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Field Testing Candidate Insecticides on Beans and Alfalfa for Control of Mexican Bean Beetle,[1] Potato Leafhopper,[2] and Plant Bugs[3] in New York State[4]

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ABSTRACT

New and standard insecticides, applied as sprays to the foliage of red kidney beans, were evaluated for control of the Mexican bean beetle, *Epilachna varivestis* Mulsant, in 1966 and 1967. Of 29 materials tested, only 2 failed to give satisfactory control of the beetle.

In 1968 granular formulations of 2 systemic insecticides, phorate (10%G) and disulfoton (10%G), applied on top of snap beans at planting time gave good control of Mexican bean beetle.

Significantly fewer plant bug nymphs (*Lygus lineolaris* (Palisot de Beauvois) and *Poecilocapsus lineatus* (F.)) were taken from treated plots of alfalfa than from control plots when 13 insecticides were applied as sprays in 1966. It was concluded that adult plant bugs and potato leafhoppers, *Empoasca fabae* (Harris), which were included in the sampling operation of this experiment, were not reliable indicators of insecticidal efficacy because of their high rate of activity and the ensuing possibility of migration from plot to plot.

In 1968, 10 to 21 insecticides applied as foliar sprays to plots of red kidney beans were found to control the potato leafhopper effectively, judged from nymphal counts taken in treatment and control plots.

Large acreages of beans and alfalfa are grown in New York State for consumption by humans and livestock. Among the many organisms which compete with man for dividends from these heavy agricultural investments are the Mexican bean beetle, *Epilachna varivestis* Mulsant; the potato leaf hopper, *Empoasca fabae* (Harris); and plant bugs—the tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) and the four-lined plant bug, *Poecilocapsus lineatus* (F.).

These insects are capable of inflicting severe damage to their host plants resulting in loss of crop and even crop failure. On beans, the Mexican bean beetle is a voracious defoliator in adult and nymphal stages (Fig. 1). Leaf hoppers and plant bugs may reduce plant vigor leading to distortion, defoliation, and loss of fruit (Ball 1919, DeLong 1938, Carter 1939, Elmore 1955), as a result of interference with the vascular elements of the plant (Putman 1941, Ladd and Rawlins 1965) and by injection of saliva containing toxic components (Carter 1939). Blossom drop and consequent failure of fruit to set (Shull et al. 1934), and reduction of vegetative growth (Carlson 1940, McLeod and Jepson 1942) are symptomatic of plant bug damage on alfalfa.

Although current control recommendations for the Mexican bean beetle, the potato leaf hopper, and plant bugs are adequate (USDA Agriculture Handbook 331, 1968) it was the object of the present work to evaluate new and standard insecticides to ensure that the highest standards of crop protection were maintained against these insects.

The insecticides used in the trials were azinphosmethyl, carbaryl, carbofuran, dialifor, dimethoate, endosulfan, methyl parathion, monocrotophos, parathion, phosalone, phoxim, promecarb, and the following compounds without approved common names:

Akton®—*O*-[2-chloro-1-(2,5-dichlorophenyl)vinyl] *O,O*-diethyl phosphorothioate
Bay 33051—ethyl mercaptophenylacetate *S*-ester with *O,O*-dimethyl phosphorodithioate
Bay 37289—*O*-ethyl *O*-2,4,5-trichlorophenyl ethylphosphonothioate
Bay 65258—*O*-ethyl *S*-methyl phosphoramidothioate
Dasanit®—*O,O*-diethyl *O*-[*p*-(methylsulfinyl) phenyl] phosphorothioate

