The results of the simulated concentrated sprays help to explain the poor performance of the 1956 spring airblast treatments discussed earlier. A very narrow latitude for the timing of concentrated sprays also suggests an explanation for the erratic results experienced in the past with mistblower applications of DDT against the shoot moth.

With diluted sprays, spring scheduling can probably be done accurately enough by calendar date (Miller & Haynes 1958b). With concentrated sprays, calendar date can also be used as a means for setting a tentative spray date, but first external larval activity (first appearance of resinous tents) is most reliable for indicating actually when to start spraying.

The period available for applying diluted DDT sprays against the summer larvae (Miller & Neiswander 1955) is similar to that for spring larvae, but it may be a little shorter. Therefore, the same procedure for scheduling diluted sprays in the spring would seem to be adequate also in the summer, that is, by calendar date (Miller & Neiswander 1955). With concentrated sprays, calendar date might best serve as a guide in the summer as in the spring, with main dependence being placed on hatching (first appearance of resinous tents) for actually starting spray operations.

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Resistance to the Mexican Bean Beetle in Several Bean Genera and Species[1]

DAN WOLFENBARGER and J. P. SLEESMAN,[2,3]
Ohio Agricultural Experiment Station, Wooster

ABSTRACT

Nine *Phaseolus* species, the cowpea (*Vigna sinensis* (Torner) Savi), the broad bean (*Vicia faba* L.), the soybean (*Glycine max* (L.) Merrill), and the Bonavist bean (*Dolichos lablab* L.) varied in resistance to the Mexican bean beetle (*Epilachna varivestis* Muls.). *Phaseolus aureus* Roxb., *P. mungo* L., *P. calcaratus* Roxb., *P. radiatus* L., *P. atropurpureus* DC., *P. lathyroides* L., *P. polystachyus* L., *Glycine max*, *Vicia faba*, *Dolichos lablab*, and *Vigna sinensis* lines exhibited varying degrees of resistance to beetle-feeding damage under field conditions. All *Phaseolus vulgaris* L. lines, one *Phaseolus acutifolius* A. Gray line, and the progenies of interspecific *Phaseolus* crosses were susceptible. *Phaseolus lunatus* lines ranged from intermediate in resistance to susceptible.

Two methods, larval counts and a visual rating of leaf feeding damage, were compared in evaluating the various lines for resistance to the bean beetle. The visual rating method was found to be as satisfactory as larval counts.

Mean maturity dates were associated with resistance in *Phaseolus* spp., the fewer days to maturity the lower the leaf-feeding resistance exhibited.

The common bean (*Phaseolus vulgaris* L.) is frequently defoliated by the Mexican bean beetle (*Epilachna varivestis* Muls.). The purpose of this investigation was to identify resistance in *Phaseolus* and related genera and compare two methods of evaluation.

List (1921), Crawford (1924), and Eddy & McAllister (1927) stated that the Mexican bean beetle freely attacks the common and lima bean types. List (1921) reported that some differences in susceptibility did exist in varieties of the common bean varying from 20% to 95% in leaf feeding damage. He also stated that the best crops were produced by the early maturing varieties and in most cases these varieties showed the greater amount of injury. Thomas (1924) and Howard & English (1924) stated that *P. vulgaris* varieties are preferred by the Mexican bean beetle to the lima bean. Howard (1930) reported that the beetle has a decided preference for the pinto, navy, lima,

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[2] Research Assistant and Professor, respectively.

[3] Seed used in these investigations were supplied by R. E. Wester, U. S. Department of Agriculture, Crops Res. Div., Beltsville, Md.; A. B. Strand, Dandridge, Tennessee; L. W. Hudson, Regional Plant Introduction Sta., Pullman, Washington; A. P. Lorz, Dept. Vegetable Crops, Fla. Agric. Expt. Sta., Gainesville, Florida; D. D. Dolan, Plant Introduction Sta., N. Y. Agric. Expt. Sta., Geneva, New York; Asgrow Seed Co.; Rogers Bros. Seed Co.; Northrup, King & Co.; and Ferry-Morse Seed Co.

kidney and snap beans. Friend & Turner (1931) stated that the common, runner, and lima bean are the preferred hosts of the bean beetle. During 1955–57, Campbell (1958) reported that Triumph, Baby Fordhook, Wade, Evergreen, and Idaho Refugee were resistant and that they showed 24.8%, 25.2%, 28.9%, 29.5%, and 31.3% foliage injury, respectively.

