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**RESEARCH ARTICLE**

# Studies on response of soft-wood grafting on moisture stress exposed rootstocks of mango (*Mangifera indica* L.) in the eastern dry zone of Karnataka

**L. Shanthala[1], R. K. Ramachandra[2], S. M. Kumar[1], G. S. K., Swamy[1], M. K. Honnabyraiah[3], H. M. Pallavi[3], Vishnuvardhana[4], B. A. Reddy[2], B. N. Rajendra[2], R.Venugopalan[5], M. Anjanappa[6]**

**1 College of Horticulture, GKVK, UHS Campus, Bengaluru-560065, India**

**2 Horticulture Research and Extension Centre, Hogalagere Kolar Disttrict-563138, India**

**3 College of Horticulture, Yelwala Mysuru-571130, India**

**4 Regional Horticulture Research and Extension Centre, GKVK, UHS Campus, Bengaluru-560065, India**

**5 Indian Institute of Horticulture Research, Hesaragatta, Bengaluru-560089, India**

**6 College of Horticulture, Tamaka, Kolar-563135, India**

**Corresponding authors email Id: alaverashi@gmail.com**

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## Abstract

The present study was conducted to evaluate mango (*Mangifera indica* L.) moisture stress induced rootstocks and their response in the success of grafts. About 16 treatments with five replications and 10 plants in each replication were used for the experiment. About six month old rootstocks of Alphonso, Dashehari, Neelum and Totapuri were treated with four different stress levels (100 % of FC- Control; 80 % of FC- moderate stress; 60 % of FC- mild stress and 40 % of FC- severe stress). Irrigation treatment I1 (100 % of FC) showed earliest sprouting, highest graft height, graft girth, more number of leaves and maximum graft success per cent and survivable per cent, followed by mild stress treatment (80 % of FC) and moderate stress treatment (60 % of FC) whereas, least was obtained in severe moisture stress treated treatment (40 % of FC). Maximum sprouts per graft was obtained in mild stressed treatment (80 % of FC) and least was found in moderate stress treatment (60 % of FC). The rootstock Totapuri recorded maximum graft success and graft survivability percent followed by Alphonso while, earliest sprouting, highest graft height, graft girth, more number of sprouts and leaves per graft was noticed in Alphonso rootstock followed Totapuri. Earliest sprout emergence, highest graft height, graft girth, more number of sprouts and leaves per graft was recorded highest in treatment interaction of well irrigated Alphonso rootstock with Mallika scion. The maximum graft success and graft survivability percent was observed in well irrigated Totapuri rootstock with Mallika scion followed by mild stress treated Alphonso rootstock.

**Key words**: Moisture stress, rootstocks, field capacity, stress tolerance

## Introduction

Abiotic stress such as temperatures, salinity and drought are the major limiting factors for plant growth and productivity. The recent trends in global climatic change and increasing erratic weather patterns further aggravate these stresses. Moisture stress is one of the most significant abiotic stress factor limiting global production. Plants exhibit number of physiological and biochemical responses at cellular and whole organism level on account of water stress environment. It is one of the most important challenges in plant production in present scenario for agricultural scientists, which affect 26 per cent of cultivated area (Blum, 1988).

Moisture stress is characterized by decrease in water content, diminished leaf water potential and turgor loss, closure of stomata and reduced cell enlargement and growth. Water stress situation may result in the arrest of photosynthesis, interruption of metabolism and finally the death of plant (Jaleel et al., 2008). Reducing canopy leaf area, stomatal conductance, deeper penetration of roots, higher relative water content and enhanced osmotic adjustment are some of the mechanism that plant employ to overcome plant stress. Agriculture is a main user of water resources in various region of the world. With increase in aridity and population, water will become a scare in the near future. A better understanding of the effects of moisture on plants is vital for improved management practices and for predicting the fate of natural vegetation under climate change.

