PERFORMANCE AND HOST PREFERENCE OF ADULT BANDED CUCUMBER BEETLES, *DIABROTICA BALTEATA*[1] WHEN OFFERED SEVERAL CROPS[2]

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Abstract: Fifteen crop plants were evaluated to determine performance and host preference of adult banded cucumber beetles (BCB), *Diabrotica balteata* LeConte. They were broccoli and cauliflower (Cruciferae), potato, bell pepper and tomato (Solanaceae), bush bean, hyacinth bean, soybean, pea and peanut (Leguminosae), sweet corn (Graminae), beet (Chenopodiaceae), and three varieties of sweet potato (Convolvulaceae). In no-choice tests, greatest fecundity and longevity occurred on broccoli, cauliflower, and potato, even though equal or greater amounts of leaf tissue were consumed on soybean, three varieties of sweet potato, bell pepper, bush bean, and tomato. No eggs were laid on sweet corn, peanut, or hyacinth bean. In multiple-choice tests, broccoli, bell pepper, cauliflower, and bush bean were more preferred for feeding by BCB adults than potato and the other plants, but BCB adults laid most eggs on potato, tomato, sweet corn, bush bean, and 'Morado' (sweet potato). Elytral color remained yellow for adults feeding on the legumes and on beet, but on the other plants the elytra turned green among various percentages of adults.

Key Words: *Diabrotica balteata*, banded cucumber beetle, host preference, resistance, fecundity, longevity.

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The banded cucumber beetle (BCB), *Diabrotica balteata* LeConte, has historically been a serious threat to potato production in Dade County, FL. The larvae feed on the tuber, causing the potato to be scarred or, if the damage occurs near harvest, subjecting the potato to infection by rot organisms. Until recently, BCB had been adequately controlled for the first 30 - 45 d of the crop by systemic insecticides applied to the soil at planting and, during the remainder of the season, by foliar insecticides applied to control the green peach aphid, *Myzus persicae* (Sulzer). With the development of economic thresholds for *M. persicae*, the number of sprays for it has been substantially reduced. Subsequently, damage to the tubers from BCB larvae has increased. It is not desirable to treat only for BCB adults because this involves the use of broad spectrum insecticides that often cause outbreaks of a secondary pest, the vegetable leafminer, *Liriomyza sativae* Blanchard. Therefore, it would be highly desirable to reduce the BCB population by other means such as habitat manipulation, varietal resistance or use of trap crops.

Preferences for varieties of corn, cantaloupe, cowpea, and sweet potato by BCB have been studied (Melhus et al. 1954; Cuthbert and Jones 1972; Overman and MacCarter 1972; Risch 1976). Overman and MacCarter (1972) studied 10

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varieties of cantaloupe for host preference and found LA-39-1 was most preferred by the BCB adults. Jewel, Centennial, and L1-193 varieties of sweet potato were susceptible to wireworm-*Diabrotica-Systena* complex which included *D. balteata* larvae (Cuthbert and Jones 1972; Jones et al. 1980). Da Costa and Jones (1971) found that varieties of cantaloupe containing cucurbitacin B were most attractive to BCB adults, followed closely by the varieties which contained cucurbitacin A. BCB adults have been found to feed on 56 species of plants (Teng 1983). In one of the few studies of host preferences, Risch (1976) found that bush bean was much more preferred than cowpea by BCB adults. Saba (1970) studied oviposition and egg viability of BCB adults fed on 22 families of plants. Harries (1975) found that bush bean, *Phaseolus vulgaris* Linnaeus, and soybean, *Glycine max* (L.) Merr., were preferred by *D. balteata* and that the beetles were rarely found on peanut, *Arachis hypogaea* L., cotton, *Gossypium hirsutum* L., rice, *Oryza sativa* L., or sorghum, *Sorghum bicolor* (L.) Moench.

The objective of this study was to evaluate feeding and ovipositional suitability in a no-choice situation and feeding and ovipositional preferences in a multiple-choice situation for several host plants by BCB adults. Preferences for these hosts were compared to that for potato to determine if a trap crop could be found for use in potato production.

