RESISTANCE OF CUCURBIT SEEDLINGS TO CUCUMBER BEETLE FEEDING

by

PREM NATH

B.S., Agriculture, University of Bihar, India, 1958

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1960

TABLE OF CONTENTS

INTRODUCTION

The striped cucumber beetle, Acalymma vittata (F.), and the spotted cucumber beetle, Diabrotica undecimpunctata howardi Barber, are among the most common insect pests attacking cucurbits in the United States. They are native to this country and inhabit all parts of the United States, east of the Rocky Mountains from Canada to Mexico.

The striped cucumber beetle, A. vittata (F.), was first described in 1775 by Fabricius in Systema Entomologiae under the name Cistela melanocephala. In 1788, it appeared in the revision of the thirteenth edition of Linen's Systema Naturae as Cryptocephalus americanus, whereas the specific name vittata was changed to stolata by Fabricius. In Entomology in about 1807, Oliver placed the species in the genus Galeruca and reemployed the specific name vittata. Later on, Chevrolat divided the genus Galeruca, putting this species in the Diabrotica section (6). According to Barber (1) the striped cucumber beetle of the genus Diabrotica was placed in new genus Acalymma and the specific name remained vittata. At the same time the spotted cucumber beetle occuring in Kansas which was heretofore regarded as D. duodecimpunctata became D. undecimpunctata howardi Barber.

Damage to cucurbits is caused in many ways by these beetles. In the spring, the newly emerged seedlings are often so severly damaged that replanting is necessary. Beetles continue to feed on the foliage and blossoms of mature plants and may reduce the vigor and subsequent yield. The larval stage feeds on the roots of cucurbits and weakens the plants. In the fall, when the leaves become tough and unattractive, the beetles frequently eat into the tender fruits. One of the most serious damages result from dissemination of the causal organism of bacterial wilt (Erwinia tracheiphilus) of cucurbits.

This thesis is the result of a study made to determine the level of resistance of cucurbit seedlings to the striped cucumber beetle, A. vittata (F.) and the spotted cucumber beetle, D. undecimpunctata howardi Barber. Its purpose was to develop more permanent and less expensive control measures through the host plant resistance. The objectives were (a) to determine the level of resistance of certain varieties of cucumber, muskmelon, and watermelon; (b) to observe the preferred area of feeding of each on the plants; and (c) to observe the insect response to feeding on resistant plants.

REVIEW OF LITERATURE

In 1841, Dr. William Harris first reported the striped cucumber beetle as an injurious insect of cucurbits in the United States. In 1843, Dr. Willis Gaylord emphasized its economic importance as an insect pest. Dr. Asa Fitch, State Entomologist of New York, in 1864, stated that the striped cucumber beetle was the most injurious pest of cucumbers (6).

Starnes (20) reported the striped cucumber beetle as being a serious pest of watermelon seedlings. He recommended tobacco dust, air-slaked lime dust, as being fairly satisfactory protectors for seedlings. He suggested that paris green might be more effective if dusted with air-slaked lime.

Quaintance (18) described the striped cucumber beetle as an important pest of cucurbits in Georgia and suggested 'trap crops' as a satisfactory control measure.

Garman (5), in Kentucky, reported details concerning the general appearance and occurrence of the striped and spotted species. Included was a list of the materials which were used during the previous forty years for control. They were plaster, Glauber's salt, tobacco dust, soft soap lime, pyrethrum, paris green, and white hellebore. However, for young plants he recommended a cover of tobacco treated muslin.

In 1908, Britton (3) described the important insect pests of cucumber, squash, pumpkin, and melons of Connecticut and emphasized the damage caused by the striped and spotted cucumber beetles. He indicated that soon after the seedling plants appeared, the beetles began to feed on the epidermis of the leaves and tender stems often causing the plants to wilt and die. He also reported that the beetles burrowed into the ground and attacked the plants before they emerged from the soil.

According to Marsh (15) the striped cucumber beetle was rare in southern Texas as compared with D. balteata and its injuries were confined to cucurbits. The spotted cucumber beetle, D. undecimpunctata howardi Barber occurred only in small numbers and no complaints of injury were received. Smith (21) published a description of the habits, life history, and control measures for these two beetles in North Carolina. Control measures include the use of a cover for the young plants, planting an excess of seed, use of trap crops, clean cultivation, repellents, arsenicals and bordeaux mixture.

The feeding habits, life history, extent of injury, chemical, mechanical and cultural control measures of the striped cucumber beetle were all described fully by Lowery (13). He indicated that the beetles preferred only the most tender parts of young plants and when the plants became woody only the leaves and blossoms were damaged. He also observed that mining of stems by the larvae did not affect the plant immediately but there was an increased tendency of both cucumber and squash plants to develop certain diseases such as Downy mildew, Pernoplasmopara Cubensis, and Anthracnose, Colletotrichum lagnerium.

