A NEW SPROUT INHIBITOR FOR POTATO TUBERS[1]

PAUL C. MARTH[2] AND E. S. SCHULTZ[3]

During experiments on the sprout-inhibiting effects of a variety of chemicals on table stock potato tubers, it was found that 3-chloro-isopropyl-N-phenyl carbamate (3-Cl-IPC)[4] was extremely effective in preventing sprout growth when compared with some other sprout-inhibiting chemicals. Of further interest is the fact that Anderson, Linder and Mitchell (1) have found that this and some related carbamates evaporate very rapidly when small amounts are exposed to room temperatures, apparently no appreciable amount of the chemical being left on the treated surface. This characteristic may be of interest from a toxicological standpoint.

EXPERIMENTAL PROCEDURES AND RESULTS IN MARYLAND

In England, Rhodes *et al.* (6) reported that isopropyl-N-phenyl carbamate (IPC) markedly reduced sprouting of stored potato tubers and that it was superior to the methyl ester of naphthaleneacetic acid (MENA) for this purpose.

Preliminary experiments on stored potato tubers started in December 1950 at the Plant Industry Station, Beltsville, Maryland, however, indicated that under certain conditions 3-Cl-IPC may be even more effective as a sprout inhibitor than the parent carbamate (IPC). In one of these experiments, IPC, 3-Cl-IPC, MENA, 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and maleic hydrazide were applied separately as dusts of 1 per cent concentration in talc. Individual 10-pound lots of unsprouted Katahdin potatoes that had been stored at 40° to 50°F. for approximately 3 months were treated with each mixture on December 6; four lots were used per treatment and four untreated lots served as controls. Immediately after treatment, all lots were placed in paper bags, sealed and then stored for 2 months in a room having an air temperature range of 40° to 50°F. After storage, the various lots were placed in a room where temperatures of 70° to 75°F. were maintained. The potatoes were examined for sprout development at intervals thereafter. The bags were resealed after each examination.

Under the conditions of this experiment, 3-Cl-IPC proved to be the most effective chemical used. Tubers treated with this compound remained dormant and relatively firm for 4 months in a room where the air temperatures ranged from 70° to 75°F. Tubers treated with IPC, 2,4,5-T or MENA remained dormant for 1 month at these temperatures but later started to develop short knobby sprouts. Maleic hydrazide was entirely ineffective in these tests, confirming the results of Marshall and Smith (3) when they applied this chemical to surfaces of the tubers. The average fresh weights (grams) of sprouts per tuber developed during 4 months at 70° to 75°F. were 8.4, 8.2, 5.1, 3.9, 3.6 and 0, respectively, for the

[1]Accepted for publication May 8, 1952.

[2]Physiologist and [3]Principal Pathologist, Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture, Beltsville, Md.

[4]3-Chloro-isopropyl-N-phenyl carbamate was furnished for these studies by Pittsburgh Plate Glass Company, Columbia Chemical Division, Pittsburgh, Pennsylvania, and by U. S. Industrial Chemicals Company, Incorporated, Baltimore, Md. The butyl ester of 2,4,5-T was supplied by the American Chemical Paint Company, Ambler, Pa.

control, maleic hydrazide, 2,4,5-T, MENA, IPC and 3-Cl-IPC treatments. Shriveling was most severe in the sprouted control lots of tubers and less so in treated lots which had fewer sprouts.

An experiment was undertaken in December 1951 to determine how quickly Katahdin tubers took up sufficient 3-Cl-IPC to cause dormancy when exposed to temperatures of 70° to 75°F. Individual lots of 10 uniform-sized tubers that had been shipped from Maine and stored at 40° to 50°F. for approximately 3 months were dipped in water suspensions of 0, 0.1, 0.5 or 1 per cent concentration. Following treatment with the chemical at different concentration levels, separate lots were held in ventilated baskets at 70° to 75°F. for 0 hour (immediate storage), 3 hours, 7 hours, 3 days, 7 days and 14 days before they were placed in 40° to 50°F. storage. Each chemical treatment was replicated twice for each of the 6 different time periods selected. For comparison, similar lots of untreated tubers were kept out of storage. At the end of 55 days from the beginning of the experiment, the tubers were removed from low-temperature storage and returned to the higher temperature (70° to 75°F.) for 2 weeks.