MATERIALS AND METHODS

Feeding, Longevity, and Fecundity

BCB adults were collected from bush bean, *P. vulgaris*, and lima bean, *P. lunatus* L., fields at Homestead, FL, and were held in 30.5 × 30.5 × 30.5 cm wire mesh cages under laboratory conditions of 27°C and 50% RH. One thousand to fifteen hundred adults were kept per cage (Cuthbert et al. 1968). Cabbage and squash served as host plants and cheesecloth served as oviposition substrate. Eggs were washed from the cheesecloth, then left on moist paper towels in a petri dish (25 × 150 mm) for 4 d. Germinated corn, *Zea mays* L., seed, cv. Golden Bantam, was used to raise larvae in a crisper. Larvae (10 - 12 d old) were transferred to a crisper in which there was a mixture of germinated corn seed and peat, and were allowed to pupate in the peat. After 12 - 15 d, adults started to emerge.

Of the 12 species of plants used in these experiments (Table 1), all except hyacinth bean, *Dolichos lablab* L., have been recorded as host plants of BCB. These greenhouse grown test plants were fertilized twice a week with a solution of 20-20-20 (N-P-K) and were free from insecticides and fungicides. The plants were used at 1 to 2 months of age.

All BCB tested were from the first generation of the laboratory colony. Separate pairs were kept in 100 × 15 mm petri dishes which were held upside down with small holes in the top to minimize moisture condensation. Wet 32-layered cheesecloth served as an oviposition site and to maintain moisture for the leaf. Pairs were given leaves of only one plant species or variety and each test plant was replicated 20 times. Fresh leaves were supplied every 2 - 3 d. For the first 11 d, a portable area meter was used to measure daily leaf consumption. Because leaf thickness of the plants varied, leaf area measurements were converted to leaf dry weight. This was done by measuring the area of several fresh leaves from each test plant, oven drying them overnight, and then weighing them. Based on this information, dry weight per cm^2 of leaf area was calculated for each test

Table 1. Plants used in host preference studies of *Diabrotica balteata.*

Scientific name	Variety	Common name
Monocotyledoneae		
Graminae		
Zea mays L.	Golden dent	Sweet corn
Dicotyledoneae		
Chenopodiaceae		
Beta vulgaris L.	Detroit dark red	Beet
Convolvulaceae		
Ipomoea batatas (L.) Lam.	Morado	Sweet potato
I. batatas (L.) Lam.	Picadita	Sweet potato
I. batatas (L.) Lam.	w-115	Sweet potato
Cruciferae		
Brassica oleracea botylis L.	Burpeeana	Cauliflower
B. oleracea italica L.	De cicco	Broccoli
Leguminosae		
Arachis hypogaea L.		Peanut
Dolichos lablab L.		Hyacinth bean
Glycine max (L.) Merr.	Williams	Soybean
Phaseolus vulgaris L.	Sprite	Bush bean
Pisum sativum L.	Miragreen	Pea
Solanaceae		
Capsicium annuum gassum Sendt	California wonder	Bell pepper
Solanum lycopersicum L.	Flora-Dade	Tomato
S. tuberosum L.	Caribou	Potato

plant. The adjusted data of dry food consumption, longevity (recorded every d) and fecundity (recorded every 4 d) were analyzed by analysis of variance, general linear model procedure, and Duncan's multiple range test for differences among plants.

Multiple Choice Feeding

The adult *D. balteata* used in this test were collected with a sweep net from yellow squash, *Cucurbita pepo* L., fields at Homestead, FL. The 12 plant species used in the first experiment (Table 1) also were used in this test. Each petri dish (57 × 10 mm) had 32-layered cheesecloth on the bottom and an excised leaf from one of the test plants. Sixteen petri dish bottoms (15 test plants and one cheesecloth-only check group) were placed randomly within a 30.5 × 30.5 × 30.5 cm wire mesh cage and exposed to 100 adults (50 males and 50 females) to allow the beetles to choose their food and oviposition sites. The petri dishes were changed daily for 5 consecutive days. A portable area meter was used to measure the amount of leaf eaten. Leaf consumption and fecundity were recorded daily. This test was replicated three times. Analysis of variance, general linear model procedure, and Duncan's multiple range test were used to test for differences in preference among test plants.

RESULTS AND DISCUSSION

No-choice Feeding

In a no-choice situation, significantly more soybean was consumed by the BCB adults compared to the other host plants (Table 2). In comparison to potato, significantly greater amounts of soybean, the three varieties of sweet potato, bell pepper, bush bean, broccoli and tomato were eaten, whereas significantly lesser amounts of beet, pea, sweet corn, peanut and hyacinth bean were eaten. There was no significant difference between the amount of potato and cauliflower consumed (Table 2).

