Quince (Cydonia oblonga Mill.)

Michel Duron, Luc Decourtye, Philippe Druart

I.4 Quince (*Cydonia oblonga* Mill.)

M. DURON, L. DECOURTYE[1], and Ph. DRUART[2]

1 Introduction

1.1 Importance of the Plant

Quince (*Cydonia oblonga* Mill.) belongs to the Rosaceae family and is the only species in the genus. It derives its generic name from Cydon, the modern Canea, near which the tree grew in great abundance (Evreinoff 1948). It is a deciduous unarmed shrub or small tree, which usually attains a height of less than 15 feet (Fig. 1). Differing from other pip fruits, blooming is terminal and solitary at the extremity of current-season growth. Leaves are densely pubescent below, dull green above. Fruits have a woolly appearance and are fragrant near maturity. Each ovary contains five compartments, each of them with numerous ovules, which produce seeds with a sticky jelly. Trees are partly self-pollinated, but fruit setting and seed number per fruit are increased by cross-pollination. According to fruit shape, different types are usually distinguished:

C. o. pyriformis (Kirchn.) Rehd. var., which is the typical form, pear-shaped, without ribs.
C. o. maliformis (Mill.) Schneid. var., with roundish fruit, is more like an apple.
C. o. lusitanica (Mill.) Schneid. var., which is also pear-shaped, but obviously ribbed.

Flesh is firm, yellow, weakly juicy and of low palatability for eating raw. The uses of the quince fruit are limited mostly to the making of jelly, marmalades and preservee, or for adding flavour to apples and pears when stewed or baked. Besides its limited production for fruiting, quince is widely used as a pear rootstock for its dwarfing effect. Quince roots produce a tree 30% to 60% of size on *Pyrus* seedlings, and, in most conditions, hasten the time of fruiting. Most of European pear orchards and some American ones, are grown on quince. Although this graft compatibility between two different genera is still quite uncommon, quince can also be used for other fruit or ornamental genera like *Mespilus, Sorbus, Amelanchier, Eryobothrium, Crataegus, Raphiolepis* etc.

This wide flexibility for other genus relationships has also to be compared with the rare phenomenon of graft hybrids, obtained at the beginning of the 20th

[1] I.N.R.A. Fruit Breeding Station, Beaucouzé, 49000 Angers, France
[2] Agronomy Research Centre, Research Station, 234 Chaussée de Charleroi, 5800 Gembloux, Belgium

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Fig. 1. Six-year-old quince cv. Portugal at the INRA's Fruit Breeding Station in Angers (1976)

century, +*Pyrocydonia* Danieli (Winkl.) Rehd., and +*Pyrocydonia* Winkleri (Daniel) Rehd. Sexual hybrids with pears, *Pyronia* have also been obtained at different times: *P. veitchii* (Trabut) Guillaumin, originated before 1913, and has since been obtained in England and the Soviet Union (Rudenko 1978). Sexual hybrids with apple (*Malus pumila*) have also been reported.

Much selection work has been carried out in Europe in this century, starting in England near 1930, to a lesser extent in Germany, Poland, Belgium, and, more recently (1950–1980), in France (Brossier 1965).

1.2 Distribution and Area Under Cultivation

The quince is a native of Western Asia, from Iran (Persia) to Turkestan. Its use seems to be very old, starting from Persia some 4000 years B.C. and spreading with the prosperous civilisations of that time all over the Mediterranean basin to the west, and to Afghanistan to the east.

Nowadays, quince fruit production is prevalent in the Balkans, Turkey, Hungary, Italy, France, Spain, Morocco, but mainly in Iran, Caucase, Turkestan

and Afghanistan (Evreinoff 1948). It is mostly grown as an isolated tree, in home gardens or associated with other crops, though occasional small commercial orchards can be found. Due to this situation, the total amount of production is quite uncertain and not tabled in annual FAO production yearbooks. Yield ranges from 15 to 30 t/ha. In North America, quince plantations started only in the 18th century and are restricted to the eastern states, where the tree number evaluated in 1965 was 30000, steadily decreasing (Childers 1976). In South America, quince production is important in Argentina with an annual production of 20000 t.

