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Standardization of vegetative propagation in *Terminalia chebula* Retz. for germplasm conservation

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Abstract

Terminalia chebula Retz. is a multipurpose tree but the primary purpose of cultivating and raising this tree species is its fruits. Large sized fruits easily fetch higher prices in the national and global markets. The availability of superior germplasm is, however, restricted by its very low natural regeneration, poor germination capacity of the seeds, very little knowledge about its propagation techniques, long juvenile period for fruits production which is almost 15–20 years. The availability of superior germplasm and shortening of long juvenile period can be resolved by the adoption of various vegetative propagation techniques. In the present study, scions of *T. chebula* Retz. were grafted on three different rootstocks; *T. chebula* Retz., *Terminalia bellirica* Roxb. and *Terminalia arjuna* Bedd to standardize vegetative propagation techniques in *T. chebula*. The grafting and budding methods used were cleft grafting, side-veneer grafting and patch budding. The results revealed that out of all the propagation techniques evaluated under nursery conditions, cleft grafting was most promising. It showed better results on principal parameters like graft survival ratio (46.67) and graft take ratio (60.00). In case of rootstocks, *T. arjuna* performed well on most of the growth parameters. Hence, it is concluded that *T. arjuna* as a rootstock can be cleft grafted with *T. chebula* Retz. scion not only to obtain healthy plants with desired characteristics in a short time but also to conserve its germplasm.

Introduction

Terminalia chebula Retz. commonly known as Harad, is a multipurpose tree belonging to family Combretaceae. In India, it is widely distributed in mixed dry deciduous forests and can be found frequently in tropical and subtropical zones, mostly in hilly tracts. It is a multipurpose species but considered primarily for its fruit which possess multitudinous medicinal properties. *Terminalia chebula* Retz. is an important component of *Triphala*, the famous polyherbal formula of Ayurveda, it plays a crucial role for maintenance of various diseases and oral health (Bhuvaneswari *et al*., 2020).The demand of Harad due to the medicinal properties is recognizable as major industries like Dabur, Kapiva, Badiyanath, Himalaya, Organic India use it for manufacturing their products (Singh *et al*., 2020).

There is huge demand of Harad in national as well as international market. Being a global dominant producer, India exports almost 20% of its total production (Saleem *et al*., 2013). However, there are some problems associated with the species i.e. the scale of natural regeneration of *T. chebula* Retz. is miniscule, its seeds have poor germination capacity, trees have long juvenile period and there is lack of availability of superior germplasm. If these problems are solved one can scale up production and amplify net returns (Singh *et al*., 2021). Thus, the present experiment was carried out to produce superior Harad clones via vegetative propagation techniques.

Material and methods

The present experiment entitled 'Standardization of vegetative propagation in *Terminalia chebula* Retz. for germplasm conservation' was carried out in experimental farm of Division of Agroforestry, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, Chatha, J&K, India 180,009 for the period of 90 d from March to June, 2022. The objective of the investigation was to standardize vegetative propagation technique and rootstock for successful propagation of *T. chebula* Retz. Cleft grafting (V_1), side veneer grafting (V_2) and patch budding (V_3) were the methods of propagation used whereas three different rootstocks were *T. chebula* Retz. (R_1), *Terminalia bellirica* Roxb. (R_2) and *Terminalia arjuna* Bedd. (R_3). Scion wood used for grafting operations was collected from the superior mother plants of Harad planted in the experimental farm itself. The design of experiment was Two Factorial CRD with nine treatment combinations and the number of replications were three. The observations

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recorded were; number of days taken to bud sprouting, graft take ratio (%), graft survival ratio (%), graft shoot diameter (mm), number of shoots per plant, number of leaves per plant, shoot length above graft union (cm), total shoot length (cm), shoot biomass (g), length of primary root (cm), number of secondary roots, root biomass (g) and root: shoot ratio. The data of different parameters were recorded at different stages of experiment i.e. the data pertaining to number of days taken to bud sprouting and graft take ratio was recorded in initial stages right after the bud break. While for number of shoots per plant, number of leaves per plant, shoot length above graft union (cm) and total shoot length (cm) the data was recorded after 60 and 90 DAG (Days After Grafting) whereas graft survival ratio, shoot biomass (g), length of primary root (cm), number of secondary roots, root biomass (g) and root:shoot ratio was evaluated at the end of vegetative period of experiment (90 DAG).To promote the upright growth lateral shoots arising from the rootstocks were pruned regularly to channelize maximum sap flow toward the scion tissue, constant weeding operations were done. There was a severe impact of heat wave in north India during the time of experiment, to alleviate its impact regular irrigation was done. The acquired data from the present experiment was analysed in statistical package RStudio.

