EVALUATION OF METHODS OF CHEMICAL CONTROL OF THE CEREAL LEAF BEETLE (<u>OULEMA</u> <u>MELANOPUS</u>, L.) WITH RESPECT TO AN INTEGRATED PLAN

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THESIS

ABSTRACT

EVALUATION OF METHODS OF CHEMICAL CONTROL
OF THE CEREAL LEAF BEETLE (*Oulema melanopus*, L.) WITH
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By Marcus Tully Wells, Jr.

In the spring of 1966, chemical control techniques, with respect to an integrated plan, suitable to reduce and maintain the cereal leaf beetle at a non-economic level were evaluated. Also four insecticides (malathion, Baygon, lindane, dieldrin) were tested to determine their relative effectiveness and to evaluate their potential for the possible use in an integrated control program.

Winter wheat fields were selected in a given area of heavy beetle infestation and treated with four known cereal leaf beetle insecticides. This was done early in the spring after the emergence of overwintering adults, but before many eggs had been laid. By treating the fields when the majority of beetles were in the wheat, it was possible to effectively reduce the egg laying population. The premise was that spring grain fields may not need treatments if the beetle is eliminated in the winter grain fields.

An experiment was also conducted to evaluate the effectiveness of a single suppression spray of malathion as compared to an eradication oriented application of four malathion treatments. The four

treatments in the eradication area allowed a significantly higher suppression of cereal leaf beetles, but beneficial predators and associated insects were kept at a much lower level after four sprays than after a single application.

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By

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INTRODUCTION

The cereal leaf beetle, *Oulema melanopus* (Linnaeus), is a significant pest of cereal crops in the Old World. Damage was recorded by Reaumur as early as 1737 (Kadocsa, undated). In the United States the beetle was first identified in Berrien County, Michigan in 1962 and control operations were begun by Ruppel and Wilson (1964).

Feeding by adults and larvae cause damage to cereal crops. Oats are favored as a host over wheat, barley or rye (Janes and Ruppel, 1964).

Since 1959 the beetle population has greatly increased and has infested large areas of spring grains. Surveys by the Plant Pest Control Division of the United States Department of Agriculture indicate that the cereal leaf beetle spread from Berrien County, Michigan in 1962 to 225 counties in Michigan, Indiana, Ohio, Illinois and Pennsylvania in 1967 (Moore, personal communication). However, severe damage has occurred only in southwestern Michigan and northwestern Indiana. Castro (1965) suggests that the rapid increase in population may be caused by the similarities in climatic conditions in the Great Lakes area and areas in eastern Europe that contain cereal leaf beetles in pest proportions, and that this U.S. location lacks the beetles' natural parasites and predators.

Insecticide control was initiated in 1962 to check the infestation of *O. melanopus* into new areas. Through the application of insecticides, the spread of the beetle to other grain producing areas has been slowed (USDA, 1963). The U.S. Department of Agriculture and involved states have developed cooperative control programs to suppress the pest. In 1966 alone spray programs in four states resulted in the application of low volume malathion to 1,616,807 acres. Suppressive spray programs in 1967 were reduced within the quarantine area and limited to areas on the perimeter of the quarantine zone. Several cooperating midwest universities are developing control methods involving natural enemies and plant resistance (USDA, 1966).

This study is part of a cereal leaf beetle investigation project being carried on cooperatively between the Entomology Research Division, Agriculture Research Service, USDA and the Michigan State University Department of Entomology. The purpose was to investigate chemical control techniques suitable to reduce and maintain the cereal leaf beetle at a non-economic level and to observe the effects on the beetle and certain associated insects.

By using insecticides specifically designed for the cereal leaf beetle, and applying them while the adult beetle is concentrated in winter wheat it may be possible to develop a practical method of control directed at the spring adult.

LITERATURE REVIEW

The cereal leaf beetle adult usually emerges from diapause and engages in active feeding by the first week of April (Castro, 1965). The spring adults feed, mate and begin to oviposit on available winter grains. As soon as spring planted grains germinate, the beetles begin to appear on this newer growth. Castro (1965) reported the heaviest feeding and egg laying on spring grains. Eggs hatch in four to 23 days depending on the temperature (Knechtel and Manolache, 1936).

In three weeks the larvae feed heavily on plant leaves and pass through four instars; the last becoming the prepupae. Pupation in the soil takes one to three weeks depending on temperature and humidity (Castro, 1965; Yun, unpublished data). The newly emerged summer adults feed for about two weeks on grain, grass and corn leaves before going into a quiescent period or diapause until the following spring (Balachowsky and Mesnil, 1935; Castro, 1965; Hodson, 1929; Kadocsa, undated; Mesnil, 1931; Venturi, 1942).

Castro and Venturi have outlined complete diagnostic characteristics for all stages of the cereal leaf beetle and should be consulted for specific information (Castro, 1965; Venturi, 1942).

Since 1831 the cereal leaf beetle has caused serious periodic damage in certain parts of Europe, in particular the interior grain areas of Hungary (Kadocsa, 1916). However, the cereal leaf beetle is found throughout Europe, extending from north Africa to Norway and

England to Siberia. In the Mediterranean basin the beetle causes little if any significant crop reduction (Venturi, 1942).

Population buildup and damage has been sporadic since the 1880's, buildups occurring every several years with an eventual gradual tapering off. Kadocsa (undated) suggested this phenomenon may be due in part to adverse climatic factors reducing the numbers of natural enemies for a number of years, and then eventually attaining a gradual recovery.

It is not known exactly how the cereal leaf beetle arrived in the United States, although beetles were discovered in cargos at ports of entry in New Jersey and Detroit in 1961 (USDA, 1962). In 1962 the insect was positively identified by specialists of the U. S. Department of Agriculture and became recognized as a cereal crop pest in the United States. A cooperative survey between the Michigan Department of Agriculture, Entomology Department of Michigan State University and the Plant Pest Control Division, Agriculture Research Service, USDA, showed that parts of southwestern Michigan and northern Indiana were infested with cereal leaf beetles in 1962 (Figure 1; USDA, 1963).

Between 1962 and 1967 the beetle population has increased enormously. Shade and Wilson (1964) indicated a ten-fold increase in infestation of an area in northern Indiana between 1962 and 1963, and showed that infestations fit a calculated wind-rose so closely as to suggest that wind may be a major dispersion-influencing factor. The winds prevailed in a northeasterly direction during the major flight season. The beetle has continued to move to the north, east and south of the initial infestation in Berrien County, Michigan. It has proceeded to infest the majority of Michigan and Indiana, and portions of

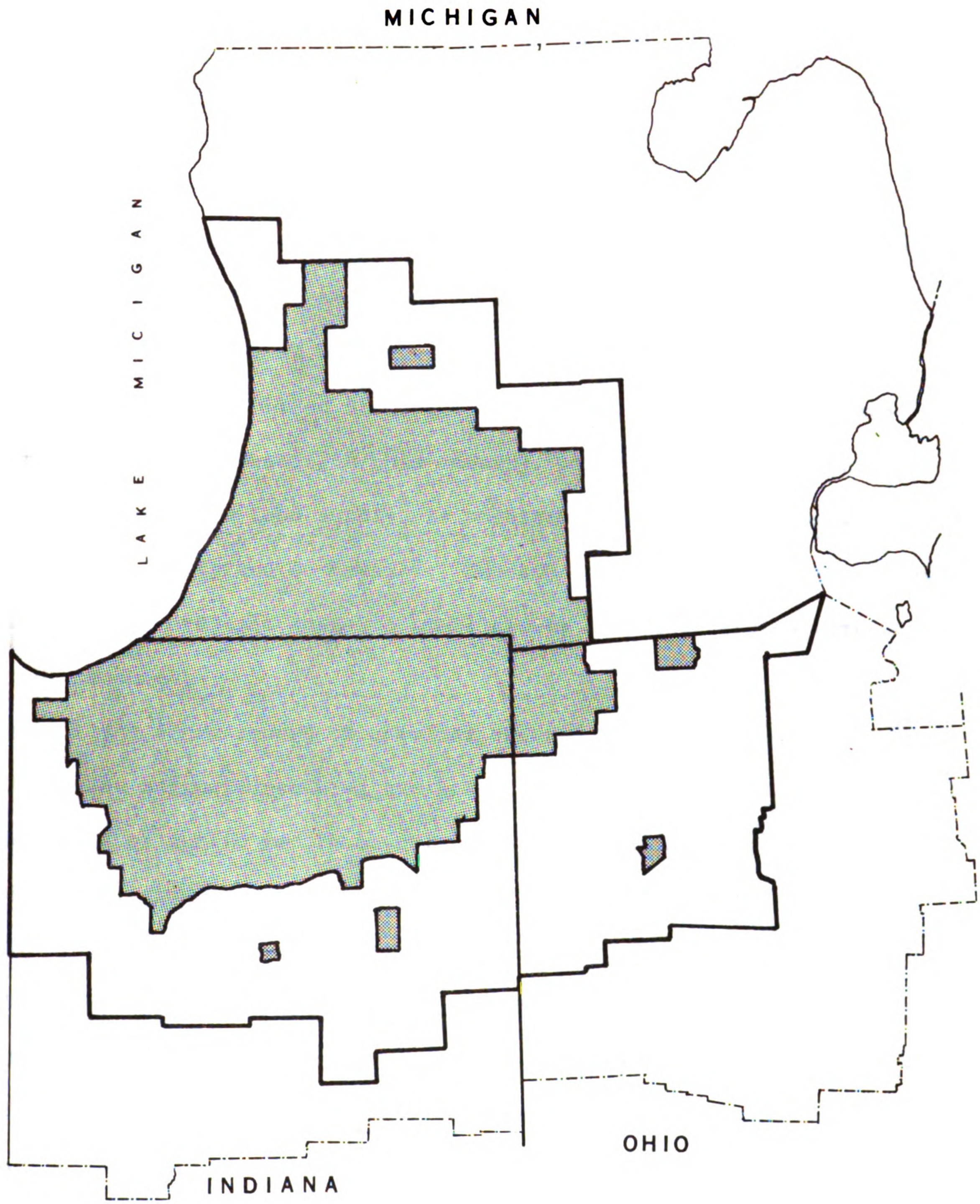

Fig. 1.--Areas infested with the cereal leaf beetle in Michigan, Indiana and Ohio in 1963.

