Seasonal Changes in the Carbohydrate Concentration in Pecan Shoots and Their Relationship to Flowering

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Abstract. Vegetative and fructifying shoots were tagged in Oct. 1982 and 1983 on ‘Squirrel’, ‘Stuart’, and ‘Cape Fear’ pecan trees [Carya illinoinesis (Wangenhi) C. Koch], and flowering was determined the following years. One-year-old shoots were sampled from vegetative and fructifying shoots of each cultivar on 14 Oct. 1982, 9 Feb., 11 Apr., 14 Oct., and 24 Nov. 1983, and 6 Jan. and 17 Apr. 1984 and analyzed for reducing and nonreducing sugars and starch concentrations. Fruiting reduced return bloom of ‘Cape Fear’ in 1983 and 1984, and ‘Stuart’ in 1983. Sugar and starch concentrations varied inversely. Sugar concentrations were increased in November, January, and February, and starch concentrations were greatest during October and April. The total carbohydrate concentration in fructifying shoots of each cultivar was greater or equal to that of vegetative shoots in all but one instance. The degree of return fructifying was positively associated with cultivars with early fruit ripening dates.

Materials and Methods

The study was conducted in central Oklahoma, using 3 cultivars (‘Squirrel’, ‘Stuart’, and ‘Cape Fear’) chosen for their differing fruit ripening dates (Table 1). Trees were 18 years old, spaced 10.7 x 18.3 m, and growing on a Port silt loam. Orchard management included mowed native sod, 2 m herbicide strips on each side of the tree rows, trickle irrigation, annual N and K application of 96 and 112 kg·ha⁻¹, respectively, and sufficient pest control to eliminate any apparent insect or disease problems.

The influence of previous year’s shoot type on the subsequent year’s flowering was determined by tagging 100 fruiting and vegetative shoots on 2 trees of each cultivar in Oct. 1982 and 1983. Return flowering then was determined as pistillate flowers became visible in the spring. Nonstructural carbohydrates were estimated from one-year-old shoots collected from the canopy periphery on 14 Oct. 1982, 9 Feb., 11 Apr., 14 Oct., and 24 Nov. 1983, and 6 Jan. and 17 Apr. 1984. The collection dates corresponded to fruit ripening (October), natural defoliation (November), mid-dormancy (January and February), and budbreak (April). Representative shoots (5 fruiting and 5 vegetative) were collected from each tree (2 trees per cultivar) on each collection date, transported on ice in plastic bags, frozen at −30°C, and then lyophilized. Samples were ground to 40-mesh screen size and stored in air-tight jars at −30°C until analyzed. Carbohydrates (reducing sugar and starch in 1982–83, and reducing, nonreducing sugar, and starch in 1983–84) were determined using Nelson’s modification of Somogyi’s method (7), which has been used on pecan tissue and described by Wood (15).

Results and Discussion

Fruiting reduced subsequent flowering of ‘Cape Fear’ in 1983 and 1984, and ‘Stuart’ in 1983 (Table 2). Fruiting and vegetative shoots of ‘Squirrel’ flowered equally well both years. Flowering of ‘Squirrel’ may have been less affected by fruiting than ‘Cape Fear’ or ‘Stuart’ because it is the earliest ripening of the 3 cultivars (Table 1). Early fruit ripening may enhance return bloom by providing a prolonged period for photosynthetic accumulation and storage between the time of fruit ripening and defoliation. It is also possible that early fruit ripening may enhance return bloom by reducing the production of flowering inhibitors by the developing fruit, by stimulating the production and/or accumulation of flower-promoting compounds in leaves, or by giving the leaf an extended period of time to export reserves from the senescing leaves.

