

CRABAPPLE

(*M. baccata* (L.) Borkh)

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1. INTRODUCTION

A crabapple is basically a small apple. The most common crabapples are hybrids of the common apple and the Siberian crabapple (*Malus sylvestris* Mill. x *M. baccata* (L.) Borkh. H Bailey (1949) listed eight species. Jefferson (1966) stated that there were more than 200 species and cultivars in the National Arboretum. Wyman (1965) stated that there were 250 cultivars in the Arnold Arboretum. The USDA (1967) listed 19 popular cultivars including six hybrids. Van Dersal (1938) listed 10 species of crabapples of value in erosion control and of value to wildlife. The crabapple fruit is not an important crop. Most crabapples are grown for their ornamental value, and cultivars are chosen because of their beautiful flowers, foliage, or fruit. The fruit is preserved or pickled or it is used in making jellies. The general appearance is similar to a small bearing apple tree. Culture is also similar to the culture of apple trees. No production data are available on the quantity of fruit that is used commercially.

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Crab apple fruit is not an important in most areas, being extremely sour and (in some species) woody, and is rarely eaten raw for this reason. In some south East Asian cultures they are valued as a sour condiment. Sometimes crab apple fruit is eaten with salt and

chili pepper, or shrimp paste. Some crab apples varieties are an exception to the reputation of being sour, and can be very sweet, such as the ‘Chestnut’ cultivar. Crab apples are an excellent source of pectin, and their juice can be made into a ruby-coloured preserve with a full, spicy flavour. A small percentage of crab apples in cider make a more interesting flavour. As old English Wergulu, the crab apple is one of the nine plants invoked in the pagan Anglo-Saxon Nine Herbs Charm, recorded in the 10th century. Apple wood gives off a pleasant scent when burned and smoke from an apple wood fire gives an excellent flavour to smoked foods. Crabapple has been listed as one of the 38 plants that are used to prepare Bach flower remedies, a kind of alternative medicine promoted for its effect on health.

2. DOMESTICATION

The crab apples are the wild forms of cultivated apples. Ignatov and Bodishevskaya (2011) had described that Wild (Crab) apple trees are ancestors and close relatives of domesticated apple trees (*Malus × domestica* or *Malus pumila*). There are at least 35 different species of wild apple, with the highest genetic diversity in Central, Inner Asia and West China region. The plants have a wide range of adaptation to different soil and climate conditions and resistance or tolerance to a number of biotic and abiotic stresses. Having the same basic chromosome number, and easily crossable with domestic apple, wild apples are valuable donors of novel traits for commercial apple cultivars. Besides this, wild apples are known worldwide as ornamental plants and are a potential source of health and medical products including polyphenols, pectins, and vitamins.

3. TAXONOMY

The genus *Malus* has 25-30 species and several subspecies so called as crab apples many of which are cultivated as ornamental trees for their profuse blossom and attractive small fruits. Most of the species intercross and since self incompatibility is common trees produce from seed obtained from a botanical garden or arboretum were collection of *Malus* are grown almost always are of either interspecific or intercultivar hybrids. The cultivated apple arose from *Malus sieversii* which is a wild from the heavenly mountains (Tien Shan) from the boundary between western china and the former Soviet Union to the edge of the Caspian Sea. The diverse and full range of variation in forms of colors and tastes are found in Kazakhstan and the other independent countries of central Asia from the breaking of union and especially alround Alm Ata (father of apple). This is the area of greatest diversity and is the centre of origin. The taxonomic position of crab apple is given below:

Kingdom: Plantae

Order: Rosales

Family: Rosales

Genus: *Malus*

Species: *baccata*

Crab apple plant grows up to 10–14 meters high with arching or overhanging red-brown branches and red-brown buds. Petioles are 2–5 cm long, with few glands and with elliptic or oval shaped leaves, (3–8) × (2–3.5) cm in size. Pedicels are slender and 1.5–4 cm long. They bear white fragrant flowers of 3–3.5 cm diameter which groups by 4–6. Petals are white and oval-shaped, with a size of 2–2.5 cm. Flowering occurs in spring, with fruits appearing in September–October. Fruits are red to yellow and are only about 1 cm in diameter; they form dense clusters and resemble cherries from a distance.

4. CENTERS OF DIVERSITY

“Crabapple” is the name given to wild North American *Malus* (apple) species or to any apple with a diameter less than 2 inches. There are many crabapple species native to North America, although only one is native to Alaska-*Malus fusca* (Raf.) C.K. Schneid., also known as *Malus diversifolia*, Western crabapple or Oregon crabapple. *Malus fusca* is found from California to South central Alaska. Wild Alaska crabapples grow on trees or shrubs 6 to 16 feet high. The leaves are oval and up to 3 inches long with toothed edges. Leaves are smooth on top and hairy on the underside. The blossoms have five white petals. The acidic wild crabapple fruit is small, oblong and less than 1 inch long. Trees bloom in June and the fruit ripens in late August through October. Though the fruit from *Malus fusca* is small and tart, the juice and puree of these small crabs can be added to other wild fruit jams or jellies.

