APPLE AND PEAR ROOTSTOCKS FOR ATLANTIC CANADA

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INTRODUCTION

The selection of the appropriate rootstock and good strains of marketable cultivars are fundamental in the success of an orchard enterprise. After the orchard is established, cultivars can be changed by grafting, however, a poor rootstock selection must either be tolerated or the orchard removed. Selection of the understock is governed by the intensity of management, financial considerations, climate, orchard site, soil, and cultivars. Obviously, with this many variables it is difficult to chose one perfect combination, so the orchard manger selects the most appropriate rootstock for optimum success.

The roots and lower part of the trunk of the tree, below the graft union, is called the rootstock. In some situations the rootstock may consist of a root system plus one or more segments grafted to the root system. Establishing the rootstock in the nursery is the first step in orchard propagation. Selected cultivars are propagated by grafting scions of a cultivar to the selected rootstock. Fruit trees grown from seed on the other hand will have components of both parents (egg plus pollen). These trees grown from seed have mixed genetic makeup and can vary from thorny with small fruit to thornless with large fruit. To obtain fruit trees of identical genetic makeup cultivars are propagated vegetatively by the means of grafting on to rootstocks.

The intent of this publication is to describe the rootstock characteristics of those presently utilized in the Atlantic region and introduce new rootstocks that are presently under going evaluation in rootstocks trials located in this region. This publication only deals with apple and pear rootstocks and not stone fruit.

DEFINITIONS

Cultivar -The word "cultivar" is synonymous with the term "horticultural variety" used in most horticultural writings prior to 1952. An International Code of Nomenclature for Cultivated Plants states that the term "cultivar" be applied to those special forms which have originated or are maintained only in cultivation and that the term "variety" be reserved for those forms of cultivated plants which are known to occur in the wild and which have names in the Latin language (botanical varieties). For example, McIntosh is no longer called a variety but is properly referred to as a cultivar.

Stock or Understock - The supporting part of the fruit tree, including the root and sometimes more or less of the stem or even the stem and part of its branches, in a grafted plant.

Rootstock - The root portion of the tree below the graft union.

Framestock -The trunk and basal portion of the main branch.

Intermediate, Stem-piece, Stem-builder, Interstock, Interstem – The piece of the tree trunk that occupies the portion between root and top in a double-worked tree.

Single, double, triple, 4-way working - The number of segments added by successive budding and/or grafting above the root. Tree is said to multiple worked.

ROOTSTOCKS

There are two types of rootstocks, seedling and clonal.

Seedling rootstocks - These rootstocks are grown from seeds (sexual propagation) either of a specific cultivar, such as Beautiful Arcade in the case of apples and Bartlett for pear, or from the various cultivars that are utilized for processing. In either case the seedling rootstock which is produced, contain's genetic material from both parents so the trees grown on seedling rootstocks will be inherently variable. If both parents are known and previous progeny are studied, at least some degree of performance can be predicted. If not, no one knows the strengths or weakness inherent in that particular seedling population. Seedling rootstocks usually grow into full-size trees, which are too vigorous for most modern high-density apple orchards. Despite this fact and the potential risks of the unknown they are still used in apple orchard under certain instances where vigour is needed such as with spur-type cultivars on low vigour soils. Until recently seedling rootstocks were the most commonly used stock for pears in North America because of the lack of well tested clonal rootstocks. Seedling roots have the advantage of being less expensive than clonal stocks, free of known virus, self supporting, and generally adapted to a wide range of soil and climatic conditions.

Clonal rootstocks - These rootstocks are produced by asexual or vegetative means, such as mound layering, hardwood cuttings, softwood cuttings, or tissue culture. Unless there is mutation, all plants are identical to the mother plant. This genetic uniformity is of great value to the commercial tree fruit grower. It allows the selection of a range of tree sizes and other traits required for particular situations. Performance of the orchard can be predicted because of research results from trials where the various introductions were evaluated. Long term trials are needed to asses the performance of new introductions and unfortunately fewer of these trials are being funded.

Tissue culture is a relatively new technology that enables rapid multiplication of plants with the same characteristics. Special methods have been developed for virus detection as well. Propagators can now provide large numbers of certified virus-free rootstock in a very short time. The elite parent material must of course be inspected and certified free of disease.

INTERSTEMS AND FRAME BUILDERS

An interstem or frame worked tree has another cultivar type grafted into provide a section between scion and root system. This could range from a 5 to 35 cm piece known as an interstem. A frame builder extends the entire trunk and basal parts of the main branches. The purpose for this genetic addition to the tree may be to improve compatibility between roots and the fruit-bearing parts, control tree growth or disease or hardiness.

