CHAPTER 19

QUINCE

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1. INTRODUCTION

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The genus Cydonia is known as quince, and this species is very closely related to apple *(Malus*), pear (*Pyrus*) and the Japanese quince (*Chaenomeles*). The name quince is derived from a Greek city situated on the islands of Crete, Cydonia, presently known as Canea (Sykes, 1972. According to Pliny the Elder, the crop has long history of cultivation over 2000 years and the author in the work Historia Naturalis described number of cultivars that were grown at the early times. Cydonia is monospecific –comprises of only one species, *Cydonia oblonga*. Quince is cultivated all over the world and fruit crop production is higher in its place of origin. According to FAO data (2010) the total quince production was about 478,813 MT and Turkey out scored all other quince producing countries with a total production of 95,395 MT/year. In the Mediterranean region Spain (12,098) is the largest producer.

On the basis of 100 g fresh of the quince fruits, it contains excellent quantity of carbohydrates (15.3 g), optimum quantity of sugars and dietary fibre (1.9 g). It is also the smaller source protein (0.4 g) and fat (0.1 g). Vitamins detected in the pear fruits include B_1 (0.02 mg), B_2 (0.03 mg), B_3 (0.2 mg), B_5 (0.08 mg), B_6 (0.04 mg), B_9 (3 μg) and Vitamin C (15 mg). Different minerals found as mg 100 g of fruit pulp are calcium (11), iron (0.7), magnesium (8), phosphorus (17), potassium (197), sodium (4) and zinc (0.04) (USDA Nutrient Database).

Fresh fruits of the most quince varieties are too hard, astringent and sour to eat raw. In Albania, Kosovo and Bulgaria quince are eaten raw during the winter. They are the excellent source of pectin and used to make jam, jelly, preserves, pickle and quince pudding, or they may be peeled, then roasted, baked or stewed. In Syria, quince is cooked in pomegranate paste (*Dibs Rouman*) with shank meat and *Kibbeh* (a Middle Eastern meat pie with *Burghul* and mince meat) and is called *Kibbeh Safarjalieh*. In Pakistan, quinces are stewed with sugar until they turn bright red. The resulting stewed quince, called *Murraba* is then preserved in jars and eaten like jam. Fruits have strong perfume like flavour, therefore, added in small quantities to apple pies and jam to enhance the flavour. The term "marmalade", originally meaning a quince jam, derives from "marmelo," the Portuguese word for this fruit. The fruit can be used to make a type of wine. Because it contains high acidity, which is mainly due to its mallic acid, these wines are usually sweet dessert wines that are high in alcohol. In the Balkans quince brandy and quince liqueur are made. Quinces are also used in Parma to produce a typical liqueur called sburlone, word coming from the local dialect and meaning the necessary high stress to squeeze those hard fruits to obtain their juice. Varieties of quince, such as 'Kuganskaya,' have been developed that do not require cooking and are eaten raw.

2. DOMESTICATION

Quince has been grown in many countries all over the world since old times and has been well-known for 4000 years. In the earlier times all species of chaenoioeles were classified as species of Cydonia as was *Pseudocydonia sinensis* and *Pyronia.* This classification was primarily based upon the morphological and molecular traits. The major differences for differentiation were styles of Cydonia are free while those of Cydonia and Chaenomeles connate, leaf margins are entire, as against serrate. Apart from these traits pollen morphology revealed considerable variation in number of pores, pollen grain shape, exine structure, along with number of abnormalities associated with fertility **(**Romanova *et al*, 1988**,** Zhon *et al* 2000). Chemotaxonomic studies through phenolic profiles for nine compounds for 36 genotypes did not show much polymorphism for the types that were collected from number of places of Portugal. Early classifications were entirely based upon the distinct morphological traits like fruit shape and for rootstocks primarily on the growth habit. Genetic diversity was also distinguished on the basis of isoenzyme polymorphism i.e. the isoenzyme analysis of acid phosphatase, esterase, peroxidase and polyphenole oxidase was able to differentiate 11 groups of Cydonia and two of Pyronia, but the type and extent of variability was of very low order. Studies have further shown that peroxidase has been successfully used to indicate graft in compatibility between Quince rootstocks and some pear scion cultivars. Esterase and malate dehydrogenase was effectively used to differentiate between eight European pear cultivars and quince rootstocks- 'Malling Quince A' and 'BA-29'.

3. TAXONOMY

Cydonia is an important member of subtribe Pyrinae, tribe Pyreae, subfamiliy Spiraeoideae (earlier Maloideae), family Rosaceae, class Magnoliopsida, and division Magnoliophyta. According to Sax (1931) genera of the Maloideae form a closely related group based on the chromosome number and presence of intergeneric hybrids. This sub-family comprises aproximately 1000 species in 30 genera and is characterised by a distinctive fruit. The species was named *Cydonia vulgaris Pers. Pyrus cydonia* L. Further within the species, a number of botanical varieties, subspecies have been described. Many of these represent genetic variation within the species. On the basis of their extensive taxonomical studies Lobachev and Korovina (1981) has divide the genus into two subspecies *C. oblonga subsp. oblonga and C. oblonga subsp. integerrima.*

4. CENTERS OF DIVERSITY

The recent artificial intergeneric hybrids with apple and pear are the exceptions. Cydonia in all likelihood has originated in northern Iran, Turkemenistan, and the Caucasus region countries like Russian Federation, Armenia and Azerbaijan. Presently the crop is distributed in the warm temperate areas of central Asia, the Transcaucasus, the Caucasus, and is in abundance in the Middle East particularly in Iran, with widespread population also in Syria, Turkey, Turkemenistan and Afghanistan. Beside these places the crop has naturalised and is cultivated in western Asia and southern Europe, as far north as England, but is well adapted particularly to the Mediterranean climate.

5. OBJECTIVE OF CROP IMPROVEMENT

5.1. Scion Breeding Objective

1. To develop high yielding, regular bearer, fire blight resistance variety.
2. To develop self-fertile variety having large, aromatic fruits of high dessert quality.
3. To develop high yielding, dwarf cultivar adaptable to different climate with low chill requirement.
4. To develop cultivars having fruits of good keeping quality without deteriorating the fruit quality in storage.

5.2. Rootstock Breeding Objective

1. To develop rootstock cultivars having well compatibility with the scion cultivars and adaptable to different climate.
2. To develop rootstock cultivars having pronounced effect on dwarfness, yield, fruit quality and tree longevity of scion.
3. To develop rootstock cultivars which would be well suited to adverse climate and soil situation and could exert resistance / tolerance to major pests and diseases.