Results

Performance of different rootstocks with respect to the observed parameters

The rootstock had a strong influence on performance of the scion with regard to different parameters (Table 1). R_3 (*T. arjuna* Bedd.) took the least (6.88) number of days for bud breaking which was statistically superior to R_1 (*T. chebula* Retz.–8.00 d) and R_2 (*T. bellirica* Roxb.–8.11 d). Rootstock R_3 (*T. arjuna* Bedd.) had significantly higher graft take ratio (72.22%) which was statistically at par with the rootstock R_1 (*T. chebula* Retz. – 70.00%) and superior than root stock R_2 (*T. bellirica* Roxb. – 11.11%). The scions of *T. chebula* Retz. grafted on R_2 (*T. bellirica* Roxb.) failed to survive. The highest survival was observed in R_3V_1 (*T. arjuna* Bedd.–70% followed by *T. chebula*- 60%).

Graft shoot diameter, number of shoots per plant, number of leaves per plant, shoot length above graft union, total shoot length, shoot biomass, length of primary root, number of secondary roots and root biomass were recorded twice i.e. at 60 d and at 90 d (Table 1). At both 60 and 90 DAG, significant impact of rootstock was observed on graft shoot diameter. In R_3 (*T. arjuna* Bedd.) maximum graft shoot diameter (60 DAG: 3.70 mm & 90 DAG: 3.88 mm) was recorded which was statistically at par with R_1 (*T. chebula* Retz.) value (60 DAG: 3.63 mm & 90 DAG: 3.76 mm).

The effect of rootstock on number of shoots was significant. R_3 (*T. arjuna* Bedd.) had the maximum (60 DAG: 1.26 & 90 DAG: 1.26) number of shoots per plant which was statistically at par with R_1 (*T. chebula* Retz.) (60 DAG: 1.22 & 90 DAG: 1.22). R_2 (*T. bellirica*Roxb.) had no shoots with all the three types of grafts.

There was significant effect of rootstock on number of leaves per plant. R_3 (*T. arjuna* Bedd.) had the maximum (60 DAG: 15.67 & 90 DAG: 21.30) leaves per plant, which was considerably higher than R_1 (*T. chebula* Retz.) (60 DAG: 12.22 and 90 DAG: 16.04).

The impact of rootstock on the shoot length above graft union was significant. R_3 (*T. arjuna Bedd.*) had the maximum (60 DAG: 33.55 cm & 90 DAG: 37.26 cm) shoot length above graft union

Table 1. Performance of different rootstocks with respect to the observed parameters

Mean				GSD (mm)		NSPP		NOLPP		SLA G (cm)		TSL (cm)						
Rootstock	NODTBS	GTR (%)	GSR (%)	60 DAG	90 DAG	60 DAG	90 DAG	60 DAG	90 DAG	60 DAG	90 DAG	60 DAG	90 DAG	SB (g)	LPR (cm)	NOSR	RB (g)	RSR
R_1	8.00	70.00 (56.97)	60.00 (50.77)	3.63	3.76	1.22	1.22	12.22	16.04	32.14	34.97	47.03	49.86	28.59	29.71	29.13	30.39	1.49
R_2	8.11	11.11 (15.92)	0.01 (0.57)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
R_3	6.88	72.22 (58.54)	70.00 (56.97)	3.70	3.88	1.26	1.26	15.67	21.30	33.55	37.26	48.00	51.70	34.27	21.18	39.45	19.75	0.63
$CD_{0.05}$	0.57	6.92 (4.56)	NS	0.25	0.26	0.19	0.19	1.05	1.65	0.85	0.91	1.25	1.37	1.72	NS	1.25	NS	0.09

NODTBS, Number of days taken to bud sprouting; GTR, Graft take ratio; GSR, Graft survival ratio; GSD, Graft shoot diameter; NSPP, Number of shoots per plant; NOLPP, Number of leaves per plant; SLAG, Shoot length above graft union; TSL, Total shoot length; SB, Shoot biomass; LPR, Length of primary root; NOSR, Number of secondary roots; RB, Root biomass; RSR, Root: shoot ratio; R_1, *Terminalia chebula* Retz.; R_2, *Terminalia bellirica* Roxb.; R_3, *Terminalia arjuna* Bedd.
*Figures in parentheses are transformed value.