In theory stem-pieces provide an attractive possibility to add the best features of two genetic traits in order to overcome one or more weakness. For example, a widely adaptable and good performance stocks like B.A. or MM.111 could be "chocked down" to give a smaller tree through use of a dwarfing interstem like M. 9, Ottawa 3, or M. 27. The tree would have superior anchorage provided by BA or MM. 111 with a tree size smaller than MM.111 alone (and would avoid the poor anchorage of the intermediate stocks when they are used as rootstocks). Research has shown that sometimes there is a good additive or synergistic effect from using this type of combination; for example, trees on MM.106 roots with M.9 stem-piece seem to be especially productive. The length of the stem piece influence tree vigour and longer stem pieces are more dwarfing than shorter pieces i.e., 25 cm-10cm". Stem pieces using M. 9 and roots of either M.106 or MM.111 have been the most commonly utilized and commercially available combinations. (Such a combination is written in top-to-root order, e.g. McIntosh/M. 9/MM. 106). For colder areas, Ottawa 3 or Bud 9 would likely be a better choice for the stem piece.

The use of stem-pieces, however, does have drawbacks:

a) Tree costs are higher.

b) They are not as readily available from commercial nurseries

c) There is more of a chance of incompatibility, especially if all parts are not free of viruses.

d) Root suckers will be more apt to develop. (There are combinations now for which this is less of a problem)

When interstem trees were first introduced tree support systems were not recommended. Burying the lower graft union to at least half way up the stempiece was thought to provide adequate support. Tree leaning and subsequent loss of vigour, however, was a problem in some of the earlier plantings where dwarf stem-pieces such as M. 9 were used. The standard practise now is to recommend support systems for these types of combinations to accommodate the early and heavy production thus avoiding tree leaning and loss of tree vigour.

In colder areas outside of the Annapolis Valley, tender cultivars should be grown on hardy framestock; such as KSC 28, Wealthy, Lobo, Beautiful Arcade or Antonovka. Hardy framestocks trees are seldom available from nurseries, unless they have been propagated by special order placed two or more years in advance of planting date.

For the pear orchard, an interstem is used to overcome compatibility problems between the dwarfing rootstock quince and certain pear cultivars. When required the cultivar Hardy, which is compatible with quince, is used for the stem piece

ROOTSTOCK CHARACTERISTICS

1. **Vigour.** Rootstocks can provide a complete range in tree size control. Once the orchard is planted it cannot be changed so selecting the best rootstock is a very important decision. Unfortunately designing an orchard with a specific tree size is not as simple as picking a certain rootstock. The ultimate tree size for an orchard is strongly influenced by many factors including; cultivar, soil type, climate, and training system as described by Embree and Woodworth in the 1996 Agriculture Agri-Food Canada technical publication # 4 "Fitting Spur-type McIntosh into the new orchard design". Note, a rootstock that provides 60% size control of a vigorous cultivar such as McIntosh will result in a much larger tree than the same rootstock with a less vigorous cultivar like Idared. .

2. **Precocity.** This is defined as the speed it takes a tree to move from vegetative to the reproductive stage. It is strongly influenced by the cultivar and rootstock. Many stocks have been promoted because of their ability to induce the cultivar to bear fruit within a year or two after planting. Although early production is desirable it may not necessarily always be an advantage. Capacities for early production are important but, not if it is at the expense of tree development and the failure of the mature trees to fully utilize its allotted space in the orchard.

3. **Production-Efficiency.** Precocity in the young tree and productivity of the same tree when mature are not necessarily correlated. Trees on size controlling stocks do tend to crop heavily for their size and therefore appear to be very efficient in converting the incoming light energy into fruit. With many trees per hectare, full yields are soon reached, but present evidence suggests that the stock listed in Table 1 will all support high yield efficiencies if trees fill their allotted space and training and pruning are suitable.

4. **Site and soil requirements.** Soil type can have a strong influence on vigour therefore it needs to be taken into consideration when determining the vigour level of rootstocks. Growers may sometimes need to use more than one rootstock with-in the same orchard site in order to compensate for changing soil types. Generally more vigorous stocks should be used on light, weaker soils and weaker stocks on stronger soils. Keep in mind that certain conditions like cold and wet or hot and dry may make a given rootstock the best choice even though it may not fit the exact size range originally envisioned. Since our soils tend to be rather variable, one should consider the use of several stocks which match the vigour mosaic of the new orchard site. e.g. A dry knoll would have a more vigorous stock for that part of each row. Soil compaction and drainage must be attended to prior to planting.

