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# Effects of Juvenility on the Rooting of Trifoliate Orange (*Poncirus trifoliata* [L.] Raf.) Stem Cuttings

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## Summary

The rooting ability of cuttings of current shoots from trifoliate orange (*Poncirus trifoliata* [L.] Raf.) trees at various ages was determined. All cuttings were collected in early June 2001. Rooting abilities varied among various ages of trifoliate orange trees. Forty-five days after cutting, the current shoots from one- and two-year-old trees had 100% rooting; those from 15- and 25-year-old trees had 0%. From three-year-old to five-year-old trees, the rooting percentage decreased as the age increased. The number of roots produced correlated positively with the rooting percentage. In another experiment, scions from current shoots from mature 'Aoshima' satsuma mandarin (*Citrus unshiu* Marc.) were grafted onto two-year-old trifoliate orange seedlings. All trifoliate orange portions of cuttings grafted with 'Aoshima' satsuma mandarin scions rooted.

**Key Words**: juvenile, mature, phase change, rooting ability, trifoliate orange.

## Introduction

Seedling plants undergo the juvenile, transitional and mature phase of development to various degrees in different parts of the plant in a gradient from base to top (Hartmann et al., 1997; Kester, 1976). During the juvenile stage, flowering does not occur. When the tree begins to flower, it is considered to have attained the adult phase. Attainment and maintenance of the potential to flower is the only consistent criterion to assess the termination of the juvenile period. Other characteristics are not consistent from species to species (Hackett, 1985). Thorniness in citrus may be an indicator of juvenility. However, trifoliate orange trees have thorns even in the adult phase.

According to Clark (1983), the length of the juvenile period for *Rosa* (hybrid tea) is 20 to 30 days, one year for *Vitis* spp., two to eight years for *Prunus* spp., five to eight years for *Citrus* spp., and 30 to 40 years for *Fagus sylvatica*. Cuttings taken during the juvenile phase of most plants inherently have a higher rooting potential than those from the mature phase.

Grape scions are often bench-grafted onto rootstock cuttings and then rooted because the rootstocks root easily. Perhaps this method could be adopted for the propagation of difficult-to-root citrus scion cultivars. Previously, 'Aoshima' satsuma mandarin (*Citrus unshiu* Marc.) were found to be difficult to root (Bhusal et al., 2001). We tested whether a juvenile trifoliate orange stem cuttings serving as the understock for 'Aoshima' satsuma mandarin scion would root easily or not.

## Materials and Methods

The experiments were carried out at the Experimental Farm, Ehime University, Hojo, Ehime Prefecture, Japan. In the first experiment, current spring shoot cuttings were made from 1-, 2-, 3-, 4-, 5-, 15- and 25-year-old trifoliate orange trees (*Poncirus trifoliata* [L.] Raf.). One- to 5-year-old trees bore no flowers; 15- and 25-year-old trees did. In Exp. 2, scions from 7-year-old 'Aoshima' satsuma mandarin trees were collected in March 2000 and grafted on two-year-old trifoliate orange seedling rootstocks. These grafted plants were grown in a greenhouse for one year.

In early June 2001, the grafted scion with 2 to 3 buds and short piece of rootstock attached was made into cuttings, 5-8 cm long. Retaining the topmost leaf that was cut transversely into half, the cuttings without any hormone treatment was inserted in a rooting medium of Kanuma soil in 50 × 35 × 7-cm size plastic trays and misted hourly for 1 minute in a greenhouse. Each experiment was triplicated with 10 cuttings per treatment and control.

Rooting percentage, number and length of primary roots, number of secondary roots, shoot number and shoot length were recorded 45 days after the start of experiment, cuttings were re-embedded into the rooting media and re-evaluated in early September 2001.

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**Table 1.** Root and shoot growth of current year cuttings from trifoliate orange trees of different ages. All data represent means ( ± SE) per cutting.

| Tree age (years) | Rooting% | | No. of main roots | Main roots length (cm) | No. of secondary roots | No. of shoots | Shoot length (cm) |
|---|---|---|---|---|---|---|---|
| | After 45 days | After 90 days | | | | | |
| 1 | 100 | 100 | 4.2 ± 0.3 | 5.3 ± 0.3 | 18.9 ± 1.8 | 2.2 ± 0.1 | 2.2 ± 0.5 |
| 2 | 100 | 100 | 4.3 ± 0.3 | 5.4 ± 0.2 | 16.8 ± 0.4 | 1.5 ± 0.1 | 1.3 ± 0.2 |
| 3 | 90.0 ± 5.8 | 100 | 4.1 ± 0.2 | 4.2 ± 0.1 | 15.1 ± 0.8 | 0.7 ± 0.2 | 1.3 ± 0.4 |
| 4 | 56.7 ± 1.0 | 93.3 ± 3.3 | 3.1 ± 0.3 | 2.9 ± 0.4 | 12.3 ± 1.3 | 0.3 ± 0.2 | 1.3 ± 0.2 |
| 5 | 23.3 ± 3.3 | 83.3 ± 3.3 | 1.8 ± 0.6 | 2.3 ± 0.3 | 9.1 ± 2.5 | 0 | 0 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 25 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Results and Discussion

Cuttings made from trifoliate orange of different ages had large variations in rooting ability. Cuttings from 1-, 2-, 3-, 4- and 5-year-old trees formed roots to varying degrees, whereas those from 15- and 25-year-old trees failed to root even after three months. Halma (1931) likewise, reported that no cuttings from mature trifoliate orange trees rooted. In Exp.1, rooting after 45 days was 100% for cuttings from 1- and 2-year-old trees, whereas it was 90%, 56.7% and 23.3% for those from 3-, 4-, and 5-year-old trees, respectively (Table 1). We also observed 100% rooting in epicotyl cuttings of 45-day-old trifoliate orange (data not presented). The rooting percentage of cuttings from 4- and 5-year-old trees was significantly increased by September. The number of main roots, secondary roots, shoots, and the length of main roots and shoots were higher in cuttings from 1-, 2- and 3-year-old trees (Table 1 and Fig. 1).

