I. Introduction

The management of nursery plants in an on-farm nursery is more intense and complicated than managing a newly planted tree in the orchard. Although an orchardist already has some of the basic skills to grow a young tree in a newly planted orchard, growing a nursery tree requires much greater inputs of management, labor, fertilizers, water, herbicides and pesticides than an orchard tree. Pre-plant soil preparation, weed control, fertilization, and pest control will be covered in other chapters of this booklet while in this chapter we will cover planting, staking, de-shooting, branching, irrigation, digging and storage.

II. Planting

Rootstocks (whether ungrafted or bench-grafted with a scion) should be planted as early in the spring as soil and weather conditions permit but not before the soil has dried out sufficiently to be worked up into a good seedbed or before the danger of severe frosts has past. The site should be properly fertilized the previous year and then prepared to seed bed quality before planting. (Tip: high rates of chicken or cow manure incorporated into the soil the previous year result in great tree growth in the nursery)

If trees are to be budded later in August, some commercial nurseries prepare the rootstock before planting by trimming back all lateral roots using commercial sheep shearing clippers. Other nurseries deem this procedure too expensive and plant them just as they are received from the rootstock supplier. Most reputable rootstock suppliers trim the side branches from the rootstock and top the rootstock at 24 inches making them ready for planting. If rootstocks are home grown be sure to remove the side branches and cut the tops to 24 inches before planting.

A small nursery planter should be used to plant either the ungrafted rootstock or the bench-grafted rootstock. Alternatively, since there is a very small root system on a rootstock liner a simple sub-soiler can also be used to create a shallow trench for hand planting. Planting depth of the rootstock or grafted tree should be no more than 6-8 inches deep. With a 24 inch long rootstock this will result in 16-18” of rootstock trunk out of the ground. With a 15 inch long bench-graft this will result in 7-9 inches or rootstock plus scion out of the ground.

Ungrafted rootstocks or grafted trees should be planted 6-12 inches apart in the row and 4-6 feet between rows depending on equipment. Many commercial nurseries have used plant spacing as close as 6 inches in the past; however, as we have emphasized the need to have branched or feathered trees, most commercial nurseries have increased plant spacing in the row to 8-12 inches. Twelve inches apart is ideal because this gives more space to grow side branches (feathers). At 6 inch spacings the tree will not produce many feathers. The between-row spacing
can also vary and will depend on available equipment. Commercial nurseries plant rows 4 feet apart but they have specialized equipment to operate in these tight spaces. For most on-farm nurseries six feet apart seems to be about right.

When planting bench grafts, great care must be taken not to damage or break the newly callused graft unions as they are extremely fragile. Handle the trees only by the rootstock when planting and take care when packing soil around the roots.
III. Care the First Season

The intensity of management the first season depends on the type of tree being produced. For the traditional tree production scheme or the 3 year tree the goal the first year is establish the rootstock, grow a strong root system and grow the top with moderate vigor to reach budable size by August. Thus a less intensive management program is required the first year. However, for the 1 year bench graft and sleeping eye production schemes there is only one year in the nursery during which the scion is grown and the finished tree produced. This requires a much more intensive management program to achieve good caliper, adequate tree height and some side branching. With the knipboom tree an intermediate intensity of management is used the first year. With this tree type, the goal the first year is to grow the scion to a moderate height and caliper to allow heading the tree back for vigorous second year growth.

Regardless of the tree type being produced, after rootstocks or grafted plants are planted, pack the soil carefully around the roots eliminating all air pockets around the soil and roots. Air around the roots will dry out and kill the limited and fragile root system. Water the newly planted bench grafted trees immediately after planting to settle the soil around the roots. The application of one gallon of a 20-20-20 starter solution fertilizer per tree will help to settle soil around the roots and provide an early feed for the newly established nursery. This solution is made by dissolving 6 lbs of 20-20-20 fertilizer in 100 gallons of water.

Irrigation, Fertilization and Weed Control: Irrigation, fertilization and weed control are the major management inputs that determine final tree size. Fertilization and weed control will be covered in later sections of this booklet. However, in general intensive fertilization (both ground and foliar) and spotless weed control will give the largest final tree size.

