First-year Shoot Development and Carbohydrate Distribution in Fall- and Spring-planted Apple Trees

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Abstract. Fall- and spring-planted spur 'Delicious' trees were monitored for first-year spur and shoot development and major carbohydrate levels in 1986 and 1987. Fall planting resulted in significantly greater shoot extension growth and lower tendency to become spurbound than spring planting during both years for two strains of spur 'Delicious'. Higher starch reserves were found following the growing season after fall planting than after spring planting. A root dip of 10,000 mg a.i. IBA/liter before spring planting in 1987 did not affect any of the characteristics measured. Chemical name used: 1H-indole-3-butyric acid (IBA).

Apple trees (Malus domestica Borkh.) commonly are planted in spring as early as soil conditions are suitable. Fall planting often is avoided in northern areas because of tree loss due to winter injury. However, most guidelines on establishment of new orchards indicate that fall planting in areas with mild winters may be advantageous to early growth (Childers, 1973, Westbrook, 1978). One major fruit tree nursery, which supplies many trees for southern U.S. orchards, recommends fall planting in hardiness zone 6 and further south (J. Prezewalski, personal communication).

Little research exists on the effects of planting date on apple tree growth. Preston (1972) compared first-year growth of 'Cox' apple trees planted in December, February, March, or April in southern England and found no effect on shoot length or trunk diameter. However, shoot number was less on December- and April-planted trees than those planted in February or March. Weight of December-planted trees was greater than those planted in April.

Nursery trees that are not shipped in fall are usually kept in cold storage until spring shipment. Preston 1972 found that there was no difference in field performance between trees kept in cold storage vs. those bedded in the field. However, significant decreases in starch (Abusrewil et al., 1983) and fructose and glucose (Larsen and Abusrewil, 1983) and increases in sucrose and sorbitol (Larsen and Abusrewil, 1983) have been found in stem tissue of apple trees after 5 months storage at 3°C. This shift of carbohydrates to soluble forms may have an effect on early tree growth.

Winter root growth in mild climates may give fall-planted trees an advantage in early establishment, especially during spring drought. Any growth advantage would be particularly important with low-vigor, spur-type 'Delicious' strains, which have a strong tendency to become spurbound during the first year in the orchard.

The objectives of this study were to determine if differences existed in first-year growth and carbohydrate levels of spur-type 'Delicious' apple trees planted in fall vs. spring in a mild climate. Two studies were conducted during the 1986 and 1987 growing seasons.

Expt. 1. Twenty-four 'Starkspur Compact Red Delicious' trees on seedling rootstock were obtained immediately after lifting from the nursery and planted at the Mountain Horticultural Crops Research Station (MHCRS, hardiness zone 7) near Asheville, N.C. on 20 Nov. 1985 in a completely randomized design with eight replications per treatment.

Table 1. Root, stem, and new shoot dry-weights of 'Starkspur Compact Delicious' apple trees planted in fall and spring before the 1986 growing season (Expt. 1).†

<table>
<thead>
<tr>
<th>Plant part</th>
<th>Planting treatment</th>
<th>Time of measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>52.2</td>
<td>48.2 a</td>
</tr>
<tr>
<td>Spring</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Root</td>
<td>74.5</td>
<td>62.3 b</td>
</tr>
<tr>
<td>Fall</td>
<td>92.1 a</td>
<td>64.9 a</td>
</tr>
<tr>
<td>Spring</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>New shoot</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>126.7</td>
<td>110.5 b</td>
</tr>
<tr>
<td>Spring</td>
<td>134.9 a</td>
<td>107.0 a</td>
</tr>
</tbody>
</table>

†Means within column and plant part not followed by the same letter are significantly different by F test (P = 0.05) with eight replications per mean.

