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FIELD EXPERIMENTS FOR THE CONTROL OF CABBAGE INSECTS

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Field experiments were conducted in small plots in southern California in 1960-61 to obtain data on the effectiveness of several insecticides and a pathogen in the control of two cabbage insects, the cabbage looper (*Trichoplusia ni* (Hübner)) and the cabbage aphid (*Brevicoryne brassicae* (L.)). This is a report of the results of these experiments and not a recommendation of any of the materials tested.[3]

Steinhauer et al.,[4] who tested insecticides against cole-crop insects in Maryland, found dimethoate superior because it controlled aphids as well as caterpillars. In the control of loopers in Iowa, Wolfenbarger and Hibbs[5] reported that endrin was the most effective compound and that Guthion, parathion, and endosulfan were superior to DDT against caterpillars on cabbage. Harcourt and Cass[6] obtained the best control with endrin, Guthion, and mevinphos. Hall and Andres[7] found *Bacillus thuringiensis* var. *thuringiensis* Berliner ineffective against the cabbage aphid and recommended the use of insecticides when this aphid was present.

1/ Retired April 1963.
2/ Resigned September 1963.
3/ Mention of a proprietary product in this publication does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture and does not imply its approval by the Department to the exclusion of other products that may also be suitable.
4/ Steinhauer, A. L., Ditman, L. P., and Wiley, R. C. Insecticidal control of insects infesting broccoli and cabbage. Jour. Econ. Ent. 52: 816-818. 1959.
5/ Wolfenbarger, Dan, and Hibbs, E. T. Insecticides and spray schedules for the control of cabbage leaf feeding Lepidoptera. Jour. Econ. Ent. 51: 443-445. 1958.
6/ Harcourt, D. G., and Cass, L. M. Control of caterpillars on cabbage in the Ottawa Valley of Ontario and Quebec, 1956-57. Jour. Econ. Ent. 52: 221-223. 1959.
7/ Hall, I. M., and Andres, L. A. Field evaluation of commercially produced *Bacillus thuringiensis* Berliner used for control of lepidopterous larvae on crucifers. Jour. Econ. Ent. 52: 877-880. 1959.

MATERIALS AND PROCEDURES

The experiments were conducted in growers' fields located in Los Angeles and Riverside Counties. Plots were single rows 50 feet long arranged in randomized blocks with five or six replicates. Except in experiment 7, the emulsion sprays were applied to both sides of the row with a knapsack sprayer at the rate of 35 gallons per acre for the first application and 50 gallons for all succeeding ones. In experiment 7, the sprays were applied with a power sprayer equipped with a four-row boom with three 6502 Tee-Jet nozzles per row. In each spray, Triton B-1956 was used at 2.8 ounces per 50 gallons as a wetting-spreading agent. The dusts were applied with rotary hand dusters at 30 to 40 pounds per acre of the diluted dust. The number of applications ranged from three to five, depending on the infestation, season, and growth of the cabbage. Applications were made at 7- to 10-day intervals before 9 a.m. Naled at 2 pounds per acre was substituted in the final spray applications on plots that earlier had received dimethoate, aldrin, endrin, Guthion, and endosulfan, which could not be used after the heads had started to form because of residues. The *B. thuringiensis* spray was prepared from a wettable powder containing 75 billion spores per gram. All other sprays were prepared from emulsifiable concentrates.

The effectiveness of the materials was rated by recording the live loopers on four to five plants per plot, 4 to 5 days after each application. Percent reduction was calculated on the basis of the infestation in the treated as compared with that in the check plots. On the last examination the mature heads plus the outer leaves were removed and each leaf was examined for insects. At each examination the loopers were classified on the basis of size; small included newly hatched larvae up to one-half inch in length; medium, one-half to 1 inch; and large, 1 inch or longer. Pupae were included with the large larvae. An aphid colony ranged from 1 to 100 or more aphids. The possible phytotoxic effect of the materials on the plants was also noted.

