### Summary

Laboratory and field tests were conducted to evaluate the effectiveness of dry baits consisting of granulated sugar with malathion, Diazinon [*O,O*-diethyl *O*-(2-isopropyl-6-methyl-4-pyrimidinyl) thiophosphate], or Bayer L 13/59 against houseflies, *Musca domestica* L. In laboratory tests the lowest test concentration of 0.1% of toxicant with sugar gave 99% kill of flies in 16 hours. Higher concentrations provided considerably faster kills. Baits containing malathion and L 13/59 showed no loss of toxicity after 1 month's storage, and the Diazinon bait was also still highly effective, although slightly slower in action.

Practical tests were run in dairy barns and poultry houses heavily infested with resistant houseflies. The baits were sifted on the floors and other locations where flies congregated, usually at the rate of 100 grams per application. Some flies died within 10 to 20 minutes after the initial applications in dairy barns, and in most of the tests reductions of at least 90% were indicated after 4 hours. Repeated applications (five per week) of baits containing 0.5 and 1% of the toxicants over a period of 2 to 3 weeks gave highly effective control in most of the dairy barns. Effective control was also obtained in poultry houses with repeated applications of baits containing 1% of the toxicants.

As flies feed on individual grains of sugar, the bait can be scattered sparsely, so that an animal would have little chance of eating more than a small fraction of it. The dry sugar bait is inexpensive and easily prepared, and the cost of equipment and time for application are negligible.



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## HERBICIDE ACTION

# Absorption and Translocation of Carbon-14 Applied As O-Isopropyl *N*-Phenyl Carbamate in *Avena* and *Zea*


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Advancement in the knowledge of chemical weed control may well depend on an extension of fundamental research on growth processes in plants on one hand and study of the mode of action of herbicides on the other. Studies on the herbicidal value of O-isopropyl *N*-phenyl carbamate were therefore undertaken to gain further information on some of the problems concerning its use as a grass killer. Information regarding its actual entry into the tissue of corn and oat plants and the transport of this herbicide from the point of entry to the other parts of plants was obtained. The results show that O-isopropyl *N*-phenyl carbamate was absorbed through the cut surface of leaves, cut surfaces of roots, and intact roots (in descending order of absorption rate). Intact leaf surfaces did not absorb it in appreciable amounts. The absorption through roots was greater in corn plants than in oat plants, which indicated the specific difference in the rate absorption. Soil application or application of this chemical immediately after cutting the grass should give better control.


ABSORPTION AND TRANSLOCATION of *O*-isopropyl *N*-phenyl carbamate (IPC) in plants have had little study. Mitchell and Marth (*3*) and Ennis (*1*) noted that soil application is necessary to obtain an effective kill, suggesting that *O*-isopropyl *N*-phenyl carbamate is normally absorbed by roots, not by the leaves. Preliminary work with radioactive tracers in this laboratory suggests that the material is translocated, but not in appreciable quantities.

The purpose of this investigation was to study the extent of absorption and translocation after application of carbon-14–labeled *O*-isopropyl *N*-phenyl carbamate ($2.82 \times 10^5$ counts per minute per mg., labeled on the secondary carbon of the isopropyl group) to intact and cut leaves and roots of oat (*Avena sativa*) and corn (*Zea mays*) plants, and to analyze the plant parts for radioactivity.

### Experimental Methods

**Plant Culture** Oat plants (*Avena sativa*, var. gray winter) and corn plants (*Zea mays*, var. yellow flint) were grown under greenhouse conditions in flats filled either with Chehalis sandy loam which had previously been treated with 10-9-4 fertilizer, or with coarse Dantor (exploded silica) and kept watered with nutrient solution until they were ready for treatment. (One liter of nutrient solution contains 2.3