**Table 2.** Number of new spurs and extension shoots (ext.) and new shoot length of 'Starkspur Compact Delicious' (Expt. 1) and 'Starkspur Supreme Delicious' (Expt. 2) apple trees planted in fall and spring.‡

<table>
<thead>
<tr>
<th>Planting time</th>
<th>May</th>
<th>July</th>
<th>December</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Growing points</td>
<td>Ext. shoots</td>
<td>Spur shoots</td>
</tr>
<tr>
<td>Fall</td>
<td>14.6 a</td>
<td>3.4 a</td>
<td>12.0 a</td>
</tr>
<tr>
<td>Spring</td>
<td>14.6 a</td>
<td>0.0 b</td>
<td>12.9 a</td>
</tr>
<tr>
<td>Expt. 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>15.1 a</td>
<td>10.8 a</td>
<td>3.8 b</td>
</tr>
<tr>
<td>Spring</td>
<td>15.4 a</td>
<td>7.1 b</td>
<td>8.8 a</td>
</tr>
<tr>
<td>Sp + IBA*</td>
<td>16.5 a</td>
<td>7.0 b</td>
<td>9.4 a</td>
</tr>
</tbody>
</table>

‡Means within column and year not followed by the same letter are significantly different at the 0.05 level F test in Expt. 1 by Tukey's LSR test; in Expt. 2, with eight replications per mean.

*New shoot length includes those growing points recorded as spurs (<2 cm).

*Spring-planted trees with a root dip of 10,000 mg a.i. IBA/liter.
Trees were headed to 30 cm and all side branches were removed. Eight similarly pruned trees were used for top and root dry-weight measurements to determine initial tree size. On 20 Mar. 1986, eight trees were selected at random, removed from the field, and top and root dry weights measured. At the same time, an additional 24 similar trees were obtained from the same nursery, eight of these were weighed immediately and 16 planted randomly among the fall-planted trees. On 14 May 1986, 4 weeks after budbreak, eight fall-planted and eight spring-planted trees were removed, the number of growing points counted, and dry weights measured on new shoots, stem, and roots. On 14 July 1986, the number of spurs (<2 cm) and new shoots were counted, but no trees removed. On 10 Dec., after leaf fall, the eight remaining trees in each planting treatment were removed and spur number, new shoot number and length, and component dry weights determined.

Expt. 2. The second season's experiment began with fall planting on 15 Dec. 1986 of 'Starkspur Supreme Delicious' trees on M.7a. The spring planting date, sampling procedure, experimental design, and number of trees used were the same as in the previous season. Trees for planting in Spring 1987 were obtained in Dec. 1986 and maintained in cold storage at 5°C until planting. An additional treatment was added, consisting of a 10-sec root dip in 10,000 mg a.i. IBA/liter in water just before planting in spring. Work with ornamentals has shown an early shoot-and-root-growth enhancement with this treatment (Struve and Moser, 1984). In this experiment, woody tissue of new shoots, stem, and roots from four of the eight replicates were subsampled for carbohydrate analyses (Brown et al., 1985) after removal from the field.

Analysis of variance was done in Expt. 1 and 2 separately and means were separated in Expt. 2 by Tukey's LSR test (P = 0.05) with eight replicates per mean.

Table 3. Root, stem, and new shoot dry weights of 'Starkspur Supreme Delicious' apple trees planted in fall or spring (Expt. 2).  

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem</td>
<td>Fall</td>
<td>60.9</td>
<td>53.9 a</td>
<td>41.8 a</td>
<td>59.9 a</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>58.3 a</td>
<td>37.9 a</td>
<td>37.3 a</td>
<td>56.3 a</td>
</tr>
<tr>
<td>Root</td>
<td>Fall</td>
<td>120.0</td>
<td>106.3 a</td>
<td>95.9 a</td>
<td>152.6 a</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>116.8 a</td>
<td>90.4 a</td>
<td>131.5 b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sp + IBA</td>
<td>116.8 a</td>
<td>90.2 a</td>
<td>133.8 b</td>
<td></td>
</tr>
<tr>
<td>New shoot</td>
<td>Fall</td>
<td>8.1 a</td>
<td>7.9 a</td>
<td>10.6 b</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>7.0 a</td>
<td>8.1 b</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Fall</td>
<td>180.9 a</td>
<td>162.0 a</td>
<td>145.8 a</td>
<td>229.4 a</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>175.1 a</td>
<td>134.5 a</td>
<td></td>
<td>192.7 b</td>
</tr>
</tbody>
</table>

Means within column and plant part not followed by the same letter are significantly different by Tukey's LSR test (P = 0.05) with eight replicates per mean.

Spring-planted trees with a root dip of 10,000 a.i. IBA/liter.

