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Comparative Field Performance of Mature Japanese Persimmon Trees Grafted on Seedling Rootstocks vs. Micropropagated Ones

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Summary

The growth of micropropagated (M) Japanese persimmon (*Diospyros kaki* Thunb. cv. Nishimura wase) trees from the 8th to 11th year after planting was compared with that of trees grafted on seedlings (G) in the orchard. The M trees grew more vigorously than did the G trees; the differences in tree canopy and trunk cross-sectional area between the M and G trees increased annually. The percentage of shoots with male flowers in the total number of shoots in the M trees was lower than that in the G trees, although the difference was not significant. The percentage of shoots with female flowers in the total number of shoots in the M trees was the same as that in the G trees. Although the yield per tree of M trees was larger than that of G trees, there was no significant difference between the G and M trees in the yield efficiency (yield per canopy volume). These results suggest that micropropagation caused reinvigoration, but not true rejuvenation. M trees showed uniform growth, flowering and fruiting.

Key Words: field performance, Japanese persimmon, micropropagation, reinvigoration, rejuvenation.

Introduction

Micropropagated fruit trees differ in field performance from their conventionally propagated counterparts, such as cuttings and trees grafted on seedlings or dwarfing rootstocks (Hammerschlag and Scorza, 1991; Quamme and Brownlee, 1993; Tetsumura et al., 1999; Webster et al., 1985). Owing to rejuvenation, micropropagated trees grow vigorously and fruiting is delayed (Webster et al., 1985). However, no investigation has been conducted on the growth of 10-year-old micropropagated trees, except Zimmerman and Steffens (1996), who did not include their counterparts.

We reported previously that 7-year-old micropropagated Japanese persimmon trees grew more vigorously than did trees grafted on seedlings (Tetsumura et al., 1999). Although the micropropagated trees bore fewer female flowers and produced less fruit for a few years soon after planting, they grew faster and showed a rapid increase in yield. Persimmon trees usually take 8-10 years to reach the full bearing stage (Kitagawa and Glucina, 1984). Hence, we have investigated the growth, flowering and fruiting of the micropropagated and grafted trees over 7 years old, and have found that they produced fruit stably but grew differently. In this paper, we compared the field performance of the mature micropropagated Japanese persimmon (M) trees with that of trees grafted on seedlings (G trees), and discuss the advantages and disadvantages of micropropagation.

Materials and Methods

The M and G trees of 'Nishimurawase' Japanese persimmon examined in this study were the same as those used in our previous report (Tetsumura et al., 1999). One-year-old nursery stocks were planted in January 1991 at an orchard of the Experimental Farm of Kyoto Univ. After thinning in 1993 and 1995, the final tree spacing was 5.2 × 6.5 m; the experimental design was a randomized complete block with four replications, comprised of one tree each. Trees were pruned to an open-center shape; they were cut back to 3.0 - 3.5 m in height in winter. Their growth, i. e., tree height, trunk cross sectional area (TCSA), canopy volume, number of shoots with male and female flowers were recorded as were the yield and fruit quality, such as average fruit weight, number of seeds, astringency and soluble solids from the 8th to the 12th year after planting. Photosynthetic rates in May and August, and leaf area index in October were measured in the 10th year after planting.

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Results and Discussion

The micropropagated (M) trees grew more vigorously than did the grafted (G) trees for 11 years after planting; hence, the M trees were taller and wider than the G trees at the end of the growing season, even though both trees were cut back to the same height in winter (Table 1). The M trees developed more lateral shoots and had a significantly larger canopy volume than had the G trees; the difference in TCSA between the M and G trees was still significant in the 11th year (Table 1). Tree size and age at planting affected the tree growth directly, making it difficult to compare the growth of the M and G trees during the first few years of orchard establishment (Hammerschlag and Scorza, 1991; Tetsumura et al., 1998). However, we avoided this situation because our trees were planted eight years ago before this study was initiated. That the differences in the tree canopy and TCSA between the M and G trees became larger every year were attributed to their difference in tree vigor.

The percentage of shoots with male flowers in the total number of shoots in the M trees was smaller than that in the G trees (Table 1), although the difference was not significant because one of the G trees bore as few male flowers as the M trees. 'Nishimurawase' trees are known to increase the number of male flowers 7–8 years after planting (Kitagawa, 1970); the same phenomenon was observed in the G trees in this study (data not presented). Hayashi et al. (2001) thought that the increment in male flowers with growth of Japanese persimmon tree indicated an accumulation of some substances related to the adult phase, whereas Yonemori et al. (1992) believe that male flower formation of Japanese persimmon tree is affected by several factors. That M trees bore fewer male flowers than G trees did even 11 years after planting indicates that the growth phase of M trees might persist longer than that of G trees. For propagation of monoecious-type Japanese persimmon, the in vitro method might be preferable to the conventional one if they are not pollinizers, because male flowering is antagonistic to female flowering and, thereby, affects fruit production directly (Hayashi et al., 2001).