Maintaining optimum soil moisture is essential to producing large nursery trees. Frequent light irrigations throughout the growing season will keep moisture at adequate levels in the nursery. As a rule of thumb we need about 1 acre inch of water per week in the hot part of the summer (June, July and August) provided by a combination of rainfall and irrigation. The amount of irrigation water per week depends on the amount of rainfall that occurs with less irrigation on wet weeks and more when it is dry. The trick is to supply roots with adequate water
without overwatering and encouraging root diseases or asphyxia of the root system. Maintaining good moisture status is absolutely essential to ensure optimum tree growth and health.

Irrigation water can be supplied by sprinklers (movable pipe or big guns) or by trickle irrigation. A semi-permanent irrigation system in the nursery can make watering easier and more effective. An inexpensive T-Tape irrigation line is effective and easy to install. Water can be supplied to the T-Tape with an above ground lay-flat header.

**Staking:** Staking each tree in the nursery helps produce a straight tree but also prevents tree breakage from birds landing on the succulent shoot or from high winds. The risk of leaving trees unstaked varies from year to year like the risk of hail and installing a stake at each tree is good insurance against breakage.

Stakes are usually installed in the year the scion bud is growing. For the traditional 1 year tree, stakes are installed at the beginning of the second year when the scion bud begins to grow. For 1 year grafts, sleeping eyes or knip trees stakes are installed soon after planting. We recommend staking each nursery tree. This will ensure straight growth and protect the bud union during the first season of growth. Use a Max-Tapener to fasten the tree to the stake as it grows.
Stakes can be made from many different materials but the common materials are: 1x1" hardwood tomato stakes that are 5 ft long (most expensive), 5 ft pieces of ½" conduit pipe (cheap if salvaged from old orchards), ¼" steel rods (expensive), or 4-5' pieces of bamboo (less expensive and the most common.)
De-shooting: With an ungrafted rootstock it is important that soon after buds begin to grow in the spring, the lateral shoots on the lower 12-15 inches of the rootstock be removed (de-shooting). This will result in a smooth lower trunk where the budding can be done in August. If rootstocks are planted 6-8 inches deep then after planting there should be about 16-18 inches of rootstock shank above the ground level. With the lower 12-15 inches devoid of lateral shoots, each plant will generally will produce 2-4 shoots near the top of the rootstock (above 15 inches) All of the shoots above 15 inches are allowed to grow during the first year to supply carbohydrate to grow the root system and increase the caliper of the liner to reach budding size by August.

With a bench graft, sleeping eye or knipboom tree, de-shooting should be done 3 times during the season.
1. About 3 weeks after planting when shoots are about 3-4” long all of the lateral shoots on the exposed part of the rootstock shank should be removed. With bench grafts or knip boom trees the best shoot on the scion piece should be selected and all other shoots on the scion piece removed.
2. When scion shoot (leader) is about 15-18 inches tall, all side shoots on the scion should be removed. This will force all of the growth to go into the leader shoot.
3. When the scion shoot is 24-30 inches tall all of the side shoots below 24 inches should be removed. By removing all side shoots below 24 inches the lowest side branches in the orchard will be high enough that they will not need to be tied up when they crop.

Branching: Obtaining side branches on a one year bench graft or sleeping eye tree is very desirable but difficult since the root system is small an newly established that season. Nevertheless branching treatments can give short side shoots (dards) which are very desirable for the super spindle and the tall spindle systems. There are 3 branching techniques which are currently used in commercial nurseries: 1. Removal of small leaves (leaf pinching or plucking), 2. Cytokinnin sprays (Maxcel or Promalin) and 3. Auxin inhibitor sprays (Tiberon).

The level of natural branching varies between varieties, years and climates. It also is strongly related to tree vigor with high vigor trees producing more natural side branches than low vigor trees. Thus, it is essential to grow the tree as vigorously as possible and often 1 year grafts or sleeping eye trees do not grow vigorous enough to produce lateral branches naturally and respond poorly to artificial branching treatments. Nevertheless, branching treatments have in many cases improved tree quality even with one-year trees production schemes. Specifics of branching treatments will be covered in the next section.

IV. Care the Second Season

Only 3 tree types have a second year in the nursery: the traditional tree, the knip boom tree and the 2 year tree (either budded or bench grafted). With all three types, intensive management is practiced the second year to obtain maximum leader growth, caliper and branching.

Topping: At the beginning of the second season the traditional tree or the 2 year tree will need to be topped before growth starts. These trees will have a dormant bud in place about 10 inches above the ground. The portion of the rootstock above the inserted bud should be removed just at green up in the spring. This is usually early to mid-April. No wound treatment is
necessary as long as a good sharp cut is made. Any sucker growth that occurs on the rootstock should be removed by rubbing it off as it appears. This may be necessary 1-2 times before the growth from the inserted buds dominate.

