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Varietal Resistance of Beans to the Mexican Bean Beetle[1, 2]

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ABSTRACT

Sixty varieties of 2 species of bush beans, *Phaseolus vulgaris* L. (snap beans) and *P. lunatus* L. (lima beans), were field tested for resistance to injury by the Mexican bean beetle, *Epilachna varivestis* Mulsant. Snap bean varieties least damaged were Idaho Refugee, Wade, Logan, Supergreen, Black Valentine, and Refugee U. S. no. 5. Lima bean varieties least damaged were Baby Fordhook Bush Lima, Triumph, Burpee's Bush Lima, Evergreen, and Henderson's Bush. Under controlled conditions in the laboratory, beetles laid fewer eggs on resistant than on susceptible varieties. The fecundity of beetles reared on resistant varieties was significantly less than of those reared on susceptible varieties. Bean variety had no effect on the rate of insect development. Females reared on resistant varieties in the field and laboratory were smaller and weighed less than females reared on susceptible varieties.

The Mexican bean beetle, *Epilachna varivestis* Mulsant, is an annual pest on beans in North Carolina, especially on beans belonging to the genus *Phaseolus*. Chapman and Gould (1928) observed that the beetle preferred bush varieties of snap, navy, and kidney beans, but cowpeas, black-eyed peas, and soybeans were also subject to injury. It is known to feed and oviposit on wild host plants (Elmore 1949) as well as on bush snap beans, pole beans, cowpeas, lima beans, crotalaria, alfalfa, peanuts, beggarweed, and kudzu, which are preferred in decreasing order (Sherman and Todd 1939).

Thomas (1924) and Knull (1930) reported the Mexican bean beetle preferred snap beans, *Phaseolus vulgaris* L., to lima beans, *P. lunatus* L.; whereas MacLeod (1934) found lima beans showed little or no injury and other beans were either susceptible or not preferred.

The present research was instigated to ascertain resistance among commercial bean varieties to the Mexican bean beetle, and the effect of plant variety on the development and fecundity of this insect.

METHODS.—All the 60 varieties of beans[4] included in this study were field tested in the mountains for 3 years at Hendersonville, N. C., and in the coastal plains for 2 years at Faison, N. C.

Fifty seeds of each variety were planted in single, 5-ft rows in a 4-replicate, randomized-block design. The percent foliage destroyed was determined by multiplying the number of leaves injured per 100 by the average foliage area consumed. Foliage area consumed was determined by visual estimates.

Following the 2nd year of field tests, 9 varieties of snap beans and 9 varieties of lima beans were selected for laboratory studies. These selections included 3 varieties with low percent foliage damage (resistant R), 3 varieties with intermediate foliage damage (intermediate I), and 3 varieties with high percent foliage damage (susceptible S).

All laboratory studies were conducted in an insect-rearing room with a controlled temperature of 78°F, 65% RH, and fluorescent lights operating from 7:00 AM until 10:00 PM daily. One plant of each of the 18 varieties was placed in a screen cage with 36 pairs of adult beetles. Six cages were prepared in this manner.

Each variety of beans was also caged separately with 12 pairs of beetles to determine varietal influence on the rate of insect development. Four such cages were prepared for each variety. Leaves containing egg masses were removed daily and placed in salve boxes for incubation. Newly hatched larvae were placed back on the same variety upon which the eggs had been laid. The stadium was recorded for each instar when more than 50% of the larvae had shed their exuviae. Development was recorded from egg to adult.

Upon reaching maturity, 12 pairs of beetles were confined in cylindrical screen cages on the same variety upon which they had fed as larvae. Eggs deposited on the leaves were counted every 3 days when a fresh bean plant was placed in each cage. The experiment was continued for approximately 5 weeks; then egg laying dropped sharply and beetles began to die.