Sugar concentrations in one-year-old shoots were greater during November, January, and February than in October and April. Starch concentrations were inversely related to the sugar concentrations (Figs. 1 and 2) and may reflect changes in the sugar:starch ratios associated with cold hardiness. Total carbo-
Carbohydrate concentrations were greater in most instances during Feb. 1983 and Jan. 1984 than other sampling dates, indicating a net movement of carbohydrates into the one-year-old shoots when cold hardiness is normally the greatest.

Defoliation prior to 15 Oct. in Oklahoma substantially reduces or eliminates pistillate flower production the following spring (6), suggesting that October carbohydrate levels in some portion of the tree may influence the next year's flower production. In this study, bearing shoots usually had more reducing and nonreducing sugars and less starch than vegetative shoots, but total carbohydrates were equal in October. After defoliation in November, further changes in carbohydrate concentrations of the shoots would be from redistribution of existing carbohydrates. Bearing shoots of 'Stuart' had more nonreducing sugar, starch, and total carbohydrates than vegetative shoots. Carbohydrate concentrations in fruiting and vegetative shoots of the other cultivars were the same.

Pistillate flower differentiation was observed in central Oklahoma in early February (unpublished data). The carbohydrate concentration at differentiation may determine if the meristem remains vegetative or develops into reproductive structures. Carbohydrate concentrations during this period did not clearly favor shoots that had been vegetative, although vegetative shoots of 'Cape Fear' and 'Stuart' generally produced more flowers. At budbreak (April), trends between bearing and vegetative shoots were similar to those in January and February, although the balance between sugar and starch was substantially different.

Carbohydrate depletion has been suggested as the cause for alternate bearing in pecan (9, 11, 12). Pecan fruit mature very late, accumulating 68% of the fruit dry weight and 93% of the kernel dry weight during the last 6 weeks before maturity (14). Sixty percent to 70% of the kernel final weight is oil, and there is only enough carbohydrate in the fruit when oil synthesis begins to account for 12% of the normal oil content (16). Therefore, most of the carbohydrates must be transported into the fruit during a short time period, creating a maximum carbohydrate stress near natural defoliation. Factors that promote carbohydrate accumulation tend to alleviate alternate bearing.

Other research suggests that carbohydrates in one-year-old shoots are not responsible for alternate bearing. Wood and McMeans (13) found that shoots of 'on' and 'off' trees were equal in total carbohydrates over a 20-week period from June through October. Worley (16, 17) defoliated trees from 1 Aug. through 1 Nov. to determine the effects on flowering and carbohydrate concentrations. He found that although flowering was inhibited by August defoliation, refoliation increased carbohydrate concentrations in shoots to that of the control by the natural defoliation date in November. This study indicates that fruiting reduces subsequent flowering in late-ripening cultivars, but carbohydrate concentrations in one-year-old shoots (pecan flowers are born terminally on the current season's growth arising from terminal or lateral buds on one-year-old wood) were equal or greater in the bearing shoots in almost all instances. This finding suggests that the level of carbohydrates in one-year-old wood is not the major factor determining flowering. At least 2 mechanisms appear to control flower production in pecan. These mechanisms are the carbohydrate concentration in the tree and phytohormonal or growth-regulator balances. There appears to be a minimum carbohydrate level necessary for floral induction.

Fig. 1. Carbohydrate concentrations in one-year-old fruiting (F) and vegetative (V) shoots of 'Cape Fear' (CF), 'Squirrel' (SQ), and 'Stuart' (ST) during Oct. 1982 and Feb. and Apr. 1983. Mean separation within dates by LSD, 5% level.
Table 1. Phenological differences among pecan cultivars.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>80% budbreak</th>
<th>10% shuck split</th>
<th>80% defoliation</th>
<th>Days from maturity to defoliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squirrel</td>
<td>15 Apr. 25 Apr.</td>
<td>5 Oct. 17 Oct.</td>
<td>6 Nov. 22 Nov.</td>
<td>33 37</td>
</tr>
<tr>
<td>Stuart</td>
<td>14 Apr. 23 Apr.</td>
<td>18 Oct. 22 Oct.</td>
<td>6 Nov. 22 Nov.</td>
<td>20 32</td>
</tr>
<tr>
<td>Cape Fear</td>
<td>15 Apr. 23 Apr.</td>
<td>22 Oct. 31 Oct.</td>
<td>7 Nov. 22 Nov.</td>
<td>16 23</td>
</tr>
</tbody>
</table>

*Days from 10% shuck dehiscence to 80% defoliation.