Table 2. Leaf consumption and longevity by *D. balteata* when offered only one plant.

Plant	Amount eaten (mg/d)*	Longevity (d)*
Soybean	13.1 a	21.7 e
Morado (sweet potato)	10.0 b	21.3 e
Bell pepper	9.0 bc	55.1 c
w-115 (sweet potato)	8.8 bc	19.7 ef
Picadita (sweet potato)	8.4 c	18.9 ef
Bush bean	7.9 cd	35.1 d
Broccoli	7.1 de	87.6 a
Tomato	6.7 e	31.6 d
Potato	6.5 f	87.5 a
Cauliflower	5.2 f	64.6 b
Beet	3.9 g	19.7 ef
Pea	3.1 gh	31.1 d
Sweet corn	3.0 gh	15.5 efg
Peanut	2.2 hi	9.8 fg
Hyacinth bean	1.8 i	7.7 fg

* Means not followed by the same letter are significantly different ($P = 0.05$) by Duncan's multiple range test.

Saba (1970) found that the edibility of plants by BCB adults when offered only one plant fell into three groups: most preferred were sweet potato, beet, broccoli, peanut, soybean, pea and bush bean; intermediate preference was exhibited toward sweet pepper, tomato, corn and cauliflower; and least preferred was potato. Thus, the relative ranking of edibility for several of these plants is similar between our study (Table 2) and Saba's. However, there are some substantial differences between the two studies, especially for the edibility of peanuts and pea (high in Saba's study and very low in our study), and potato (low edibility in Saba's study but intermediate in our study). Use of different host varieties (Saba did not indicate the varieties he studied) and different aged plants may have contributed to these differences.

Mean adult longevity (Table 2) was greatest on broccoli and potato, but some BCB on cauliflower and bell pepper also lived greater than 100 d (Fig. 1). However, daily consumption of tomato, bush bean, the three varieties of sweet potato and soybean was greater than or equal to that of broccoli and potato (Table 2). These results suggest that unfavorable, nutritional and/or allelochemical composition of the latter plants reduces BCB longevity in spite of considerable food consumption. The especially steep survivorship curves for BCB on hyacinth