Illinois, Ohio and Pennsylvania. In 1967 it was reported to be within miles of the Kentucky border. The heaviest infested areas and areas threatened with significant damage problems are located, in the southwest and northern portions of Michigan and Indiana, respectively. Figure 2 indicates the entire area, as of September, 1967, of infestation for the cereal leaf beetle; a total of 68,759,040 acres, including 225 counties in five states (Moore, personal communications).

The cereal leaf beetle has encountered little environmental resistance in the United States. It has virtually no natural parasites and few predators in this country. This, along with a suitable climate and ample food supply, is probably why the beetle has increased in number and spread so rapidly. The steady spread and the threat of substantial economic loses to small grains has necessitated some control measures.

The first record of chemical control was in 1831, when a Hungarian suggested soaking the grain seeds in water containing several handfuls of garlic for 24 hours; the results indicated little control (Kadocsa, undated). Early attempts to control the pest led to the development of several tobacco extracts and nicotine combinations. Tharton, a nicotine extract, proved successful but expensive in Hungary (Kadocsa, 1916), and nicotine sulphate gave varying control in the Soviet Union (Vassiliev, 1913); nicotine however, was used to no avail in Spain (Urquijo, 1940). Tobacco extracts combined with Pyrethrum were noted as effective in France (Mesnil, 1931). Pyrethrum alone was ineffective in Hungary, but effective in England 30 years later (Hodson, 1929; Kadocsa, 1916).

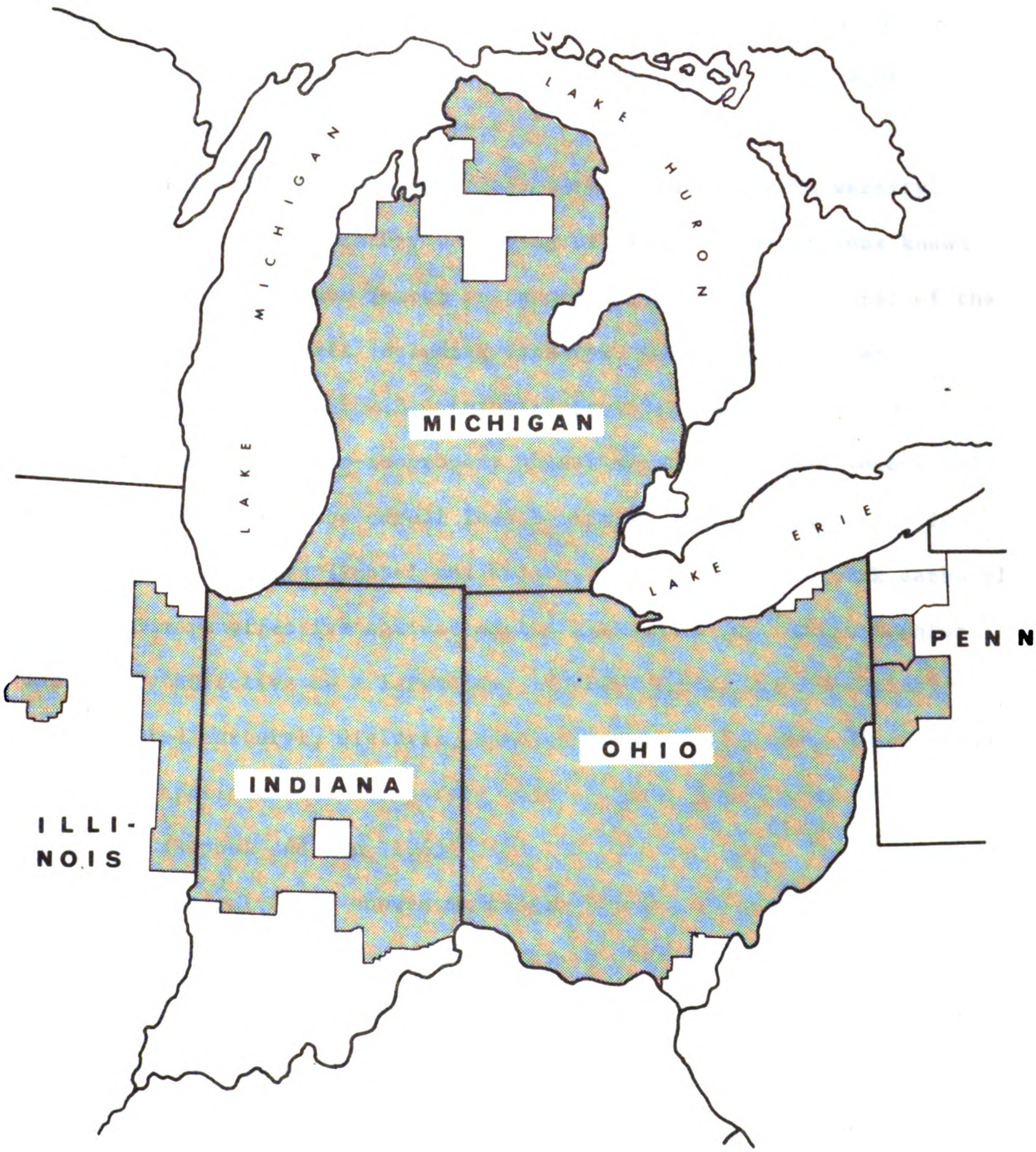

Fig. 2.-- Areas infested with the cereal leaf beetle in Michigan, Indiana, Ohio, Illinois and Pennsylvania in 1967.

Inorganic compounds produced little control and proved awkward, troublesome and expensive to apply (Balachowsky and Mesnil, 1935; Kadocsa, 1916; Vassiliev, 1913; Venturi, 1942), the exception being lead arsenate which was reported to be an effective control agent (Urquijo, 1940).

In 1963, Yun and Ruppel (1965) at Michigan State University, began a program of laboratory screening of organic insecticides known to be effective on other insect pests and chrysomelids. Several of the more promising chemicals including carbaryl, malathion, Guthion (O,O-dimethyl-S-(4-oxo-1,2,3,-benzotriazinyl-3-methyl) phosphorodithioate) and Baygon (o-isopropoxy phenol methylcarbamate) were later field tested against the cereal leaf beetle by aerial application in southwestern Michigan (Ruppel and Wilson, 1964). In their work carbaryl was found more effective against adults than malathion, while Guthion was highly effective as a larvacide. In 1964 Ruppel and Yun (1965) field tested carbaryl, dieldrin, endrin, Guthion, lindane and malathion by ground application and reported that all gave good control except malathion (Ruppel and Yun, 1965).

Biological tests showed malathion to have an immediate kill with a short two to three day residual effectiveness (Ruppel and Wilson, 1964; Wilson, Ruppel and Treece, 1965). Yun (1964) also found that malathion was not as toxic to several insects associated with the cereal leaf beetle as other materials tested. On the basis of these results malathion was registered in 1962 and has been the most popular insecticide for the control of the cereal leaf beetle for the past four years. In 1966, 1,616,807 infested acres in Michigan, Illinois and Indiana were treated with low volume malathion under the cooperative control program of the states involved and the Plant Pest Control Division, U. S. Department of Agriculture (Janes and Ruppel, 1964; USDA, 1966).

Frequently, chemical control alone can be more detrimental than beneficial in controlling a pest species. In Canada, as a precautionary measure, apple orchards were often sprayed before pests appeared. The chemical used removed parasites and predators of the pest as well as the pest itself. By selecting a pesticide and dosage that spared the pest's natural enemies, and treating only severe outbreaks, insecticide costs were lowered and crop yield was as good or better than before (Pickett, et al., 1946; Pickett and Patterson, 1953). Side effects often follow the use of many pesticides, such as residue problems, resistant pest populations and the destruction of natural enemies of the pest controlled and of other pests (Briggs, 1965; Smith and Hagen, 1959). Almost every example of strict chemical control has shown a harmful influence of the chemical on the ecosystem and resulted in inadequate results that are temporary and uneconomical (Hagen and Smith, 1958). Chemical control agents can be responsible for the destruction of environmental resistance which often results in increases in pest numbers (DeBach, 1964). Insecticides should be fitted into an ecosystem, not imposed upon it (Laird, 1963; Stern, et al., 1959).

Through effectively applying and integrating ecological concepts and methods to the problems of economic entomology, alternative and complementary methods of chemical control are being developed for use on insect pest problems (Pickett, et al., 1946; Smith and Hagen, 1959).

Few control methods involving only chemical or only biological factors alone have been able to adequately subdue pest species (Wigglesworth, 1965). All suitable methods of pest population reduction must be considered and integrated into a functional control approach (Pickett, 1959; van Emden and Wearing, 1965). Kennedy (1965) suggests that the idea of integrated control should consider such factors as plant culture, cultivation, resistance and breeding and should look at the possibilities of manipulating the delicate ecosystem. Briggs (1965) stated that these approaches have probably been overlooked because we lack the essential information on how the ecosystem itself is integrated.

The ecological, physiological and systematic relationships of the fauna must be understood, but cannot be applied without a working knowledge of the principles that underlie the fluctuations in the populations concerned (Glen, 1954; Stern *et al.*, 1959). For instance, methods utilizing parasites, predators, or pathogens to control pest species (biological control) cannot be devised without at least basic information on the ecosystems involved (Pickett, 1959). Thus the main approach to the successful control of pest populations must include the interaction or integration of every feasible control method available (Chant, 1966).

Natural control of the cereal leaf beetle must occur in Europe since the population increase is limited and more or less stabilized by environmental factors. When introduced insects meet a favorable climate in the absence of their natural enemies they often increase in numbers to pest proportions (DeBach, 1958). One of the best means of modifying the environment to lower a pest's population permanently is through the use of its natural enemies (DeBach, 1964; Turnbull and Chant, 1961).

