Which is better for mother stock of leaf-bud cuttings of kaki (*Diospyros kaki*), root-sucker or hedge?©

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INTRODUCTON

We have demonstrated how to propagate kaki (*Diospyros kaki* Thunb.) using softwood cuttings (Tetsumura et al., 2000, 2001, 2002, 2003, 2009, 2011, 2015b, 2017; Hejazi et al., 2018). One of key success factors of softwood cutting propagation, which had been thought to be difficult (Tao and Sugiura, 1992), was the length of cuttings; the shorter the cuttings were, the higher the rooting percentages were (Tetsumura et al., 2000, 2001). We recommend using 3- to 4-cm-long single-node stem cuttings with one leaf, namely leaf-bud cuttings (Figure 1). Another factor was the cuttings collected from root-suckers (Figure 2), not from hedges (Figure 3) (Tetsumura et al., 2001, 2002, 2009, 2011, 2015b, 2017). Although micropropagation is thought to create physiologically juvenile and to provide cuttings with improved rooting (Howard, 1987; Osterc and Štampar, 2015), cuttings from the hedges derived from micropropagated plants of 'Hiratanenashi' and FDR-1 kaki showed lower rooting rates than those from root-suckers (Tetsumura et al., 2002, 2017). The idea of using root-suckers was got by the in vitro results, which showed that rooting percentages of shoots regenerated from roots of kaki cultivars were higher than those of shoots that originated from shoot tips (Tetsumura and Yukinaga, 2000). Del Tredici (1995) pointed out that root-suckers are physiologically juvenile and tend to root more readily than cuttings taken from other parts of the tree.

Figure 1. 'MKR1' leaf-bud cuttings rooting well 2 months after planting.

Figure 2. Root-suckers sprouting on roots of 'MKR1' in summer.

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Figure 3. A hedge of 'MKR1' in summer.

Recently, we found that the cuttings from hedge of 'MKR1', a dwarfing rootstock for kaki, rooted well, although the rooting speed was slower (Tetsumura et al., 2015b). Hence, the objective of this study was to confirm, "which is better for mother stock of leaf-bud cuttings of kaki, root-sucker or hedge?"

MATERIALS AND METHODS

Four micropropagated 'MKR1' nursery stocks were planted in the Field Science Center, Faculty of Agriculture, University of Miyazaki, in December 2008. One was cut back to a height of 40 cm each winter for establishment of a hedge to provide a mother stock for cuttings. In March 2011, the others were cut to just above ground level and then the surface soil of approximately 0.25 m^2 around the stump was removed to a depth of 20 cm (Figure 4). Roots >0.5 cm in diameter were exposed to sunlight to promote differentiation of 'MKR1' root-suckers. Rootstock a (R-a) (Tetsumura et al., 2010, 2015a) propagated by cutting was also used for this study. Two rooted cuttings were planted in March 2001. One was made for the hedge and, in May 2006 the other was cut for supplying root-suckers.

Figure 4. 'MKR1' roots for supplying root-suckers.

Root-suckers and shoots on hedges of 'MKR1' and R-a were collected on June 15, 2014 and 2015. The leaf-bud cuttings were prepared, dipped at their bases in 50% aqueous ethanol with 3000 ppm indole-3-butyric acid (IBA) for 5 s, planted singly in a plastic pot (EG-90, 300 mL, Minamide Inc., Japan) which was filled with Metro-Mix®360 (Sun Gro, Horticulture Distribution Inc., Washington DC), and then placed under a vaporized aluminum netting (80% shading) in a propagation frame covered with plastic film. The propagation frame was intermittently misted (30-s mist and 15-min stop in the daytime) using micro sprinklers (DN752A, SUN HOPE Inc., Tokyo, Japan), and was ventilated with fans when the ambient air reached 38°C. Twenty-four cuttings per cutting source were used. When the roots were visible at the bottom of the pot (Figure 5), the cutting was considered as "rooted," and then the rooted cuttings were transplanted singly to a plastic pot (EG-105, 400 mL, Minamide Inc., Japan) filled with Metro-Mix® 360. Controlled-released fertilizer (1 g pot^{-1}; Hi-control all 10, JCAM AGRI. Co., Ltd., Japan), containing 10% N, 10% P, 10% K, and 10% Ca, which releases for 100 d when the soil temperature reached 25°C, was applied upon transplanting of the rooted cuttings. Pots were placed in a propagation frame covered with 50% shade netting with the plastic film open at the sides and were watered adequately. Survival of rooted cuttings over the winter was confirmed by whether the cuttings sprouted leaves in April of the following year.