[1] Coleoptera: Coccinellidae.
[2] Hemiptera: Cicadellidae.
[3] Hemiptera: Miridae.
[4] Approved by the Director of the New York State Agricultural Experiment Station as Journal Paper no. 1691, Mar. 11, 1969. Received for publication Mar. 17, 1969.
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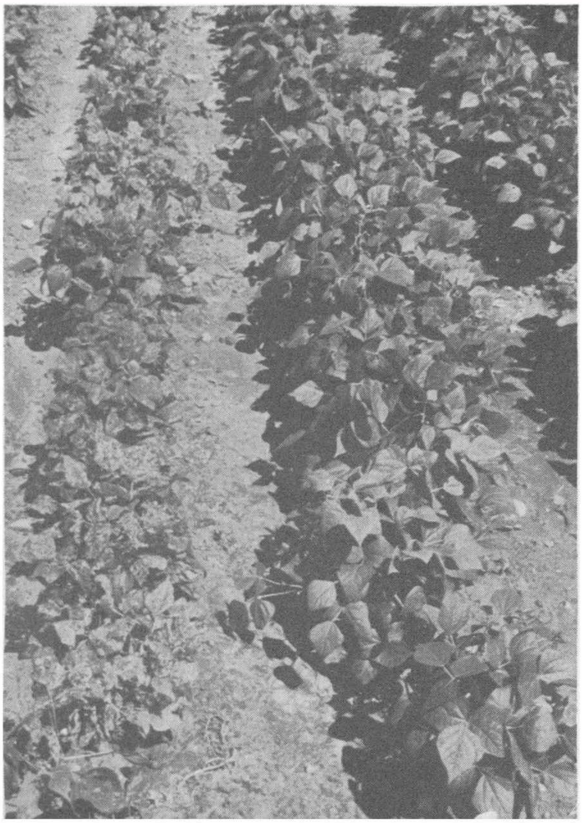

FIG. 1—Mexican bean beetle damage on untreated red kidney beans (left) and effective control treatment (right).

DuPont 1642—methyl *N*-(carbamoyloxy) thioacetimidate
Dursban®—*O,O*-diethyl *O*-3,5,6-trichloro-2-pyridyl phosphorothioate
Dyfonate®—*O*-ethyl *S*-phenyl ethylphosphonodithioate
Fundal®—*N*-(2-methyl-4-chlorophenyl)-*N′,N′*-dimethyl formamidine hydrochloride
Galecron®—*N*-(2-methyl-4-chlorophenyl)-*N′,N′*-dimethyl formamidine
Gardona®—2-chloro-1-(2,4,5-trichlorophenyl) vinyl dimethyl phosphate
GC-6506—dimethyl *p*-(methylthio) phenyl phosphate
GS-13005—*O,O*-dimethyl phosphorodithioate *S*-ester with 4-(mercaptomethyl)-2-methoxy-Δ^2-1,3,4-thiadiazolin-5-one
Hercules 13462—*O,O*-dimethyl phosphorodithioate *S*-ester with *N*-(1-mercaptoethyl) succinimide
Hoechst 2838—1,2,3,4,7,7-hexachloro-5-(2,2,3,3-tetrafluorocyclobutyl)-2-norbornene
Imidan®—*O,O*-dimethyl *S*-phthalimidomethyl phosphorodithioate
Lannate®—*S*-methyl *N*-[(methylcarbamoyl) oxy] thioacetimidate
Monitor®—*O,S*-dimethyl phosphoroamidothioate
SD 14045—*alpha*-methyl-*p*-(methylthio) benzyl 3-hydroxycrotonate dimethyl phosphate
UC 34096—4-[[(*N,N*-dimethylamino) methylene]amino] *m*-tolyl methylcarbamate hydrochloride
VCS-506—*O*-(4-bromo-2,5-dichlorophenyl) *O*-methylphenyl phosphonothioate
Zinophos®—*O,O*-diethyl *O*-2-pyrazinyl phosphorothioate

MEXICAN BEAN BEETLE.—*Methods.*—1966.—Part of a field of red kidney beans infested with Mexican bean beetle was divided into plots consisting of 2 rows 60 ft long separated from adjacent plots by 2 buffer rows on each side.

Insecticides were applied July 26 with a low-gallonage, tractor-mounted, 2-row, drop-nozzle sprayer, operated at a pressure of 60 psi and driven at a speed to deliver 28 gal/acre. Application of each insecticide was replicated on 3 separate plots. Replicate plots were situated in 3 blocks in a random design. Blocks were separated by a 15-ft strip from which all beans had been removed. The control plots were untreated.

The plots were sampled for bean beetles on July 29; 15 plants showing signs of feeding damage (Fig. 1) were selected from each plot and the live larvae and pupae were counted. Adults were not counted, as they migrate to and from other parts of the crop; thus their presence or absence could be misleading in the interpretation of data.

