RESISTANCE OF SELECTED VARIETIES OF CUCURBITS TO THE SPOTTED CUCUMBER BEETLE, *DIABROTICA UNDECIMPUNCTATA HOWARDI* BARBER, AND THE STRIPED CUCUMBER BEETLE, *ACALYMMA VITTATA* (FABRICIUS)

by

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INTRODUCTION

Some one hundred years have passed since man first became acquainted with cucumber beetles and has recognized them as important economic pests. Insects, man's competitors in every field, have led him to progress in a search for various methods in controlling such pests. Destruction and damage done by cucumber beetles needs to be balanced by our continuing effort to find effective means of control either by developing chemicals, natural enemies or by host plant resistance to surpress further economic losses.

The Cucurbitaceae, which includes muskmelon, cucumber, squash, pumpkin and watermelon is of an increasing economic importance, especially in their value to man as food. Their production, however, is often limited because of severe injury caused by cucumber beetles either directly or indirectly. The great losses in cucurbit crops caused by actual feeding injury of the cucumber beetles and by disease transmission justify thorough consideration of the control for these pests.

Control of cucumber beetles is not easily obtained since they avoid poisoned plants (Compton, 1932). The use of resistant varieties of cucurbits as a method of control can prove to be more economically successful for the home garden and especially for large scale production. Screening of some *Cucurbita* varieties for resistance to the cucumber beetles in Manhattan, Kansas, was started by Hall and Painter (1956). In the field they observed some varieties to be resistant (non-preferred), some moderately resistant, and others susceptible (preferred). The mechanisms involved in the observed resistance are still unknown.

The spotted and striped cucumber beetles are probably the most common and destructive pests attacking cucurbits in Kansas. Not only do they destroy seedlings, but they also do extensive damage to the roots, blossoms and fruits. In addition to their destruction of the plants, the beetles spread the organisms which cause bacterial wilt and anthracnose.

The development of resistant varieties of crop plants that are equal in yielding ability and quality to those now in use would be the most desirable and economical control measure. Vegetable crops probably offer the greatest opportunity today for original work in the field of breeding for insect resistance.

This study was designed to determine the level of resistance (preference and tolerance) of selected varieties of cucurbits to the spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber and the striped cucumber beetle, *Acalymma vittata* (Fab.).

REVIEW OF LITERATURE

History and Economic Importance

Cucumber beetles are found in the United States only east of the Rocky Mountains and in eastern Canada. They are native American insects and have been known for many years. There are numerous published notes on their biology, life history, control and economic importance.

Dr. Asa Fitch, State Entomologist of New York, in 1864, stated that the striped cucumber beetle was the most injurious pest of cucumbers (Gould, 1944). Haseman (1937) in Missouri, reported that the most destructive work was done by the striped cucumber beetle soon after it comes out of hibernation and that the spotted cucumber beetle was a more ravenous feeder and when abundant quickly killed young plants.

Harris and Matsumori (1956) reported the striped and spotted cucumber beetles were destructive to cucurbits, especially in the seedling stage of growth. Gould (1943) stated that during the past twelve seasons the striped cucumber beetle had been a pest not only in feeding but as a spreader of bacterial wilt. Rand (1915) reported that the transmission of bacterial wilt by the striped cucumber beetle was not purely accidental, but that it appeared to be an adaptation in which the beetle preferred the diseased plant rather than the healthy plant. In Wisconsin, Dudly et al. (1923) reported that the striped cucumber beetle was a constant crop hazard to cucurbits, not only in their feeding but as a vector of the wilt and mosaic diseases.

According to Isely (1927) the striped cucumber beetle is a voracious feeder and its obvious and most important damage is to cucurbit plants in the seedling stage. Within a few hours after the plants' first two seed leaves appear above the ground, the plants may be killed outright by feeding of the striped cucumber beetles (Compton, 1932). The striped cucumber beetles, according to Houser and Balduf (1925), often destroy newly emerged plants and require two or three plantings. Peairs and Davidson (1956) stated that the striped cucumber beetle was very destructive to cucurbit seedlings and would eat off the stems and cotyledonous leaves as soon as they pushed through the soil. Metcalf et al. (1951) noted that the striped cucumber beetle feeds on cucurbits from the moment the plants appear above the ground.

Britton (1908) reported that in Connecticut the cucumber beetle would feed upon the newly emerged leaves and tender stems, eating away the epidermis, often causing the plants to wilt and die. Hall and Painter (1960) noted that cucumber beetles, in the past four seasons, were numerous at the Ashland Horticultural Farm and damage was severe as a result of the feeding. They noted that the most severe damage occurred on the underside of the cotyledonous leaves which hindered control attempts with insecticides, but stem, blossom, and fruit damage also proved to be of economic importance.

Cucumber Beetles and Resistance

Only recently has man purposely taken into account the food preference of insects and tried to raise non-preferred crops. Bailey (1941) stated that with each individual crop-insect association, different factors or combination of factors appeared to be involved. The type of insect mouthparts, oviposition response, toxic or distasteful substances in the plant fluid, rapidity of growth of the plant and recovery from injury, as well as type of growth, thickness of epidermis, etc. all limit insect activity on its host. Some evidence exists that insects distinguish food plants through sense of taste. An example is some grasshoppers, where the sense of taste has been demonstrated to be in the tarsi as well as about the mouthparts (Painter, 1943). According to Snelling (1941) certain varieties of crop plants are known to be unattractive to the insects, while the resistance of other varieties depends upon the absence of certain substances or conditions attractive to the insects that attack them. Thorsteinson (1960) stated that food-plant selection of some phytophagous insects consists essentially of a series of take-it-or-leave-it patterns in which the insect has the opportunity to accept or reject the host-plant. Painter (1958) stated that if a plant does not possess a specific attractant, the reaction of the insect may be as if the plant were not there. It was also mentioned that the insect may find the plant by chance. Thorsteinson (1960) noted that if an insect had no selection, or if of the immobile type, it would either feed or die of starvation.

Lees (1926) stated that insects attacking plants have a direct influence on the true internal condition of the plant. Munford (1931) reported that resistance of plants to insect pests might be due to external protective agencies. Painter (1951) stated that hardness of plant tissue often has been cited as a cause of resistance in plants. It was also noted by Painter (1943) that differences in hardness of tissue between varieties of one plant species are large enough to affect the degree of feeding. Painter (1951) further stated that preference of varieties might be due to a combination of surface attraction and hardness of tissue.