6. CYTOGENETICS

As for apple pear, quince and loquat is also diploid with basic chromosome number 2n=34 and Dickson *et al.* (1992) has assessed the nuclear DNA content which in 0.73pg. The basic number, n=17 of *Cydonia* is said to be a secondary unbalanced number and the genus is probably a secondary polyploidy. At present there is no information on the development of cytogenetic stocks using the wild relatives of *Cydonia*. Other species, *C. cathayensis*, *C. japonica*, and *C. speciosa* has later been confirmed by Weber (1964); Saito and Kaneko (1975) and Singhal (1990) also have same chromosome number. The same chromosome number has recently been obtained for *C. thibetica*. Tetraploidy has been reported only in one cultivar with very large flowers (Weber 1964). A large number of *C. japonica* polyploids have however been developed within the ongoing plant breeding program. However, both triploid and tetraploid genotypes of *Cydonia* x *Malus* intergeneric hybrids have been successfully developed.

7. INHERITANCE PATTERN/LINKAGE

Rudenko and Rotaru (1988) studied the seed anatomy in diploid cultivars of apple, pear and quince. They observed that in the allotetraploid F_2 quince x apple hybrids and in the diploid pear x quince, the testa epidermis structure features were inherited from quince and the sclerenchyma structure were derived either from pear or apple and other traits were inherited quantitavely.

Till date no genetic linkage maps of intergeneric hybrids quince has been developed. Although apple genetic maps very dense in nature has been developed. The progress in recent times seen in the construction of genomics libraries and genome physical maps of apple (Han *et al.,* 2007) has opened up means and techniques for rapid development of quince genomes.

Dilleman (1950) assessed the hydrogen cyanide content of the F_1 hybrid (quince x pear); which were intermediate between the high cyanide quince and low of pear.

As no genetic maps has been developed for *Cydonia* the magnitude/ degree of system with other genera of the family rosaceae is not possible to be ascertained

8. PROBLEM IN BREEDING

i. Non availability of types resistant to high pH.
ii. Non availability of types with good root system.
iii. In the field under varied conditions, the crop is highly susceptible to spring frost and high summer temperature and hence *in vitro* preservation of collection are needed.
iv. Lack of information on inheritance pattern/ linkage of economical characters associated which are the pre-requisite for successful breeding. Development of linkage maps with other genera of rosaceae is therefore urgent requirement.

v. Graft incompatibility is one of the bottlenecks in quince propagation.

vi. Non-availability of biotic and abiotic stress types.

vii. Breeding of a new quince variety takes as long as 10 years from the first crossing to release a commercial apple cultivar.

viii. A juvenile period from 3 to 5 or more years slows down the process of pomes evaluation and sexual propagation for obtaining segregating progenies.

ix. There are three groups, self-fertile, partly self-fertile and self-sterile cultivars are usually occur in quince. Therefore fruit set is very low with natural autogamy, so it requires cross-pollination to achieve sufficient yield. On the other hand, for an adequate fruit quality more than 70 ovules need to be fertilized in a quince flower, so it needs more pollen for cross-pollination than other Maloideae fruit crop plants. Furthermore, flower density of quince is low as compared with other fruit species so it needs at least 20-25 per cent fruit set to reach an adequate yield (Nagy-Déri, 2013).

9. FLORAL BIOLOGY

9.1. Flowering

The quince flower is similar to the apple, but in general it is coarser and more colourful. It develops on first year growth and therefore appears later in the season than the apple blossom. Quince trees may bloom from February to May depending upon the species and geographical area. Blooms on a tree may last 11 to 20 days with full bloom last 6 to 10 days.

9.2. Flower

Flower may be as much as 2 inches across, with five cup-shaped petals that vary, according to cultivar, from white to scarlet. It bears 20 or more stamens and five styles leading to a five-carpel ovary that, as a fruit, may produce the more than 50 seeds. The stamens and pistils are fully twice as large as and thicker than those of the apple (Waite, 1899). A nectar at the base of the styles is half concealed by the closely spaced filaments, and only honey bees or larger insects can push in between the petals and stamens to reach the nectar.

The 3-whorled androecium of *Cydonia oblonga* L. consists of 15-20 stamens with purplish filaments and light yellow anthers (Halmagyi and Keresztesi, 1975). Size of anthers is influenced by flower size (Delph *et al*., 1996). The level of pollen production is directly related to anther size and inversely related to pollen grain size (Lopez *et al*. 1999). Quince has yellow pollen grains (Mohacsy and Porpaczy, 1958). Shape and size of pollen often change with variable air temperature and humidity and other environmental factors (Thakur and Thakur, 1970). According to Baker and Baker (1979) pollen grains collected by honeybees are smaller than those which are transferred by butterflies and birds. Structure of stigma, length and thickness of style can also be related to pollen size (Cruden and Lyon, 1985; Kirk, 1993) In subfamily Maloideae (Rosaceae) pollen shape is

highly diverse. Typical pollen grains are oblate or spheroidal, with a triangular or circular equatorial outline (Halbritter and Schneider 2000). Quince possesses spheroidal pollen grains (PÅE, P/E=0.88-1.14), which are round in equatorial view (Erdtman 1966, Halbritter and Schneider 2000). According to the classification of Erdtman (1966), the trizonocolporate pollen grains of quince were considered as large (50-100 μm) by Erdtman (1966) and Sotonyi *et al.* (2000), contrasting the view of Halbritter and Schneider (2000), who classified quince pollen in the medium (26-50 μm) category. According to Sotonyi *et al.* (2000), length of *C. oblonga* pollen changed between 50.4-54.4 Mm, its width was in the range 23.6-24.1 Mm, and the average length and width ratio was 2.19. In comparison, the mean length of pollen grains in apple was 44 μm, mean width 23.1 μm and mean shape index was 1.9 (Sotonyi *et al.*, 2000).

9.3. Stigma Receptivity and Anther Dehiscence

The stigma of the quince is receptive even before the flower opens. When it opens, the outer anthers are first to dehisce, the inner ones remaining closed and beneath the receptive stigma. Because most insects settle on the flower center, crossing is affected before selfing is possible. Later, the inner anthers dehisce in contact with the stigma, but whether it remains receptive seems to be unknown. The question then deals with the effectiveness of this self-pollination.

