting in hardwood cuttings of apple clonal rootstocks using indole-butyric acid and rooting media

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(Received May 26, 2025; accepted August 01, 2025)

ABSTRACT

The present investigation was carried out to obtain best combination of rooting media and IBA concentration for propagating apple clonal rootstocks in the experimental field of Division of Fruit Science, SKUAST-Kashmir, Shalimar campus, Srinagar. The experiment consisted of three rootstocks (S_1: M_7, S_2: M_9T_{337} and S_3: MM_{106}), three IBA concentrations (G_1: 2500 ppm, G_2: 3000 ppm and G_3: 3500 ppm) and four combinations of rooting media [M_1: Sand + Vermicompost (1:1), M_2: Sand + Vermicompost + Vermiculite (1:1:1), M_3: Sand + Vermicompost + Perlite (1:1:1) and M_4: Sand + Vermicompost + Cocopeat (1:1:1)]. Results obtained revealed that $S_3G_2M_3$ treatment combination i.e. (MM_{106} + 3000 ppm + Sand + Vermicompost + Perlite (1:1:1)) recorded significantly highest root diameter (3.79 mm), maximum number of roots (13.00), maximum average root length (38.33 cm), maximum length of longest root per cutting (52.00 cm), highest fresh weight of root (7.50 g) as well as dry weight of root (3.56 g) and maximum percentage of rooted cuttings (66.66%). The maximum root: shoot ratio (0.23) was recorded in rootstock cuttings with treatment combination $S_3G_2M_4$. The results obtained from this study can be utilized to create a protocol for production of quality planting material of apple clonal rootstocks through cuttings.

Key words: Apple, growth hormone, media, perlite rootstocks, vermi-compost

Rootstocks are vital for enhancing fruit quality and productivity due to their adaptability and traits like pest and disease resistance, improved nutrient uptake, and tolerance to challenging soils (Kumar *et al.*, 2021). They also influence scion performance by controlling tree vigor and canopy structure, making high-density orchards possible. While seedling rootstocks are easy and cheap to propagate, they show genetic variability, leading to inconsistent vigor and yield (Sharma and Kumar, 2019). Clonal rootstocks, widely used in advanced fruit-growing regions, offer uniformity, precocity and higher productivity. In apples, clonal rootstocks are commonly propagated by mound layering, but hardwood cuttings are a simpler alternative. Rooting success can be improved with plant growth regulators like indole-butyric acid (IBA) and suitable rooting media. According to Shanker *et al.* (2019), a good rooting medium supports the plant, stores nutrients and water, and ensures proper oxygen diffusion. Cocopeat holds water well but limits aeration, which can be improved by mixing in coarser materials like perlite (Abad *et al.*, 2002; Sambo *et al.*, 2008; Paradiso and De-Pascale, 2008). The present study investigates how different IBA concentrations and rooting media affect rooting success in three apple clonal rootstocks.

MATERIALS AND METHODS

The experiment was conducted in the experimental nursery block of Division of Fruit Science, SKUAST-Kashmir, Shalimar Campus Srinagar, J and K during 2019. Hardwood cuttings of three rootstocks (S_1: M_7, S_2: M_9T_{337} and S_3: MM_{106}) were treated with three IBA concentration (G_1: 2500 ppm, G_2: 3000 ppm and G_3: 3500 ppm) and placed in four different rooting media [M_1: Sand + Vermicompost (1:1), M_2: Sand + Vermicompost + Vermiculite (1:1:1), M_3: Sand + Vermicompost + Perlite (1:1:1) and M_4: Sand + Vermicompost + Cocopeat (1:1:1)]. Hardwood cuttings from previous year growth were collected in February (dormant season), stored in a cool place by covering with sand and proper level of moisture was ensured in the sand till they were planted in polybags. Cuttings were then taken out from the sand and washed with water to remove the sand particles that adored the cuttings. The cuttings having length of 15-20 cm, 4-5 nodes and thickness of 0.8-1.0 cm were taken from the hardwood portion and prepared by giving first basal cut just below the node and the top cut half to one inch above the node. The basal cut was straight while the top cut was slant. Cuttings were treated with IBA at the time of planting by quick dipping the cuttings for 10-15 seconds. Each treatment was replicated thrice under controlled randomized design. Observations were recorded on different root parameters. Root diameter was measured with the help of digital vernier caliper and expressed in mm. Number of roots emerging from each rooted cuttings was counted as numbers. Root length and length of longest root per cutting under each replication was measured with scale from base to tip, average and expressed in cm. Roots were cut from the shoot with the help of secateurs and fresh weight of roots under each replication was recorded by weighing all the roots on digital weighing balance. Both root and shoot portion was dried in the oven at 65°C till they attained constant weight and dry weight of both root and shoot were taken by weighing dried roots and shoots on digital weighing balance. Root:shoot ratio was calculated by dividing dry weight of root with dry weight of shoot. Rooted cutting per cent age under each replication and treatments were recorded after removing the cuttings from their respective polybags and by counting the number of rooted cuttings out of the total number of cuttings planted per treatment. Data generated from the investigations were statistically analyzed at 5 per cent level of significance (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