4.1. Distribution

Little is known about either distribution or genetic diversity of this species. The species apparently occupies at least two distinct climate regions: a colder, drier northern region and a warmer, wetter southern region. Total area of habitat encompasses 356,780 km² of low-lying areas along the Pacific coast. A total of 239 *M. fusca* individuals sampled from across its native range were genetically compared using six microsatellite markers to assess for possible geographic structuring of genotypes. The primer amplified 50 alleles. Significant isolation by distance was identified across the 2600 km (straight line) where samples were distributed. These results may help establish priorities for in situ and ex situ *M. fusca* conservation. Wild apple is a threatened indigenous species in Flanders. Scattered relict populations can be found across Flanders. These are restricted to small populations with diminished numbers of trees, or solitary specimens. Only in Meerdaal Forest, close to Leuven, a large population is present of around 200 trees. The relict crab apples are not only threatened by reduced population size, but also by hybridisation and introgression of foreign genetic information originating from domesticated apples. The one can observe not only morphologically pure types, but also intermediate forms between crab apple and domesticated cultivars. For conservation purpose, the distinction between pure crab apples and hybrid types is necessary. An interesting additional objective is the examination of the potentials of crab apples and old country races of

domesticated apples in the current apple breeding programs. The clonal gene bank in Dentergem will serve as a seed garden in the future, to produce plant material for landscape and woodland restoration projects.

5. OBJECTIVES OF IMPROVEMENT

As these types – crab apples are progenitors of cultivated forms the, very few, *M. zumi* cold hardiness and resistance. *M. floribunda* for scab resistance have been used in breeding programmes otherwise the fruit traits being much inferior compare to the cultivated types, number of breeding cycles are increased for the fruit characteristics.

6. CYTOGENETIC/CYTOTAXONOMIC BACKGROUND

Malus and *Pyrus* belong to the sub-family Pomoideae of the family Rosaceae and all have a basic chromosome number of $x=17$. Rehder (1954) has classified the genus *Malus* into 25 species (distributed in five sections) and the genus *Pyrus* into 15 species (in single section).

Most plants in most species in both genera are diploid, although tetraploids and /or triploids have been frequently, or even usually, found in several species. The *Malus* species in the section Chloromeles (all indigenous in North America) are the major exception being mostly either triploid or tetraploids, although *M. ioensis*, possibly the fact that all species which have contributed to cultivated varieties are diploid a relatively high proportion of scion varieties, especially of apple, are triploid. Selection by man has been strongly in favour of plants which resulted from the fertilization of unreduced ovules by normal haploid pollen.

Cytologically and genetically, $2n=2x=34$ plants usually behave as normal diploids. Nevertheless, over the years, there have been a number of suggestions, often conflicting (Knight, 1963), regarding the possible origin of *Malus* and *Pyrus* by secondary polyploidy from species with lower basic chromosome numbers. However, the origin from more primitive types was so remote in time that clarification of the issue is likely to be extremely difficult.

It has been traditional to classify the cultivated apple as *M. pumila* (formally *M. communis* or *Pyrus malus*), although some workers prefer to split this species into *M. domestica* (the cultivated apple), *M. pumila* (including var. *paratisiaca*, the paradise apple) and *M. sylvestris* (the wild crab apple). However, since the apple is self-incompatible and can be hybridized readily with most other *Malus* species it is probable that most European and Asian species have contributed to the evolution of present day cultivars.

It is considered that *M. sylvestris*, and *M. pumila*, were the major ancestral species of modern apples but with *M. spectabilis*, *M. prattii*, *M. baccata*, *M. prunifolia* and *M. astracanica* as significant additional contributors. He considers *P. communis*, *P.*

nivalis and *P. serotina* to be major contributors to the cultivated pear, with *P. syriaca*, *P. ussuriensis* and *P. longipes* significant minor donors. Other authors have implicated several additional wild forms in the origin of modern cultivars (Knight, 1963).

The Rosaceae family has traditionally been divided into four subfamilies on the basis of fruit type. These include:

1. Rosoideae (e.g., *Rosa*, *Fragaria*, *Potentilla*, *Rubus*, fruit an achene, $x = 7, 8$ or 9)
2. Prunoideae (e.g., *Prunus*, fruit a drupe, $x = 8$)
3. Spiraeoideae (e.g., *Spiraea*, fruit a follicle or capsule, $x = 9$)
4. Maloideae (e.g., *Malus*, *Pyrus* and *Cotoneaster*, fruit a pome, $x = 17$)

The crab apple (*Malus baccata* Borkh.) also have somatic chromosome number $2n=34$

7. INHERITANCE PATTERN

Inheritance of certain economic characters in hybridization between apples and crab-apples showed a fairly wide range of variation for winter hardiness (Chi-pin and Mo., 1964). A larger number of the progeny seedlings were cold resistant. There seemed to be a kind of “transgressive segregation” for the smallest fruit size, while the largest fruit segregates were only half the size of apple parents. Most of the progeny seedlings were poor in fruit quality. Even the best quality segregates were not able to approach to the highest quality apple parents such as Golden Delicious and Delicious. For time of ripening, the inheritance of the progenies tended toward the early maturity of the crab apple parents, most seedlings of the progeny ripened from the late of August to the beginning of September. When the combinations of apples $\times$ crab apples and their reciprocals crab apples $\times$ apples were compared, the progenies of the former produced seedlings with larger fruits, better quality and better keeping capacity, while those of the latter were prevalent in winter hardiness and slightly earlier both in time of fruiting and in time of ripening. The correlations between hardiness and fruit size, quality, time of ripening or keeping capacity were all insignificant. Significant positive correlations were found only between fruit size and quality or keeping capacity, and also between time of ripening and keeping capacity.