In delayed homogamous flowers, the stigma became receptive in the bursting bud preceding anthesis. In the young open flower some of the stigmatic papillae lost their turgor already, and no stigmatic exudates were detected by the end of anther dehiscence. Nectar production also starts at the bursting bud simultaneously with stigmatic activity. The largest yields produced by the young, opened and pollen shedding flowers. Secretion of nectar continued until the end of anther dehiscence. Homogamous flowers classified into three functional groups according to the active period of the pistils and anthers. Their anther dehiscence and stigma secretion commenced at the same time. The stigmas ceased to be active either after all anthers have dehisced (1 and 2 groups) or remained receptive for 2-4 hours after the pollen shedding phase (3 group). In the 1st functional group of homogamy both reproductive organs became active in the bursting bud, and at the same time nectar secretion also started. Highest volumes of nectar with highest sugar concentrations found in the young, opened flowers and in flowers with at least half of the anthers dehisced. Nectar production lasts to the end of pollen shedding. In the 2nd and 3rd functional group of homogamy, anther dehiscence and stigma secretion commences in the young opened flowers. Nectar secretion starts at the beginning of stigma receptivity. In the 2nd group flowers the most attractive after half of the anthers dehisces, by producing the highest volumes of nectar with the highest sugar concentrations. At the end of pollen shedding and stigma receptivity, nectar production also exhausts. In the 3rd functional group of homogamy the peaks of nectar secretion found after half of the anthers open and after anther dehiscence finishes. Secretion of nectar lasts until the stigma remained glossy and receptive (Nagy-Déri 2013).

9.4. Pollination

Nectar secretion and pollination of the common quince was studied by Stancevic (1963) and Simidchiev (1967) who found that the amount secreted by a blossom in 24 hours varied from 0.851 to 1.634 mg on an average in the different cultivars with sugar concentration varying from 41.3 to 49.9 percent. Nectar secretion continued day and night for 5 days but was highest around noon each day. The flowers are freely visited by pollen and nectar collecting insects.

The most thorough study of pollinating agents of quince was made by Simidchiev (1967) on five cultivar of the common quince. He showed that quince is highly attractive to honey bees throughout the day for both nectar and pollen. This activity is highly conducive to transfer of pollen from anther to stigma between cultivars as well as within the individual flower. Simidchiev (1967) noted that under favourable conditions for bee flight, when bees visited the blossoms from morning to night, 5 per cent gathered only nectar, 11 per cent gathered only pollen, and 84 per cent gathered both. The flowers are highly attractive to honey bees, therefore where needed they should be satisfactory pollinating agents.

9.5. Pollen Viability, Pollen Germination and Pollen Tube Growth

Accoding to Rumpunen (2002) pollen viability in Japanese quince is in general good and pollen germination varied between 39.7 and 64.5 per cent for pollen parents. In a compatible combination, a high percentage of the pollen grains germinated, germination was fast, and pollen tubes grew rapidly in a dense cluster through the style.

Pollen germination started immediately after pollination. A compatible combination was characterized by a rapid germination, a high number of germinating pollen grains, and after 24 h most of the pollen grains had germinated. At the same time, in an incompatible combination only a small number of the pollen grains had germinated. A small number of the pollen tubes reached the base of the ovary, usually not until 6–7 days after pollination. Fertilization occurred late (after 7–9 days), and the percentage of presumed fertilized ovules (tips of pollen tubes entering micropyle) was very low (about 5%). However, also after self-pollination, a small number of the pollen tubes reached the base of the style already in 2–3 days in some genotypes, but fertilization (if any) was always delayed compared to cross-pollination **(**Kaufmane and Rumpunen, 2002**)**

Most of the pollen tubes reached the base of the ovary within 2–5 days. Fertilisation of ovules took place within 4–8 days after pollination, depending on the genotype. In an incompatible combination a low percentage of pollen grains geminated, germination was slow, the pollen tubes grew slowly and they were often completely arrested in the style. Callose was accumulated along the tube and at its end and the percentage of fertilised ovules was very low. In defective pistils germination of pollen grains was extremely low, about 1.5 per cent. A few pollen tubes grew into the ovary, but seed-buds were undeveloped and fertilisation could not take place.

9.6. Fertility and Sterility

Kaufmane and Rumpunen (2002) stated that the flowers of the quince varieties seem self-fruitful enough, but he did not indicate whether he referred to self-compatibility or self- fertilization. Waite (1899) cross-pollinated several cultivars and observed no striking benefit to be derived from pollinating insects bringing pollen from other cultivars. Gardner *et al.* (1952) and Shoemaker and Teskey (1959) also concluded that quinces were self-fertile. Mace (1949) stated that insects cross-pollinate the flowers shortly after the open, but if this is not accomplished the flowers self later. He did not indicate how he arrived at this conclusion.

Ershov (1966) conducted fertility studies on quince varieties from different places over a 5-year period. Of 23 varieties tested, only five were self-fertile. The other were partially to completely self-sterile. He concluded that for all practical purposes the quince is a self-sterile crop. Where mutual pollination exists, a good harvest can be obtained.

There seems to be no question that pollinating insects are needed when the flower first opens. In apples and numerous other plants, pollination at the earliest possible time is highly desirable. This would appear to be the case with quince.

10. DIFFERENT SPECIES

10.1. Quince

Quince (*Cydonia oblongata*), is a small fruit tree of the rose family (Rosaceae). The much-branched shrubs or small trees have entire leaves with small stipules and bear large, solitary, white or pink flowers like those of the pear or apple but with leafy calyx lobes and a many-celled ovary, in each cell of which are numerous horizontal ovules. The fruits may be round and flattened or somewhat pear-shaped, with a large, leafy calyx on the mature fruit. *Cydonia oblonga* is a deciduous tree growing to 7.5 m (24ft) by 7 m (23ft) at a medium rate. It is hardy to zone 4 and is not frost tender. The plants are in flowering in May, and the seeds ripen in November. The flowers are hermaphrodite (have both male and female organs) and are pollinated by insects. It is suitable for light (sandy), medium (loamy) and heavy (clay) soils having acidic, neutral and basic (alkaline) soils. It can grow in full shade (deep woodland) semi-shade (light woodland) or no shade. It prefers moist soil. Different subspecies, botanical varieties and forma of *Cynodia oblonga* have been presented in Table 1.

Table 1. Subspecies, botanical varieties and forma of *Cydonia oblonga* Mill.

1.	*Cydonia oblonga subsp. oblonga*
2.	*Cydonia oblonga subsp. integerrima Lobachev*
3.	*Cydonia oblonga subsp. maliformis (Mill.) Thell.*
4.	*Cydonia oblonga subsp. pyriformis Medik. ex Thell.*

[Table Contd.

