Preliminary Tests with Systemic Insecticides[1]

George E. Gould, Purdue University

A systemic insecticide is one that is absorbed by the plant and translocated in the sap so that parts of the plant other than those treated become toxic to sucking insects. This type of insecticidal action was demonstrated for selenium compounds by Gnadinger (1) and others as early as 1933. These compounds were never used extensively as quantities of the material dangerous to humans accumulated in sprayed plants or in plants grown in treated soils. Recently German chemists have developed a number of phosphorus compounds that show systemic action. In our tests three of these compounds have been tried in comparison with three related phosphorus compounds for which no systemic action has been claimed.

The development of these systemic and other phosphorus compounds have been based on the discoveries of the German chemist Schrader in 1942 (German patent 720,577). After World War II this information became available to the Allied Governments and soon numerous compounds were released for experimental purposes. At present three of the non-systemic compounds, parathion, hexaethyl tetraphosphate and tetraethyl pyrophosphate, are available commercially. The first of the systemics tested was C-1014, a formulation similar to Pestox 3 (octamethylpyrophosphoramide) which has been used in England. The other two in our tests were Systox with its active ingredient belonging to a trialkyl thiophosphate group and Potasan, diethoxy thiophosphoric acid ester of 7-hydroxy-4-methyl coumarin. Two additional phosphorus compounds used in some tests included Metacide, a mixture containing 6.2% parathion and 24.5% of O, O-dimethyl O-p-nitrophenyl thiophosphate, and EPN 300, ethyl p-nitrophenyl thionobenzine phosphonate.

Parathion (O,O-diethyl O-p-nitrophenyl thiophosphate) was the first available for experimental use in 1947 and was found to be quite effective against many insects. In the laboratory a median lethal dose (M.L.D. 50) for the female German roach was .042 percent of the active ingredient as compared to 1.1 percent for DDT and 13.5 for sodium fluoride (Gould 2). In the field a parathion spray killed 100 percent of the grasshopper nymphs on corn in one hour, whereas chlordane, benzene hexachloride and toxaphene required 48 hours for the maximum kill. In the untreated area of this field the nymphs migrated through and severely damaged the first 150 rows of corn, while all treatments stopped the migration.

Against the striped cucumber beetle parathion gave a complete kill within one hour and even prevented the dispersal of beetles that

[1] Systox, Potasan and Metacide were furnished by the Pittsburgh Agricultural Chemicals Co., C-1014 by the Dow Chemical Co., parathion by the American Cyanamid Co., and EPN-300 by duPont & Company.

follows applications of most dusts. This material has given excellent control of plant lice and red spider in numerous tests on many vegetable crops. In one test against the potato aphid on tomatoes the population stayed at a low level for 21 days after treatment, whereas on other treated plots the numbers started increasing again in seven to 10 days. Against the European corn borer on sweet corn parathion gave a control about as good as DDT. In 1947 parathion gave a 99% reduction of borers and DDT a 91% reduction. In 1948 parathion gave a 97% reduction on borers on the Spancross variety and DDT 94%, and on Golden Cross Bantam parathion gave 92% reduction with DDT 98%. In 1949 on the North Star variety parathion gave a 95% reduction and DDT 93%. Parathion has been used against potato insects where it gave good control but the yield was not as high as that of the DDT plots. Several large potato growers used this material as a substitute for DDT for one or two applications in 1950 when plant lice became abundant. On peppermint plants most insects including the looper and the spittle bug adult were controlled, although spittle bugs reinfested plants within a week. Against onion thrips both a 1% and 2% dust and a spray gave significant increases in yield over the check. Against the following insects parathion was only fair to good: tomato hornworm, cabbage worm, cabbage looper, blister beetles and squash bugs.

Parathion has been used on many plants and at many dilutions. On only two groups of plants, tomatoes and the cucurbits, has any injury been observed and in both cases only the spray caused injury. On small direct-seeded tomato plants the spray caused serious burning. On cucumbers and cantaloupes .25%, .50% and 1.0% dusts caused no injury but the spray caused some burning to small plants. Plants starting to vine had no apparent injury.

Tests with the other materials were made in 1950 and were not as extensive as those with parathion over a four year period. C-1014 was applied three times to sweet corn for corn borer control. This material as a water miscible concentrate containing 63.3% active ingredients was applied at a rate of 4 quarts in 100 gallons of water with a knapsack sprayer so as to thoroughly wet the plants and run down the stalk. At the time of dissection about three weeks later this corn had 380 borers per 100 plants as compared with 124 on the untreated. Five applications of C-1014 at this dilution had no influence on the striped cucumber beetle population on treated cantaloupes.

