Evaluation of Vegetable Soybean Genotypes for Resistance to Corn Earworm (Lepidoptera: Noctuidae)[1]

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ABSTRACT Petri dish bioassays were used to evaluate terminal foliage from 47 field-grown genotypes of vegetable-type soybean, *Glycine max* (L.) Merrill, from maturity groups III through VIII, for resistance to corn earworm, *Helicoverpa zea* (Boddie), in 1993 and 1994. Larvae reared on "Sato", IAC 100, V89-1301, V89-1563, and V88-100 had low mean weights, not significantly different from resistant controls. However, larval weights ranged from moderate to high on most vegetable-type soybeans. The most susceptible genotypes were "Geulph", PI 561291, and "Rokusun", followed by "Kanrich", "Kura", "Camp", "Wolverine", G2246, G4032, "Kim", "Hahto", PI 561294, N2962, and D71-V89. Mortality averaged 2.9% in 1993 and 13.5% in 1994, but was not generally useful in evaluating resistance within maturity groups. High percent mortality and low weights of larvae reared on both resistant and susceptible genotypes in maturity group VII/VIII in 1994 may have been related to the use of insect-damaged foliage. Soluble leaf sugar was determined in 1994 samples and ranged from 0.50% (PI 416868-B) to 1.04% (PI 561291) of dry weight. A small but significant positive correlation (r = 0.20, P = 0.009) was found between sugar content and larval weight in maturity groups III through VI. Exceptional low larval weights in maturity groups VII and VIII were not related to leaf sugar content.

KEY WORDS Vegetable soybean, Antibiosis, Insect Resistance, *Helicoverpa zea*

Soybean, *Glycine max* (L) Merrill, has been a major component of Asian diets for centuries and is now being developed in the United States for both export and domestic needs. The health benefits associated with soybean consumption include a reduction in cholesterol levels (Carroll and Kurowska 1994) and a decrease in certain types of cancers (Messina et al. 1994). In addition, soybean provides an inexpensive protein source for a growing world population.

The term "vegetable soybean" usually refers to soybean consumed in the green pod stage (edamame). Herein, a vegetable-type soybean is defined as any genotype that is either used for human consumption or has specific traits

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desired by consumers. This includes genotypes and traits used for tofu, sprouts, natto (fermented whole beans),or miso (fermented soup base). Vegetable-type soybeans have important characteristics that are specific to the product: flavor, texture, sugar and/or protein content, nutritional content, seed color, and seed size. The Chinese prefer large-seeded (25 to 50 g/100) varieties with yellow seed coats for edamame. Small-seeded (<10g/100) types are preferred for sprouts, tofu, and fermented products (Floyd et al. 1990).

Vegetable-type soybeans should be evaluated for resistance to insect pests to reduce dependence on pesticides, lower production costs, and improve pod quality. An earlier study found many vegetable-type soybean cultivars to be susceptible to defoliation by Mexican bean beetle, *Epilachna varivestis* Mulsant (Kraemer et al. 1994). These cultivars may be susceptible to other defoliating insects because resistance in soybean is often expressed against multiple pest species (Clark et al. 1972, Luedders and Dickerson 1977, Turnipseed and Sullivan 1976).

Corn earworm (*Helicoverpa zea* Boddie) is the most serious pest of soybean in much of the mid-Atlantic and southern coastal plain (Stinner et al. 1980). The moth is attracted to soybean at the time of flowering (Johnson et al. 1975) where it prefers to oviposit on developing new foliage (Eckel et al. 1992). Small larvae are found in even greater density on young foliage, perhaps because of protection provided by rolled leaves. Later migration of older larvae to the developing pods may cause severe economic loss. The present two-year study was conducted to evaluate vegetable-type soybean for antibiosis to corn earworm.