At low concentration 3-Cl-IPC lost its effectiveness very rapidly when the treated tubers were held at a warm temperature (Table 1). For instance, at 0.5 per cent concentration the chemical was completely effective only on tubers stored at the low temperature immediately after treatment. At this dosage, 20 per cent of the effectiveness of the chemical was dissipated within 3 hours at high temperature (70° to 75°F.). Tubers that were treated at the 1 per cent level, however, and held for as long as 14 days in a warm room retained sufficient chemical to cause complete inhibition of bud growth.

In order to develop a more effective method of using 3-Cl-IPC, dormant unsprouted Katahdin potato tubers were dipped in water suspensions containing 0.1, 0.25, 0.5 or 1 per cent concentration and immediately sealed in single-thickness Kraft paper bags on December 7, 1951. Two separate lots consisting of 16 tubers each for each treatment, along with two untreated lots, were placed in storage at 40° to 50°F. and similarly treated and untreated lots were placed at 70° to 75°F. The sealed bags of tubers were removed from the lower to the higher temperature after 57 days. Sprouting data were obtained after all lots had been kept for at least 2 weeks at 70° to 75°F.

Of the tubers stored continuously at the high temperatures for 71 days, those treated with 1 per cent 3-Cl-IPC remained completely dormant. Ten per cent of the tubers that had been dipped at the 0.5 per cent concentration were sprouted. Both the 0.1 and the 0.25 per cent concentrations were ineffective in preventing sprouting and the treated tubers were badly shriveled.

On tubers placed in low-temperature storage immediately after treatment, concentrations of 0.25, 0.5 and 1 per cent of 3-Cl-IPC were effective in preventing sprouting after their transfer to the higher temperature. At the lowest dosage level (0.1 per cent) the chemical was ineffective.

Tubers bruised in shipment before treatment with a dip containing 3-Cl-IPC at 1 per cent concentration developed a slightly more intense browning than did bruises on the controls. This effect was not apparent when smaller amounts of the chemical were applied. Losses from decay were negligible in all lots.

TABLE 1.—*Effect of 3-Cl-IPC on sprout development on Katahdin potato tubers treated and held at 70° to 75°F. for various periods prior to storage at 40° to 50°F.*

(Twenty tuber samples were treated on December 7 and kept at 70° to 75°F. or stored at 40° to 50°F. or both for 55 days. Data were obtained after the tubers had been held after storage for an additional 2 weeks at 70° to 75°F. to permit sprouting.)

Dip Concentration of 3-Cl-IPC	Percentage of tubers with sprout growth ¼ to ½ inch long when held at 70° to 75°F. for indicated period before storage					
	0 Hour	3 Hours	7 Hours	3 Days	7 Days	14 Days
Control	100	100	100	100	100	100
0.25 Per cent	60	100	100	100	100	100
0.5 Per cent	0	20	40	40	100	100
1.0 Per cent	0	0	0	0	0	0

Throughout the experiments with 3-Cl-IPC it was noted that apical dominance was reduced in those treatments that did not effectively control sprouting. In one experiment, for instance, the number of eyes from which sprouts developed was found to average 3.8 per tuber for the controls and 6 per tuber for the treated lots. Sprouts on the treated tubers were distributed over the entire tuber.

In a preliminary field experiment in which 3-Cl-IPC was used as a spray on the tops of potato plants this compound was not effective in retarding sprout development of the tubers. Apparently it was not absorbed or translocated as is the case with 2,4,5-T and maleic hydrazide (2, 5). On July 17, at Beltsville, Maryland, 4 plots of 10 hills each of vigorously growing Katahdin potatoes were sprayed with a water mixture containing 0, 0.06, 0.1 or 0.25 per cent concentration of 3-Cl-IPC. Tween-20 at 0.5 per cent concentration was used as a dispersing agent.