The start of host-plant resistance, as stated by Flint and Bigger (1938), consisted mainly of field observations and the testing of varieties and strains that had been developed through natural selection in areas where certain species of insects were usually abundant. Resistance, as stated by Snelling (1941), includes those characteristics which enable a plant to avoid, tolerate or recover from the attacks of insects under conditions that would cause greater injury to other plants of the same species.

Gould (1959) compared susceptibility of cucurbit species to the striped cucumber beetle. He found that cucumber and muskmelon were more affected than watermelon but not as much as the squash varieties belonging to *Cucurbita maxima*.

Nath (1960) reported that certain varieties of cucumbers as a group were more resistant to the striped cucumber beetle than those of muskmelon and watermelon. He also stated that certain varieties of muskmelon were more resistant to the spotted cucumber beetle than the cucumber and watermelon varieties as a group.

MATERIALS AND METHODS

Three different types of experiments were conducted at Ashland Horticultural Farm and in the Horticultural Greenhouse during the 1960 growing season.

Host Plants

Selected varieties of muskmelon, Cucumis melo L.; cucumber, Cucumis sativus L.; squash, Cucurbita pepo L.; and watermelon, Citrullus vulgaris Schrad. were used in this study. All varieties had been screened in the field at the Kansas State University Horticultural Farm and were selected for this study because they appeared to be resistant or susceptible. Varieties are listed in decreasing order of resistance to the combined two species of insect in the field, and the previous mean rating (0-3) given by which each was selected.

Variety	Seed Source
Muskmelon	
Hearts of Gold (0)	D. V. Burrell Seed Growers Co.
Powdery Mildew Resistant 4-50 (0)	D. V. Burrell Seed Growers Co.
Cranshaw (2-3)	Lawrence Robinson & Sons Seed Co.
Smith Perfect (3)	D. V. Burrell Seed Growers Co.

Variety	Seed Source
Cucumber	
Niagara (0)	Ferry-Morse Seed Co.
Fletcher (0)	Lawrence Robinson & Sons Seed Co.
Ohio MR-17 (0)	Associated Seed Growers Inc.
Stono (1)	Lawrence Robinson & Sons Seed Co.
Squash	
Early Golden Bush Scallop (0)	Lawrence Robinson & Sons Seed Co.
Royal Acorn (0)	Ferry-Morse Seed Co.
Caserta (3)	Associated Seed Growers Inc.
Black Zucchini (2)	Associated Seed Growers Inc.
Watermelon	
Blacklee (0.25)	Willhite Melon Seed Farm
Peacock (0.30)	Willhite Melon Seed Farm
Yellow Belly Black Diamond (1.3)	Willhite Melon Seed Farm
Blackstone (2.1)	D. V. Burrell Seed Growers Co.

Insects

The striped cucumber beetle, *A. vittata* (F.) and the spotted cucumber beetle, *D. undecimpunctata howardi* Barber were the species used. Both insects belong to the order Coleoptera and to the leaf-feeding family Chrysomelidae.

Striped cucumber beetles were first collected on May 2, 1960 in a field of alfalfa three miles south of Manhattan, Kansas near a row of willow trees which were in bloom. Gould (1944) stated that the striped cucumber beetles sometimes feed on willows as an alternate host.

Striped cucumber beetles were again collected on May 13, 1960 at the John Britt farm three miles southwest of Manhattan. These beetles were collected from cucurbit seedlings in hotbeds. At this date the spotted cucumber beetles were not in sufficient numbers to be collected for the study. Both species of insects used in all experiments were collected at the Ashland Horticultural Farm.

Preference Experiments

In all tests, it was desired to have uniform size, age and condition of plants. However, when using several species of cucurbits, uniformity in size and age was not always attainable because varieties of some species were small compared with others because of unequal lengths of time required for seed germination. Therefore, in these experiments, differences in size, age, and condition could only be kept to a minimum.

Field Experiments. A plot 15' x 45' located at the Ashland Horticultural Farm was used in both field experiments (Plate I, Fig. 1). A randomized block design was used. All varieties were hand seeded and planted in three foot rows spaced three feet apart, with three replications each. An adequate number of seeds were planted on June 15 for a rating of 20 seedlings on June 27 and July 1, 1960.

The second experiment was a duplicate of the first. The seeds were planted July 9 and ratings were made on July 20 and July 24, 1960. The first rating was made when seedlings were in the cotyledonous leaf stage.

EXPLANATION OF PLATE I

Fig. 1. Field plot 15' x 45' which included three replications of each variety in three foot rows spaced three feet apart.

Fig. 2. Mesh screen wire cages, 8" high and 3" in diameter, used to confine one randomly selected beetle with two seedlings of the same variety.

PLATE I

Fig. 1

Fig. 2

The striped cucumber beetle was the most abundant in the first field experiment and the spotted cucumber beetle became increasingly abundant as the season progressed to the second experiment.

Greenhouse Experiments. Seeds were planted in four flats in a randomized manner with two replications for each species of insect. Each flat contained four varieties of cucurbits but because of poor seed germination of some, the total number of varieties was reduced from 16 to 14. Seeds were planted in rows which ran across the flats and at a rate to permit a final stand of ten seedlings per variety for each replication.

Cages were assigned at random for both spotted and striped cucumber beetles. Seeds were planted on July 3, 1960. Both species of insects were collected and evenly distributed in their respective cages. On July 10, 140 insects of each species were collected and seventy insects were placed in each of the four cages for each 140 seedlings. Ratings on the seedlings were made at the end of the second day on July 12, and at the end of the fifth day on July 15, 1960.

Experiment two was a duplicate of experiment one but a re-randomized design was used. Seeds were planted on July 14, and again the cucumber beetles were collected and placed in their respective cages on July 20, in the same manner as in experiment one. Ratings were made on July 22, and July 25, 1960.

Further experiments were not conducted after August 3, because of insufficient numbers of striped cucumber beetles. The spotted cucumber beetles could be collected in great numbers at this date.

Tolerance Experiment

Individual cages were designed and constructed from mesh screen wire eight inches high and three inches in diameter, covered with cheesecloth (Plate I, Fig. 2). These cages were designed to cover two plants and house one beetle. The experiment was designed to pair the beetles in a random manner. A total of 240 individual cages were used. Five seeds of each variety were planted in hills with two hills per row and eight rows per flat, with a total of eight replications of each variety. Seeds were planted on June 28, and upon seedling emergence thinned to two plants per cage. Individual beetles were placed in their respective cages on July 4, 1960. Beetles were inspected daily and those that died were replaced. Ratings were made on July 6, and July 9, 1960, in the same manner as previous experiments.