The effect of plant variety on the weight of female beetles was also measured. Pupae were collected from insect-resistant and insect-susceptible bean varieties in the field and in the laboratory. They were placed in quart ice cream cartons until adults emerged. Field-reared beetles were killed with carbon tetrachloride and weighed on an analytical balance. An average of 11.5 ♀ were weighed from each variety. Laboratory-reared beetles were weighed alive in plastic vials on the day of emergence and prior to feeding. An average of 8.1 ♀ were weighed from each variety.

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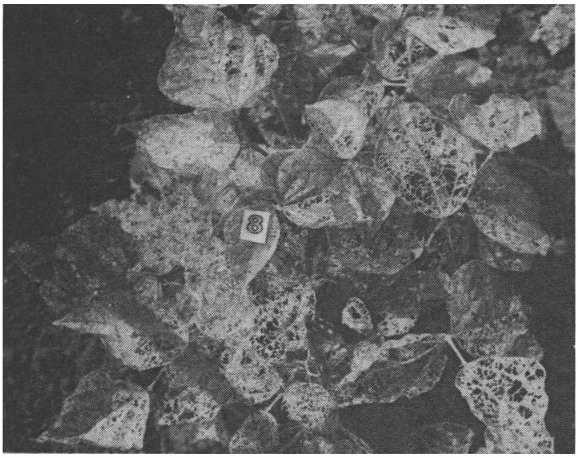
[4] Seeds were supplied by the following companies: Associated Seed Growers, Atlanta, Ga.; W. Atlee Burpee Company, Philadelphia, Penn.; Corneli Seed Company, St. Louis, Mo.; F. W. Woodruff and Sons, Atlanta, Ga.



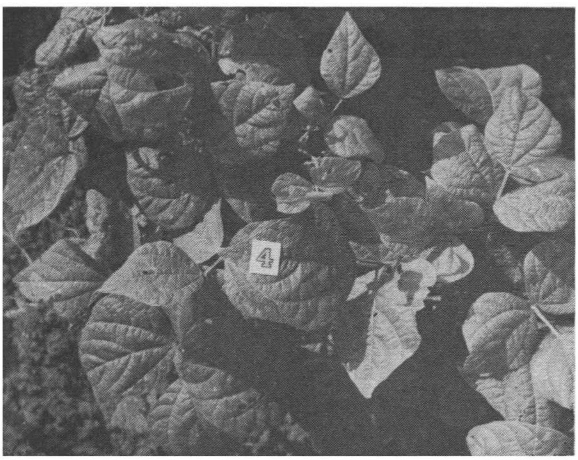


FIG. 1 (top).—Snap bean variety Bountiful, susceptible to Mexican bean beetle. Photographed July 22, Hendersonville, N. C.

FIG. 2 (bottom).—Snap bean variety Wade, resistant to Mexican bean beetle. Photographed July 22, Hendersonville, N. C., growing in a plot adjacent to plants shown in Fig. 1.

RESULTS AND DISCUSSION.—Snap bean varieties least damaged by Mexican bean beetles in the field ranged from an average of 25% leaf damage for Idaho Refugee to 37% for Black Valentine. Other varieties within this range were Wade (Fig. 1), Logan, Supergreen, and Refugee U. S. no. 5. These, in comparison with other snap bean varieties included in this study, were considered resistant to the Mexican bean beetle. Their accumulated leaf damage averaged 31%, and at the 5% level by Duncan's multiple range test they were significantly less damaged than those snap bean varieties designated as susceptible.

In the susceptible category were included Unrivalled Wax, Burpee's Stringless Green Pod, Pencil Pod Black Wax, King Green, Topcrop, Bountiful (Fig. 2), Dwarf Horticultural, and State. The accumulated leaf damage for these varieties was 53%.

An intermediate category between the resistant and susceptible snap beans included Burpee's Tender Pod, Dixie Belle, Full Measure, Antwerp, Puregold Wax, Seminole, Davis Stringless Wax, Improved Tendergreen, Contender, Longreen, Florida Belle, Cherokee Wax, Plentiful, Improved Commodore, Woodruff's Hyscore, White Seeded Tendergreen, Tendergreen, Rustproof Golden Wax, Giant Stringless, Stringless Hort, Tenderlong 15, Stringless Red Valentine, and Keystonian. These varieties had an accumulated leaf damage of 45%.

