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Original Paper

RESULTS OF PROPAGATION OF THREE CULTIVARS OF JAPANESE QUINCE (*CHAENOMELES JAPONICA*)

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The aim of the trial was to determine the optimal propagation methods for three Japanese quince cultivars. Rooting trials with cultivars 'Darius', 'Rasa', and 'Rondo' were conducted in 2017–2019 in a greenhouse, to investigate the rooting and shoot quality of softwood cuttings, using different treatments. At the beginning of fruit production, growth and amount of the first yield was evaluated depending on propagation method. Softwood cuttings of Japanese quince rooted well (average 82–93%) in a greenhouse with heated substrate and partly automated temperature and moisture control, in spite of different weather conditions during three vegetation periods. The best results for rooting were found for cultivar 'Rondo'. On average, better results of rooting for all cultivars were obtained when cuttings were soaked in indolylbutiric acid solution and trichodermin was added to the substrate. Significant differences in length and diameter of the bush shoots found between years for both propagation methods and also between years for one type of propagation. On average, microproagated plants had the highest shoot length. After evaluating the first yield, no significant differences were found between cultivars during the first two trial years, but micropropagated plants had significantly higher yield per bush.

Keywords: *softwood cuttings, micropropagation, rooting, shoot quality.*

INTRODUCTION

Plants of *Chaenomeles* sp. are known as ornamentals worldwide. However, Japanese quince (*Chaenomeles japonica*) as a fruit crop is well known only in the Baltic countries, Ukraine, Belarus, Scandinavia and Poland. Japanese quince fruits are valuable as raw material for the food industry because of their nutritional value. Breeding of *Chaenomeles japonica* as a fruit crop in Latvia was initiated in the 1950s. The first large plantations of Japanese quince were established in the 1970s, which reached approximately up to 300 ha in the 1980s. All these commercial plantations were established using seedlings, which were very heterogeneous (Ruisa, 1995; Rumpunen, *et al*., 1998; Rumpunen, *et al*., 2000; Tics, 2000). At the Institute of Horticulture (LatHort), breeding of Japanese quince was started in the 1990s with the aim to obtain local cultivars adapted to the Latvian climate. After evaluation at LatHort, three cultivars were selected and registered in Latvia: 'Rasa' selected from Latvian breeding material and 'Darius' and 'Rondo' selected within a common breeding programme with Swedish and Lithuanian scientists (Kaufmane and Ruisa, 2020). Japanese quince is considered to be a significant commercial crop in Latvia (558 ha in 2020). During the last five years, the area of plantations in Latvia has increased four times, showing that cultivation of Japanese quince has become more popular every year. However, the quality of fruits currently available on the market is diverse, since most of the growing areas are still planted using seedling material, which does not guarantee high-quality material for processing.

There are still many unsolved questions when it comes to acquiring homogenous, high-quality seedling material. To provide material, while still maintaining the characteristics of a specific genotype, the issue of cultivar vegetative propagation has to be solved (Rumpunen, 2002). Japanese quince can be propagated with softwood cuttings (Kviklys and Rumpunen, 1996; Kviklys, 1998) as well as with hard-

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wood cuttings, however, the latter method is less efficient (Wells, 1955; Albrecht and Schulze, 1980; Ratomskyte, 1990). Propagation with pieces of roots is possible too, but it is not considered to be cost-effective (Eley, 1970). In accordance with currently available literature, propagation with softwood cuttings is most suitable for Japanese quince, but many factors (genotype, cutting length, microclimate, treatment with growth regulators etc.) (Kauppinen *et al*., 2003) affect the outcome. There is data on micropropagation (Stanys *et al*., 2006), which can provide the market demand for plants, but there is a lack of data about branching of different cultivars, as well as the time of first yield and other parameters following propagation with softwood cuttings.

The aim of this study was: to assess propagation methods of three Japanese quince cultivars and choose the most suitable for each cultivar.

MATERIAL AND METHODS

Two experiments with three cultivars of Japanese quince 'Darius', 'Rasa', 'Rondo' were carried out at the Institute of Horticulture (LatHort) in 2017–2019.