Materials and Methods

Soybean Accessions. Terminal foliage of 68 soybean accessions in maturity groups III through VIII was evaluated for resistance to corn earworm during the early flowering stage. Vegetable-type selections included 17 cultivars, 12 plant introductions (PIs), 1 forage crop (FC), 9 breeding lines, and 13 genotyes provided by Taiwan (ROC) and China (PRC) through a 1991 USDA/OICD sponsored visit. Five of the Chinese genotypes were assigned PI numbers by the USDA: 561287A, 561289, 561291, 561293, and 561294, whereas the remaining eight are AGS-129, IAC-100, G2246, G4032, N1535-1, N2962, N7788, and N8806. Selection of the other PIs from the USDA soybean germplasm collection was based on vegetable-type traits, nutritional importance, resistance to insects, and/or tolerance of ozone (Kraemer et al. 1994). The large-seeded breeding lines, D71-V86 and D71-V89, and V-series in maturity group V, were provided by Edgar Hartwig (USDA-ARS) and Glenn Buss (Virginia Polytechnic Institute and State University), respectively.

Resistant controls were included in all maturity groups. These included PIs with multiple insect resistance to defoliation (PIs 171451, 227687, and 229358), and breeding lines (HC-83-123-9 and HC-83-46-1) and a cultivar (Lamar) developed from these resistant accessions (Cooper and Hammond 1988, Hartwig et al. 1990). PI 416868-B (maturity group III) and PI 36906 (maturity group VI) were selected as "resistant controls" solely from previous field evaluations of Mexican bean beetle defoliation (Kraemer et al. 1988, 1990, 1994). The Mexican bean beetle evaluations were also used to select susceptible controls: PIs 399055 and 398972 (maturity group V), 201422 (maturity group VI), 181565 (maturity group VII), and 417134 (maturity group VIII).

Field Plot Design and Petri Dish Evaluations. With one exception, each maturity group was planted separately to allow comparisons within the same growth stage. Maturity groups VII and VIII were combined because flowering date and maturity were similar at our location, and only three maturity group VIII accessions were included: PIs 227687, 417061 and 417134

The following experimental design was used in both 1993 and 1994. Soybean accessions were planted in 1.8 m rows, 28 seeds/m, with 0.9-m spacings and 1.5 m between furrows. All maturity groups were planted during the last week of May in a randomized complete block design with three replications. Foliage was collected when all plants in a maturity group had reached the flowering stage. Half to fully expanded terminal trifoliates were excised, placed in plastic ziplock bags, and transported to the laboratory in a cooler. The trifoliates were separated into leaflets with petioles removed and placed in 150 × 15 mm plastic Petri dishes lined with moistened Whatman #2 filter paper. Four Petri dishes were used per accession per replication, for a total of 12 Petri dishes per accession. Two neonate corn earworm larvae were placed onto the foliage in each Petri dish to allow for possible first instar mortality unrelated to leaf antibiosis. The Petri dishes were then held in an environmental chamber at 25°C and a 14:10 (L:D) photoperiod. Although relative humidity within the environmental chamber was not controlled (50 to 60%) the filter paper within each Petri dish was kept moist with approximately 1 ml of water every other day. The number of larvae per Petri dish was reduced to one after 4 to 5 days. After 10 days the larvae were weighed and mortality was determined. When more than one corn earworm larva was found in a Petri dish, probably from eggs brought in on the foliage, the largest larva was selected for analysis.

Sugar Analysis. Samples of foliage collected for the 1994 Petri dish assay were freeze-dried and ground to pass through a 20-mesh screen. The procedure for the extraction of soluble sugar was similar to the method described by Ciha and Brun (1978). Fifty ml of extracting solution [glacial acetic acid: methanol: water, 1:4:15 (v/v/v)] was added to 0.5 g dry leaf tissue and heated to boiling in a water bath for 1 h. After vacuum filtration and wash, total soluble sugar was quantified using the phenolsulfuric acid assay (Dubois et al. 1956) with absorbance measured at 490 nm. Glucose was used as a standard, and data are expressed as percent of dry weight.

Statistical Analysis. Data were analyzed using SAS/STAT software (SAS Institute 1990). Analysis of variance was performed with the general linear model procedure (PROC GLM) for larval weight and mortality, and sugar content of foliage. Treatment means were separated ($P = 0.05$) using Duncan's multiple range test (DMRT) when F values were significant. Simple linear correlation (PROC CORR) was used to determine the correlation coefficient of corn earworm larval weight and sugar content of foliage.