Technique of Evaluation

In designing the study, a technique of evaluating cotyledonous leaf injury was adopted which was designed and first used by Hall (1956) to determine levels of resistance in cucurbit seedlings.

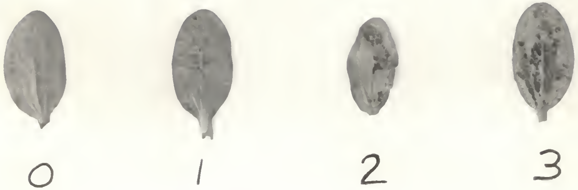
Rating the injury of cotyledonous leaves by each beetle species in the greenhouse and the combined two species in the field was done in the manner described below and illustrated in Plate II.

Degree of Cotyledonous Leaf Injury	Rating
No injury	0
Slight injury	1
Moderate injury	2
Severe injury	3

EXPLANATION OF PLATE II

Rating system of damage made by the spotted and striped cucumber beetle.

PLATE II



Stem injury ratings were assigned to the seedlings as none, slight, moderate, and severe injury.

After the beetles were placed in the greenhouse cages for the preference experiments, it was observed they moved to the most susceptible plants to feed. At the end of the fifth day of feeding, the final readings were taken and a mean seedling injury was calculated for each of the two beetle species and for each variety of cucurbit species.

Injury ratings of varieties above 2.00 are regarded as most susceptible (preferred) and those below 1.00 as resistant (non-preferred) and those in between 2.00-1.00 as moderately resistant.

EXPERIMENTAL RESULTS

Preference Experiments

Table 1 includes a summary of the two field experiments. Results from the greenhouse experiments where both insect species were separated are presented in Table 2.

Field Experiment One. The level of preference was based only on cotyledonous leaf injury in contrast to the greenhouse experiments where both stem and leaf injury were measured.

Muskmelon. Plants of the variety Cranshaw (2.28) were significantly preferred over those of Smith Perfect (1.84); both Cranshaw and Smith Perfect were preferred over PMR 4-50 (0.26) and Hearts of Gold (0.24) by field populations of a mixture of both cucumber beetle species. Cranshaw was most preferred; Smith Perfect, moderately preferred; and both PMR 4-50 and Hearts of Gold were relatively non-preferred.

Table 1. Mean degree of injury of selected varieties of cucurbits to the spotted and striped cucumber beetles, field experiments, Ashland Horticultural Farm, 1960.

Variety	Preference Experiments	
	One	Two
	Muskmelon	
Cranshaw	2.28	2.58
Smith Perfect	1.84	2.60
PMR 4-50	0.26	0.54
Hearts of Gold	0.24	0.38
L.S.D. .05 level	0.36	0.32
	Cucumber	
Stono	0.82	0.60
Ohio MR-17	0.61	0.62
Fletcher	0.51	1.18
Niagara	0.47	1.28
L.S.D. .05 level	non-significant	0.32
	Squash	
Black Zucchini	3.00	3.00
Caserta	3.00	3.00
Royal Acorn	0.69	0.37
E. G. Bush Scallop	0.66	0.73
L.S.D. .05 level	0.20	0.20
	Watermelon	
Blackstone	2.12	1.59
Y. B. Black Diamond	1.59	1.84
Blacklee	1.11	2.18
Peacock	0.12	0.26
L.S.D. .05 level	0.29	0.44

Data from experiment two indicate an increase in preference (injury) for Cranshaw (2.58) and Smith Perfect (2.60) both of which were highly preferred, whereas PMR 4-50 (0.54) and Hearts of Gold (0.38) were again relatively non-preferred. Significant differences in preference occurred with Cranshaw and Smith Perfect being highly preferred over PMR 4-50 and Hearts of Gold.

The increased injury in experiment two over experiment one was probably the result of a larger spotted cucumber beetle population which was the heavier feeder of the two species.

Cucumber. In experiment one no significant difference in preference was noted between varieties. However, all varieties showed a definite degree of resistance. In experiment two the population of the spotted cucumber beetle had increased and significant differences in preference between Fletcher (1.18), Niagara (1.28) and Stono (0.60), Ohio MR-17 (0.62) occurred. The beetles showed a moderate preference for Fletcher (1.18) and Niagara (1.28), whereas Stono (0.60) and Ohio MR-17 (0.62) were relatively non-preferred.

Squash. Significant differences at the 5 percent level were obtained between Black Zucchini and Caserta (3.00) and Royal Acorn (0.69) and E. G. Bush Scallop (0.66) in field experiment one. Black Zucchini and Caserta were highly preferred whereas Royal Acorn and E. G. Bush Scallop were relatively non-preferred.

Experiment two was a duplicate of one with exception that a significant difference in feeding was noted between Royal Acorn (0.37) and E. G. Bush Scallop (0.73).

Watermelon. The varieties appeared to be highly preferred by both cucumber beetles with the exception of Peacock. However, significant differences were observed between all varieties in experiment one. Blackstone (2.12) and Peacock (0.12) were the preferred and non-preferred varieties of the group; while Y. B. Black Diamond (1.59) and Blacklee (1.11) were moderately preferred.

In experiment two, significant differences were detected between Blacklee (2.18) and Blackstone (1.59) but not between Y. B. Black Diamond and either of these varieties. Also, Peacock (0.26) showed a significant difference in non-preference when compared with all other watermelon varieties. Blacklee, which was found to be relatively resistant in experiment one, proved to be highly preferred, which was probably because of the increased number of cucumber beetles present. Blackstone (1.59) and Y. B. Black Diamond (1.84) were moderately resistant.

Greenhouse Experiment. Results are summarized in Table 2.

Muskmelon. Within varieties no significant difference in injury was noted between either insect species. When the varieties were compared, however, there were significant differences between varieties with Smith Perfect and Cranshaw having mean ratings of 1.83 and 2.08, whereas Hearts of Gold and PMR 4-50 had ratings of 0.38 and 0.35, respectively, for the spotted cucumber beetle. Similar significant differences of preference for the feeding of the striped cucumber beetle between Smith Perfect (1.66), Cranshaw (1.88) and PMR 4-50 (0.93), Hearts of Gold (0.56) are shown in Table 2. Cranshaw (2.08) was preferred by the spotted cucumber beetle and only moderately preferred by the striped cucumber beetle. Smith Perfect was also moderately preferred and Hearts of Gold and PMR 4-50 were relatively non-preferred by both species of insects.

