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# Influence of Planting Depth on Growth and Anchorage of Young 'Delicious' Apple Trees

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*Abstract.* **Shallow-planted trees of 'Delicious' apple (*Malus domestica* Borkh.) on Malling (M) 7A and Malling Merton (MM) 111 rootstock had increased frequency of burrknots and were less likely to be loosened in the soil by wind than were deep-planted trees. Deep-planted trees on seedling roots were more likely to be loosened by handshaking; however, burrknots were not a problem. Leaf size was larger significantly for all shallow-planted trees. Growth differences were related to soil type, rootstock, and planting depth.**

Deep planting of apple trees has been recommended as a means of reducing or eliminating problems such as cold injury to roots (1), burrknots (5), and poor anchorage of dwarfing rootstocks (4). Improved anchorage has become the dominant reason for deep planting as mechanical support systems have become almost prohibitive in cost. Some nurseries graft trees on seedling roots 15 cm high and recommend burying the union up to 7.5 cm deep. Many nurseries graft clonal rootstocks at 30 cm and recommend leaving only 2 to 5 cm of the rootstock above ground at planting.

A Virginia survey (2) conducted in Spring 1980 revealed that many of these deep-planted trees were not rooting along the buried shank of the rootstock. Trees with deeper crown roots were significantly smaller and more likely to lodge or form cone-shaped air pockets extending from the soil surface to the crown roots. Such trees were much more likely to die in the next year than trees not exhibiting this symptom.

Parry and coworkers (3, 4) have suggested that setting clonal rootstocks such as M7 and East Malling (EM) 26 eight to 15 cm deeper than nursery depth was beneficial to anchorage and performance, but planting deeper than this could be detrimental to growth.

Trials were initiated at the Winchester Fruit Research Laboratory Research Farm and at a grower orchard in 1981 to investigate the effects of deep planting on 'Delicious' apple trees. Trees of each cultivar/rootstock combination were selected for uniformity of trunk diameter at planting.

In expt. 1, trees of standard 'Delicious'/M-7A, grafted at 30 cm height above the soil line, and spur 'Delicious'/MM-111, grafted at 20 cm, were planted at 2 depths, 5 cm and 15 cm deeper than nursery depth. 'Delicious'/M-7A were planted at 5 cm and 25 cm deeper than nursery depth. Five trees were set at each depth in 2 different subsoil types; a subsoil that would not glaze when an auger was used to drill planting holes to a depth of 40 cm, and a subsoil where the sides of the hole would start to glaze at a depth of 15 to 20 cm. Clay content of the latter subsoil was in excess of 40%. The experimental design was completely randomized. In expt. 2, trees of 'Redchief Delicious' on seedling roots grafted at 15 cm above the soil line were used. Ten trees were set in a completely randomized manner at each of the following depths: 5, 10, 15, and 20 cm below nursery depth.

In mid-May 1981 and 1982, the leaf area of the largest, fully expanded leaf on each of 5 shoots per tree was measured in both experiments. Area was determined as length × width × 0.7. Trunk diameter was measured in Fall 1981 and 1982 at 2.5 cm above the soil surface. Depth to the first root was determined in Fall 1981 by excavating around each tree until a root was encountered. In expt. 1, the severity of looseness or air pockets was rated visually in June 1982 following a windstorm on a scale of 1 (no opening) to 5 (about a 15-mm opening or cone surrounding the base of the tree). Poor growth the first year in expt. 2 (Table 3) precluded any looseness following the windstorm, so in Fall 1982 each tree was shaken by hand and data recorded as to whether or not an opening formed. No attempt was made to rate quantitatively the severity of this opening as uniformity of pressure was not possible.

Table 1. Effect of subsoil type and depth of planting on growth of spur 'Delicious'/MM 111.

| Treatment | Depth to first root (cm) | Avg leaf size ($cm^2$) 1981 | Avg leaf size ($cm^2$) 1982 | Trunk diam (mm) 1981 | Trunk diam (mm) 1982 | Burrknots[z] (%) | Looseness rating[y] |
|---|---|---|---|---|---|---|---|
| Loose subsoil 5-cm-deep[x] | 1 a[w] | 13 a | 29 a | 25 b | 39 b | 100 | 1.0 b |
| Loose subsoil 15-cm-deep | 1 a | 10 b | 25 b | 24 a | 40 b | 20 | 1.4 ab |
| Glazed subsoil 5-cm-deep | 1 a | 13 a | 30 a | 28 c | 47 a | 100 | 1.0 b |
| Glazed subsoil 15-cm-deep | 1 a | 11 b | 26 b | 24 a | 37 b | 20 | 1.8 a |

[z]Total of 5 trees.
[y]Rated on a scale of 1 to 5 (most severe).
[x]Planting depth below nursery depth.
[w]Mean separation in columns by Duncan's multiple range test, 5% level.

Table 2. Effect of subsoil type and depth of planting on growth of standard 'Delicious'/M 7A.

| Treatment | Depth to first root (cm) | Avg leaf size ($cm^2$) 1981 | Avg leaf size ($cm^2$) 1982 | Trunk diam (mm) 1981 | Trunk diam (mm) 1982 | Burrknots[z] (%) | Looseness rating[y] |
|---|---|---|---|---|---|---|---|
| Loose subsoil 5-cm-deep[x] | 1 a[w] | 12 bc | 34 b | 27 a | 47 a | 100 | 1.2 a |
| Loose subsoil 25-cm-deep | 2.0 a | 10 a | 32 a | 27 a | 45 a | 0 | 3.4 b |
| Glazed subsoil 5-cm-deep | 1 a | 13 c | 36 b | 26 a | 45 a | 100 | 1.2 a |
| Glazed subsoil 25-cm-deep | 3.2 a | 11 ab | 30 a | 24 a | 41 a | 20 | 2.6 ab |

[z]Total of 5 trees.
[y]Rated on a scale of 1 to 5 (most severe).
[x]Planting depth below nursery depth.
[w]Mean separation in columns by Duncan's multiple range test, 5% level.