1967.—A 2-acre field of red kidney beans was divided into plots and application of insecticides was made as just described, except that there were 4 replications of each treatment. Application of insecticides was made July 27, and plots were sampled July 31 and Aug. 10.

1968.—To investigate the possibility of using systemic insecticides to control Mexican bean beetle and leafhoppers on beans, the following field trial was carried out at the Robbins Farm, Geneva, N. Y.

Plots consisting of 4 rows 50 ft long were staked out and planted with 'Tendergreen' snap beans, using a 2-row, tractor-mounted, John Deere flexiplanter. Granular formulations of 2 systemic insecticides were applied on top of the beans at seeding time with a Gandy applicator, at the rates of 1 and 2 lb AI/acre. Beans were replicated twice in a randomized block design.

The insecticides tested were disulfoton (10%G) and phorate (10%G).

Preliminary sampling indicated that populations of leafhoppers in untreated control plots were too small to warrant sampling treated plots. Similarly, populations of Mexican bean beetles in control plots planted June 24 and July 12 (3rd and 4th plantings) did not develop. However, infestations of Mexican bean beetles were found in control plots of beans planted June 7 and June 17 (the 1st and 2nd plantings). Plots were sampled by counting the plants showing symptoms of Mexican bean beetle feeding. More than 100 damaged plants were found in each control plot, whereas a total of 25 damaged plants was found throughout the treatment plots. All these damaged plants were found at the end of the rows in 2 treatment plots. We concluded that the flow of insecticide on these 2 rows had been prematurely cut off at planting time.

Results and Discussion.—The small population of Mexican bean beetles in the 1966 trial does not permit a good evaluation of materials in terms of relative efficiency. On the basis of larval counts (Table 1), all materials produced significant reduction in numbers when compared with the untreated control.

Heavy infestation of beetles in the 1967 trial demonstrated unequivocally (on the basis of larval counts) that, with 2 exceptions, all materials tested reduced number of Mexican beetle larvae to a low

Table 1.—The mean numbers of Mexican bean beetle larvae and pupae found in samples taken in 1966 and 1967 from trial plots of red kidney beans after spray application of various insecticides.[a]

Treatment	Rate (lb AI/acre)	Applied 7-26-66, sampled 7-29-66		Applied 7-27-67			
				1st sample 7-31-67		2nd sample 8-10-67	
		Larvae	Pupae	Larvae	Pupae	Larvae	Pupae
Phosalone	0.5	0.7 a	7.7 ab				
	.25			0.25 a	13.7 abc	1.25 a	0 a
	.75			1.0 a	8.0 a	0.25 a	a
	1.0			.25 a	6.7 a	.5 a	a
Carbaryl	.5	1.7 a	3.7 a	2.75 a	11.2 ab	.25 a	a
GC-6506	"	2.0 ab	25.7 def				
Bay 65258	"	2.3 ab	4.7 a				
Parathion	"	2.7 abc	5.7 a	2.25 a	12.7 ab	1.75 a	a
Monocrotophos	"	3.0 abcd	17.0 abcd	.75 ab	11.7 ab	1.0 a	.5 a
Promecarb	"	3.3 abcd	18.7 abcd				
Gardona	"	3.7 abcd	10.7 abc	.25 a	11.0 ab	a	a
Phoxim	"	4.7 abcde	34.3 f				
Lannate	"	6.7 bcde	9.7 abc				
Monitor	"	7.0 bcde	12.7 abcd				
Dyfonate	"	7.7 cde	13.3 abcd	3.0 a	6.2 a	42.5 b	1.0 a
Bay 33051	"	8.3 de	20.3 bcde				
Dimethoate	"	9.0 e	22.3 cdef				
Hoechst 2868	"	13.7 f	12.0 abcd				
Carbofuran	"	14.0 f	32.0 ef	a	9.0 a	a	a
Bay 37289	"			.75 a	13.0 ab	5.0 a	.2 a
UC 34096	"			a	13.7 abc	5.25 a	.5 a
Azinphosmethyl	"			1.0 a	4.0 a	a	a
Dasanit	"			.25 a	9.5 a	.25 a	.2 a
SD-14045	"			.5 a	5.5 a	.75 a	a
GS-13005	"			a	4.2 a	6.75 a	.2 a
Dialifor	"			a	25.7 bc	1.0 a	a
Herc. 13462	"			1.25 a	10.0 a	.25 a	a
Zinophos	"			.75 a	16.0 abc	6.0 a	a
Imidan	"			1.25 a	17.2 abc	a	a
Endosulfan	"			3.5 a	11.5 ab	2.5 a	.7 a
Fundal	"			138.25 c	11.0 ab	168.7 d	19.2 b
Control (untreated)		19.7 g	16.0 abcd	110.5 b	23.0 bc	110.5 c	38.2 c

