

Technical Papers

Evaporation of Some Plant Growth Regulators and its Possible Effect on their Activity

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Very minute amounts of growth-regulating compounds may be applied to plants to bring about a variety of responses, such as improving the storage quality of vegetables, preventing fruit drop at harvesttime, and killing undesirable plants. The compound must remain in contact with the plant and be absorbed into its tissues in order to bring about the desired effects. Rate of evaporation is therefore of particular interest, and rapid evaporation is disadvantageous. It is not implied, however, that evaporation of a growth-regulating compound may be altogether undesirable. For example, it is desirable to use one that evaporates readily if the vapors are to be utilized in treating plant material. In the present studies, some carbamates that are used to prevent sprouting of stored vegetables and also as herbicides were found to evaporate at relatively rapid rates at ordinary temperatures. It has been reported that detectable amounts of esters of 2,4-dichlorophenoxyacetic acid evaporate and that their rates of evaporation vary (1, 2).

The rates of evaporation of six plant growth-modifying compounds¹ were studied in the experiments reported here. Three of these, ethyl 2,4-dichlorophenoxyacetate (2,4-D ethyl ester), isopropyl-N-phenyl carbamate (IPC), and 3-chloro-isopropyl-N-phenyl carbamate (3-Cl-IPC), had relatively rapid rates of evaporation. The remaining compounds, 2,4-dichlorophenoxyacetic acid (2,4-D acid), α -naphthalenacetic acid and (4-hydroxy-5-isopropyl-2-methylphenyl)trimethyl ammonium chloride, 1-piperidinecarboxylate (Amo 1618), did not evaporate appreciably under the conditions used.

Several separate experiments were conducted. In a preliminary one, IPC evaporated at an average daily rate of 277 μ g when a relatively large sample (about 7 mg) was spread as a thin layer over an area of about 3 cm² on a watch glass and exposed to air. The sample lost 55% of its original weight when stored for 2 weeks at temperatures of 70°–85° F.

This preliminary result indicated that some carbamates may evaporate rather readily at moderate

temperatures. An additional experiment using IPC and 3-Cl-IPC was therefore done to determine temperatures that are critical in the evaporation of these compounds. The compounds were stored separately in tinfoil cups having sides approximately 3 mm high, each containing about 30 mg of chemical. The area of the bottom of each cup, over which each chemical was spread, was 1.8 cm². The IPC used was in the form of minute but visible crystals, and the 3-Cl-IPC was a liquid. In this experiment loss of weight was determined to the nearest 0.1 mg.

The samples of IPC lost 2, 21, and 25% of their original weight because of evaporation when stored for 2 weeks at temperatures of 60°, 70°, and 85° F, respectively. In contrast, measurable amounts of similar samples stored at 16°, 32°, 40°, and 50° F did not evaporate during this same period. The samples of 3-Cl-IPC stored in a similar manner lost an average of 12% of their original weight at 85° F, but measurable amounts did not evaporate at the other temperatures.

An additional experiment was performed to determine the rate of evaporation of 3-Cl-IPC when a small amount was distributed evenly over a metallic surface. This method was used in order to simulate the amount and surface distribution of plant growth-regulating compounds when applied commercially to the leaves, stems, or fruits of plants. A weighed piece of tinfoil, having a surface area of 30 in.² was dipped into an alcohol solution containing 10,000 ppm of 3-Cl-IPC. After the alcohol had evaporated, 3252 μ g of 3-Cl-IPC was left on the metal—equivalent to about 1.5 lbs of the chemical per acre of surface. When the coated tinfoil was exposed to air at 83°–85° F, the compound evaporated at an average rate of approximately 177 μ g/hr, the loss being most rapid during the first several hours. Under the conditions used most of the 3-Cl-IPC had evaporated by the end of the first 24-hr period of the experiment.

In a similar experiment, the rate of evaporation of Amo 1618, a less well-known carbamate, was also measured. During a 4-day period, there was no measurable loss in weight of the 4651 μ g originally dispersed over the surface of the tinfoil. This indicates that some carbamates do not evaporate as readily as others.

No loss in weight of α -naphthalenacetic acid was detected during the first week after 3300 μ g of the compound was dispersed over the surface of the tinfoil.