The three systemic materials were applied on August 7 to late cabbage at a rate of 2 quarts per 100 gallons. The amount of active ingredients in each spray differed, as C-1014 has 63% active ingredients in the concentrate, Systox emulsion concentrate 32%, and Potasan emulsion concentrate 30.6% Cabbage loopers were not numerous, but cabbage worms were abundant. Counts of dead and live worms were made on August 9. Treatments were repeated on August 20 and September 7. Since three materials were supposed to be absorbed by the

plants, the amount of damage from feeding was evaluated on August 31 and September 18. The figures for each material are given in Table I.

TABLE I. Kill of Cabbage Worms and Damage Evaluation.

	August 9 Percent Dead	August 31 Damage Evaluation	September 18 Damage Evaluation
C-1014	50	274	206
Systox	97	342	126
Potasan	84	326	196
Rotenone dust	100	198	60
Check	0	396	330

These same three materials plus Metacide and EPN 300 were applied to eggplant on August 10 and 30. The first three plus Metacide emulsion concentrate (33.4% active ingredients) were used at 2 quarts per 100 gallons and the EPN-300 wettable powder (27% active ingredients) at 4.8 pounds per 100 gallons. The plants were old, having been set in the field about June 1 and had a serious infestation of red spider, and light to moderate infestations of plant lice and flea beetle. All materials gave excellent control of the lice and red spiders and caused the flea beetles to disappear for about a week after each application. However, two materials, Systox and Potasan, caused serious distortion of the new growth. This injury was the typical hormone-like growth and eventually affected the terminal 8 to 10 inches of the plants. The old leaves were not affected and so with the control of the pests the plants finally produced many normal fruits.

The three systemic materials were compared with rotenone and several other insecticides for the control of various insects on late beans. The Mexican bean beetle, which is a major pest of beans, in home gardens, was present in small numbers on the early plantings. The late planting was made in the same area and about 1000 beetles were released on the small plants. The old plants were then pulled up to force all beetles to feed and lay eggs on the young plants. In place of the usual two applications for bean beetle control, this crop was dusted or sprayed four times on the following dates: August 7, 16, 30 and September 7.

The bean plants were infested with several insects, including the potato leafhopper, the bean leaf beetle, *Colaspis*, the 12-spotted cucumber beetle and the Mexican bean beetle. The bean beetle was not too injurious until in September when the larvae of the released beetles were reaching maturity. Those plots adjacent to the eggplant became heavily infested with red spider. As in the case of eggplant, the two systemics, Systox and Potasan, caused serious distortion of the plants. This distortion was noticeable after the first application and became more pronounced with the later applications. Plants had the typical

distortion of the hormone-like growth and were stunted in size. Plants were not completely killed by the frost of September 24 and on October 20 these plots had a heavy crop of beans.

Harvest of the beans started on September 22 and was finished after frost nipped the upper leaves. Plants on the two systemic plots had a few small pods and many blooms. The average yield of beans from 50 plants were as follows:

Dust B	8.9 pounds
Rotenone dust	7.6 pounds
Check	5.0 pounds
C-1014 spray	6.8 pounds
Systox spray	3.1 pounds
Potasan spray	1.9 pounds

An analysis of variance showed that differences in yield were highly significant and that a difference of 1.9 pounds between any two treatment averages was significant.

The cabbage maggot has become a destructive pest of cabbage, turnips, radishes and related crops in the Indianapolis area. In September a number of treatments, including C-1014, were applied to turnip seedlings when they first appeared above ground. C-1014 was applied as a spray to and around the small seedlings. In late October the turnips were pulled and many damaged turnips were found in both treated and untreated rows. Plots treated with this material had fewer undamaged turnips than the check.

The squash bug is the one major pest of vegetable crops for which there is no satisfactory control. Five of these new materials were applied in late August to two varieties of squash heavily infested with nymphs of the squash bug. The spray was applied thoroughly to plants and to the ground around the base of the plant. Both Metacide and EPN-300 killed many 12-spotted cucumber beetles in the first 24 hours but the plants were reinfested on the seventh day. These two materials killed some of the squash bug nymphs by contact action, but on the seventh day both adults and nymphs were present in the usual numbers on the plants treated by these two materials and on those treated by the three systemics.

Summary

Three new systemic insecticides were used for the control of several insects and gave good control only against plant lice and red spider. One or all three of the materials were used against the following pests and gave poor results: cabbage worms, European corn borer, cucumber beetle, 12-spotted cucumber beetle, squash bug, Mexican bean beetle and flea beetles. Three related phosphorus derivatives, parathion, Metacide, and EPN-300, gave good control of plant lice and red spider and, except for the squash bug, good to excellent control of the other insects. Two materials, Systox and Potasan, caused serious distortion and stunting on beans and eggplant.

Literature Cited

1. GNADINGER, C. B. 1933. Selenium: insecticide material for controlling red spider. Ind. & Eng. Chem. **25**:633-37.
2. GOULD, G. E. 1950. The German roach as a laboratory test animal. Proc. Ind. Acad. Sci. **59**:173-180.