Several parasites and predators of O. melanopus are known to exist in Europe (Hilterhaus, 1966). As of May, 1967, 16 parasites and one predator that directly and/or indirectly affect the pest have been reported to occur in Europe (Sailer, unpublished report). Since 1963, research programs have investigated the feasibility of using the cereal leaf beetle's natural enemies in biological control in the United States (USDA, 1966). Laboratories in France, Yugoslavia and Poland find, investigate and send the potentially useful natural enemies to the U. S. for further study or release in infested areas.

Presently, research programs are underway at Michigan State University, Ohio State University, Purdue University and the University of Wisconsin to investigate all aspects of the cereal leaf beetle. In addition, a laboratory in Niles, Michigan organized by the Plant Pest Control Division, Agriculture Research Service, USDA, has initiated a program to mass produce and distribute cereal leaf beetle parasites. To date the parasite, Anaphes flavipes Foerster, is the only one that has been produced and released in large numbers.

In 1967, an egg parasite, Trichogramma minutum Riley, was recorded from cereal leaf beetle eggs in Berrien County, Michigan. Investigations are presently being carried out at Niles, Michigan on the general biology of this parasite (Stehr, personal communication). Also in 1967, 20,000 cereal leaf beetle larvae collected from Michigan fields were examined in a continuous survey for natural parasites; however, no parasites were found. The most recently discovered parasite, Hylalomyodes triangulifera Loew., parasitizes the summer adult beetle. Parasitized beetles have been found in Berrien County, Michigan. Studies are being conducted at Michigan State University concerning the nature of the insect's relationship to the cereal leaf beetle (Wellso, personal communication).

One native predator, the spotted lady beetle, Coleomegilla maculata lengi Timberlake, has been found in Michigan (Castro, 1965). It overwinters as an adult appearing in the field at approximately the same time as the cereal leaf beetle. Coleomegilla maculata is normally an aphid and pollen feeder, but has been reported to cause ten to fifty percent mortality in cereal leaf beetle eggs (Castro, 1965). The spotted lady beetle will readily feed on O. melanopus eggs until the aphid population builds up later in the season. Other Coccinellidae observed in the field but not known to be predaceous on cereal leaf beetles are: Coccinella 9-notata Herbst, Hippodamia 13-punctata tibialis Say and Hippodamia convergens Guerin (Castro, 1964). Castro (1964) considered the spotted lady beetle to be the only predator important in cereal leaf beetle population reduction.

Malathion is highly toxic to the spotted lady beetle (Harris and Volcarce, 1955; Yun and Ruppel, 1964), while endrin and Baygon are slightly to moderately toxic (Campbell and Hutchins, 1953; Harris and Volcarce, 1955; Yun and Ruppel, 1964). All of the above investigators agree that dieldrin in only slightly toxic to C. maculata. Bartlett (1963) tested insecticides on six coccinellids, but did not include the spotted lady beetle. His results showed that malathion was highly toxic to all six species. Recent work by Yun and Ruppel

(1964) agrees with Bartlett that dieldrin, endrin and lindane were slightly or non-toxic to the coccinellides tested. All the previous authors that have tested insecticides on C. maculata are in agreement that the chlorinated hydrocarbons were the least toxic.

METHODS

This study was initiated in 1966 to investigate the use of chemicals in an integrated control program. The main objective was to find the most effective material and method of exposing the cereal leaf beetle population to the toxic effects and still minimize contamination of the environment. The three controllable parameters were type of insecticide, timing and localization of treatment.

By the first week of April the cereal leaf beetle emerges from overwintering sites and feeds primarily on winter-grains which are much more abundant than wild grasses. Castro (1965) has shown that more than ninety percent of the beetle population will infest winter grains before any desirable spring grains germinate, and that less than one percent of the eggs are laid by early April. In view of these facts it would appear possible to control the cereal leaf beetle by treating only those winter grain fields that are heavily infested by spring adults at this time. The premise is that spring grain fields may not need treatments if the beetle is eliminated in the winter grain fields.

Experiment I

Malathion, Baygon, lindane and dieldrin were selected based on studies of a large number of materials tested against the cereal leaf beetle in 1963 and 1964 (Ruppel and Yun, 1965; Ruppel and Wilson, 1964; Wilson, Ruppel and Treece, 1965; Yun and Ruppel, 1965). These investigators reported good control of the pest with each of the four materials, and varying effects on other associated insects. Beetle migration to and from winter grain fields minimize its exposure to the insecticides and timing of the treatment becomes an important factor in addition to the residual effectiveness of a material. A material such as malathion controls the pest effectively for two or three days but provides no control of beetles migrating later into the winter grain fields. This exposes only a small portion of the population to the material. On the other hand a more persistent insecticide like dieldrin may have more lasting effects to the beetle and to other susceptable organisms (Chant, 1966). Yun and Ruppel (1965) found Baygon and lindane to have about a ten day residual effect which is intermediate between malathion and dieldrin.

The treatment area was located in four sections of Galien Township and the adjoining four sections of Weesaw Township, Berrien County, Michigan (Figure 3). Area selection was based on 1965 survey results indicating a high number of overwintering adult beetles in the Galien area (Gomulinski, unpublished data). Every fall-planted small-grain field within the area was treated. The forty-four fields ranged in size from three-fourths to forty-nine acres.

The residue problem with dieldrin, lindane and Baygon prevented their use near dairy farms so these fields were treated with malathion. The remaining fields were randomly assigned one of the four insecticides.

Above normal precipitation in April (Figure 4) prevented ground application so materials were applied by air. A Piper Pawnee spray plane calibrated for a swath thirty-five feet wide at an altitude of

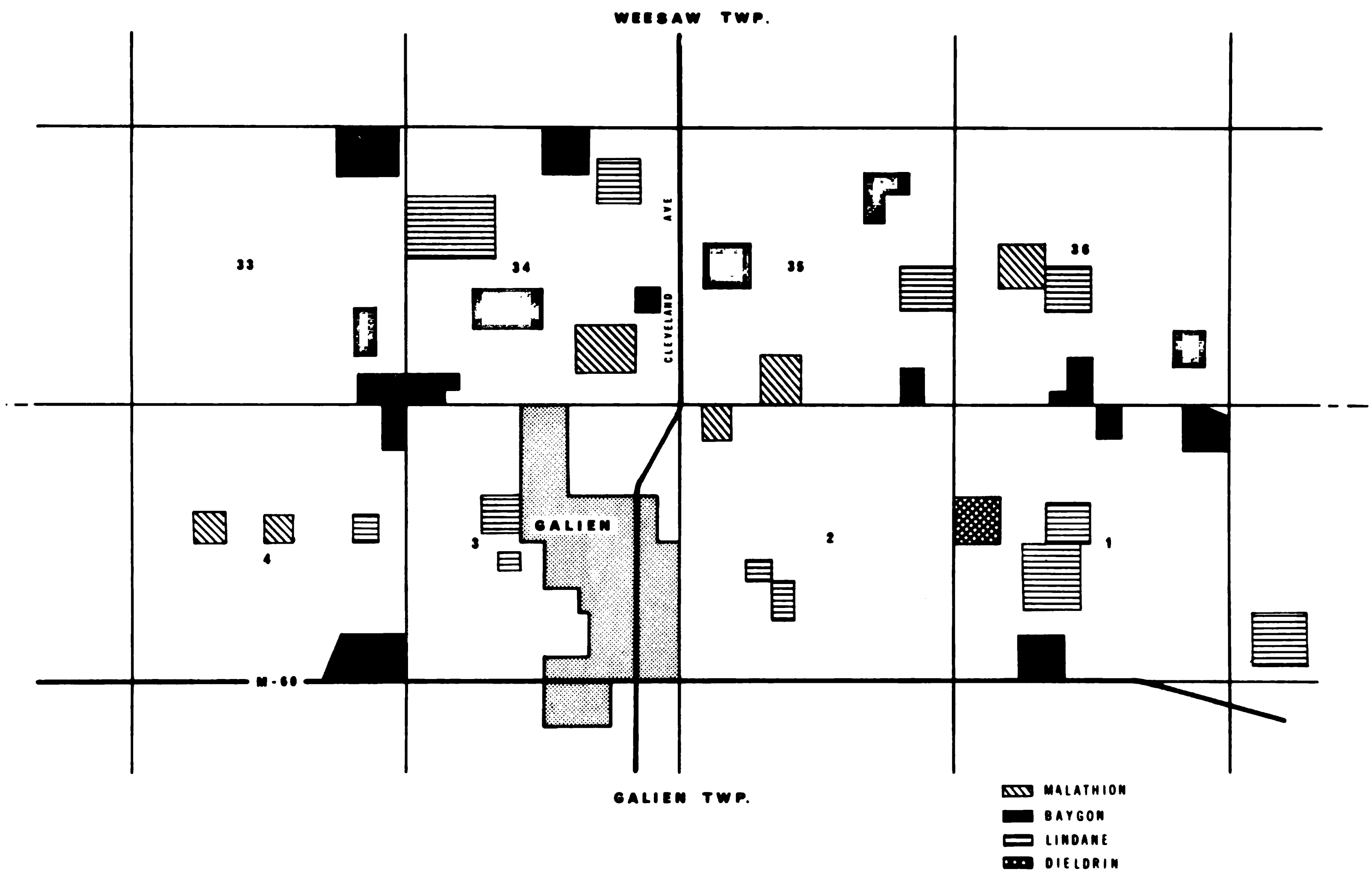

Fig. 3.--Location of experiment 1 study fields in Weesaw and Galien Twps. (Berrien Co., Michigan).