RESULTS

Table 1 shows that in experiment 1 endrin, naled plus *B. thuringiensis*, and dimethoate were the most effective against the cabbage looper. Malathion or mevinphos plus *B. thuringiensis*, toxaphene plus parathion, and malathion alone were intermediate in effectiveness. Naled alone, American Cyanamid 24055, *B. thuringiensis* alone, and Hercules 5727 were inferior. There was no significant difference among materials in aphid control, but dimethoate gave the best results.

In experiment 2, Guthion at 1 and 1½ and naled at 2 pounds per acre gave good control of the cabbage looper. Guthion at one-half pound was not adequate against loopers, but was fairly effective against aphids. Dimethoate and naled were especially effective as aphicides. General Chemical 3583, Methyl Trithion, Bayer 29491, and Shell Compound 4072 gave good control of aphids; and all compounds used except Methyl Trithion showed promise against loopers.

In experiment 3, five spray applications were required because of the slow growth of the fall-planted cabbage. In looper control, all materials gave significant reductions when compared with the check. Excellent control was obtained with endrin, endosulfan, and Guthion. Good control was obtained with naled, dimethoate, malathion, and 2 pounds of American Cyanamid 24055. Trichlorfon, aldrin, and 1 pound of American Cyanamid 24055 gave fair control. Against cabbage aphids, dimethoate and endosulfan were especially outstanding. Guthion, endrin, and naled were also highly effective against aphids. Trichlorfon and both dosages of American Cyanamid 24055 were ineffective against the aphids.

In experiment 4, conducted in August, eight materials were compared with endrin in toxicity to loopers on month-old cabbage. Counts of loopers on August 23 showed that aside from endrin and General Chemical 3583, these materials, after one application, gave inadequate control of both small and medium-sized loopers.

Experiment 5 was a continuation of experiment 4 to compare the toxicity of naled with that of certain other insecticides against cabbage loopers. Bayer 29491 and fenthion caused severe burn to the leaves of the cabbage. Bayer 29491, naled, and Shell Compound 4072 gave good control of loopers. Methyl Trithion and Bayer compounds 30911, 37341, and 39007 gave only partial control.

Two insecticide experiments against cabbage aphids were conducted in February 1961 in single-row plots of cabbage in the Dudley field near Corona (Riverside County), where minimum temperatures ranged from 5° to 10° F. lower than those in Los Angeles County. In each experiment two spray applications were made on February 9 and 21. Aphid counts were made on February 13, 20, and 27. In experiment A, dimethoate at 1 pound per acre was the most effective (98-percent control). Endosulfan, Guthion, and Zectran at 1 pound per acre, naled and carbaryl at 2 pounds, and toxaphene at 3 pounds plus parathion at one-half pound gave 64-percent control and less. In experiment B, no commercially acceptable control of aphids (less than 55 percent) was obtained with the following insecticides and pathogen applied at the indicated dosages in pounds per acre: Toxaphene 3 plus parathion one-half, Zectran one-half, 1, and 2, Guthion 1, General Chemical 3583 1, and B. thuringiensis $1\frac{1}{2}$. The lower temperatures in the Corona area may have been responsible for reducing the effectiveness of parathion, Guthion, and endosulfan.

As shown in table 1, additional experiments (6-8) were conducted against loopers and aphids in the Dudley field.

In experiment 6, the cabbage grew slowly; thus, five spray applications were necessary between February 28 and April 25. Two combinations of materials included in this experiment but not shown in the table were eliminated after one application because of the excessive buildup of cabbage aphids. These materials were carbaryl (50-percent wettable powder) 1 pound plus piperonyl butoxide 1 pound and *B. thuringiensis* 2 pounds (5 billion spores per gram) plus 1-percent rotenone 0.4 pound applied as a dust. Bayer 39007 (emulsifiable concentrate) at 1 and 2 pounds per acre was eliminated from this experiment also after one application, because the leaves of the treated cabbage were burned severely.

Of the five remaining materials used in experiment 6, the naled-phosphamidon mixture, Guthion, and demeton plus parathion gave only partial control of loopers, but these materials and malathion were highly effective as aphicides. Menazon controlled cabbage aphids, but gave poor control of loopers.

