Short Scientific Report

doi:10.19071/jpc.2016.v44.i2.3095
Journal of Plantation Crops, 2016, 44(2): 109-113

# Evaluation of compatibility and nursery performance of new graft combinations in tea (*Camellia* spp.)

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*(Manuscript Received: 13-10-15, Revised: 02-03-16, Accepted: 19-05-16)*

*Keywords:* Cleft grafting, composite plants, rootstock, scion, tea clones

South Indian tea industry is confronted with poor productivity of the old seedling populations, heightened production cost and poor price realization. To overcome these constraints, the approach of replanting old unproductive tea plantations with high yielding and high quality clones is being recommended (Ilango, 2007). The tea growing areas in south India generally experience a drought period from mid-December to mid- March. Occasionally, indeterminate delays in the summer rains and early termination of North-East monsoon stretch the drought from end November to April-May. This dry season adversely affects the replanted areas as well as the young tea plants planted as infills leading to extensive casualty (Rajasekar *et al.,* 1988). Even though several tea clones with superior yield and high quality have been released, the modest drought tolerance level of the high yielding clones and poor yield potential of high quality clones are issues of great concern that need to be addressed immediately.

Nursery grafting is one of the approaches that offer promising prospects to produce composite plants by combining the yield/quality of the scion and the drought tolerance of the rootstock (Sharma and Satyanarayana, 1981; Satyanarayana *et al*., 1992). A study done by Sreedhar and Satyanarayana (1996) has reported that grafting success and vegetative vigour of composite plants in the nursery could be used as an index to evaluate the compatibility between clones. Based on long term field evaluation, six compatible graft combinations were already identified and recommended for large scale commercial adoption (Satyanarayana *et al*., 1992).

In order to have a wide choice of compatible graft partners, the recently released high yielding clones *viz.,* UPASI-28 and TRF-1 and a high quality clone TRF-2, were selected as scions for cleft grafting on the drought tolerant rootstock clones *viz.,* UPASI-2, UPASI-9, ATK-1 and TRI-2025 in the nursery. Parameters like per cent graft success, phytomass of shoot and root system of the grafted plants were recorded at the end of one year and the graft vigour was quantified.

The study was carried out in one of the estate's nursery in Valparai located in the Anamallais, Coimbatore District, Tamil Nadu, at an elevation of 1050 m above msl during May 2012 to May 2013. The average maximum and minimum temperatures were 26.2 °C and 15.3 °C, respectively. This area receives an annual average rainfall of 3500 mm. Fresh, green, semi-hard wood cuttings were used for grafting. Cleft grafting of the selected scions on the selected rootstocks was carried out for clonal compatibility studies as outlined by Haridas (1979). A specially designed plastic grafting clip was used to hold the graft partners firmly as recommended by Satyanarayana and Sreedhar (1995). One of the recommended graft combinations UPASI-8 grafted on UPASI-9 was included as standard for comparison. All the grafts and single-nodal cuttings were treated as per the standard practices (Sharma, 1976). All the treatments were replicated thrice comprising of 100 grafts/cuttings each.

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**Table 1. Influence of rootstocks on growth characteristics of the scion clone TRF-1**

| Sl. No. | Grafts/ Standards | Height (cm) | No. of leaves | Stem diameter (cm) | Maximum root length (cm) | Shoot dry weight(g) | Root dry weight(g) |
|---|---|---|---|---|---|---|---|
| 1 | TRF-1 | 36.5 [b] | 09.0 [a] | 0.40 [a] | 28.0 [a] | 4.3 [a] | 2.2 [a] |
| 2 | TRF-1/UPASI-9 | 40.5 [c] | 10.5 [ab] | 0.41 [a] | 32.0 [b] | 6.0 [e] | 3.2 [bc] |
| 3 | TRF-1/ATK-1 | 45.0 [d] | 11.5 [b] | 0.43 [a] | 31.0 [ab] | 6.2 [e] | 3.1 [bc] |
| 4 | TRF-1/UPASI-2 | 39.0 [c] | 10.0 [ab] | 0.42 [a] | 35.3 [c] | 5.4 [cd] | 3.3 [bc] |
| 5 | TRF-1/TRI-2025 | 39.7 [c] | 10.0 [ab] | 0.42 [a] | 31.0 [ab] | 5.8 [de] | 3.3 [bc] |
| 6 | UPASI-9 | 55.2 [f] | 13.7 [c] | 0.42 [a] | 33.7 [bc] | 5.1 [bc] | 3.1 [bc] |
| 7 | ATK-1 | 55.0 [f] | 13.7 [c] | 0.46 [b] | 31.8 [b] | 5.9 [e] | 3.0 [b] |
| 8 | UPASI-2 | 34.3 [a] | 10.3 [ab] | 0.46 [b] | 32.8 [bc] | 4.9 [b] | 4.4 [e] |
| 9 | TRI-2025 | 40.0 [c] | 11.0 [b] | 0.47 [b] | 35.2 [c] | 5.3 [c] | 3.8 [d] |
| 10 | UPASI-8 | 49.5 [e] | 11.0 [b] | 0.43 [a] | 33.3 [bc] | 4.1 [a] | 3.1 [b] |
| 11 | UPASI-8/UPASI-9 | 64.0 [g] | 15.0 [c] | 0.50 [b] | 37.3 [c] | 7.9 [f] | 3.4 [c] |