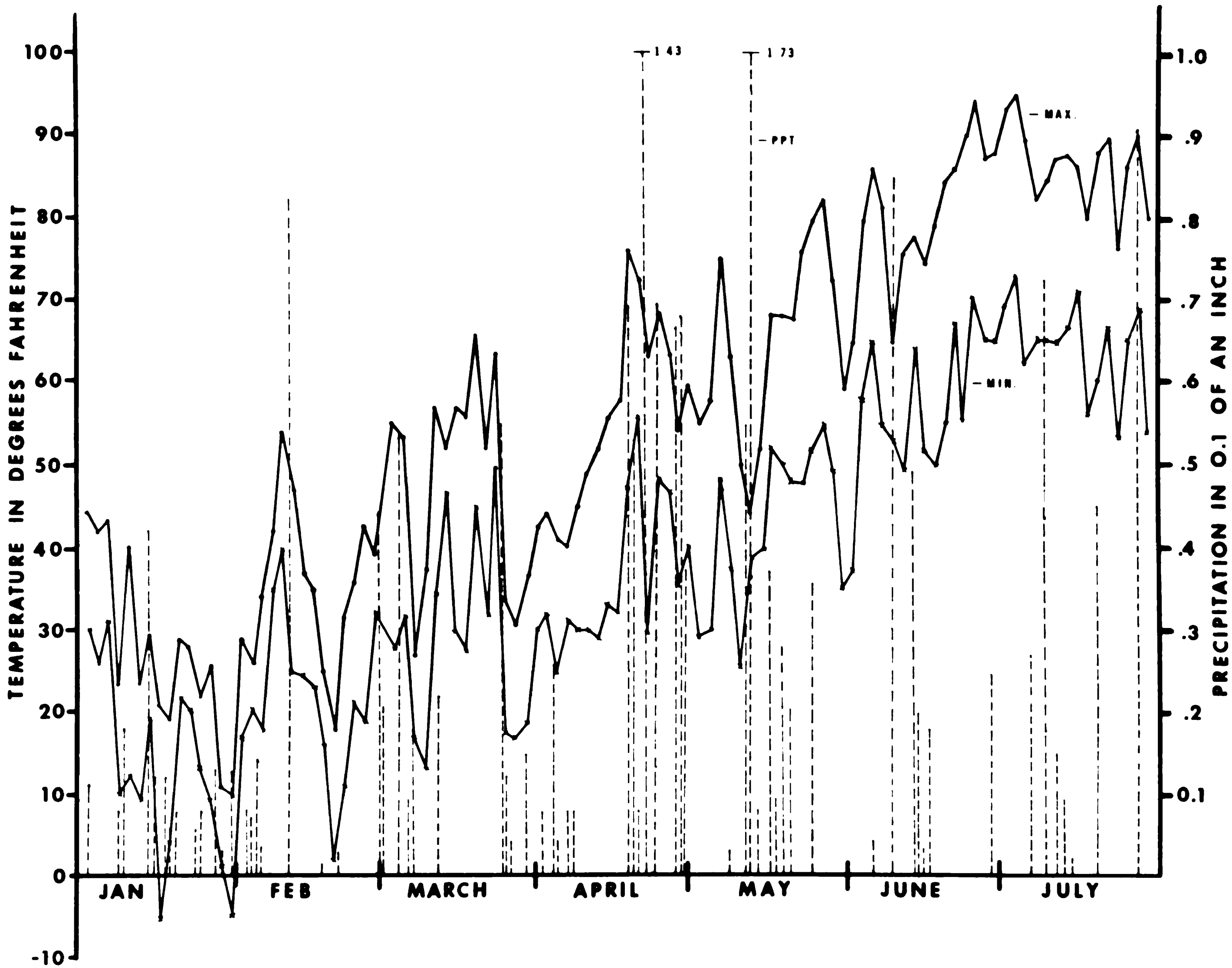

FIG. 4.-- Weather chart showing precipitation, maximum and minimum temperatures at two-day intervals recorded at Eau Clare Station (January to July, 1966).

three to thirty feet was used to treat all fields in this experiment. The optimum spray date was April 15, but atmospheric conditions prevented treatments until May 2. Eggs were abundant at this time in the winter grains and beetles could be found in oat fields.

Two hundred and sixty-five acres were sprayed on May 2 and the remaining one hundred and sixty-eight acres were treated on May 4. Time of day, temperature and wind conditions for the two spray dates are indicated in Table 1 while the dosages used are given in Table 2.

An unsprayed check area was established for comparative purposes. This area, approximately one mile from the nearest treated field, contained twenty-two winter grain fields in an area of similar size (two miles by four miles) and beetle density.

Samples were obtained using a standard 15 inch sweep net. Pre-treatment samples of 200 sweeps per field were taken on April 26. Post-spray samples were taken on May 5, May 24, June 2 and June 6, and consisted of 500 sweeps in each treated field. Samples in the check area consisting of 100 sweeps were taken on May 20, May 26 and June 7 in each of the twenty-two fields. Each field sample was placed in seventy percent ethyl alcohol, labelled and stored for analysis at a later date.

Experiment II

Malathion, Baygon, lindane and dieldrin were applied in a paired plot design in six fields (Figure 5). Application was made with ground equipment to two fields, and by air in four fields. The purpose of the experiment was to compare the effectiveness of the chemicals and methods of application.

TABLE 1.--Time of day, temperature, moisture and wind conditions for aerial spraying of selected winter-grain fields in Berrien County, Michigan - 1966

				Wind				Moisture	
Load	Date	Time	Material	Direction	Velocity	Sky	Temp. °F	Soil	Plants
1	May 2	7:05-8:15 a.m.	Lindane	E-SE	4-6 mph	Clear	42-48°	wet	damp
2	May 2	8:55-10:00 a.m.	Lindane	SE	6-8 mph	Clear	48-55°	wet	damp
3	May 2	10:50-11:30 a.m.	Baygon	S-SW	8-10 mph	Clear	55-60°	wet	dry
4	May 4	6:40-8:00 a.m.	Baygon	E	0-4 mph	Clear	38-45°	wet	damp
5	May 4	8:35-9:30 a.m.	Malathion	E	7-10 mph	Clear	45-50°	wet	damp
6	May 4	10:00-11:00 a.m.	Dieldrin	SE	6-12 mph	Clear	51-55°	wet	damp

TABLE 2.--Dosage, acres sprayed and application rates of four insecticides applied to selected winter-grain fields in Berrien County, Michigan

Material	Oz. Active Ingredient/ Gal. H_2O	Oz./Acre	Acres/Gal.	No. Acres Sprayed	No. of Fields
Malathion	24 E.C.[1]	16	1.5	65	7
Baygon	24 E.C.	6	4.0	178	18
Lindane	24 E.C.	3	8.0	179	12
Dieldrin	24 E.C.	4	6.0	11	1
Check Area	none	--	--	--	22

[1]Emulsifiable concentrate.

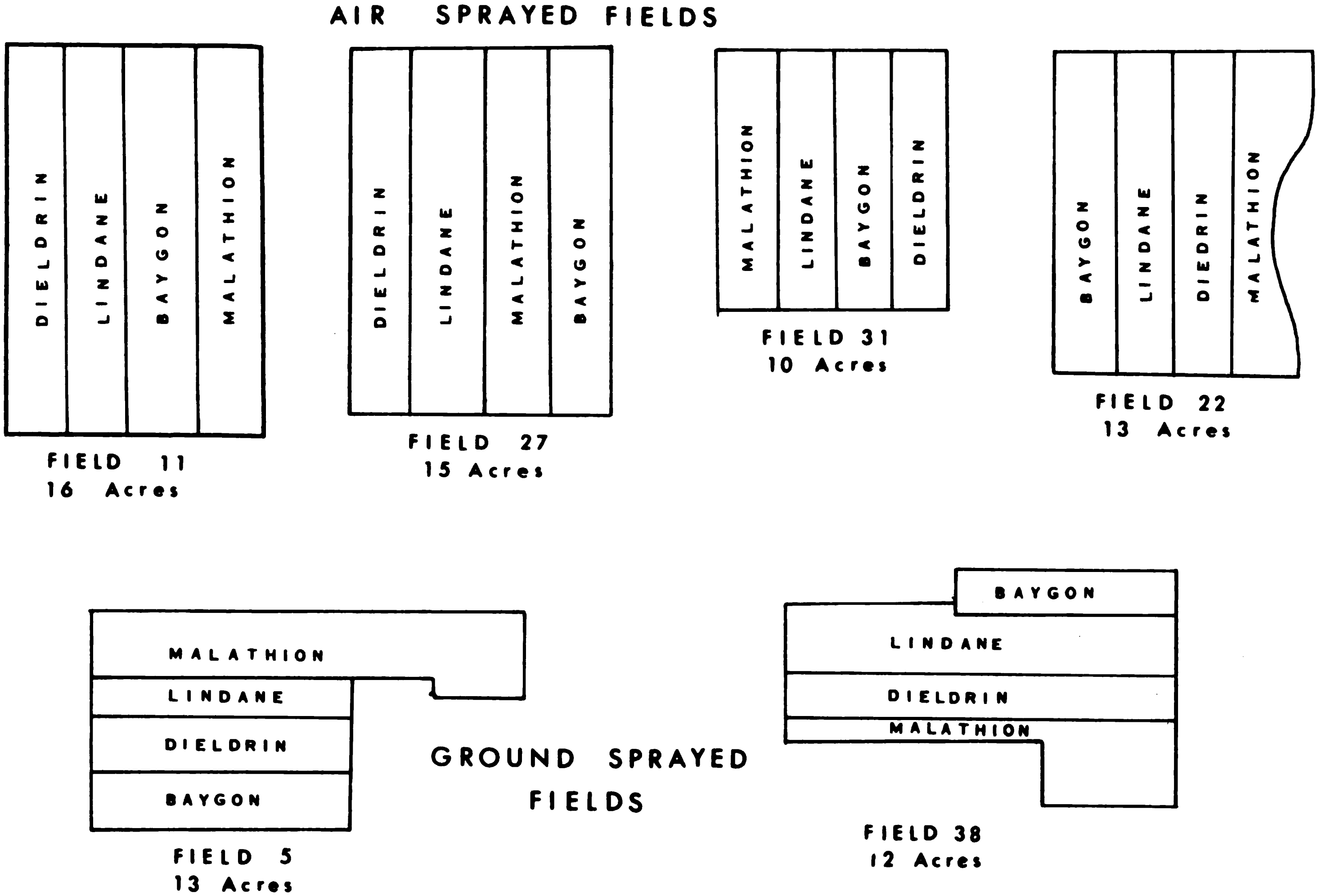

Fig. 5--Arrangment of insecticides in study fields of experiment 2.