Houser and Balduf (11) reported detailed information regarding the striped cucumber beetle. Results from palatibility experiments of cucurbits showed these to be preferred above all crops by the striped cucumber beetle and that it was able to find cucurbit plants by means of the sense of smell. According to them the cucurbit crop in Ohio was decreased 50 percent due to this pest.

Isley (12) described the striped cucumber beetle as the most important pest of cantaloupes, cucumbers, and melons in Arkansas. According to him the beetles multiply during rainy seasons and they may become quite rare during dry hot weather. He also indicated that in the season of 1922 and 1923 about 20 percent of the commercial cantaloupe crop in Arkansas was destroyed by this beetle.

The overwintering habits of the striped cucumber beetle were studied in cage experiments by Haseman (9) and it was found that the beetles collected in bunches beneath green as well as dry grass but they did not burrow into the soil.

In 1937, Haseman (10) reported that the striped cucumber beetle gnawed both the stems and the cotyledons and after the crop once began to vine, the beetles continued feeding on the blossoms and newly set fruits. In addition to feeding injury he reported that the beetles spread bacterial wilt from plant to plant or field to field.

Complete information regarding the biology, habits and chemical control of the striped cucumber beetle was described by Gould (6). According to him Indiana alone estimated a loss of $525,000 in 1936 with 50 to 70 percent of the cucurbit crops destroyed in spite of several control measures.

Frank and Peterson (4) gave some information regarding the effect of chemicals like dieldrin, aldrin, chlordane, etc., on Hale's Best muskmelons to reduce the population of the striped cucumber beetle.

Bradfield (2) tested 'Marlate' 50 methoxychlor to control the striped cucumber beetle on melons and he was actually able to kill them by this insecticide.

Harries and Matsumori (8) described rotenone, lindane, dieldrin, aldrin, heptachlor, etc., as the effective insecticide to control A. vittata (F.) and D. undecimpunctata howardi Barber in Ohio but they could not conclude the relative effectiveness of the better insecticides.

Most of the information concerning resistance of different host plants to insect pests was reviewed by Painter (17). Squash was one of the crops he mentioned which was being studied in Kansas was for resistance to striped and spotted cucumber beetles, and the squash bug, Anasa tristis.

Rolston (19) reported that the striped cucumber beetle feeds inconspicuously beneath the leaves of cucumber seedlings and chew on the stems while hidden beneath loose soil or in cracks in the soil.

An article regarding the work done on the varietal susceptibility or resistance of cucurbits to the striped cucumber beetle, was published by Gould (7) from Lafayette, Indiana. He reported that in plots treated with an insecticide, Butternut squash, C. moschata, showed the least effect of beetle attack and Hubbard squash, C. maxima, the greatest. He also indicated that of the other cucurbits used in the tests, cucumber and muskmelon were more affected than watermelon but not as much as the squash varieties belonging to C. maxima.

MATERIALS AND METHODS

Three experiments were conducted in the horticultural greenhouse at Kansas State University between September, 1959, and July, 1960.

Host Plants

From varieties of cucumber, Cucumis sativus; watermelon, Citrullus vulgaris; and muskmelon, Cucumis melo, were used in all three experiments.

Variety	Seed source
Cucumber	
Nappa 63	Lawrence Robinson & Sons Seed Co.
Palomar	Burrell's Seed Co.
Model	Burrell's Seed Co.
MR 7097	Ferry-Morse Seed Co.
Watermelon	
Hope Diamond	Lawrence Robinson & Sons Seed Co.
Charleston Gray	Ferry-Morse Seed Co.
Blackstone	Burrell's Seed Co.
Black Diamond	Ferry-Morse Seed Co.
Muskmelon	
Gold Cup 55	Ferry-Morse Seed Co.
No. 6	Associated Seed Growers, Inc.
Georgia 47	Georgia Agricultural Expt. Station
Cranshaw	Lawrence Robinson & Sons Seed Co.

Seedlings were evaluated in the cotyledonous leaf stage in all three experiments.

Insects

Two species of insects were used for the experiments. They were the striped cucumber beetle, *Acalymma vittata* (F.); and the spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber. Both of the insects belong to the family *Chrysomelidae* and order *Coleoptera*.

For the first experiment, in the early fall of 1959, spotted cucumber beetles were collected from cucurbit seedlings at the Ashland Horticultural Farm. It was easy to collect them by hand in early morning when they were in abundance. They were kept in screen wire cages in the greenhouse provided with favorable moisture, temperature and proper food which consisted of flowers and tender cucurbit fruits. However, by the time the first experiment was completed, the insect supply had been depleted and then could not be collected until spring. During the spring of 1960, only the striped cucumber beetles could be obtained in sufficient numbers to conduct the second and third experiments. These beetles were collected from the nearby vegetable growers' hotbeds where cucurbit seedlings were being raised for transplanting and from the cucurbit plantings at the Horticultural Farm, Kansas State University. There were few spotted beetles available before June 15, so the striped beetles were used in experiments two and three.