Observations on root diameter were significantly influenced by rootstock, rooting media and growth hormone (Table1). Maximum root diameter (2.51 mm) was recorded in rootstock S_3 (MM_{106}) which was significantly higher than other rootstocks and followed by S_1 (M_7) having root diameter of 2.29 mm whereas minimum root diameter was measured for M_9T_{337} (1.88 mm). With respect to growth hormone treatments, maximum root diameter (2.90 mm) was observed in rootstock cuttings treated with IBA @ 3000 ppm (G_2) which was significantly higher than other treatments however minimum root diameter (1.80 mm) was recorded in cuttings treated with IBA @ 3500 ppm (G_3). Application of auxin enhances the histological features like arrangement of callus, tissue and differentiation of vascular tissue and IBA at lower concentration induces early development of callus and vascular bundles thereby resulting in larger root diameter (Negi*et al*., 2015). Rooting media also had a significant influence on root diameter. Maximum root diameter (2.63 mm) was observed in rooting media i.e., M_3 (Sand + vermicompost + perlite (1:1:1)) which was significantly higher than M_4 (Sand + vermicompost + cocopeat (1:1:1)) and M_2 (sand + vermicompost + vermiculite (1:1:1)) with a value of 2.41 and 2.05 mm, respectively and minimum root diameter (1.82 mm) was measured in rooting media M_1 (sand + vermicompost (1:1)). The combined impact of rootstock, growth hormone and rooting media on root diameter become proven that $S_3G_2M_3$ remedy mixture become recorded altogether most noteworthy root diameter (3.79 mm). Rooting media containing perlite is probably the main reason of getting higher root diameter as perlite is recognized to have exciting capillary interest which makes it a major growing medium for increasing aeration and better rooting ability (Paradisco and De-Pascale, 2008). Perusal of data presented in (Table 2) revealed that rootstock, rooting media and

growth hormone significantly influence the number of roots per cutting. Maximum number of roots (8.88) was observed in MM_{106} rootstock cuttings which were statistically at par with M_7 (8.02) rootstock cuttings whereas minimum number of roots per cutting was recorded in M_9T_{337} (7.00). Significantly higher number of roots per cutting (9.91) was counted with IBA @ 3000 ppm (G_2) which were statistically higher than other dose of IBA treatment whereas minimum number of roots per cutting (6.77) was observed with IBA @ 3500 ppm (G_3). Maximum number of roots per cutting (9.55) was recorded in rooting media M_3 i.e. sand + vermicompost + perlite which was statistically higher among other rooting media whereas minimum number of roots per cutting (6.48) was counted in sand + vermicompost rooting media. This could because of the role of auxin in elongation and differentiation of cambial initials into root primordia and also its role in the mobilization of reserve food material towards root initiation (Ullah *et al*., 2005). Non-significant results were obtained among interaction studies of rootstock, growth hormone and rooting media on number of roots per cutting however maximum number of roots per cutting (13.00) was recorded in $S_3G_2M_3$ combination. Significant influence was observed by rootstock, growth hormone and rooting media on average root length (Table 3). Average root length was maximum (30.19 cm) in rootstock S_3 (MM_{106}) which was significantly higher than other rootstocks, however minimum average root length (25.08 cm) was measured by rootstock M_9T_{337}. Maximum average root length (31.88 cm) was recorded with growth hormone G_2 i.e. IBA @ 3000 ppm which was statistically higher than other dose of growth hormone whereas minimum average root length (25.19 cm) was observed in G_3 i.e. IBA @ 3500 ppm. Rootstock cuttings planted in rooting media, M_3 (sand + vermicompost + perlite) (1:1:1) recorded significantly higher average root length (31.03 cm) and was followed by rooting media, M_4 (sand + vermicompost + cocopeat) (1:1:1) and M_1 (sand + vermicompost) (1:1) having the average root length of 28.81 and 25.88 cm respectively. The rooting media, M_2 (sand + vermicompost + vermiculite) (1:1:1) registered the minimum average root length (25.74 cm).

