

## Evaluation of different grafting methods to citrus cultivars

Zahoor Hussain<sup>1,2</sup>, Faheem Khadija<sup>3</sup>, Abdul Aziz<sup>3</sup>, Muhammad Nawaz Khan<sup>3</sup>,  
Muhammad Raza Salik<sup>3</sup> & Raheel Anwar<sup>3</sup>

### SUMMARY

Citrus is one of the most important fruit crops of the world and are propagated by sexual and asexual methods. Citrus rootstocks are produced by seed (zygotic seedling) while scion cultivars are propagated by asexual methods such as budding, cutting, layering and grafting. In Punjab-Pakistan, mostly T-budding and T-grafting as well as side grafting are used to propagate new plants with low success rate. In the current study, we investigated the effects of different methods of grafting such as 'side grafting', 'wedge (or cleft) grafting' and 'tongue grafting' to propagate mandarin cv. Kinnow and sweet orange [*Citrus sinensis* (L.) Osbeck] cvs. Succri and Jaffa on rough lemon (*C. jambhiri* Lush.) rootstock. The experiment was designed as a split-plot in a randomized complete block designed, with three replications, where a single plant was considered as an experimental unit. Thirty plants were grafted in each method of grafting. The results showed that wedge and side grafting had the highest graft take with Kinnow mandarin (90.00% and 86.67%, respectively); tongue grafting had the highest graft take with the Jaffa sweet orange (76.67%); and, the side grafting alone had the highest graft take with the Succri sweet orange. The shoot length was significantly higher in mandarins cv. Kinnow (16.00 cm) followed by sweet orange cv. Succri (11.67 cm) as compared to Jaffa (11.00 cm). In general, the results showed that side grafting was the most effective method of propagation for all evaluated cultivars in the province of Punjab-Pakistan.

**Index terms:** Kinnow mandarin, Succri sweet orange, Jaffa sweet orange, side graft, wedge graft, tongue graft.

### Avaliação de diferentes métodos de enxertia para cultivares de citros

### RESUMO

Os citros constituem de um grupo de frutíferas das mais importantes do mundo e estes são propagados por métodos sexuais e assexuais. Os porta-enxertos de citros são produzidos por sementes (plantulas zigóticas ou nucelares), enquanto as cultivares de copa são propagadas por métodos assexuados, como a borbúlia, estaquia, encostia e enxertia. Em Punjab, Paquistão, são utilizadas principalmente as técnicas de borbúlia em "T" invertido, garfagem em "T" e a garfagem lateral para propagar novas plantas, porém com baixas taxas de sucesso. Nesta pesquisa, foram investigados os efeitos de diferentes métodos: 'garfagem lateral', garfagem em 'fenda cheia' e a garfagem em 'inglês complicado', para a propagação de tangerina Kinnow e das laranjas-doce [*Citrus sinensis* (L.) Osbeck] cvs. Succri e Jaffa, em porta-enxertos de limão rugoso (*C. jambhiri*

<sup>1</sup> University College of Agriculture, University of Sargodha, Sargodha, Pakistan

<sup>2</sup> Citrus Research Institute, Sargodha, Pakistan

<sup>3</sup> Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan

**Corresponding author:** Zahoor Hussain, University College of Agriculture, University of Sargodha, Sargodha, Pakistan. [zahoorhussain@uos.edu.pk](mailto:zahoorhussain@uos.edu.pk) and [zachoundi@yahoo.com](mailto:zachoundi@yahoo.com)

Lush.). O experimento foi estabelecido seguindo um esquema de parcelas divididas, em blocos casualizados, com três repetições, sendo cada planta considerada como uma unidade experimental. Trinta plantas foram enxertadas em cada método de enxertia. Os resultados mostraram que a garfagem em 'fenda cheia' e a garfagem lateral tiveram a maior porcentagem de pegamento para tangerina Kinnow (90,00% e 86,67%, respectivamente); a garfagem em 'fenda cheia' teve a maior porcentagem de pegamento para laranja doce Jaffa (76,67%); e, a garfagem lateral foi melhor para a laranja doce Succri. O comprimento dos ramos foi significativamente maior nas tangerinas Kinnow (16,00 cm), seguido de laranja doce Succri (11,67 cm), em comparação com Jaffa (11,00 cm). De uma maneira geral, os resultados mostraram que a garfagem lateral foi o método de propagação mais eficaz para todas as cultivares avaliadas na província de Punjab-Paquistão.