Values with same alphabets are not significant @ P≤0.05 @ LSD test post hoc (IBM SPSS 20)

Per cent survival was taken after three months from grafting; plant height, number of leaves, stem diameter and maximum root length, were assessed at the end of one year in five plants of each treatment. After the assessment, the shoot and root system were separated individually and kept in a hot air oven at 72 °C for 48 hours to record the dry weight. The data was subjected to statistical analysis with IBM SPSS 20 software. LSD post hoc test was done to compare the various combinations and the P values ≤ 0.05 was considered as statistical significance.

The composite plants of the scion clones TRF-1 and TRF-2 grafted with all the four rootstock clones recorded significantly higher shoot and root biomass compared to their self-rooted plants (Tables 1 & 2). However, significantly higher graft success and vigour was obtained when these clones were grafted on the rootstocks of UPASI-9 and ATK-1 than grafted on UPASI-2 and TRI-2025 (Tables 1 & 2; Fig. 1). The graft success percentage of TRF-1 and TRF-2 was the lowest with the clone TRI-2025. In case of the scions of UPASI-28, the rootstock clone UPASI-9 produced vigorous shoot and root system, when compared to that of other rootstocks as well as self-rooted UPASI-28 (Table 3). The graft survival rate was the lowest, when the scions of UPASI-28 were grafted on the rootstocks of UPASI-2,

**Table 2. Influence of rootstocks on growth characteristics of the scion clone TRF-2**

| Sl. No. | Grafts/ Standards | Height (cm) | No. of leaves | Stem diameter (cm) | Maximum root length (cm) | Shoot dry weight (g) | Root dry weight (g) |
|---|---|---|---|---|---|---|---|
| 1 | TRF-2 | 39.0 [b] | 09.3 [a] | 0.38 [a] | 25.0 [a] | 2.7 [a] | 0.9 [a] |
| 2 | TRF-2/UPASI-9 | 72.0 [g] | 15.0 [c] | 0.52 [c] | 33.0 [cd] | 7.7 [f] | 1.8 [bc] |
| 3 | TRF-2/ATK-1 | 71.8 [g] | 16.7 [c] | 0.53 [c] | 33.0 [cd] | 7.2 [e] | 1.7 [bc] |
| 4 | TRF-2/UPASI-2 | 48.5 [c] | 11.0 [ab] | 0.41 [a] | 31.0 [bc] | 4.7 [b] | 1.6 [b] |
| 5 | TRF-2/TRI-2025 | 53.0 [d] | 12.3 [b] | 0.41 [a] | 29.0 [bc] | 5.4 [cd] | 2.0 [c] |
| 6 | UPASI-9 | 55.2 [e] | 13.7 [bc] | 0.42 [ab] | 33.7 [cd] | 5.1 [bc] | 3.1 [de] |
| 7 | ATK-1 | 55.0 [e] | 13.7 [bc] | 0.46 [bc] | 31.8 [bc] | 5.9 [d] | 3.0 [d] |
| 8 | UPASI-2 | 34.3 [a] | 10.3 [a] | 0.46 [bc] | 32.8 [cd] | 4.9 [bc] | 4.4 [g] |
| 9 | TRI-2025 | 40.0 [b] | 11.0 [ab] | 0.47 [bc] | 35.2 [d] | 5.3 [c] | 3.8 [f] |
| 10 | UPASI-8 | 49.5 [c] | 11.0 [ab] | 0.43 [ab] | 33.3 [cd] | 4.1 [b] | 3.1 [de] |
| 11 | UPASI-8/UPASI-9 | 64.0 [f] | 15.0 [c] | 0.50 [c] | 37.3 [d] | 7.9 [f] | 3.4 [e] |