In comparison with the control plots, 3-Cl-IPC did not cause noticeable effects on the vines at any of the concentration levels employed. The tubers were harvested on August 1 and stored at 40° to 50° F. for 90 days. Upon removal from storage to the higher temperatures (70° to 75°F.) tubers in the controls as well as in all the treated lots, started sprouting profusely and evenly. Since the spray treatments were applied at the prevailing air temperatures of 85° to 90°F., it seems quite likely that much of the applied chemical may have evaporated soon after it was deposited and that the quantity which remained was not translocated into the tubers in sufficient amounts to affect sprout development.

EXPERIMENTS WITH POTATO TUBERS ON WASTE PILES IN MAINE

Experience has shown that potato waste or dump piles are a primary source of spores that cause late blight infection. Sprouts contract late blight from infected tubers deposited on dump piles; from infected sprouts of these tubers the late blight spores are blown to potato tops in commercial fields as soon as the plants are up and before the fields are sprayed.

To facilitate control of late blight development on dump piles, sprout

inhibitors were used experimentally in Maine in 1950 (4), when it was found that 2,4,5-T butyl ester prevented sprout development as well as stopped growth of sprouts that had been formed before treatment.

In 1951 butyl ester of 2,4,5-T and 3-Cl-IPC were used on potato waste piles. Water suspensions containing 0.25 per cent of 2,4,5-T or 0.5 or 1 per cent concentration of 3-Cl-IPC were sprayed on each layer of tubers as they were deposited on the piles. A gallon of one mixture or the other was used for spraying 360 pounds of tubers. The tubers represented mixed varieties (Chippewa, Green Mountain, Mohawk and Teton)

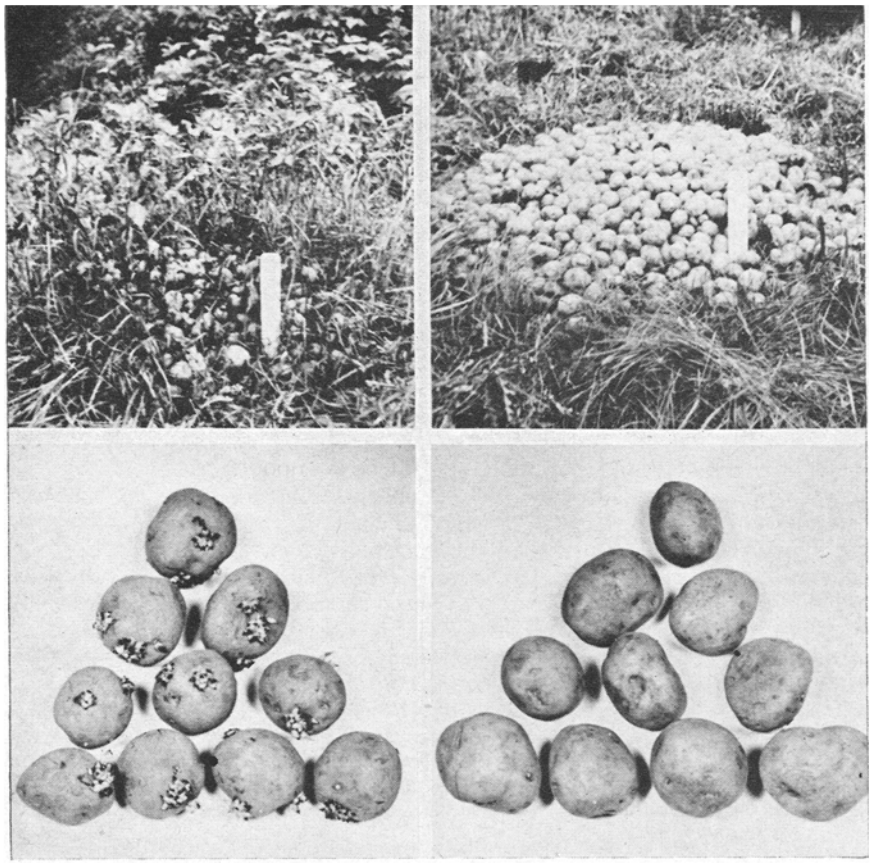

Figure 1.—Upper left, potato waste pile not sprayed with dormancy-inducing chemical. Tall potato tops developed; some plants were infected and killed by late blight fungus. Upper right, *treated*: potato waste pile sprayed with 1 per cent 3-Cl-IPC on May 26, free from sprouts on September 2, when both the untreated and the treated piles were photographed.