Each insecticide was randomly selected for one of the strips. These fields were located in the same area as those in experiment I. The air applications were also of the same dosages and applied on the same dates (May 2 and 4) as the first experiment (Table 2). Ground applications were made on May 4 and 5, with a John Bean sprayer calibrated at 4.55 gallons per acre. Dosages, weather and application rates are shown in Table 3.

TABLE 3.--Ground applied insecticide rates, dates, dosages, and weather conditions for two fields treated with four insecticides near Galien, Michigan - 1966

Material	Spray Date	Oz. Active Ingredient /Gal H_2O	Oz./ Acre	Temp.	Wind	
					Direct.	Veloc.
Malathion	5 May	24 E.C.[1]	16	67° F	SW	10-12mph
Baygon	4 May	24 E.C.	6	59°	S	8-12
Lindane	4 May	24 E.C.	3	55°	S	5-6
Dieldrin	5 May	24 E.C.	4	60°	SW	0-1

[1]Emulsifiable concentrate

Pre-spray samples of 200 sweeps per field were taken on April 26. Post-treatment samples of 500 sweeps per strip were taken on May 20, 23, 26 and June 2.

Experiment III

If a major portion of spring adult cereal leaf beetles could be eliminated early in the spring while concentrated in winter grains, then the pest's threat to oats, planted later in the season, would be lessened. This experiment represents a comparison of two groups of oats fields; one group (14 fields), located within an area where all winter-grain fields were treated for beetles in the first week of May, and a second group (15 fields) located in an area where no control measures had been taken.

Since winter-grains in the unsprayed area were not treated, oats fields in this area were susceptable to the pests migration from both outside areas and from beetles in the winter-grains. Oats in the treated area would only be threatened by those beetles that were not stopped in the treated winter-grain fields. Accordingly, if the number of beetles in winter-grain of the treated area were significantly changed by insecticides, then the number of beetles eventually appearing in oats in the sprayed area should have changed in comparison to those in oats fields in the untreated area.

Counts were made in oats fields on June 17, in both test and unsprayed areas. Eggs and second to fourth instar larvae were prevalent in most of the fields. A random sample of twenty stems was collected from the central portion of each field, and the number of unhatched cereal leaf beetle eggs and larvae were totaled and recorded as live units.

Experiment IV

Low-volume technical malathion has been shown to be a practical method for suppression and control of cereal leaf beetle (Wilson, Ruppel and Treece, 1965). These investigators indicate that this treatment is highly effective against spring adults and should be equally effective against the summer adults. Ruppel (unpublished report) shows that near eradication of the beetle can be achieved if two or more stages of the pest are controlled. Previous studies in Indiana have been conducted on the effectiveness of insecticides for suppression and also on block eradication trials (Ruppel and Wilson, 1964).

In 1966 an experiment was carried out by the Plant Pest Control Division, USDA, to evaluate the feasibility of achieving an eradication of the cereal leaf beetle through the use of a properly timed insecticide applied for adult beetles.

A sixteen square mile area was chosen in Fillmore Township in Allegan County, Michigan for the eradication experiment (Figure 6). This area was located near two natural barriers; Lake Michigan to the west and Allegan Forest to the south, and contained a light infestation of cereal leaf beetles. These barriers helped to eliminate migration of the beetle into the test area. Therefore, the evaluation was over an area comparable to one with an isolated infestation where outside infestation was lacking.

The Michigan Department of Agriculture also treated several thousand acres to the east and north of the eradication experiment area with a single blanket low-volume (4 ounce per acre) malathion treatment in an attempt to suppress the spread of the beetle from southern Michigan to central and northern Michigan. The eradication experiment area lay within this blanket treatment area. An eight square mile area within this blanket suppression area and about five miles from the eradication site was selected for evaluation and comparison with the eradication experiment.

An aerial application of four ounces actual malathion per acre using a flight height of 125 feet was applied on May 4, to the blanket

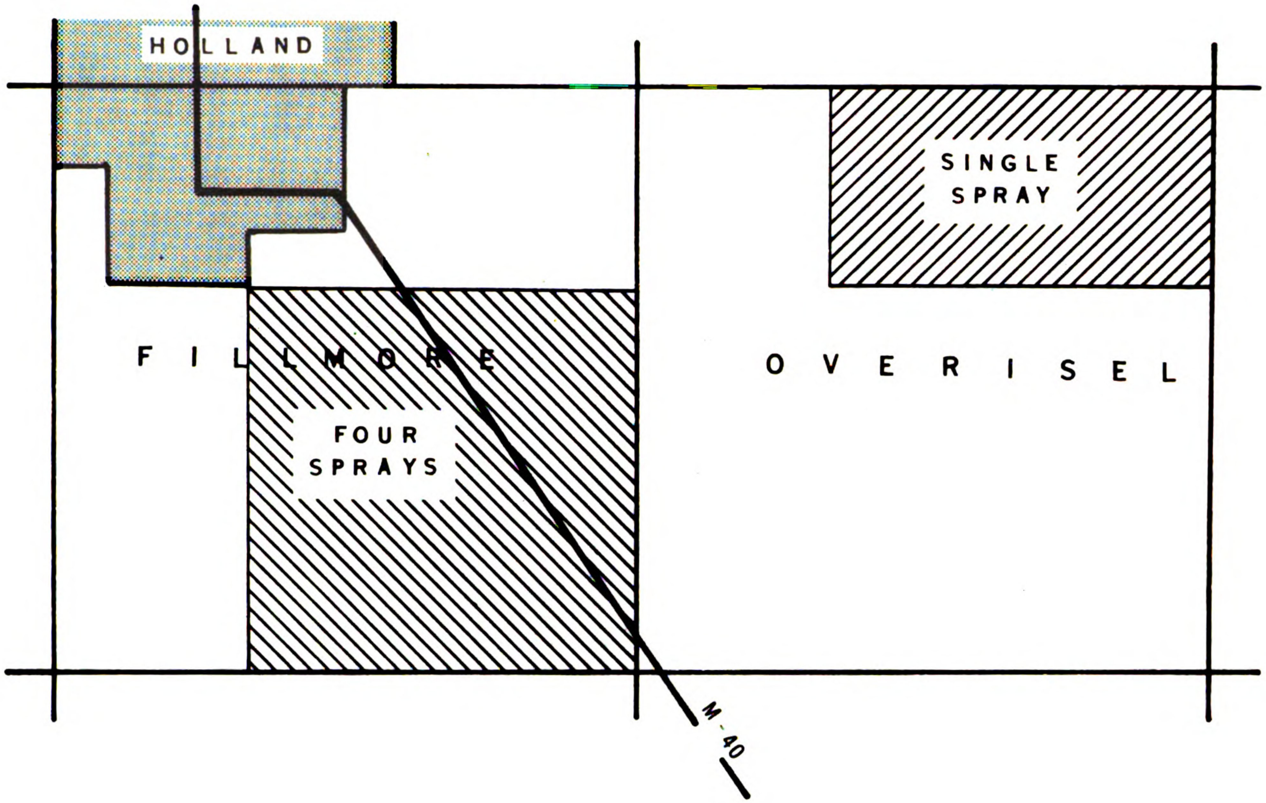

Fig. 6.-- Location of experiment 4 study fields in Fillmore and Oveisel Twps. (Allegan Co., Michigan).

suppression and eradication areas. The treatments were aimed particularly at the adult beetle. By May 4, the majority of spring adults had probably emerged from overwintering quarters.

The May 4 application was the only treatment applied to the blanket suppression area, but three additional treatments were applied to the eradication area on May 14, June 29, and July 15, 1966.

Thirty-two winter-grain fields in the four spray area were sampled as well as twenty fields in the single spray area. Oats fields were also sampled later in the season in both areas. A comparison of these samples should indicate whether or not beetles remained after treatment or if a significant difference existed between the two control approaches. It would also indicate the number of adult and larval cereal leaf beetles migrating or otherwise infesting the oats fields.

In the winter grains a 1000-sweep sample per field was taken in the four spray area on April 22, April 29, May 5 and May 16. Oats were sampled on June 14. All the beetles were counted in the 1000 sweeps but only the last 400 sweeps were preserved for later analysis of associated insects. On July 12, 500 sweeps each were taken in ten oats fields and their peripheral margins of grasses. The last 100 sweeps from the grasses were saved and counted; however, counts of the beetle representing 1000 sweeps from the grasses and oats were combined.

Each of the twenty single spray fields were swept 500 times on April 25, May 17, May 25 and June 6. Thirteen oats fields in this area were swept 1000 times on June 6 and June 17, and 500 times in the adjoining grasses on July 15.

Stem counts of cereal leaf beetle eggs and larvae found on all stems present in 15 linear row feet were also made in oats in both areas. Three feet subsamples were taken from five random locations in each field. These counts were made on June 14 in the four spray area and on June 16 in the single spray area.

Results

Experiment I

Thirty-five of the original forty-four fields selected for this experiment yielded usable data. Nine fields were either mowed or plowed by the farmer. Table 5 indicates the number of fields treated with each material used in the experiment and the mean number of insects per 100 sweeps collected one day after treatment.

Sweep samples and visual observations one day after treatments (May 5) indicated a high mortality of cereal leaf beetle adults in all treated fields (Table 5). No significant differences in the effectiveness of the four materials against cereal leaf beetles were present on May 5.

Total number of insects per treatment per date is given in Table 4 and illustrates the relative effectiveness of the four materials as compared to the unsprayed check area, after insecticide applications. Samples taken on May 24 show malathion, Baygon and lindane to have no significant differences with respect to each other or the unsprayed fields. However, dieldrin, in comparison to the other materials, imposed significantly higher control of cereal leaf beetle adults on this date.