8. PROBLEM IN BREEDING

The *Malus baccata* form are the wild types and western Himalayan region is the secondary centre of its diversity. A number of species have been involved in the evolution of cultivated apple namely *M. sylestris*, *M. baccata* (imparted hardiness) while *M. micromalus*, *M. prunifolia* and *M. floribunda* were disease resistance sources. For resistance breeding these wild forms have played a significant role, but as for qualitative traits improvement a lot of problems are placed. The fruit quality traits are inferior and number of cycles is needed to improve the fruit trait. This increases the evaluation and selection to some period and adds to the cost of managing the vast population

9. FLORAL BIOLOGY

9.1. Inflorescence

The flower is similar to that of the apple. Nectar secretion and pollen production has not been studied in detail. Bees freely visit the flowers, for both nectar and pollen.

9.2. Flowering

Crabapple blossoms appear in April to May, depending on variety and elevation. Some crabapple varieties bloom relatively early, others bloom mid-season and some bloom towards the end of crabapple season. Crabapple flowers may be single (5 petals), semi-double (6 to 10 petals) or double (more than 10 petals). Single-flowered crabapple varieties tend to bloom earlier than semi-double or double-flowered varieties. Actual dates of blossoming can vary each year depending on weather conditions. The length of the blossoming period can range from 1 to 2 weeks, depending on the variety and weather conditions. Crabapple flower buds are attractive even before they open, developing color as they swell-called the balloon or bud stage. The balloon may be a different color than later flowers. For example, the balloon may be red-purple but flowers open later to pink or white. Although a crab apple flowers at the correct time and the pollen is shown to be compatible from hand pollination tests, this does not necessarily mean that it is the best one. Research conducted in the United States and at Orange in NSW has shown that bees, when out foraging apple blossoms, tend to stay with the same colour flower and fly past a different colour, especially if the blossom colours are very different, such as deep red or white with a tinge of pink. This could negate cross-pollination. Although there are reports of using a red crab apple variety in New Zealand, pollination there is carried out by both honey bees and bumble bees.

Most crab apples have quite a long flowering period due to spur flowers opening first, followed by one-year-wood flowers. Delicious varieties tend to flower only on spurs, but many other varieties flower on spurs and one-year wood. Spur flowers when set tend to produce larger fruits of more even good quality, rather than a mixture of fruit on spur and one-year-old wood, for storage as well as for grading.

9.3. Anthesis and Dehiscence

About 10 per cent of the flowers are open on 6th May, 80 per cent open by 12th May, and 90 per cent by 18th May. In this scenario the 80 per cent figure is equivalent to the peak blossom day mentioned above, when it is most useful as a pollinator and to be pollinated. However because a spread of dates is provided, the flowering times data is more useful than just knowing the blossom day, as it allows comparisons to be made with other varieties. It also explains a key point about the flowering groups mentioned previously, i.e. that varieties in neighboring groups are likely to overlap in their flowering times and therefore have the potential to cross-pollinate.

9.4. Pollination Requirements

Like the apple, the crabapple appears to require cross-pollination between cultivars by insects. Bradford and Bradford (1949) and Crandall (1928) concluded that all native crabapples are self-sterile. Pammell (1920) stated that self-pollination is impossible and that pollinating insects are absolutely needed. Cook (1891) covered 200 blossoms, which set no fruit, the same number not covered set three fruits. Jefferson (1968) discussed a new crabapple cultivar called “Fugi” whose anthers are generally sterile.

9.4.1. Pollinators

Little is known about which insect pollinators are of most value to crabapples. Pammel and King (1930) noted that the often cultivated Iowa wild crabapple was freely visited by honey bees. Considering that the only difference between the crabapple and the apple is fruit size, the deduction would appear reasonable that the most effective pollinator of apples, the honey bee, should be equally effective on the crabapple. Although the evidence is meager, it indicates that pollinating insects are essential for crabapple fruit production.

9.4.2. Pollination Recommendations and Practices

Individual or dooryard plantings usually are likely to receive ample insect pollination. If commercial fruit production is anticipated, and crabapple trees are grown along with other fruit trees in commercial orchards, there is likelihood that additional pollinating insects will be required. If the grower is providing bees for his other fruits, then he should provide enough for crabapples also.