In experiment 7, six materials or combinations were applied as sprays with power equipment in replicated plots four rows wide by 98 feet long. Applications were made on March 30, April 12, and 25. Infestation counts were made after each application and at harvesttime on May 9, when all leaves on eight heads per plot were examined for loopers and aphid colonies. All materials or combinations significantly reduced the infestations of small, medium, and large loopers. Endosulfan gave excellent control of all loopers and of aphids. The mixtures parathion plus *B. thuringiensis* and toxaphene plus parathion also were effective against these pests. Toxaphene plus demeton gave the best control of aphids. Some leaf burn was noted after each application of the mixtures containing parathion.

Experiment 8 included materials or combinations showing the most promise in previous tests. Applications were made on May 5, 16, and 26. Looper and aphid counts were made after each application and at the time of harvest on June 6. Zectran and parathion plus *B. thuringiensis* gave the best control of all sizes of loopers, but poor control of aphids. Dimethoate at 1 and at one-half pound was highly effective as an aphicide, but the latter dosage did not adequately control loopers. All remaining materials provided significant reductions in loopers when compared with the check but gave only fair control of aphids.

CHEMICAL NAMES OF PROPRIETARY MATERIALS OR COMPOUNDS WITHOUT ACCEPTED COMMON NAMES MENTIONED IN TEXT OR TABLES

American Cyanamid 24055	1,1-dimethyl-3-(*p*-acetamidophenyl) triazene
Bayer 29491	*O*-[3-chloro-4-(methylthio)phenyl] *O*,*O*-dimethyl phosphorothioate
Bayer 30911	*O*-2,4-dichlorophenyl *O*-methyl methylphosphonothioate
Bayer 37341	*O*,*O*-diethyl *O*-[4-(methylthio)-3,5-xylyl] phosphorothioate
Bayer 39007	*o*-isopropoxyphenyl methylcarbamate
Geigy G-30494	*S*-[[(2,5-dichlorophenyl)thio]methyl] *O*,*O*-dimethyl phosphorodithioate
General Chemical 3583	2-chloro-1-(2,5-dichlorophenyl)vinyl diethyl phosphate

Guthion	O,O-dimethyl S-(4-oxo-1,2,3-benzotriazin-3-(4H)-ylmethyl) phosphorodithioate
Hercules 5727	m-isopropylphenyl methylcarbamate
Imidan	O,O-dimethyl S-phthalimidomethyl phosphorodithioate
Methyl Trithion	S-p-(chlorophenylthio)methyl O,O-dimethyl phosphorodithioate
Shell Compound 4072	2-chloro-1-(2,4-dichlorophenyl)vinyl diethyl phosphate
Stauffer R-1448	O,O-diethyl S-phthalimidomethyl phosphorodithioate
Stauffer R-1505	O,O-diethyl S-phthalimidomethyl phosphorodithioate
Stauffer R-1571	O,O-dimethyl S-phthalimidomethyl phosphorothioate
Stauffer R-2968	2-(diethoxyphosphinodithioyl)ethyl carbamate
WARF antiresistant	N,N-dibutyl-p-chlorobenzenesulfonamide
Zectran	4-dimethylamino-3,5-xylyl methylcarbamate

SUMMARY

In field experiments in California during 1960-61 on the control of the cabbage looper (*Trichoplusia ni* (Hübner)) on cabbage, naled, endrin, endosulfan, dimethoate, and Guthion gave the best control. Except for endrin, the same materials were also highly effective against the cabbage aphid (*Brevicoryne brassicae* (L.)). Four or five applications were required in the fall and about three in the spring. *Bacillus thuringiensis* var. *thuringiensis* Berliner applied alone in sprays was fairly effective against loopers, and when combined with other materials did not increase their effectiveness materially. The antifeeding compound American Cyanamid 24055 gave fair control of loopers, but this compound and *B. thuringiensis* were ineffective against the cabbage aphid. Results with malathion were inconsistent; the compound gave good to fair control of aphids but poor control of loopers. Zectran and Shell Compound 4072 showed promise against loopers in one experiment.