The first trial. Softwood cuttings were rooted in a greenhouse with automatically regulated temperature on the floor and artificial air humidification. The greenhouse was shaded with a net to provide 50% light transmission. Substrate consisting of 25 l perlite added to 250 l neutralised and enriched peat (KKS-1) was used for planting and rooting of cuttings. Substrate was filled in cassettes and a 0.5–1 cm perlite layer was sifted on the surface. Substrate consisting of five parts of neutralised and enriched peat (KKS-1), mixed with two parts of gravel was used for potting and further growing of softwood cuttings. Softwood cuttings were prepared from shoots of Japanese quince collected from plants in the field during a period of intensive growth in the second decade of June. The shoots were kept wet in a cool room to maintain turgor. Softwood cuttings were cut approximately 20–22 cm in length with a slope cut on the lower part below a bud and a straight cut on the upper part of the plant. According to previous studies, the size of the cutting is also important. Larger cuttings (above 20 cm) root rapidly, produce more roots, and show better winter survival (Kviklys, 1998; Kauppinen *et al*., 2003). All leaves were removed from the lower part of cuttings (4–5 cm). Cuttings were soaked for 18 hours in a growth regulator consisting of 30 ppm indolebutyric acid (IBA). IBA was chosen due to its positive effect on rooting both in previous studies done with Japanese quince (Kviklys, 1998) and other, related fruit plant species (Hansen, 1990; Ozkan, *et al*., 2005; Zhang, 2019). To obtain a sufficient number of rooted plants for further measurements, 48 cuttings (16 cuttings in three replications) for each treatment were prepared and inserted into the cassettes with substrate. The cassettes were placed on a heated floor (temperature +28 °C) in a greenhouse, with added artificial mist to create an environment with 97% humidity. Fertiliser was added four weeks later. Cuttings were repotted in bigger pots when roots of cuttings filled the nests of cassettes (in the middle of August). Cuttings had fertiliser added every two weeks. Young plants were prepared for wintering in autumn. Four treatments of cuttings vere selected: K (control) – cuttings were soaked in 30 mg/l IBA (indolebutyric acid); IS + Tr – cuttings were soaked in 30 mg/l IBA, then inserted in substrate with trichodermin (biological fertiliser containing microscopic fungus (*Trichoderma harzianum* and *Trichoderma viride*); K+Vi and IS + Tr + Vi – fertiliser "Vito" (Vi) (20 ml/10 l water) was sprayed on leaves of half of the cuttings. Rooting quantity in % and quality of softwood cuttings was evaluated 5–6 weeks after inserting in pots. Number and length of shoots (cuttings), diameter of shoots (at the base), and branching for ten plants from each cultivar for all four cutting treatments (in total) were determined in autumn at the end of vegetation, when plants were preparing for dormancy.

The second trial. To assess the effect of propagation method (softwood cuttings or micropropagation) on growth of shoots, the length, diameter, time of beginning of harvest, yield during the first two years and average and maximum weight of fruit were measured in a field trial planted in 2016 at LatHort, Dobele. Rooted softwood cuttings were obtained from the LatHort nursery, and micropropagated plants were obtained from the Joint Stock Company "*Latvijas Valsts meži*" nursery in Kalsnava from which also data on rooting *in vitro* of all studied **cultivars** were obtained. Planting material was of equivalent quality in both cases. The experimental field was situated in the southern part of Latvia, latitude 56° 36.633` and longitude 23°17.888`. The soils in the orchards were neutral or slightly alkaline (pH 6.7–7.4) sandy loam. Planting distance was 4 × 0.9 m. Average length and diameter of currant growth shoots (five per shrub) were measured in the years 2017, 2018, and 2019. Harvest and fruit data were analysed from year 2018 and later, as in 2017 there were no fruit, except for a few from some shrubs. In the study period metheorological conditions were rather variable. During the vegetation period of 2017 and 2019, a higher amount of precipitation was observed than in 2018, which stood out with a long dry period from the second decade of April until the second decade of September and with comparatively high temperatures, especially at the time of flowering, fruit growth and ripening (Fig. 1).