Table 4. Starch, soluble carbohydrates (sucrose, glucose, fructose), and sorbitol in 'Starkspur Supreme Delicious' apple trees planted in fall or spring (Expt. 2).  

<table>
<thead>
<tr>
<th>Carbohydrate fraction (CHO)</th>
<th>Plant part</th>
<th>Planting treatment</th>
<th>March 1987</th>
<th>May 1987</th>
<th>December 1987</th>
</tr>
</thead>
<tbody>
<tr>
<td>Starch</td>
<td>Stem</td>
<td>Fall</td>
<td>18.5 b</td>
<td>13.1 a</td>
<td>26.1 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>30.8 a</td>
<td>10.4 a</td>
<td>29.7 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring + IBA</td>
<td>30.8 a</td>
<td>8.1 a</td>
<td>42.8 a</td>
</tr>
<tr>
<td></td>
<td>Root</td>
<td>Fall</td>
<td>115 b</td>
<td>83.9 a</td>
<td>173 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>134 a</td>
<td>93.2 a</td>
<td>160 b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring + IBA</td>
<td>134 a</td>
<td>33.3 b</td>
<td>153 b</td>
</tr>
<tr>
<td></td>
<td>New shoot</td>
<td>Fall</td>
<td>---</td>
<td>8.5 a</td>
<td>31.9 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>---</td>
<td>6.7 a</td>
<td>22.9 b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring + IBA</td>
<td>---</td>
<td>4.1 a</td>
<td>15.3 b</td>
</tr>
<tr>
<td>Soluble CHO</td>
<td>Stem</td>
<td>Fall</td>
<td>35.5 a</td>
<td>18.2 a</td>
<td>73.1 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>20.1 b</td>
<td>27.0 a</td>
<td>68.3 a</td>
</tr>
<tr>
<td></td>
<td>Root</td>
<td>Fall</td>
<td>62.6 a</td>
<td>46.4 a</td>
<td>70.0 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>59.0 a</td>
<td>41.9 a</td>
<td>65.5 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring + IBA</td>
<td>59.0 a</td>
<td>47.5 a</td>
<td>68.4 a</td>
</tr>
<tr>
<td></td>
<td>New shoot</td>
<td>Fall</td>
<td>---</td>
<td>50.4 a</td>
<td>67.7 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>---</td>
<td>53.8 a</td>
<td>68.9 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring + IBA</td>
<td>---</td>
<td>52.2 a</td>
<td>69.3 a</td>
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<tr>
<td>Sorbitol</td>
<td>Stem</td>
<td>Fall</td>
<td>10.9 a</td>
<td>20.1 a</td>
<td>25.2 a</td>
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<tr>
<td></td>
<td></td>
<td>Spring</td>
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<td>20.1 a</td>
</tr>
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<td></td>
<td>Root</td>
<td>Fall</td>
<td>14.0 a</td>
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<td>15.7 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>12.9 a</td>
<td>25.5 a</td>
<td>18.0 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring + IBA</td>
<td>12.9 a</td>
<td>14.3 a</td>
<td>18.2 a</td>
</tr>
<tr>
<td></td>
<td>New shoot</td>
<td>Fall</td>
<td>---</td>
<td>64.9 a</td>
<td>32.1 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>---</td>
<td>71.8 a</td>
<td>31.3 a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Spring + IBA</td>
<td>---</td>
<td>83.1 a</td>
<td>27.0 a</td>
</tr>
</tbody>
</table>

Means within column and plant part not followed by the same letter are significantly different by Tukey's LSR test (P = 0.05) with four replicates per mean.

Spring-planted trees with a root dip of 10,000 a.i. IBA/liter.
trees may be better prepared for growth re-
sumption the following spring, although this
was not verified by this study. There were
no differences in sorbitol levels at any time
throughout the study.

Results from this study indicate that grow-
ers in mild climates may obtain some sig-
nificant first-season growth advantage from
fall-planting spur-type 'Delicious' strains.
Trees may have greater shoot growth, lower
tendency to become spurbound, and higher
carbohydrate reserves the following fall.