9.4.3. Pollination

Pollination of flowering crabapples doesn't seem to be a concern, as though most are self-compatible. Some varieties naturally tend to produce a lot of blossom over a long period, and/or are genetically highly compatible with a lot of other varieties - this makes them good pollinators for other varieties. Most crab apples fall into this category and commercial apple orchards sometimes inter-plant them for this purpose. Some varieties are very poor pollinators. Bramley's Seedling is a particular case in point, because it is a 'triploid' variety which means its own pollen is ineffective at pollinating other varieties. Crab apple can be a better option for pollenizer. In general terms each species can only pollinate others of its own kind-apples will only pollinate other apples, pears will only pollinate pears, and so on. Amongst apples there is generally no distinction between crab apples, cider apples, and mainstream apples - they can all potentially cross-pollinate each other. Pollination is carried out by insects, often bees. Since pollination happens in early spring, good weather which will encourage bees. Pollination also depends on blossom and risk of late frosts which can damage blossom sometimes. Frosts just after pollination can also damage the first stages of fruit formation. Temperatures at blossom time are also very significant for effective pollination.

10. DIFFERENT SPECIES

10.1. *Malus baccata* var. *himalaica* (Maxim.) Schneid

It was collected from Himachal Pradesh at an altitude of 3000 m, Meghalaya at an altitude of 1303 m (Randhawa, 1987) and also grows wild in the hills of Uttar Pradesh (Srivastava *et al.*, 1977) whereas is used as rootstock as apple cultivars. Trees are small produce red colour fruits and partially resistance to collar rot (*Phytophthora cactorum*), root rot (c.o. *Dematophoranecatrix*) and wooly aphid (*Eriosomalnigerum*), Preliminary evaluation at IARI Regional Station, Shimla, based on leaf stomatal counts, indicate that it could be more dwarfing than M9 rootstocks, has very low chilling requirement and thus could be useful in breeding programme or for use as rootstock in warmer low chilling area (Randhawa and Kishore 1987, Kishore and Randhawa 1987). Since rootstock influence chilling requirement for scions (Young and Werner, 1985) there is scope to utilize such types as rootstocks for extension of apple cultivation. Clonal propagation of this species by mound layers did not succeed.

10.2. *Malus baccata* (Linn) Borkh (Shillong)

It was collected from Shillong (Meghalaya), locally named *Soh-sheur* at an altitude of 1300 m (Randhawa, 1987). It forms a small low branching tree producing small scarlet red fruits. Based on leaf stomatal counts, it appears to be similar in vigorous for M9. Its chilling requirement is higher than that of *Malusbaccata* var. *himalaica* but is much lower than M9 and MM106. Its propagation by mound layering yield profusely rooted suckers and the graft suckers of Golden scion is good with less shoot growth than on MM106 rootstock.

10.3. *Malus baccata* (Linn) Borkh (Khrot)

Locally known as *banphall*, this was collected from Khrot in Himachal Pradesh at an altitude of 2000m. Randhwa (1987) has reported that the plants in wild are low and spreading. The tree produces small fruits overlaid with red stripes. Seedlings of this species are also used locally as rootstocks for apple. On the basis of leaf stomatal count, it has been categorized to be as dwarfing as M9. It is easy to propagate, has good dwarf take of Golden Delicious scions exhibited appreciably less vigor than M9. Its chilling requirements is comparable to that of *Malusbaccata* (Shillong).

10.4. *Malus baccata* (Linn) Borkh (Giabung)

This variant has been collected from Giabung, (Himachal Pradesh, and altitude 2900 m). The tree locally known a *Lead* is small with slender branches produces small scarlet red fruits that are depressed at the apex. Propagation by mean of mound layering is fairly

easy (Randhawa, 1987). Though the stomatal density count showed it to be similar to M9 in vigour (Randhawa and Kishore 1987), actual growth with Golden delicious scions has shown to be more dwarfing than M9 (Kishore 1989).

10.5. *Malus baccata* (Linn) Borkh (Dhak)

Locally called *Bomtu*, it was collected from Dhak at an altitude 2060 m in Himachal Pradesh (Randhawa, 1987). In natural habitat the plants are tall and spreading. The fruits which are red with the yellow background are the largest (3.1 cm diameter) of all *M baccata* biotypes maintained at the IARI regional station, Shimla. Stomatal density counts indicated that it may be as dwarfing as M9, but the growth of one year old graft showed it to be semi- vigorous. For satisfactory propagation through mound layers, shoots must be blanching at the bases and treated with growth regulators. Its chilling requirement is less than that of M9 and MM106.

10.6. *Malus baccata* (Linn) Borkh (Rohru)

Collected from Rohru (Himachal Pradesh, altitude 2100 m), it is small bushy tree. The stomatal density count indicates that it may be more dwarfing than M9 (Randhawa and Kishore, 1987). Its chilling requirement is as low as that of *M. baccata* var. *himalaica* and under field conditions, it is stated to be moderately resistant to powdery mildew (c.o. *Podoshaera leucotricha*).

10.7. *Malus baccata* (Linn) Borkh (Srinagar)

It was collected from Srinagar (J & K) at an altitude of 1390 m (Randhawa, 1987). In natural habitat, the trees are not very large and produce small yellow coloured fruits. It was categorized as being similar in vigor to the semi dwarfing MM106, but the actual growth with Golden delicious scions has shown to be more vigorous (Kishore 1987). Its chilling requirement also appears to be appreciably lower than that of M9 and MM 106.