List (1921) reported that the broad bean (*Vicia faba* L.) is free of attack by the bean beetle. Thomas (1924), Crawford (1924), Howard (1924), and Eddy & McAllister (1927) reported that rarely have soybeans (*Glycine max* (L.) Merrill) been seriously attacked, whereas Strand (1943) stated that soybeans were practically defoliated in Tennessee.

Friend & Turner (1931) stated that the soybean, cowpea (*Vigna sinensis* (Torner) Savi), and Bonavist bean (*D. lablab* L.), although damaged, were not preferred hosts. Howard (1924), Howard & English (1924), and Friend & Turner (1931) found that the mungo bean (*Phaseolus mungo* L.) and the mung bean (*Phaseolus aureus* Roxb.) were practically immune from injury and are rarely fed upon. Friend & Turner (1931) reported that the mung bean and broad bean are free of or immune to attack. Strand (1943) stated that the mungo bean is highly resistant to bean beetle feeding, whereas the Adzuki (*Phaseolus angularis* Willd.) and common bean are about equal in susceptibility. He reported also that certain lines of an interspecific cross between the susceptible Asgrow Stringless Greenpod (*P. vulgaris*) and the resistant mungo bean possess more resistance than others to bean beetle feeding.

MATERIALS AND METHODS.—At Marietta, Ohio, in 1958, 1959, and 1960, 20 to 40 seeds of various bean genera and species were planted in single 5-foot rows separated by a 3-foot space between the rows and between the plots in the row.

In 1958, larval counts and a nine-class leaf feeding damage rating were made, whereas during 1959–60 only the leaf feeding damage ratings were recorded. The visual ratings used for classifying the leaf surface area damaged were as follows:

Class 1 = no feeding;
Class 2 = 1 to 9%
Class 3 = 10 to 19%
Class 4 = 20 to 29%
Class 5 = 30 to 39%
Class 6 = 40 to 49%
Class 7 = 50 to 69%
Class 8 = 70 to 89%
Class 9 = 90 to 100%

In the relative leaf feeding rating scale, lines which rated 1 to 3 were considered resistant, lines which rated 4 to 6 were considered intermediate in resistance, and lines which rated 7 to 9 were considered highly susceptible.

Figure 1 shows characteristic damage in classes 1, 4, and 9, respectively, of the described visual leaf damage ratings.