5. **Hardiness.** The three periods when winter injury can occur are late fall, mid winter, and early spring. In the Maritimes, lack of hardening in the late fall and/or loss of hardening in the early spring followed by a cold dip are the major cause of winter injury. While most stocks in themselves are hardy, they do not change to any great extent the hardiness of the cultivar grafted onto them. Areas which normally experience winter lows of -25°C or lower, the frame should always be of a hardy cultivar or framestock. In New Brunswick root hardiness is also important. Serious damage can occur when soil temperatures throughout the root zone fall below - 8°C.

6. **Anchorage.** Dwarfing rootstocks are not usually well anchored. Roots on these stocks tend to be brittle, less fibrous and have a high portion of bark to wood. In more vigorous rootstocks there are larger spreading roots that provide considerable anchorage and have a root spread proportional to the top. A tree support system is therefore required for dwarf stocks. Shallow rooting and rooting from one side of the stock is also a problem with certain rootstocks so regardless of the vigour classification support systems may be required. Deep planting may help support the new tree however the graft union should be a least 5 cm above the soil line to prevent scion rooting (Fig 1). Hilling (ridging) the site for each row before planting will considerably assist root development where soils are weak or less well drained.

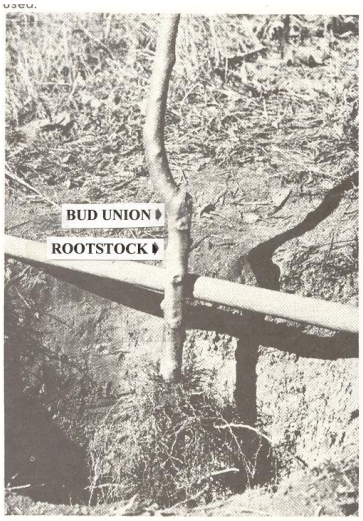

Fig.1

7. **Root suckering.** This is usually a factor that is prevented by the plant breeder. However, some stocks recommended because of certain special traits may have a greater tendency to produce root suckers around the base of the tree. Root suckers, may develop more profusely when a dwarfing stem-piece is inserted between the cultivar and roots. Such trees should be planted with half of the interstem buried below ground as this helps reduce suckering.

8. **Incompatibility.** Certain scion and stock combinations will not grow together properly. The union is therefore more easily broken especially when early heavy crops are present during a fall windstorm, e.g. Northern Spy/ M 26. In other cases the scion is actually unthrifty. Many of the more dwarfing stocks become much larger in diameter than the scion but, this dose not necessarily indicate incompatibly (occasionally the reverse, a small stock than scion will occur).

9. **Virus status.** There are a number of viruses that may be present in apple and pear rootstocks and cultivars. Many of these do not show visual symptoms. They can, however, alter or reduce performance of the orchard. A scion virus can interact with a rootstock virus and cause incompatibilities at the graft union. While viruses do not necessarily reduce tree efficiency, attempts to control tree size by means of introduced mild viruses do not show promise. Many of the older rootstock selections carry viruses, for example, M. 9 and M. 7. These were exposed to a heat treatment process, which eliminated most of the viruses to give the stock designation M. 9a, and M. 7a. A further clean up of these stock resulted in the EMLA series, M. 9 EMLA, M. 7 EMLA, etc. Apple tree grown on M.9 EMLA will be more vigorous than those grown on M. 9a and M.9. Likewise those grown on M.9a will be more vigorous than those on M. 9. Using only virus free material is recommended. Viruses cannot be transmitted through cross-pollination and therefore seedling stocks are considered to be virus free prior to grafting. Freedom from virus is especially important for the multiple-worked tree.

10. **Susceptibility to disease and pests.**

Collar rot (Phytophthora cactorum) is a soil born fungal disease that affects apple trees usually just after the orchard has produced its first heavy crop. Infections occur at or near the soil line. The best control is to use resistant stocks like the Cornell-Geneva Series, especially on seasonally waterlogged soils. Under maritime conditions MM 106 is noted for its susceptibility to this disease.

Fire blight (Erwinia amylovora) is a bacterial disease that is more commonly found in warmer climates, but its occurrence in Nova Scotia and New Brunswick is becoming more common. Burr knots, bark cracks and root suckers may provide a point of entry for the pathogen, which can result in tree mortality or diminished productivity. It is usually more adept at entering through the blossom which can lead to the movement of the bacteria to the rootstock. The stocks M. 26 and M9 are noted for their sensitivity and susceptibility to fire blight. The more resent Cornell-Geneva rootstock introductions are fire blight resistant.