**Table I. Radioactivity Recovered from Parts of Oat Plants Receiving Radioactive IPC Through Intact Leaves**

Each group consists of 12 plants. Radioactivity applied 3.42 × $10^4$ (counts per minute per group)

| | 1 Day | | 3 Days | | 7 Days | |
|---|---|---|---|---|---|---|
| | Total activity in plant part, counts/min. | % of amount applied | Total activity in plant part, counts/min. | % of amount applied | Total activity in plant part, counts/min. | % of amount applied |
| IPC alone | | | | | | |
| Treated leaves | 1790 | 5.2 | 3700 | 10.8 | 3190 | 9.3 |
| Leaves and stems above treated leaves | 120 | 0.4 | 140 | 0.4 | 230 | 0.7 |
| Coleoptiles and stem below treated leaves | 0 | 0 | 0 | 0 | 0 | 0 |
| Roots | 240 | 0.7 | 0 | 0 | 0 | 0 |
| Total radioactivity recovered | 2150 | 6.3 | 3840 | 11.2 | 3250 | 10.0 |
| IPC + 0.5% Tween-20 | | | | | | |
| Treated leaves | 4550 | 13.3 | 3570 | 10.4 | 8010 | 23.4 |
| Leaves and stems above treated leaves | 0 | 0 | 220 | 0.6 | 0 | 0 |
| Coleoptiles and stem below treated leaves | 0 | 0 | 0 | 0 | 0 | 0 |
| Roots | 0 | 0 | 150 | 0.4 | 0 | 0 |
| Total radioactivity recovered | 4550 | 13.3 | 3940 | 11.4 | 8010 | 23.4 |

Figures are averages of duplicate runs.

ml. of 1*M* magnesium sulfate, 2.3 ml. of 1*M* calcium nitrate, and 4.6 ml. of 1*M* potassium dihydrogen phosphate. (Solutions were made to volume with tap water.) The study was divided into four sections.

### *Application of Radioactive IPC to Intact Leaves*

**1A. Oat Plants** On the eighteenth day after planting the seeds, the second leaf was fully expanded and the third still rolled. Seventy-two uniform plants were selected and divided into two groups of 36 plants each. All plants were treated with 10 γ of radioactive *O*-isopropyl *N*-phenyl carbamate per plant on the tip of the second leaf. On the first group, an acetone solution containing 0.1% *O*-isopropyl *N*-phenyl carbamate was used, while on the second group a solution containing 0.1% *O*-isopropyl *N*-phenyl carbamate and 0.5% Tween-20 was used in order to determine the effect of Tween-20. Twelve plants from each group were harvested 1, 3, and 7 days after treatment and each was divided into the following parts: (1) treated leaves, (2) leaves and stems above treated leaves, (3) coleoptiles and stems below treated leaves, and (4) roots. They were dried for 24 hours at 80° C. in a vacuum oven (except the treated leaves).

**1B. Corn Plants** When the plants had grown to the fourth leaf stage, ten uniform plants were selected and treated with 0.05 ml. of an acetone solution containing 0.1% radioactive *O*-isopropyl *N*-phenyl carbamate (50 γ) on the tip of the second leaf. A group of five plants was harvested 6 and 9 days after treatment. All plants were sectioned and dried. Because no radioactivity was found even on the treated leaves, the experiment was repeated using twelve plants which were harvested 7 days after treatment.

### *Application of Radioactive IPC To Cut Edges of Leaves*

**2A. Oat Plants** Thirteen uniform plants in the flats of experiment 1A were selected. All plants were treated by cutting the tip of the second leaf and placing it immediately in a vial containing 0.5 ml. of aqueous radioactive solution (20 p.p.m. or 10 γ). The vials were stoppered with cotton. Between the day of treatment and the day of harvest the vials were filled daily with water to keep the leaf from dying owing to drying out of the cut edge. Twelve plants were harvested after 7 days and were divided into the following parts: (1) treated portion of treated leaves, (2) untreated portion of treated leaves, (3) leaves and stems above treated leaves, (4) coleoptiles and stems below treated leaves, and (5) roots. The treated portions of the treated leaves were further divided into the following lots for carbon-14 analyses: four plants dried in the vacuum oven, four plants fresh, and four plants washed with 10 ml. of acetone. This was done to determine whether any *O*-isopropyl *N*-phenyl carbamate was left unabsorbed on the leaf surface and whether any radioactivity was removed by the drying process. The plant parts were dried in the usual manner.