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Table 3. Effect of planting depth on growth of 'Redchief'/seedling.

| Planting depth (cm)[z] | Depth to first root (cm) | Avg leaf size (cm$^2$) 1981 | Avg leaf size (cm$^2$) 1982 | Trunk diam (mm) 1981 | Trunk diam (mm) 1982 | Loose trees[y] (%) |
|---|---|---|---|---|---|---|
| 5 | 2.7 a[x] | 16 b | 26 b | 22 b | 30 b | 20 |
| 10 | 6.3 a | 16 b | 25 ab | 22 b | 29 b | 40 |
| 15 | 12.0 b | 13 a | 23 a | 20 a | 27 a | 70 |
| 20 | 15.7 b | 12 a | 26 b | 19 a | 26 a | 60 |

[z]Planting depth below nursery depth.
[y]Total of 10 trees.
[x]Mean separation by Duncan's multiple range test, 5% level.

Deep planting of spur 'Delicious'/MM 111 caused a reduction in leaf size in both years, regardless of subsoil type (Table 1). Trunk diameter was decreased also by deep planting on both soil types the first year, but only in the glazed subsoil the 2nd year. Trees planted deep in the glazed subsoil also had larger air pockets in the soil around their base than did shallow-planted trees. Deep-planted trees in the loose subsoil did not have significantly larger air pockets than shallow-planted trees. All shallow-planted trees had burrknots on the aboveground portion of the rootstocks while only one tree in the deep-planted treatments had any burrknots. All trees had roots near the soil surface regardless of subsoil type or planting depth.

Trunk diameter of standard 'Delicious'/M 7A was unaffected by planting depth or subsoil type, but leaf size was affected adversely both years by deep planting (Table 2). Trees planted deeply in the loose subsoil had larger openings around their trunks than did either of the shallow plantings. All shallow-planted trees but only one deep-planted tree had burrknots.

A planting depth greater than 10 cm below nursery depth had a negative effect on growth of 'Redchief Delicious' in 1981 and 1982 (Table 3). Depth to the first root, an indication of rooting along the buried shank, also increased at depth below 10 cm. In 1981, average leaf size was reduced in trees set with crown roots below 10 cm; however, in 1982 only those set at the 15-cm depth were affected. There was a numerical increase in loose trees for all depths over 5 cm. No burrknots were observed on any trees.

The results of this study support the findings of an earlier survey (2) that trees planted more than 10 to 15 cm deeper than the nursery planting depth are more susceptible to the soil forming air pockets around their base. The problem becomes even more acute when soil and growth conditions are such that little or no rooting occurs along the buried portions of the rootstock. Strong roots near the soil surface are needed to reduce this problem.

Growth differences were influenced by both cultivar/rootstock combinations and subsoil type. Growth of standard 'Delicious'/M 7A was unaffected by planting depth; spur 'Delicious'/MM 111 growth was significantly greater for the first year on shallow-planted trees and both subsoil types, but different only on the heavier subsoil type the 2nd year. 'Redchief'/seedling trees were smaller both years when planted deeper than 10 cm. In no case did deep-planted trees perform better for the first 2 years than shallow-planted trees.

Burrknots on aboveground portions of clonal rootstocks are of major concern in Virginia because borers feed in them and damage the trees; all shallow-planted trees exhibited them in this trial. In view of the data presented herein, it appears that a grower receiving trees with long shanks must decide whether to have burrknots or increase his chances of reduced growth and loose trees.

These findings suggest that clonal rootstocks be grafted no higher than 15 to 20 cm if aboveground rootstock portions are to be avoided. By using shorter shanks on the rootstocks and setting most of the shank below the soil surface, the problem of loose trees may be lessened and the problems of excessively deep planting avoided.

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# Effects of Modified Fruit and Leaf Weight Loss on Apple Mineral Content and Firmness Loss in Storage

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***Abstract.*** **Applications of an antitranspirant (8% v/v Vapor Gard) to leaves decreased concentrations of N, P, Mg, and Ca in leaves, decreased apple dry-matter content, mass, and the amount of Ca per apple, but increased fruit firmness at harvest and after 120 days of 0°C air storage. Surfactant applications (8% v/v Tween 20) to fruit decreased fruit mass and N and Mg concentrations in leaves, but increased fruit dry-matter content and firmness after storage. Since selective application of either an antitranspirant or a surfactant to leaves or fruit, respectively, to modify the water loss balance between the fruit and leaves did not increase Ca concentrations in fruit, increased fruit firmness was probably due to reduced fruit mass and increased dry-matter contents.**

Most movement of Ca into apple fruit occurs via xylem transport during the first few weeks of fruitlet development (15, 16). Later, Ca may continue to enter the fruit at a slower rate, but is diluted by increased fruit growth and can be retranslocated from the fruit to nearby spurs and leaves (12, 15, 16). Ca can be withdrawn from the fruit during periods of drought and rapid water loss through leaves surrounding the fruiting spur (12, 16). The net change in Ca during late stages of fruit development appears to depend on the degree of water loss from surrounding leaves, which is subject to environmental stress.

The postharvest life of an apple is critically determined by its Ca concentration. Fruit which are low in Ca may respire faster and succumb to premature senescent disorders (3, 4, 10), while fruit that have received exogenous Ca applications may maintain their firmness longer in storage (8).

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