Also there were differences noted in stem injury caused by the spotted cucumber beetle between varieties Cranshaw (severe) and both Hearts of Gold and PMR 4-50 (slight). However, for the striped cucumber beetle, differences were noted between Smith Perfect (severe) and Hearts of Gold (slight).

Cucumber. No significant differences were noted in feeding between varieties for either insect species. The variety Stono was moderately

Table 2. Mean degree of injury to selected cucurbit varieties by the spotted and striped cucumber beetles, greenhouse, 1960.

Variety	Cotyledonous Leaf Injury			Stem Injury	
	Spotted		Striped	Spotted	Striped
			Muskmelon		
Cranshaw	2.08		1.88	Severe	Moderate
Smith Perfect	1.83		1.66	Moderate	Severe
Hearts of Gold	0.38		0.56	Slight	Slight
PMR 4-50	0.35		0.93	Slight	Moderate
L.S.D. .05 level = 0.72					
			Cucumber**		
Ohio MR-17	0.36		0.46	Slight	Slight
Stono	0.94		1.03	None	Slight
Niagara	0.96		0.39	None	Slight
Fletcher	0,91		0.44	Slight	Slight
			Squash		
Black Zucchini	2.90	*	1.89	Moderate	Slight
Caserta	2.76		2.35	Slight	Slight
E. G. Bush Scallop	0.24	*	0.81	None	None
Royal Acorn	0.60		0.92	None	None
L.S.D. .05 level = 0.54					
			Watermelon**		
Y. B. Black Diamond	1.53		1.06	Severe	Moderate
Blackstone	1.58		0.95	Severe	Moderate

** L.S.D. .05 level non-significant.

* Indicates significant feeding differences between species of insects.

EXPLANATION OF PLATE III

Figs. 1 and 2, typical cotyledonous leaf injury and relative preference or non-preference for each variety of the muskmelon and cucumber group by the spotted cucumber beetle (left) and the striped cucumber beetle (right), respectively.

PLATE III

Fig. 1

Fig. 2

EXPLANATION OF PLATE IV

Figs. 1 and 2, typical cotyledonous leaf injury and relative preference or non-preference for each variety of the squash and watermelon group by the spotted cucumber beetle (left) and the striped cucumber beetle (right), respectively.

PLATE IV

Fig. 1

Fig. 2

preferred by the striped cucumber beetle with all other varieties of the group being relatively non-preferred by both species of insects.

Squash. Significant differences in injury were noted between Black Zucchini and E. G. Bush Scallop with mean ratings of 2.90 and 0.24 for the spotted cucumber beetle and 1.89, 0.81 for the striped cucumber beetle, respectively. There were significant differences in injury by the spotted cucumber beetle between (1) Black Zucchini (2.90) and Caserta (2.76); and (2) E. G. Bush Scallop (0.24) and Royal Acorn (0.60). Both Black Zucchini and Caserta were significantly preferred over E. G. Bush Scallop and Royal Acorn. Similar differences were observed between varieties as a result of feeding by the striped cucumber beetle. However, Caserta (2.35) was more highly preferred, with Black Zucchini (1.89) being moderately preferred and both E. G. Bush Scallop (0.81) and Royal Acorn (0.92) relatively non-preferred.

Watermelon. No significant difference was found in this group. Both Y. B. Black Diamond (1.53) and Blackstone (1.58) were moderately preferred by the spotted cucumber beetle. Y. B. Black Diamond (1.06) was moderately preferred and Blackstone relatively non-preferred by the striped cucumber beetle.

Tolerance Experiment

<u>After Two Days Feeding</u>. The level of tolerance was based on the degree of feeding on cotyledonous leaves when seedlings were caged separately with each insect species.

Muskmelon. Only Cranshaw and PMR 4-50 showed significant differences in feeding between the two species of beetles. Mean injury ratings for the spotted cucumber beetle were Cranshaw (3.00) and PMR 4-50 (0.62). Mean ratings for the same two varieties for the striped cucumber beetle were 1.84 and 1.62, respectively. Within the group, the damage inflicted by the spotted cucumber beetle to Cranshaw (3.00) was significantly greater than that for all other varieties. The mean injury ratings for Smith Perfect and Hearts of Gold were 2.14 and 1.24, respectively; Smith Perfect and PMR 4-50 (0.62) were also significant for the same beetle species. Of the muskmelon group, Smith Perfect (2.14) and Cranshaw (3.00) were the least tolerant; Hearts of Gold (1.24) was moderately tolerant; and PMR 4-50 (0.62) was the most tolerant to the spotted cucumber beetle. Mean injury ratings for the striped cucumber beetle were not significant between muskmelon varieties; however, all were moderately tolerant.

Differences in the amount of stem injury caused by the two species are shown in Table 3. Plants of both Smith Perfect and Cranshaw were severely injured by the spotted and only slightly by the striped cucumber beetle. The greatest differences in stem injury were to Smith Perfect and Cranshaw, severe; Hearts of Gold and PMR 4-50 none, for the spotted cucumber beetle.

Cucumber. Significant differences were noted between the feeding by the spotted and striped cucumber beetles in which the mean cotyledonous leaf injuries were Ohio MR-17 (1.01, 0.16), Niagara (1.76, 0.50), and Fletcher (2.09, 0.30), respectively. There were significant differences in the amounts of feeding by the spotted cucumber beetle between varieties Fletcher (2.09) and Stono (1.21) and Ohio MR-17 (1.01). Of the cucumber varieties, Fletcher (2.09) was the least tolerant, whereas Niagara (1.76), Stono (1.21), and Ohio MR-17 (1.01) were moderately tolerant to the spotted cucumber beetle. There were no significant differences in feeding by the striped cucumber beetle between cucumber varieties and all varieties were quite tolerant.

Table 3. Mean degree of tolerance of selected varieties of cucurbits to the spotted and striped cucumber beetles after two days feeding, greenhouse 1960.