Values with same alphabets are not significant @ P≤0.05 @ LSD test post hoc (IBM SPSS 20)

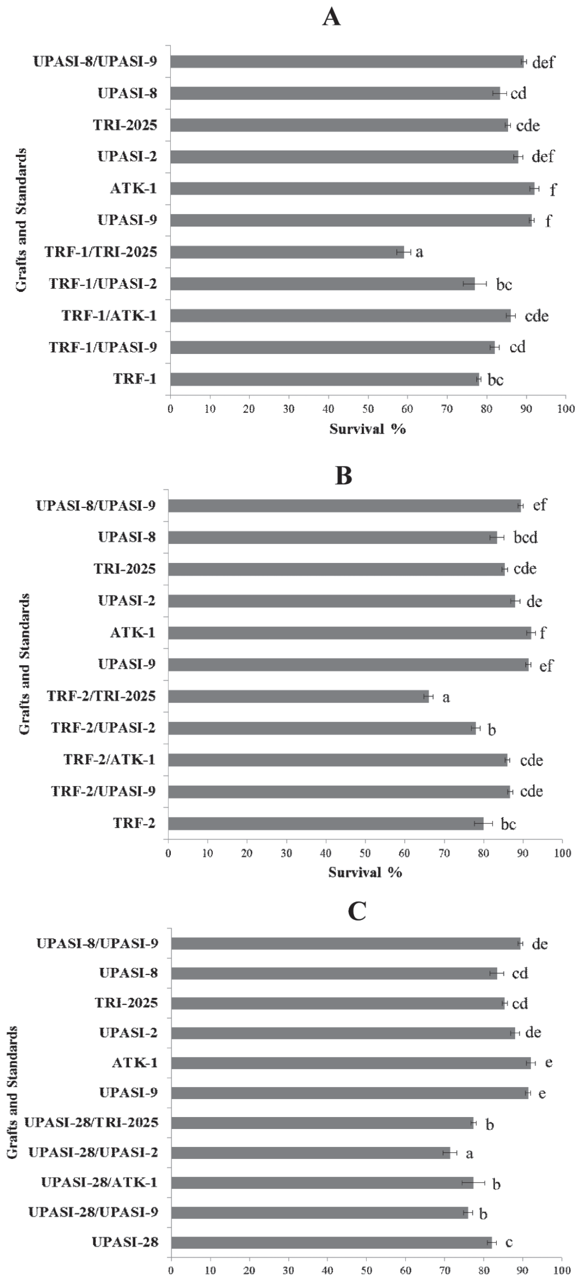


**Fig. 1. Survival percentage of various new graft combinations. A) TRF-1 B) TRF-2 C) UPASI-28. Means (± SE) in a bar followed by the same alphabets are not significantly different at P≤0.05 (IBM SPSS 20)**

whereas, there was no significant difference in the survival rate of UPASI-28 when grafted on UPASI-9, ATK-1 and TRI-2025 (Fig. 1).

The non-grafted rootstock clones, UPASI-9 and ATK-1, recorded high survival rate than TRI-2025 and UPASI-2 (Fig. 1). Among the rootstock clones the shoot biomass of ATK-1 was significantly superior, whereas the root biomass of UPASI-2 was significantly higher when compared to the other three rootstocks (Tables 1, 2 & 3). The performance of the standard graft combination UPASI-8 grafted on UPASI-9 stood superior to all other new combinations as well as the self-rooted plants of UPASI-8 that were tried in this study at nursery level.