1.3 Diseases

Compared with other fruit trees, quince is not strongly affected by diseases, although it can occasionally be damaged by nearly all the insects or diseases which attack apple and pear. The most severe is fire blight contamination by bacteria *Erwinia amylovora*, in any area where the bacteria is present. Spray control, even in countries where antibiotic uses are possible, is not fully efficient. Cultural practices, like low nitrogen application and little pruning, are helpful to reduce the development of the most susceptible vigorous shoots (Childers 1976).

Among the fungal diseases, *Monilia (Sclerotinia cydoniae)* can be difficult to control under wet weather, contaminating the flower, dry-rotting the young fruit and killing the shoot. Other fungi, like scab (*Venturia inaequalis*) or *entomosporiosis (Entomosporium maculatum)* can arise, but should be easy to control by adequate spraying.

Among insects, borers can be a serious pest, and have to be dug out as in the case of apple or pear trees. Codling moth (*Cydia pomonella*) and oriental fruit moth (*Grapholita molesta*) have also to be controlled by adequate sprays. In North America, two arthropods (*Quadrapidistus pernicissus* and *Dacus ryoni*) are considered as the most serious pests after fire blight.

Several viruses, like vein yellow, mosaic and rubbery wood can infect quince, with clonal differences indicating the severity of symptoms (Lemoine 1977). Viruses are also responsible for graft incompatibility, especially when they combine with other viruses of the scion. All quince rootstocks are presently available virus-free.

1.4 Conventional Practices

1.4.1 Culture

The quince has no special needs and will grow on a wide range of soil types, although a well-drained clay loam, fairly fertile, and moderately retentive of moisture, is preferred. Better adaptation to wet soil will be achieved by using Angers type rootstock, while Provence type would be more suitable for a dry situation with high pH. Quince is moderately resistant to frost, to about the same degree as peach, and can tolerate some drought.

In spite of the long time that quince has been under cultivation, a limited number of varieties are described. Evreinoff (1948) reports description for 11 of them: Beretzki, Géant de Leskowatz, Monstrueux de Vrania, Champion, Du Portugal, De Symrne, De Constantinople, Gros de Provence, Meech's Prolific, Fuller, Van Deman. From a comparative trial planted in 1964, in different parts of France, between cultivars Champion, Geant de Vranja, Bourgeault, Portugal and the rootstock C.185, Michelesi et al. (1973) concluded for a better yield of Champion, followed by Geant de Vranja and Bourgeault. In North America, cv. Orange is outstanding for its earliness, quality and colour, followed by Champion, Fuller, Meech and Smyrna.

1.4.2 Pruning

Because of the growth habit, which is rather slow, crooked and angular, comparatively little pruning is needed. Pruning should largely consist in thinning out cuts, with occasional cutting back of main limbs to stimulate moderate shoot growth upon which the fruits are borne.

1.4.3 Quince as Pear Rootstock

Besides fruit production, use as a rootstock for pear trees gives its main importance to this species. Brossier (1965) reports that its use as a rootstock was first mentioned at the beginning of 14th century, in a document which advises against its use. It became more popular soon after, with the development of a new training system, against walls with wires, starting from Italy and spreading over Europe.

With a pear orchard area of nearly 135000 ha planted with 1450 trees per ha, some 200 mil quince rootstocks can be expected for Europe alone. They are mainly produced in Italy, France, Spain, The Netherlands (3.6 million plants were produced in France in 1980).

At the beginning of the 20th century, three different populations of quince rootstock were commonly available in nurseries: the Angers, the Fontenay, and the more recently used Provence quinces.

1.4.4 Improvement

A first classification of these populations occurs with the work of Hatton from East Malling in 1920's, in seven groups, named from A to G. Two of these selections have been commercially propagated, Quince A, which appears to be a good Angers quince and is still commonly used, and to a smaller extent, the more dwarfing Quince C.