The number of roots produced was correlated positively with rooting percentage ($r$=0.90 for main roots and $r$=0.89 for secondary roots significant at 5% level), similar to our previous report (Bhusal et al., 2001). Halma (1931) also reported that after two or three months the cuttings develop a fairly extensive root system. Hartmann et al. (1997) found that softwood cuttings produced roots in two to four or five weeks in most cases. In Exp. 1, rooting time was much faster with juvenile cuttings. Inhibitors appear to be correlated with the decrease in root initiation (Heuser, 1976). Crow et al. (1971) identified rooting inhibitors in *Eucalyptus* as derivatives of 2,3-dioxabicyclo (4,4,0) decane. The drastic decline in the rooting ability of cuttings from mature trifoliate orange trees may be associated with the presence of some inhibitors.

All cuttings of 'Aoshima' satsuma mandarin/ trifoliate orange combination rooted (Fig. 2). Cuttings of current shoots from mature 'Aoshima' satsuma mandarin trees rooted poorly (Bhusal et al., 2001). It seems that adult phase scions do not affect the rooting of rootstock portions. Our results suggest that patch or ring grafting the base of difficult-to-root citrus species with a strip of bark from an easy-to-root juvenile trifoliate orange may induce rooting in the scion. Furthermore, it is suggested that bench grafting 'Aoshima' scions on juvenile trifoliate orange cutting may be successful. Our present results reveal that cuttings from trifoliate orange trees up to 3-year-old have a very good rooting potential. Now, we need to investigate what physiological and biochemical changes are involved in the

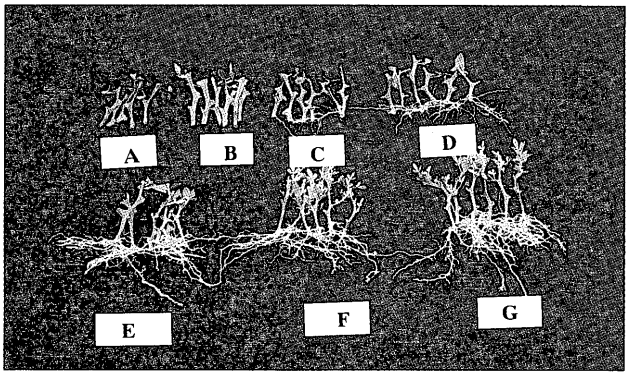


**Fig. 1.** Rooting in current shoot cuttings of trifoliate orange (*Poncirus trifoliata* [L.] Raf.) taken from various ages trees. A, 25 years; B, 15 years; C, 5 years; D, 4 years; E, 3 years; F, 2 years and G = 1 year old.

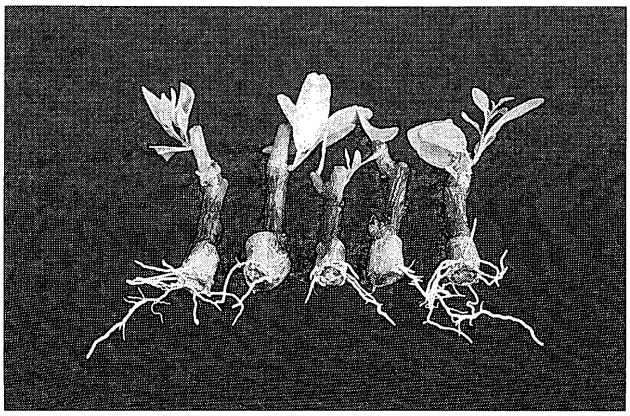

**Fig. 2.** Rooting of trifoliate orange cuttings topworked with 'Aoshima' satsuma mandarin (*Citrus unshiu* Marc.) scions. Note rooting only occurred in the trifoliate orange rootstock.

maturation process that reduced the rooting capacity of mature trifoliate orange trees.

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# 幼若性がカラタチの枝挿しの発根に及ぼす影響

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## 摘　要

異なる樹齢のカラタチから得た当年生枝を挿し穂としてその発根能力を調査した．全ての挿し穂は2001年6月に採取した．発根能力は樹齢によって異なった．挿し木後45日目に調査したところ，1，2生樹から採取した当年枝の発根率は100%だったのに対し，15，25年生樹からの当年枝は0%だった．3年生から5年生の樹より採取した当年枝の発根率は樹齢が大きくなるにつれて発根率が減少した．発根数は発根率が高いほど多かった．また，別の実験で‘青島温州’の成木から採取した当年枝を2年生カラタチ実生台木に接ぎ木をして1年間養成したあと，台木の部分をつけて挿し穂を取り，挿し木をしたところ，全てカラタチの台木の部分から発根した．