The present study confirms significant differences in clonal compatibility between scions and rootstocks. The root dry weight of ungrafted UPASI-2 and TRI-2025 was significantly higher than their combination with TRF-1 and UPASI-28, whereas, there was no significant difference in the root dry weight of ungrafted UPASI-9 and ATK-1 and their combination with TRF-1 and UPASI-28 (Tables 1 & 3). Thus a distinct variation in clonal compatibility for grafting fresh cuttings in the nursery could be discerned depending upon the clonal combinations as reported by Sharma and Satyanarayana (1981) in tea and other crops like

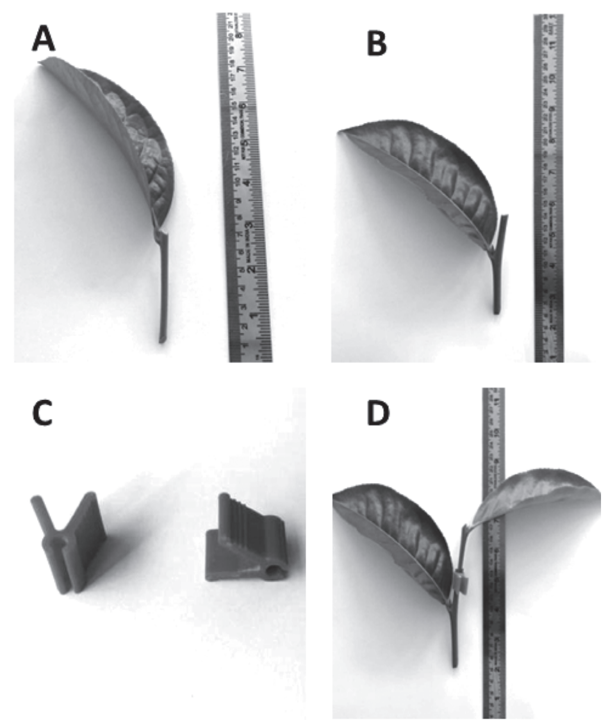


**Fig. 2. A) Scion B) Rootstock C) Grafting clips D) Cleft grafting using grafting clip**

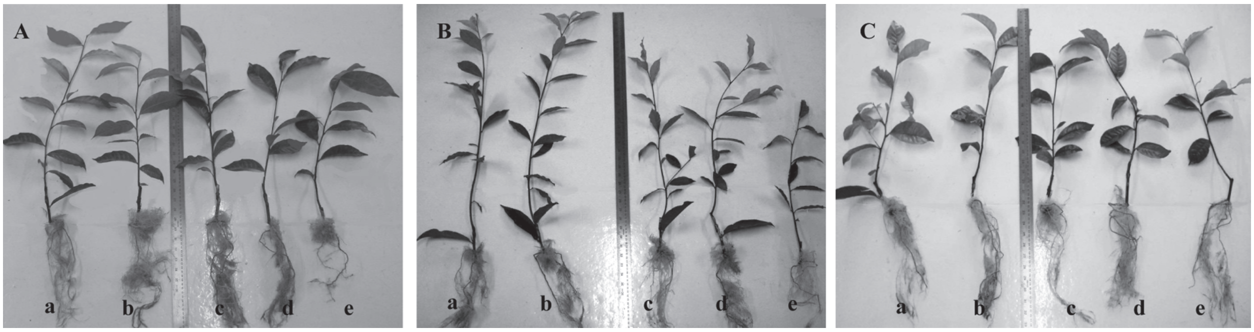


**Fig. 3. (A) TRF-1 grafted on various rootstocks. a) TRF-1/ATK-1 b) TRF-1/UPASI-9 c) TRF-1/UPASI-2 d) TRF-1/TRI-2025 e) self-rooted TRF-1; (B) TRF-2 grafted on various rootstocks. a) TRF-2/ UPASI-9 b)TRF-2/ ATK-1 c)TRF-2/UPASI-2 d) TRF-2/TRI-2025 e) self-rooted TRF-2; (C) UPASI-28 grafted on various rootstocks. a) UPASI-28/ UPASI-9 b) UPASI-28/ ATK-1 c) UPASI-28/UPASI-2 d) UPASI-28/TRI-2025 e) self-rooted UPASI-28**

coffee (D'Souza *et. al.,* 2011) and cashew (Adiga *et al.,* 2014).