**2B. Corn Plants** On the twenty-eighth day after the seeds had been planted, the second leaf of corn plant was cut under water and treated by placing in a vial containing 1.00 ml. of aqueous radioactive solution (50 p.p.m. or 50 γ). Twenty plants were used. Seven days after treatment, the plants were harvested, dried, and sectioned as indicated.

### *Application of Radioactive IPC to Intact Roots*

**3A. Oat Plants** Ten days after the seeds had been planted in a flat of coarse Dantor, they were removed by flooding the flat and washing the Dantor from the roots. Forty-eight uniform, uninjured plants were chosen and placed four to a cup in waxed food cups (6 inches in diameter, 1-pint size) containing Dantor. One intact root of each plant was placed in a vial containing 0.5 ml. of aqueous radioactive solution (10 γ). Each vial was stoppered with cotton after inserting the root. The plants were harvested, sectioned, and dried 7 days after treatment.

**Table II. Radioactivity Recovered from Parts of Plants Receiving Radioactive IPC Through Cut Leaves**

(Plants harvested after 7 days of treatment)

| | Oat Plants | | Corn Plants | |
|---|---|---|---|---|
| | Total activity in plant part, counts/min. | % of amount applied | Total activity in plant part, counts/min. | % of amount applied |
| Number of plants used | 12 | | 20 | |
| Radioactivity applied, counts/min. | 3.42 × $10^4$ | | 2.85 × $10^5$ | |
| Treated portion of treated leaves | 9,450 | 27.6 | 38,700 | 13.6 |
| Untreated portion of treated leaves | 2,752 | 8.0 | 5,100 | 1.8 |
| Leaves and stems above treated leaves | 520 | 1.5 | 52,500 | 18.4 |
| Coleoptiles and stems below treated leaves | 0 | 0 | 3,500 | 1.2 |
| Roots | 0 | 0 | 14,100 | 4.9 |
| Total radioactivity recovered | 12,690 | 37.1 | 113,900 | 39.9 |

Figures are averages of duplicate runs.

**Table III. Radioactivity Recovered from Parts of Plants Receiving Radioactive IPC Through Intact or Cut Roots**

(Plants harvested 7 days after treatment)

| | Oat Plants | | Corn Plants | |
|---|---|---|---|---|
| | Total activity in plant parts, counts/min. | % of amount applied | Total activity in plant parts, counts/min. | % of amount applied |
| Treatment through intact roots | | | | |
| Number of plants used | 48 | | | |
| Radioactivity applied, counts/min. | $1.36 \times 10^5$ | | | |
| Leaves | 880 | 0.64 | | |
| Stems | 330 | 0.24 | | |
| Treated roots | 9,800 | 7.16 | | |
| Untreated roots | 2,180 | 1.50 | | |
| Total radioactivity recovered | 13,190 | 9.63 | | |
| Treatment through cut roots | | | | |
| Number of plants used | 24 | | 10 | |
| Radioactivity applied, counts/min. | $6.84 \times 10^4$ | | $2.85 \times 10^4$ | |
| Leaves | 650 | 0.95 | 1,370 | 4.8 |
| Stems | 1,560 | 2.28 | 2,500 | 8.8 |
| Treated roots | 9,500 | 13.89 | 5,450 | 19.1 |
| Untreated roots | 290 | 0.42 | 830 | 2.9 |
| Total radioactivity recovered | 12,000 | 17.54 | 10,150 | 35.6 |

Figures are averages of duplicate runs.

No experiment was run with application of *O*-isopropyl *N*-phenyl carbamate to intact corn roots.

### Application of Radioactive IPC to Cut Surface of Roots

**4A. Oat Plants** The procedure of experiment 3A was followed. Twenty-four of the plants were treated by placing one root (with the tip cut off) in a vial containing 0.5 ml. of aqueous radioactive solution (10 $\gamma$). All plants were harvested, sectioned as indicated, and dried.