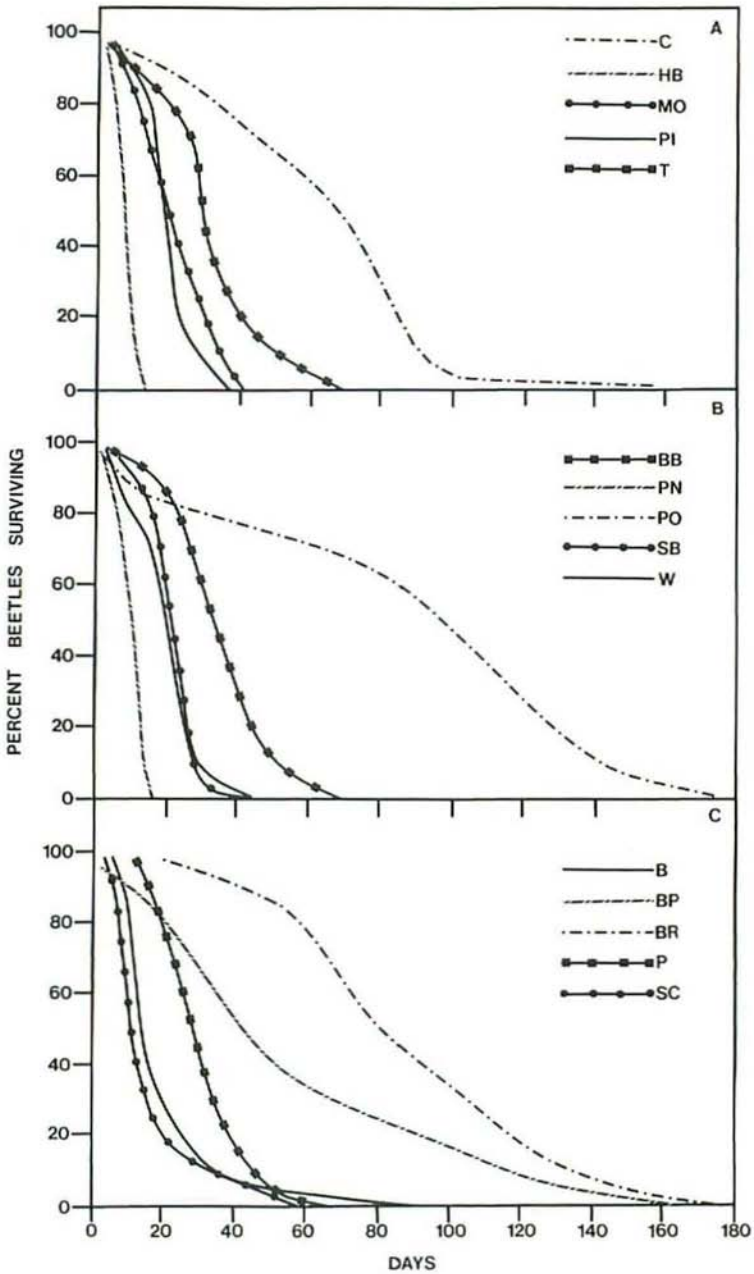

Fig. 1. Adult longevity of *Diabrotica balteata* when fed on: [A] cauliflower (C), hyacinth bean (HB), morado (MO), picadita (PI), or tomato (T); [B] bush bean (BB), peanut (PN), potato (PO), soybean (SB), or w-115 sweet potato (W); and [C] beet (B), bell pepper (BP), broccoli (BR), pea (P), or sweet corn (SC).

bean and peanut (Fig. 1) are associated with very low consumption of these plants (Table 2), suggesting that death through starvation occurred. However, this cannot be confirmed because the longevity of starved, newly emerged BCB adults was not determined. Although consumption of sweet corn, pea and beet was also very low (Table 2), a few adults on these plants were able to live longer than 50 d (Fig. 1).

Fecundity ranged widely, both between plant species and varieties and on any one plant species (Table 3). Greatest mean fecundity occurred for females on broccoli (where all females laid eggs), but high fecundity also occurred for some females on cauliflower, potato and, to a lesser extent, bell pepper. On these and the other plants, there were some females that never oviposited (Table 3). No females on sweet corn, peanut or hyacinth bean oviposited, which was in accord with low consumption (Table 2) and greatly reduced longevity (Table 2 and Fig. 1), on these plants.

Table 3. Fecundity of *Diabrotica balteata* on different host plants when offered only one host plant.

Treatment	No. eggs/female*		% Females laying eggs
	Range	Mean	
Broccoli	205-1938	963.3 a	100
Cauliflower	0-1581	594.1 b	90
Potato	0-1067	570.5 b	77
Bell pepper	0- 883	265.2 c	75
Bush bean	0- 326	138.3 d	81
Tomato	0- 362	111.9 de	73
Morado (sweet potato)	0- 332	64.0 de	35
Picadita (sweet potato)	0- 270	59.8 de	48
Beet	0- 722	48.9 de	21
Soybean	0- 144	38.1 de	40
w-115 (sweet potato)	0- 121	28.2 de	47
Pea	0- 105	24.2 de	53
Sweet corn	0	0.0 e	0
Peanut	0	0.0 e	0
Hyacinth bean	0	0.0 e	0

*Means within a column not followed by the same letter are significantly different ($P = 0.05$) by Duncan's multiple range test.

Elytral Color Change

The elytral color of newly emerged adults was yellow or olive. For adults feeding on Leguminosae (bush bean, pea, hyacinth bean, peanut and soybean) and Chenopodiaceae (beet), elytral color remained yellow, whereas green bands developed on the elytra of 5 to 100% of the adults feeding on the other plants (Convolvulaceae: the three varieties of sweet potato; Cruciferae: broccoli and cauliflower; Graminae: sweet corn; and Solanaceae: bell pepper, potato and tomato) (Table 4). The change to green occurred fastest and in the greatest percentage of adults for BCB feeding on sweet potato (Morado and w-115) and cauliflower; on the other plants, the change in color took longer to occur and less BCB exhibited the change (Table 4).

Table 4. Elytral color change of *Diabrotica balteata* when fed as adults on different host plants.