The root dry weight of the composite plants of TRF-2 grafted with all the four rootstocks was significantly lower than the non-grafted plants of the four rootstock clones. But all the four root stock clones exert significant influence on the scion clone TRF-2 to produce vigorous shoot system than the self-rooted TRF-2 (Table 2). The results indicate that shoot growth and root growth are negatively correlated to each other and the intense shoot growth reduced the root growth, thereby resulting in lesser root biomass of the composite plants of TRF-2 (Table 2). This observation is in concurrence with the findings of Rahman and Dutta (1988) and Willaume and Pages (2006). However, the root biomass of TRF-2 grafted with all the four rootstock clones was significantly higher when compared to the self-rooted TRF-2.

Therefore, to obtain high percentage of graft success and vigorous composite plants of TRF-1 and TRF-2, the clones ATK-1 and UPASI-9 appear to be the ideal rootstocks. Similarly for the scion clone UPASI-28, the clone UPASI-9 appears to be a suitable rootstock. The results of the present study demonstrate that nursery grafting of the scions of high yielding and high quality clones with the root stocks of drought tolerant clones enhanced the vigour of the resultant composite plants. The root and shoot biomass of the compatible graft combinations were superior to the self-rooted scion plants. The former (increased root biomass) could be taken as an index of drought tolerance and the latter (increased shoot biomass) as an indicator of

**Table 3. Influence of rootstocks on growth characteristics of the scion clone UPASI-28**

| Sl. No. | Grafts/ Standards | Height (cm) | No. of leaves | Stem diameter (cm) | Maximum root length (cm) | Shoot dry weight (g) | Root dry weight(g) |
|---|---|---|---|---|---|---|---|
| 1 | UPASI-28 | 41.0$^{d}$ | 11.0$^{b}$ | 0.42$^{abcd}$ | 32.0$^{ab}$ | 4.5$^{ab}$ | 2.0$^{a}$ |
| 2 | UPASI-28/UPASI-9 | 38.0$^{c}$ | 12.0$^{b}$ | 0.48$^{de}$ | 32.0$^{ab}$ | 5.2$^{c}$ | 3.2$^{bc}$ |
| 3 | UPASI-28/ATK-1 | 37.5$^{c}$ | 10.0$^{ab}$ | 0.44$^{abcd}$ | 33.0$^{bc}$ | 4.7$^{b}$ | 2.9$^{b}$ |
| 4 | UPASI-28/UPASI-2 | 28.0$^{a}$ | 09.0$^{a}$ | 0.41$^{abcd}$ | 34.5$^{bc}$ | 4.6$^{ab}$ | 3.4$^{c}$ |
| 5 | UPASI-28/TRI-2025 | 39.5$^{cd}$ | 11.0$^{b}$ | 0.46$^{bcde}$ | 30.0$^{a}$ | 4.9$^{bc}$ | 3.3$^{c}$ |
| 6 | UPASI-9 | 55.2$^{f}$ | 13.7$^{c}$ | 0.42$^{abcd}$ | 33.7$^{bc}$ | 5.1$^{c}$ | 3.1$^{bc}$ |
| 7 | ATK-1 | 55.0$^{f}$ | 13.7$^{c}$ | 0.46$^{cde}$ | 31.8$^{ab}$ | 5.9$^{d}$ | 3.0$^{bc}$ |
| 8 | UPASI-2 | 34.3$^{b}$ | 10.3$^{ab}$ | 0.46$^{cde}$ | 32.8$^{bc}$ | 4.9$^{bc}$ | 4.4$^{e}$ |
| 9 | TRI-2025 | 40.0$^{cd}$ | 11.0$^{b}$ | 0.47$^{de}$ | 35.2$^{bc}$ | 5.3$^{c}$ | 3.8$^{d}$ |
| 10 | UPASI-8 | 49.5$^{e}$ | 11.0$^{b}$ | 0.43$^{abcd}$ | 33.3$^{bc}$ | 4.1$^{a}$ | 3.1$^{bc}$ |
| 11 | UPASI-8/UPASI-9 | 64.0$^{g}$ | 15.0$^{c}$ | 0.50$^{e}$ | 37.3$^{c}$ | 7.9$^{e}$ | 3.4$^{c}$ |

Values with same alphabets are not significant @ $P \leq 0.05$ @ LSD test post hoc (IBM SPSS 20) yield increase at field level. All the new graft combinations were planted in the field along with the respective standards for further evaluation.

## Acknowledgement

The authors thank the Director, UPASI Tea Research Foundation, Valparai and M/s. Nullacathu Estate Nursery, Valparai for all the support and facilities extended during the course of the study.

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