With knip boom tree the scion leader of the tree is cut back severely at 24-28 inches above the ground of at the beginning of the second year. The exact heading height depends on the desired height of the side branches. Generally the knip tree will have achieved a height of 4-5 feet in the first year so that a large portion of the scion growth from the first year will be cut off at the beginning of the second year. The severe heading cut to the leader will result in very vigorous growth of the knip tree which will be focused into a single new leader shoot. Because of the high vigor of this single shoot it will produce lateral branches naturally with little or not branching treatment.

Irrigation, Fertilization and Weed Control: In the second year all tree types receive intensive fertilization (both ground and foliar) and spotless weed control and frequent irrigation as described in the previous section.
De-shooting: With a traditional tree, a 2 year tree or a knipboom tree, de-shooting should be done 3 times during the second season.

1. About 3 weeks after topping when shoots are about 1-2” long all of the lateral shoots on the exposed part of the rootstock shank should be removed. With a knip boom wait until shoots are 3-5” long and then select the best shoot near the heading cut on the leader and remove all other shoots on the leader.

2. With the traditional tree and the 2 year tree when scion shoot (leader) is about 15-18 inches tall, all side shoots on the scion should be removed. This will force all of the growth to go into the leader shoot. With the knip tree a second de-shooting should be done when the new leader is about 10-12 inches to again remove any side shoots below the heading cut to force all of the growth into the new leader shoot.

3. With the traditional tree and the 2 year tree, when the scion shoot is 24-30 inches tall all of the side shoots below 24 inches should be removed. By removing all side shoots below 24 inches the lowest side branches in the orchard will be high enough that they will not need to be tied up when they crop. With the knip tree, a third de-shooting is not needed.

Branching: The level of natural branching varies between varieties, years and climates. It also is strongly related to tree vigor with high vigor trees producing more natural side branches than low vigor trees. Thus, it is essential to grow the tree as vigorously as possible. Since trees
in their second year in the nursery have established root systems them almost always grow quite vigorously the second year. They will often produce some lateral branches naturally and respond well to artificial branching treatments.

The Knip tree grows the most vigorously the second year because of the severe heading cut to the leader, the established root system and greater N and carbohydrate reserves stored in the trunk and rootstock shank. As a consequence many varieties such as Jonagold, Gala and McIntosh will produce 5-7 nice feathers immediately above where the heading cut was made on the new leader shoot. In the past 5-7 feathers was considered adequate but with the tall spindle system having 10 or more feathers is desirable. In addition if the tree only produces 5 feathers they each grow too long and are difficult to manage in the orchard. However if 10-15 feathers are produced they each remain shorter and require less management in the orchard as well as producing higher second and third year yields.

There are 3 artificial branching techniques currently used in commercial nurseries:

1. **Removal of small leaves (leaf pinching or plucking).** This technique is based on the physiological principle that young developing leaves are the source of auxins in a shoot and auxins produced in these small leaves are transported down the shoot and inhibit the growth of lateral buds. By removing all or part of these small developing leaves, the level of auxin in the shoot declines and some lateral buds begin to grow. The technique is manual procedure and is accomplished by holding the growing tip of the between 2 fingers to protect if while with the other hand gathering all of the young developing leaves and tearing them away from the shoot tip. It is essential not to damage the growing tip but to only remove the young developing leaves. The procedure is usually done 3-5 times in the second year. The first leaf pinching is done when the new tree reaches the height where the first branches are desired (24-30 inches tree height which in NYS is about mid June). Since the reduction in auxin supply is only temporary until new leaves are developed by the shoot tip this procedure must be repeated 3-5 times to give good branching. It is repeated every 2 weeks until mid August. This procedure can be accomplished quite rapidly on each tree but is costly when done on thousands of trees. Thus nursery growers prefer a chemical approach.
2. Cytokinin and Gibberellin sprays (Maxcel or Promalin) Maxcel contains only the cytokinin, Benzyl Adenine while Promalin is a 1:1 mixture of Benzyl adenine and Gibberillins4+7. Both chemicals induce lateral branching by overwhelming the suppression of lateral branching by internal auxins. Either chemical should be sprayed the first time when the new tree reaches the height where the first branches are desired (24-30 inches tree height which in NYS is about mid June). Only the top 8-10 inches of the leader shoot need to be sprayed. Rates of 250-500ppm of either chemical are common with 500ppm being the most common rate. The effect of one spray usually results in 3-5 lateral branches. To achieve 10 to 15 branches requires multiple sprays every 2-3 weeks. Usually 3 sprays (mid June, early July, late July) gives the best response.