Seedbed Preparation

Field soil from the Horticultural Farm was placed in greenhouse flats. The soil was well worked and steam sterilized to provide a good growing medium for the seedlings.

Design of Experiments

A completely randomized design was used. Three replicates of each of the twelve varieties were included in each experiment. Two rows of seedlings were planted in each flat, giving a total of six flats per replicate or a total of 18 flats per experiment. Each row contained twenty seedlings in the first experiment and twelve in experiments two and three. An adequate number of seeds were planted in rows spaced eight inches apart so that each could be thinned to an equal number of seedlings before the insects were released in the cage. A screen covered greenhouse bench was used to confine the insects with the plants.

Description of Experiments

Experiment One. The seeds were planted on October 14, 1959. The flats of seedlings were placed inside the cage on October 26. Sixty spotted cucumber beetles were released in the cage for each replicate, giving a total of 180 insects for 720 seedlings. The first observation was made on October 28, the second on November 2, and the final on November 6, 1959.

Experiment Two. The same varieties were planted according to the same techniques and with the same design except that the striped cucumber beetle was used. The seeds were planted on May 6, 1960, and on May 16, the beetles were released inside the cage. A total of 108 insects were released for the 432 seedlings. The first observation was made on May 18 and the last on May 22, 1960.

Experiment Three. This experiment was a duplicate of experiment two. Seeds were planted on May 24, and the seedlings were ready by June 3, when a total of 108 striped beetles were released inside the cage containing 432 seedlings. The insects were uniformly distributed throughout the cage as in previous experiments. The first observation was made on June 5, and the final on June 9, 1960.

Technique of Evaluation

Soon after the beetles were released inside the cage, it was noted that they moved toward the preferred varieties and started feeding on them. Overall damage on each row was not rated before the sixth day after release and the final observations were taken on the seventh day. Below is a brief description of the rating system of damage which was used and is illustrated in Plate I. This rating system had been used in field experiments since 1956 and was adopted for the greenhouse study.

EXPLANATION OF PLATE I.

Rating system of damages made by the spotted and the striped cucumber beetles.

PLATE I

Degree of cotyledonous leaf injury	Rating
No injury	0
Slight injury	1
Moderate injury	2
Severe injury	3

As soon as symptoms appeared on the seedlings, individual plants were inspected and rated by the above key. The mean seedling injury was calculated by replications for each variety, then an over-all for each. In general, seedlings showing a mean degree of injury of equal to or more than 2.00 were regarded as susceptible and seedlings having a degree of damage less than 2.00 were regarded as fairly resistant.

EXPERIMENTAL RESULTS

Experiment One

Based on cotyledonous leaf and stem injury, the muskmelon varieties as a group were the most resistant, followed next by cucumber; watermelon was the most susceptible. However, there were variations within each group in cotyledonous leaf and stem injury.

Of the muskmelon varieties, both No. 6 and Gold Cup 55, were free from damage with 0.00 rating on both stems and cotyledonous leaves. Georgia 47 was the next most resistant with 1.66 rating on the cotyledonous leaves and 0.33 on stems compared with 2.33 and 0.00 on Cranshaw. However, thirteen percent of the Georgia 47 seedlings were injured with only ten percent for Cranshaw.

In the case of cucumber, there was little difference in the level of damage on cotyledonous leaves among the varieties Nappa 63 (1.16), MR 7097 (1.33), and Model (1.50). Moreover, there was no stem damage except for

Table I. Mean degree of injury to cotyledonous leaves and stems of cucumber, muskmelon, and watermelon seedlings by the spotted cucumber beetle, D. undecimpunctata howardi Barber, in the greenhouse, Fall, 1959.

Variety	No of seedlings evaluated	Average		
		Percentage of seedlings injured	Cotyledonous leaf injury *	Stem injury *
		Cucumber		
Nappa 63	60	31.6	1.16	0.00
MR 7097	60	13.3	1.33	0.25
Model	60	18.3	1.50	0.00
Palomar	60	23.3	2.00	0.66
		Muskmelon		
No. 6	60	00.0	0.00	0.00
Gold Cup 55	60	00.0	0.00	0.00
Georgia 47	60	13.3	1.66	0.33
Cranshaw	60	10.0	2.33	0.00
		Watermelon		
Charleston Gray	60	33.3	2.00	2.41
Hope Diamond	60	30.0	2.50	2.33
Blackstone	60	60.0	2.90	2.75
Black Diamond	60	68.3	3.25	3.08

* 0 - No injury; 1 - Slight injury; 2 - Moderate injury; and 3 - Severe injury.

MR 7097 which had a mean rating of 0.25. However, these varieties were more resistant than Palomar which had a damage rating of 2.00 on cotyledonous leaves and 0.66 on stems. The maximum number (32 percent) of the Nappa 63 seedlings were injured, Model (18 percent) was intermediate and MR 7097 the least (13 percent).