10.8. *Malus sikkimensis* (Hook. f.)KochneexSchneider

It was collected from the Lachen Valley in Sikkim (altitude 1970 m), locally called *Tipsi*, it is used in Sikkim as rootstock for apple (Randhawa, 1987). The tree is small to medium in size producing small, pointed, dull red fruits. Owing to occurrence of apomixes, its true to type propagation is possible through seed. Although mound layering first blanching the basis of shoots before mounding is also possible (Kishore and Randhawa, 1987). In vigour, it appears to be akin to M9 (Randhawa and Kishore, 1987). Preliminary evaluation indicates it to be resistant to cooler rot (Randhawa and Ram 1977) and powdery mildew (Ram and Randhawa 1979). Brown (1975) observed it to be highly sensitive to the latent viruses present in the scion wood. Since virus free bud sticks are not readily available in India, it would not be advisable to use it as rootstock.

11. CROP IMPROVEMENT METHODS

11.1. Selection

The Crabapple Evaluation Program began in 1984 at United States and distributed 49 crabapple taxa to 25 locations. The purpose of evaluation program was to select some of the good-quality crabapple cultivars that were readily available and test them at different locations throughout the United States. Previous crabapple evaluations were conducted in established collections. Disease resistance and other differences within a given cultivar were observed at various locations. The Crabapple Evaluation Program was designed to reduce variables in scion source and under stock which could be the cause of some of the evaluation variation. By 1990 most trees that had been distributed were large enough to evaluate for disease resistance and autumn aesthetic appeal. After four years of evaluation it was determined that there were a few cultivars that performed well at most of the test sites. However, many of the cultivars are affected by regional diseases and environmental factors. Crabapples recommended for use in a given area should be based upon the performance of the crabapples located in the closest test plot rather than from a generic list.

11.2. Hybridization

Hybridization done in European crab apple (*Malus sylvestris*) to investigate the genetic variation in Danish populations of the endangered European crab apple (*Malus sylvestris*). According to Larsena *et al.* (2006) special emphasis was given to hybridization between the wild species and its cultivated relative *Malus x domestica*. A total of 178 wild individuals from four Danish populations were studied along with a reference sample of 29 old cultivars. The genetic variation within and among samples was studied at ten microsatellite marker loci. Additionally, a morphological analysis was carried out to identify hybrids and test for correspondence between phenotypic and genotypic indices of hybridization. From application of ordination and a model based cluster analysis to the molecular data, two clusters were identified consisting of wild and cultivated individuals respectively. This indicates that pronounced admixture between the two species is not present. At the population level, a high correspondence was found between geographic isolation from *M. x domestica* and genotypic and morphological indices of hybridization. As expected, isolated populations appeared less affected by hybridization than poorly isolated populations. Isolated 'pure' *M. sylvestris* populations could thus be identified. However, morphological and molecular evidence of hybridization was found to be divergent at the individual level. This is suggestive of some historical introgression into the *M. sylvestris* gene pool, and indicates that relying exclusively on either morphological or molecular characters as diagnostic markers in studies of hybridization between *M. x domestica* and *M. sylvestris* might lead to fallible results. Combined application of genetic and morphological markers is therefore recommended.

11.3. Polyploidy Breeding

Gene flow from crops to wild populations is of increasing scientific and public interest, but the potential effects are not well understood when taxa differ in ploidy. The potential for hybridization and gene flow between the introduced diploid domestic apple, *Malus domestica* Borkh., and the tetraploid crabapple, *Malus coronaria* (L.) Miller. using ploidy and isozyme markers, was inferred the incidence of hybrids in natural populations (adults and open-pollinated seed) and in controlled crosses (Kron and Husband, 2009). Geographic range and flowering time overlapped sufficiently for cross-pollination between domestic apple and *M. coronaria*. Heterospecific crosses produced as many fruit and seeds. Some seeds from heterospecific pollinations were hybrids, while others were apomictic in origin. In a natural population, all adult trees tested were tetraploid, but open-pollinated seeds varied in ploidy: 57 per cent tetraploid (sexual or apomictic); 7.7 per cent diploid (apomictic); 7.4 per cent hexaploid or octaploid (sexual); and 27.5 per cent triploid or pentaploid hybrids. Despite previous reports showing that the native and introduced gene pools remain distinct, the high proportion of hybrid seeds suggests there is significant potential for gene flow from domestic apples into native *M. coronaria* populations. Susceptibility of the various varieties to bacterial fire blight (*Erwinia amylovora*) disease varies from susceptible to highly resistant.

12. DIFFERENT FORMS ON THE BASIS OF GROWTH PATTERN

12.1. Weeping-Spreading Form

***Malus* 'Molten Lava':** Highly rated crabapple. White flowers, yellow-orange fruits, 8 to 10 feet. Outstanding weeping-spreading crabapple for much of the year, and never mediocre. Fruits and yellowing fall foliage provide a fiery cascading image. After the fruit falls, the remaining pedicels provide an attractive feathery winter effect that complements the elegant branching structure. Trace of scab, but not a factor ornamentally.