Lima bean varieties least damaged by the Mexican bean beetle ranged from an average 20% for Baby Fordhook Bush Lima to 35% for Henderson's Bush. Other varieties within this range were Triumph, Burpee's Bush Lima, and Evergreen. Accumulated leaf damage for this category averaged 26%. These varieties were classed as resistant to the Mexican bean beetle and were significantly less damaged than those classed as susceptible.

In the susceptible category were included Burpee's Improved Bush, Woods Prolific, Woodruff's Prolific, and Clarks Bush. Accumulated leaf damage for these varieties averaged 46%.

An intermediate category between the resistant and susceptible lima beans included Fordhook 242, Burpee's Fordhook, Speckled Butterpeas, Dixie White Butterpeas, Allgreen, Cangreen, Jackson Wonder, and Thorogreen. The accumulated leaf damage for this group averaged 39%.

Table 1.—Mexican bean beetle feeding and oviposition preference under caged conditions on varieties of beans classified in categories as resistant (R), intermediate (I), or susceptible (S).

		% foliage destroyed (avg)		No. egg masses (avg)	
Variety	Category	Variety	Category	Variety	Category
	Snap beans[a]				
Idaho Refugee	R	25.2		1.33	
Wade	R	34.3		0.50	
Logan	R	34.0	31.2	2.00	1.28
Seminole	I	52.7		3.00	
Florida Belle	I	40.3		.67	
Tendergreen	I	42.5	45.2	2.00	1.89
State	S	67.5		2.83	
Dwarf Horticultural	S	57.2		2.83	
Bountiful	S	61.7	62.1	2.00	2.55
LSD at 5% level (within category)		27.6		2.54	
LSD at 5% level (category)			15.9		1.46
	Lima beans[a]				
Triumph	R	24.8		1.50	
Evergreen	R	25.7		0.67	
Henderson	R	24.7	25.1	1.50	1.22
Allgreen	I	26.3		1.00	
Thorogreen	I	27.2		1.50	
Wood's Prolific	I	32.3	28.6	1.83	1.44
Burpee's Improved	S	61.3		2.17	
Clarks	S	43.3		3.00	
Woodruff's Prolific	S	39.7	48.1	1.50	2.22
LSD at 5% level (within category)		23.5		2.84	
LSD at 5% level (category)			13.5		1.63

[a] Correlation between foliage injury and egg laying for snap beans (+ 0.681) and for lima beans (+ 0.700).

Table 2.—Fecundity of the Mexican bean beetle when reared on resistant (R), intermediate (I), and susceptible (S) varieties of beans.

		Avg no.[a]		Category Avg	
Variety	Category	Egg masses	Eggs	Egg masses	Eggs
	Snap beans				
Idaho Refugee	R	45.8	1690.5		
Wade	R	51.8	2041.0		
Logan	R	56.5	2173.3	51.4	1968.3
Seminole	I	68.5	2882.8		
Florida Belle	I	69.5	3814.0		
Tendergreen	I	74.3	3104.3	70.8	2933.7
State	S	106.8	4959.5		
Bountiful	S	106.3	4936.8		
Dwarf Horticultural	S	105.5	4713.8	106.2	4636.7
LSD at 5% level (within category)			1651.2		
LSD at 5% level (category)					950.3
LSD at 1% level (category)					2192.3
	Lima beans				
Evergreen	R	51.3	2022.8		
Henderson	R	61.8	2485.0		
Triumph	R	70.0	3100.0	61.0	2535.9
Allgreen	I	74.3	3029.0		
Thorogreen	I	87.3	3771.5		
Wood's Prolific	I	99.0	4325.8	86.9	3708.8
Clarks	S	113.3	5067.8		
Woodruff's Prolific	S	108.3	4843.8		
Burpee's Improved	S	120.3	5335.5	114.0	5082.4
LSD at 5% level (within category)			1388.9		
LSD at 5% level (category)					804.1
LSD at 1% level (category)					1855.0

[a] 12 pairs of beetles used for each variety.