RESULTS

Rooting of softwood cuttings. Regarding rooting data, despite different weather conditions over the three vegetation periods, softwood cuttings of all three studied quince cultivars rooted well in the experimental conditions, on average 82–93% (Fig. 2). The best results in a three-year average were observed for 'Rondo' (83.3–97.9%); the other two cultivars, 'Darius' and 'Rasa', successfully rooted in 66.3–95.8% and 64.5–93.8% of cases, respectively. There were no statistical significant difference between cultivars. The best results for propagation treatment were achieved

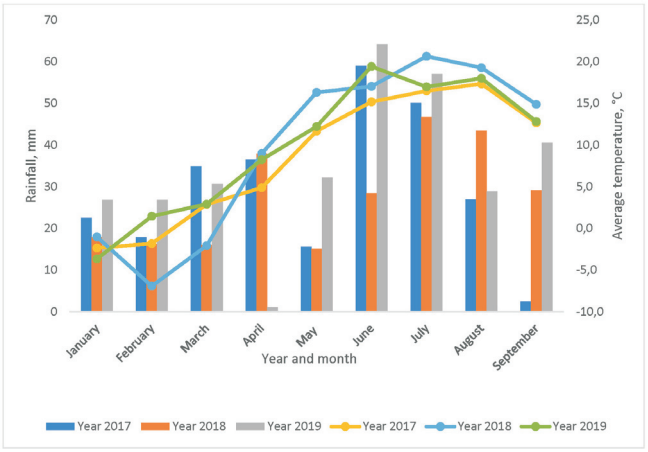


Fig. 1. Amount of rainfall (mm) and average temperature (°C) in 2017–2019.

by dipping cuttings in an IBA solution and then planting in a substrate with added trichodermin (average 89.8%; max. 97.9%), as well as when cuttings had both trichodermin and plant fertiliser "Vito" added to the substrate (avg. 88.6%; max. 95.9%).

Diameter and length of the rooted cuttings. Regardless of treatment or cultivar, every year branching of cuttings was observed only in 0.1% of cases. On the other hand, the diameter and length of the shoots differed each year, and depended on cultivar and treatment. The longest shoots were observed for 'Rasa' (13.4 cm), but no significant differences were found between cultivars. 'Rondo' had an average shoot length of 13.0 cm, 'Darius' – 11.2 cm. The best results of all treatments were achieved for cuttings soaked in IBA (average length 13.3 cm; max. 20.8 cm). However, significant differences between treatments were not found ($p > 0.05$) (Fig. 3).

The largest shoot diameter during the study years was observed for 'Rondo': 2.6 mm, but no significant differences were found between 'Rondo' and 'Rasa' (2.5 mm) and 'Darius' (2.4 mm). No significant differences in shoot diameter ($p > 0.05$) were found for all cultivars depending on propagation treatment. Slightly better results (average diameter 2.7 mm; max. 3.3 mm) were recorded in the control treatment (softwood cuttings soaked in IBA without additional fertiliser being added).

Effect of propagation method on growth in the field. Bushes were two-years-old at the start of the study. No statistically significant ($p > 0.05$) differences were observed between propagation methods or cultivars for a single year. However, statistically significant differences were recorded between years and between propagation methods, as well as when comparing data between cuttings propagated in the same way.

'Rasa' had the longest shoots when calculated as a three-year average shoot length (22.9 cm), but the length was not significantly higher than for 'Rondo' (20.7 cm) or 'Darius' (17.6 cm). Micropropagation yielded the best results in terms of shoot length for all cultivars, but the differences were not statistically significant ($p > 0.05$).