3. Auxin inhibitor sprays (Tiberon) Tiberon is an auxin transport and action inhibitor which when sprayed on apple trees in the nursery releases lateral buds from auxin inhibition and gives good lateral branching. Like Maxcel, Tiberon should be sprayed when trees reach the desired height of the first branches. Only the top 8-10 inches of the leader shoot need to be sprayed. Tiberon induces branching about 1-4 inches below the point where it is sprayed. Either 1 or 2 sprays of 50-100ppm gives good branching depending on the varietal response. The second spray should be applied 2 weeks after the first. A third spray is not legal.

V. Digging

After the nursery tree is fully grown (at the end of the first year for 1-yr bench grafts or sleeping eye trees or after the second year for the traditional tree or knipboom trees or after the 3rd year for a 2 year tree) the trees must be transplanted to the orchard. All commercial nurseries dig the trees in the fall and either deliver them immediately to the grower for fall planting in the orchard or they store them for spring planting. Many apple growers do not have a suitable tree storage facilities forcing them to either fall plant or leave the trees in the nursery until spring.
Leaving trees outside in the on-farm nursery is risky if we have a harsh winter since the trees may receive some winter damage. If trees are to be left out over the winter then N fertilization of the nursery should be curtailed in early August to allow the trees to harden off well before winter. If trees are to be dug and stored they can be pushed with N fertilizer until mid-September which results in a larger tree.

Trees should not be dug with leaves on them. Leaves transpire large amounts of water and can dry a tree out in a matter of days. Trees in commercial nurseries are usually sprayed with a chemical to aid in defoliation. Copper chelate is the most common chemical. Copper sprays must be applied 2 weeks before digging and in some years can damage buds on the trees. For many on-farm nurseries which are smaller and the job can be done by hand thus eliminating the risk of copper injury. When hand defoliating, wait to defoliate the trees until the day before digging to allow as much N to be shipped back from the leaf to the bud and wood.

Trees should be dug in early November but before the ground freezes or the first severe cold snap which usually occurs in late Nov. in NYS. Trees can be dug by hand or with tree digging machines. The most elaborate machines dig a large portion of the root system and protect the tree in the digging operation but are expensive. Home-made digging machines usually dig up less of the root system but are much cheaper.

VI. Grading

After harvest trees should be graded to allow uniform trees to be planted in the orchard. Most growers of on-farm nursery are hesitant to throw away any tree they have grown and plant all of the trees including the small ones. This results in orchards with variable tree quality and variable performance. We recommend that growers of on-farm nurseries institute a rigorous grading system and discard any tree smaller than 7/16" caliper and shorter than 4' tall. In some cases this would result in more than half of the trees being discarded but if there has been excellent management a high proportion of the trees will make this minimum grade. Although
rigorous grading might seem drastic, in the long run such action will benefit the grower by having better orchards instead of "junk" orchards.

VII. Storing

If trees are to be stored they must be kept from freezing. The optimum storage temperature is 33-35°F although trees can tolerate slightly less than 32°F or warmer temperatures up to 45-50°F. At warmer temperatures trees will begin to break bud in the very early spring often before they can be planted in the field. For on-farm storage the lower level of old barns can be insulated and used as an unrefrigerated tree storage. This works relatively well as long as the trees do not freeze during the coldest part of the winter.

A second storage requirement is high humidity (>95%) to prevent the trees from drying out over the winter. Keeping the floor wet or running a humidifies are good ways to keep the storage room humid.

The third storage requirement is to avoid ethylene gas. All apple storages have ethylene gas which is produced by the apples. Thus trees should not be stored in the same room with apples.

VIII. Summary

On-farm nurseries require intensive management to produce acceptable tree size and quality. This includes high levels of pre-plant soil preparation (virgin land and lots of manure), excellent weed control, intensive fertilization, excellent pest control, proper irrigation and intensive horticultural manipulation including, grafting, budding, topping, de-shooting, and branching treatments. The production phase must be linked with excellent harvest, grading and storage techniques to end up with a quality tree in the orchard. If all the pieces of the puzzle are done properly good quality trees can be produced but it is unlikely the tree size and branching from on-farm nurseries will be comparable to commercial nursery trees.