***M.* 'Red Jade':** White flowers, red fruits, 8 to 10 feet. Great strength is its attractive spreading habit, providing interest through the year, especially in winter. Impressive blossom and fruit displays. Strap-like leaves and twisting of petioles are characteristic of this cultivar.

***M.* 'Mary Potter':** White flowers, red fruit, 10 to 15 feet. It is very attractive during the summer months due to pleasing spreading growth habit. Trace of scab, but overall very clean foliage. Exfoliating trunk bark is an intriguing feature.

***M.* 'White Cascade':** White flowers, small yellow fruits, 10 to 15 feet. Exquisite flower display with waterfalls of cascading blossom covered branches. It provides an effective presentation from early to mid summer due to its attractive weeping form. However, moderate scab and a trace of frog-eye reduce its appeal in late summer.

12.2. Small Spreading Form

12.2.1. *M. sargentii*

White flowers, red fruits, 6 to 10 feet. Attractive low-spreading growth habit is an excellent feature, especially as plant ages. It is resistant to scab with just a trace of frog-eye leaf spot. Fruits tend to shrivel early in fall, diminishing winter impact. *M. sargentii* 'Rosea' differs from the species in that it has rose-pink buds.

12.2.2. *M. Red Jewel*

White flowers, cherry red fruit, 10 to 15 feet. Attractive, persistent red fruits are outstanding, complementing its small, delicate growth habit. Most effective through fall and winter months. Foliage is relatively scab free with a trace of frog-eye.

12.3. Large Rounded Form

12.3.1. *M. 'Donald Wyman'*

Highly rated crabapple. White flowers, bright red fruits, 20 feet. Lustrous green foliage, good overall growth habit, and outstanding small glossy fruits make this tree exceptional. Traces of scab and frog-eye on leaves are negligible. Alternate flowering pattern results in "off" or sparse bloom, though this selection typically has outstanding blooms.

12.3.2. *M. 'Sugar Tyme'*

White flowers, brilliant red fruits, 15 to 18 feet. Marvelous fruit and flower displays. Foliage remains clean with only traces of scab and frog-eye leaf spot. Excellent all-purpose tree due to captivating fruit display which begins in mid-fall and persists through the winter.

12.3.3. *M. baccata 'Jackii'*

White flowers, maroon-red fruits, 30 to 40 feet. Glossy, large, disease-free, deep green leaves are an exceptional ornamental feature. Handsome overall form and structure. Fruit somewhat sparse, but shiny and in attractive clusters; becoming soft in November. Large tree is mediocre throughout winter months.

12.3.4. *M. 'Bob White'*

White flowers, yellow fruits, 20 feet. Outstanding feature from November through February is persistent, small, firm yellow-gold fruits maturing by January into orange-gold color. Foliage relatively clean with just a trace of scab and frog-eye leafspot. Only mediocre during spring and summer months.

12.4. Upright Form

M. 'Sentinel': White with pink tinged flowers, red fruits, 15 to 20 feet. Vase-shaped upright habit. Pink buds opening to tinged white flowers are sensational. Trace of scab

does not diminish the ornamental effect of this tree. Persistent fruits through the winter are nice but can detract during spring and early summer until they fall off.

12.5. Unique Growth Form

M. 'Strawberry Parfait': Pink flowers, fruits start yellow with increasing red blush. Unusual erratic upright-spreading growth habit is one of best features. Good firm fruits into the winter. Foliage was striking as it developed along the upright stems in the spring. Excellent scab resistance with a trace of frogeye leaf spot. Unusual shape is not for every landscape.

13. CRAB APPLES VARIETIES

Three crab apple cultivars 'Kuku', 'Ritika', and 'Ruti' have been bred by K. Kask, crossing in 1986 'Cortland' with a scab resistant berry-apple type seedling No 23, found incidentally. Fruits are small, 20 g (sometimes 30 g). Flesh is sour and sweet Juice of 'Kuku' is very tasty. All have been registered in 2009. 'Kuku' is included into the List of fruit cultivars recommended for growing in Estonia (crab-apple for salad) since 2005.

13.1. Manchurian

Fairly large white flowers with pale pink buds; prolific flowering on one-year wood; upright tree habit. Suitable for Braeburn, Granny Smith, king flowers of Delicious as well as many others, but it may be too early for Fuji and Gala.

13.2. Golden Hornet

Medium white with deep pink bud; upright tree habit. Mostly suitable for Fuji, Gala, Jonagold and Delicious, but in certain seasons may miss some king flowers.

13.3. John Downie

Medium white with a touch of pink in the bud. Tallish spreading tree habit.

13.4. Pink Flower Types

Pink flowers are more intermediate for crossing with white. Some bees will bypass the colour but others will also cross from colour to colour.

13.4.1. *M. × magdeburgensis*

Large pink semi-double flower with same colour in the bud. Spreading tree habit. Good timing for Delicious but late for Braeburn.

13.4.2. *Hillierii*

Smallish pale pink. Very prolific flowering. Spreading and weeping tree habit. Good timing for Delicious but late for Braeburn.

13.5. Red or winey red flower types

Bees tend to forage flowers of a similar colour, so different colours are less likely to be cross-pollinated.