TABLE 4.--Total number of cereal leaf beetles and associated insects in winter wheat, air sprayed with four insecticides near Galien, Michigan - 1966[1]

Material	26 April	5 May	24 May	6 June
Cereal leaf beetle (adult)				
Malathion	83.8 a[2]	3.9 cd	21.2 f	4.2 i
Baygon	25.1 b	1.8 c	18.0 f	11.7 i
Lindane	14.5 b	1.5 c	27.5 f	12.4 i
Dieldrin	19.0 b	0.0 d	0.0 g	7.0 i
No treatment	NC	95.0 e	45.0 h	1.7 j
Cereal leaf beetle (larvae)				
Malathion	--	--	3.7 k	259.0 n
Baygon	--	--	2.0 l	140.0 o
Lindane	--	--	0.1 l	50.0 o
Dieldrin	--	--	0.0 l	109.0 o
No treatment	--	--	93.0 m	360.0 p
Coleomegilla maculata				
Malathion	2.0	1.6	3.0	18.0
Baygon	3.0	2.8	42.0	18.0
Lindane	3.0	2.2	10.0	25.0
Dieldrin	0.0	NC	2.0	15.0
No treatment	NC	62.0	36.0	34.0
Coccinellidae				
Malathion	1.0	0.2	2.0	3.0
Baygon	1.5	2.0	6.0	32.0
Lindane	1.5	1.0	4.0	17.0
Dieldrin	0.0	NC	0.0	15.0
No treatment	NC	18.0	9.0	62.0
Miridae				
Malathion	1.0	4.6	0.0	34.0
Baygon	1.5	6.2	3.0	56.0
Lindane	1.5	2.4	1.0	82.0
Dieldrin	0.0	NC	0.0	13.0
No treatment	NC	2.0	7.0	805.0
Aphidae				
Malathion	83.0	55.4	415.0	NC
Baygon	204.5	403.2	3200.0	NC
Lindane	163.5	163.6	789.0	NC
Dieldrin	59.5	NC	228.0	1433.0
No treatment	NC	1726.0	1789.0	9205.0

NC = no counts taken.

[1]Spray dates: May 2, 4, 1966.

[2]Numbers sharing common letter are not significantly different at the 5% probability level.

TABLE 5.--Mean number of insects per 100 sweeps from fields air sprayed with 4 materials one day after treatment near Galien, Michigan (1966)[1]

Material	No. of Fields	Cereal Leaf Beetle Adults	*Coleomegilla maculata*	Coccinellidae	Miridae	Aphidae
Malathion	6	3.93	.27	.03	.78	9.23
Baygon	17	1.80	.16	.12	.36	23.73
Lindane	11	1.53	.13	.06	.14	13.63
Dieldrin	1	0.00	1.00	0.00	0.00	228.00
No insect-icide	22	95.18	2.82	.82	.09	78.45

[1] Spray dates: May 2, 4, 1966.

By June 6 no differences between the four materials against the cereal leaf beetles were evident, and as many adults occurred in the treated area as in the untreated area. The lower number of adult beetles on June 6 was due to natural mortality and not to insecticides.

The first larvae of the cereal leaf beetle appeared on May 20. Table 4 indicates the larval increase from May 24 to June 6. Dieldrin allowed the lowest increase of larvae while Baygon and lindane treated fields showed significantly lower numbers of larvae in comparison with the unsprayed fields. Malathion sprayed fields gave little resistance to the pest by May 24. By June 6 the treated area showed a definite indication of a lower population of larvae than the check area. Samples were not taken after June 6 because the mature condition of the grain made sweeping difficult.

Table 5 shows the mean number of insects associated with the cereal leaf beetle per 100 sweeps one day after the application of insecticides. All treatments showed a marked reduction in other insects. Malathion and dieldrin caused the lowest mortality of *Coleomegilla maculata*, while Baygon and lindane caused moderate reductions. Other coccinellids were affected greatest by dieldrin, malathion and lindane. Malathion, Baygon and lindane caused no reduction of mirid species but gave high control of aphids.

Table 6 indicates percent reduction of *C. maculata*, other coccinellids, mirids and aphids on three dates following applications. On May 5 all insects except the mirids were reduced by malathion, Baygon and lindane. Twenty days after application *C. maculata* reduction was high in all but the Baygon treated fields which showed a slight increase in numbers over unsprayed check fields. Baygon also provided less reduction of coccinellids and mirids. Baygon showed no reduction of aphid numbers as compared to malathion, lindane and dieldrin.

TABLE 6.--Percent reduction of 4 insects associated with the cereal leaf beetle in winter wheat fields treated with 4 insecticides near Galien, Michigan (1966)[1]

Date	Material	*Coleomegilla maculata*	Coccinellidae	Miridae	Aphidae
5 May	Malathion	97.4	98.9	0.0	96.8
	Baygon	95.5	88.9	0.0	76.6
	Lindane	96.5	94.4	20.0[2]	90.5
	Dieldrin	NC	NC	NC	NC
24 May	Malathion	88.9	77.8	100.0	76.8
	Baygon	16.7[2]	33.3	57.1	78.8[2]
	Lindane	83.9	66.7	85.7	55.9
	Dieldrin	94.4	100.0	100.0	87.3
6 June	Malathion	47.1	95.2	95.8	NC
	Baygon	47.1	48.4	93.0	NC
	Lindane	26.5	72.6	89.8	NC
	Dieldrin	94.1	75.8	98.4	84.4

[1]Spray dates: May 2, 4, 1966.

[2]Percent increase over unsprayed control field counts.

Thirty days after treatments (Table 4) malathion, Baygon and lindane indicated no significant differences between their effectiveness on the spotted lady beetle. It is doubtful that a 95.2 percent reduction (Table 6) of other coccinellids on June 6 was due to the effects of malathion. The similar percent reduction of mirids for all materials could hardly be due to the insecticidal effects, since malathion, Baygon and lindane could not possibly be effective thirty days after application. Most likely the insects had moved to other more suitable habitats.

Experiment II

All five insect groups showed a marked reduction in populations in the first sampling on May 20 (Table 7). The three samples following indicated a general upward trend in population densities. Table 7 indicates the mean number of adult and larval cereal leaf beetles per date for the four insecticides in the six evaluation fields. Adult beetles, after a rapid increase in number, leveled off and then decreased. This phenomenon was due to the fact that by June 2 oats had become available. The cereal leaf beetle larval counts indicate a significant increase between May 26 and June 2. Table 8 shows the mean number of cereal leaf beetles for the four sampling dates indicating the overall differences between the four treatments. Relative differences between the insecticide's effect on the five different insects are shown in Table 9. As in the first experiment, all four treatments indicated no significant differences on spring adult cereal leaf beetles; however, the beetle larvae were affected in noticeably different ways.

Malathion had little effect on the larvae as compared to dieldrin, Baygon or lindane. Malathion did give somewhat better

TABLE 7.--Individual treatment effectiveness of application methods of four insecticides on the adult and larval cereal leaf beetle in winter wheat near Galien, Michigan - 1966

Material[1]	20 May		23 May		26 May		2 June	
	Ground	Air[2]	Ground	Air	Ground	Air	Ground	Air
	Mean Number of Insects							
Adult								
Malathion	15.5a[3]	59.5a	60.0b	139.8b	38.0d	153.0e	18.5f	32.0f
Baygon	20.5a	101.0a	67.0b	62.5b	49.0e	153.8e	17.0f	28.3f
Lindane	10.0a	45.5a	62.0b	84.5b	27.0e	106.8e	22.0f	69.0f
Dieldrin	16.0e	18.5a	29.0c	121.0b	30.0e	106.5e	17.5f	86.8f
Larvae								
Malathion	--	--	--	--	326.0g	444.0g	1838.0h	1013.3h
Baygon	--	--	--	--	71.5g	105.8g	505.5h	389.5i
Lindane	--	--	--	--	196.0g	72.5g	691.5h	453.8h
Dieldrin	--	--	--	--	21.5g	72.3g	56.5j	450.3h

[1]Treatments applied: May 2, 4, 5.

[2]Method of application.

[3]Means sharing common letter are not significantly different at the 5% probability level.

TABLE 8.--Mean number of cereal leaf beetles from six fields treated with four insecticides in a paired plot design near Galien, Michigan - 1966

		Cereal Leaf Beetle	
Date	Material	Adult	Larvae
20 May	Malathion	44.83	--[1]
	Baygon	74.33	--
	Lindane	33.69	--
	Dieldrin	17.67	--
	No insecticide	453.20	--
23 May	Malathion	113.17	--
	Baygon	64.00	--
	Lindane	77.00	--
	Dieldrin	90.33	--
	No insecticide	**[2]	**
26 May	Malathion	114.67	404.67
	Baygon	118.83	94.33
	Lindane	80.17	113.67
	Dieldrin	81.00	55.33
	No insecticide	229.30	47.10
2 June	Malathion	27.50	1288.17
	Baygon	24.50	428.17
	Lindane	53.33	533.00
	Dieldrin	63.67	319.00
	No insecticide	8.10	1806.00

Spray dates: May 2, 4, 5.

[1] Dash indicates larval emergence had not occurred by these dates.

[2] No samples taken in untreated area on May 23.

TABLE 9.--Mean number of insects from evaluation fields treated with four insecticides indicating overall differences in treatment effects near Galien, Michigan, 1966[1]

Treatment	Number of Insects					
	CLB Adult	CLB Larvae[2]	*C. maculata*	Coccinelidae	Miridae	Aphidae
Malathion	58.29a[3]	653.85b	3.54d	.90f	3.24h	142.04i
Baygon	50.41a	189.16c	5.30e	3.00g	4.11h	268.94j
Lindane	44.02a	236.16c	6.40e	1.76f	4.15h	242.36j
Dieldrin	45.38a	127.14c	7.58e	4.20g	4.02h	383.55k

[1]Samples taken May 20, May 23, May 26, June 2.

[2]Samples taken May 26, June 2.

[3]Means sharing common letter are not significantly different at the 5% probability level.

control of aphids than the three other materials, but it also produced a higher mortality of the various lady beetles, including C. maculata. Baygon gave relatively good control of cereal leaf beetle larvae and aphids and had a milder effect on the coccinellids than malathion or lindane. Lindane also controlled the cereal leaf beetle adult and larvae. Only dieldrin produced a lower mortality on the spotted lady beetle. Lindane resulted in a high death rate of other coccinellids, but also controlled aphids quite well. Dieldrin, with its long residual effectiveness, was most effective on cereal leaf beetle larvae, but had little effect on aphids, Coleomegilla or other lady beetles. None of the insecticides seemed to significantly affect the mirids.