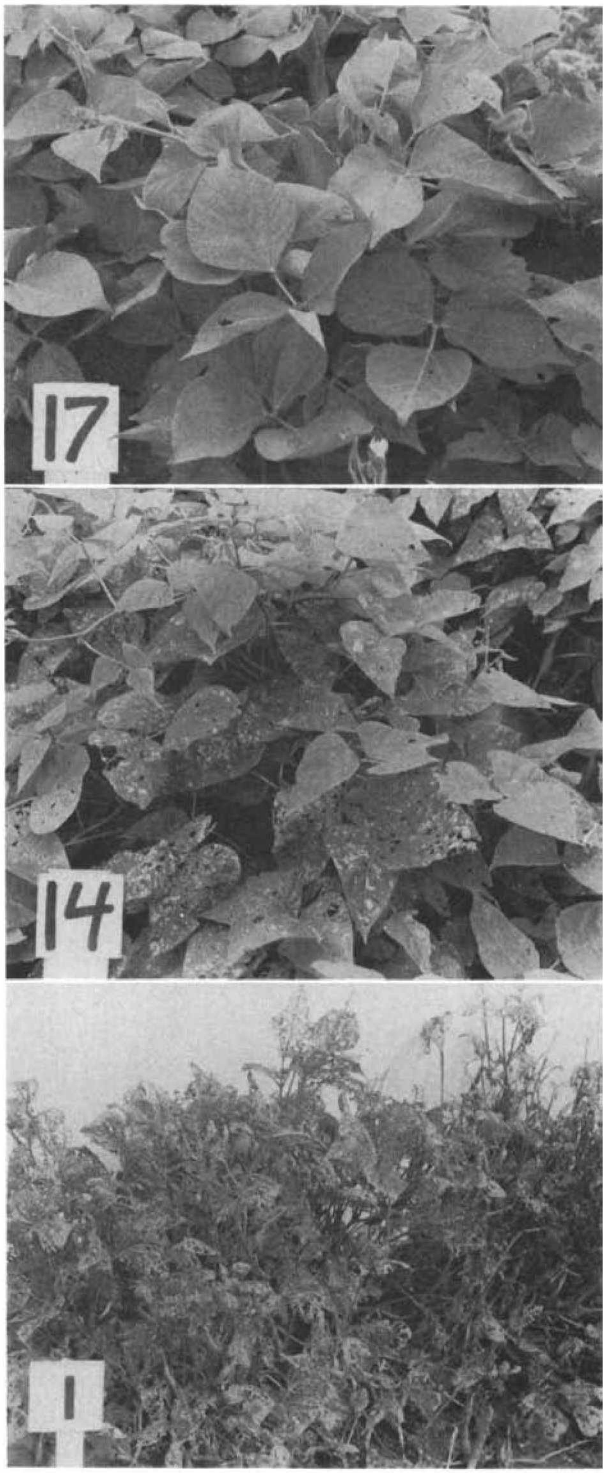

FIG. 1.— Classes of relative leaf feeding damage by the Mexican bean beetle (Top) Class 1 shows no injury (*P. calcaratus*); (Middle) Class 4 shows intermediate injury (*P. lunatus* PI 194314); (Bottom) Class 9 shows severe injury (*P. vulgaris* × *P. mungo* No. 12 throwback).

RESULTS AND DISCUSSION.—The data obtained from field evaluations show in table 1 that *Phaseolus aureus*, *P. mungo*, *Phaseolus calcaratus* Roxb., *Phaseolus radiatus* L., *Phaseolus atropurpureus* DC., *Phaseolus lathyroides* L. Selection 22, *Glycine max*, and *Vicia faba* were free of leaf feeding damage. *Dolichos lablab*, *Vigna sinensis*, and *Phaseolus polystachyus* L. exhibited a lower degree of resistance. *Phaseolus lunatus* L. lines ranged from intermediate in susceptibility to susceptible. *P. lunatus* PI 194314 was the most resistant. Wester (1959) reported that at Beltsville, Md., *P. lunatus* 4913 was the most resistant and that Piloy, Thaxter, and Fordhook Bush

Table 1.—Reaction of several genera and species of beans to the Mexican bean beetle. Marietta, Ohio. 1958–60.