Woolly aphid, a major problem in the Southern Hemisphere, is not usually a consideration for this region. The MM. series were bred for resistance to woolly aphid.

Dogwood borer, along with other bores has been found in burrknots and can reduce tree vigour. Rootstocks such as M. 26 and MM.111, which are prone to produce burrknots, are most often infested. This insect is presently not a problem in the Maritime region.

11. Longevity. For most modern tree fruit plantings the productive life of the orchard is estimated to be 15-25 years

therefore "old age" is not usually a factor for any stock. This does not mean that some stocks will not have more tree losses than others; but if cared for and not affected by injury or disease, all live equally long. Although orchards on dwarf rootstock have been known to live a long time (up to 40 years) they reach the senescence spur bound condition much quicker than the more vigours rootstocks. The life expectancy of an orchard on dwarf rootstock may be as short as 15 years because of economic and management reasons.

12. **Fruit quality.** It has been observed that rootstocks influence fruit size. Some dwarf rootstocks like M. 9 increase fruit size while others like M. 27 the size is reduced. Since dwarf rootstocks have a lower shoot to spur ratio therefore the apples produced on them generally have more colour.

CLASSIFICATION OF STOCKS

History indicates that fruit-tree gardeners had discovered grafting more than 2000 years ago and were actually propagating apple trees on dwarf rootstock. Prior to the 21st century many nurseries in Europe had selected apple rootstocks with a wide array of traits, which often led to considerable confusion. In 1912, researchers at the East Malling Research Station in England began collecting rootstocks and identifying their characteristics. These rootstocks were later grouped according to the following categories for potential vigour:

- very dwarf
- semidwarf
- vigorous
- very vigorous

A more recent classification system developed in North America has five categories which are as follow:

- subdwarf
- dwarf
- semidwarf
- semivigorous
- vigorous

The latter has been adapted for use in this publication (Fig. 2).

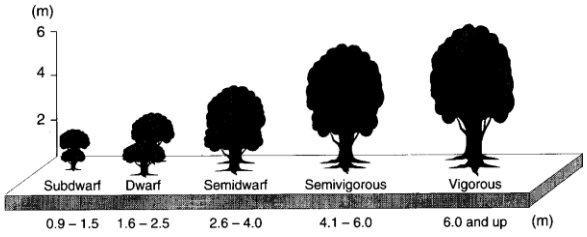

Fig. 2: Vigour classification for apple rootstocks.

Past and present rootstocks:

Following the identification and classification of apple rootstocks at East Malling, research results began to show the superior performers, for each vigour classification. All rootstocks were identified as EM I through EM XXIV. The East Malling rootstock breeding program has introduced a number of new rootstocks since then. One of the most widely planted is M.26 which was crossed in 1929. The Roman numerals were subsequently changed to Arabic and the EM to M. A cooperative breeding program with the John Innes Research Institute, then located in Merton, England, gave rise to the Malling Merton Series, and later labelled MM. The most widely planted of these is MM.106.

Other countries have also been developing new rootstocks for apple. All have specific objectives such as improving hardiness or disease resistance. Introductions from these various programs have their own designations such as the Budagovsky series from Russia (Bud.). In cases where only a single rootstock is selected or discovered, they are identified here under the miscellaneous group.

Introductions

Malling (M) and Malling Merton (MM) series The origin of this group is out lined above. There have been few introductions recently because funding for the development of new rootstocks here has been reduced. The most recent candidates have not been evaluated long enough to show significant advantage for eastern Canadian conditions.

Kentville Stock Clones (KSC) The Kentville stock clones (KSC series) originated from the Beautiful Arcade seed orchard in which Antonovka was planted as the pollinator. The KSC series are thirty survivors of a 1969-1970 mid winter event in New Brunswick. The survivors were in a nursery of approximately 9000 seedlings. Field trials with McIntosh and Red Delicious revealed a wide range of tree vigour; however, most are in the semivigorous or vigorous categories. KSC 18 and 28 are in the semidwarf group and have demonstrated good overall performance. In the semivigorous group, KSC 7, 11, and 24 rated highest, whereas in the vigorous group KSC 3 and 6 rated best. For situations where superior hardiness and fruit size reduction is needed KSC 28 could be recommended. Since these rootstocks do not propagate well in a stool bed micro-propagation techniques are suggested.