Table 1.--Effectiveness of various materials applied as sprays and as dust against cabbage looper and aphids on cabbage, Los Angeles and Riverside Counties, Calif., 1960-61.

Insecticide and pounds of active ingredient per acre per application	Cabbage loopers: Number surviving per plant: Small	Medium	Large	Percent control	Aphids: Colonies per head	Percent control
Experiment 1 - O'Kuma field (applications on May 19, 31, June 9, 1960)						
Endrin 1/4 [1/] -----------	0.4	0	0	88	1.3	62
Naled 2 plus B. thuringiensis $1\frac{1}{2}$ --	.5	.1	0	82	3.2	6
Dimethoate 2 [1/] ---------	.6	0	0	82	0	100
Malathion $1\frac{1}{2}$ plus B. thuringiensis $1\frac{1}{2}$ --	.6	.1	0	79	.5	85
Toxaphene 3 plus parathion 1/2 --------	.8	0	0	77	3.7	0
Malathion $1\frac{1}{2}$ ----------	.6	.2	0	77	.4	88
Mevinphos 1/2 plus B. thuringiensis $1\frac{1}{2}$ --	.8	.1	0	75	.4	88
Naled 2 ---------------	1.1	.1	0	63	.7	79
American Cyanamid 24055 (5-percent dust) 2 ---	1.0	.2	.1	62	8.3	0
B. thuringiensis $1\frac{1}{2}$ ---	1.3	.3	.1	51	1.4	59
Hercules 5727 1 -------	1.2	.5	.1	48	7.1	0
Tepp 1 pt. plus B. thuringiensis $1\frac{1}{2}$ --	1.7	.4	.1	36	1.8	47
Untreated check -------	2.4	.8	.3	--	3.4	--
L.S.D. 5 percent ------	.6	.5	.1	20	n.s.	--

Table 1.--Continued

Experiment 2 - Tougouchi field (applications on Aug. 26, Sept. 1, 14, 1960)						
Guthion 1 1/ ------------	.1	.1	.1	92	.7	88
Guthion 1½ 1/ ----------	.1	0	.2	92	.4	93
Naled 2 ----------------	.1	.1	.3	88	.1	98
Bayer 29491 1/2 --------	.2	.2	.3	81	.8	86
Shell Compound 4072 1 --	.1	.3	.4	79	1.0	82
Guthion 1/2 ------------	.2	.3	.4	77	.6	89
Dimethoate 1 1/---------	.3	.5	.4	69	0	100
General Chemical 3583 1 ----------------	.2	.3	.7	68	.6	89
Methyl Trithion 1 ------	.4	.7	1.4	34	.8	86
Untreated check --------	.6	1.1	2.1	--	5.6	--
L.S.D. 5 percent -------	.2	.3	.2	18	1.4	--
Experiment 3 - O'Yallo field (applications on Sept. 28, Oct. 6, 14, 24, Nov. 7, 1960)						
Endrin 1/4 1/-----------	.03	.03	.02	98	1.4	91
Endosulfan 1 1/---------	.05	.01	.04	96	.5	97
Guthion 1 1/------------	.05	.06	.04	95	1.0	93
Naled 2 ----------------	.12	.03	.08	92	1.5	90
Dimethoate 1 1/---------	.15	.03	.08	92	0	100
Malathion 1½ -----------	.24	.10	.16	84	2.0	87
American Cyanamid 24055 2 ---------------	.37	.08	.06	84	17.7	0
Trichlorfon 1 ----------	.22	.22	.28	77	9.3	38
Aldrin 3/4 1/-----------	.49	.34	.49	58	2.4	84
American Cyanamid 24055 1 ---------------	.75	.51	.33	49	11.6	23
Untreated check --------	1.28	.86	.96	--	15.1	--
L.S.D. 5 percent -------	.21	.13	.18	10	7.3	--

Experiment 4 - Togouchi field (application on Aug. 17, 1960)

