
Conjugation of Foliar Absorbed NAA by Selected Fruit Crops

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Abstract. Conjugation of 14C-1-naphthaleneacetic acid (NAA) was followed in leaf discs of apple, apricot, grape, orange, peach and pear. NAA was metabolized by all crops studied. Free NAA and 2 metabolites that chromatographed with naphthylacetyl-D-glucose (NAG) and naphthylacetylaspartic acid (NAAsp) constituted 90% of the radioactivity recovered, NAG was most complete in orange (98%), intermediate in apple, apricot, peach and pear and least in grape (68%).

Weak organic acid type auxins, notably NAA, 2,4-D, 2,4,5-TP, etc., are often used to control specific physiological processes in tree fruits. One of the chief disadvantages common to such auxins is the marked variation in response shown by various crops and often by cultivars within a single crop. The cause of this varied response is not known.

The conjugation of such auxins with glucose and aspartic acid in tissue segments is well established. Conjugation may inactivate the auxin, alter its transport and metabolism and modify its availability to tissues. Therefore, fundamental differences among plants in their capacity to conjugate foliar applied auxins may be related to their physiological response to the auxin. Thus, we were interested in determining the auxin conjugation capacity of leaves of selected fruit crops. The crops and cultivars were chosen because weak organic acid auxins are used in their production and they differ in their response to auxins.

Conjugation of NAA was followed in the crops and cultivars noted in Table 1 as a cooperative effort between our 2 laboratories. Studies were performed in a similar manner with exceptions noted below. At East Lansing, the 14C-1-NAA (16.0 μCi/μmol, 6.25 × 10^5 μCi/mmol) buffered with phosphate-citrate at pH 4.2 was provided in a vial (i.d. 7 mm or 15 mm) for 21 hr at 25°C under fluorescent illumination (1.08 × 10^4 lux). At Rehovot, leaf discs were floated on 10 ml of phosphate-citrate buffer (0.015M) at pH 4.2 containing 14C-1-NAA (54.5 μCi/mmol, 3.15 × 10^6 μCi/mmol) for 21 hr at 25°C at 6.5 × 10^3 lux. After incubation the leaf discs were thoroughly washed with distilled water and blotted dry. Extraction, chromatography, identification of NAA and metabolites and radioassay were performed as previously reported. Each experimental unit consisted of 3 to 8 discs replicated 2 or 3 times. Experiments were repeated 2 or 3 times.

NAA was metabolized by all crops studied (Table 1). Most of the radioactivity (90% or greater) was found associated with 3 chromatographic zones with Rf's similar to those of NAA, NAAsp and NAG (Fig. 1). NAG was the major metabolite (45–90%) followed by NAAsp (5–30%) and NAA (2–22%). Conjugation was most complete in orange (98%), intermediate in apple, apricot, peach and pear and least in grape (68%).

Table 1. Uptake and conjugation of 14C-1-NAA by leaf discs of selected fruit crops.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Cultivar</th>
<th>Total uptake 14C-NAA (nmol/cm²)</th>
<th>Distribution (%)</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>NAG</td>
<td>NAAsp</td>
<td>NAA</td>
</tr>
<tr>
<td>Apple</td>
<td>Golden Delicious</td>
<td>3.78</td>
<td>73.3</td>
<td>15.5</td>
</tr>
<tr>
<td>Apple</td>
<td>Vered</td>
<td>1.02</td>
<td>82.6</td>
<td>11.6</td>
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<tr>
<td>Apricot</td>
<td>Curtis</td>
<td>1.25</td>
<td>79.0</td>
<td>9.2</td>
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<td>Apricot</td>
<td>Canino</td>
<td>0.59</td>
<td>79.7</td>
<td>10.0</td>
</tr>
<tr>
<td>Grape</td>
<td>Concord</td>
<td>0.16</td>
<td>45.1</td>
<td>13.1</td>
</tr>
<tr>
<td>Orange</td>
<td>Shamouti</td>
<td>0.66</td>
<td>68.5</td>
<td>29.7</td>
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<tr>
<td>Peach</td>
<td>Redskin</td>
<td>2.94</td>
<td>79.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Peach</td>
<td>Benita</td>
<td>0.41</td>
<td>90.3</td>
<td>5.3</td>
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<tr>
<td>Pear</td>
<td>Bartlett</td>
<td>1.34</td>
<td>66.8</td>
<td>19.1</td>
</tr>
</tbody>
</table>

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2Thanks are due to Mr. M. Huberman for his skillful technical help.

3Abbreviations: 2,4-D = 2,4-dichlorophenoxyacetic acid; 2,4,5-TP = 2-(2,4,5-trichlorophenoxy) propionic acid; IAA = indole-3-acetic acid.

2Studies designated with an asterisk were performed at East Lansing; the remainder were performed at Rehovot.

Table 1. Distribution data for East Lansing studies were based on total radioactivity recovered from all RF zones, while data from Rehovot were based on total radioactivity associated with RF zones for NAA and the 2 metabolites, representing at least 90% of total radioactivity.

*Ratio represents conjugated (NAG + NAAsp) NAA divided by free NAA.
Fig. 1. TLC of a 'Golden Delicious' leaf extract after 21 hr incubation in $^{14}$C-NAA illustrating the distribution of radioactivity. Developing solvent-chlorormethane: ethyl acetate:formic acid (5:4:1, v/v). Markers at the top denote RF zones that were used as an index for NAG, NAAsp and NAA.

The rapid conjugation reported by (5, 13). The high levels of NAA needed for reducing seed number in mandarins Shindy et al. (16) for NAA-treated with our conclusion, since mandarin fold higher than that needed for thinning in apricots (4). A relatively high level of NAA (150—600 ppm) is also required for reducing seed number in mandarins (5, 13). The high levels of NAA needed to induce responses in Citrus may be related to the high rate of conjugation. The rapid conjugation reported by Shindy et al. (16) for NAA-treated 'Kinnow' mandarin fruit is consistent with our conclusion, since mandarin

('Wilking') has been shown to tolerate high levels (1000 ppm) of NAA (3). The low uptake of NAA by grape leaves is of concern, in that, it may be reflected in the low conjugation observed in this crop, although we have no evidence that this is the case. Apple, apricot, peach and pear, considered more sensitive than orange, absorbed equal or greater quantities of NAA as orange, but conjugated less suggesting that uptake may not be crucial providing that sufficient NAA is absorbed to induce the appropriate conjugating enzymes.

No distinct relationship was apparent among apple, apricot, peach and pear between their capacity to conjugate NAA and their general response to auxin, except that they were intermediate between grape and orange. This is not to imply that no such relationship exists, but rather that studies are needed to establish specific parameters and ratings for crop sensitivity to a particular auxin and to determine the system capacity to conjugate that auxin. Information currently available is general in nature and is based primarily on pooled observations made under varied conditions and on numerous processes. Before we can establish the role of conjugation, further studies are needed particularly on comparative uptake, enzyme induction and kinetics of conjugation.

Literature Cited