The combined interaction effect between different rootstock, application of growth hormone and rooting media exhibited non-significant effect on average root length. The results are in conformity with Rahimi *et al.* (2011) who reported that low auxin concentrations caused decrease in root numbers but increment its length. Utility of IBA may also activate the early anticlinal cell division and root primordial formation (Ali *et al*., 2009). Length of longest root per cutting was also affected by different rootstock, growth hormone and rooting media and showed significant results (Table 4). Maximum length of longest root (42.44 cm) was observed in rootstock MM_{106} which was significantly higher than other two rootstocks and followed by M_7 (36.91 cm) whereas minimum length of longest root (29.63 cm) was recorded in rootstock M_9T_{337}. The maximum length of longest root (41.94 cm) was recorded in rootstock cuttings treated with IBA @ 3000 ppm which was statistically higher and was followed by cuttings treated with IBA @ 2500 ppm recorded 35.16 cm length of longest root. Minimum length of longest root (31.88 cm) was recorded in the cuttings treated with IBA @ 3500 ppm. So far as the rooting media was concerned, the maximum length of longest root (40.55 cm) was recorded in rootstock cuttings planted in rooting media M_3 (sand + vermicompost + perlite (1:1:1)) which was found significantly superior than other rooting media however, minimum length of longest root (33.14 cm) was observed in rootstock cuttings planted in rooting media (sand + vermicompost (1:1)). The interaction effect of different rootstock, application of growth hormone and rooting media showed significant influence on length of longest root per cutting. Maximum length of longest root per cutting was measured in $S_3G_2M_3$ (52.00 cm) followed by $S_1G_2M_3$ (48.00 cm) whereas minimum length of longest root was observed in $S_2G_1M_1$ with the value 20.33 cm. The results are in conformity with Karakurt *et al.* (2009) and Singh and Singh (2016). Data presented in (Table 5) and (Table 6) reveals significant influence of different rootstock, growth hormone and rooting media on fresh and dry weight of root. Maximum fresh (4.13 g) and dry (2.07 g) weight of root was recorded inMM_{106} rootstock which was statistically higher among other rootstocks whereas minimum fresh (2.46 g) and dry (1.06 g) weight of root was recorded in M_9T_{337}. Rootstock cuttings treated with IBA @ 3000 ppm registered maximum fresh and dry weight of roots (4.41 g and 2.11 g) which was significantly higher among all other concentrations of IBA whereas minimum fresh and dry weight of roots (2.49 g and 1.00 g).