Contd. Table]

5.	*Cydonia oblonga var. oblonga*
6.	*Cydonia oblonga var. biserrulata Kakhadze*
7.	*Cydonia oblonga var. integerrima*
8.	*Cydonia oblonga var. integerrimo-sepala Lobachev*
9.	*Cydonia oblonga var. integerrimoespala Kakhadze*
10.	*Cydonia oblonga var. lusitanica (Mill.) C. K. Schneid.*
11.	*Cydonia oblonga var. maliformis (Mill.) Rehder*
12.	*Cydonia oblonga var. obpyricarpa Lobachev*
13.	*Cydonia oblonga var. obpyriformis Lobachev*
14.	*Cydonia oblonga var. orbiculato-complanata Lobachev*
15.	*Cydonia oblonga var. ovalicarpa Lobachev*
16.	*Cydonia oblonga var. ovalis Lobachev*
17.	*Cydonia oblonga var. plano-cyclocarpa Lobachev*
18.	*Cydonia oblonga var. pomiformis Lobachev*
19.	*Cydonia oblonga var. rotundata Kakhadze*
20.	*Cydonia oblonga var. serrulata C. K. Schneid.*
21.	*Cydonia oblonga var. typica Kakhadze*
22.	*Cydonia oblonga var. urceolata Lobachev*
23.	*Cydonia oblonga forma lusitanica (Mill.) Rehder*
24.	*Cydonia oblonga forma marmorata (Dippel) C. K. Schneid.*
25.	*Cydonia oblonga forma pyramidalis (Dippel) Rehder*
26.	*Cydonia oblonga forma pyriformis (Dierb.) Rehder*

(**Source:** Encyclopedia of Life, 2009)

10.2. Japanese Quince

The Japanese quince (*Chaenomeles* species) has been widely used as an ornamental shrub in gardens, particularly because of the beauty of the flowers that appear on the stems before the leaves open fully in late winter and early spring. Some of the small shrubs bear large, green, fragrant fruits that are inedible in the fresh state but have been used in making preserves.

Japanese quince shrubs when in flower are a welcome sight on winter days, as they are covered in blooms. Japanese quince shrubs have an extremely unusual strategy for finding pollinators. Their flowers are bee-pollinated, but there are absolutely no bees. When the weather warms up, beehives are send out to see if anything is blooming. On warm January days, Japanese quince has a monopoly on the blooming business, so any bees that are out will pollinate the Japanese quince.

Japanese quinces were brought to the United States as an ornamental and edible plant centuries ago. In the US, they are a slightly old-fashioned but well-loved garden plant.

They are unique in their ability to brighten a dark winter day, but they also produce useful fruit, called a quince. Quinces are relatives of apples and pears, and some types of quinces are well-loved in Asian and European cooking. The quinces of the Japanese quince shrubs are small, hard and bitter, but they can be used to make excellent jams and jellies. If these flowers are pollinated, we'll have some quince fruits later in the spring or early summer. Japanese quince shrubs have a few thorns to protect their quinces.

10.2.1. *Species of Japanese Quince*

10.2.1.1. Chaenomeles Speciosa

Chaenomeles speciosa is known as the common flowering quince. It grows up to 10 feet tall and wide, because of its thorns and fast growth, this shrub can be used as a barrier.

10.2.1.2. Chaenomeles Japonica

Chaenomeles japonica is a small type of flowering quince, only growing to about 3 feet tall. Unlike the other types, which are native to China, this quince is native to Japan.

10.2.1.3. Chaenomeles Cathayensis

Chaenomeles cathayensis is perhaps better thought of as a tree, since it grows to more than 19 feet high.

10.2.1.4. Chaenomeles thibetica

Chaenomeles thibetica is the most recently discovered member of the Chaenomeles genus. It grows to about 10 feet tall. In its native Tibet, the shrub has been found at elevations of about 2 miles.

10.2.2. *Chaenomeles Cultivars*

Stand-out cultivars of *Chaenomeles* include diminutive

'**Texas Scarlet**' which produces an abundance of red flowers, apple blossom, with its pink tinted flowers

'**Cameo',** which blossoms with peach-hued flowers and is also resistant to blight.

11. CROP IMPROVEMENT METHODS

11.1. Selection

Quince selections made in various growing countries like Bulgaria, Spain and India for various traits desired in a quince like higher yield, attractive appearance, fruit quality,

rootstocks and resistance to biotic and abiotic stress. Fire blight is the common problem occurs in quince. Therefore it was worked out to identify the resistance sources.

Levels of fire blight susceptibility in native apple, pear and quince have been scored on the basis of lesion length on shoots. Resistance levels of accessions were classified according to genotype susceptibility index (GS1 %). The GS1 values ranged 17.2 to 55.1 per cent for pear and 17.8 to 43.4 for quince genotypes. No resistance genotype in any of the three fruit was observed. Considerable variation would contribute to breeding efforts. From 7600 seedling at double the spineless forms gave a produce of 47 kg/bush. They were distinct for vitamin-C and organic acid range. Five promising spineless form with high yields, early maturity and good fruit composition were selected for breeding (Ruiss, 1987).

Twenty nine forms (mostly single trees basis) has been studies on the basis of fruit weight, size, proportion of pulp content of moisture, acids, pectin crude fibre, invert sugar, dry matter and six jam quality characters, the coefficient of variability were high. Most of the forms were suited for jam making and some for fresh consumption (Reina *et al*, 1983).

A new cultivar 'Ronda' was selected from open pollinated seedlings of 'Reas Maammoth', bears larger regular sharp aroma, ripens mid October, compatible with quince rootstocks (Quince A) forms vigorous compact trees start early cropping. Self fertile, high yield and quality, ideal for jelly making, syrup, Jam and pulp are ideal for quince production (Aeppli and Gaemminger, 1984)

11.2. Hybridization

The eminent Russian plant breeder, Ivan Michurin, made some very wide crosses between pome fruit species in an attempt to develop productive fruit cultivars that could thrive in colder parts of the Soviet Union. Some of his hybrids included combinations involving *Crataegus*, *Mespilus*, *Pyrus* and *Malus*. Recent hybrids generated in Japan between *Cydonia* and the Asian pear, *Pyrus pyrifolia*, and between domestic apple and pear used embryo rescue to recover seedlings. In Italy and the Czech Republic a purported hybrid between quince and apple (*Cydomalus*) has been touted as a possible rootstock for both apples and pears (De Paoli *et al*., 2002; Wertheim 2002). Keulemans *et al*. (2010) obtained 13 triploid and tetraploid *Cydonia* × *Malus* hybrids from Rudenko in Moldavia and used them in backcrosses to apple. Phenotypes and genotypes suggested that the parents and their progeny were intergeneric.