		CLASS OF LEAF FEEDING DAMAGE[a]				
		Midseason Evaluation	Final Evaluation			
		1960	1958	1959	1960	Mean Final Evaluation
SPECIES	VARIETY, ACCESSION NO., OR STRAIN	July 20	August 4–5	July 21	August 12	
P. aureus	PI 164889	1.0		1.0	1.0	1.0
P. aureus	PI 207504	1.0		1.0	1.0	1.0
P. lathyroides	Selection 22		1.0			1.0
P. mungo	PI 101581	1.0	1.0	1.0	1.0	1.0
P. calcaratus		1.0		1.0	1.0	1.0
P. atropurpureus		1.0			1.0	1.0
P. radiatus	57703	1.0			1.0	1.0
P. radiatus	57704			1.0		1.0
V. faba	Broad Windsor	1.0			1.0	1.0
V. faba	Best of All Broad Bean	1.0			1.0	1.0
G. max	Chippewa	1.0		1.0	1.0	1.0
G. max	Blackhawk	1.0		1.0	1.0	1.0
G. max	Harosoy	1.0		1.0	1.0	1.0
V. sinensis	73-05110	1.0		1.0	1.0	1.0
V. sinensis	18-17-2110	1.0		1.0	1.0	1.0
V. sinensis	644210	1.0		1.0	2.0	1.5
V. sinensis		1.0	1.0	2.0	2.0	1.8
D. lablab	Bonavist Bean	1.0			2.0	2.0
P. polystachyus				3.0		3.0
P. lunatus	PI 194314	1.0		2.5	4.0	3.3
P. lunatus	PI 180462	3.0		3.5	5.0	4.3
P. lunatus	PI 183412	2.0		4.0	5.0	4.5
P. lunatus	Early Thorogreen	1.0		3.0	6.0	4.5
P. lunatus	Fordhook C2	1.0		3.0	6.0	4.5
P. lunatus	PI 195344	1.0		4.0	5.0	4.5
P. lunatus	PI 195339	1.0		3.0	7.0	5.0
P. lunatus	PI 195340	2.0		3.0	7.0	5.0
P. lunatus	PI 164891	1.0		4.0	6.0	5.0
P. lunatus	Burpee's Improved Bush	1.0		2.5	8.0	5.2
P. lunatus	PI 162668	1.0		3.5	7.0	5.3
P. lunatus	Fordhook 242	1.0		4.0	7.0	5.5
P. lunatus	PI 162689	1.0		4.0	7.0	5.5
P. lunatus	PI 180324	3.0	4.0		7.0	5.5
P. lunatus	Thorogreen	2.0		2.0	8.0	6.0
P. lunatus	PI 164893	3.0		4.0	8.0	6.0
P. vulgaris	PI 181786		5.5	7.0		6.3
P. vulgaris	PI 169903		6.0	7.0		6.5
P. lunatus	PI 209051	1.0		6.5	7.0	6.8
P. lunatus	Piloy	2.0			7.0	7.0
P. lunatus	4913	1.0			7.0	7.0
P. lunatus	Limagreen	2.0			7.0	7.0
P. vulgaris	PI 172025	2.0	6.0	7.0	8.0	7.0
Wade×*P. lathyroides*				7.0		7.0
P. vulgaris	PI 177514	2.0	6.5	8.0	8.0	7.5
P. vulgaris	PI 169794	3.0	6.5	8.0	9.0	7.8
P. vulgaris	U. S. Refugee #5	1.0	7.5	8.0		7.8
P. vulgaris	White Half Runner	4.0		7.0	9.0	8.0
P. vulgaris×*P. lathyroides*	Selection 22		7.5	8.5		8.0
P. lunatus	Wood's Prolific	7.0			8.0	8.0
P. lunatus	Thaxter	1.0			8.0	8.0
P. lunatus	Dixie Butterpea	3.0			8.0	8.0
P. vulgaris	Stringless Red Valentine	8.0	8.0	9.0		8.5
P. vulgaris	Bountiful Canner	1.0	8.0	9.0		8.5
P. vulgaris	White Seeded Refugee	1.0	9.0	8.0		8.5
P. vulgaris	Idaho Refugee	1.0	8.0	8.5	9.0	8.5
P. vulgaris	Wade	2.5	7.5	9.0	9.0	8.5
P. vulgaris	Sweetheart	5.0	8.0	9.0		8.5
P. vulgaris	Improved Supergreen	1.0	8.3	9.0		8.7
P. vulgaris	Topmost	1.0	8.6	9.0		8.8
P. vulgaris	Tennessee Greenpod	4.0	8.3	9.0		8.8
P. vulgaris	Plentiful	4.0	8.7	9.0		8.9
P. vulgaris	Dwarf Horticultural	3.0	9.0	9.0		9.0
P. vulgaris	Tenderlong-15	4.0	9.0	9.0	9.0	9.0

[a] Based on 1 least, 9 most.