**Termos de indexação:** tangerina Kinnow, laranja Succri, laranja Jaffa, garfagem lateral, garfagem em fenda cheia, garfagem em inglês complicado.

## INTRODUCTION

Citrus is one of the most important commercial fruit crops grown in all continents of the world, and areas under citrus are in continuous expansion. It is highly prized and an economically remunerative fruit. Pakistan has a prominent position among the top 13 citrus producing countries of the world and it has more potential for fresh citrus production. Citrus fruits have the largest share of produced fruit that contributes for 34% of the total fruit production of the country. It is mainly produced in the Sargodha, Multan, Sahiwal, and Bahawalpur districts of Punjab, the Hyderabad division of Sindh and the Peshawar division of Khyber Pakhtunkhwa. Citrus grown in the Punjab produces 95% of the country's crop yield due to the favorable growing conditions and adequate water supply (Mughal, 2004). However, Kuwait, Saudi Arabia, Dubai, Bahrain, Oman, Qatar, Netherlands, Singapore, Indonesia, UK, Russia and Malaysia are the major markets of the Pakistani Kinnow mandarin.

Pakistan citrus industry is facing different problems such as plant protection measures, physiological problems such as alternate bearing, unfruitfulness and fruit drop, poor management during harvesting, transportation, packing and storage, and shortage of skilled labor on grafting or budding techniques. These problems lead to low quality and quantity of fruits which ultimately results in less export and high economic losses to the country.

Citrus is a long-living perennial tree. However, citrus is propagated by sexual and asexual methods. Citrus rootstock is seed while scion cultivars are propagated by asexual methods such as budding, cutting, layering and grafting. In Punjab-Pakistan, mostly T-budding and T-grafting were used to propagate new plants with low success percentage due to method of grafting and environmental condition (Hartmann et al., 1997).

Grafting is a propagation technique which is used in propagation of many fruit trees to achieve maximum success

in the take, dwarfism in trees depending on rootstock types (Simons, 1987), resistance against insects and pests, salinity tolerance (Colla et al., 2010) as well as enhancing the fruit production (Mitani et al., 2008; Mng'omba, 2007). Therefore, many tropical and subtropical as well as temperate fruits such as mango, avocado, citrus, peach, pear, and plums are commonly propagated by grafting as compare to stem cuttings and marcots which may not be successful as a result of difficulties in root development.

There are many factors that influence on grafting, such as skilled grafter, air temperature, relative humidity, moisture and plant water status, growth stage of scion and rootstock, method and time of grafting, compatible size of grafts of both scions and their respective rootstocks (Hartmann et al., 2007; Mng'omba et al., 2010; Pina & Errea, 2005) and age of the mother plants (Salaudin, 2003). Rootstock with 10-mm stem diameter has been considered ideal for grafting of citrus (Hartmann et al., 1997).

Different grafting methods are used to propagate different fruit species, such as tongue, wedge and veneer in walnut (Muzaffar & Kumar, 2011), cleft grafting in citrus (Hartmann et al., 1997; Coronel & Dotto, 2001; Ledesma & Campbell, 2001), soft wood grafting in Khasi mandarin (Patel et al., 2010) and epicotyls grafting in mango (Baghel et al., 2002; Hema et al., 2002).

In the current study, we investigated the effects of different methods of grafting such as side, wedge or cleft and tongue to propagate different species of citrus such as mandarins (*Citrus reticulata* Blanco) cv. Kinnow and sweet orange [*C. sinensis* (L.) Osbeck] cvs. Succri and Jaffa.