The two-decade history of fire blight in Bulgaria revealed quince as one of the most frequently attacked hosts and production of quince on a large scale has been almost eliminated. Nevertheless, this species will play an important epidemiological role as a permanent source of inoculum for spread of the pathogen to other hosts because of its traditional presence in many private yards, and its bloom period coinciding with favourable

fire blight conditions in the late spring. Fire blight disease evaluations were made for 3 years in a collection of the most important quince cultivars in Bulgaria (Bobev *et al.,* 2011). Two native cultivars, 'Hemus' and 'Triumph', were found to have high levels of field resistance (Bobev and Deckers, 1999). The promising resistance response of these cultivars encouraged a program which examined the fire blight resistance of 274 hybrid progenies (3 replicates per combination on the rootstock BA 29.

11.2.1. *Intergeneric Crosses*

Quince enjoys long history of cultivation. Breeding efforts to improve quince both for fruit and rootstock has been accomplished through inter specific hybridization. Crosses between *Cydonia, Pyrus* and *Malus* to some extent has been successful but inter-generic hybridization among *C. oblonga, pseudocydonia sinesis and Chaenomeles sinesis* has failed altogether. The cross between Cydonia × Sorbus, was also unsuccessful as pollen tube failed to reach the embryo sac (Kursakov *et al.,* 1976)**.** The first and the successful hybrid between *Pyrus* × *Cydonia* was developed before 1916 (Trabut, 1916**;** Rudenko, 1985) and presently is used as virus indicator plant. Shimura *et al.* (1983) was successful in developing a hybrid variety between *Pyrus serotina* and *C. oblonga.* Later a clone of *Pyronia veitchii* var. luxemburgiana was backcrossed with pear to develop a suitable stock for pear.

Rudenko (1972) has produced a viable hybrid between apple (*Malus pumila*) and quince (*Cydonia oblonga*). The hybrid produced/ set large number of parthinocarpic fruits which combine the trait of the two parents. Diploid, triploid and tetraploid F_2 seedling were raised through cross pollination and invariably the tetraploid were weak in growth, few were normal. The developed hybrids did bear fruits with apple flavour but in appearance were like that of quince. Rudenko (1983) analysed the fruit traits and reported that a triploid (F_2) developed large fruit (230kg) and when a allotetraploid F_2 were backcrossed with apple, produced 50 tetraploid hybrids which mostly had apple characteristics. On similar line of work, Panov *et al.* (1965) in Bulgaria, crossed a quince cultivar 'champion' with pollen mixture of five apple cultivars. From the resultant hybrids two had fruit and other anatomically traits that were intermediate between the parental lines.

Semin (1961) have also developed some inter-generic hybrids by mixture of foreign pollen plus pollen from the same species which was thought to have weakened by exposure to ionizing radiation. Irradiated pollen was also used with a view to develop a hybrid between Pear × quince and apple × quince. In the quince improvement work Rudenko (1972) showed varied chromosome behavior in the hybrids. In some crosses normal meiosis with bivalent formation and were highly fertile, however in most cases fertile seed rarely developed. Anatomical studies showed that palisade layer of the leaves were usually thinner than parents.

Negru (1984) made intergeneric crosses between various polyploidy forms i.e. diploid, triploid and tetraploid quince and apple. The petiole anatomy feature was intermediate

between the two selected parents. In some hybrids the features were much closer to one species as compared to other species. As for flower number per inflorescence was inherited in an incompletely dominant fashion in F_2, quince x apple hybrid, with most resultant hybrids had only a single blossom (Rudenko and Negru, 1984). Useful sources of single flowered inflorescence were identified when tetraploid clones were backcrossed to apple. They appeared to be allotriploid and were similar to quince and nearly 15 per cent of the allotriploids resembled apple, as they had seedless fruits and flower number per blossom/inflorescence varied from 2-3.

Intergeneric crossing is fairly rare in plants, but has occurred naturally on occasion in the Rosaceae. While not as promiscuous as its cousins *Sorbus* and *Mespilus, Cydonia* has a number of encounters with related genera that resulted in intergeneric offspring. In 1913 Mr. Veitch in London sent scions of a quince-pear hybrid to Louis Trabut, the Algerian botanist. Trabut proposed the name *Pyronia veitchii* for this curious seedless-fruited hybrid (Trabut 1916). *Pyronia* is little known today, except by fruit tree pathologists who use the virus sensitive clone as a graft-inoculated indicator to detect virus diseases in pome fruits. Another more recent hybrid generated in Japan between *Cydonia* and the Japanese pear, *Pyrus pyrifolia,* was probably the product of embryo rescue, a controlled tissue culture technique. In Italy and the Czech Republic, a purported hybrid between quince and apple (*Cydomalus*) has been touted as a possible rootstock for both apples and pears.

11.2.2. *Interspecific Hybridization*

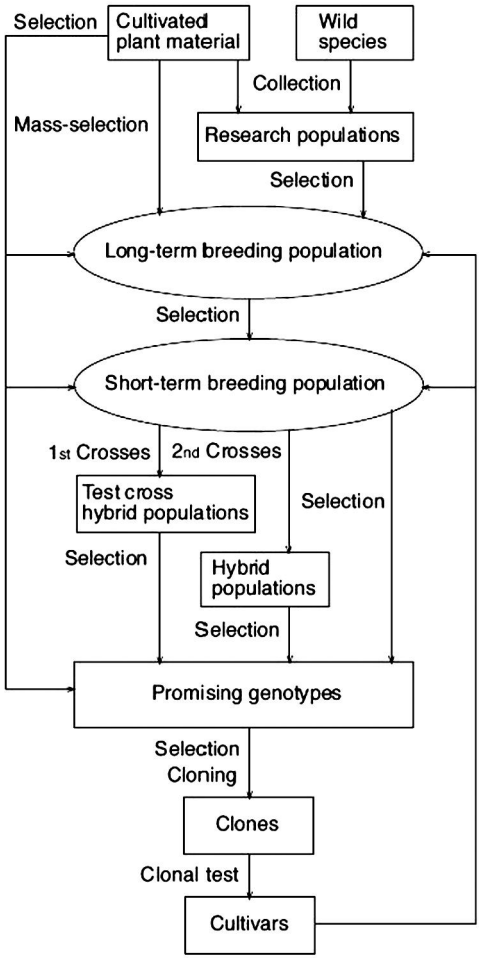
Since there are no barriers against interspecific hybridisation in the genus *Chaenomeles* (*C. thibetica* not yet tested) this is the obvious method for transferring useful characters between species. Whereas the three Chinese species are possible donors of genes for larger fruits and higher plants, they would probably also contribute inferior hardiness. Repeated backcrosses to *C. japonica* might restore cold hardiness and improve adaptability. However, plants of *C. thibetica* seem to be better adapted to the Baltic climate than either *C. speciosa* or *C. cathayensis* plants (unpublished results). Interspecific crosses between *C. japonica* and *C. thibetica* should therefore be given priority.