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and it was significantly higher than R_1 (*T. chebula* Retz.) (60 DAG: 32.14 cm & 90 DAG: 34.97 cm).

In case of total shoot length, R_3 (*T. arjuna* Bedd.) had the maximum (60 DAG: 48.00 cm & 90 DAG: 51.70 cm) total shoot length and it was statistically at par with R_1 (*T. chebula* Retz.) at 60 DAG (47.03 cm) but superior when compared at 90 DAG (49.86 cm) (Table 1).

The species of rootstock significantly affected the shoot biomass. Maximum shoot biomass was recorded in R_3 (*T. arjuna* Bedd. 34.27 g) which was statistically superior to R_1 (*T. chebula* Retz. 28.59 g).

The kind of rootstock affected the number of secondary roots significantly. R_3 (*T. arjuna* Bedd.) had the maximum (39.45) number of secondary roots which was statistically superior to R_1 (*T. chebula* Retz. 29.13). The effect of rootstock on root: shoot ratio was significant. R_1 (*T. chebula* Retz.) had the maximum (1.49) root: shoot ratio which was statistically superior to with R_3 (*T. arjuna* Bedd.) (0.63).

Performance of vegetative propagation techniques with respect to the observed parameters

There was a significant effect of vegetative propagation methods (Table 2). V_3 (patch budding) resulted into earliest (4.44 d) bud sprouting and was statistically superior to the other propagation techniques. V_1 (cleft grafting) had the highest graft take ratio (60.00%) and it was statistically superior to the other vegetative propagation methods (Fig. 1). The plants with cleft grafting (V_1) showed the highest survival (46.67%) which was statistically at par with V_3 (patch budding – 42.22%) and superior to V_2 (side-veneer grafting – 41.11%).

The effect of method of vegetative propagation on graft shoot diameter, number of shoots per plant, number of leaves per plant, shoot length above graft union, total shoot length, shoot biomass, length of primary root, number of secondary roots and root biomass were recorded twice i.e. at 60 d and at 90 d.

V_3 (Patch budding) showed highest value (60 DAG: 2.78 mm & 90 DAG: 2.88 mm) and turned out to be statistically superior to other propagation techniques (Fig. 2). V_1 (cleft budding) showed highest value (60 DAG: 1.03 & 90 DAG: 1.03) and turned out to be statistically superior to other propagation techniques. The highest number was observed in cleft grafting (V_1) (60 DAG: 11.33 & 90 DAG: 15.23) followed by V_3 (60 DAG: 8.64 & 90 DAG: 11.37) and V_2 (60 DAG: 7.92 & 90 DAG: 11.07) after 60 d and 90 d respectively. In patch budded (V_3) plants, maximum shoot length above graft union (60 DAG: 27.77 cm & 90 DAG: 29.97 cm) was registered and minimum length (60 DAG: 17.37 cm & 90 DAG: 19.44 cm) was recorded in side-veneer grafting (V_2). The maximum total shoot length was found to be in V_3 (patch budding) (60 DAG: 39.22 cm & 90 DAG: 41.41 cm) followed by V_1 (60 DAG: 29.66 cm & 90 DAG: 31.92 cm) and V_2 (60 DAG: 26.14 cm & 90 DAG: 31.92 cm). Propagation through cleft grafting (V_1) outperformed among the three methods with the maximum value (23.70 g) which is statistically superior to V_2 (side-veneer grafting 19.26 g) and V_3 (patch budding 19.88). The length of primary root was found to be maximum in cleft grafted plants (V_1) (17.66 cm). It was statistically at par with V_2 (16.64 cm) and V_3 (16.59 cm). V_1 (cleft grafting) performed significantly better in case of number of secondary roots with the maximum value (24.19) which was statistically superior to V_2 (side-veneer grafting) (Fig. 3) and V_3 (patch budding). V_3 (patch budding) had the maximum (17.30 g) value which was

Table 2. Performance of vegetative propagation techniques with respect to the observed parameters