Melvin R. Hall1, Suhas R. Ghate2, and Sharad C. Phatak3

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Additional index words. Citrullus lanatus, raw seeds, transplants, yield

Abstract. Field-establishment from germinated 'Crimson Sweet' watermelon [Citrullus lanatus (Thunb). Matsum. & Nakai] seeds was more rapid than from raw seeds, and
differences were greater when soil temperatures ranged from less than the optimum
(21.3 to 35.3°C) to slightly less than the minimum (15.7°C) for watermelon seed ger-
mination. Total yields were not influenced by planting methods, but germinated seeds
and transplants enhanced early yield in 1983.

Mulches (1, 2, 9), transplants (9), and frost
protectors (9) aid in establishment and early
growth of watermelons planted before soil
and air temperatures reach optimums for seed
germination and plant growth, but they add
to production costs. Also, their value for
promoting early harvest declines as the
planting season advances and temperatures
approach optimums for seed germination and
growth of watermelon. Sachs (10) noted ear-
lier establishment of watermelon plants from
primed seeds than from raw seeds at sub-
optimal soil temperatures, but growth after
emergence was slow and he concluded that
young seedlings would continue satisfactory
development only at temperatures near opti-
mum for growth. Earlier establishment and
faster growth of other vegetable crops planted
from germinated seeds compared to raw seeds
(3–5) and recent technological advancements
in fluid drilling of germinated seeds (6) sug-
gest the possibility of earlier establishment
of watermelon from fluid drilling of germi-
nated seeds when temperatures are slightly
below optimum for watermelon seed ger-
mination and growth. The objective of this
work was to compare field-establishment of
watermelon plants from germinated and raw
seeds as soil and air temperatures ap-
proached optimums for watermelon seed
germination and plant growth and to com-
pare their yields with those from transplants.

On 1 and 15 Apr. and 6 and 31 May 1982
and 1 and 28 Apr. 1983, germinated seeds,
raw seeds, and transplants of 'Crimson Sweet'
watermelon were planted manually in hills
90 cm apart in 9.0 x 3.6 m plots in a Tifton
sand loam soil (fine-loamy siliceous, thermic

Childers, N.F. 1973. Modern fruit science. Som-
erst Press, Somerville, N.J.

Literature Cited
Abusrewil, G.S., F.E. Larsen, and R. Ritts, Jr. 1983. Prestorage and poststorage starch levels
in chemically and hand-defoliated 'Delicious'
108:20–23.
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not mentioned. This research was supported by
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University of Georgia Coastal Plain Experiment Station climatological data were used to calculate
means for the daily minimum and average
5-cm depth soil temperatures from planting
till establishment and means for the daily minimum and average 1.5-m air tempera-
tures for the actual growing days from planting
until the last harvest from each planting.

Yields were calculated from marketable
fruit heavier than 6.8 kg. In 1982, severe
outbreaks of foliar diseases affected the 6
and 31 May plantings and yields are not re-
ported for those two plantings. Harvests of
other plantings were bi-weekly in 1982 but
weekly in 1983. Early harvests consisted of
the first harvest from each planting in 1982
and the first two harvests from each planting in
1983.

In each year, the experimental design was a
split-plot with planting dates as main plots;
subplots were planting methods arranged in a
randomized complete block design in four rep-
lications. Count data for weighted average days
to emergence and number of plants per hill
were subjected to a ($x^0.5$)1/2 transforma-
tion before analysis to normalize their distri-
butions, while data for early and total marketable
yields were subjected to a ($x + 0.5$)1/2 transfor-
mations to equalize their variances (11). All
transformed means were back-transformed for
presentation.

Germinated watermelon seeds required
fewer average days than raw seeds for hill
establishment (Tables 2–4), except for the
28 Apr. 1983 planting. With later planting
dates, both germinated seeds and raw seeds
required fewer average days from planting
until establishment. A similar response has
been observed with germinated and raw seeds
of other crops (3–5) and for salt-primed and
raw watermelon seeds (2). Optimum soil
temperature for watermelon seed germina-
tion ranges from 21.3 to 35.3°C; 15.7°C is the
minimum temperature at which germination
reportedly occurs (8). Differences in average
days from planting until establishment of
germinated compared to raw seeds (Table 3)
were generally less when average soil tem-

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Germinated Seeds for Field-
construction of Watermelon

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