Mangoes are usually drought resistant to some extent but will not achieve optimum growth if they do not receive sufficient rainfall. An average annual rainfall of 663 mm and especially its even distribution throughout the year are considered to be the most important factors for economic mango production. Mango production in the year 2018 was 14 lakh tonnes and it was dipped to about 3-4 lakh tonnes in the year 2019 due to drought and unseasonal rain. Today the concern is with improving cultural practices and crop genotypes for drought-prone areas. The main aim of this research was to evaluate mango (*Mangifera indica* L.) moisture stress induced rootstocks and their response in the success of grafts.

## Material and methods

The Present experiment was conducted at Horticulture research and extension centre (HREC), Hogalagere, Kolar, Karnataka (India) during the year 2019-2020 in a Factorial Completely Randomized Block Design (FCRD).There were 16 treatments with five replications and 10 plants in each replication. Six month old rootstocks of Alphonso, Dashehari, Neelum and Totapuri were treated with four different stress levels (100 % of Field Capacity-Control; 80 % of FC- moderate stress; 60 % of FC- mild stress and 40 % of FC- severe stress). Stress was imposed by withholding watering for 15 days and on 16th day plants were irrigated up to 100 per cent of FC and again stress was created for another 15 days. Six such serial stress cycles were given to study the variations among the rootstocks under the stress period (1st January to April 4th). Later on seedlings were allowed to recover by irrigating daily (100% of FC) in the month of April (recovery period). Observations were recorded at monthly interval and pooled data were subjected to statistical analysis and the treatment means were compared by critical difference values computed at 5% level of significance.

**Results and discussion**

In case of different water stress levels, there was a statistically significant variation among the treatments. Irrigation treatment $I_1$ (100 % of FC) showed highest graft success percentage (98.33 %), this may be due to favourable environment condition without any stresses would result in successful graft union formation while, treatment I4 (40 % of FC) was recorded lowest graft success percentage (90.89 %).In case of different rootstocks, there was a statistically non-significant variation among the treatments. Rootstock $V_2$ (Totapuri) recorded maximum graft success percentage while, $V_1$ (Alphonso) was recorded lowest graft success percentage (Table1). Shantagouda *et al*. (2008) observed the effect of different mango rootstocks on success of softwood grafting. Here Alphonso variety grafted on Sindhura showed significantly highest graft success (77.8 %). The effect of interaction between water stress levels and rootstocks on graft success per cent was statistically non-significant. Interaction treatment $I_1V_2$ (100 % of FC + Totapuri) with Mallika scion showed maximum graft success percentage and survivable percentage whereas, $I_4V_1$ (80 % of FC + Alphonso) was recorded lowest graft success percentage and survivable percentage (Table1). In case of different water stress levels, there was a statistically significant variation among the treatments. Irrigation treatment $I_1$ (100% of FC) showed highest graft survivable percentage (97.180 %) whereas treatment $I_4$ (40% of FC) was recorded lowest graft survivable percentage (93.307%). This might be due to the favourable environment condition without any stresses would result in successful graft union formation and also for longer survivability. Sampath *et al*. (2017) conducted a study on grafting methods on graft success and graft survival of Kari Ishada selections of mango. The result shows that softwood grafting got survival of 57.39% with one year old rootstockIn case of different rootstocks, there was a statistically significant variation. Rootstock $V_2$ (Totapuri) recorded maximum survivable percentage (96.51 %) whereas, $V_1$ (Alphonso) was recorded lowest graft survivable percentage. Maximum survivable per cent was may be due to the presence of enough carbohydrates and food materials in the scion and rootstock which in turn higher meristematic activity of the scion. Sivudu *et al*., (2014) noted Banganapalli grafted on Bangalora rootstock recorded the maximum survival percentage (67.18 %).Islam *et al*. (2004) stated that the maximum survival percentage of Amrapalli was 52.98 per cent than Gopalbhog (38.58 %) under Bangladesh conditions. Nalage *et al*. (2010) reported that the maximum survival percentage was recorded in Kesar variety of mango grafted on local variety rootstock.. The effect of interaction between water stress levels and rootstocks on graft survivability was statistically non-significant. Interaction treatment $I_1V_2$ (100% of FC +Totapuri) with Mallika scion showed maximum graft survivable percentage whereas, $I_4V_1$ (80% of FC + Alphonso) was recorded lowest survivable percentage (Table1).