In 1955, Brossier, in the Angers Fruit Research Station, undertook a wide search among wild quince, mainly in the south of France among the Provence population, which allowed the selection of an improved Provence quince, the BA 29 clone. This rootstock is slightly less dwarfing than Quince A, it is less suscepti-

ble to chlorosis and viruses, and has a better graft compatibility with most pear varieties. Later, a new selection of Angers quince, Sydo, was released slightly more dwarfing than Quince A (−10%) but better yielding (+18%) in a wider range of situations. It appears also more tolerant to contamination by different viruses like vein yellow, mosaic and rubbery wood (Lemoine and Michelesi 1984). Other selections, mainly for a better frost resistance, have been made in Germany (Pillnitz quince) and Poland, but they do not seem to be in commercial use.

In spite to these breeding works and of the significant improvements obtained, graft incompatibility problems remain with some varieties, which need either to use an interstock fully compatible with quince, or to favour scion-rooting by deep plantation, or to look for new dwarfing rootstocks within the genus *Pyrus*.

1.4.5 Propagation

Quince varieties are budded on Angers or Provence quince as an understock, as are pear varieties. For rootstocks, hardwood cuttings can work with some of them, but with inconsistent results. Softwood cuttings give good results, but this needs skill and expensive facilities. In practice, rootstocks are propagated by mound layering. Rooted cuttings are cut down to force shoot growth below the cut, then mounded to allow self-rooting during the vegetative growth season. In the autumn, rooted shoots are cut off the mother plant and used as a rootstock in the nursery, to be budded the following summer.

It takes a long time to establish a stool-bed before it reaches its maximum yield. For this reason, it has to be run for many years. Stool-beds also need special qualities for soil, a fertile loam soil well supplied with organic matter and a high moisture-holding capacity, so that most of the main zones of production are located in a small number of areas.

1.5 Need to Incorporate Unconventional Methods

Although the removal of rooted shoots from the parent stem is now mechanized and has noticeably reduced labour costs, rootstock production by layering remains a long and costly job. Moreover, this technique does not meet the needs of the market within a short period: several years are necessary to produce rootstocks from a new stool-bed. Conversely, stool-beds have to be worked every year, whatever the demand of the market. The same slow process is prevalent when releasing a new selection.

From the point of view of commercial propagation, true to type in vitro methods should be able to offer a quicker method to remain close to the market needs. Of course, they should also be able to compete with the cost of the conventional method. Over a longer term, in vitro culture might be a new tool for rootstock breeding, either through mutation work or interspecific hybridizations.

2 In Vitro Approaches

Quince is mainly used as pear rootstock, and can be propagated easily by traditional horticultural methods. In some cases, symptoms of more or less harmful graft incompatibility appear related with the genotype of the pear variety and the soil conditions. So, research is being done in the genus *Pyrus* to try to find plants suitable to be used as rootstock, conferring an appropriate vigour to the scion and at the same time eliminating the problem of graft incompatibility. These are the main reasons why so few publications deal with in vitro culture of quince, although it is not very difficult, as we will see below. The situation is quite different with other important fruit trees species such as apple, plum, etc. for which a lot of work has been carried out through in vitro techniques (see Bajaj 1986).

The work so far done on in vitro culture of quince was mainly with the aim of plant propagation. In only one publication (Moore 1984) did the author try to elucidate the problem of graft incompatibility by tissue culture, associating callus of quince and pear.

2.1 Summary of the Work so Far Done

All the work done on in vitro culture of quince may not have been published. We recently learned briefly that quince is propagated in Switzerland (Collet 1985), the work we know of is summarized in Table 1.

Table 1. In vitro culture of quince (*Cydonia oblonga* Mill.)

Cultivar	Explant source	Multiplication	Callus	Reference
A	Meristem	X	–	Druart et al. (unpubl.)
C	Meristem	X	–	Druart et al. (unpubl.)
BA 29	Meristem	X	–	Nemeth (1979)
Provence	Shoot tip	X	–	Al Maarri et al. (1986)
BA 29	Shoot tip	X	–	Duron (unpubl.)
Van Deman	Stem segments	–	X	Moore (1984)

– no reference.

2.2 Sterilization of the Explants

Two kinds of explants were used to initiate the cultures for plant propagation: meristems and shoot tips. Meristems are picked from hardy twigs which can withstand a more aggressive sterilization process than shoot tips. Buds are surface-sterilized by immersing in a 9% calcium hypochlorite solution followed by three rinses in sterile water. Then the meristems were picked up without apparent problems of contamination.