Variety	Cotyledonous Leaf Injury			Stem Injury	
	Spotted		Striped	Spotted	Striped
		Muskmelon			
Smith Perfect	2.14		1.68	Severe	Slight
Cranshaw	3.00	*	1.84	Severe	Slight
Hearts of Gold	1.24		1.69	None	Slight
PMR 4-50	0.62	*	1.62	None	None
		Cucumber			
Ohio MR-17	1.01	*	0.16	None	None
Stono	1.21		0.71	Slight	Slight
Niagara	1.76	*	0.50	Slight	None
Fletcher	2.09	*	0.30	None	None
		Squash			
Black Zucchini	1.26		0.55	None	None
Caserta	1.00		0.78	None	None
E. G. Bush Scallop	1.00		1.28	None	None
Royal Acorn	1.02		0.50	None	None
		Watermelon			
Y. B. Black Diamond	2.10	*	1.14	Severe	Slight
Blackstone	1.40		1.88	Moderate	Slight
Blacklee	1.21		0.84	Moderate	Slight

L.S.D. .05 level = 0.77

* Indicates significant feeding differences between species of insects.

EXPLANATION OF PLATE V

Figs. 1 and 2, relative degree of feeding injury on cotyledonous leaves of plants of muskmelon and cucumber varieties in the tolerance experiment after two days. The left cotyledonous leaf for each variety represents injury caused by the spotted cucumber beetle and right, the striped cucumber beetle.

PLATE V

Fig. 1

Fig. 2

EXPLANATION OF PLATE VI

Figs. 1 and 2, relative degree of feeding injury on cotyledonous leaves of plants of squash and watermelon varieties in the tolerance experiment after two days. The left cotyledonous leaf for each variety represents the injury caused by the spotted cucumber beetle and right, the striped cucumber beetle.

PLATE VI

Fig. 1

Fig. 2

There were no appreciable differences in stem injury caused by the two insect species.

Squash. There were no significant differences between mean injury ratings for the two insect species. Black Zucchini (1.26) and Royal Acorn (1.02) were moderately tolerant whereas Caserta (1.00) and E. G. Bush Scallop (1.00), were tolerant to the spotted cucumber beetle. The only significant difference in feeding by the striped cucumber beetle was between the varieties E. G. Bush Scallop (1.28) and Royal Acorn (0.50). E. G. Bush Scallop (1.28) was moderately resistant whereas Black Zucchini (0.55), Caserta (0.78), and Royal Acorn (0.50) were more resistant to the same insect species.

Watermelon. Within the watermelon group, Y. B. Black Diamond showed the only significant difference in feeding by the two insect species. The mean cotyladonous leaf injury ratings were 2.10 for the spotted cucumber beetle and 1.44 for the striped cucumber beetle. Differences in injury by the spotted cucumber beetle between Y. B. Black Diamond (2.10) and Blacklee (1.21) were significant. Y. B. Black Diamond was the least tolerant of the group with Blackstone (1.40) and Blacklee being moderately tolerant. There were significant differences in feeding by the striped cucumber beetle between Blackstone (1.88) and Blacklee (0.84); Y. B. Black Diamond (1.14) and Blackstone (1.88). Blacklee was the most tolerant of the group and the other varieties were only moderately tolerant.

Differences in stem injury for Y. B. Black Diamond were severe and slight for the spotted and striped cucumber beetles respectively.

After Five Days Feeding. Final ratings were given all varieties for the two species of insects as indicated in Table 4.

Muskmelon. Hearts of Gold and PMR 4-50 were the only varieties to show significant differences in injury between the feeding of the two insect

Table 4. Mean degree of tolerance of selected varieties of cucurbits to the spotted and striped cucumber beetles after five days feeding, greenhouse 1960.

Variety	Cotyledonous Leaf Injury			Stem Injury	
	Spotted		Striped	Spotted	Striped
		Muskmelon			
Smith Perfect	2.30		2.19	Severe	Moderate
Cranshaw	3.00		2.41	Severe	Slight
Hearts of Gold	1.45	*	2.42	Slight	Moderate
PMR 4-50	1.01	*	2.19	Slight	Slight
		Cucumber			
Ohio MR-17	1.39		0.70	None	None
Stono	1.78		1.31	Slight	Slight
Niagara	2.10	*	1.28	Moderate	Slight
Fletcher	2.36	*	0.85	Slight	None
		Squash			
Black Zucchini	1.58	*	0.71	None	None
Caserta	1.36		1.00	None	None
E. G. Bush Scallop	1.76		1.66	None	None
Royal Acorn	1.44		1.32	None	None
		Watermelon			
Y. B. Black Diamond	2.81	*	1.70	Severe	Slight
Blackstone	2.18		2.31	Severe	Slight
Blacklee	2.00		1.70	Moderate	Slight

L.S.D. .05 level = 0.71

* Indicates significant feeding differences between species of insects.

species. The mean injury ratings for the spotted cucumber beetle was Hearts of Gold (1.45) and PMR 4-50 (1.01). Mean injury ratings for the striped cucumber beetle were 2.42 and 2.19 respectively. Within the group, the mean injury ratings caused by the spotted cucumber beetle to cotyledonous leaves and stems were Cranshaw (3.00, severe), Smith Perfect (2.30, severe), Hearts of Gold

(1.45, slight) and PMR 4-50 (1.01, slight) respectively. Both Cranshaw (3.00) and Smith Perfect (2.30) were susceptible whereas Hearts of Gold (1.45) and PMR 4-50 (1.01) were moderately resistant to the spotted cucumber beetle. There were no appreciable differences in tolerance between muskmelon varieties to the striped cucumber beetles. All varieties of muskmelon were fairly susceptible to both insect species.

Cranshaw showed the greatest amount of difference in feeding injury by the two species on stems. The spotted cucumber beetle caused severe stem injury whereas the striped cucumber beetle only caused slight injury.

Cucumber. The amount of damage caused by the spotted and striped cucumber beetles were significant in Niagara (2.10, 1.28) and Fletcher (2.36, 0.85) respectively. Within the cucumber group there were significant differences in tolerance between varieties Fletcher (2.36), Niagara (2.10) and Ohio MR-17 (1.39) to the spotted cucumber beetle. Both Fletcher (2.36) and Niagara (2.10) were the least tolerant of the group to the spotted cucumber beetle whereas Ohio MR-17 (1.39) and Stono (1.78) were moderately tolerant. No significant difference was shown in the amount of damage inflicted by the striped cucumber beetle to the cucumber varieties. However, Ohio MR-17 (0.70) and Fletcher (0.85) were more tolerant than Stono (1.31) and Niagara (1.28).