The rates of evaporation of 2,4-D acid and of 2,4-D ethyl ester were determined by applying them to glass surfaces in a way comparable to that used in previous experiments with tinfoil. Weighed pieces of glass, each having a surface area of 25 cm², were dipped separately into a solution consisting of 500 mg of either 2,4-D acid or 2,4-D ethyl ester in 50 ml of alcohol. After the alcohol had evaporated there were 343 μ g

¹ Isopropyl-N-phenyl carbamate and 3-chloro-isopropyl-N-phenyl carbamate used were supplied by U. S. Industrial Chemicals Company; (4-hydroxy-5-isopropyl-2-methylphenyl)trimethyl ammonium chloride, 1-piperidinecarboxylate was supplied by the Bureau of Agricultural and Industrial Chemistry, U. S. Department of Agriculture.

of the 2,4-D acid remaining on one piece of glass and 475 µg of the 2,4-D ethyl ester on the other. During the following 3-day period, there was no measurable loss in weight of the 2,4-D acid sample, but the sample of 2,4-D ethyl ester lost 86% of its original weight. The temperature varied from 79° to 90° F but was about 85° during most of this period.

With the exception of Amo 1618, the rates of evaporation of those chemicals that were previously applied to tinfoil were also measured after they had been applied in a similar manner to glass. The period of evaporation was 24 hr, and the temperature varied from 85° to 88° F. In this experiment, approximately equal amounts of each compound were applied. The carbamate Amo 1618 did not adhere to the surface of the glass, and therefore tinfoil was used in place of glass. Results of these later experiments were similar to the earlier ones with tinfoil. IPC and 3-Cl-IPC both evaporated at a very rapid rate, whereas an appreciable amount of α-naphthalenacetic acid did not evaporate. As would be expected, the 2,4-D ethyl ester

TABLE 1

EVAPORATION OF SOME GROWTH-REGULATING COMPOUNDS DURING THE FIRST 24-HR PERIOD AFTER BEING FINELY DISPERSED ON GLASS SLIDES HAVING A SURFACE AREA OF 25 CM²

Compound	Temperature range (°F)	Amount used (µg)	Percentage evaporation in 24 hr
3-Cl-IPC	85-88	364	91.9
IPC	85-88	382	79.6
2,4-D ethyl ester	79-90	475	29.0
α-Naphthalenacetic acid	85-88	492	5.5
2,4-D acid	79-90	343	0
Amo 1618*	79-90	4651	0

* Amo 1618 applied to tinfoil instead of glass.

evaporated, and the 2,4-D acid failed to do so. On the other hand, the ethyl ester did not evaporate nearly as fast as did either the IPC or the 3-Cl-IPC (Table 1).

These experiments show that certain carbamates evaporate at a relatively rapid rate at moderate or comparatively high temperatures. This would seem to indicate that when they are applied in small amounts their effectiveness as plant growth regulators might be reduced through rapid evaporation. Rhodes *et al.* (3) reported that the sprout-inhibiting effect of isopropyl-N-phenyl carbamate decreased when treated potato tubers were exposed to air. Marth and Schultz (4) reported that relatively small amounts of 3-Cl-IPC inhibited the sprouting of potatoes stored at room temperatures, but only when the treated tubers were temporarily stored at low temperatures (40°-50° F) prior to storage at the higher temperatures (about 70°-75° F). In their experiments an average of approximately 4.5 mg of the 3-Cl-IPC was applied per tuber. It would be expected, on the basis of the present results, that practically all of this would

evaporate during the first 24-hr period following its application unless it penetrated into the tuber. Temporary storage at low temperatures apparently allowed time for the tubers to absorb an effective amount of the compound before it evaporated.

Some growth-regulating substances are effective when applied to plants in minute amounts, even at relatively high temperatures, since they apparently do not evaporate at a sufficient rate to reduce their effectiveness. For example, apple drop, which sometimes occurs before harvest, may be greatly reduced by the application of sprays that contain only 10 ppm α-naphthalenacetic acid. In supplementary experiments the acid was applied at this rate to mature apples, and the fruits retained an average of only about 4 µg of the chemical.

Stevens and Carlson (5) reported that temperatures below 75° F markedly delayed the disappearance of 3-chloro-isopropyl-N-phenyl carbamate following its application to soil. It would appear from the present results that, when growth-regulating compounds such as IPC and 3-Cl-IPC are used as herbicides at high temperatures, they may evaporate in sufficient amounts to reduce their effectiveness.

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The Antithyroid Activity of some Compounds that Inhibit Peroxidase

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The percutaneous absorption of resorcinol has been reported to induce myxedema with goiter in human subjects (1), and the parenteral administration of this substance to the rat acutely depressed the accumulation of radioactive iodine by the thyroid gland (2). In a recent study of many polyhydric phenols Arnott and Doniach (3) showed that compounds containing hydroxyl groups *meta* to one another (e.g., resorcinol, phloroglucinol, hydroxyhydroquinone) were most effective in decreasing iodine uptake by the rat thyroid, and these authors suggested, on the basis of an earlier observation of an inhibitory action of resorcinol on milk peroxidase (4), that the antithyroid effect of substances of this kind might be ascribed to inhibition of a thyroid peroxidase. Their report prompts us to record experiments along similar lines performed in