Ottawa (O) series The hardy Ottawa clones is a series of rootstock developed at the AAFC Research Station in Ottawa and include Ottawa 3, 4, 5, 6, 7, 8, 11, and 12. Of these introductions, one of the dwarf type candidates Ottawa 3 has been most widely tested. Ottawa 3 is the progeny of "Robin" X M9 cross made in 1956. This stock has been very difficult to propagate in a stool bed and therefore has not been extensively available for use.

Michigan apple clone (MAC) series Dr. R. Carlson at Michigan State University collected open-pollinated seed from a planting of Malling rootstocks plus Alnarp 2 and Robusta in an attempt to find a rootstock better adapted to conditions in the United States. At least five of these have been released and are called the MAC series. MAC9 an open pollinated seedling of M.9 is a dwarf stock, which was later named Mark, and is the most widely planted. Mark was introduced as a stock similar in size to M. 9 or slightly larger being well anchored and would not require tree support. Grower experience have shown that Mark is between M.9 and M.26 in size and that tree support is required to support crop load and prevent breakage at the union. On sites where drought stress occurs trees on Mark can be smaller then M. 9 EMLA while on heavier soils or where draught stress doesn't occur, trees on Mark have been closer to M. 9 EMLA in size. The concern about this rootstock is the gall-like swelling or root mass proliferation, at or just below the soil line. Trees that have this growth may have the symptom of light green leaves and reduced vigour. Experience to date with this stock in the Atlantic region has shown it to be a high performing dwarf rootstock that is well adapted to cool weather and our high moisture periods. Poor performance of an orchard with this rootstock on the west cost has result in the industry moving away from this stock and consequently it is not readily available from commercial nurseries.

Budagovsky (Bud) series A program designed to improve hardiness of apple rootstock was initiated at the Michurinsk College of Agriculture in Russia. A number of dwarf and semidwarf selections from this series are now being evaluated. Bud 491 very dwarfing, Bud 9 a dwarf and Bud 490 semi vigorous and Bud 118 standard are commercially available in North America.

Polish (P) series The objective for the breeding program in Poland was to build hardiness and productivity into dwarf and semidwarf rootstocks. At least six have been introduced; P.22 is a subdwarf, P. 2 dwarf, P.14 semi-dwarf and P.18 standard.

Cornell-Geneva (CG) series Dr. J. Cummins started the rootstock breeding program at Geneva, N.Y.in 1968. Hardiness collar rot and fire blight resistance were the primary goals for this program. This has now been moved to USDA/Cornell joint program led by Dr. Gennaro Fazio. A number of candidates from this breeding program have been released to certain nurseries for liner and tree production. These stocks have demonstrated resistance or partial

resistance to collar rot and fire blight, are classed in the dwarf to semivigorous size range, with good production and proven precocity. These are known as the CG series of which CG. 30 a semidwarf stock is showing good potential for use in the Atlantic Region. Nursery tree on G 16, (M.9EMLA size range) and G11 (M.26 EMLA size range) are commercially available also. G.41 (smaller than M.9) G.935 (between M.26 and M.7), G.202 (M.26 size) and G.210 (semi-dwarf) are some of the Geneva selections that should be commercially available in the very near future. Novole was also developed at Geneva, N.Y., this very vigorous stock is resistant to voles and mice. It is sensitive to common latent viruses.

Czechoslovakian (J-Te) series Dr. Dvorak at the Techobuzice station has developed a series of dwarfing apple rootstocks identified with the letters J-Te. Some of these selections such as J-Te-H are smaller than M.9, some are larger than M.26. These stocks have now been brought into Canada for future research trials.

Supporter series This series of rootstock originated in the 1920's from the Pillnitz Research Station near Dresden Germany. Little was know about these stocks until the fall of the Berlin Wall. Pillnitzer Supporter 4 (Pi.80), a cross between M.9 and M.4, is reported as being similar in size and in anchorage to M.26. Yield capacity is reported to be better than that of M.26. It is the only one of four Supporter rootstocks that is presently being used by commercially apple tree nurseries in North America.

Vineland series Dr Aleck Hutchinson at the Vineland station in Ontario, select a series of seven rootstock from crosses with Kerr crabapple. Size range for the stocks varies between M.9 and M.7. V.1 which is reported to produce trees similar in size or slightly larger than M.26 became commercially available in 2003. Yield efficiency and fruit size are equal to or greater than M.26. However, unlike M.26, it appears to be highly resistant to fire blight.