All watermelon varieties showed a definite damage on cotyledonous leaves as well as on stems. There was little difference in the level of damage on cotyledonous leaves among the varieties Charleston Gray (2.00), Hope Diamond (2.50), Blackstone (2.90), and Black Diamond (3.25). So far as stem injury on all four varieties was concerned, it was more or less the same as on cotyledonous leaves. In other words, the level of cotyledonous leaf and stem injury was the same in all the watermelon varieties. However, the varieties Charleston Gray and Hope Diamond had a smaller percentage (33 and 30 percent) of the seedlings injured when compared to Blackstone (60 percent) and Black Diamond (68 percent).

It appears that in the case of both muskmelon and cucumber the cotyledonous leaf injury was greater than on stems, but for watermelon there was a very little difference.

The undersurface of cotyledonous leaves received the greatest damage. On watermelon seedlings the damage was also common on the stems but very little stem injury was observed on the muskmelon and cucumber varieties such as Georgia 47, MR 7097 and Palomar. The beetles destroyed most or all the plants of some watermelon varieties as a result of severe damage to the undersurface of cotyledonous leaves and stems.

EXPLANATION OF PLATE II

Damage on cucumber, muskmelon and watermelon seedlings by the striped cucumber beetle.

PLATE II

Cucumber Seedlings

Muskmelon Seedlings

Watermelon Seedlings

Experiment Two

Results are in Table II. As indicated in Table II, the cucumber varieties as a group were more resistant than those of muskmelon varieties and the watermelon varieties were the most susceptible.

Among the four cucumber varieties, the mean damage ratings for cotyledonous leaves were 0.27 for Nappa 63, 0.58 for MR 7097, 0.63 for Palomar and 0.89 for Model. There was no significant difference among the four means. However, in the case of Nappa 63 the rating for some of the cotyledonous leaves went as high as 2.00 (Plate II) but only 80 percent of the seedlings were injured whereas in other varieties one hundred percent of the seedlings showed damage. So far as the stem injury was concerned, there was negligible damage on each variety, with the average ratings of 0.08, 0.20, 0.05, and 0.06 on Nappa 63, MR 7097, Palomar, and Model, respectively. As a whole, stem injury was lower than the cotyledonous leaf injury. In each variety almost all the seedlings showed some damage.

Of the muskmelon varieties, the cotyledonous leaves of Gold Cup 55 and No. 6 were least injured with the ratings of 0.59 and 1.00, respectively. There was no significant difference in the level of damage on cotyledonous leaves between these two varieties. These two varieties were followed next by Georgia 47 (1.90), and Cranshaw showed the most injury with the average damage of 2.32 on cotyledonous leaves. There was a significant difference in the level of damage between the varieties Gold Cup 55 and Georgia 47; No. 6 and Georgia 47; Cranshaw and Georgia 47; and Gold Cup 55 and Cranshaw. So far as the stem injury was concerned, Gold Cup 55 and No. 6 were free from injury with the rating of 0.00 whereas Georgia 47 had average stem injury of 1.20 and Cranshaw the lesser (0.61). However, the injury on cotyledonous

Table II. Mean degree of injury to cotyledonous leaves of cucumber, muskmelon, and watermelon seedlings by the striped cucumber beetle, in the greenhouse, spring, 1960.

Variety	No. of seedlings evaluated	Average cotyledonous leaf injury *
	Cucumber	
Nappa 63	36	0.27
MR 7097	36	0.58
Palomar	36	0.63
Model	36	0.89
	Muskmelon	
Gold Cup 55	36	0.59
No. 6	36	1.00
Georgia 47	36	1.90
Cranshaw	36	2.32
	Watermelon	
Hope Diamond	36	1.67
Charleston Gray	36	2.00
Blackstone	36	2.84
Black Diamond	36	2.94

* 0 - No injury; 1 - Slight injury; 2 - Moderate injury; 3 - Severe injury.

leaves was greater than stem injury in each case. As compared to Cranshaw (2.32), Georgia 47 (1.90) had less damage on cotyledonous leaves, but the stem injury was greater in Georgia 47 (1.20) than in Cranshaw (0.61) and still the stem injury was less than injury on cotyledonous leaves.

The watermelon varieties as a group were susceptible with Blackstone (2.84) and Black Diamond (2.94) showing the maximum susceptibility on the cotyledonous leaves among the four varieties. Hope Diamond and Charleston Gray showed average damages of 1.67 and 2.00, respectively, on cotyledonous leaves. However, there was no significant difference in the level of damage on cotyledonous leaves among the varieties Blackstone and Black Diamond, but there existed significant difference between the varieties Hope Diamond and Black Diamond, Hope Diamond and Charleston Gray, Charleston Gray and Blackstone, and Charleston Gray and Black Diamond. Over-all, the stem injury was less than the injury on cotyledonous leaves in each variety and the level of damage came in order of Hope Diamond (0.64), Charleston Gray (1.05), Blackstone (1.32) and Black Diamond (1.34) and this order was the same as found in the case of injury on cotyledonous leaves. A 100 percent of the seedlings of each variety were injured.