Figure 5. A root (arrow) coming out from a pot, in which a 'MKR1' cutting was planted 2 months earlier.

Two micropropagated 'Maekawajiro' nursery stocks were planted in the Field Science Center in December 2002. One was made for the hedge and, in May 2006 the other was cut for supplying root-suckers. Four Rootstock c (R-c, previous name "KD-3") (Tetsumura et al., 2003) nursery stocks propagated by cutting were planted in December 2008, and one was made for the hedge and, in March 2011 the others were cut for supplying root-suckers. On June 9, 2016, the cuttings collected from hedges and root-suckers of 'Maekawajiro', 'MKR', R-a and R-c were planted in the pots. The experiments were conducted by the same methods as those in 2014 and 2015.

RESULTS AND DISCUSSION

In 2014 and 2015, the cuttings collected from root-suckers of 'MKR1' and R-a started

rooting from one month after planting and almost all of the cuttings had rooted by the end of two months after planting (Figure 6). The final rooting percentages were 100% in the two years. Cuttings from 'MKR1' hedge also started rooting from one month after planting; however, the rooting speed was slow and the final rooting was 54%. In 2012, the rooting of cuttings from 'MKR1' hedge gradually increased and occurred even when the average daily temperature in the propagation frame decreased at 20°C, and the final rooting percentage was 92% (Tetsumura et al., 2015b). The temperature in the propagation frame may not have made the difference in the final rooting percentage, because the temperature changes in 2014 and 2015 was similar to that in 2012 (data not presented). Cuttings from R-a hedge started rooting from one and a half months after planting and the final rooting percentage was higher than that of 'MKR1', although the rooting speed was as slow as that of 'MKR1' (Figure 6).

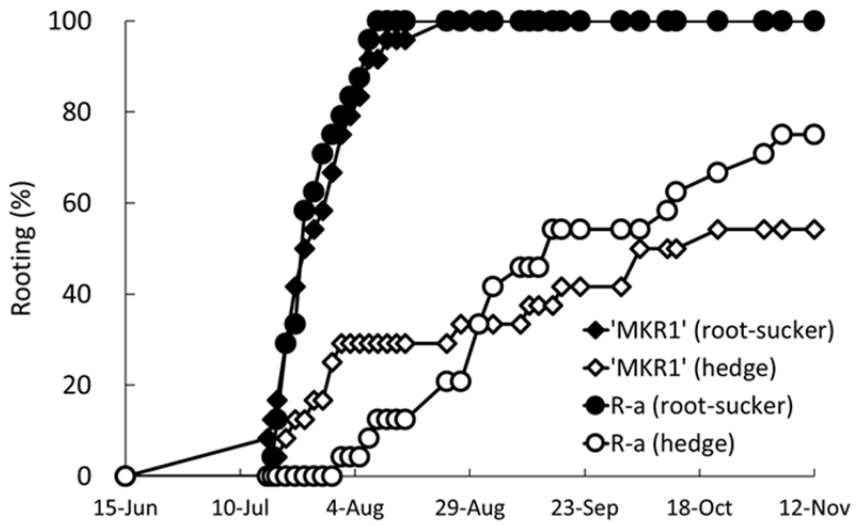

Figure 6. Rooting percentages of the cuttings collected from root-suckers and hedges of 'MKR1' and R-a in 2014 and 2015.

The overwinter survival percentage of the rooted cuttings collected from root-suckers of 'MKR1' was higher than that from hedge (Tetsumura et al., 2011, 2015b), and this tendency was also shown in this study; the survival of the rooted cuttings collected from root-suckers in the following year was 84% and that from hedges was 59%. Moreover, the same was true of R-a; the survival from root-suckers was 81% and that from hedges was 31%. The fact that almost all of the cuttings, especially from the hedges, rooting after 2 months of planting could not be overwintered (data not presented) made these differences in the survival percentages. Earlier rooting very likely contributed to a well-developed root system of the transplanted cuttings because the duration of growing season after transplanting was longer. The developed root system of the cuttings likely contributed to overwinter well (Tetsumura et al., 2011). Furthermore, the number of roots must have related to the development of the root system, and the cuttings collected from root-suckers had more roots than those from hedges (Tetsumura et al., 2011).