The shoot tips were the terminal part of actively growing shoots of plants cultivated in the greenhouse. They were sterilized following the two-step method

published by Jones et al. (1977). The sterilizing was performed with a solution of sodium hypochlorite (0.14% w/v available Cl during the first, and 0.42% w/v available Cl for the second sterilization), and the method proved to be efficient (Duron unpubl.)

No more problems were mentioned using shoot tips sterilized by dipping in 95% ethanol for 30 s, then immersed for 20 min in 10% Domestos (a commercial preparation of sodium hypochlorite) followed by three washes in sterile water (Al Maarri et al. 1986).

With the aim to obtain callus, Moore (1984) sterilized actively growing stems in 70% ethanol for 2 min, washed in 10% sodium hypochlorite and then rinsed three times in sterile water for 20 min.

2.3 Media Composition

The composition of the culture media differs mainly according to the objective of the culture. The minerals are those of Murashige and Skoog (1962) solution or variations from this basal solution. The main difference is the composition in growth substances related to the aim of the culture. When one wants to obtain the development of the explant (meristem or shoot tip) into a rosette or a shoot, the ratio cytokinin/auxin ranges from 5 to 1000, depending on the author (see Table 2) and kind of auxin used. To induce an undifferentiated stage the ratio is quite different, callus formation occurs on MS medium supplemented with 1:1 cytokinin/auxin ratio (Moore 1984).

The media vary during further stages of the culture mainly with regard to the growth substances. BAP is used to initiate axillary branching, while IBA or NAA are the more efficient auxins to induce rooting of the microcuttings.

2.4 Meristem and Shoot Tip Culture

2.4.1 Meristem Culture

Nemeth (1979) and Druart (unpubl.) started their culture with meristem explants. Their size was 0.1 mm for Druart (meristem without or with one leaf primordium) and 0.1–0.5 mm for Nemeth. The meristems were picked up from twigs developed during the preceding growing season. They were harvested in August for Quince A and in October for Quince C. The evolution of the explants into the rosette stage was 70% for Quince A (Druart unpubl.).

Three different media were tested with Quince C, all of them variations from the basal medium described in Table 2 (= A medium). B medium has vitamin E (0.5 mg/l) in place of 2,4-D and C medium is similar to B but deprived of GA_3. Table 3 summarizes the development of the explants of the different media after 1 and 2 months of culture.

It appears that it is necessary to leave the explants on the first medium for at least 2 months to obtain better development of the meristems. Although some of them died, the majority evolved into a rosette. It seems that GA_3 has a beneficial

Table 2. Meristem, shoot tip and stem segments culture media

Explants	Meristems		Shoot tips			Stem segments
Reference	Druart (1980)	Nemeth (1979)	Al Maarri et al. (1986)	Duron		Moore (1984)
Macronutrients	MS/2	Walkey's medium	Lepoivre (1978)	MS		MS
Micronutrients	Nitsch		Lepoivre (1978)[a]	MS		MS
Vitamins (mg/l)	Jacquiot (Gautheret 1959)	Boxus and Quoirin (1974)				
Myoinositol			100	100		MS
Thiamine, HCl			0.4	0.4		
Growth regulators (mg/l)						
Kin	–	Boxus and Quoirin (1974)	–	–		0.2
BAP	1		0.5	1		
GA_3	0.1		0.2	0.5		–
IBA	–		0.1	0.1		–
2,4-D	0.001		–	–		0.25
Sucrose (g/l)	20	30	30	30		30
Agar (g/l)	6	6	6	7		NS
pH	5.8	NS	5.5–5.7	5.7		NS

NS = not specified.
[a] Fe added in Al Maarri's media as Fe Na EDTA = 20 mg/l.

Table 3. Development of the meristems according to the media after 1 or 2 months

Time (month)	Media	Rosette	Necrosis	Total
1	A	9	0	19
	B	7	0	17
	C	5	1	19
2	A	16	3	19
	B	14	3	19
	C	12	6	19

effect on the survival and evolution of the explants. The effects of 2,4-D and vitamin E are not significantly different. It must be noted that about half of the rosettes exhibited vitrification symptoms.