Differences in stem injury between Ohio MR-17 (none) and Niagara (moderate) were observed as a result of the feeding by the spotted cucumber beetle. No stem injury was obtained when Ohio MR-17 and Fletcher were caged with the striped cucumber beetle.

Squash. After five days feeding, mean ratings for Black Zucchini for the spotted and striped cucumber beetles were 1.58 and 0.71, respectively. There were significant differences in injury caused by the striped cucumber beetle between Black Zucchini (0.71) and E. G. Bush Scallop (1.66). E. G. Bush Scallop and Royal Acorn (1.32) were rated as moderately tolerant. Both Black Zucchini (0.71) and Caserta were relatively tolerant to the striped cucumber beetle in this case. No significant differences were detected between varieties for tolerance to the spotted cucumber beetle. The final ratings for all squash indicate that they are moderately tolerant to the spotted cucumber beetle, with no stem injury detected in this experiment for either insect species.

Watermelon. The only significant difference between feeding by the spotted and striped cucumber beetles was with Y. B. Black Diamond with mean ratings of 2.81 and 1.70, respectively. No significant differences were noted between varieties for the spotted cucumber beetle. All varieties were considered highly susceptible at the time of the final rating. For the same varieties, no significant difference was noted in injury caused by the striped cucumber beetle. Although Blacklee (1.70) and Y. B. Black Diamond (1.70) were more tolerant than Blackstone (2.31).

Also appreciable differences were noted in stem injury for Y. B. Black Diamond (severe, slight) and Blackstone (severe, slight) caused by the spotted and striped cucumber beetles respectively.

DISCUSSION

In this study, two criteria were used in measuring the components of resistance. They were (1) preference and (2) tolerance. The reason a certain variety is resistant (non-preferred or tolerant), should be explored because such information would be of vital importance in breeding crops for insect resistance; however, no information was obtained on the "why" of tolerance and preference in this study.

Results from field preference experiments indicated that non-preference by the spotted and striped species of cucumber beetles was one component of resistance of PMR 4-50 and Hearts of Gold (muskmelon) seedlings when compared with those of the preferred varieties, Cranshaw and Smith Perfect.

In both cucumber experiments, Stono and Ohio MR-17 were consistently non-preferred when compared with Fletcher and Niagara both of which were injured more in the second experiment. This was probably because the population of spotted cucumber beetles increased in the second experiment. Fletcher and Niagara were selected on the basis of results of previous field experiments where a large number of varieties were screened for resistance. However, it is possible that all previous experiments were conducted during the season when the striped cucumber beetles were the most prevalent.

Black Zucchini and Caserta of the squash group, were both highly preferred when compared with Royal Acorn and E. G. Bush Scallop. These results confirmed those of the original screening experiment from which the varieties for this study were selected. In Experiment Two a significant difference was obtained between Royal Acorn and E. G. Bush Scallop. This was probably the result of a slight decrease in the striped and an increase in the spotted cucumber beetle populations.

Injury to all watermelon varieties was fairly consistent, with the exception of Peacock which received little injury because of delayed emergence of the seedlings which did not allow the beetles to have the same amount of feeding time as the other varieties. The increase in injury to Y. B. Black Diamond and Blacklee in Experiment Two was again probably the result of an increase in the population of the spotted cucumber beetle. The decreased mean injury of

Blackstone was probably the result of the feeding activity of the striped cucumber beetle being slowed, along with increased spotted cucumber beetle population.

Early preferences (rating after two days) by the cucumber beetles were consistent in all field experiments. The beetles selected the most preferred varieties and only "sampled" or "tasted" those varieties which were least preferred.

The differences in preference responses of the two beetles for Smith Perfect and PMR 4-50, muskmelon, are indicated in Table 2. Insects use a particular plant for food, for oviposition, for shelter or for combination of the three (Painter, 1951). It was obvious that the attraction of a variety was not governed by the oviposition needs but by either or both the needs for food and shelter.

In the greenhouse preference experiment, there were no significant differences in preference by the two insect species for muskmelon, cucumber or watermelon varieties. The greenhouse preference data are consistent with field preference data in that Smith Perfect and Cranshaw were preferred over Hearts of Gold and PMR 4-50 (all muskmelon). No significant differences were noted between varieties of either cucumber or watermelon.

In the squash group, the spotted cucumber beetles preferred Black Zucchini seedlings more than did the striped cucumber beetles as indicated by injury caused by each. E. G. Bush Scallop was significantly preferred by the striped cucumber beetle, although the mean rating was only 0.81. Again, varietal preferences by the cucumber beetles were similar to those of the original field screening experiments with Black Zucchini and Caserta being more highly preferred than E. G. Bush Scallop and Royal Acorn.

The areas of major feeding by the cucumber beetles were in all cases on the lower epidermis of the cotyledonous leaves and to a lesser extent on the epidermis of the stem. This characteristic feeding habit of the beetles is probably the result of light or temperature or a combination of the two, both of which appear to regulate the activity of these insects.

It appeared that the preference for certain varieties was possibly accomplished by the "tasting" or "sampling" method. This would account for the increase, with time, in the number of beetles that remained on susceptible varieties and a relatively few beetles on the more resistant varieties. For example, in the squash group, Black Zucchini and Caserta had 56, 53 and 22, 15 spotted and striped cucumber beetles respectively; and 3, 4 and 3, 6 for the more resistant Royal Acorn and E. G. Bush Scallop in which a total of 60 plants were observed after two days feeding.

Temperature along with the light intensity appeared to affect the activity of the beetles. Greenhouse temperatures in this study were not as fluctuating as those in the field.

The mean greenhouse temperature was 75 degrees F. with the fluctuation being from 60 to 90 degrees F. Field temperatures had a greater fluctuation and probably the light intensity was higher, because of shading on the greenhouse glass. These differences may have affected the activity of the beetles.

The reasons for possible "dislike" of the cucumber beetles for feeding on a particular variety manifested by the small amount of injury, could be due to absence of feeding stimulants in the plants, to the presence of some chemical repellent or to the absence of some chemical nutrient required by either or both species of insects.

In all cases, there was an increase in injury at the end of the five days over the two day feeding period. The insect either fed or starved and those which died were replaced in order to maintain equal populations for all crops. This could account for some increased injury in the more resistant varieties since the beetles appeared to "sample" the plant in determining its "like" or "dislike".