13.5.1. *M. × aldenhamensis*

Medium winey red with a deep red bud. Spreading tree habit. Later flowering that will probably miss Delicious king flowers, but could be suitable for Gala, Fuji and Jonagold.

13.5.2. *Profusion*

Medium to large bright red with deep red buds. Spreading tree habit. Wide spread of flowering from very early to mid-late, and could be more useful for early flowering varieties such as Braeburn, Granny Smith or Jonathan.

14. ACCORDING TO HERMAN *et al.* (2011) RECOMMENDED CULTIVARS ARE AS FOLLOWS

14.1. Rosy-Pink Flowers

14.1.1. *Adams Crabapple*

Malus x ‘Adams’ Z3.5 Introduced by Adams Nursery, Westfield, MA. Foliage green, reddish-purple tinted in spring. Dense, rounded tree form. Flower buds carmine, flowers bright pink, fades. Fruits are dark glossy-red, 5/8", very persistent. Excellent disease resistance to date. Usually develops orange-red fall colour. Grow under “hardening conditions” first several years.

14.1.2. *Centurion Crabapple*

Malus x ‘Centzam’ Z3 Simpson Nursery selection, Vincennes, IN. Leaves reddish-purple in spring, green with purple-red tint in summer. Upright in form, becoming more open and round-spreading with spire-like branches. Flowers are rosy-red, showy. Glossy cherry-red fruits, - 5/8", persist for several months in the fall. Excellent disease resistance to date. Russet coppery fall colour develops. Very hardy.

14.1.3. *Indian Magic Crabapple*

Malus x ‘Indian Magic’ Z3 Simpson Nursery selection. Dark green foliage. Open, rounded in form. Flower buds red. Flowers are rich, deep pink. Glossy, red 1/3 fruits, changing to deep orange, are very persistent. Disease resistance very good to date in Northern Plains. Some reports state good to intermediate apple scab resistance. Red-orange fall colour is usually excellent. Hardy.

14.1.4. *Indian Summer Crabapple*

Malus x 'Indian Summer' Z3.5 Simpson Nursery, sister seedling of Centurion®. Leaves purple-green in spring, bronze-green summer. Broadly rounded in form. Rose red showy flowers. Bright red, 5/8 - 3/4" fruits are very persistent. Excellent disease resistance to date. Grow under "hardening conditions" first several years.

14.1.5. *Selkirk Crabapple*

Malus x 'Selkirk' Z2b-3 Introduced at Morden Research Station. Spring leaves bronzy-green, summer leaves dark green. Round, spreading form. Rose-purple buds, rosy-pink flowers. Glossy, dark red." fruits. They are not persistent beyond the end of October so can be messy. Very good disease resistance, but intermediate for apple scab. Very hardy.

14.2. Pink Flowers

14.2.1. *Red Splendor Crabapple*

Malus x 'Red Splendor' Z3 Bergeson Nursery introduction. Reddish green spring foliage, becomes mostly green, semi-glossy. Tree form spreading, fairly dense. Flower buds rosy, open bright pink, they do fade. Shiny, cherry-like red, extremely persistent fruits. Fairly good disease resistance, slight apple scab and moderate fire blight susceptibility. Fall colour deep russet coppery shades. Very hardy.

14.3. White Flowers

14.3.1. *Beverly Crabapple*

Malus x 'Beverly' Z3.5 Originated at the Morton Arboretum, Lisle, IL. Leaves are bright green. Dense, rounded in form. Flower buds reddish-pink, opening to white. Bright, glossy red 2/3", retentive fruits. Very good disease resistance, highly apple scab resistant. Moderate susceptibility to fire blight, but little or none in our trials to date. Leaves turn yellow in fall. Grow under "hardening conditions" first several years.

14.3.2. *Winter Gem Crabapple*

Malus x 'Glen Mills' Z3.5 Introduced by Peter Overdezest, Glen Mills Nursery in PA. Leaves are bright green. Growth habit is rounded, dense and well-branched. Flower buds are pink, flowers opening to white. Red, glistening S 1/3" fruits in abundance. Excellent retention in fall. This cultivar is not commonly found in the commercial nursery trade, but was singularly outstanding in fruit display even into the winter. No disease problems to date. Excellent golden, orange-tinged fall colour. Grow under "hardening conditions" first several years.

14.3.3. *Canary Crabapple*

Malus x 'Canary' Z3.5 Introduced by Simpson Nursery. Leaves green. Open, spreading somewhat, horizontal branching is almost reminiscent of weeping crabapple. Abundance of small, white flowers. Fruits are S 1/3", shiny golden-yellow. Cling through October, but

birds favour them so no droppage in our tests. Disease resistant to date. Yellow, tinged orange, autumn colour. If evaluations continue to be promising, 'Canary' may be superseded in the near future by recommending Harvest Gold Crabapple – *Malus* x 'Hargozam'. The latter grows upright-oval with dark green leaves; flowers are white and fruits are yellow. Disease resistance has been good to date. Grow both of these cultivars under "hardening conditions" first several years.