Lower left, untreated Katahdin table stock potatoes showing sprout development when held for 2 weeks at room temperature (70° to 75°F.) after removal from storage. Lower right, comparable potatoes treated with a water dip containing 0.5 per cent 3-Cl-IPC and stored immediately after treatment on December 7. Both lots were removed from storage after 55 days and held for 2 weeks at 70° to 75°F. prior to taking of photograph on February 14.

that had formed 2- to 3-inch sprouts before treatment on May 26. Five piles of tubers were treated while 3 piles served as untreated controls.

Observations from June to September on the treated tubers disclosed that all treatments had prevented formation of sprouts as well as inhibited further growth of the sprouts that had developed before the tubers were treated (Figure 1). The tubers in the untreated controls developed 20- to 30-inch plants that contracted late blight during the season (Figure 1).

These results show that treatments with 0.5 to 1 per cent spray concentrations of 3-Cl-IPC effectively control sprouting on potato waste piles and so facilitate disposal of waste potatoes and control of late blight on potato dump piles.

Discussion and Summary

In the present experiments 3-Cl-IPC has proved to be a very potent sprout inhibitor when applied to stored potato tubers. The conditions under which the chemical is applied strongly influence the inhibiting response. The effective treatment with 3-Cl-IPC was a water dip containing 1 per cent of the chemical. Only one-half as much of this chemical was required when the tubers were stored at low temperatures (40° to 50°F.) for about a month prior to storage at room temperatures (70° to 75°F.). A lower concentration (0.25 per cent) was effective only when the treated tubers were sealed in paper bags and stored for about one month or longer at the low temperatures before they were placed in the warm room.

The fact that 3-Cl-IPC apparently evaporated from a treated surface rather readily at ordinary room temperature (1) makes it of additional interest from the standpoint of chemical treatment of food products, for there is a possibility that only a small amount of residue would be left on the surface of potatoes or other plants to which this compound might be applied. It is also of interest that under the prevailing summer weather conditions in Maine, where the average temperatures are somewhat cooler than at Beltsville, 3-Cl-IPC effectively controlled sprouting in cull piles.

Caution: Since data on the effects of repeated dosages of small quantities of 3-Cl-IPC and IPC on animals and humans are lacking at present, these chemicals are not recommended or endorsed for applications to potatoes to be used for food.

Literature Cited

1. Anderson, W. Powell, P. J. Linder, and John W. Mitchell. 1952. Evaporation of some compounds in relation to their effectiveness as plant growth regulators. Science (In press).
2. Ellison, J. H., and Ora Smith. 1948. Effects of spraying a sprout inhibitor on potato plants in the field. Proc. Amer. Soc. Hort. Sci. 51: 397-400.
3. Marshall, E. R., and Ora Smith. 1951. Maleic hydrazide as a sprout inhibitor for potatoes. Bot. Gaz. 112: 329-330.
4. Marth, P. C., and E. S. Schultz. 1950. Effect of growth regulators on sprouting of stored table stock potatoes and on waste piles for control of diseases. Amer. Potato Jour. 27: 23-32.
5. Paterson, D. R., S. H. Wittwer, L. E. Weller, and H. M. Sell. 1952. The effect of pre-harvest foliar sprays of maleic hydrazide on sprout inhibition and storage quality of potatoes. Pl. Phys. 27: 136-142.
6. Rhodes, A., W. A. Sexton, L. G. Spencer and W. G. Templeman. 1950. Use of isopropyl phenyl carbamate to reduce sprouting of potato tubers in storage. Research 3: 189-190.