The cuttings collected from root-suckers of 'MKR1' planted in 2016 showed the same rooting performance as those in 2014 and 2015 (Figure 7). On the other hand, the cuttings from 'MKR1' hedge showed the same performance as those in 2012 (Tetsumura et al., 2015b); they continued rooting until early November and the final rooting percentage became 88%. However, the overwintering survival was very low (33%) so that the number of survived cuttings in the following year was almost the same for the three years. All of the rooted cuttings from root-suckers of 'MKR1' transplanted in 2016 overwintered successfully,

that is, all the cuttings planted in the mist system could be used as rootstocks.

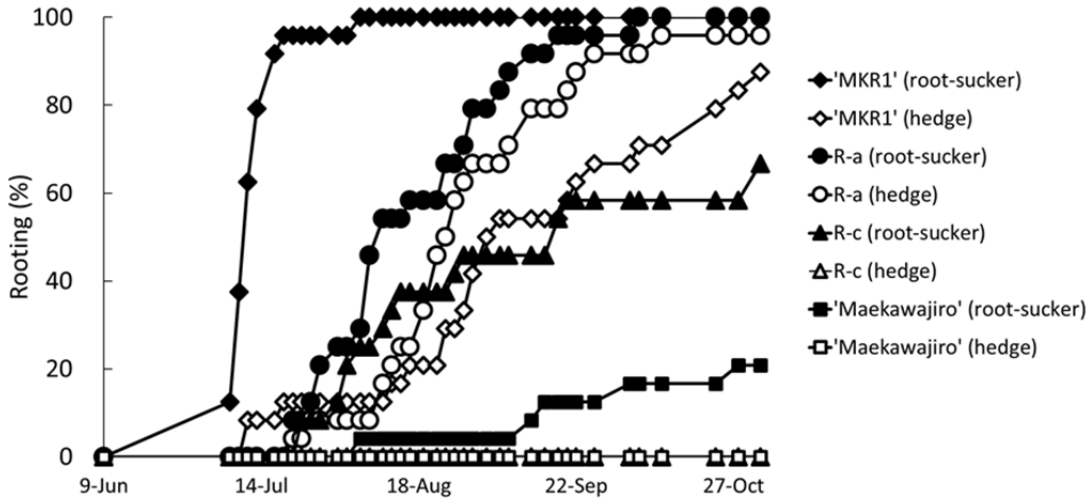

Figure 7. Rooting percentages of the cuttings collected from root-suckers and hedges of 'MKR1', R-a, R-c, and 'Maekawajiro' in 2016.

The start of rooting of the cuttings from root-suckers of R-a planted in 2016 was half a month later than that in 2014 and 2015 and the rooting speed was slower, although all of them rooted by the beginning of October (Figure 7). The start of rooting of the cuttings from R-a hedge planted in 2016 was the same as that in 2014 and 2015 and the rooting speed was also the same, but almost all of them rooted. However, the same as rooted cuttings from 'MKR1' hedges, the overwintering survival was extremely low (22%). As a result, 21% of cuttings from R-a hedges planted in 2016 survived, while 79% from R-a root-suckers did. In 2014 and 2015, 23% from R-a hedges survived.

In 2016, the cuttings from root-suckers of 'Maekawajiro' and R-c rooted to some extent (Figure 7), and in 2017, 60 and 69% of the rooted cuttings sprouted, respectively. However, the cuttings from their hedges did not root at all.

On the whole, the final rooting percentages of cuttings from 'MKR1' and R-a hedges occasionally became almost the same as those from root-suckers, but the overwintering survival rates of the rooted cuttings were always low. The cuttings from hedges derived from micropropagated plants of 'Jiro' and 'Nishimurawase' rooted as well as those from their root-suckers, but their overwintering survivals were not investigated (Tetsumura et al., 2002). Moreover, the cuttings from hedges of 'Maekawajiro' and R-c did not root. Hence, in conclusion, we recommend using root-sucker rather than hedge for mother stock of leaf-bud cuttings of kaki, because one can get many rooted cuttings from root-suckers.

ACKNOWLEDGEMENTS

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