2.4.2 Shoot Tip Culture

Shoots tips were taken from small shoots (5–10 cm) arising from buds just grafted a few months ago (Duron unpubl.) or from shoots arising from the roots of grafted pot plants of Passe-Crassane (Al Maarri et al. 1986). In this case shoot tips developed more easily than if they were collected on trees in the orchard even in the fast growing season. Almost all of them burst and elongate after 2 months in culture. Shoot tips seem to be very convenient to establish the culture when the mother plant is virus-free and when we are able to suppress any exogenous contamination.

The rosettes or the small shoots are then involved in the further steps of the plant production process.

2.5 Multiplication Phase

The multiplication media (Table 4) differ slightly from the initiation media. Druart used half-strength macroelement solution and discarded 2,4-D. Al Maarri et al. (1986) tried the influence of BAP concentration on shoot proliferation and shoot elongation; 4 mg/l is optimal for shoot proliferation but at this concentration shoot elongation was very poor.

Under our conditions, a monthly multiplication rate of 4–5 is obtained with 1 mg/l of BAP, 0.1–0.5 mg/l of GA_3 and IBA (0.1 mg/l) which is beneficial for the shoot quality (Fig. 2).

2.6 Rooting

In vitro rooting is very often a critical phase in the in vitro woody plant propagation process (Nemeth 1986), however, it does not seem to be very difficult with quince, as Nemeth (1979) obtained rooted shoots on the multiplication medium.

Table 4. Multiplication media

	Druart	Nemeth (1979)	Al Maarri et al. (1986)	Duron
Macronutrients	Lepoivre $\frac{1}{2}$	Dudits et al. (1975)	Lepoivre	MS
Micronutrients	Lepoivre[a] $\frac{1}{2}$	Dudits et al. (1975)	Lepoivre	Lepoivre
Vitamins and amino acids (mg/l)				
Myoinositol	100	100	100	100
Pantothenate Ca	–	0.25	–	–
Nicotinic acid	–	5	–	–
Thiamine, HCl	0.4	10	0.4	0.4
Pyridoxine, HCl	–	1	–	–
Glycine	–	10	–	–
Growth regulators (mg/l)				
BAP	1	1.12	2	1
GA_3	0.1	–	0.5	0.5
IBA	–	–	0.1	0.1
Adenine	–	40	–	–
Sucrose (g/l)	20	30	30	30
Agar (g/l)	6	7	6	6
pH	5.5	5.0	5.5–5.7	5.5–5.7

[a] Fe as Fe Na EDTA: 10^{-1} mM.