Fruiting reduced return bloom of 'Cape Fear' and 'Stuart', but carbohydrate concentrations in bearing shoots were equal to or greater than those in vegetative shoots. Fruiting did not reduce return bloom of 'Squirrel', probably because it ripens earlier than 'Cape Fear' or 'Stuart'. This suggests the possible involvement of growth regulators from both the leaf and fruit.

Our data support the use of early ripening cultivars and management practices that maintain healthy foliage. Such practices should reduce alternate bearing by increasing carbohydrate production and storage and maintaining a source for flower-promoting substances.
Table 2. Return flowering of previous year shoot types for pecan cultivars.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Previous year shoot type</th>
<th>Flowering shoots (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1983</td>
<td>1984</td>
</tr>
<tr>
<td>Squirrel</td>
<td>Fruiting</td>
<td>82.2</td>
</tr>
<tr>
<td></td>
<td>Vegetative</td>
<td>92.4</td>
</tr>
<tr>
<td>Stuart</td>
<td>Fruiting</td>
<td>39.4</td>
</tr>
<tr>
<td></td>
<td>Vegetative</td>
<td>56.9</td>
</tr>
<tr>
<td>Cape Fear</td>
<td>Fruiting</td>
<td>48.8</td>
</tr>
<tr>
<td></td>
<td>Vegetative</td>
<td>83.3</td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>Shoot type within cv.</td>
<td>12.8</td>
</tr>
<tr>
<td>Cv. within shoot type</td>
<td></td>
<td>14.2</td>
</tr>
</tbody>
</table>

Literature Cited


Physiology of Melon Leaf Membrane Thermostability During Heat Conditioning

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Abstract. Seedling leaf segments of 2 Cucumis melo L. cultivars were heated for 15 min at 50°C to observe the influence of duration of temperature conditioning on the acclimation and deacclimation of membrane thermostability. The percentage of injury was measured by the increase in electrolyte leakage from leaf segments. Leaves from seedlings held for 5 days at 15°C had a higher percentage of injury following heat stress than those held 5 days at 35°C. Acclimation for 2 to 4 hr at 35°C was enough to reduce the percentage of injury to leaves from 15°C-grown plants. Deacclimation for 8 hr at 15°C increased the percentage of injury to leaves from plants grown at 35°C. Heat injury regressed as a function of mean relative leaf-blade growth rate with temperature and leaf age with temperature yielded predictive regression equations suggesting leaf age is better as a predictor of membrane thermostability than is leaf growth rate.

High temperatures during plant growth impose a stress on plants and consequently decrease crop yield (4). However, the degree of heat stress in plants is dependent on thermal tolerance, stage of growth, and length of heat stress (3). Terri (7) demonstrated that growth and differentiation of various genotypes over a range of temperatures appears to be correlated with seasonal and daily temperature ranges of their native habitat and that yield is primarily dependent on plant acclimation to daily temperature perturbations. Little is known about the mechanisms of heat tolerance in such warm-season crops as melons. Lester (5) has demonstrated that cell membranes of 5-day-old, 15°C-grown melon leaves acclimate to 35°C by 24 hr. The objective of the present study was to determine more precisely the time required to acclimate and deacclimate melon leaf-cell membranes to heat stress. Additionally, the relationship of leaf cell membrane thermostability to mean relative leaf blade growth rate and to leaf age as predictors of membrane thermostability was determined. Conductance due to electrolyte leakage was used to determine membrane thermostabilities of melon leaves.

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