Maximum fresh and dry weight of root (4.11 g and 1.97 g) was obtained when the cuttings were planting in the rooting media M_3 (sand + vermicompost + perlite) (1:1:1) whereas minimum fresh (2.78 g) and dry (1.08 g) weight of roots was registered in the cuttings planted in rooting media (Sand + Vermicompost (1:1) and (Sand + Vermicompost + Vermiculite (1:1:1), respectively. Combined influence of different rootstock, application of growth hormone and rooting media noticed significant effect on fresh and dry weight of root. The highest fresh weight of root (7.50 g and 3.56 g respectively) was attained with $S_3G_2M_3$. Similar results were obtained by Dutra *et al*., (2002) and Hakim *et al*., (2018). Root:shoot ratio presented in (Table 7) revealed significant influence of rootstock, growth hormone and rooting media. Cuttings of MM_{106} rootstock recorded maximum root:shoot ratio (0.14) however minimum root:shoot ratio was recorded in M_9T_{337} rootstock. Significantly higher root: shoot ratio (0.14) was observed with growth hormone IBA @3000 ppm followed by IBA @ 2500 ppm (0.10) whereas lower root: shoot ratio (0.07) was recorded with IBA @ 3500 ppm. Maximum root: shoot ratio (0.13) was recorded in rooting media M_3 (sand + vermicompost + vermiculite (1:1:1)) whereas M_1 i.e. Sand + Vermicompost (1:1) and M_2 i.e. Sand + Vermicompost + Vermiculite (1:1:1) recorded minimum root:shoot ratio (0.08). As evident from the perusal of data, the combined interaction of rootstock, application of growth hormone and rooting media also exhibited a significant effect on root: shoot ratio of apple clonal rootstocks. The maximum root: shoot ratio (0.23) was recorded in rootstock cuttings with treatment combination $S_3G_2M_4$. Murthy *et al*. (2010) stated that exogenous utility of auxin seems to prompt sugar metabolism which inturn provide energy and protein necessary for cellular division and differentiation during the period of adventitious root primordial initiation or development. Significant influence on rooting percentage of cuttings was recorded due to rootstock, growth hormone and rooting media (Table 8). Rootstock MM_{106} recorded maximum percentage of rooted cuttings (53.05%) which was significantly higher than other studied rootstock whereas M_9T_{337} rootstock recorded minimum percentage of rooted cuttings (40.27 %). Growth hormone IBA @ 3000 ppm recorded highest percentage of rooted cuttings (51.94%) which was significantly higher than other concentration of IBA growth hormone, however lowest percentage of rooted cuttings (41.94%) was recorded under IBA @ 3500 ppm. Rooting media, M_3 (sand + vermicompost + perlite @ 1:1:1) registered maximum percentage of rooted cuttings (52.59%) which was significantly higher than other rooting media and was followed by rooting media, M_4 (sand + vermicompost + cocopeat @ 1:1:1) and rooting media M_1 (sand + vermicompost, 1:1) recorded minimum percentage of rooted cuttings (41.48 %). Combination of different rootstock, application of different growth hormone and rooting media was found to have non-significant influence on percentage of rooted cuttings. The results are in conformity with Dutra *et al*., (2002) who reported highest rooting percentage with IBA treatment in peach cuttings. Verma and Chauhan (2015) proposed that IBA favors the conjugation among endogenous IAA and amino acids, which ends up in the synthesis of the particular proteins essential for formation of root initials.

CONCLUSION

From the present investigation, it can be concluded that rooting capacity and quality of rootstock changes with genotype, rooting media and growth hormone concentration. Moreover the hardwood cuttings of MM_{106} clonal rootstock treated with IBA @ 3000ppm and planted in the rooting media of sand + vermicompost + perlite (1:1:1) had better quality rootings. These results can be utilized to create a convention for generation of quality planting material of apple clonal rootstocks through cuttings.

CONFLIT OF INTEREST

All the authors affirm that there is no conflict of interest among them. All research activities comply with relevant legal, institutional and ethical standards.

AUTHOR CONTRIBUTION

All the authors contributed equally in the present study.

Table 1: Influence of rootstock, growth hormone and rooting media on root diameter (mm)

M / S	M_1			Sub mean	M_2			Sub mean	M_3			Sub mean	M_4			Sub mean	Mean	Factor mean
G	G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3			
S_1	1.90	2.36	1.42	1.89	1.97	2.68	1.83	2.16	2.31	3.67	2.23	2.74	2.28	3.02	1.85	2.38	2.29	G_1: 1.98
S_2	0.99	2.23	1.23	1.48	1.21	2.46	1.50	1.72	1.94	2.86	2.04	2.28	1.65	2.76	1.71	2.04	1.88	G_2: 2.90
S_3	2.00	2.44	1.82	2.09	2.02	2.95	1.84	2.27	2.69	3.79	2.16	2.88	2.77	3.63	2.02	2.81	2.51	G_3: 1.80
Mean	1.63	2.34	1.49	1.82	1.73	2.70	1.72	2.05	2.31	3.44	2.14	2.63	2.23	3.13	1.86	2.41		