Table 1.—(*Continued*)

		CLASS OF LEAF FEEDING DAMAGE[a]				
		Midseason Evaluation	Final Evaluation			
		1960	1958	1959	1960	
SPECIES	VARIETY, ACCESSION NO., OR STRAIN	July 20	August 4–5	July 21	August 12	Mean Final Evaluation
P. vulgaris	Sulfer	7.0			9.0	9.0
P. vulgaris	Blue Ribbon	4.0			9.0	9.0
P. vulgaris	Gardengreen	1.0	9.0	9.0		9.0
P. vulgaris	Genuine Cornfield	4.0			9.0	9.0
P. vulgaris	Italian or Romano	4.0			9.0	9.0
P. vulgaris	Morses Pole 191 (U. S. #4)	4.0			9.0	9.0
P. vulgaris	Selected Canadian Wonder	4.0			9.0	9.0
P. vulgaris	Asgrow Black Valentine	3.0	9.0	9.0		9.0
P. vulgaris	Ranger	5.0	9.0	9.0		9.0
P. vulgaris	Topcrop	2.0	9.0	9.0		9.0
P. vulgaris	Cooper Wax	2.0	9.0	9.0		9.0
P. lunatus	Small White Lima	2.0			9.0	9.0
P. lunatus	King of the Garden	3.0			9.0	9.0
P. lunatus	Clark's Bush	1.0			9.0	9.0
P. vulgaris×*P. mungo*	No. 12 throwback	3.0			9.0	9.0
P. vulgaris×*P. mungo*	No. 12 segregating	3.0			9.0	9.0
P. acutifolius	PI 200920	5.0		9.0	9.0	9.0

follow in an increasing order of susceptibility, whereas at Marietta these lines were all susceptible.

Progenies of crosses between resistant and susceptible *Phaseolus* (from A. B. Strand) species were susceptible. No resistant segregates were noted. Data in table 1 support the report by Strand (1943) that resistance appears to be a recessive characteristic.

Almost all *P. vulgaris* lines exhibited susceptibility to beetle feeding damage. Only two *P. vulgaris* Plant Introductions (PI 181786 and PI 169903) exhibited an intermediate degree of resistance in the final evaluation. Strand (1959) and Campbell (1958) stated that Wade was the most resistant of *P. vulgaris* varieties; however, the data presented in table 1 do not support this conclusion. Strand (1959) stated that Wade, with its dark green foliage, showed more resistance than varieties with light colored foliage such as Refugee, although Campbell (1958) reported that Idaho Refugee was almost as resistant as Wade. One *P. acutifolius* A. Gray line was highly susceptible.

Table 2.—Mean leaf-feeding damage to *Phaseolus* spp., interspecific *Phaseolus* crosses, *V. faba*, and *G. max* by the Mexican bean beetle in relation to maturity date and evaluation date. Marietta, Ohio. 1958–60.

SPECIES	NUMBER LINES MATURED	MEAN MATURITY DATE[a]	LEAF-FEEDING DAMAGE[b] 1960	MEAN LEAF-FEEDING DAMAGE[b]	NUMBER LINES EVALUATED
P. aureus	4	124	1.0	1.0	7
P. mungo	1	116	1.0	1.0	1
V. faba	2	100	1.0	1.0	2
P. radiatus	1	123	1.0	1.0	2
G. max	6	117	1.0	1.0	6
P. polystachyus	1	98	—	3.0	1
P. lunatus	14	110	1.9	5.5	29
P. vulgaris× *P. lathyroides*	1	104	—	8.0	1
P. vulgaris	63	94	2.9	8.5	63
P. vulgaris× *P. mungo* #12	2	97	3.0	9.0	2

[a] 90% pods dry as exhibited on each plot.
[b] Based on 1 least, 9 most; 27 days to midseason evaluation in 1960. Days to final evaluation: 76 in 1958; 62 in 1959; 80 in 1960.

In 1958, July 12 larval counts vs. the August 5 classes of visual ratings were compared by a simple correlation on 1456 susceptible *P. vulgaris* lines. The correlation coefficient ($r = +0.86$ at 1% level) indicated a close linear relationship between mean larvae and the leaf feeding rating. However, lines that exhibited a complete defoliation (August 5 visual rating) might have had no larvae present when the midseason or July 12 count was made. Of the lines in Class 9 (90% to 100% leaf surface area damaged per plot), 7.2% had zero larvae on July 12 and yet at the end of the season the plots were defoliated. Since leaf feeding damage ratings differentiate resistant from susceptible lines with less effort and time than counting larvae it is a better method to use.