In the muskmelon group, both Cranshaw and Smith Perfect were highly susceptible to both species of insects. The striped cucumber beetle injured Hearts of Gold and PMR 4-50 seedlings more than the spotted cucumber beetle; this might be the result of differences in nutritional requirement of the two beetles. Hearts of Gold and PMR 4-50 seedlings ware more tolerant to the spotted cucumber beetle than were those of Smith Perfect and Cranshaw. This may have been because of differences in the chemical make-up of plants of the different varieties. The high level of injury on seedlings of the muskmelon group as a whole by the striped cucumber beetle was probably because of a lesser degree of tolerance of all varieties.

For the cucumber group, injury by the spotted cucumber beetle was greater than that of the striped cucumber beetle. Significant differences in injury were noted on plants of Niagara and Fletcher for the two insect species. Again, this may be because of the differences in the chemical make-up of the plants. Probably for these same reasons injury to seedlings of Ohio MR-17 and Fletcher by the striped cucumber beetles was limited.

In the tolerance experiment injury to seedlings of the susceptible varieties of the squash as a group was lower than for the same varieties in both preference experiments. This was because of the number of insects feeding on the preferred varieties. Seedlings of both Black Zucchini and Caserta hed many more beetles feeding on them when the insects were given e choice. When given no choice the beetles still did not injure seedlings of these varieties to as high a degree. This wes probably because the population was limited to only one beetle per two plants. Moderete resistance wes noted for all muskmelon varieties es e group to the spotted cucumber beetle. Also, the squash varieties E. G. Bush Scellop and Royel Acorn were moderately resistent to the striped cucumber beetle. Bleck Zucchini and Caserte showed a marked degree of tolerance to feeding by the striped cucumber beetle. There was e significant difference in the amount of feeding by the spotted and striped cucumber beetles on seedlings of Bleck Zucchini, with the greatest emount of tolerance being shown to the striped cucumber beetle. Although no date were obtained es to the reesons for the differences, one might speculate that they were because of differences in the nutritional requirements of the two species.

There were significant differences noted between the feeding of the two insects on seedlings of Y. B. Bleck Diamond, watermelon. The group as a whole showed a low degree of tolerence with the least meen degree of injury of 1.70 for the striped end 2.00 for the spotted cucumber beetle. It was observed thet feeding on the wetermelon group was as heevy or nearly equal to thet of the muskmelon group for both species of beetles. Differences between the amount of injury caused by the cucumber beetles to different species of cucurbits could have been the result of some morphological cheracteristic of the plent species. However, no information wes obtained on this phase. In considering the more resistent end susceptible species of cucurbits, such plent morphologicel cheracteristics of the resistent species might have acted as "mechanicel barriers" egainst the feeding of the beetles. In such cese, the reverse should have been true with the susceptible species.

It was noted that in some cases injury to both preferred and non-preferred varieties were about equal in the tolerance experiment. This indicates that the non-preferred varieties Hearts of Gold and PMR 4-50, muskmelon, and E. G. Bush Scallop and Royal Acorn, squash, are subject to injury when the beetles do not have a choice. Also those that are preferred, in some cases, Black Zucchini and Caserta, squash, were quite tolerant to the striped cucumber beetle. In this case, the number of beetles present probably was the controlling factor.

As a result of this study the components of resistance, preference and tolerance could not be completely separated with all varieties, since the more highly preferred squash varieties (Black Zucchini and Caserta) also demonstrated a high level of tolerance in cage feeding experiments. Therefore, among the selected varieties of cucurbits studied, three possible combinations of resistance were observed: (1) lack of preference, (2) tolerance, and (3) a combination of both.

SUMMARY AND CONCLUSIONS

This study involved the determination, in both the greenhouse and field, of the components of resistance or susceptibility of selected varieties of cucurbits to the spotted and striped cucumber beetles. These varieties were selected from previous screening experiments either because they appeared to be resistant or susceptible to field populations of cucumber beetles.

Results from all preference experiments, both field and greenhouse, indicated that for both beetle species the following varieties of the respective crops were the least preferred or the most resistant: muskmelon (PMR 4-50 and Hearts of Gold); cucumber (Stono and Ohio MR-17); squash (Royal Acorn and E. G. Bush Scallop). There were exceptions in the cucumber (Fletcher and Niagara) and in the watermelon group (Y. B. Black Diamond and Blacklee) in which all were more susceptible in the second field experiment than in the first and with just the reverse on Blackstone (watermelon). This difference may have been the result of nutritional requirement of the two insect species or to the relative number of the two beetle species present.

There were significant differences in feeding between the two species on seedlings of the susceptible variety, Black Zucchini, and the resistant variety, E. G. Bush Scallop of the squash group. There were other differences (non-significant) between the mean degrees of injury of the two insect species on PMR 4-50, muskmelon, (0.35, 0.93), Niagara (0,96, 0.39) and Fletcher (0.91, 0.44), cucumber, and Blackstone (1.58, 0.95), watermelon, for the spotted and striped cucumber beetles respectively.

Differences in the amount of injury caused by the two species to a particular variety were most prevalent in the tolerance experiment. The resistant varieties (Hearts of Gold, PMR 4-50; muskmelon and Niagara, Fletcher; cucumber) showed significant differences between the feeding of the two insect species. These differences may have been due to differences in plant stimulant requirement of each insect. Differences in feeding of the two insect species on seedlings of Black Zucchini (squash) and Y. B. Black Diamond (watermelon) were also noted in these susceptible varieties.

Although a particular variety may be highly preferred this does not indicate that it is not resistant to some degree. This was true in the case of Cranshaw (muskmelon). In other cases, Black Zucchini and Caserta (squash) showed a marked degree of tolerance to one beetle per plant (1.58, 1.36) for the spotted cucumber beetle and (0.71, 1.00) respectively for the striped cucumber beetle when compared to the mean ratings of 3.00 for both varieties in the field experiments. The reverse is shown in the more non-preferred varieties.

For continued work to be done in host plant resistance in cucurbits, it may be well to consider the following differences: (1) feeding by the two beetles; (2) times of seasonal appearance of the two beetles with the striped cucumber beetle the most active in the early part of the season, and the spotted cucumber beetle, the heavier feeder of the two, appearing about a month later in the season in much larger numbers; and (3) that certain vari eties possess particular factors that class them as susceptible or resistant to either or both the spotted and striped cucumber beetle.

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LITERATURE CITED

Bailey, S. F. 1941. Breeding vegetables for resistance to insect attack. Jour. Econ. Ent. 34:352-358.