[a] Results were analyzed using analysis of variance and Duncan's multiple range test. Means followed by a common letter are not significantly different ($P < 0.01$).

level. Fundal did not provide control, and Dyfonate-treated plots were not adequately protected, judged by the number of larvae taken at the 2nd sampling.

Pupal counts made in 1966 and at the 1st sampling in 1967 indicated that many of the insecticides did not kill the beetles when they were in the pupal stage. This theory is supported by inspection of pupal counts made 14 days after application of insecticides at the 2nd sampling in 1967. Thus most of the pupae present at the time of the 1st sampling (and at the time of insecticide application) would have molted to become adults by the second sampling. However, as very few larvae were counted in treated plots at the 1st sampling, because of the insecticidal effects of materials applied, it is not surprising that there were few pupae counted at the 2nd sampling. In control plots and plots treated with Fundal, similar numbers of pupae were counted at 1st and 2nd samplings.

The excellent control of Mexican bean beetle with phorate and disulfoton in the 1968 trial suggests further investigation of these materials, incorporating them with planting for control of the range of insect pests on beans.

Plant Bugs and Potato Leafhoppers on Alfalfa. —*Methods*.—Tarnished plant bugs, four-lined plant bugs, and potato leaf hoppers were found in a strip of 2-year-old alfalfa at the Robbins Farm in 1966, in numbers large enough to suggest organization of trials to evaluate insecticides for control of these insects.

Longitudinal and lateral strips 14 ft wide were cut in the alfalfa leaving plots 15×50 ft. These plots were sprayed with insecticides on Aug. 10 with a tractor-mounted 12-ft brushboom sprayer, operated at 60 psi and driven at such a speed as to deliver 48 gal/acre. Application was effected by making 1 longitudinal pass along the center of each plot with the sprayer. Each insecticide was applied to 3 replicate plots, which were arranged in a randomized block pattern. In controls the tractor-mounted spray rig was driven down the center of each plot, but no spray was applied.

Plots were sampled Aug. 12 and Aug. 18 by making fifteen 180° sweeps of a 15-in. sweepnet along the center line of each plot. The insects collected were shaken to the bottom of the net and trapped there by encircling a small pocket of the net with finger and thumb. A small amount of ether was applied to the outside surface of the net and after a wait of a few seconds the contents of the net were shaken onto a white enamel tray and the insects were counted. Adult four-lined and tarnished plant bugs could readily be differentiated, but the nymphs of these species were difficult to separate, and for the sake of expediency were classified collectively as plant bug nymphs.

Table 2.—Mean numbers of nymphs and adults of plant bugs and leafhoppers found in samples taken from plots of alfalfa in 1966 after spray applications of various insecticides (rate 0.5 AI/acre).[a]