Plant	% Change from yellow to green	Mean No. d to change
Chenopodiaceae		
Beet	0	–
Convolvulaceae		
Morado (sweet potato)	100	1.7
Picadita (sweet potato)	40	7.8
w-115 (sweet potato)	97	5.2
Cruciferae		
Broccoli	75	24.2
Cauliflower	100	5.4
Graminae		
Sweet corn	40	12.6
Leguminosae		
Bush bean	0	–
Pea	0	–
Hyacinth bean	0	–
Peanut	0	–
Soybean	0	–
Solanaceae		
Bell pepper	25	10.4
Potato	25	7.4
Tomato	5	12.0

Multiple Choice Feeding

When given a choice among all 15 species and varieties of plants, BCB adults consumed broccoli and bell pepper the most, followed closely by cauliflower and bush bean, and then potato and beet (Table 5). Low consumption of the other plants occurred, especially hyacinth bean and sweet corn. Because of high variability in ovipositional preference, only the values for potato and tomato were significantly different from the cheesecloth check (Table 5). However, in addition to these two plants, there seemed to be some ovipositional preference for sweet corn, bush bean and sweet potato (Morado) (Table 5). This apparent preference for sweet corn was especially surprising, because of the small amount of this plant eaten in the choice test (Table 5) and the overall poor performance on this plant in the no-choice test (Tables 2 and 3). Risch (1980) found that BCB larvae showed a preference for sweet corn over bean.

CONCLUSION

Overall, BCB did not show a particular specialization to, or preference for, plants in any one family. The two species in the Cruciferae (broccoli and

Table 5. Leaf consumption and eggs laid per d over a 5-d period per cage in which 50 male and 50 female *Diabrotica balteata* had the chance to choose among all the plants.

Treatment	Amount eaten (cm^2)*	No. eggs
Broccoli	8.25 a	9.3 bc
Bell pepper	8.00 a	2.1 c
Cauliflower	6.90 b	2.9 c
Bush bean	6.35 b	11.3 abc
Potato	4.53 c	24.8 a
Beet	3.74 c	9.6 bc
Picadita (sweet potato)	1.33 d	8.8 bc
Tomato	1.22 de	20.5 ab
Soybean	1.03 de	2.5 c
Morado (sweet potato)	0.97 de	10.6 abc
w-115 (sweet potato)	0.69 de	1.1 c
Pea	0.52 de	0.0 c
Peanut	0.27 de	7.9 bc
Hyacinth bean	0.04 e	0.0 c
Sweet corn	0.02 e	15.4 abc
Check	–	0.3 c

* Means within a column not followed by the same letter are significantly different ($P = 0.05$) by Duncan's multiple range test.

cauliflower) produced high fecundity and longevity in the no-choice test, and high consumption in the choice test, but little ovipositional preference was exhibited in the choice test. BCB performance on bush bean tended to rank at the top of the Leguminosae, and reasonably high among all of the plants tested, whereas performance on hyacinth bean was so consistently low in both the no-choice and choice tests that we conclude it is probably not a food or ovipositional plant for BCB adults. Among the Solanaceae, longevity and fecundity of adults on potato and bell peppers were near the top of the list for all plants in the no-choice test. In the choice test, these two plants were also readily consumed, but only potato was highly preferred for oviposition. Performance and preference for the three varieties of sweet potato among Convolvulaceae ranged from intermediate to low. The only member of the Chenopodiaceae tested, beet, supported intermediate BCB performance in the no-choice test and intermediate feeding and ovipositional preference in the choice test. Finally, longevity and fecundity on Graminae, sweet corn, was very low in the no-choice test, but ovipositional preference of BCB for sweet corn in the choice test ranked high.

Several dramatic differences were observed in BCB performance between the no-choice and choice tests. For example, tomato supported only intermediate fecundity and sweet corn supported no oviposition in the no-choice test, whereas in the choice test these two plants seemed to be highly preferred for oviposition. Results such as these suggest that data from no-choice experiments are of questionable value in determining "relative host preference" of a particular insect species.

No plant was more attractive than potato for BCB oviposition in the choice test, suggesting that none of the tested plants would be a good candidate for a trap plant for ovipositing females. Field tests are needed to test this hypothesis. Judging by the high amounts of broccoli and bell pepper eaten in the choice test compared to potato, however, there is the possibility that these two species could serve as trap plants, attracting newly emerged adult BCB in search of food away from a potato crop. If adult females remained on these trap plants during most of the duration of their preovipositional period [ca. 12 d at the least, at 27°C, (Teng 1983)], then possibly they could be treated in some manner to prevent their movement into the potato crop. Field testing of this hypothesis is, however, required before such a technique is recommended for BCB management on potato crops.

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