$CD_{0.05}$					
Rootstock (S)	:	0.097	Rootstock x Rooting media	:	NS
Growth hormone (G)	:	0.097	Growth hormone x Rooting media	:	0.193
Rooting media (M)	:	0.167	Rootstock x Growth hormone x Rooting media	:	0.335

S_1: M_7 S_2: M_9T_{337} S_3: MM_{106} G_1: 2500 ppm G_2: 3000 ppm G_3: 3500 ppm M_1: Sand + Vermicompost M_2: Sand + Vermicompost + Vermiculite M_3: Sand + Vermicompost + Perlite M_4: Sand + Vermicompost + Cocopeat

Table 2 Influence of rootstock, growth hormone and rooting media on number of roots/cutting

M / S	M_1			Sub mean	M_2			Sub mean	M_3			Sub mean	M_4			Sub mean	Mean	Factor mean
G	G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3			
S_1	6.00	8.00	5.33	6.44	6.33	10.00	6.00	7.44	9.00	11.66	9.00	9.88	8.00	10.33	6.66	8.33	8.02	G_1: 7.22
S_2	4.66	6.66	5.00	5.44	6.33	9.66	5.66	7.22	6.66	10.66	6.66	8.00	6.00	10.00	6.00	7.33	7.00	G_2: 9.91
S_3	7.00	9.00	6.66	7.55	8.00	9.66	7.33	8.33	10.00	13.00	9.33	10.77	8.66	10.33	7.66	8.88	8.88	G_3: 6.77
Mean	5.88	7.88	5.66	6.48	6.88	9.77	6.33	7.66	8.55	11.77	8.33	9.55	7.55	10.22	6.77	8.18		

$CD_{0.05}$					
Rootstock (S)	:	0.983	Rootstock x Rooting media	:	NS
Growth hormone (G)	:	0.983	Growth hormone x Rooting media	:	NS
Rooting media (M)	:	1.136	Rootstock x Growth hormone x Rooting media	:	NS

S_1: M_7 S_2: M_9T_{337} S_3: MM_{106} G_1: 2500 ppm G_2: 3000 ppm G_3: 3500 ppm M_1: Sand + Vermicompost M_2: Sand + Vermicompost + Vermiculite M_3: Sand + Vermicompost + Perlite M_4: Sand + Vermicompost + Cocopeat

Table 3 Influence of rootstock, growth hormone and rooting media on average root length (cm)

M / S	M_1			Sub mean	M_2			Sub mean	M_3			Sub mean	M_4			Sub mean	Mean	Factor mean
G	G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3			
S_1	27.00	30.33	21.00	26.11	26.66	30.00	22.66	26.44	30.00	35.33	28.33	31.22	29.33	32.33	27.00	29.55	28.33	G_1: 26.52
S_2	18.33	29.00	24.00	23.77	20.00	24.33	24.33	22.88	22.33	34.00	27.33	27.88	21.00	32.00	24.33	25.77	25.08	G_2: 31.88
S_3	28.33	31.33	23.66	27.77	29.00	30.66	24.00	27.88	35.00	38.33	28.66	34.00	31.33	35.00	27.00	31.11	30.19	G_3: 25.19
Mean	24.55	30.22	22.88	25.88	25.22	28.33	23.66	25.74	29.11	35.88	28.11	31.03	27.22	33.11	26.11	28.81		

$CD_{0.05}$					
Rootstock (S)	:	1.026	Rootstock x Rooting media	:	NS
Growth hormone (G)	:	1.026	Growth hormone x Rooting media	:	NS
Rooting media (M)	:	1.185	Rootstock x Growth hormone x Rooting media	:	NS

S_1: M_7 S_2: M_9T_{337} S_3: MM_{106} G_1: 2500 ppm G_2: 3000 ppm G_3: 3500 ppm M_1: Sand + Vermicompost M_2: Sand + Vermicompost + Vermiculite M_3: Sand + Vermicompost + Perlite M_4: Sand + Vermicompost + Cocopeat

Table 4 Influence of rootstock, growth hormone and rooting media on length of longest root/cutting (cm)