14.3.4. Donald Wyman Crabapple

Malus x 'Donald Wyman' Z3 Arnold Arboretum introduction. Semi-glossy dark-green foliage. Spreading, rounded form. Flower buds rosy pink, open to near white. Fruits glossy-red, 3/8", very persistent through winter. Very good disease resistance. Golden orange fall colour develops. Grow under "hardening conditions" for several years.

14.3.5. Jack or Korean Crabapple

Malus baccata 'Jackii' Z3 Foliage is semi-glossy, green. Trees develop rounded crowns. Flower buds light pink, open pure white. Fruits small, 3/8", variably reddish blushed, semi-persistent. Excellent disease resistance. Yellow fall colour. Very hardy.

14.3.6. Spring Snow Crabapple

Malus x 'Spring Snow' Z3 A Dolgo Crabapple seedling. Bright green, semi-glossy foliage. Narrow, upright-oval form, becoming rounded with age. Pure white fragrant flowers; no fruits, sterile. Good disease resistance to date in Northern Plains, but fire blight can occur and reports of apple scab susceptibility are appearing in the literature. Good heat tolerance. Some yellow fall colour develops. Very hardy.

14.3.7. White Candle Crabapple

Malus x 'White Candle' Z3 Inter-State Nurseries introduction, NJ. Dark green foliage, long leaves. Narrow, erect growth form. Flower buds dark pink, open to near white; many flowers, semi-double. Fruits 5/8, red, medium numbers produced, not heavily set, only semi-persistent. Average to good disease resistance, some susceptibility to apple scab and fire blight. Little or no autumn colour. Hardy.

14.4. Purple foliage

14.4.1. Cardinal Crabapple

Malus x 'Cardinal' (PP #7147) Z3.5 Princeton Nursery introduction, NJ. Leaves purple-red to purple, glossy. Upright, becoming more spreading to somewhat flat-topped with age. Flower buds deep red; flowers bright red, fade to magenta-pink. Fruits are sparse, deep red, S 1/3". Fall colour brilliant, showy deep red. Reputed to be the most disease resistant purplish-leaved cultivar. Grow under "hardening conditions" first several years.

14.4.2. Purple Prince Crabapple

Malus x 'Purple Prince' (PP #8478) Z3.5 A Father John Fiala selection introduced by J. Frank Schmidt and Son Co. Spring foliage purple, summer bronze-green. Young trees oval, becoming rounded. Carmine-red buds, open to bright rosy-red, petals narrow. Fruits abundant, non-showy, glaucous bluish-purple, quite persistent in fall. Bark is cherry like. Purple red fall foliage. Excellent disease resistance. Grow under "hardening conditions" first several years.

14.4.3. Thunderchild Crabapple

Malus x 'Thunderchild' Z2b-3 Canadian introduction. Purple foliage is its major asset. Upright, round-spreading in form. Deep rosy-pink flowers. Purple-red fruits, produced only in moderate numbers, not very persistent. Fall color is non-showy. Foliage break down may occur in fall. Newer cultivars superior in this regard. Very hardy. A severe strain of apple scab has become a major problem in the Prairie Provinces of Canada. 'Gladiator' is a new purplish-foliage crabapple with glossy leaves and improved disease resistance and is being recommended as a replacement for 'Thunderchild'. 'Gladiator' is narrowly upright in form. Selected by Rick Durand, Prairie Shade Nursery, Portage la Prairie, MB. Jeffries Nurseries introduced Purple Spire, a new compact, columnar form with showy purple foliage, also in Portage la Prairie.

14.4.4. Velvet Pillar Crabapple

Malus x 'Velvetcole' (PP #4758) Z4 Leaves purple to purple-red. Upright, ascending branches, nearly columnar in early years. Flowers pink, somewhat sparse. Fruits also sparse, red, semi-glossy, fairly persistent. Very good disease resistance, but only fair apple scab resistance reported. Fall colour a showy deep red. Grow under "hardening conditions" first several years. Somewhat borderline in hardiness during establishment years.

14.5. Weeping Form

14.5.1. Molten Lava Crabapple

Malus x 'Molazam' (PP #6672) Z3 Selected by Father John Fiala and introduced by Lake County Nursery, Perry, OH. Green leaves. A semi-weeper, spreading horizontal branching. Flower buds red, flowers open to white. Fruit S 1/3" bright shiny red, quite persistent. Very good disease resistance. Golden-yellow fall colour, orange-tinged. Hardy.

14.5.2. Royal Fountain Crabapple

Malus x 'Huber' Z3. A small, weeping crabapple. Purple leaves, becoming bronze-green. Flowers are a beautiful rosy-wine. Fruits, deep red-purple 3/8", good persistence, but not very showy. Fair to good apple scab-fire blight resistance to date. Very striking in flower display.

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CRABAPPLE (*M. baccata* (L.) Borkh)



Siberian crab apple



Malus 'Adams'



Centurion® Crabapple



Indian Magic Crabapple



Indian Summer Crabapple

CRABAPPLE (*M. baccata* (L.) Borkh)



Thunderchild Crabapple



White Candle Crabapple



Purple Prince Crabapple



Molten Lava Crabapple



Royal Fountain ® Crabapple