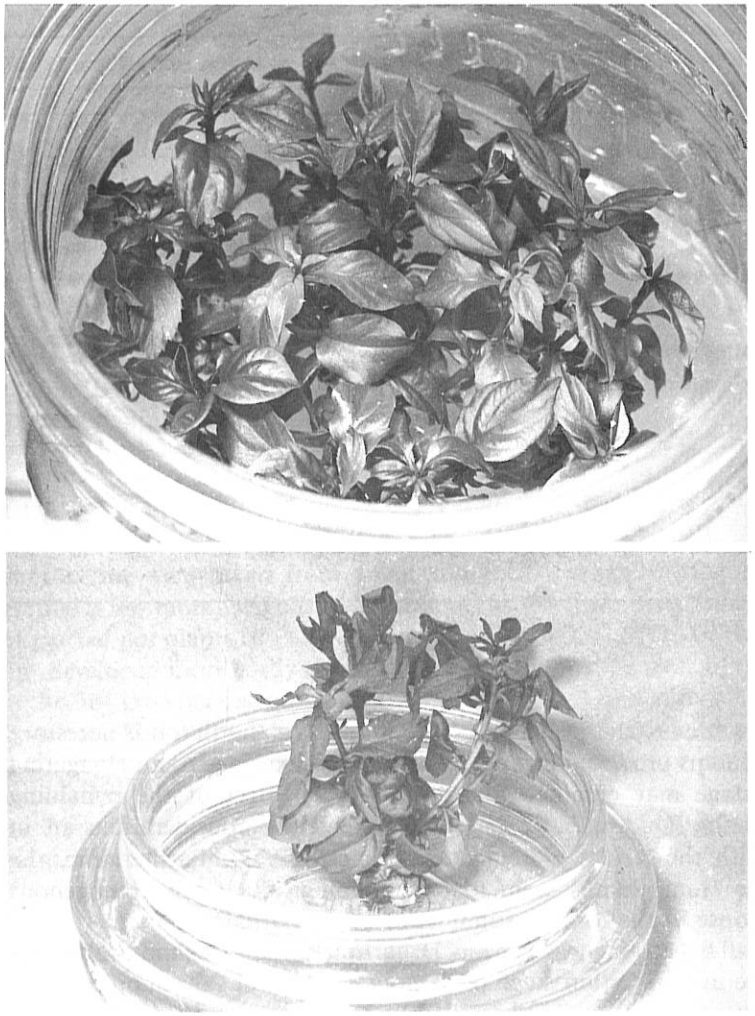
Some authors (Boxus and Debergh, pers. commun.) claim that it is necessary to transfer the clumps produced during the multiplication stage to an elongating medium. This stage may eliminate the unfavourable effect of the remaining cytokinin on rooting (Quoirin et al. 1977). However, these considerations are in contradiction with the results presented by Nemeth (1979). Furthermore, the elongated shoots from clumps seem to be physiologically more homogenous against the response to the rooting stimulus of auxin (Druart 1980).

Thus before all his rooting experiments Druart picked up the clumps obtained at the end of the multiplication stage on Lepoivre's mineral salts supplemented with the vitamins of Jacquiot (Gautheret 1959), 2% sucrose and 1 mg/l GA_3. 20 to 30 days later, shoots at least 2 cm high can be taken for rooting experiments.

2.6.1 Effect of Light

Contradictory results have been presented with other fruit tree species on the influence of a dark period during the first days of root induction. The stay in darkness ranges from 4 to 12 days according to the authors. An increased percentage of rooting was obtained with Quince A on the medium described (Table 5) in relation with the length of the dark period from 20% (for the control) to 79% after 12 days in darkness.

The influence of light intensity on rooting percentage of quince cv. BA 29 has been tried by Nemeth (1979). A significant decrease in rooted shoots was observed when the light intensity was reduced from 2000 lx (32% of rooted shoots) to



a

b

Fig. 2. Quince 4 week old on multiplication medium (the explant of the subculture was a piece of stem already in culture) **a.** General aspect of the multiplication vial. **b.** Multiplication from one explant

800 lx (4.8% of rooted shoots). These results of rooting were obtained where the shoots grew on the multiplication medium.

2.6.2 Effect of Riboflavin

As with other fruit trees, Druart incorporated riboflavin in the rooting medium and obtained a stimulating effect at low concentration. The percentage of rooted shoots was raised from 32 for the control to 70 for shoots grown on the medium supplemented with the optimal dose of 1 mg/l of vitamin B2. There was reduction of the callus at the cut end of the plantlets and the roots grew more quickly.

Table 5. Rooting media

	Druart	Al Maarri et al.	Duron
Macronutrients	Lepoivre $\frac{1}{2}$	MS $\frac{1}{3}$	Dudits et al. $\frac{1}{2}$ (1975)
Micronutrients	Lepoivre[a]	MS $\frac{1}{3}$	Dudits et al. $\frac{1}{2}$ (1975)
Vitamins (mg/l)			
Myoinositol	100	100	100
Thiamine, HCl	0.4	0.4	0.4
Riboflavin	1	–	–
Growth regulators (mg/l)			
IBA	1 (ammonium salt)	–	0.5 – 1
NAA	–	0.1 – 1	0.5 – 1
IAA	–	–	0.5 – 1
BSAA[b]	1 (ammonium salt)	–	–
Sucrose (g/l)	20	30	20
Agar (g/l)	6	6	6
pH	5.5	5.5 – 5.7	5.5

[a] $Fe = 2 \times 10^{-1}$ mM Fe.
[b] BSAA = auxin analogue [benzo(b)selenienyl-3] acetic acid.