M / S	M_1			Sub mean	M_2			Sub mean	M_3			Sub mean	M_4			Sub mean	Mean	Factor mean
G	G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3			
S_1	33.33	34.00	29.00	32.11	32.00	43.00	31.66	35.55	39.00	48.00	38.00	41.66	38.00	45.00	32.00	38.33	36.91	G_1: 35.16
S_2	20.33	32.33	22.66	25.11	23.33	33.00	27.33	27.88	30.66	37.00	36.00	34.55	24.00	37.33	31.66	31.00	29.63	G_2: 41.94
S_3	48.66	48.66	29.33	42.22	46.00	47.66	37.00	43.55	46.66	52.00	37.66	45.44	40.00	45.33	30.33	38.55	42.44	G_3: 31.88
Mean	34.11	38.33	27.00	33.14	33.77	41.22	32.00	35.66	38.77	45.66	37.22	40.55	34.00	42.55	31.33	35.96		

$CD_{0.05}$					
Rootstock (S)	:	0.795	Rootstock x Rooting media	:	1.590
Growth hormone (G)	:	0.795	Growth hormone x Rooting media	:	1.590
Rooting media (M)	:	0.918	Rootstock x Growth hormone x Rooting media	:	2.754

S_1: M_7; S_2: M_9T_{337} S_3: MM_{106} G_1: 2500 ppm G_2: 3000 ppm G_3: 3500 ppm M_1: Sand + Vermicompost M_2: Sand + Vermicompost + Vermiculite M_3:Sand+Vermicompost + Perlite M_4: Sand + Vermicompost + Cocopeat

Table 5: Influence of rootstock, growth hormone and rooting media on fresh weight of root (g)

M / S	M_1			Sub mean	M_2			Sub mean	M_3			Sub mean	M_4			Sub mean	Mean	Factor mean
G	G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3			
S_1	2.10	2.36	2.10	2.18	2.36	3.26	2.26	2.63	3.70	6.60	3.46	4.58	3.16	4.73	2.53	3.47	3.22	G_1: 2.91
S_2	1.90	2.23	1.96	2.03	2.23	2.76	2.03	2.34	2.60	3.73	2.26	2.86	2.20	3.60	2.03	2.61	2.46	G_2: 4.41
S_3	4.16	5.50	2.73	4.13	3.10	5.30	2.56	3.65	4.00	7.50	3.20	4.90	3.40	5.40	2.80	3.86	4.13	G_3: 2.49
Mean	2.72	3.36	2.26	2.78	2.56	3.77	2.28	2.87	3.43	5.94	2.97	4.11	2.92	4.57	2.45	3.31		

$CD_{0.05}$					
Rootstock (S)	:	0.066	Rootstock x Rooting media	:	0.132
Growth hormone (G)	:	0.066	Growth hormone x Rooting media	:	0.132
Rooting media (M)	:	0.076	Rootstock x Growth hormone x Rooting media	:	0.229

S_1: M_7 S_2: M_9T_{337} S_3: MM_{106} G_1: 2500 ppm G_2: 3000 ppm G_3: 3500ppm M_1: Sand + Vermicompost M_2: Sand + Vermicompost + Vermiculite M_3: Sand + Vermicompost + Perlite M_4: Sand + Vermicompost + Cocopeat

Table 6: Influence of rootstock, growth hormone and rooting media on dry weight of root (g)

M / S	M_1			Sub mean	M_2			Sub mean	M_3			Sub mean	M_4			Sub mean	Mean	Factor mean
G	G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3			
S_1	0.71	1.06	0.58	0.78	1.02	1.07	0.87	0.98	1.79	2.51	1.44	1.91	1.57	2.43	1.18	1.72	1.35	G_1: 1.37
S_2	0.49	0.66	0.54	0.56	0.63	0.73	0.67	0.68	1.35	2.44	0.68	1.49	1.25	2.34	0.99	1.53	1.06	G_2: 2.11
S_3	2.08	3.20	0.99	2.09	1.69	2.15	0.93	1.59	2.36	3.56	1.66	2.52	1.55	3.21	1.52	2.09	2.07	G_3: 1.00
Mean	1.09	1.64	0.70	1.14	1.11	1.31	0.82	1.08	1.83	2.83	1.26	1.97	1.46	2.66	1.23	1.78		