In case of different water stress levels, there was a statistically non-significant variation among the treatments. Irrigation treatment $I_1$ (100 % of FC) showed early sprouting, this indicated that there was good and quick union between rootstock and scion under well irrigated treatment whereas, late shooting was found in treatment $I_4$ (40 % of FC). Rootstock $V_1$ (Alphonso) recorded least number of days to sprout emergence whereas, rootstock $V_2$ (Totapuri) recorded maximum days for sprouting (Table1). The effect of interaction between water stress levels and rootstock on sprouting was statistically non-significant. Interaction treatment $I_1V_1$ (100% of FC + Alphonso) with Mallika scion showed minimum number of days for sprouting and $I_4V_1$ (40% of FC + Alphonso) recorded maximum number of days for sprouting (Table1).

In case of different water stress levels, there was a statistically significant variation among the treatments. At 30 (Plate 1) , 60 (Plate 2) and 90 (Plate 3) DAG, irrigation treatment $I_1$ (100% of FC) showed highest graft height and it was decreasing with increase in water stress level and lowest graft height was recorded in treatment $I_4$ (40% of FC). The reduction in graft height is generally associated with reduction in the cell enlargement under water deficit. Karna *et al*. (2017) studied on success of softwood grafting in mango (*Mangifera indica* L.). They found that maximum shoot length and graft height were reported at 15$^{th}$ September grafting with 60 cm grafting height.In case of different rootstocks, there was a significant variation in graft height. At 30, 60 and 90 DAG, rootstock $V_1$ (Alphonso) recorded maximum graft height whereas, rootstock $V_2$ (Totapuri) recorded minimum graft height. Differences in graft height among the varieties might have resulted from genotypic variability of the varieties.These results were supported by Sivudu*et et al*., (2014). They stated that Banganapalli grafted on Bangalora rootstock recorded the maximum graft height (17.92 cm) under Anantharajupet conditions. The effect of interaction between water stress levels and rootstocks on graft height was statistically non significant. At 30, 60 and 90 DAG, interaction treatment $I_1V_1$ (100% of FC + Alphonso) with Mallika scion showed maximum graft height whereas, $I_4V_2$ (40% of FC + Totapuri) recorded minimum graft height. (Table2). In case of different water stress levels, there was a statistically significant variation among the treatments. At 30, 60 and 90 DAG, irrigation treatment $I_1$ (100 % of FC) shows highest graft girth whereas treatment $I_4$ (40 % of FC) recorded lowest. In case of different rootstocks, there was a significant variation in graft girth. At 30, 60 and 90 DAG, rootstock $V_1$ (Alphonso) recorded maximum graft girth whereas, rootstock $V_2$ (Totapuri) recorded minimum graft girth. Similar results were obtained by Gurudutta *et al*. (2004). They found that six months after grafting, Dashehari reported vigorous nature and gives the highest values for scion length andheight of new graft, while, the highest scion girth was noted in Mallika as compared with the other varieties. We studied the effect of interaction between different water levels and rootstocks on graft girth. The effect of interaction between water stress levels and rootstocks on graft girth was statistically non significant. At 30, 60 and 90 DAG, interaction treatment $I_1V_1$ (100 % of FC + Alphonso) with Mallika scion showed maximum graft girth whereas, $I_4V_2$ (40 % of FC + Totapuri) recorded minimum graft girth. A steady increase in stem diameter was observed in control and mild stress treatment, whereas there was no increase in stem diameter in case of water stress condition (Luvaha *et al*., 2011).