2.6.3 Effects of Growth Substances

An increasing percentage of rooted shoots and more roots per shoot were obtained with a concentration range of NAA from 0 to 1 mg/l (Al Maarri et al. 1986). At the optimal NAA concentration of 0.5 mg/l, the shoots reached 90% rooting. The average root length was maximum in control medium without auxin and decreased with raising NAA concentration. On the contrary, the root number per shoot increased with the auxin concentration. They also compared the effect of the duration of the stay on medium with auxin, transferring part of the shoots on auxin-free medium after 6 days. Cuttings transferred on this medium had about the same rooting percentage and the same root number per cuttings, but better elongated roots.

A 4-day dark period has been associated with the auxin treatment during the root induction stage. After the dark treatment the shoots (cv. BA 29) were transferred on the same medium deprived of auxin and illuminated 16 h every day at 2500 lx (Duron unpubl.). Among the auxins IBA and NAA were the most efficient to induce root formation (Table 6). Four weeks after the beginning of the experiment, the percentage of rooting was maximum with 0.5 mg/l IBA or NAA (Fig. 3).

An analogue of IAA, the synthetic compound BSAA (benzo(b)selenienyl-3-acetic acid) has been experimented with cuttings of Quince A. Its auxin-like activity was first mentioned by Hofinger et al. (1980). In this experiment all the auxins were dissolved in a solution of KOH. The results (Table 7) were quite similar for IBA and NAA. BSAA was more efficient than IAA, both to induce rooting and a high number of roots per shoot of Quince A (Druart unpubl.).

The stimulatory effect of cytokinin on rooting has been pointed out by Nemeth (1979). Shoots rooted on the multiplication medium. Among the concen-

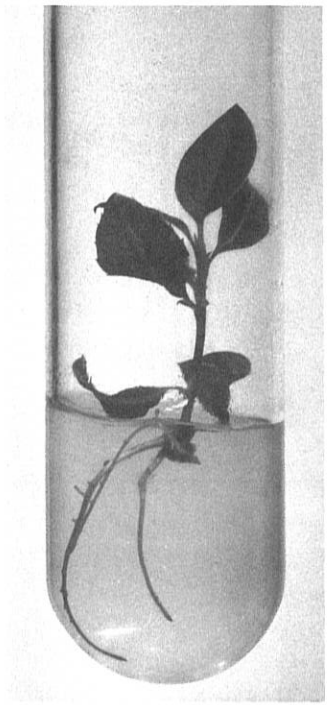


Fig. 3. Rooted shoot of quince cv. BA 29 on an auxin-free medium 4 weeks after the beginning of the rooting process

Table 6. Influence of auxin on rooting of quince cv. BA 29

Auxin (mg/l)	IAA			IBA		NAA	
	0	0.5	1	0.5	1	0.5	1
% Rooting[a]	16	25	66	100	70	100	75

[a] Mean of two replicates with 20 shoots for each auxin concentration.

Table 7. Influence of auxin and auxin-like substance on rooting of Quince A

Auxin (1 mg/l)	IBA	NAA	IAA	BSAA
% Rooting	100	93	28.6	78.6
Average root number	10.8	10.6	1.5	7.6

trations experimented 5×10^{-6} M of BAP was the optimal, giving 35% of rooted shoots. The beneficial effect of cytokinin in rooting is quite uncommon in the literature, and has been recently reviewed (Nemeth 1986). With cherry, Wilkins and Dodds (1982) obtained root formation on 6- to 10-week-old culture on medium having 2.5–5 mg/l BAP.

With *Eremophila lanii*, an Australian native woody plant, Williams et al (1985) had 62% of rooted shoots on a medium containing 1 µM kin+1 µM BAP.

Similar results were observed on 10–12-week-old culture on multiplication media with *Spirea bumalda* cv. Anthony Waterer and clones of *Vaccinium angustifolium*. In the last example, roots might be formed either inside the medium or along the basal half part of the shoots. In that case the roots elongated towards the medium (Duron unpubl.).

2.7 Protocol

From these different results it is possible to summarize the following for the in vitro multiplication of quince.