11.3. Polyploidisation

Polyploidisation is another approach to induce variation in Japanese quince. Through polyploidisation gigas effects may be obtained, *e.g.* in plant growth habit and fruit size. Tetraploids could be used to develop triploids, which are likely to have reduced seed set and an increased proportion of fruit flesh. Procedures for successful polyploidisation of Japanese quince are now available (Stanys *et al.,* 2002).

11.4 Mutation

In Russia mutation work has been carried out regarding creation of variability without any conclusive results.



A short- and long-term breeding strategy for the fruit crop Japanese quince (*C. japonica*). Source: Rumpunen (2002)

11.5. Biotechnological Approach for Crop Improvement

11.5.1. *In vitro Tissue Culture and Regeneration of Cydonia*

Very limited advances on the molecular markers and genomics studies on quince have been done. At present research work is more concentrated on plant biotechnology major emphasis being on *in vitro* tissue culture and regeneration. With a view to study the problem of graft incompatibility, Moore (1984) was successful in induction of callus from both pear and quince. Later Chartier Hollis (1993) established the protocols for callus induction, maintenance and shoot regeneration were developed. Both pear and quince requires GA_3 apart from IBM to sustain callogenesis**.** D' Onofrio *et al.,* (1999) was successful in isolating the quince leaf protoplast. However using this culture on somatic embryogenesis or genetic transformation has not yield fruitful results. Dolcet Sanjuan *et al*.,

(1991) registered highly successful *in vitro* adventitious shoot regeneration from leaves of *C. oblonga* cv. Quince A, in a culture media that contained thiodiazuron (TDZ) and á naphthalene acetic acid (NAA). Results showed that shoot rooted in medium having 5µM NAA for 1 week and then shifted on to auxin free medium was very effective *in vitro* adventitious shoot regeneration (Baker and Bhatia, 1993; Staniene and Stanys 2004, Erig and Schuchs 2005).

The role of genotype as a determinant factor in the success of shoot regeneration was observed by Aygun and Dumanoglu (2007), who obtained the highest shoot organogenesis in MS basal medium supplemented with TDZ + NAA and $AgNO_3$. The effect of light regime on adventitious shoot regeneration of three Lithuanian quince clones was assessed by Zalunskaitr *et al.*, (2007) for an initial period of 4 weeks in the dark before transfer to a 16/8 h (light/ dark) photoperiod significantly increased shoot regeneration, which could be additionally augmented if leaf explants were sampled from the apical part of the shoots. Optimal temperature regimes for induction and regeneration phases were established by Morini *et al*. (2004), while the impact of the gaseous environment in regeneration ability was studied by Marino and Berardi (2004)**,** who found that sealing petri dishes with polyvinyl chloride (PVC) transparent film resulted in much lower concentrations of carbon dioxide and ethylene and much better regeneration in comparison with petri dishes sealed with parafilm. The beneficial effect of ethylene reduction on regeneration ability via addition of aminoethoxyvinylglycine (AVG) was later found by Marino *et al.* (2008)**.** The effect of NaCl and CaCl in somatic embryogenesis, root regeneration, and shoot regeneration was studied by D'Onofrio and Morini (2002a, b), who observed a favorable effect from low concentrations of NaCl in somatic embryo formation and adventitious shoot and root regeneration. CaCl apparently mitigated the adverse effect of higher concentrations of NaCl (and NaSO4) on the *in vitro* regeneration processes. A two-step procedure, induction in liquid media supplemented with 2, 4-D for a few days followed by regeneration in gelled media for 35–40 days, was introduced by Antonelli (1995) for somatic embryogenesis induction. Using a similar induction treatment and varying the length of a subsequent kinetin + NAA treatment and the absence versus presence of growth regulators (BA, GA3, and IBA), D'Onofrio and Morini (2006) were able to modulate in vitro regeneration of somatic embryos and adventitious shoots and roots.

The effect of micronutrients in the regeneration process was evaluated by Fisichella *et al*, (2000) tested on eight different media for in vitro tissue culture and the study showed that MS medium was the best. Recently Mingozzi and Morini (2009) recorded much higher root generation and embryogenesis in leaves from shoots which were earlier subjected to high photosynthetic photon flux density (PPFD) which clearly showed the effect of *in vitro* culture condition of donor shoots on subsequent morphogenesis of the leaf explants.

11.5.2. *Somaclonal Variation*

The quince rootstocks are particularly dwarfing in nature, therefore are extensively used for intensive pear production. However this stocks exhibits some major constraints like graft incompatibility with some pear cultivars, lime induced chlorosis (Fe deficiency)

especially in calcareous soil, susceptible to low temperature. Some studies were carried out for the selection for tolerance to stress factors as salinity (Marino and Molendini, 2005) but most emphasis was to select superior type tolerance to lime induced chlorosis. Dolcet-Sanguana *et al.* (1992) isolated two somaclonal variants IE-1 and IE-2 that were more tolerant to iron deficiency under *in vitro* conditions compared to the test clone "Quince A" which had higher chlorophyll concentration and the ability of the roots to induce Fe^{3+} and to acidify the medium. These young plants under greenhouse showed higher resistance to iron deficiency, but under field condition tolerance level was variable (Bunnag *et al.,* 1996**).** Marino *et al*., (2000) tried to recover lime tolerant clone through somaclonal variation and has obtained tolerant somaclones after regeneration in the presence of high medium p^H or with lower concentrations of Fe^{3+} EDTA combined with different concentrations of potassium bicarbonate (Cinelli *et al*., 2004**).** The selected clones performance is needed to be evaluated under field condition to know whether these clones are better than the earlier used rootstock- BA-29.

11.5.3. Species and Varietal Study through Molecular Aids

In the earlier times all species of *chaenoioeles* were classified as species of *Cydonia* as was *Pseudocydonia sinensis* and *Pyronia.* This classification was primarily based upon the morphological and molecular traits. The major differences for differentiation were styles of *Cydonia* are free while those of *Cydonia* and *Chaenomeles* connate, leaf margins are entire, as against serrate. Apart from these traits pollen morphology revealed considerable variation in number of pores, pollen grain shape, exine structure, along with number of abnormalities associated with fertility **(**Romanova *et al.*, 1988**,** Zhon *et al.,* 2000). Chemotaxonomic studies through phenolic profiles for nine compounds for 36 genotypes did not show much polymorphism for the types that were collected from number of places of Portugal. Early classifications were entirely based upon the distinct morphological traits like fruit shape and for rootstocks primarily on the growth habit. Genetic diversity was also distinguished on the basis of isoenzyme polymorphism i.e. the isoenzyme analysis of acid phosphatase, esterase, peroxidase and polyphenole oxidase was able to differentiate 11 groups of *Cydonia* and two of *Pyronia*, but the type and extent of variability was of very low order. Studies have further shown that peroxidase has been successfully used to indicate graft incompatibility between Quince rootstocks and some pear scion cultivars. Esterase and malate dehydrogenase was effectively used to differentiate between eight European pear cultivars and quince rootstocks- 'Malling Quince A' and 'BA-29'.