## MATERIALS AND METHODS

The current study was conducted at the experimental area of Department of Horticulture, University College of Agriculture, University of Sargodha, in 2015. The experiment

was conducted in open field during autumn (September, 2015) and at a temperature of  $25 \pm 5$  °C. One-year old seedlings of Rough lemon (*C. jambheri* Lush) were selected on the basis of size, vigor and other morphological character's in order to keep the variation at minimal level. Similarly, scion wood of three different cultivars of citrus such as mandarin's cv. Kinnow and sweet oranges (cvs. Succri and Jaffa) were selected to be grafted on the Rough lemon rootstock. The side, wedge and tongue methods of grafting were used. In vegetative propagation, however, no genetic change takes place since no genetic union with recombination of genes occurs.

Propagation through wedge grafting is preferred for deciduous and top working older tree of inferior varieties (Malik, 1994). Similarly, whip and tongue grafting are commonly used for bench grafting fruit trees. Tongue or whip graft works best when the stock and scion are of similar diameter, preferably between 1/4 and 1/2 inch. The scion wood was prepared by clipping off the leaves leaving petiole stubs 0.5 cm long intact. Graft wood, 10 cm in length, 9 to 12 months old, rounded with white streaks, was detached from the scion trees and grafted on 12-month-old seedling stocks at 20 cm from the ground level. Polythene sheet was wrapped over the graft and both ends were tied with polythene sheet (to conserve the moisture) covering the scion/stock union. The binding material and the top of the graft were removed when enough sprouting from the graft was observed. De-sprouting of the stock below the graft union was continued since the time of grafting. All the agronomic and cultural practices such as spraying pesticides and fertilizer as well as weeding were kept constant and carried out regularly with all treatments.

Grafts take percentages were recorded by using the method of Chalise et al. (2013). The sprouted scions were recorded in successful graft take. However, in some cases, the late sprouting was also observed and, finally, sprouting percentage was considered as the graft success percentage in relation to the total number of grafts.

Death of sprouted grafts was observed during the study and the survival percentage was calculated by using the method of Chalise et al. (2013) in relation to the total number of sprouted grafts. Similarly, the shoot length and number of shoots were recorded according the method of Salik et al. (2015). The experiment was designed as a split-plot in a randomized complete block designed, with three replications, where a single plant was considered as an experimental unit.

The standard procedure was used for data collection such as graft success percentage, mortality percentage,

shoot length (cm) and number of shoots after 5 months since the treatment application.

## RESULTS AND DISCUSSION

The data recorded on survival percentage of grafts showed that the wedge and side grafting had the highest graft take with Kinnow mandarin (90.00% and 86.67%, respectively); tongue grafting had the highest graft take with the Jaffa sweet orange (76.67%); and, the side grafting alone had the highest graft take with the Succri sweet orange (Tables 1 and 2). It may have argued that success in grafting, subsequent growth of scion shoot and development of the successful graft depend on a number of factors including time of grafting, fruit type variety, method of grafting, selection and preparation of

**Table 1.** Degrees of freedom (df) and P-values (P-value > F) of the on the primary effects and possible interactions of cultivars and grafting methods on the graft take, shoot length and number of shoots

Source	df	Graft take	Shoot Length	Number of shoots
		P-value > F		
Cultivars	2	0.022*	0.556	0.346
Methods	2	0.003**	0.199	0.999
Cultivars *	4	0.006**	0.0474*	0.465
Methods				

\* P<0.05; \*\* P<0.01.

**Table 2.** Effect of different grafting methods on graft take percentage of different citrus cultivars

Grafting Methods	Graft take percentage		
	Cultivars		
	Kinnow	Succri	Jaffa
Side Grafting	86.67 aA	82.33 aA	74.33 abA
Tongue Grafting	61.00 abB	50.00 bB	76.67 aA
Wedge Grafting	90.00 aA	63.33 bB	61.00 bA

Means followed by the same letter within each interaction do not differ (Tukey, 5%); lowercase letters = between cultivars (row); uppercase letters = between grafting methods (column).

scion, rootstock materials and environmental condition (Hartmann et al., 1997).