Lima beans generally showed less damage than snap beans, but at Faison approximately ½ of the lima varieties showed more damage than the most resistant snap bean. Lima bean varieties grown at Hendersonville showed about 50% less damage than the snap bean varieties, but such a difference was not evident at Faison. The relative resistance of these varieties may vary in other locations (Wolfenbarger and Sleesman 1961).

Field ratings of varieties for resistance to the Mexican bean beetle were confirmed by damage evaluations in the laboratory. The 3 snap bean varieties selected as resistant (Idaho Refugee, Wade, and Logan) showed approximately 31% less injury than varieties of the susceptible category (State, Dwarf Horticultural, and Bountiful). This difference was significant at the 5% level (Table 1); however, differences between extremes in damage were less than in the field. Differences in the number of egg masses deposited on the 3 categories of beans were not significant, although twice as many egg masses were collected from the susceptible category as from the resistant category.

Lima beans exhibited less insect injury than snap beans. The difference in damage between the resistant and susceptible category was significant; the within-category difference was not significant. Although more egg masses were deposited on the susceptible and intermediate categories, these differences were not significant from the resistant category. Egg laying was positively correlated with foliage injury for snap beans and lima beans with a coefficient of 0.681 and 0.700, respectively (Table 1).

Incubation period for eggs on all varieties ranged from 5.0 to 5.3 days. The developmental period for instars on all varieties ranged as follows: instar 1, 3.0–4.2 days; instar 2, 3.0–3.5 days; instar 3, 3.2–3.8 days; and instar 4, 3.8–4.5 days. The prepupal period ranged from 1.3 to 2.0 days and the pupal period ranged from 4.7 to 6.0 days. The average period from egg to adult on all varieties ranged from 25.5 to 27.5 days. Neither the bean species nor varieties within the species had any effect on the rate of beetle development.

Bean variety had a marked effect on fecundity of the bean beetle when ovipositional records were obtained from the same variety upon which the beetle was reared. The number of eggs deposited on resistant snap beans averaged 1968 as compared with 4637 on susceptible varieties (Table 2). Similar differences were obtained for lima bean varieties. Differences between the resistant (R) and susceptible (S) categories were significant at the 5% level for both bean species.

Beetles reared in the field weighed approximately ⅓ less than beetles reared in the laboratory. More significant was the effect of bean variety on the weight of females (Table 3). Female beetles reared in the field on resistant varieties (Wade, Idaho Refugee, and Logan) weighed 12.6 mg less than fe-

Table 3.—Influence of resistant (R) and susceptible (S) bean varieties on the weight of adult female Mexican bean beetles.

		Avg weight of beetles in grams			
		Field-reared[a]		Lab.-reared[b]	
Variety	Category	Variety	Category[c]	Variety	Category[c]
		Snap beans			
Bountiful	S	0.0223		0.0384	
Dwarf Horticultural	S	.0274		.0442	
State	S	.0282	0.0259	.0346	0.0391
Wade	R	.0088		.0258	
Idaho Refugee	R	.0114		.0252	
Logan	R	.0197	.0133	.0278	.0263
		Lima beans			
Woodruff's Prolific	S	0.0209		0.0364	
Clark's Bush	S	.0231		.0362	
Burpee's Improved	S	.0235	0.0225	.0391	0.0372
Henderson	R	.0164		.0269	
Triumph	R	.0165		.0266	
Evergreen	R	.0185	.0171	.0261	.0265

[a] An avg of 11.5 ♀ were weighed for each variety with a range of 8–15.
[b] An avg of 8.1 ♀ were weighed for each variety with a range of 5–12.
[c] Difference significant at 5% level (snap beans) and 1% level (lima beans) by "F" test.

males reared on susceptible varieties (Bountiful, Dwarf Horticultural, and State); similarly, females reared in the laboratory on the same resistant varieties weighed 12.8 mg less than those reared on susceptible beans. Smaller, but significant differences were found also in the weight of female beetles reared on resistant and on susceptible categories of lima beans. This fact obtained for both field- and laboratory-reared beetles. The small size and weight of females reared on resistant bean varieties indicate antibiotic (Painter 1951) factors in the relationship of plant to insect.