Mean				GSD (mm)		NSPP		NOLPP		SLAG (cm)		TSL (cm)						
Propagation method	NODTBS	GTR (%)	GSR (%)	60 DAG	90 DAG	60 DAG	90 DAG	60 DAG	90 DAG	60 DAG	90 DAG	60 DAG	90 DAG	SB (g)	LPR (cm)	NOSR	RB (g)	RSR
V_1	8.77	60.00 (51.28)	46.67 (38.17)	2.35	2.45	1.03	1.03	11.33	15.23	20.55	22.81	29.66	31.92	23.70	17.66	24.19	16.91	0.81
V_2	9.77	48.88 (43.38)	41.11 (34.69)	2.21	2.31	0.77	0.77	7.92	11.07	17.37	19.44	26.14	28.22	19.26	16.64	21.82	15.93	0.66
V_3	4.44	44.44 (36.76)	42.22 (35.45)	2.78	2.88	0.66	0.66	8.64	11.37	27.77	29.97	39.22	41.41	19.88	16.59	22.56	17.30	0.65
$CD_{0.05}$	0.57	6.92 (4.56)	5.08 (3.15)	0.25	0.26	0.19	0.19	1.05	1.65	0.85	0.91	1.25	1.37	1.72	1.38	1.25	4.37	0.09

NODTBS, Number of days taken to bud sprouting; GTR, Graft take ratio; GSR, Graft survival ratio; GSD, Graft shoot diameter; NSPP, Number of shoots per plant; NOLPP, Number of leaves per plant; SLAG, Shoot length above graft union; TSL, Total shoot length; SB, Shoot biomass; LPR, Length of primary root; NOSR, Number of secondary roots; RB, Root biomass; RSR, Root: shoot ratio; V_1, Cleft grafting; V_2, Side–veneer grafting; V_3, Patch budding.
*Figures in parentheses are transformed value.

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Figure 1. Cleft grafting of harad using *Terminalia arjuna* as rootstock.

Figure 2. Patch budding of harad using *Terminalia arjuna* as rootstock.

Figure 3. Side veneer grafting of harad using *Terminalia arjuna* as rootstock.

statistically at par with the remaining vegetative propagation techniques. V_1 (cleft budding) showed highest ratio (0.81) and was statistically superior from other propagation techniques.

Performance of treatment combinations with respect to the observed parameters

The interactions between root stock and method of vegetative propagation helped to finally reach to conclusion (Table 3). As regards individual parameter and the interaction, the results are as follows:

The interaction R_3V_3 (*T. arjuna* Bedd. × patch budding) took the minimum days – 6.33 d for bud sprouting and was statistically at par with R_3V_1 (*T. arjuna* Bedd. × cleft grafting – 6.66 d) and R_1V_3 (*T. chebula* Retz. × patch budding – 7.00 d). Interaction, R_2V_2 (*T. bellirica* Roxb. × side-veneer grafting) took the maximum −13.00 d for bud sprouting, whereas, R_2V_3 (*T. bellirica*Roxb. × patch budding) failed to sprout. The scions of *T. chebula* Retz. grafted on R_2 (*T. bellirica* Roxb.) failed to survive. The highest survival was observed in R_3V_1 (*T. arjuna* Bedd. × cleft grafting – 76.66%) and minimum in R_1V_3 (*T. chebula* Retz. × patch budding – 56.66%).

The interaction effect was significant in case of graft shoot diameter. R_3V_3 (*T. arjuna* Bedd. × patch budding) showed the maximum graft shoot diameter (60 DAG: 4.47 mm & 90 DAG: 4.65 mm) which was statistically superior to the remaining treatment combinations. However, the least graft shoot diameter was recorded in R_3V_2 (*T. arjuna* Bedd. × side-veneer grafting) (60 DAG: 3.18 mm & 90 DAG: 3.36 mm).