Miscellaneous rootstocks

Alnarp 2 - This Swedish introduction is semivigorous, productive, and easy to graft. It seems well adapted to the Maritime climate, produces few root suckers and is hardy. It needs nutritional balance and is sensitive to magnesium deficiency.

Antonovka - Seedlings are still used by some nurseries. There are a number of selections of this old hardy Russian cultivar. The cultivar itself is reported to be very hardy and as rootstock its seedlings are expected to produce trees in the vigorous size category.

Beautiful Arcade - Seedlings of this old Russian cultivar are still produced at the seed orchard in Kentville. The seedlings have a fibrous root system and generally produce trees smaller than most other seedlings. They have performed especially well with McIntosh and Cortland. This stock is reliable for a wide range of soil conditions. Triploids such as Gravenstein and King are usually slow to come into production on this stock.

Y.P. - Selected in Finland from open-pollinated Malus baccata, Borkh., this rootstock is productive, vigorous, and hardy. It is susceptible to fire blight.

Bemali - This Swedish introduction is about the size of M.26. It is resistant to fire blight and appears well anchored.

Jork 9 - Known as J9, this rootstock was developed at the Jork Research Station in Germany. It resembles M.9 but is easier to propagate. It has above average hardiness but is very susceptible to fire blight.

NOTES ON STOCKS FOR THE ATLANTIC REGION

Beautiful Arcade seedlings (B.A.): This rootstock was extensively planted in Nova Scotia during the 1950's to about late 1970's' however with changes in orchard systems only minor use is made of this stock. Trees are about 80% size of a fully vigorous rootstock, precocious, productive, easy to grow, widely adaptable, hardy and well anchored. Tree size may further be reduced to 50% through the use of spur-type cultivars and strains and by correct training methods. Interstems have been used with this rootstock where a good hardy vigorous root system is required for a high density orchard planting. As mentioned earlier one of the drawbacks to using interstem's is that they are more incline to produce root suckers. Uniformity of tree size, which can be a problem with seedling stock, maybe reduced with proper stock grading in the nursery. Seeds for propagation of this rootstock are available.

Malling-Merton 111 (MM. 111). Among the available clonal stock, this is the nearest to B.A. in performance and size (80% size), good soil adaptability, tolerant of draughty soils, good autumn maturity, readly available. It will develop burr knots in the above ground portion of the rootstock. Burr knots can cause fluting of the trunk, partial girdling and stunting of trees. To reduce the impact of burr knots, minimum exposure of the stock above the ground level (8 to 10 cm) is advised.

Malling-Merton 106 (MM. 106). This stock was a major factor in introducing size-controlling stocks to North America because of its precocity and good anchorage. It is very susceptible to collar rot following its first full crop and infected trees usually die. Tree size is given as 65%, but this may reflect the early crops; as tree matures, it tends to be larger than expected. MM.106 should only be planted on well drained sites and ridging under the tree row is recommended.

Malling 4 (M. 4). M.4 produces trees about 5-10% larger than MM. 106. It induces early and heavy fruit production. This rootstock is especially resistant to collar rot, but has a tendency for lop sided root development. Tree support may be required in some instances. This stock has not been extensively utilized in this region but is worthy of consideration were collar rot is a concern.

Malling 7 (M. 7). This semi-dwarf rootstock was at one time the most commonly used stock in the United States because it was the most disease tolerant, and most adaptable to a range of soil types and climates. In this region M. 7 has had modest utilization with the undesirable trait of poor anchorage and root suckering being the limiting factors in more extensive use of this stock. Vigorous cultivars such Northern Spy, Gravenstein and Red Delicious have a greater tendency to lean on this stock and tree support is recommended. Cultivars on this stock will be smaller then those on MM. 106 at an estimated 55 to 65% of a full size tree size. Growers should note that cultivars on the relatively virus clean stock M.7a will be lager then those on M.7 and those on the EMLA M. 7 will be even larger.

G.30. This is a semi-dwarf rootstock that produce trees in between the size of M.26 and M.7 about 50-60% the size of a seedling tree. If allowed to crop heavily from and early age trees size is closer to M.26. It has shown strong resistance to collar rot (Phytopthora), fire blight and good tolerance to replant disease. It is winter hardy and performs well on a verity of soil types. It produces few root suckers and burr knots. It produces trees with high yield efficiencies and large fruit size. In trials at Kentville it produced large crops with larger fruit than some of the other rootstocks under evaluation. Produces tree with good crotch angles. It appears to have brittle wood and the graft union which is being investigated. A good tree support system will help to overcome this problem. In the nursery it produces numerous small shoots all along the developing liner so stool bed production requires significantly more labour time to remove and is an added cost for the nurseries.