The single date effects of the four materials on cereal leaf beetle adults and larvae with respect to ground or air application are shown in Table 7.

The June 2 comparison of cereal leaf beetle larvae in Baygon sprayed fields indicated aerial application to be more effective than the ground spray. The overall toxic effects on larvae were significantly higher when lindane was applied by air. However, the overall effects of malathion, Baygon and dieldrin as a result of the application method did not vary significantly.

Ground applications of all four materials showed somewhat greater mortality on all insects at some time or other (Table 10). Ground applied dieldrin resulted in higher overall mortality than did dieldrin when applied by air. No other significant overall differences occurred with malathion, Baygon or lindane.

TABLE 10.--Overall and individual treatment effectiveness of application methods of four insecticides on the associated insects of the cereal leaf beetle in winter wheat near Galien, Michigan - 1966

		Application Method		Effective Method[1]	
		Ground	Air	Individual	Overall
Material	Date	Mean No. of Insects			
Coleomegilla maculata					
Malathion	20 May	1.0	0.8	**	**
	23 May	3.5	2.3	**	
	26 May	1.5	12.8	ground	
	2 June	4.5	6.0	**	
Baygon	20 May	2.5	1.5	**	**
	23 May	11.0	5.0	**	
	26 May	9.5	13.3	**	
	2 June	5.0	5.0	**	
Lindane	20 May	5.5	8.0	**	
	23 May	9.0	7.8	**	
	26 May	5.5	12.3	**	
	2 June	5.5	8.5	**	
Dieldrin	20 May	3.5	0.8	**	**
	23 May	12.0	11.8	**	
	26 May	5.0	28.3	ground	
	2 June	4.0	6.3	**	
Coccinellidae					
Malathion	20 May	2.0	0.3	**	**
	23 May	0.5	1.8	ground	
	26 May	0.5	1.0	**	
	2 June	0.5	1.8	ground	
Baygon	20 May	3.0	1.0	**	**
	23 May	2.5	24.0	ground	
	26 May	2.5	3.8	**	
	2 June	0.5	1.8	**	
Lindane	20 May	1.0	0.8	**	**
	23 May	4.5	2.0	**	
	26 May	1.0	3.5	ground	
	2 June	1.5	1.8	**	
Dieldrin	20 May	2.0	1.3	**	ground
	23 May	4.5	11.0	ground	
	26 May	3.0	7.5	**	
	2 June	2.0	6.5	**	

TABLE 10--Continued

Material	Date	Application Method: Ground	Application Method: Air	Effective Method[1]: Individual	Effective Method[1]: Overall
		Mean No. of Insects			
Miridae					
Malathion	20 May	--	--		
	23 May	--	--		
	26 May	1.0	2.5	**	**
	2 June	4.5	24.5	**	
Baygon	20 May	--	--		
	23 May	--	--		
	26 May	1.5	2.8	**	**
	2 June	11.0	31.3	ground	
Lindane	20 May	--	--		
	23 May	--	--		
	26 May	0.5	1.5	**	**
	2 June	10.5	40.8	**	
Dieldrin	20 May	--	--		
	23 May	--	--		
	26 May	0.5	3.3	ground	ground
	2 June	5.5	40.0	ground	
Aphidae					
Malathion	20 May	40.5	22.3	**	**
	23 May	99.0	140.3	**	
	26 May	116.5	186.8	**	
	2 June	259.0	587.3	**	
Baygon	20 May	16.5	56.8	**	**
	23 May	67.0	203.8	ground	
	26 May	267.0	424.8	**	
	2 June	429.0	1239.0	ground	
Lindane	20 May	12.0	36.8	**	**
	23 May	107.5	177.8	**	
	26 May	608.5	486.0	**	
	2 June	699.0	784.0	**	
Dieldrin	20 May	64.5	67.5	**	ground
	23 May	176.5	353.8	**	
	26 May	422.5	1208.8	ground	
	2 June	364.0	979.8	ground	

[1]Most effective method of application; ** indicates no significance between methods.

Experiment III

Table 11 indicates the total number of cereal leaf beetle eggs and larvae occurring in oats fields in the treated and untreated areas. An analysis of the data (one way analysis of variance) suggests that the number of combined eggs and larvae or live units, in the oats fields from experiment I are not significantly different from those in the unsprayed check area. This would indicate that the insecticidal treatments in the first experiment (spraying individual winter-grain fields early in the season when maximum numbers of the pest are present) did not effectively eliminate the majority of the egg laying populations of cereal leaf beetles.

TABLE 11.--Total number of cereal leaf beetle eggs and larvae occurring in oats fields in treated and untreated areas - 1966

Experiment I Area			Unsprayed Check Area		
Field No.	20 Stems E/L[1]	Live Units	Live Units	20 Stems E/L	Field No.
200	1/7	8[2]	340	24/316	501
201	1/2	3	143	52/91	502
202	1/5	6	26	1/25	503
203	1/3	4	7	2/5	504
204	3/4	7	44	12/32	505
205	3/34	37	60	25/35	506
206	4/105	109	9	1/8	507
207	6/33	39	6	1/5	508
208	11/33	43	61	5/56	509
221	3/0	3	5	4/1	510
222	3/1	4	1	0/1	510-X
223	5/0	5	36	2/34	511
224	5/17	22	97	15/82	512
225	9/85	94	44	18/26	513
			17	5/12	514

[1]E/L = eggs over larvae.

[2]The number of eggs and larvae were recorded from 20 stems taken randomly over each field. The eggs and larvae were then totaled and considered live units.

Experiment IV

Even though the treatment areas contained only a light infestation of cereal leaf beetle spring adults, a significant reduction occurred following the malathion treatment in both areas (Figure 7). The mean number of *Oulema* adults for the twenty fields was 19.40 eight days before the treatment and 0.18 beetles thirteen days after the insecticide application. Although several days had elapsed between the May 4 treatment date and the first post-spray sample it was not likely that the beetle had moved out of the winter wheat, since the germination of other small grains had not begun. Larval cereal leaf beetles did not begin to appear until after June 1.

In all cases initial population densities of the associated insects decreased after the malathion treatment. *Coleomegilla maculata* and other coccinellids did not regain populations of initial densities after the treatment, even though the aphid species increased their numbers by June 6 to three-and-one-half times their pre-treatment populations. The mirid species more than doubled their numbers by June 6 following a slight decrease immediately after treatment.

Two pre-spray counts were taken in the thirty-two winter-grain fields of the eradication area. Adult populations increased slightly from 4.40 on April 22 to 5.39 on April 29. After the first treatment of May 4 the number of beetles in the eradication area decreased to 0.25 beetles per 1000 sweeps. The May 14 treatment reduced the mean number of beetles to 0.1 per 1000 sweeps. Figure 7 also indicates an increase in beetles in the single spray area, but no increase in the four spray area. Both areas showed a considerable increase of beetles

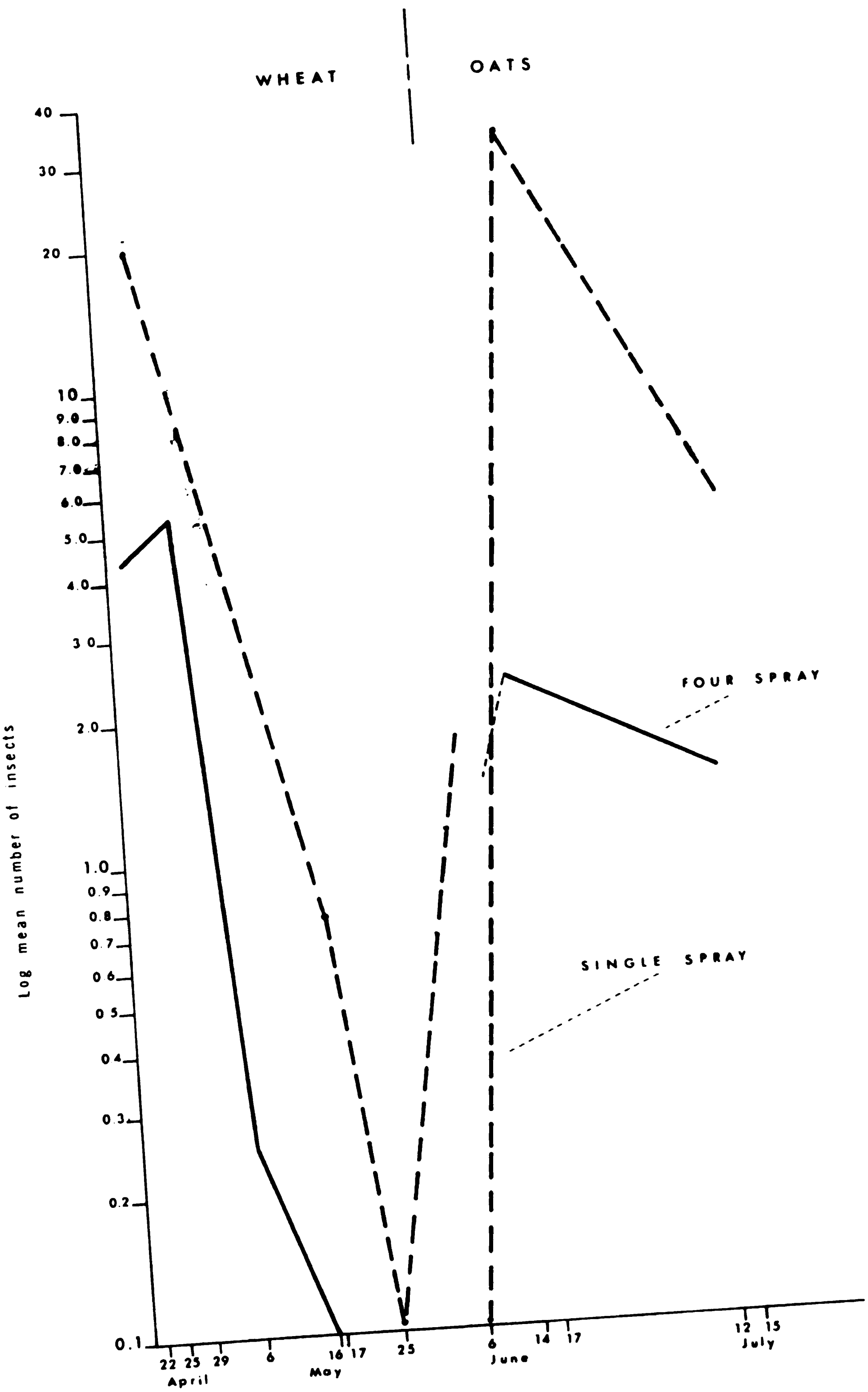

Fig. 7.-- Log mean number of adult and larval cereal leaf beetles in wheat and oats showing differences between two suppression methods - 1966.

in oats on June 14 and 17. However, the mean number of cereal leaf beetles in the single spray area increased significantly more than the population in the four spray area. By July 15 all larvae had pupated and were emerging as summer adults. The decrease of cereal leaf beetles shown in Figure 7 between June 14, 17 and July 12, 15 is a result of natural mortality and a movement to overwintering sites.