The effect of vegetative propagation method was significantly observed in number of leaves per plant. R_3V_1 (*T. arjuna*

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Table 3. Performance of treatment combinations with respect to the observed parameters

Mean																		
				GSD (mm)		NSPP		NOLPP		SLAG (cm)		TSL (cm)						
Treatment combinations	NODTBS	GTR (%)	GSR (%)	60 DAG	90 DAG	60 DAG	90 DAG	60 DAG	90 DAG	60 DAG	90 DAG	60 DAG	90 DAG	SB (g)	LPR (cm)	NOSR	RB (g)	RSR
T_1 (R_1V_1)	8.33	76.66 (61.19)	63.33 (52.75)	3.59	3.71	1.44	1.44	14.11	18.45	28.44	30.77	42.11	44.44	30.67	30.55	30.14	29.92	1.66
T_2 (R_1V_2)	8.66	70.00 (56.97)	60.00 (50.74)	3.45	3.58	1.22	1.22	10.77	14.11	27.33	30.22	40.33	43.22	26.92	28.81	27.81	29.20	1.41
T_3 (R_1V_3)	7.00	63.33 (52.75)	56.66 (48.82)	3.87	3.98	1.00	1.00	11.77	15.55	40.67	43.92	58.67	61.92	28.18	29.77	29.44	32.06	1.40
T_4 (R_2V_1)	11.33	23.33 (28.76)	0.01 (0.57)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
T_5 (R_2V_2)	13.00	10.00 (18.42)	0.01 (0.57)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
T_6 (R_2V_3)	–	0.01 (0.57)	0.01 (0.57)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
T_7 (R_3V_1)	6.66	80.00 (63.90)	76.66 (61.19)	3.46	3.65	1.67	1.67	19.88	27.25	33.22	37.66	46.88	51.33	40.45	22.44	42.44	20.81	0.76
T_8 (R_3V_2)	7.66	66.66 (54.76)	63.33 (52.75)	3.18	3.36	1.11	1.11	13.00	19.11	24.78	28.11	38.11	41.44	30.87	21.11	37.66	18.61	0.58
T_9 (R_3V_3)	6.33	70.00 (56.97)	70.00 (56.97)	4.47	4.65	1.00	1.00	14.14	17.55	42.66	46.00	59.00	62.33	31.48	20.00	38.25	19.83	0.55
$CD_{0.05}$	0.99	NS	NS	0.44	0.45	NS	NS	1.83	2.87	1.48	1.59	2.17	2.38	2.98	NS	2.17	NS	NS

NODTBS, Number of days taken to bud sprouting; GTR, Graft take ratio; GSR, Graft survival ratio; GSD, Graft shoot diameter; NSPP, Number of shoots per plant; NOLPP, Number of leaves per plant; SLAG, Shoot length above graft union; TSL, Total shoot length; SB, Shoot biomass; LPR, Length of primary root; NOSR, Number of secondary roots; RB, Root biomass; RSR, Root:shoot ratio; R_1, *Terminalia chebula* Retz.; R_2, *Terminalia bellirica* Roxb.; R_3, *Terminalia arjuna* Bedd.; V_1, Cleft grafting; V_2, Side –veneer grafting; V_3, Patch budding; T, Treatment combination.
*Figures in parentheses are transformed value.

Bedd. × cleft grafting) had the maximum (60 DAG: 19.88 & 90 DAG: 27.25) leaves per plant which was best among all treatments. Whereas, R_1V_2 (*T. chebula* Retz. × side-veneer grafting) had the minimum (60 DAG: 10.77 & 90 DAG: 14.11) number of leaves per plant.

The shoot length above graft union was significantly affected both by rootstock and the propagation method performed over it. R_3V_3 (*T. arjuna* Bedd. × patch budding) exhibited the maximum (60 DAG: 42.66 cm & 90 DAG: 46.00 cm) shoot length above the graft union and performed statistically superior among all other treatment combinations. However, the least (60 DAG: 24.78 cm & 90 DAG: 28.11 cm) shoot length above graft union was recorded in R_3V_2 (*T. arjuna* Bedd. × side-veneer grafting).

The interaction affected the total shoot length significantly. R_3V_3 (*T. arjuna* Bedd. × patch budding) recorded the maximum (60 DAG: 59.00 cm & 90 DAG: 62.33 cm) shoot length and it was statistically at par with R_1V_3 (*T. chebula* Retz. × patch budding) (60 DAG: 58.67 cm & 90 DAG: 61.92 cm). The least total shoot length was recorded in R_3V_2 (*T. arjuna* Bedd. × side-veneer grafting) (60 DAG: 38.11 cm & 90 DAG: 41.44 cm).