Among *Phaseolus* species listed in table 2, a correlation coefficient ($r = -0.90$ at 1% level) was found between maturity and mean leaf feeding damage indicating that resistance is found in *Phaseolus* species which take longer to mature. In the midseason evaluation, *P. vulgaris* lines were fed upon approximately 100% more than *P. lunatus* lines. Final evaluation showed an 80% increase in leaf feeding which indicates that lima beans were more tolerant than the common bean.

The various species exhibited a 30-day differential (ranging from 94 to 124 days) in maturity. Data in table 2 show that final evaluations of plots in the 1958–60 seasons were made in 76, 62, and 80 days after planting, respectively. Many of the *P. vulgaris* lines had already matured (80 days after planting) whereas 62 days did not allow sufficient time for bean beetle feeding on *P.*

lunatus lines. The mean of 62 and 80 days, or 71 days, would be more nearly right for the final evaluation when attempting to compare *Phaseolus* spp. and related genera relative to bean beetle feeding injury.

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The Effects of Some Insecticides on the Metabolites of *Blattella germanica*[1]

HUBERT B. CLARK and ANDREW BUTZ,
Department of Biological Sciences, University of Cincinnati, Cincinnati 21, Ohio

ABSTRACT

A study was made of the effects of some insecticides on the metabolites of adult German cockroaches (*Blattella germanica* (L.)), by comparing the glucose, glycogen, fat, and water constituents of normal and exposed whole insects.

Pieces of filter paper were impregnated with 5% concentrations of DDT, dieldrin, methyl parathion, and Strobane® (terpene polychorinates (65% chlorine)) in peanut oil. Insects were exposed to the various insecticides by being caused to walk on the pieces of filter paper for 2-minute periods.

Insects exposed to DDT showed that 62% of glucose, 73% of glycogen, and 16% of fat were utilized in 3 days. Insects exposed to methyl parathion showed a 55%, 64%, 0% decrease in metabolites, respectively. Insects exposed to Strobane showed a 57%, 56%, 19% decrease in metabolites, whereas those exposed to dieldrin showed no change.

There is thus some evidence to support the hypothesis that a reduction in metabolites is associated with the killing action of some insecticides, but also, that not all insecticides have this effect. Evidently dieldrin kills by some mechanism different from that operative with the other insecticides tested.

The purpose of this investigation is to determine the changes that occur in the metabolite composition of the German cockroach (*Blattella germanica* (L.)) as a result of exposure to DDT, dieldrin, methyl parathion, and Strobane® (terpene polychorinates (65% chlorine)), and to compare the results with that of other investigators on starvation, where energy-furnishing metabolites are lost, and insecticidal contact in other insects.

MATERIAL AND METHODS.—Adult *Blattella germanica* were obtained from the departmental animal room by catching them in funnel cockroach traps containing karo syrup. The cockroaches were taken from the traps and placed in culture dishes where they were given an abundant supply of food and water. For each analyzed metabolite, 10 separate tests were made and an average was taken. Chemical analyses were made on normal German cockroaches and on those which had been exposed to 5% concentration of insecticides. The insecticides (obtained from Nutritional Biochemicals Corporation) were dissolved in refined peanut oil in such a manner as to give a 5% concentration of each insecticide. Dissolved samples of insecticides were placed on filter papers and rotated in a glass dish until the paper became thoroughly impregnated. Test insects were taken from the culture dishes and confined for 2 minutes on the treated filter paper which completely covered the test area. An inverted petri dish was used to keep the insects confined within the test area. After 2 minutes of exposure the insects were placed in separate labeled culture dishes containing ample supplies of food and water. Preliminary experiments indicated that the insects lived approximately 5 days after such exposure to each insecticide, therefore chemical analyses were made 3 days following exposure in order that they would be alive at the time of analysis.

Determination of reducing substances, expressed as glucose, were made on the entire insects, by Folin-Malmros (1929) analysis. Glycogen was precipitated by a modified Pflüger technique (Good et al. 1933). Determination of fat was made by ether extraction in a Soxhlet apparatus; this procedure gave values for free, or ether extractible, fat. Water content was determined by weighing before and after complete vacuum desiccation, and determining the difference.

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