It is evident that in all three species of cucurbits the cotyledonous leaf injury was greater than the stem injury.

In case of the cucumber varieties, it was observed that the greatest damage was on the undersurface of cotyledonous leaves and near the margins. Also, the beetles chewed holes in the leaves in some cases. However, no significant difference in the regions of feeding on plants of the different varieties were noted. The third leaf was damaged by the final observation.

Damage to seedlings of all varieties of muskmelon was on the undersurface of the cotyledonous leaves but not on margins as on cucumber. Some holes were eaten in the cotyledonous leaves as in the cucumber seedlings. Also, the third leaf which appeared by the final observation was damaged.

Watermelon seedlings showed the most damage on the undersurface of the cotyledonous leaves (1.67, 2.00, 2.84, 2.94) and less on the stems (0.64, 1.05, 1.32, 1.34).

Within twenty minutes after the insects were released inside the cage they moved toward the plants most preferred and the damage was soon observed on undersurface of leaves of plants of Palomar and Model cucumber. After two days it was noted that the beetles were feeding on the varieties Hope Diamond, Blackstone, Nappa 63, Cranshaw, MR 7097, Palomar and Model for which the average ratings after two days were 0.00, 0.11, 0.11, 0.13, 0.17, 0.19, and 0.25, respectively. However, a maximum level of damage was found on Model (3.08), Palomar (2.33), MR 7097 (2.08), Cranshaw (1.66) and Blackstone (1.38), with a range of eight percent for Model to 31 percent of the seedlings injured for Blackstone, whereas during the final obseration almost all the seedlings in each variety showed some damage. After three days the beetles were feeding on almost all the seedlings of all the varieties.

Experiment Three

This was merely a repetition of experiment two, conducted for the purpose of obtaining additional information about each of the varieties tested in the previous experiment. Results from the final observations are shown in Table III.

As shown by the cotyledonous leaf injury the cucumber varieties as a group were the most resistant followed next by muskmelon with watermelon being the most susceptible. But due to non-consistency in the results obtained in this experiment, no significant difference in the level of damage on cotyledonous leaves among the three species could be established.

Table III. Mean degree of injury to cotyledonous leaves of cucumber, muskmelon, and watermelon seedlings by the striped cucumber beetle, in the greenhouse, Spring, 1960.

Variety	No. of seedlings evaluated	Average cotyledonous leaf injury *
	Cucumber	
Nappa 63	36	0.90
Palomar	36	1.05
MR 7097	36	1.52
Model	36	1.70
	Muskmelon	
Gold Cup 55	36	0.86
No. 6	36	0.98
Georgia 47	36	1.16
Cranshaw	36	2.26
	Watermelon	
Hope Diamond	36	1.88
Charleston Gray	36	1.99
Blackstone	36	2.87
Black Diamond	36	3.04

* 0 - No injury; 1 - Slight injury; 2 - Moderate injury; 3 - Severe injury.

The four cucumber varieties, Nappa 63, Palomar, MR 7097, and Model, were least affected with the average ratings of 0.90, 1.05, 1.52, and 1.70, respectively, on cotyledonous leaves, but from the results obtained there the differences were consistent among the varietiec. As indicated by the statistical analysis there was a significant difference in the level of injury between the varieties Palomar (1.05) and Model (1.70); Palomar (1.05) and MR(7097); MR 7097 (1.52) and Model (1.70); Model (1.70) and Nappa 63 (0.90); and MR 7097 (1.52) and Nappa 63 (0.90). The varieties Palomar and Model showed a mean stem damage of 0.02 and 0.08, respectively, with no stem injury on Nappa 63. But in the case of MR 7097 there was an average stem injury of 0.36. However, in each case the stem injury was much less than for the cotyledonous leaves. In each variety almost all the seedlings showed some damage.

Of the muskmelon varieties, Gold Cup 55 and No. 6 were least affected with an average level of injury of 0.86 and 0.98, respectively, on cotyledonous leaves. Georgia 47 (1.16) was second in resistance and Cranshaw was most susceptible with an average damage of 2.26 on the cotyledonous leaves. However, no stem injury was observed on Gold Cup 55 and No. 6. As in experiment two, Georgia 47 was less affected (1.16) than Cranshaw (2.26) on the cotyledonous leaves but the stem injury was greater in Georgia 47 (0.41) than for Cranshaw (0.08). However, in each variety the injury on cotyledonous leaves was prominent over the stem injury. Due to inconsistency in the results obtained in this experiment there was no significant difference in the level of damage on cotyledonous leaves among the four varieties.