The interaction also significantly affected the shoot biomass. Maximum shoot biomass (40.45 g) was noticed in treatment combination R_3V_1 (*T. arjuna* Bedd. × cleft grafting) and it was statistically superior than the remaining interactions. The minimum (26.92 g) shoot biomass was observed in R_1V_2 (*T. chebula* Retz. × side-veneer grafting).

Though the interaction had non-significant effect on number of primary roots and root biomass and root shoot ratio, but in case of secondary roots, maximum number of secondary roots (42.44) was observed in treatment combination R_3V_1 (*T. arjuna* Bedd. × cleft grafting) and it was statistically significant than the remaining combinations. However, the minimum number of secondary roots were recorded in R_1V_2 (*T. chebula* Retz. × side-veneer grafting 27.81) (Table 3).

Discussion

The basic purpose of conducting this study was to identify the best rootstock and vegetative technique for propagation of Harad. Although, the vegetative propagation techniques using harad as rootstock had already been reported by Saleem *et al.* (2013) but the germination percentage of harad fruits is very low (20–30%) compared to *Terminalia bellerica* (upto 50%) and *T. arjuna* (upto 90%). Besides, Harad is slow growing compared to other two species. Identification of suitable rootstock and vegetative techniques would help in mass multiplication of superior strains and their conservation.

The effect of rootstock was significant in most of the observations except graft survival ratio, length of primary roots and root biomass. R_3(*T. arjuna* Bedd.) performed well when compared to R_1(*T. chebula* Retz.) with higher values in major and essential parameters like; number of days taken to bud sprouting (6.88), graft take ratio (72.22%) etc. (Table 1). Whereas R_2 (*T. bellirica* Roxb.) failed miserably to survive the experiment. It might be due to high temperature and low humidity (35.4°C and 22%) in the third week of March, *T. bellerica* requires mean annual temperature in the range of 22–28°C and annual rainfall in the range of 900–1300 mm for its best growth. Although in few plants bud breaking was reported but it might be due to the reserve food material present in the scion tissue. Later on the sprouted buds turned yellow and perished, thus no further readings were

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recorded for *Terminalia bellerica* as rootstock. The performance of R_3 (*T. arjuna* Bedd.) was better among all and it might be due to the better root morphology when compared to R_1 (*T. chebula* Retz.) The number of secondary roots in R_3 (39.45) were significantly higher compared to R_1 (29.13). On ocular basis it was observed that the R_3 was having denser fibrous root structure when compared to R_1. Also, there was presence of fine root hairs over tertiary roots of grafted R_3 which was absent in R_1 and control R_3. Root branching, its development during the crop period and penetration in soil might have resulted in better plant growth and stock scion union. Similar findings have been reported by Wang *et al.* (2006) regarding the role of root morphology in nutrient uptake. Zhu *et al.* (2021) has also stated that fine root hairs play better role in belowground ecosystem which in turns helps greatly in nutrient cycling with in the plant. Thus it can be concluded that better root morphology of *T. arjuna* Bedd. and development of fine root hairs might have amplified the nutrient cycling and resulted in overall better growth of scion tissue when grafted on R_3 which in turn resulted in development of healthy plants.

The effect of vegetative propagation techniques was significant in all parameters. V_1 (cleft grafting) showed promising results in most of the desired parameters like; graft take ratio (60.00), graft survival ratio (46.67) etc. (Table 2) but the earliest bud break was recorded in the V_3 (Patch Budding). Both V_1 and V_3 performed well in said parameters and can be recommended but the survival and take ratio was higher in the V_1. Rahayu *et al.* (2020) had stated that success of graft depends on cambium fusion. In cleft grafting the exposed area of cambium is much larger compared to other methods, also the interlocking tongues of rootstock provided natural pressure which play an important role in union formation. Similar results regarding cleft grafting have been observed by Singh *et al.* (2019) in *Juglans regia* L. and Tripathi and Karunakaran (2019) in *Persea americana* Mill.

Out of all treatment combinations, T_7 (Cleft grafting on *T. arjuna* Bedd.) showed promising results (Table 3). From the present nursery studies, it has been found that *T. arjuna* Bedd. rootstock cleft grafted with superior Harad scion wood resulted into healthy plants with desirable characteristics. Further on farm trials and extensive experimentation is required to prove the success of this intra species grafting involving *T. chebula* and *T. arjuna*.

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