2.7.1 Culture Initiation

The culture may be initiated either from shoot tip or meristem. Shoot tips must be picked from virus-free mother plants. It is necessary to have greenhouse facilities to prepare the plants from which relatively clean shoot tips will be picked up. Such process facilitates the success of the sterilization: 100% contaminant-free cultures are usually obtained under our conditions. Furthermore, picking shoot tips is easier than dissecting meristems. During the first step of the culture, shoot tips elongate quicker than meristems.

The different media (Table 2) are well suited to shoot tip or meristem culture. Nemeth (1979) did not give the percentage of surviving explants, so it might be suitable to follow Druart's technique for meristem culture.

2.7.2 Proliferation

Quite similar results were obtained using different mineral media tabulated in Table 4. From Al Maarri's experiment, 2 mg/l BAP is the optimal cytokinin concentration compatible with a satisfactory shoot elongation.

2.7.3 Rooting

From an economical point of view it is necessary to have the best rooting percentage with a reduced number of manipulations. As far as possible, an elongation phase or a transfer of shoots after the root induction stage must be avoided. Thus, Al Maarri's medium with 0.5 mg/l NAA is a satisfactory rooting medium. For a commerical production the optimal pathway would be (as Zimmerman et al. 1985, did with apple) to induce rooting by dipping the base of the shoots into an auxin solution and then transferring them to the greenhouse in a horticultural substrate.

Fig. 4a, b. Acclimatizated plants of quince clone S_1 (Photographs by T. Orlikowska, Research Institute of Pomology and Floriculture, Skierniewice, Poland). **a** One month after transfer to soil. **b** Two months after transfer to soil

2.7.4 Transfer to Soil

The transfer of the plantlets to horticultural conditions was performed in a substrate made of peat (3) and sand (1). To avoid desiccation, they were protected by a plastic film laid about 20 cm above the top of the plantlets. The film was removed gradually and a full acclimatization of nearly 100% of the plantlets were obtained within 2 to 3 weeks (Fig. 4).

2.8 Callus Culture

Callus cultures of quince were raised by Moore (1984) to try to find if it is possible to reproduce the graft incompatibility phenomenon between quince and pear at the tissue culture level. Callus were obtained from quince (*Cydonia oblonga* cv. Van Deman – see Table 2) and pear (*Pyrus communis* cv. Bartlett) under a 16-h light per day photoperiod at 28 °C. The intact callus masses of pear and quince were placed at about 0.5 mm from each other on the same culture medium, and were allowed to grow in contact either directly or separated by a polycarbonate membrane with 0.2-mm pores permeable to diffusible substances produced by the callus masses.

After microscope studies of the cells of pear and quince callus, it was concluded that the necrosis characteristic of graft incompatibility occurs in both cases in pear cells as it does in vitro. He believed that it may be due to the involvement of toxin(s), as had been already attributed by Gur et al. (1968), and that tissue culture is a useful tool for investigating the graft incompatibility process.

3 Conclusion

Quince may be propagated easily in vitro starting from meristems or shoot tips with a multiplication rate of four to five per month. Rooting in vitro is not a real problem: 100% of rooted shoots may be obtained in the optimal conditions. Our experiments revealed that the acclimatization of the in vitro plantlets by standard methods is quite easy. As far as we know, large-scale in vitro propagation is not widespread. The literature mentions only two laboratories using this technique, one in New Zealand (Plant Propagation Laboratories Ltd., PO Box 10, Havelock North) and the other in Switzerland (Collet 1985).

In European countries where fire-blight disease is endemic, the importance of pear culture and consequently the progagation of quince are decreasing. Further, the tendency is to use pear rootstocks in place of quince to eliminate graft incompatibility problems. This may be an explanation of why the facilities provided by in vitro culture of quince are so little utilized. Nevertheless, the technique may be helpful in other countries which do not encounter the same problems and in those where quince is cultivated as a fruit tree, and to propagate new cultivars better suited to local weather conditions. The clone S1, selected within a population of Quince A at the Research Institute of Skierniewice (Poland), has been propagated in vitro to establish mother plantations and nursery experiments (Orlikowska, pers. commun.).

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