Treatment 8-10-66	Plant bug nymphs, sampled		Four-lined plant bug adults, sampled		Tarnished plant bug adults, sampled		Leafhopper nymphs and adults, sampled	
	8-12	8-18	8-12	8-18	8-12	8-18	8-12	8-18
Monitor	0.3 a	2.0 a	0.3 a	3.3 a	1.0 ab	22.0 abc	a	0.3 a
Monocrotophus	.3 a	1.0 a	a	4.0 a	0.7 ab	25.3 abcd	a	2.3 ab
Lannate	.7 a	2.7 a	.3 a	2.0 a	2.0 abc	30.0 cdef	a	1.3 ab
Bayer 65258	.3 a	2.3 a	a	2.3 a	2.0 abc	30.7 cdef	.3 a	3.7 abc
GC-6506	a	0.3 a	a	1.7 a	2.0 abc	30.0 cdef	a	3.3 abc
Carbofuran	a	2.3 a	a	1.7 a	a	37.7 f	.3 a	2.3 ab
Phosalone	2.0 a	8.3 a	a	5.7 a	4.7 def	19.0 ab	.7 a	6.3 cd
Dyfonate	1.3 a	1.7 a	.3 a	3.3 a	4.3 def	27.7 bcde	.7 a	1.0 ab
Phoxim	a	1.0 a	.3 a	2.0 a	2.7 bcd	35.3 ef	a	3.3 abc
Gardona	.7 a	1.7 a	.3 a	3.0 a	4.7 def	32.0 def	a	3.3 abc
Hoechst 2868	.3 a	.7 a	a	2.3 a	9.3 f	30.7 cdef	a	3.3 abc
Bayer 33051	a	a	a	4.0 a	5.3 ef	33.7 def	a	4.0 bc
Parathion	.3 a	1.0 a	.7 a	3.0 a	3.3 cde	33.7 def	a	8.0 de
Control	63.3 b	30.0 b	10 b	14.7 b	6.3 f	16.3 a	3.3 b	11.3 e

[a] Results were analyzed by analysis of variance and Duncan's multiple range test. Means followed by a common letter are not significantly different ($P < 0.01$).

Results and Discussion.—All materials tested significantly reduced the population of plant bug nymphs taken on alfalfa at both sampling dates in 1966, compared with the untreated control (Table 2). The small number of adult four-lined bugs and leafhoppers preclude drawing similar conclusions about the effects of the insecticides on these insects, in spite of significant differences between treatments and the control.

Although no valid conclusions could be made on the basis of the number of tarnished plant bug adults taken, with respect to insecticidal efficiency, the results obtained were instructive. Because the adult stage of this insect was extremely active in hot weather and therefore likely to migrate from plot to plot, it was questionable whether it was worth the time spent counting them in this type of test. The numbers taken in the 1st sampling were low, but the population was evenly distributed over the plots. This fact suggested that there may have been considerable mortality in some of the plots, as a result of insecticide application, but subsequent migration from surrounding plots and vegetation, prior to the 1st sampling, obscured these insecticidal effects. The total number of adults taken in the 1st sampling was increased by a factor of 9 when the 2nd sample was collected 6 days later, and as in the 1st sample the population was fairly evenly distributed over the area covered by the trial. This dramatic increase in the number of adults must have been due to immigration from surrounding vegetation and was proof of the fact that these adults were untrustworthy indicators of insecticidal efficiency.

Table 3.—Mean numbers of leafhopper nymphs found in samples taken from plots of red kidney beans in 1968 after spray application of various insecticides (rate 0.5 lb AI/acre).[a]

Treatment 8-1-68	Leafhopper nymphs	
	Sampled 8-8	Sampled 8-15
Monocrotophos	2.25 a	2.0 a
Phosalone	1.75 a	10.25 a
VCS-506	5.75 ab	3.0 a
Dursban	4.25 a	11.0 a
Carbofuran	4.0 a	20.0 ab
GC-6506	5.5 ab	18.25 a
Dasanit	8.75 ab	10.5 a
Dimethoate	9.75 abc	1.75 a
Akton	10.0 abc	18.0 a
Monitor	10.5 abc	5.75 a
Carbaryl	10.75 abc	57.75 b
Endosulfan	19.0 bcd	Not sampled
GS-13005	22.75 cde	"
Methyl parathion	25.0 de	"
Gardona	26.75 de	"
Parathion	35.75 ef	"
Dyfonate	43.5 fg	"
Lannate	52.0 gh	"
DuPont 1642	54.0 gh	"
Galecron	71.0 i	"
Phoxim	74.0 i	"
Control A	89.5 j	163.0 d
Control B	94.0 j	114.0 c
Control C	64.5 hi	108.2 c

[a] Results were analyzed by analysis of variance and Duncan's multiple range test. Means followed by a common letter are not significantly different ($P < 0.01$).