The watermelon varieties which showed the least injury on the cotyledonous leaves were Hope Diamond (1.88) and Charleston Gray (1.99), whereas Blackstone and Black Diamond were the most injured with the ratings of 2.87 and 3.04, respectively. However, there was no significant difference in the level of damage between the varieties Blackstone and Black Diamond. As in experiment two, there was a significant difference in the level of damage on the cotyledonous leaves between the varieties, Hope Diamond and Black Diamond, Hope Diamond and Charleston Gray, Charleston Gray and Black Diamond, and Charleston Gray and Blackstone. The stem injury was less than cotyledonous leaf injury in each variety but the order of damage Hope Diamond (0.19), Charleston Gray (0.30), Blackstone (0.61), and Black Diamond (0.61), was the same as observed in the damage of cotyledonous leaves which ranked Hope Diamond (1.88), Charleston Gray (1.99), Blackstone (2.87), and Black Diamond (3.04), respectively; 100 percent of the seedlings were injured.

In all the three species, injury on the stem was less than on the cotyledonous leaves.

DISCUSSION OF RESULTS

This work has established the fact that there are certain varieties which may be used as resistant parents for breeding purposes. In the spotted cucumber beetle studies, the muskmelon varieties Gold Cup 55 and No. 6 showed no damage; the cucumber varieties, Nappa 63, MR 7097 and Model, and the muskmelon variety Georgia 47 were slightly injured. The varieties Palomar (cucumber), Cranshaw (Muskmelon) and the watermelon varieties Hope Diamond, Blackstone, Black Diamond showed the greatest damage.

Since only one experiment was conducted with the spotted beetle, evidence for comparison of injury between the two species is inconclusive.

In both of the striped cucumber beetle studies Nappa 63 was least affected and Model the most. MR 7097 and Palomar were intermediate. However, in the last experiment Palomar was less affected than MR 7097. This inconsistency of Palomar was not statistically significant. As indicated by the statistical analysis there was no significant difference in the level of damage among the cucumber varieties in experiment two, but in the last experiment a significant difference was found.

Results for the muskmelon varieties were similar in the two experiments. Gold Cup 55 was the most resistant whereas Cranshaw was least resistant. Since, the results in experiment two were not consistent, the statistical analysis indicated that there was no significant difference in the level of damage between the varieties Gold Cup 55 and No. 6. However, in the last experiment no significant difference was found among all the four varieties.

Experiments with the four watermelon varieties produced similar results in both cases with Hope Diamond being the most resistant and Black Diamond the least. There was a significant difference in the level of damage among all the four varieties in both the experiments. However, in both the experiments there was no significant difference in the level of damage between Blackstone and Black Diamond.

In experiment two, the cucumber varieties as a group were the least affected, the muskmelon varieties intermediate, and the watermelon varieties suffered the greatest damage. The three species differed significantly in the order given. Also in the last experiment, the order of level of damage among the varieties in each species was the same but due to consistency in the results obtained, there was no significant difference in the level of damage among the three species.

In both the experiments the order of level of damage follows the same pattern within each species. In other words, in both cucumber experiments, Nappa 63 was the least affected and Model the most. In the muskmelon experiments, Gold Cup 55 showed least damage whereas Cranshaw the most. Of the four watermelon varieties, Hope Diamond was the least damaged when compared to Black

Diamond which was most susceptible to the striped cucumber beetle. However, whatever may be the similarity between results of the two experiments in order of resistance or susceptibility among the varieties in each species, the actual level of damage in muskmelon and cucumber showed a reversal but there was a consistency in the varieties of watermelon in both experiments. In both the experiments, with the exception of Cranshaw all cucumber and muskmelon varieties had a damage rating of below 2.00. All of the watermelon varieties had an average rating damage above 2.00, except Hope Diamond and Charleston Gray of which the average damage rating were 1.77 and 1.99, respectively. This shows that Nappa 63, MR 7097, Palomar, Model, Gold Cup 55, No. 6, Georgia 47, and Hope Diamond were slightly to moderately resistant and Charleston Gray, Cranshaw, Blackstone, and Black Diamond were moderately to highly susceptible. Muskmelon and cucumber varieties were not so susceptible to the striped cucumber beetle under greenhouse conditions which may or may not be true under field conditions.

The statistical analysis of the detailed data from the second experiment indicated that there was a significant difference among the species so far as the susceptibility to the striped beetle was concerned but in the last experiment this statement was not true which may be explained as follows. The temperature had great effect on germination and growth of cucumbers, muskmelons, and watermelons and in each experiment, cucumber germinated earlier than muskmelon, and muskmelon earlier than watermelon. Here in the two experiments variation in temperature could not be avoided; in experiment two, the mean temperature recorded was 70 degrees F. and during experiment three, it was 90 degrees F. The number of days spent between the date of seeding and the two-leaf stage (when the insects were released inside the cage for feeding), were the same in the two experiments but the size of seedlings was greater with the rise in temperature in the later experiment. It seems that this change in size of seedlings influenced the amount of feeding. However, in all cases the studies were made with seedlings in the two-leaf stage. Another possibility may be that the temperature itself had an effect on the feeding habit of the beetles. Due to the above mentioned factors, there existed an inconsistency in the result of the last experiment so far as the difference in the level of damage between the three species was concerned, though the order of damage among the varieties in each species ranked the same. It is difficult to give any explanation of the fluctuation without further experimentation.