**Plate 2: Depicted mango grafts at 30 days after grafting treatment $T_1$ to $T_8$**

**Plate 2: Depicted mango grafts at 60 days after grafting treatment $T_1$ to $T_8$**

**Plate 3: Depicted mango grafts at 90 days after grafting treatment $T_1$ to $T_8$**

For all the plate 1, 2 and 3 read as $T_1$-Well watered Alphonso;$T_2$-Well watered Totapuri;$T_3$-Mild stress treated Alphonso;$T_4$-Mild stress treated Totapuri;$T_5$-Moderate stress treated Alphonso; $T_6$-Moderate stress treated Totapuri;$T_7$-Severe stress treated Alphonso; $T_8$-Severe stress treated Totapuri

We have used different water stress levels in our experiments. In case of different water stress levels, there was a statistically non significant variation among the treatments. At 30, 60 and 90 DAG, irrigation treatment $I_2$ (80% of FC) shows highest sprouts per graft whereas lowest was found in treatment $I_3$ (60% of FC). In case of different rootstocks, there was a non significant variation in number sprouts per graft. At 30, 60 and 90 DAG, rootstock $V_1$ (Alphonso) recorded maximum sprouts per graft whereas, rootstock $V_2$ (Totapuri) recorded minimum sprouts per graft. (Table3) The effect of interaction between water stress levels and rootstocks on number of sprouts per graft was statistically non significant. At 30, 60 and 90 DAG, interaction treatment $I_1V_1$ (100% of FC + Alphonso) with Mallika scion showed maximum sprouts per graft whereas, $I_4V_2$ (40% of FC + Totapuri) recorded minimum sprouts per graft and the number of sprouts increases as the number of days increases. The highest number of sprouts was found at 90 DAG at all the treatments. (Table3). In other words sprouting increases and highest at 90 DAG. In case of different water stress levels, there was a statistically significant variation among the treatments.

**Table1: Response of soft-wood grafting on graft success, survivable percentage and days to sprouting in mango**

| Treatments | Graft success percentage at 90 DAG | Graft survivable percentage at 90 DAG | Days to sprouting |
|---|---|---|---|
| **Factor 1 (Water stress levels)** | | | |
| $I_1$ | 98.33 | 97.18 | 11.50 |
| $I_2$ | 96.1 | 96.53 | 13.50 |
| $I_3$ | 95.55 | 95.33 | 13.17 |
| $I_4$ | 90.89 | 93.31 | 13.67 |
| S.Em± | 1.32 | 0.74 | 0.74 |
| CD at 5% | 4.00 | 2.22 | NS |
| **Factor 2 (Rootstocks)** | | | |
| $V_1$ | 94.11 | 94.66 | 12.92 |
| $V_2$ | 96.33 | 96.51 | 13.00 |
| S.Em± | 0.94 | 0.52 | 0.52 |
| CD at 5% | NS | 1.57 | NS |
| **Interaction effect** | | | |
| $I_1V_1$ | 97.77 | 96.62 | 11.33 |
| $I_1V_2$ | 98.89 | 97.74 | 11.67 |
| $I_2V_1$ | 94.44 | 96.47 | 14.00 |
| $I_2V_2$ | 97.77 | 96.59 | 12.33 |
| $I_3V_1$ | 94.44 | 94.17 | 12.67 |
| $I_3V_2$ | 96.66 | 96.50 | 13.67 |
| $I_4V_1$ | 89.78 | 95.22 | 14.67 |
| $I_4V_2$ | 91.99 | 91.39 | 14.33 |
| S.Em± | 1.87 | 1.04 | 1.05 |
| C.D at 5% | NS | NS | NS |

$I_1$ (100 % of FC); $I_2$ (80 % of FC); $I_3$ (60 % of FC); $I_4$ (40 % of FC)$V_1$(Alphonso); $V_2$(Totapuri); DAG-Days after grafting NS-Non Significant