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Quantitation of Effect of Several Stimuli on Landing and Probing by *Aedes aegypti*[1]

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ABSTRACT

The effect of several stimuli on the attraction, landing, and probing by *Aedes aegypti* (L.) was studied in a specially constructed tower. The stimuli studied were heat (34°C), water-vapor, carbon dioxide, and combinations of these. The human palm was studied as a natural source of attractive stimuli. The number of mosquitoes found to 1 foot above the source of stimulus in a 10-minute period was quantitated. This estimate of attraction was broken down for counting into 3 parameters: the number of mosquitoes (1) flying, (2) landing on the bottom, and (3) probing toward the stimulus. Heat activated the mosquitoes but did not induce landing. Addition of moisture to heat increased landings and induced some probing. CO_2 activated the mosquitoes and in the presence of heat and moisture elicited a few more landings. Moisture and CO_2 per se or in combination did not elicit a landing or a probing response from *A. aegypti*. The maximal attraction as well as landing and probing was obtained with the palm. It is concluded that the maximal attraction and the high incidence of landing and probing by *A. aegypti* over the palm is due to some "component" of skin emanation other that heat, moisture, or CO_2.

Previously (Khan, et al. 1966) the effect of several stimuli on the approach of *Aedes aegypti* (L.) females was quantitated in a specially constructed tower using 5 heights. The stimuli included heat (34°C), moisture, CO_2, their combinations, and the palm of the human hand as a natural source of attractive stimuli. In this study we quantitated the effect of these stimuli on the landing and probing by *A. aegypti*.

MATERIALS AND METHODS.—Experiments were conducted in a tower 44 in. high. It had a top section 1×1×1 ft and a similar section in the bottom (Sec. C). The 2 were connected in the middle with a 20-in.-high polyethylene tube 1 ft² in cross section. The construction of the tower has been described in detail elsewhere (Khan et al. 1966). It was modified for this study as follows: There was no partition separating the middle section from the top. An opening 8×8 in. was cut in the sliding partition that separated the bottom section from the rest of the tower. This opening was covered with a 20-mesh net. The stimulus was placed under a 4×5 in. opening in the floor of the bottom section. This was also covered with 20-mesh net.

Stimuli.—Heat.—A 2-liter Erlenmeyer flask filled with warm water was stoppered and inverted. A Whatman filter paper (15 cm) was fastened on the bottom with Scotch tape and the temperature was recorded on top of the filter paper. The water temperature was varied until a temperature of 34 ± 0.5°C was obtained. This temperature simulated the temperature of the palm.

Moisture.—Water vapor was introduced in the tower by placing 5 ml of distilled water on top of the filter paper on the flask. This quantity was sufficient to keep the paper from drying during 1 10-min experiment.

Carbon Dioxide.—A 30-ml hypodermic syringe was filled with CO_2 from a gas cylinder and the gas was introduced into the tower by puncturing the side of the bottom section near the center.

Palm.—The human palm substituted for the flask, was used as a natural source of attractive stimuli.

Twenty female *A. aegypti*, 8–11 days old and previously fed on 5% sugar solution only, were introduced in the bottom section (Sect. C of tower) with the partition in place. The mosquitoes were introduced by shaking the aspirator tube gently instead of by blowing, to avoid activating them by the breath. The mosquitoes were allowed to settle for 10 min. They alighted on the net covering the opening in the partition. This procedure fixed the distance of the mosquitoes from the source of the stimulus at 1 ft.

[1] Accepted for publication April 19, 1966.

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