Results pertaining to the area of damage to plants support the statement made by Britton (3) and Rolston (19) that in general the striped cucumber beetles prefer to feed on epidermis of the undersurface of leaves. Obviously the beetles prefer to hide under the leaf while feeding. There might be some difference in the chemical constituents of the lower and upper epidermis of leaves, but it appears more likely to be an ecological factor related to light, since the beetles tend toward a shaded habitat. Also, the beetles chewed holes on leaves of cucumber and muskmelon plants which agrees with the statement made by Metcalf and Flint (16). In case of watermelons, the stem damage was also on epidermal tissues.

Also, the larger seeds of watermelon as compared to cucumber and muskmelon, cracked the soil at the time of germination which allowed the beetles to hide under a clod of soil and feed on the stem early.

Soon after the insects were released inside the cage, the cucumber varieties, Palomar and Model were preferred most by the striped beetle which agrees with the result obtained by Houser and Balduf (11). But, as a whole, the total amount of damage was relatively smaller on cucumber as compared to watermelon plants.

SUMMARY AND CONCLUSION

In studies on resistance to the striped cucumber beetle there was little difference among the cucumber varieties Nappa 63, Palomar, MR 7097, and Model so far as the level of resistance was concerned. All varieties were fairly resistant with Nappa 63 being the most resistant. In muskmelon, Gold Cup 55 and No. 6 were highly resistant, Georgia 47 fairly resistant and among the four varieties Cranshaw was most susceptible.

There was no significant difference in the level of damage by the striped cucumber beetle between the watermelon varieties Blackstone and Black Diamond. However, these two varieties were highly susceptible. Hope Diamond was fairly resistant as compared to Charleston Gray which was slightly resistant.

Black Diamond, Blackstone and Cranshaw were the most susceptible to the striped cucumber beetle among the twelve varieties of the three species under test, whereas Nappa 63, Gold Cup 55 and No. 6 were highly resistant. There was little difference in the level of resistance between cucumber and muskmelon with the exception of Cranshaw and the average damage on both was below 2.00.

In all three species, the undersurface of the cotyledoncus leaves were the most preferred area for feeding by the striped cucumber beetles. In the watermelon varieties, stem damage was also common. There was slight damage to the resistant varieties which indicated the lack of immunity. Model and Palomar were most preferred.

Studies with the spotted cucumber beetle in the greenhouse indicated that all watermelon varieties, i.e., Hope Diamond, Charleston Gray, Blackstone, and Black Diamond, were susceptible. The muskmelon and cucumber varieties were fairly resistant. No. 6 and Gold Cup 55 were found to be entirely free of damage. Most of the damage occurred on undersurface of the leaves. In the case of the watermelon varieties, stem damage was also severe.

ACKNOWLEDGMENTS

The author desires to express his sincere and heartfelt thanks to Dr. Wm. F. Pickett, Head of the Department of Horticulture for the facilities provided for conducting this research and for his advice and encouragement.

Much gratitude is due to Dr. C. V. Hall, the author's major instructor for his able guidance and valuable suggestions in the conduct of the investigation and above all in the selection of the problem which is of much use in India.

The author also wishes to express his sincere feelings of gratitude to Mr. Gary Krause, for his assistance in the statistical interpretation of the data.

Many sincere thanks are due to every member of the Department of Horticulture for their cooperation and material assistance.

Finally, the author wishes to acknowledge the grateful thanks to his Government for the grant of leave which enabled him to come to the United States for advanced study.

LITERATURE CITED

1. Barber, H. S.
Diabrotica and two new genera (Coleoptera, Chrysomelideae), Proc. Ent. Soc. Wash. 49 (6) :151-57, 1947.

2. Bradfield, K. W.
Melon Protection pays in Gibson County, Indiana, Ag. Newsletter 23(3) :55-56, May-June, 1955.

3. Britton, W. E.
Insects attacking cucurbitaceous plants in Connecticut, Conn. Ag. Expt. Sta. Rept. 1907-8 :805-9, 1908.

4. Frank, W. D. and L. E. Peterson
Some effects of treating muskmelons with insecticides, J. Econ. Ent. 47 (5) :807-11, 1954.