The current study was supported by the findings of Poon (1999) has also observed higher success (91.75%) with veneer method in mandarin. However, Gautam et al. (2001) has been reported highest success (87.50%) when grafting was done at 31<sup>st</sup> January as compared to the grafting (85.00%) which was carried out during 16<sup>th</sup> January at Lumle, Kaski. Adhikari (2006) also observed highest graft success (79.73%) when acid lime was grafted on trifoliolate orange. Salauddin (2003) also done an experiment on grafting and found that best season for grafting operation was June as compared to July and August. Similarly, the author also found that scion collected from higher age (6 years old) showed excellent results as compared to other scions of different ages. Similarly, Soft wood grafting in Khasi Mandarin (*C. reticulata*) were carried out by Patel et al. (2007) at Meghalaya, India under poly-house, net-house and open field conditions at 15-day intervals from 15 June to 15 October. The found early sprouting, graft success and best scion growth under poly-house conditions and *C. Jambhiri*, was the best rootstock for soft wood grafting in Khasi Mandarin.

It may be argued that mortality may occur due to the transpiration loss from the tender leaves due to lack of cuticle layer and higher number of stomata on the young leaves. In short term, sufficient moisture is the responsible for mortality in the young emerging plants. Similarly, higher temperature is also another factor which causes the mortality in young emerging plants. Similarly, Chalise et al. (2013) was also observed lowest (0.17%) mortality of sprouted grafts in 29<sup>th</sup> December grafting, while it was observed higher in earlier and late season grafting.

The shoot length and numbers were also recorded, and a significant interaction effect was found only in shoot length (Table 1). The highest shoot length (16.00 cm) was recorded in mandarin's cv. Kinnow with the wedge grafting, relative to others cultivars; and, the lowest shoot length was recorded in sweet orange cv. Succri (11.67 cm) and Jaffa (11.00 cm) (Table 3).

Grafting is not a new method of propagation fruit plants and in recent decades also with vegetable. Taxonomic proximity is a general prerequisite for successful graft-take and long-term survival of the grafted, composite plant (Goldschmidt, 2014). It may be argued that auxin play an important role in the wound healing and vascular regeneration within the graft union zone. It has been previously reported that success in grafting, subsequent

**Table 3.** Effect of different grafting methods on shoot length of different citrus cultivars

Grafting Methods	Shoot length (cm)		
	Cultivars		
	Kinnow	Succri	Jaffa
Side Grafting	9.33 bB	9.33 bA	13.67 aA
Tongue Grafting	11.00 aB	11.67 aA	11.00 aA
Wedge Grafting	16.00 aA	11.67 bA	11.00 bA

Means followed by the same letter within each interaction do not differ (Tukey, 5%); lowercase letters = between cultivars (row); uppercase letters = between grafting methods (column).

growth of scion shoot and development of the successful graft depend on grafting season, method, selection and preparation of scion, rootstock materials and environmental condition such as temperature (Hartmann et al., 1997).

Similarly, it has been reported previously that temperature plays a significant role with respect to vegetative growth in different horticultural plants such as citrus (Chaudhary & Ishfaq, 2004), sweet orange (Salik et al., 2015), pummelo (Paudyal, 1999), acid lime (Adhikari, 2006), watermelon (Colla et al., 2010), mango (Baghel et al., 2002; Hema et al., 2002; Kumar et al., 2000) and walnut (Karadeniz, 2005; Muzaffar & Kumar, 2011).

## CONCLUSIONS

For the conditions encountered in study, it was concluded that in general, side grafting is the most effective method of propagation in the Sargodha-province of Punjab-Pakistan for the evaluated citrus cultivars.

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