Table 12 indicates the mean number of associated insects in wheat and a comparison of the effects of the treatments on them. The four treatments gave significantly higher mortality to the spotted lady beetle and the mirid species than the single treatment. No significant differences between treatment methods were produced on other coccinellids. Aphids exhibited a significantly higher mortality in the eradication fields. In oats, all associated insects (Table 13) indicated significantly lower mortality with single spray than with four sprays.

TABLE 12.--Mean number of insects per 1000 sweeps from wheat fields in an eradication spray area and a blanket spray area (1966)[1]

Sampling Date	Spray Method[2]	*Coleomegilla maculata*	Coccinellidae	Miridae	Aphidae
25 April	E	.54	2.03	.32	21.00
25 April	B	1.60	1.70	3.40	139.10
6 May	E	.09	0.00	0.00	.06
17 May	B	.70	0.00	2.34	37.44
16 May	E	.03	.06	.26	12.00
25 May	B	.34	.34	.44	234.88
6 June	B	0.00	.12	6.28	497.52

[1]Dates sprayed: Four spray area - May 4, 14; June 29; July 15.
Single spray area - May 4.

[2]E = Four spray area
B = Single spray area.

TABLE 13.--Mean number of insects per 1000 sweeps from oats fields in an eradication spray area and a blanket suppression spray area - 1966[1]

Insect	14 June E	17 June B	12 July E	15 July B
Coleomegilla maculata	.05	.62	.50	12.15
Coccinellidae	.20	.46	3.50	34.30
Miridae	12.05	65.23	8.25	30.00
Aphidae	517.30	NC	92.00	1629.30

[1]Dates sprayed: four spray area - May 4, 14; June 29; July 15. single spray area - May 4.

[2]E = four spray; B = single spray; NC = no count.

DISCUSSION

Experiment I

The results of this experiment tend to suggest that treatment of individual fields with an insecticide does initially suppress the overall egg-producing population of cereal leaf beetles. However, the insecticides tested, other than dieldrin, did not give adequate control long enough. Malathion's residual effectiveness does not last long enough to eliminate the pests that are continuously moving into a field from overwintering sites and from other areas. Baygon may produce an active residue for a longer period than malathion. It is less toxic to the cereal leaf beetle's associated species and gives good control of aphids. Nevertheless, after thirty days beetle populations did not vary significantly between the four treatments indicating little remaining toxicity.

Poor weather conditions prevented treatment applications before spring grain germination. These spring grains alleviated the necessity for the pest to remain in winter wheat. Eggs were observed on oats, even though they were only from two to three inches high at the time of insecticide application on wheat in this experiment. The presence of beetles on oats indicated that we had not eliminated the desired percentage of egg-laying adults in the winter wheat. Timing of insecticide application, therefore, would seem to be one of the most critical factors of this control method.

However, factors such as migration and insecticide residual effectiveness are also of utmost importance. A material with a longer residual effect that is not lethal to the beneficial associated parasites and predators would help to control beetles migrating out of overwintering sites and other areas. A basic problem still remains in that cereal leaf beetles are active throughout the growing season and may be attracted to spring grains, particularly oats, from outside the intensive treatment area (Wilson and Ruppel, 1964).

Experiment II

Ground application of malathion, lindane and dieldrin was significantly more effective in controlling the beetle adult than was the aerial application, but no significant difference in methods was evident with Baygon. Samples taken May 26 in the malathion treated fields indicated that ground spray was more effective. This may have been due to the fact that the air sprayed malathion strips lay to the outside of the area in three fields and allowed reinfestation to occur more easily. Malathion strips, even though bordering on the outside of the ground treated fields, were protected on one side by lindane or dieldrin. This may have had an effect on the beetle's reinfestation.

Until some other adequate and reliable method of control for the cereal leaf beetle is developed, chemical suppression must be employed. This requires a material that kills cereal leaf beetle adults and larvae as well as other insect pests such as aphids, that are potentially dangerous to small grains. It must also be fairly non-toxic to other beneficial insects.

Of the four materials tested Baygon and lindane generally appeared more favorable in the aforementioned aspects than malathion. Dieldrin, although highly effective against the cereal leaf beetle, cannot be used in Michigan so it is eliminated from further consideration. Baygon shows a favorable potential by indicating significant cereal leaf beetle larval control. Baygon also produced lower mortality of coccinellid species, which are possibly significant egg and larval predators of the cereal leaf beetle. Malathion has too short a residual effect to be of value without reapplications to infested areas throughout the growing season. However, malathion is desirable if infested fields near dairy stock or harvestable produce must be treated.

These results suggest that ground applied insecticides are capable of greater reduction of numbers of cereal leaf beetle adults, but they also indicate that ground applications produce a higher mortality of associated and beneficial insects.

The results also suggest that by applying insecticides in a paired plot design (Figure 5) a method of testing experimental insecticides is made available. Even though the four materials were applied side by side the results closely approximated the material evaluations of experiment I and the work of Ruppel and Yun (1965), Ruppel and Wilson (1964) and others.

Experiment III

The results of this experiment further suggest that even though initial suppression in winter wheat (experiment I) was adequate for winter wheat, a large enough number of beetles survived or evaded the treatments or migrated into the area to infest the oats fields that had not been treated, but which lay within the treated area.

The experimental approach of experiment I definitely did not prevent the beetle from infesting the spring grains within the experimental area.

Experiment IV

Because the blanket area was sprayed only once with a material with a short residual effectiveness, cereal leaf beetle adults not yet out of overwintering and freshly laid eggs may have not been exposed to the insecticide at all. Aphids, with their high reproduction potential reinfested the area soon after the residue had worn off. On the other hand, the four treatments in the eradication area kept a more continual check on beetle and aphid populations. Likewise, in oats all other associated insects showed significantly lower mortality in the single spray area than in the four spray area.

Although results of this experiment indicate a substantial initial decrease in spring adult cereal leaf beetles, a significant reinfestation was evident in the single spray area. It must be stressed that timing is critically in this control technique.

The four spray treatments produced greater suppression of cereal leaf beetles than did the single treatment but by no means did eradication of the pest take place. Also, beneficial predators of the beetle were kept at a much lower population after four treatments than after just one.

SUMMARY AND CONCLUSION

In the spring of 1966, chemical control techniques, with respect to an integrated plan, suitable to reduce and maintain the cereal leaf beetle at a non-economic level were evaluated. Also four insecticides were tested to determine their relative effectiveness and to evaluate their potential for the possible use in an integrated control program.

At the time the cereal leaf beetle emerges from overwintering little food material is available other than winter wheat. Since the beetle feeds primarily on this, it was thought that by treating these winter wheat fields at a time or early spring infestation a reduction in the egg producing population would occur. In other words all wheat fields were selected in a given area and treated with four known cereal leaf beetle insecticides (Malathion, Baygon, lindane and dieldrin). This was done early in the spring after the emergence of overwintering adults, but before many eggs had been laid. By treating the fields when the majority of beetles were in the wheat, it was hoped to effectively reduce the egg laying population in spring grains.

However, a comparison with an unsprayed control area indicated only initial significant suppression with no adequate control over the entire growing season. It is possible that control could have been attained through proper timing of the insecticide application and by using a material with a longer residual effectiveness.

Four insecticides, malathion, Baygon, lindane and dieldrin were evaluated with respect to relative effectiveness on the cereal leaf beetle adult and larvae, Coleomegilla maculata (spotted lady beetle) and other coccinellid species which are known predators of cereal leaf beetle eggs and larvae. Miridae species (index species) and aphids were also evaluated as to insecticide effectiveness. Of the four materials tested Baygon represented a more appropriate choice for overall suppression because of its longer residual effect and selective kill. It showed high mortality of cereal leaf beetles and aphids and a high survival of coccinellids.

A second experiment was designed to compare the effectiveness of malathion, Baygon, lindane and dieldrin on the cereal leaf beetle and associated insects. In addition the experiment compares the effects of these materials when applied by air and by ground equipment.

Insecticide evaluation results paralleled those of experiment I. Generally, when the materials were applied by ground they gave somewhat better control of the cereal leaf beetle. The results also suggest that ground applications produce a higher mortality of associated and beneficial insects.

Because the evaluation results of this experiment closely approximated those of the first experiment and Ruppel and Yun (1965) it is felt that insecticides may be adequately field tested when applied side by side in a paired plot design.

In a third experiment, cereal leaf beetles in oats fields within the treatment area of experiment I were compared with oats fields in an unsprayed check area. The results indicate that no significant differences in beetle populations occurred between oats fields of the two areas. The experimental approach of the first experiment did not prevent the pest from infesting the spring grains within the treated area.

Another experiment was conducted to evaluate the effectiveness of a single spray treatment as compared to four spray treatment. An application of malathion was completed by aircraft just after spring adults had emerged from overwintering quarters, but before many eggs had been laid. Although initial populations were low the results indicated that suppression was occurring but that egg-laying was continuing and larval survival was high. Again a more suitable material and more accurate timing could have yielded greater suppression. The four spray treatments allowed a significantly higher suppression of the beetle but by no means did eradication take place. Beneficial predators of the cereal leaf beetle also were kept at a much lower level after the four treatments in the eradication area than after just one treatment in the blanket area.

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