To provide an estimate of multiple pest resistance, antibiosis data from this study was compared with previously reported data on resistance to Mexican bean beetle (Kraemer et al. 1994). Simple linear correlation (PROC CORR) was used to determine the relationship between corn earworm weight data and percent defoliation by Mexican bean beetle (3-year combined means), for the 42 genotypes common to both studies.

Results and Discussion

Larval Weight. Significant differences between mean larval weights were found within each maturity group in both 1993 and 1994 (Tables 1-5). Although unequal variances precluded combined analysis, accessions in each table are listed in order of unweighted averages of larval weights across years. Mean larval weights ranged from 13 mg to 207 mg in 1993 and from 2 to 189 mg in 1994.

The results from resistant and susceptible controls were consistent with expectations. With few exceptions, larvae reared on the resistant controls had the lowest weights in their respective maturity groups: HC-83-123-9 and HC-83-46-1 in maturity group IV, L-76-0049 in maturity group V, Lamar in maturity group VI, and PIs 171451, 229358, 227687 and 417061 in maturity group VII/VIII. In the 1993 evaluations of maturity group III, the mean weight of larvae reared on the "resistant control", PI 416868-B, was significantly higher than larvae reared on the cultivar Kunitz (Table 1). Although larvae reared on PI 416868-B had the lowest mean weight in 1994, it was not significantly less than 6 of the 8 cultivars in maturity group III. The relatively high mean weights of larvae reared on PI 416868-B (133 mg and 91 mg) indicates that this "resistant control' has, at best, only slight resistance to corn earworm. These results support earlier observations based on Mexican bean beetle evaluations, that plant introductions belonging to the earlier maturity groups are not a good source of resistance to defoliating insects (Kraemer et al. 1990).

The susceptible controls helped to establish a scale of relative resistance. Except for maturity group VII/VIII in 1994, larvae reared on foliage from the susceptible controls had higher mean weights than the resistant controls and many other genotypes.

Apparent differences in resistances between maturity groups were found. The mean larval weights for 1993 and 1994 for maturity groups III to VII/VIII were 133 and 130 mg, 70 and 58 mg, 98 and 124 mg, 75 and 147 mg, and 40 and 17 mg, respectively. Low larval weights in maturity group IV (Table 2) were possibly due to soil splashed onto leaves from earlier heavy rains, 2 to 7 days before samples were collected. Although these leaves were washed with water, the fine soil particles or microorganisms that remained after washing could have interfered with feeding and/or digestion. The very low mean larval weights of maturity group VII/VIII (Table 5) in 1993 (40 mg) and 1994 (17 mg) may have been the result of several factors: the number of resistant genotypes included, previous insect damage, and/or maturity group effect. Four highly resistant genotypes were included in this group, PIs 171451 (Kosamame), 227687 (Miyako White), 229358 (Soden-daizu), and 417061 (Kosa Mame). Resistance to insects can be increased in soybean foliage with feeding damage (Bi et al. 1994). Because the foliage of maturity group VII/VIII was the last to be collected, in late-August to early-September, there was a greater exposure to insect damage. In addition, there appears to be a maturity effect on the expression of resistance. Rowan et al. (1993) found susceptible maturity group VII and VIII genotypes had less defoliation from late season lepidopterous pests than resistant maturity group V genotypes.

Table 1. Mean 10-d larval weights (mg) and percent mortality (%M) of corn earworm larvae reared on terminal foliage of maturity group III soybeans, and free sugar content (% wt/wt) of foliage.*

		1993		1994		
Accession	T**	Weight	%M	Weight	%M	Sugar
"Guelph"	VG	207 a	0	151 abc	8	0.58 bc
"Kanrich"	VG	169 b	0	167 ab	17	0.64 bc
"Kura"	VG	114 cde	8	178 a	0	0.90 a
"Wolverine"	VG	145 bc	0	136 abc	8	0.53 bc
"Kim"	VG	142 bc	0	108 c	8	0.74 ab
"Pella"	VG	112 cde	0	124 abc	17	0.57 c
PI 416868-B	RC	133 bcd	0	91 c	8	0.50 bc
"Willomi"	VG	99 de	0	119 bc	0	0.64 bc
"Kunitz"	VG	80 e	8	99 c	0	0.65 bc
Mean		133	2	129	7	0.64
F		7.82	_	2.71	_	3.05
P		0.0001	_	0.0101	_	0.0234

* Means within a column not followed by the same letter are significantly different (DMRT, $P < 0.05$). Mortality means were not significantly different.
** Vegetable-type (VG), Resistant control (RC).