Malling 26 (M. 26). This is a dwarf category rootstock producing trees in the 40 to 50% size range. In general this stock needs support and it will not tolerate soils that are too draughty or become water-logged in spring and fall. It has demonstrated partial incompatibility that leads to easy breakage at the union and especially with some cultivars such as Northern Spy. It is also prone to burr knots and very susceptible to fire blight. The length of the rootstock

that is above ground level will influence tree growth. Tree size diminishes as the rootstock portion above ground increases. To eliminated problems with tree size variability trees should be planted so that the graft unions are at a uniform height of 8 to 10 cm above the soil line.

Malling 9 (M. 9). This stock is the most commonly used dwarf rootstock throughout the world but its use in this region has been very limited to date. This rootstock produces trees in the 25 to 35% size range. This stock has also been the most commonly used one for interstem trees. Over time a number of sub clones, such as M9 Pajam 2, M-9 Nic 29 M-9T337, of this stock have been selected. Some of these are more vigorous (M9 Pajam 2 and M-9T337) and may prove to be better adapted for this apple growing region. Tree vigour and performance are affected by virus and the removal of viruses has increased vigour. Resent plantings of M 9 in Nova Scotia have been on M.9 EMLA and this stock is more vigorous then M 9. - which didn't perform well when planted in the 1970's. This stock is very sensitive to poor soil conditions, weeds competition, frost heaving and poor management and is still under evaluation as a rootstock suitable for the Atlantic region.

Bud. 9. A hardy dwarfing rootstock breed in Russia, which is noted for its red leaves. Its tree size is similar to or slightly larger then M. 9 EMLA and growing traits similar to M. 9 EMLA, however, it is much hardier. In a rootstock trial located at the Kentville Research Station spur type red delicious on this stock were 30 % smaller then M. 26 EMLA. A recent hardy frame builder study showed its lack of hardiness for the trunk portion of the tree.

Bud. 490. Trees on this stock are in the MM. 106 size range, very hardy, induces early production, and are resistant to crown rot. It is considered as a replacement for MM 106 were crown rot and or hardiness is of concern. Commercial availability is limited.

A Summary of the Most Useful Apple Rootstocks for Atlantic Canada

Dwarf: M. 9 to M.26 size range.

P. 2: A very hardy stock from the Polish series producing tree slightly smaller then M. 9 EMLA .

V. 1, 2 and 3: Hardy stocks from the Vineland selection producing trees in the M. 9 to M. 26 size range. NC-140 tests suggest that V. 1 is comparable to or slightly larger than M. 26, V. 2 is similar to M. 26 and V. 3 is similar to M.9 and B. 9 in vigour.

MAC. 39: A stock from the Michigan Clone Series that produce trees between M.9 EMLA and M.26 EMLA size range. It is less precocious and yield efficient then M.9 EMLA but similar to that of M.26 EMLA.

G.41: Released in the US for commercial propagation in 2005. Produce a tree similar in size to M.9T337, highly resistant to fire blight and collar rot. It is very winter hardy. Precocity and productivity are report as being exceptional surpassing that of M.9.

G.11: A stock from the Geneva series released in 1993 producing trees similar to or slightly larger than M.26. It is resistant to collar rot and has few burrknots. Scion cultivars on this stock are precocious and productive.

G.935: Released in the US for commercial propagation in 2004. Is semi-dwarf stock producing trees slightly larger than M.26. A very productive stock that is resistant to fire blight and collar rot. It produces a free standing tree but would benefit from a support system to hold up the heavy crop load.

Semi-dwarfing: Producing trees in the M.7 size range.

G.202: Released in the US for commercial propagation in 2004. Produce a tree that is slightly larger than M.26 and is resistant to fire blight and collar rot. Precocity and production similar to that M.26 produces very few burr knots or root suckers.

CG. 30: Well adapted, productive with all cultivars including Spy and Honeycrisp

P. 14: A stock from the Polish series that is similar in size to M. 7. It is hardier then this stocks, and is more productive and well anchored.

AR86-1-20: A new stock from East Malling producing trees in between M. 7 and MM. 106 size. It is still on trial but no special traits have been noted to date.

KSC-28: This stock is in the 1992 NC-140 planting which has provided more reliable test results. This rootstock is about the size of M 7 but produces few root suckers. It has very hardy roots and an excellent survival record at the site where it is being tested. It has been found to reduce fruit size. Where hardy roots and fruit size reduction is required this stock is worthy of planting.