11.5.4. *Molecular Markers*

Studies on RAPD analysis of genetic relatedness among selected quince (*Cydonia oblonga* Mill.) accessions from different parts of Turkey were evaluated by Bayazitl *et al.* (2011). Different cultivated and local quince genotypes are grown in almost all parts of Turkey for fruit usage. In this study, randomly amplified polymorphic DNA (RAPD) technology was used to study the genetic relationships among 13 quince accessions

selected from different parts of Turkey. Thirty decamer primers were used and 14 of them did not produce any polymorphism. The remaining 16 primers ranged in their amplification fragments between one (P-402, P-437, OPA 10, OPA 16, OPA 18 and OPA-19) and five (OPA-06 and OPA-07). The size of fragments varied from 100 to 1500 bp. Similarity values among the studied genotypes ranged between 0.483 and 0.925. The resulting dendrogram clustered into two groups (0.69 similarity value) based on evaluation of genetic similarities and differences. The results suggest that RAPD analysis could be used to distinguish and determine genetic variation among quince accessions. Also, the obtained clustering based on RAPD markers agreed to some extent with the geographical origin of the studied set of quince accessions. Kuden *et al.* (2006) reported the pomological characteriza-tion of these quince genotypes but included no in-formation about molecular characterization. These results indicate that RAPD is useful for analysing genetic variation and geographic distribution of quince accessions. Consequently our studies were very informative molecular characterization of quinces genotypes of Turkey. The addition of the novel molecular data to previously made pomo-logical analyses completed the characterization of our Turkish quince advance selection collection. The genotypes from this collection will be used in the forthcoming cross breeding studies. The char-acterization results will be of great importance on the selection of the parents and the combinations

Analysis of sequence of internal transcribed spacers (ITS) were used to study the relationship between 19 *Maloideae* genera. The study revealed that there is strong relationship between *Cydonia* and *Pseudocydonia.* Confirmation by random amplified polymorphic DNA (RAPD) markers, the close genetic relationship between *Cydonia* and *Pseudocydonia* was established and the genetic distinctness from the flowering quince (*Chaenomeles*) was helpful to explain why there was failure of hybrid production between the two former species and the flowering quince. Studies using randomly amplified markers like RAPD, inter-simple sequence repeats (ISSR), amplified fragment length polymorphism (AFLP) for genetic characterization of quince has not been published so far as there was differently in discrimination between quince cultivars and the RAPD markers used as similar molecular patterns were displayed. Fifty per cent of the SSR markers derived from Japanese & European cultivars and 73 per cent markers derived from apple were amplified in quince. In contrast to this cultivars used as rootstock appeared genetically distinct from varieties cultivated for fruit production as seven of the analysed eight rootstocks clones were clustered together in a developed phenogram.

11.5.5. *Genetic Transformation*

Despite concerted efforts there is no confirmed report on the transformation of quince with genes isolated from other related genera. It is said that genetic transformation is still in its infancy and most of the research is concentrated on the adoption on development of different techniques. The *in vitro* axillary shoot culture and adventitious regeneration method are very well established for *Cydonia* **(**Chevreau and Bell, 2004). Davidson *et al.* (1998) two strain of *A. tumefaciens*, LBA 4404 and EHA 101 to transform quince with the expression of the vector containing the A (GUS) reporter gene and the npt2 selectable marker. It was

observed that GUS expression in the treated leaves increased over on 8- day period after cultivation. In a work on intergeneric hybrid × *Pyronia veitchii* was transformed with wild type *Agrobacterium rhizogene* by Bassi and cossio (1993). The chimeric with better rooting efficiency were obtained. Ease of adventitious rooting is a prerequisite trait for rootstocks. Razanskiene *et al* (2006) transformed three quince rootstocks with rol B gene isolated from *A. rhizogene* using two plasmid and three gene promoters. The results revealed variability in regeneration percentage of transgenic shoots due to the effect of rootstock clones, plasmid and concentration of thiodiazuron in the regeneration medium.

12. CULTIVARS DEVELOPMENT

Characteristics of quince varieties

Variety	Flowering	Maturity	Size, shape and quality	Colour on cooking
Missouri Mammoth	Early	Early	Large, round	Pale pink
Portugal	Early mid	Early mid	Medium, pear-shaped, poor quality (small fruit strain)	Pale pink
Powell's Prize	Early mid	Early mid	Small, pear-shaped	Pink
De Vranja	Early mid	Early mid	Large, long pear-shaped, good quality	Pink
Apple shaped	Mid late	Mid	Medium, short pear-shaped, good quality	Yellowish
Champion	Early mid	Mid	Medium, pear-shaped, good quality	Pale pink
Orange	Early	Mid	Small-medium, pear-shaped, poor quality	Pink
Rea's Mammoth	Early mid	Mid	Large, short pear-shaped	Pink
Smyrna	Mid	Mid	Large, long pear-shaped, good quality	Pale pink
Mummery's Seedling	Early	Mid late	Large, pear-shaped, good quality	Pale pink
Fuller's	Early	Mid late	Medium-large, pear-shaped	Pale pink
Pineapple	Late	Mid late	Medium, pear-shaped, good quality	Pale pink
Master's Early	Early	Late	Medium-large, pear-shaped	Pink
De Bourgeaut	Late	Late	Medium large, pear-shaped	Deep pink
Van Deman	Early	Very late	Medium, pear-shaped	Orange

12.1. Aromatnaya

Russian variety. One of the sweetest quinces, reputedly can be eaten as a dessert fruit when fully ripe. Hardy and heavy cropping. Harvest in September and use in October to December.

12.2. Arthur Coby

A very old cultivar named in honour of Dr Authur AS Coby Urbana Illinois, derived from *Chaenomeles lagenaria and C japonica*. Small bush like, grows up to 5-6 feet, upright and spreading, flower bright red in colour two or more inch across, showy, ornamental value. Fruit is large, round, flat, greenish yellow, smooth, late in ripening, good for making jelly.