5. Garman, H.
Enemies of cucumber and related plants, Ky. Ag. Expt. Sta. Bul. 91, 1901.

6. Gould, G. E.
The biology and the control of the striped cucumber beetle, Purdue Univ. Ag. Expt. Sta. Bul. 490, 1944.

7. Gould, G. E.
Varietal susceptibility of cucurbits to cucumber beetle attack, Ind. Acad. Sci. Proc. 68, 1958 :186-89, 1959.

8. Harries, F. H. and H. Matsumori
Tests of insecticides for control of cucumber beetle in Ohio, J. Econ. Ent. 49 (1) :131-33, 1956.

9. Haseman, L.
Controlling insect pests of melons, cucumber, and related crops, Mo. Ag. Expt. Sta. Bul. 391 :3-9, 1937.

10. Haseman, L.
Observations on the wintering habits of the striped cucumber beetle, J. Econ. Ent. 24 :486-90, 1931.

11. Houser, J. S. and W. V. Balduf
The striped cucumber beetle, Ohio Ag. Expt. Sta. Bul. 388, 1925.

12. Isley, D.
The striped cucumber beetle, Ark. Ag. Expt. Sta. Bul. 216, 1927.

13. Lowry, O. S.
The striped cucumber beetle, Conn. Ag. Expt. Sta. Bul. 203 :262-73, 1917.

14. Marcovitch, S.
Control of insect enemies of melons, cucumbers and squash, Tenn. Ext. Servi. Pub. 115, 1931.

15. Marsh, H. O.
Biologic notes on species of Diabrotica in Southern Texas, USDA, Bur. Ent. Bul. 82 (4) :82-84, 1910.

16. Metcalf, C. L. and W. P. Flint
Insects injurious to cucurbits, Destructive and Useful Insects, their habits and Control, McGraw-Hill Book Co., 1939 :494-97.

17. Painter, R. H.
Resistance of plants to insects, Ann. Rev. Ent. 3 :267-90, 1958.

18. Quaintance, A. L.
Some important insect enemies of cucurbits, Ga. Ag. Expt. Sta. Bul. 45, 1899.

19. Rolston, L. H.
Control of Pickle pests, Ark. Farm. Res. 8 (2) :p. 6, 1959.

20. Starnes, H. N.
Watermelons, Ga. Ag. Expt. Sta. tenth rept., p. 83, 1897.

21. Smith, R. I.
Insect enemies of Cantaloupes, cucumbers and related plants, N. Carolina Ag. Expt. Sta. Bul. 205, 1910.

RESISTANCE OF CUCURBIT SEEDLINGS TO CUCUMBER BEETLE FEEDING

by

PREM NATH

B.S., Agriculture, University of Bihar, India, 1958

AN ABSTRACT OF
A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1960

The spotted cucumber beetle, D. undecimpunctata howardi Barber, and the striped cucumber beetle, A. vittata (F.), are among the most injurious insect pests of cucurbits in the United States. In some of the cucurbit growing areas as much as 70 percent loss of cucurbits has been reported.

Various control measures have been used by workers since they were reported as injurious pests in 1841. The methods used were mechanical and chemical protectors, repellents, inorganic and organic insecticides but from all of them no satisfactory control has been developed. Since World War II, many new insecticides have been developed but as yet none are completely satisfactory.

The level of resistance of four varieties each of cucumber, muskmelon, and watermelon to the cucumber beetles was determined in the greenhouse. Included among each group of varieties were those which had shown resistance and susceptibility in the field. It was hoped that strains might be used in breeding programs.

In the fall of 1959, spotted cucumber beetles, which were collected from the Horticultural Farm, were used in the first experiment. However, in the spring of 1960 only the striped cucumber beetles could be collected and were used in the last two experiments. They were collected from a nearby grower's hotbed which contained cucurbit seedlings being raised for transplanting and from Ashland Horticultural Farm.

From the first experiment it was found that muskmelon varieties as a group were more resistant than the cucumber varieties and watermelon varieties were the least resistant. The muskmelon varieties, Gold Cup 55 and No. 6 were free from damage.

The second and third experiments were conducted in the greenhouse in the spring of 1960, using the same host varieties but the beetle used was a striped one instead of the spotted beetle used in the first experiment. It was observed that the cucumber varieties as a group were the more resistant, followed next by the muskmelon, and lastly the watermelon varieties. There was no significant difference in the level of resistance among the four cucumber varieties, Nappa 63, Palomar, MR 7097, and Model. Among the muskmelon varieties, Gold Cup 55 was the most resistant and Cranshaw the least; No. 6 and Georgia 47 were intermediate. Among the watermelon varieties, Blackstone and Black Diamond were the most susceptible with Nappa 63 and Gold Cup 55 the most resistant.

For the spotted cucumber beetle the order of resistance from high to low was muskmelon, cucumber, and watermelon, whereas for the striped beetle the order was cucumber, muskmelon and watermelon.

Since chemical control has failed to provide a satisfactory solution to the problem, efforts in this study were directed toward host plant resistance.