Endrin 1/4 1/ ----------	.08	.12	0	90	--	--
General Chemical 3583 1/2 ----	.33	.17	.04	74	--	--
Imidan 1/2 ------------	.50	.58	.08	44	--	--
Dimethoate 1/2 --------	.96	.33	0	38	--	--
Stauffer R-1571 1/2 ---	.79	.46	.08	36	--	--
Stauffer R-1505 1/2 ---	.75	.50	.12	34	--	--
Geigy G-30494 1/2 -----	1.21	.46	.08	16	--	--
Stauffer R-1448 1/2 ---	1.21	.42	.17	14	--	--
Stauffer R-2968 1/2 ---	1.21	.71	.04	6	--	--
Untreated check -------	1.04	.79	.25	--	--	--
L.S.D. 5 percent ------	.66	.42	n.s.	38	--	--

Experiment 5 - Togouchi field (application on Aug. 17, 1960)

Bayer 29491 1 ---------	0	.08	0	95	--	--
Naled 1 ---------------	.17	.04	0	88	--	--
Shell Compound 4072 1 ---------------	.13	.08	.04	86	--	--
Fenthion 1 ------------	.17	.42	.04	64	--	--
Methyl Trithion 1 -----	.25	.46	.17	50	--	--
Bayer 30911 1 ---------	.58	.29	.17	43	--	--
Bayer 37341 1 ---------	.75	.38	.04	34	--	--
Bayer 39007 1 ---------	.63	.63	0	29	--	--
Untreated check -------	.92	.58	.25	--	--	--
L.S.D. 5 percent ------	.5	.27	.17	31	--	--

Experiment 6 - Dudley field (applications on Feb. 28, Mar. 10, 27, Apr. 11, 25, 1961)

Naled 1 plus phosphamidon 1/2 -------	.11	.02	0	69	.01	99
Guthion 1 ---------------	.10	.05	.01	62	.15	96
Demeton 1/2 plus parathion 1/2 ----------	.10	.04	.03	60	0	100
Malathion 2 -------------	.24	.05	0	31	.15	96
Menazon (WP) 1 ----------	.27	.10	.06	0	.04	96
Untreated check ---------	.26	.12	.04	--	1.1	--
L.S.D. 5 percent --------	.12	.07	.03	40	.29	--

Experiment 7 - Dudley field power spray (applications on Mar. 30, Apr. 12, 25, 1961)

Endosulfan 1 ------------	.08	.02	0	92	.10	92
Parathion 1/2 plus *B. thuringiensis* $1\frac{1}{2}$ ----	.17	.02	.02	85	.14	88
Toxaphene 3 plus parathion 1/2 ----------	.19	.02	0	84	.14	88
Guthion 1 ---------------	.18	.03	.02	83	.24	80
Toxaphene 3 plus demeton 1/2 ------------	.26	.05	.03	74	.03	98
Naled 1 plus phosphamidon 1/2 -------	.39	.06	.05	62	.18	85
Untreated check ---------	.78	.29	.24	--	1.21	--
L.S.D. 5 percent --------	.20	.06	.09	16	n.s.	--

Table 1.--Continued

Experiment 8 - Dudley field (applications on May 5, 16, 26, 1961)						
Zectran 2 --------------	.13	0	0	88	2.8	48
Parathion 1/2 plus *B. thuringiensis* 1½ ---	.16	.01	0	85	1.9	65
Dimethoate 1 -----------	.24	.02	.01	76	.04	99
Naled (EC) 2 -----------	.29	.02	0	73	1.4	74
Guthion 1½ -------------	.28	.04	.01	71	1.3	76
Naled (WP) 2 -----------	.28	.07	.01	68	4.2	22
Bayer 39007 (WP) 1 -----	.27	.10	.06	62	1.0	81
Dimethoate 1/2 ---------	.51	.05	.01	50	.2	96
DDT 2 plus WARF 0.4 ----	.44	.15	.07	43	.8	85
Carbaryl 2 -------------	.52	.14	.06	37	1.3	76
Untreated check --------	.83	.22	.09	--	5.4	--
L.S.D. 5 percent -------	.28	.10	.04	30	1.8	--

1/ Naled at 2 pounds per acre was substituted for endrin, dimethoate, Guthion, aldrin, and endosulfan in last application.

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