Soybean seeds contain a variety of proteins that have anti-nutritional properties, e.g., lectins, lipoxgenases and protease inhibitors. Although heat treatment can eliminate or reduce the activity of many of these compounds, lower initial levels are desired. Unlike most soybean genotypes, the cultivar Kunitz (Table 1) does not have a major inhibitor of the digestive enzyme trypsin (Bernard et al. 1991). The lack of this anti-nutritional compound in soybean seeds, did not appear to affect levels of antibiosis expressed in the foliage (Table 1). Larvae reared on foliage of "Kunitz" had the lowest mean weight in maturity group III (80 mg) in 1993, and second lowest in 1994 (99 mg). The medium size of "Kunitz" seed (14 g/100) is not compatible with most vegetable uses, but it could be useful in developing new cultivars.

"Sato", in maturity group IV (Table 2), showed the most resistance of any vegetable-type cultivar relative to the resistant controls. Mean larval weights (44 mg in 1993 and 37 mg in 1994) were higher than the resistant controls HC-83-123-9 (19 and 20 mg) and HC-83-46-1 (23 and 12 mg), but the differences were not significant. Similarly, several large-seeded breeding lines in maturity group V (V88-100, V89-1563, and V89-1301) also showed good levels of antibiosis. Larvae reared these genotypes had mean larval weights not significantly greater than the resistant control, L-76-0049, in both years (Table 3).

Intermediate levels of antibiosis were found in a promising maturity group VI introduction from Japan, PI 417310 (Shiro Aki Daizu). Mean weights of larvae

Table 2. Mean 10-d larval weights (mg) and percent mortality (%M) of corn earworm larvae reared on terminal foliage of maturity group IV soybeans, and free sugar content (% wt/wt) of foliage.*

Accession	T**	1993		1994		
		Weight	%M	Weight	%M	Sugar
PI 407820	VG	124 a	0	94 a	0 b	0.90 ab
PI 561289	VG	92 bc	0	94 a	0 b	0.86 ab
"Sanga"	VG	99 ab	17	69 abc	0 b	0.78 abc
"Jefferson"	VG	80 bcd	0	82 ab	0 b	0.85 ab
"Kailua"	VG	88 bc	0	70 abc	0 b	0.58 cd
PI 561287A	VG	85 bcd	0	49 abcd	17 b	1.00 a
PI 248511	VG	64 cde	0	64 abc	0 b	0.71 bcd
PI 561293	VG	71 bcde	8	53 abcd	0 b	0.53 d
"Emerald"	VG	64 cde	0	61 abcd	0 b	0.70 bcd
AGS-129	VG	76 bcd	0	47 abcd	8 b	0.57 cd
PI 360847	VG	56 de	0	56 abcd	0 b	0.85 ab
"Sato"	VG	44 ef	8	37 bcd	8 b	0.83 ab
HC-83-123-9	RC	19 f	0	20 cd	42 a	0.69 bcd
HC-83-46-1	RC	23 f	8	12 d	50 a	0.83 ab
Mean		70	3	58	9	0.76
F		11.19	–	2.19	7.84	3.39
P		0.0001	–	0.0129	0.0001	0.0031

* Means within a column not followed by the same letter are significantly different (DMRT, $P < 0.05$). Mortality means were not significantly different in 1993.
** Vegetable-type (VG), (GR), Resistant control (RC).

reared on this genotype, 65 mg in 1993 and 130 mg in 1994, were slightly lower than the maturity group averages, 75 and 147 mg, respectively (Table 4). In previous studies this genotype had moderate Mexican been beetle resistance (Kraemer et al. 1994), high green pod yield (Mebrahtu et al. 1991), low levels of lipoxygenase activity (Mohamed and Rangappa 1992), and tolerance to ozone exposure (Mebrahtu and Mersie 1992).