At 30, 60 and 90 DAG, irrigation treatment $I_1$ (100 % of FC) shows highest number of per graft whereas lowest was found in treatment $I_2$ (80 % of FC). In case of different rootstocks, there was a significant variation in number of per graft. At 30, 60 and 90 DAG, rootstock $V_1$ (Alphonso) recorded maximum number of per graft whereas, rootstock, $V_2$ (Totapuri) recorded minimum number of per graft . The variation in number of leaves among rootstocks was due to their different vegetative growth patter and also for their genotypic variations. Similar observation was found by Jana (2007). The maximum leaf number was analyzed in Tommy Atkins (26.95) and Amrapalli (2.36) respectively. Earlier findings of Nanditha *et al*., (2017) recorded that as more number of leaves due to genotypic character in Sardar guava. The effect of interaction between water stress levels and rootstocks, on number of leaves per graft was statistically non significant. At 30, 60 and 90 DAG, interaction treatment $I_1V_1$ (100% of FC + Alphonso) with Mallika scion showed maximum leaf number per graft whereas, $I_4V_1$ (40% of FC + Alphonso) recorded minimum leaf number per graft. The number of leaves increases as the number of days increases. The highest number of leaves was found at 90 DAG at all the treatments (Table3).

**Table 2: Response of soft-wood grafting on graft height (cm) at different treatments**

| Treatments | 30 DAG | 60 DAG | 90 DAG |
|---|---|---|---|
| **Factor 1 (Water stress levels)** | | | |
| $I_1$ | 41.02 | 42.83 | 44.67 |
| $I_2$ | 39.97 | 41.50 | 44.00 |
| $I_3$ | 38.72 | 40.50 | 42.17 |
| $I_4$ | 38.08 | 39.83 | 41.67 |
| S.Em± | 0.69 | 0.66 | 0.67 |
| CD at 5% | 2.08 | 1.98 | 2.03 |
| **Factor 2 (Rootstocks)** | | | |
| $V_1$ | 40.99 | 42.58 | 44.50 |
| $V_2$ | 37.90 | 39.75 | 41.75 |
| S.Em± | 0.48 | 0.46 | 0.48 |
| CD at 5% | 1.47 | 1.40 | 1.44 |
| **Treatments** | **30 DAG** | **60 DAG** | **90 DAG** |
| **Factor 1 (Water stress levels)** | | | |
| $I_1$ | 41.02 | 42.83 | 44.67 |
| $I_2$ | 39.97 | 41.50 | 44.00 |
| $I_3$ | 38.72 | 40.50 | 42.17 |
| $I_4$ | 38.08 | 39.83 | 41.67 |
| S.Em± | 0.69 | 0.66 | 0.67 |
| CD at 5% | 2.08 | 1.98 | 2.03 |
| **Factor 2 (Rootstocks)** | | | |
| | 40.99 | 42.58 | 44.50 |
| $V_2$ | 37.90 | 39.75 | 41.75 |
| S.Em± | 0.48 | 0.46 | 0.48 |
| CD at 5% | 1.47 | 1.40 | 1.44 |
| **Interaction effect** | | | |
| $I_1V_1$ | 42.27 | 44.33 | 46.33 |
| $I_1V_2$ | 39.77 | 41.33 | 43.00 |
| $I_2V_1$ | 41.50 | 43.00 | 45.33 |
| $I_2V_2$ | 38.43 | 40.00 | 42.67 |
| $I_3V_1$ | 40.67 | 42.33 | 44.00 |
| $I_3V_2$ | 36.78 | 39.00 | 41.00 |
| $I_4V_1$ | 39.53 | 39.00 | 42.33 |
| $I_4V_2$ | 36.63 | 38.67 | 40.33 |
| S.Em± | 0.98 | 0.95 | 0.95 |
| C.D at 5% | NS | NS | NS |

Where, DAG- Days after grafting $I_1$ (100 % of FC); $I_2$ (80 % of FC); $I_3$ (60 % of FC); $I_4$ (40 % of FC)
$V_1$(Alphonso); $V_2$(Totapuri) NS-Non Significant

Hence, in conclusion by analyzing the various soft-wood grafting on moisture stress exposed rootstocks of mango, it is concluded that Mallika scion grafted on rootstocks Alphonso and Totapuri, there was statistically non-significant variations occurred among the treatments for grafting success and survivability. A graft of both rootstocks comes up well but grafts of Totapuri rootstock got higher success per cent (98.89 %) and survivable per cent (97.74 %) followed by Alphonso (97.77 % and 96.62 %). Grafting techniques will be useful for Mango breeder who develops $F_1$'s which in turn takes many years for its fruitful production. So to develop early bearing of $F_1$ through rootstock is always option for breeder.