There was no significant difference between the M and G trees in yield efficiency, but the actual yield per M trees was larger than that of the G trees, chiefly owing to their larger canopy volume (Table 1). As with micropropagated apple trees (Zimmerman and Steffens, 1995), therefore, micropropagated Japanese persimmon trees may not be a good substitute for trees on dwarfing

Table 1. Growth, flowering and fruiting of micropropagated (M) 'Nishimurawase' Japanese persimmon trees compared with that grafted on seedlings (G) from the 8th through the 11th year after planting in the orchard.

Propagation method	Year after planting			
	8	9	10	11
	Tree height (m)			
M	4.00 ± 0.07a[z]	4.60 ± 0.03a	4.49 ± 0.08a	4.10 ± 0.10a
G	3.51 ± 0.13b	4.12 ± 0.17a	3.77 ± 0.18b	3.61 ± 0.20a
	TCSA (cm^2)			
M	139 ± 2a	181 ± 4a	206 ± 6a	225 ± 8a
G	92 ± 8b	115 ± 6b	139 ± 11b	155 ± 12b
	Canopy volume (m^3)			
M	19.2 ± 1.2a	32.7 ± 2.0a	43.9 ± 1.7a	48.0 ± 2.0a
G	13.3 ± 1.2b	23.3 ± 2.3b	26.8 ± 3.3b	33.1 ± 3.7b
	Number of shoots with male flowers per number of total shoots (%)			
M	12.0 ± 2.4a	5.0 ± 3.3a	21.9 ± 1.2a	21.8 ± 2.7a
G	44.9 ± 4.3a	31.1 ± 7.8a	39.7 ± 6.9a	45.3 ± 8.6a
	Number of shoots with female flowers per number of total shoots (%)			
M	9.8 ± 2.7a	46.7 ± 0.9a	31.3 ± 1.1a	25.8 ± 4.9a
G	9.7 ± 14.4a	34.2 ± 16.6a	28.3 ± 8.8a	22.0 ± 17.2a
	Yield (kg/tree)			
M	12.0 ± 2.6a	40.1 ± 1.3a	29.6 ± 2.3a	23.9 ± 1.3a
G	8.9 ± 3.5a	20.8 ± 4.4b	17.1 ± 3.9b	15.0 ± 3.4b
	Yield efficiency (yield/canopy volume, kg/m^3)			
M	0.71 ± 0.19a	1.26 ± 0.07a	0.71 ± 0.03a	0.52 ± 0.03a
G	0.71 ± 0.26a	0.91 ± 0.07a	0.70 ± 0.17a	0.44 ± 0.12a

[z]Mean ± SE. Different letters within columns and measured parameters represent significant differences at $P < 0.05$.

rootstocks. However, the standard errors of the data on growth, flowering and fruiting of the M trees were smaller than those of G trees (Table 1), because the M trees grew, flowered and fruited uniformly. These uniformities may be an advantage when planning to thin non-permanent trees in high-density planting. The cropping efficiency of micropropagated peach trees is more uniform than trees budded on seedling rootstocks (Hammerschlag and Scorza, 1991).

No consistent difference in fruit quality was observed between the M and G trees; likewise, photosynthetic rate and leaf area index in the 10th year after planting were not significantly different.

The results of this study demonstrate that the M trees grew more vigorously even 11 years after being planted. However, it is difficult to explain how the effect of rejuvenation brought by micropropagation on the M trees continued for 11 years, because the M trees bore as many female flowers and fruit as did the G trees. In addition, micropropagated 'Jiro' Japanese persimmon trees bore flowers soon after they were planted outdoors (Tao et al., 1994). Why M trees on their own roots could be so vigorous is difficult to explain because in another study micropropagated trees grew more vigorously than did the trees propagated by cuttings (Tetsumura et al., 2003). In conclusion, possibly, micropropagation caused reinvigoration rather than true rejuvenation of micropropagated Japanese persimmon trees; this reinvigoration persisted for more than 10 years.

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異なる繁殖方法(微細繁殖および接ぎ木繁殖)で得たカキ成木の生長の比較

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摘　要

定植後8~11年目の微細繁殖したカキ'西村早生'樹(培養樹)の生長を，同樹齢の実生台に接ぎ木した樹(接ぎ木樹)と比較調査し，その特性を評価した．培養樹は接ぎ木樹より旺盛な生長を示し，樹容積や幹横断面積の差は広がり続けた．全体の枝数に占める雄花着生枝数の割合に，有意差はなかったものの，培養樹の方が接ぎ木樹より小さかった．一方，雌花着生枝数の割合は同じであった．樹容積あたりの果実生産効率に有意差はなかったが，1樹あたりの果実生産量は培養樹の方が接ぎ木樹より多かった．これらの結果は微細繁殖が真の若返りをもたらすのではなく，再活性化をもたらすことを示唆していた．培養樹は生長，着花および果実生産において均一性を示した．

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