PEAR ROOTSTOCKS

Unlike apple with its well defined rootstock traits there are few pear rootstocks that control vigour and give high yields of large fruit. Pear trees planted in the Atlantic Region generally come from nurseries located in the United States and central Canada which only provide the grower with a few rootstock options. These options are limited to one or two selections from the OH x Farmingdale series (OHXF), seedling rootstock and quince. In the past seedling has been the primary rootstock used in this region as clonal quince dwarfing rootstock developed in Europe are not hardy enough for this region and the OHXF series were not available. Seedling rootstock in Canada and the United States is usually grown from the commercial pear cultivar 'Bartlett' which provides some size controlling compared to other pear seedlings. Until recently clonal rootstocks for pears have been limited primarily to selections of Quince. Quince is the main rootstock used in the milder regions of Europe such as the United Kingdom and the Netherlands while seedling is still used in the cooler regions of Eastern Europe. The use of Quince rootstock in the United States is primarily limited to California and Southern Oregon with seedling rootstock being the predominant pear rootstock used throughout this country. Limited use of P. calleryana and P. betulifolia are also used in these two warm growing regions. Growers have begun to make more use of the OHXF series as they become commercially available. These are clonal stocks developed from 'Old Home' X 'Farmingdale' crosses with some of these selections being more dwarfing, precocious and productive then seedlings and hardier then Quince. There have been a limited number of pear rootstock trials in Atlantic Canada but recommendations at this time are restricted seedling for general use and OHXF 40, 69, 87 and 97 on a trial bases.

Seedling: grown from seeds of the commercial cultivar 'Williams' (Bartlett) or 'Winter Nelis' these stocks are hardy, well anchored, producing a tree 90% of a standard in size and is classed as being only fair in terms of precocity and production. Some what tolerant of poorly drained soils. They are compatible with most cultivars.

Quince: There are several quince rootstock used of which QA, QC, Provence Q Lapage C, PQBA 29, are the more commonly planted. Quince stocks are generally poorly anchored and require a tree support system. These dwarfing rootstocks produce trees in the 50 to 55 % size range, are precocious and productive. They are not hardy, and not compatible with many cultivars thus requiring an interstock of the cultivar Hardy to overcome the incompatibility.

Old Home X Farmingdale Colonial Series (OHXF): The original aim of Old Home X Farmingdale crosses in Canada was to fight pear decline. Pears on OHXF rootstock were less susceptible to pear decline and had some resistance to fire blight. In time grower and researcher became interested in the dwarfing characteristic of these rootstocks. Researchers in Oregon selected 13 selections from the 516 seedlings of open pollinated 'Old Home' X 'Farmingdale'. These 13 clonal selections are under going evaluation and several of the selections are now commercially available. The 13 selections are all well anchored and compatible with most cultivars. The size range varies from 60 to 100 % of a standard; however, early indications are that these stocks are no more precocious then Bartlett seedlings but they are slightly more productive. In terms of size control and cropping the selections OH X F 40, 87 and 69 look to be the most promising. The selection OH x F97 is easy to propagate and productive so it is also frequently used. With the exception of OH X F 51 these stock are as hardy as Bartlett seedling and all selection are fire blight resistant which is the main advantage of these stocks.

TABLE 1

Characteristics of Selected Rootstocks

Rootstock	Vigor Induced %	Precocity	Productivity	Anchorage	Hardiness	Water Logging Tolerance	Drought Tolerance	Collar Rot Res.	Nursery Behavior	Notes
Domestic Seedlings	100	- ±	A ±	+	Hardy	A	A	A±	+++	
Alnarp 2	80	+	+	+	Hardy, better than average.				+	
B.A.	80	+	+	++	Hardy, better than average			+	+++	
MM. 111	80	+	+	+	Moderate	A		+	+++	
M. 4	70	++	++	-	Moderate			+	A+	
MM. 106	65	++	+	A	Very susc. early, hardy late winter	--		---	A+	
M. 7a	60	++	+	-	Moderate, roots tender, snow cover for best protection				+	Do not shallow plant
C G 30	60	++	+	+	Hardy	A	A	+	-	
M. 26	45	++	++	--	Hardiest of M. or MM. series; somewhat slow to harden off	--		+	-	
Bud. 9	30	++	++	---	Hardier than M.9			+	+	
M.9	30	+++	++	----	Slightly hardier than M.7a	--	-	++	-	There are several strains

A - Average + - Better than Average - Poorer than Average Blank indicates lack of information, probably more or less than average

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