**Table 3: Response of different rootstocks on number of sprouts and number of leaves at different treatments**

| Treatments | 30 DAG | | 60 DAG | | 90 DAG | |
|---|---|---|---|---|---|---|
| **Factor 1 (Water stress levels)** | | | | | | |
| | **Number of sprouts** | **Number of leaves** | **Number of sprouts** | **Number of leaves** | **Number of sprouts** | **Number of leaves** |
| $I_1$ | 1.33 | 19.33 | 1.83 | 20.17 | 2.33 | 20.33 |
| $I_2$ | 1.67 | 14.00 | 2.33 | 14.67 | 2.67 | 15.00 |
| $I_3$ | 1.17 | 14.33 | 1.67 | 15.00 | 2.00 | 15.00 |
| $I_4$ | 1.17 | 18.33 | 2.00 | 19.00 | 2.33 | 19.50 |
| S.Em± | 0.19 | 1.61 | 0.33 | 0.71 | 0.46 | 0.87 |
| CD at 5% | NS | 0.53 | NS | 2.15 | NS | 2.64 |
| **Factor 2 (Rootstocks)** | | | | | | |
| $V_1$ | 1.17 | 17.83 | 2.08 | 18.58 | 2.33 | 18.92 |
| $V_2$ | 1.50 | 15.17 | 1.83 | 15.83 | 2.33 | 16.00 |
| S.Em± | 0.13 | 0.38 | 0.24 | 0.50 | 0.32 | 0.62 |
| CD at 5% | NS | 1.141 | NS | 1.52 | NS | 1.87 |
| **Interaction effect** | | | | | | |
| $I_1V_1$ | 1.00 | 24.67 | 2.67 | 25.67 | 3.00 | 25.67 |
| $I_1V_2$ | 1.33 | 15.33 | 2.00 | 16.00 | 2.67 | 16.33 |
| $I_2V_1$ | 1.33 | 21.33 | 2.33 | 22.00 | 2.67 | 22.67 |
| $I_2V_2$ | 2.00 | 16.00 | 2.33 | 16.67 | 2.67 | 16.67 |
| $I_3V_1$ | 1.00 | 13.33 | 1.67 | 14.00 | 1.67 | 14.00 |
| $I_3V_2$ | 1.33 | 15.33 | 1.67 | 16.00 | 2.33 | 16.00 |
| $I_4V_1$ | 1.33 | 12.00 | 1.67 | 12.67 | 2.00 | 13.33 |
| $I_4V_2$ | 1.00 | 14.00 | 1.34 | 14.67 | 1.67 | 15.00 |
| S.Em± | 0.26 | 0.76 | 0.47 | 1.01 | 0.65 | 1.4 |
| C.D at 5% | NS | 2.28 | NS | 3.05 | NS | 3.74 |

Where, DAG- Days after grafting $I_1$ (100 % of FC); $I_2$ (80 % of FC); $I_3$ (60 % of FC); $I_4$ (40 % of FC)
$V_1$ (Alphonso); $V_2$ (Totapuri)

By analyzing the various soft-wood grafting on moisture stress exposed rootstocks of mango, it is concluded that Mallika scion grafted on rootstocks Alphonso and Totapuri, there was statistically non-significant variations occurred among the treatments for grafting success and survivability. A graft of both rootstocks comes up well but grafts of Totapuri rootstock got higher success per cent (98.89 %) and survivable per cent (97.74 %) followed by Alphonso (97.77 % and 96.62 %). Grafting techniques will be useful for Mango breeder who develops $F_1$'s which in turn takes many years for its fruitful production. So to develop early bearing of $F_1$ through rootstock is always option for breeder.

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