Britton, W. E. 1908. Insects attacking cucurbitaceous plants in Connecticut. Conn. Agr. Expt. Sta. Rpt., 807-809.

Compton, C. C. 1932. Insects feeding on truck and garden crops and how to control them. Ill. Agr. Expt. Sta. Cir. 391:26-28.

Dudly, J. E., Jr., H. F. Wilson and W. D. Mecum. 1923. Nicotine dusts kill cucumber beetles. Wis. Agr. Expt. Sta. Bul. 355. 10p.

Flint, W. P., and J. H. Bigger. 1938. Biological control of insects through plant resistance. The Canadian Ent. 70(12):244-246.

Gould, G. E. 1943. Insect pests of cucurbit crops in Indiana. Ind. Acad. Sci., Proc. 53:165-166.

__________. 1944. The biology and control of the striped cucumber beetle. Purdue Univ. Agr. Expt. Sta. Bul. 490. 28p.

__________. 1959. Varietal susceptibility of cucurbits to cucumber beetle attack. Ind. Acad. Sci., Proc. 68:186-189.

Hall, C. V. 1956. "Technique of evaluating injury of the cucumber beetles". Unpublished Notes, Kansas Agr. Expt. Sta., Manhattan, Kansas.

Hall, C. V., and R. H. Painter. 1956. "Resistance of cucurbits seedlings to the cucumber beetles". Unpublished Notes, Kansas Agr. Expt. Sta., Manhattan, Kansas.

__________. 1960. Insect resistance studies with cucurbits. Amer. Soc. Hort. Sci., Ann. Meeting Abs. No. 170.

Harris, F. H., and H. Matsumori. 1956. Tests of insecticides for control of cucumber beetles in Ohio. Jour. Econ. Ent. 49(1):131-133.

Haseman, L. 1937. Controlling insect pest of melons, cucumbers and related crops. Mo. Agr. Expt. Sta. Bul. 391:3-9.

Houser, J. S., and W. V. Balduf. 1925. Striped cucumber beetle. Ohio Agr. Expt. Sta. Bul. 388. 364p.

Isely, Dwight. 1927. The striped cucumber beetle. Ark. Agr. Expt. Sta. Bul. 216. 36p.

Lees, A. H. 1926. Insect attack and the internal condition of the plant. Ann. Applied Biol. 13:506-515.

Metcalf, C. L., W. P. Flint and R. L. Metcalf. 1951. Destructive and useful insects, third edition. New York: McGraw-Hill Book Co. 1071p.

Munford, E. P. 1931. Studies in certain factors affecting the resistance of plants to insect pests. Science 73:49-50.

Nath, Prem. 1960. "Resistance of cucurbit seedlings to cucumber beetle feeding". Unpublished Master's Thesis, Kansas State University, Manhattan, Kansas.

Painter, R. H. 1943. Insect resistance of plants in relation to physiology and habits. Amer. Soc. Agron. 35:725-732.

__________. 1951. Insect resistance in crop plants. New York: Macmillan Co. 520p.

__________. 1958. Resistance of plants to insects. Ann. Rev. Ent. 3:267-290.

Peairs, L. M., and R. H. Davidson. 1956. Insect pests of farm, garden, and orchard, fifth edition. New York: John Wiley & Sons, Inc. 661p.

Rand, F. V. 1915. Dissemination of bacterial wilt of cucurbits. Jour. Ag. Res. 5:257-260.

Snelling, Ralph O. 1941. Resistance of plants to insect attack. Bot. Rev. 7:543-586.

Thorsteinson, A. J. 1960. Host selection in phytophagous insects. Ann. Rev. Ent. 5:193-218.

RESISTANCE OF SELECTED VARIETIES OF CUCURBITS TO THE SPOTTED CUCUMBER BEETLE, DIABROTICA UNDECIMPUNCTATA HOWARDI BARBER, AND THE STRIPED CUCUMBER BEETLE, ACALYMMA VITTATA (FABRICIUS)

by

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This study was designed to determine the effect of preference and tolerance in the level of resistance of selected varieties of cucurbits to the spotted cucumber beetle, D. undecimpunctata howardi Barber and the striped cucumber beetle, A. vittata (Fab.).

Selected varieties of muskmelon, Cucumis melo L., (Cranshaw, Smith Perfect, PMR 4-50, and Hearts of Gold); cucumber, Cucumis sativas L., (Stono, Ohio MR-17, Niagara, and Fletcher); squash, Cucurbita pepo L., (Black Zucchini, Caserta, E. G. Bush Scallop, and Royal Acorn); and watermelon, Citrullus vulgaris Schard., (Y. B. Black Diamond, Blackstone, Blacklee, and Peacock) were used.

Field preference experiments consisted of randomized blocks with three replications. As near 60 seedlings as possible were rated for each experiment.

In the greenhouse preference experiments, the two species of beetles were assigned to cages randomly where all varieties were planted in rows across flats in a random manner to permit a final stand of 10 seedlings per variety for each of four replications.

In the tolerance experiment, two hundred and forty cylindrical screen wire cages each containing two plants and one beetle were used.

The selected varieties were subjected separately to each species of beetle in the greenhouse and to the combined two species in the field. Ratings of damage to cotyledonous leaves were: 0.00 = no injury; 1.00 = slight injury; 2.00 = moderate injury; and 3.00 = severe injury. Stem injury ratings of none, slight, moderate, and severe were also used. Seedlings having a mean injury rating above 2.00 were regarded as the most susceptible (preferred) and those below 1.00 as most resistant (non-preferred) with those in between 2.00 and 1.00 as moderately resistant.

Results from all preference experiments, both field and greenhouse, indicated that for both species of insects the following varieties of the respective groups were the least preferred or the most resistant: muskmelon (PMR 4-50 and Hearts of Gold); cucumber (Stono and Ohio MR-17); squash (Royal Acorn and E. G. Bush Scallop). There were significant differences in feeding between the two species of beetles on seedlings of the susceptible variety, Black Zucchini and resistent, E. G. Bush Scallop of the squash group.

Differences in the amount of injury caused by the two species of beetles to a particular variety were most prevalent in the tolerance experiment. The resistant varieties (Hearts of Gold and PMR 4-50, muskmelon: Niagara and Fletcher, cucumber) showed significant differences between the feeding of the two beetles. Differences in feeding of the two beetles on seedlings of Black Zucchini (squash) and Y. B. Black Diamond (watermelon) were also noted in these susceptible varieties.