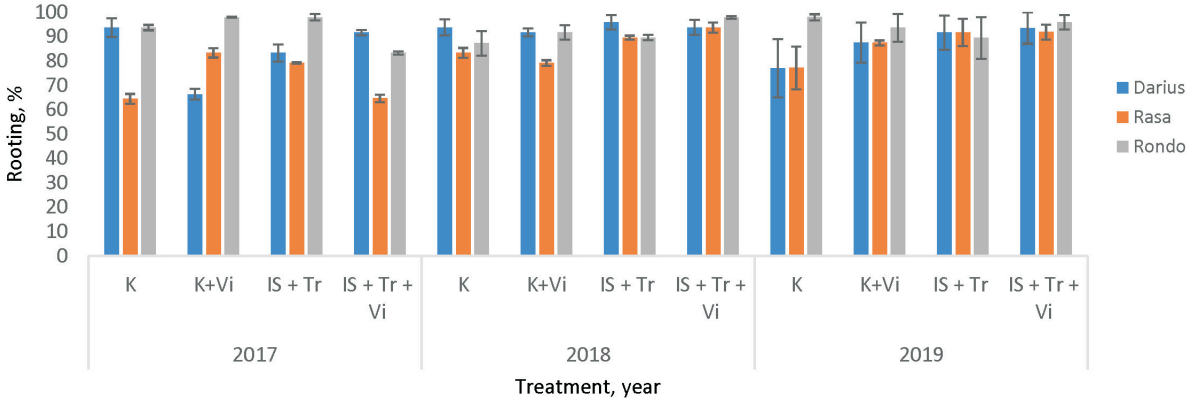


Fig. 2. Rooting of the cultivars 'Darius', 'Rasa', and 'Rondo' using different treatments, in 2017–2019. **K** (control) — cuttings soaked in 30 mg/l IBA (indolebutyric acid); **IS + Tr** — cuttings soaked in 30 mg/l IBA, then inserted in substrate with trichodermin; **K+Vi** and **IS + Tr + Vi** – Fertiliser "Vito" (Vi) (20 ml/10 L water) — sprayed on leaves of half of the cuttings.

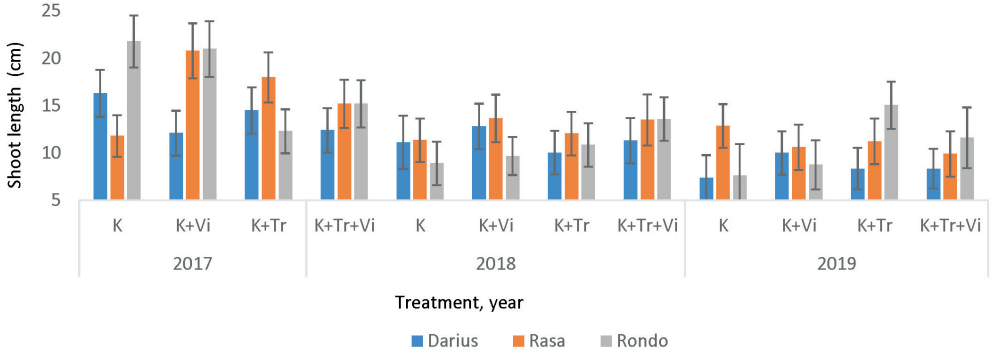


Fig. 3. Average shoot length (in cm) of the cultivars 'Darius', 'Rasa', and 'Rondo' using different treatments, in 2017–2019. **K** (control) — cuttings soaked in 30 mg/l IBA (indolebutyric acid); **IS + Tr** — cuttings soaked in 30 mg/l IBA, then inserted in substrate with trichodermin; **K+Vi** and **IS + Tr + Vi** — Fertiliser "Vito" (Vi) (20 ml/10 l water) — sprayed on leaves of half of the cuttings.

'Rasa' also had the largest shoot diameter in the three-year period (4.6), which was significantly larger than those of 'Darius' (3.7 mm) and 'Rondo' (3.6 mm). The best results in terms of average shoot diameter were achieved for softwood cuttings, but the differences were not significant ($p > 0.05$).

Effect of propagation method on yield and fruit weight. To compare the parameters of plants propagated *in vitro* and with softwood cuttings, for two years the yield per shrub was evaluated, as well as the average and maximum weight of fruit recorded from 20 randomly selected plants per treatment. Overall (among all measured plants, irrespective of the cultivar), after the second year, micropropagated plants had the highest yield per bush (793–922 g/bush). Plants propagated by softwood cuttings had a yield of 289–582 g fruit per bush.