Evidence of migratory behavior, similiar to that deduced for tarnished plant bug adults, was apparent for 2 other categories of insects studied in this test. In each category the total number of insects collected at the 1st sampling increased by factors of 4 (four-lined plant bug adults) and 10 (potato leafhoppers) when 2nd samples were collected.

As might be expected there was limited or no migration of the wingless plant bug nymphs, consequently the total numbers collected at 1st and 2nd samplings were comparable.

Based on these observations we concluded that only nymphs of these insects should be used as indicators of insecticidal activity in this type of trial at this time of year.

POTATO LEAFHOPPER ON RED KIDNEY BEANS.—*Methods.*—A 3-acre field of red kidney beans containing a population of leafhoppers suitable for field testing of candidate insecticides was located in 1968.

The procedure of plot organization and insecticide application was similar to that described in the tests on Mexican bean beetle. There were 4 replications of each treatment. Treatments were applied Aug. 1.

When sampling, 15 plants were picked at random from each plot and the number of potato leafhopper nymphs found thereon was recorded. Adults were not included in counts because of the possibility of migration. All plots were sampled Aug. 8, and as sampling procedure was tedious only plots treated with materials giving promising results at the 1st sampling were sampled a 2nd time on Aug. 15.

Results and Discussion.—Materials tested in 1968 against leafhopper fell into 2 categories, those which did and those which did not significantly reduce the number of nymphs compared with untreated controls, based on results of the 1st sampling taken 7 days after application of insecticides. Of the effective materials only carbaryl appeared to have lost some of its insecticidal potency judged by the numbers of nymphs observed at the 2nd sampling (Table 3) taken 14 days after application.

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Action of Nicotine on Neural Synaptic Transmission in the American Cockroach[1,2]

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ABSTRACT

The blocking action of nicotine on the neutral synapse in the 6th abdominal ganglion of *Periplaneta americana* (L.), is diphasic. Synaptic transmission was reversibly blocked in the presence of nicotine. The duration of block was dependent on method of application and independent of the concentration. The duration of recovery also was dependent on method of application and independent of concentration. Based on these observations a hypothesis is developed suggesting that the effects of nicotine present the possibility of different types of postsynaptic receptors and that a part of the total effect may be mediated through the release of synaptically active material.

One of the real mysteries of insect nerve physiology was that, although acetylcholine (ACh) appeared to have a vital role in nerve conduction, it had no effect when injected into or applied to insect nerve preparations (Roeder 1939, 1948a; Hopf 1952). These findings were considered as indication that the ACh system found in vertebrates was absent in insects. However, recent observations have suggested that the inability of ACh and other compounds to stimulate intact nerve preparations is due to the impermeability of the nerve sheath (Hoyle 1952; Twarog and Roeder 1956; O'Brien 1957, 1959; O'Brien and Fisher 1958).

More recent studies have revealed that organic and inorganic ions penetrate rapidly into the tissues of the abdominal nerve cord of the cockroach (Treherne and Smith 1965a; Treherne 1961a, b, c, d, 1962a, b, c). They measured directly the passage of labeled material and concluded that there was no barrier to entry. On the other hand, Lord et al. (1963) measured the hydrolysis of ACh by whole and homogenized nerve tissues from the house fly, *Musca domestica* L. From their results they inferred that there indeed was a barrier to the penetration of ACh. These latter contradictory reports were best resolved by Treherne and Smith (1965b), Eldefrawi and O'Brien (1967), and Lord et al. (1967). They showed that ACh did penetrate the whole nerve cord as had been reported, but that a cholinesterase barrier was present in the glial cell layer which prevented penetration to the neuropile of the ganglia. In addition, they demonstrated that cations penetrated the central nervous system but encountered a regulatory system that effectively presented a discriminatory barrier. Thus, while the physiological details of the interaction of charged compounds with the insect central nervous system may be quite complex, the net result of such an interaction is an effective barrier.

The last abdominal ganglion of the American cockroach, *Periplaneta americana* (L.), contains synapses where 100–140 afferent fibers from each cercus converge onto 6–10 giant fibers which ascend the abdominal nerve cord. The giant fibers eventually synapse in locomotor centers in the thorax. This

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