12.3. Champion

Suitable for cooking, Regular cropper producing yellow-green, pear-shaped fruit. The fruit is large with pear shaped and fuzzy, golden-yellow skin. It is a late-season quince, valued for its delicate, slightly lemony flavor.

12.4. Cooke's Jumb

The fruits are large, yellowish-green with pear shaped with tender, white flesh. It is most commonly used for baking, preserves and jelly.

12.5. Meech's Prolific

Self fertile cultivar, suitable for cooking. It produces large, yellow fruit and subtle pink flowers

12.6. Orange

Orange-yellow flesh, golden skin, rich flavour, low chill fruit. An old favourite also known as "Apple," *Cydonia oblonga* "Orange" quince is a richly colored fruit with round shape and a strong fragrance. The tender flesh is yellow with an orange tint. "Orange" quince is sweeter and milder than most varieties, and is one of the few varieties suitable for eating raw.

12.7. Pineapple

It is a preferred low chill variety with pineapple flavour; white flesh and golden skin. With its rounded shape, light skin and tender, pale flesh, *Cydonia oblonga* "Pineapple" quince is so-named because its flavor is similar to the pineapple. Widely grown in California, "Pineapple" quince is harvested from August through late winter. Off-season, it is often imported from Chile. Because the fruit is tart and firm, it is most often used in cooking.

12.8. Portugal

Fruits grow on a small tree or shrub (8-12 feet tall) with twisted, bumpy branches. It is grown as flowering ornamental or for fruit for processing purposes. Adapted to many climates. It tolerates to "wet feet" better than most other deciduous fruit trees. It trees bloom late, which means that they avoid spring frosts. It has many of the same pest problems as apple and pear. Varieties are self-fruitful, used as a dwarfing rootstock for pear.

12.9. Rich's Dwarf

Contrary to its name, the fuzzy, lemon-yellow fruit of *Cydonia oblonga* "Rich's Dwarf" quince is unusually large. The name is due to the size of the tree, a smaller tree easily maintained at a height and width of 8 to 10 feet.

12.10. Serbian GolD (syn. Leskovac)

Self-fertile cultivar, suitable for cooking, medium to large fruit, good for stewing. Fruts are also used for alcohol production in Serbia. It is one of the hardiest quinces. Highly productive with good disease resistance. Harvest in October, use November to February. A healthy, heavy cropping variety, can be used to make quince liquor.

12.11. Smyrna

Large fruit with brown pubescence. Light, tender flesh, yellow skin, low chill cultivar. *Cydonia oblonga* "Smyrna" has a stronger fragrance than most varieties. The fruit is rounded or slightly oblong, and the flesh is white. Although "Smyrna" quince keeps longer than most varieties but flavor is least.

12.12. Vranja

Self fertile, suitable for cooking, produces pale green-yellow fruit, similar in size to Meech's Prolific. Large, aromatic fruit, good for stewing. Vigorous, upright tree, moderately productive. Harvest in September to October and use in October to February.

Variety susceptibility to fleck

Susceptible	Moderately susceptible	Moderately resistant	Resistant
Orange	Champion	Appleshaped	De Vranja
Powell's Prize	Fuller's	De Bourgeaut	
	Missouri Mammoth	Master's Early	
	Pineapple	Mummery's Seedling	
	Portugal	Smyrna	
	Rea's Mammoth		
	Van Deman		

13. FUTURE PROSPECTS/THRUST

The large phenotypic and genetic diversity in the genus *Chaenomeles*, as inferred from morphological and biochemical traits, and from molecular markers, is advantageous for crop improvement through breeding and selection. The high content of dietary fiber and pectin in the fruit makes a promising candidate for the manufacture of dietary fiber-

containing food products and pectin. The pleasant flavor and high acidity of the fruit, make the crop interesting as raw material for development of a range of sweetened food products. At present, the absence of selected cultivars limits the possibility for large-scale product development. The first cultivars should be available for marketing within a few years. It will then be possible to establish pilot plantations, yielding high quality fruits for further product development and marketing of this new crop.

The existing germplasm of quince is generally preserved as ex-situ in the form of clonally propagated trees, further the types/ clones preserved for fruit purposes are usually propagated by budding or grafting on a clonal quince rootstock (Quince A, B, BA-29, etc.). The commercially used rootstocks can be propagated onto specific or desired rootstock, may be maintained in stool beds as self-rooted plants or planted as self-rooted trees. Besides this conventional approach, in-vitro preservation methods are needed as secondary or back up collection as a protective measure against loss of the genotype(s) in the orchard plantation or in nursery against climatic hazard, insect pests and diseases. In vitro culture of shoots are used for medium term storage and cryopreservation of in vitro cultured apical meristems in liquid nitrogen has been achieved for as long term storage, using gas permeable bags in place of glass tubes viable cultures have been successfully maintained and stored for over 2 years at 4°C . The same could be maintained for 12-18 months with a 16 h photoperiod. Duart (1985) was able to store defoliated shoots for about 4 years at 2°C on agar medium without growth regulators. As regards cryopreservation, Reed and Chang (1997) has referred to three major techniques i.e. slow freezing, vitrification and encapsulation-dehydration.

Future thrust of quince is summarized below:

- Selection criteria for breeding; i.e. is tree architecture of self-rooted trees a predictor of performance as a rootstock is desirable.
- Inheritance studies of key traits;
- Further investigations are required to see the utility of intergeneric apple x quince hybrids as a novel fruit crop.
- Detailed analysis of the effects of dwarfing rootstocks on scion *vis a vis* tree architecture and fruiting;
- Underlying mechanisms of dwarfing unique to pear (i.e. graft incompatibility, water relations, nutrient uptake and synthesis, photosynthate and carbohydrate synthesis and distribution, phytohormone metabolism and transport, etc).
- A thorough analysis of the mechanisms of dwarfing is absolutely imperative as a basis for applied research;
- Research is required on the consumer acceptability with respect to the texture and overall quality of fruits.

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QUINCE VARIETY



Aromatnaya



Champion



De Vranja



Flower Buds of a Japanese Quince



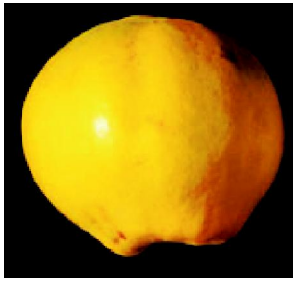
Gold Portugal



Jumbo Quince
(Aka Golden)



Meech's Prolific



Missouri Mammaoth



Pineapple Quince



Portugal



Pyronia (*Pyrus pyrifolia* x *Cydonia oblonga*)



Quince - Plant, Flower, and Fruiting



Siberian



Smyrna Quince



Van Deman



Vranja