'Darius' and 'Rasa' had the highest yield in the first year: 'Darius' – 922 g/bush for microprogated plants and 852 g/bush for softwood cuttings; 'Rasa' – 2441 g/bush and a maximum of 4214 g/bush when micropropagated. 'Rondo' bushes grown from softwood cuttings had an average yield of 1072 g/bush and a maximum of 1474 g/bush in the second year (Fig. 4). No significant differences ($p > 0.05$) among cultivars were found for the first yield of plants propagated by softwood cuttings and micropropagated plants during the first two years. However, bushes grown from micropropagated plants had a significantly ($p < 0.05$) higher yield per bush.

DISCUSSION

The results show that all studied cultivars root well when propagated with softwood cuttings (up to 97%), which is in accordance to previous studies done in different areas with different genotypes (Kviklys, 1998; Mezensky, 2004). Overall, no significant differences were found ($p < 0.05$) between cultivars nor between treatments, but, when comparing years and cultivars separately, differences did appear. For example, no significant differences were found between treatments for 'Darius' between 2018 and 2019, however, in 2017 in the control treatment (IBA) and treatment with added fertiliser there was a significantly ($p < 0.05$) lower rate of rooting (66.3 %). 'Rasa' yielded significantly better results with trichodermin and fertiliser treatments in 2018 and 2019, but in 2017, the control treatment (IBA) and trichodermin + fertiliser treatment had significantly lower rooting rates, 64.5% and 64.6% respectively. May 2017 was extremely dry with low temperatures, while in June the amount of precipitation increased sharply, which may have negatively affected the quality of cuttings. Therefore, in that year the rooting for these two cultivars was lower in some treatments. This proves that the result depend on multiple factors, including genotype and microclimate, which change between years and depend on substrate and other environmental factors (Kauppinen, *et al.*, 2003).

Overall, significant differences in growth traits such as cutting length and diameter between cultivars and treatments were not obtained, but when evaluating data each year separately, significant differences were found. 'Darius' shoots in 2019 had significantly shorter shoots in all treatments, except for the control with added fertiliser ($p < 0.05$). Similarly, shoot length 'Rondo's was significantly different ($p < 0.05$) between years — significantly higher in 2017 than in other years. That could be explained by different weather conditions during the study period of three years.

By autumn, one dominant shoot grew for all cultivars propagated via softwood cuttings and branching was observed only in 0.1% of cases in all years independent of treatment or cultivar. This is in contradiction with existing literature, though it must be noted that often different concentrations of IBA and substrates are used, and thus the cuttings usually grow one or two dominant shoots, on rarer occasions three (Kviklys, 1998; Kauppinen *et al.*, 2003; Mezensky, 2004).

When evaluating the shoot quality in field conditions, 'Rasa' and 'Rondo' had the biggest new shoot diameter and fastest growth in the first years. This makes sense, as the two cultivars are known to grow strongly, in contrast to 'Darius' (Kaufmane and Ruisa, 2020).

In the first year of harvest, the average yield per bush of the studied cultivars varied from 289 to 922 grams per bush, however in the second year the yield varied from 498 to