$CD_{0.05}$					
Rootstock (S)	:	0.065	Rootstock x Rooting media	:	0.131
Growth hormone (G)	:	0.065	Growth hormone x Rooting media	:	0.131
Rooting media (M)	:	0.075	Rootstock x Growth hormone x Rooting media	:	0.226

S_1: M_7 S_2: M_9T_{337} S_3: MM_{106} G_1: 2500 ppm G_2: 3000 ppm G_3: 3500 ppm M_1: Sand + Vermicompost M_2: Sand + Vermicompost + Vermiculite M_3:Sand + Vermicompost + Perlite M_4: Sand + Vermicompost + Cocopeat

Table 7 Influence of rootstock, growth hormone and rooting media on root:shoot ratio

M / S	M_1			Sub mean	M_2			Sub mean	M_3			Sub mean	M_4			Sub mean	Mean	Factor mean
G	G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3			
S_1	0.05	0.07	0.04	0.05	0.08	0.07	0.07	0.07	0.13	0.17	0.11	0.13	0.12	0.17	0.09	0.12	0.10	G_1: 0.10
S_2	0.04	0.05	0.05	0.04	0.05	0.05	0.05	0.05	0.11	0.16	0.05	0.10	0.10	0.17	0.07	0.11	0.08	G_2: 0.14
S_3	0.15	0.19	0.08	0.14	0.12	0.16	0.06	0.11	0.16	0.19	0.12	0.16	0.11	0.23	0.11	0.15	0.14	G_3: 0.07
Mean	0.08	0.10	0.05	0.08	0.08	0.09	0.06	0.08	0.13	0.17	0.09	0.13	0.11	0.19	0.09	0.11		

$CD_{0.05}$					
Rootstock (S)	:	0.005	Rootstock x Rooting media	:	0.010
Growth hormone (G)	:	0.005	Growth hormone x Rooting media	:	0.010
Rooting media (M)	:	0.009	Rootstock x Growth hormone x Rooting media	:	0.018

S_1: M_7 S_2: M_9T_{337} S_3: MM_{106} G_1: 2500 ppm G_2: 3000 ppm G_3: 3500 ppm M_1: Sand + Vermicompost M_2: Sand + Vermicompost + Vermiculite M_3: Sand + Vermicompost + Perlite M_4: Sand + Vermicompost + Cocopeat

Table 8 Influence of rootstock, growth hormone and rooting media on root cuttings (%)

M / S	M_1			Sub mean	M_2			Sub mean	M_3			Sub mean	M_4			Sub mean	Mean	Factor mean
G	G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3		G_1	G_2	G_3			
S_1	36.66	40.00	40.00	38.88	40.00	46.66	43.33	43.33	50.00	56.66	50.00	52.22	43.33	50.00	46.66	46.66	45.27	G_1: 44.72
S_2	33.33	43.33	30.00	35.55	36.66	43.33	33.33	37.77	46.66	53.33	40.00	46.66	40.00	46.66	36.66	41.11	40.27	G_2: 51.94
S_3	50.00	60.00	40.00	50.00	50.00	53.33	46.66	50.00	56.66	66.66	53.33	58.88	53.33	63.33	43.33	53.33	53.05	G_3: 41.94
Mean	40.00	47.77	36.66	41.48	42.22	47.77	41.11	43.70	51.11	58.88	47.78	52.59	45.55	53.33	42.22	47.03		

$CD_{0.05}$					
Rootstock (S)	:	3.100	Rootstock x Rooting media	:	NS
Growth hormone (G)	:	3.100	Growth hormone x Rooting media	:	NS
Rooting media (M)	:	3.580	Rootstock x Growth hormone x Rooting media	:	NS

S_1: M_7 S_2: M_9T_{337} S_3: MM_{106} G_1: 2500 ppm G_2: 3000 ppm G_3: 3500 ppm M_1: Sand + Vermicompost M_2: Sand + Vermicompost + Vermiculite M_3: Sand + Vermicompost + Perlite M_4: Sand + Vermicompost + Cocopeat

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