**4B. Corn Plants** Ten uniform, uninjured plants were planted, one to a cup, in half-pint, waxed food cups (3 inches in diameter). Each cup was filled with Dantor and kept damp with nutrient solution. Each plant was treated at the time of planting by placing one root (with the tip cut off) in a vial containing aqueous radioactive *O*-isopropyl *N*-phenyl carbamate solution. Seven days after treatment all plants were harvested, sectioned, and dried.

**Radioactivity Measurement** The dry plant samples were weighed to the nearest 0.1 mg., cut up finely with scissors, and further ground in a mortar and pestle. Twenty- to 30-mg. samples were weighed and then oxidized using the Van Slyke-Folch wet-combustion method (*4*). The carbon dioxide was precipitated as barium carbonate, and the barium carbonate was mounted on thin planchets and counted by means of a thin mica window Geiger-Müller counter (1.9 mg. per sq. cm.) attached to a Tracerlab Autoscaler (*2*). The scale selector was set at 4096 counts. The specific activity of all barium carbonate samples was corrected to zero thickness.

### Results and Discussion

A negligible amount of radioactivity was found in both runs (experiment 1B) from parts of corn plants receiving radioactive *O*-isopropyl *N*-phenyl carbamate through intact leaves, indicating that no absorption occurred during the experimental period. The results of experiment 1A (with oats) are summarized in Table I. Most of the radioactivity was found on the treated leaves. From these experiments, it appears that *O*-isopropyl *N*-phenyl carbamate is not readily absorbed by intact leaves. The oat plants showed considerable radioactivity at the point of application. This radioactivity is probably due to unabsorbed *O*-isopropyl *N*-phenyl carbamate remaining on the surface of the leaves, because the treated sample of oat leaves was oxidized without drying in vacuum oven at high temperature. When the dry sample of treated corn leaves was oxidized, only a trace of radioactivity was observed. The Tween-20 may play a part only in reducing the vaporization from the leaf surfaces, as the oat leaves showed more radioactivity when Tween-20 was applied with *O*-isopropyl *N*-phenyl carbamate.

Experiments 2A and 2B are summarized in Table II. Application of the radioactive material to cut surfaces of leaves resulted in finding radioactivity throughout the upper portions of the oat plants and throughout the whole of the corn plants. *O*-Isopropyl *N*-phenyl carbamate appears to be most readily absorbed through the cut surfaces of leaves. Approximately 40% of the applied radioactivity was recovered in both oat and corn plants. The radioactivity was more uniformly distributed in the corn plants than in the oat plants, suggesting that the material is more readily translocated in corn than in oat plants.

The radioactivity recovered from the treated portion of the treated leaves was greater in the cases of the fresh leaves (12,420 counts per minute). The dried leaves (9380 counts per minute) were somewhat lower in radioactivity and the washed leaves were considerably lower (4300 counts per minute). The acetone washing of the washed leaves was colored, showing that the acetone had extracted substances from within the leaves. Thus it could not be relied upon to wash off only the *O*-isopropyl *N*-phenyl carbamate on the surface. Drying the samples in a vacuum oven probably was more effective in removing the non-absorbed chemical on the surface without removing it from within the leaf. Thus, in all subsequent experiments, the treated parts were dried.

The results from experiments 3A, 4A, and 4B are summarized in Table III. Radioactivity was evidenced throughout the plants in all experiments. These results indicated that *O*-isopropyl *N*-phenyl carbamate is readily absorbed and translocated throughout the plants, though the absorption rate is lower than that through the cut edges of leaves. Again, more radioactivity (percentage-wise) was found in the nontreated parts of corn plants than in the identical parts of oat plants to prove further that the material is more readily passed from cell to cell in corn plants.

These experiments confirmed that *O*-isopropyl *N*-phenyl carbamate is normally absorbed not by intact leaves but by roots. Whether the substance or substances absorbed and translocated are *O*-isopropyl *N*-phenyl carbamate itself, some breakdown or conjugation products, or some combination of these, has not yet been determined. At the present time, studies are being conducted to determine the nature of the absorbed and translocated substances.

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