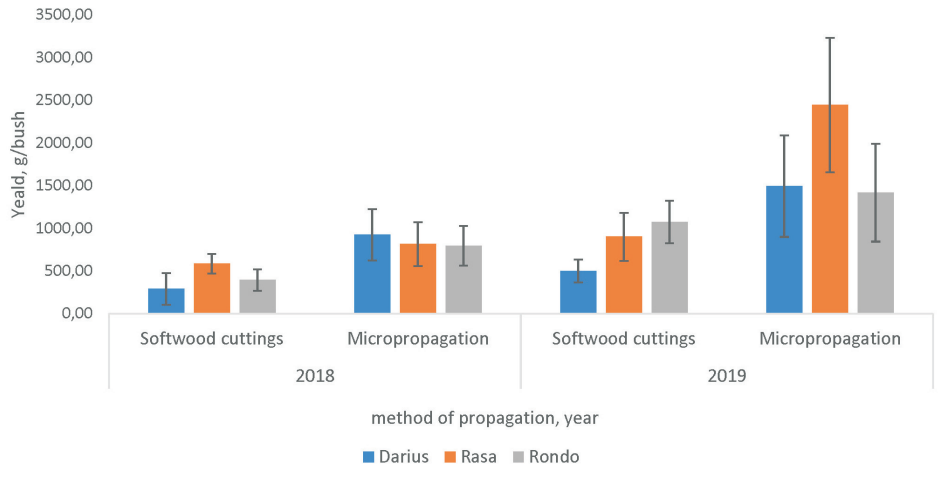


Fig. 4. Average yields per bush (g) in 2018–2019 using two different methods of propagation (by softwood cuttings and micropropagation).

2441 grams per bush. This is considered a good harvest for Japanese quince in Latvia, according to study of a wider set of genotypes at LatHort (Ruisa and Rubauskis, 2005).

No significant differences were found when assessing the average mass of fruit, which varied depending on cultivar, year and treatment, from 31.2 g to 55.2 g. The cultivar 'Rasa' had the largest fruits regardless of propagation method — average weight 55.2 g, maximum 104.1 g in the two-year period, which coincided with previous studies (Kaufmane and Ruisa, 2020).

Considering all growth data and data of the first harvests of all three tested cultivars, recommendation of one propagation method as better than another is not possible. All cultivars can be propagated well both by soft wood cuttings and by micropropagation, and yield of the first harvests did not differ significantly. Micropropagation can be advocated to obtain a greater number of plants from a small amount of start material; in this case a big plantation of stock plants would not be required (Kauppinen, *et al.,* 2003; Stanys, *et al*., 2006).

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KRŪMCIDONIJU (*CHAENOMELES JAPONICA*) TRĪS ŠĶIRŅU PAVAIROŠANAS REZULTĀTI

Pētījuma mērķis bija apkopot datus par iespējamām krūmcidoniju trīs šķirņu pavairošanas metodēm un izvēlēties katrai no tām piemērotāko. 2017.–2019. gadā tika pētīta šķirņu 'Darius', 'Rasa' un 'Rondo' lapaino spraudeņu apsakņošanās plēves siltumnīcā, novērtējot to apsakņošanos un dzinumu kvalitāti pie dažādiem apstrādes veidiem. Sākoties ražai, uz lauka izvērtēti ar divām dažādām metodēm (ar lapainajiem spraudeņiem un *in vitro)* pavairotu šo šķirņu stādu veģetatīvie parametri, ražošanas sākums un pirmo ražu apjomi. Visu šķirņu krūmcidoniju spraudeņi apsakņojās labi (vidēji 82–93%) plastmasas seguma siltumnīcā ar apsildāmu substrātu un daļēji automatizētu temperatūras un mitruma kontroli, neraugoties uz atšķirīgiem laika apstākļiem trīs veģetācijas periodos. Vislabākie apsakņošanās rezultāti konstatēti šķirnei 'Rondo'. Kopumā šķirnēm labāka apsakņošanās konstatēta variantā, kur spraudeņi mērcēti indomertilsviestskābes šķīdumā un substrātam pievienits trihodermīns. Visu šķirņu spraudeņiem bija viens dzinums, zarošanās tika novērota tikai 0,1% gadījumu. 'Rasai' konstatēti visgarākie dzinuma garumi, 'Rondo'— visresnākie dzinumi vidēji pa trim izmēģinājuma gadiem. Lauka izmēģinājumos, salīdzinot krūmu dzinumu garumu un diametru, tika konstatēta būtiska atšķirība starp gadiem abiem pavairošanas veidiem, kā arī starp gadiem vienas pavairošanas metodes ietvaros. Kopumā *in vitro* pavairotajiem augiem konstatēti garāki dzinumi. Vērtējot pirmo gadu ražas, būtiskas atšķirības starp šķirnēm divu gadu laikā netika konstatētas. Taču, augiem, kas pavairoti *in vitro*, bija būtiski augstāka raža no krūma.