A second exception to the superior performance of the resistant controls was found in maturity group VII/VIII (Table 5). Larvae reared on IAC-100, a small-seeded vegetable-type introduction from Taiwan, had the lowest mean weight recorded in 1993 (13 mg), significantly lower than two of the four resistant controls (Table 5). In 1994, the mean weight of larvae reared on IAC-100 (15 mg) was not significantly different from the resistant controls, or the susceptible controls. The results from this evaluation are questionable because of the use of

Table 3. Mean 10-d larval weights (mg) and percent mortality (%M) of corn earworm larvae reared on terminal foliage of maturity group V soybeans, and free sugar content (% wt/wt) of foliage.*

		1993		1994		
Accession	T**	Weight	%M	Weight	%M	Sugar
PI 561291	VG	162 ab	0	189 a	0	1.04 a
PI 399055	SC	167 a	0	172 abc	0	0.94 abc
PI 416981	VG	150 abc	0	186 ab	0	0.93 abc
"Camp"	VG	151 abc	0	139 cde	0	0.78 cde
"Essex"	GR	144 abc	0	138 cde	0	0.87 abcd
PI 398972	SC	136 bc	0	138 cde	0	1.01 a
G2246	VG	126 cd	0	136 cde	0	0.57 f
PI 561294	VG	132 bc	0	121 def	0	0.67 ef
N2962	VG	80 ef	0	172 abc	0	0.81 bcde
N7788	VG	88 ef	8	139 cde	0	1.00 a
"Forrest"	GR	76 ef	0	143 bcd	0	0.88 abcd
N8806	VG	67 f	0	148 abcd	0	0.96 ab
V89-3410	VG	88 ef	0	125 def	0	0.74 def
PI 417288	VG	85 ef	0	118 def	0	0.93 abc
V86-659	VG	71 ef	0	116 def	0	0.72 def
V71-370	VG	100 de	0	80 fgh	0	0.78 cde
V88-795	VG	62 fg	0	95 efg	0	0.66 ef
V88-100	VG	59 fg	0	80 fgh	0	0.65 ef
V89-1563	VG	56 fg	0	67 gh	0	0.66 ef
V89-1301	VG	35 g	0	60 gh	0	0.76 cde
L-76-0049	RC	34 g	8	44 h	0	0.67 ef
Mean		98	1	124	0	0.81
F		16.89	–	8.36	–	8.11
P		0.0001	–	0.0001	–	0.0001

* Means within a column not followed by the same letter are significantly different (DMRT, $P < 0.05$). Mortality means were not significantly different.
** Vegetable-type (VG), Grain-type (GR), Resistant control (RC), Susceptible Control (SC).

Table 4. Mean 10-d larval weights (mg) and percent mortality (%M) of corn earworm larvae reared on terminal foliage of maturity group VI soybeans, and free sugar content (% wt/wt) of foliage.*

		1993		1994		
Accession	T**	Weight	%M	Weight	%M	Sugar
"Rokusun"	VG	116 a	0	184 a	0	0.74 bcd
PI 201422	SC	97 abc	0	166 ab	8	0.75 bcd
G4032	VG	90 abc	0	168 ab	0	0.67 d
D71-V86	VG	101 ab	0	157 ab	0	0.82 abcd
"Hahto"	VG	74 bcd	8	179 a	0	0.76 bcd
D71-V89	VG	88 abc	0	163 ab	0	0.81 abcd
"Centennial"	GR	48 de	0	162 ab	8	0.96 a
FC 31665	VG	76 bcd	0	131 bc	0	0.70 d
PI 417310	VG	65 cde	8	130 bc	0	0.87 abc
"Tracy-M"	GR	54 de	0	137 bc	0	0.72 cd
PI 36906	RC	53 de	17	111 c	0	0.89 ab
"Lamar"	RC	39 e	17	72 d	8	0.73 bcd
Mean		75	4	147	2	0.78
F		4.31	–	7.31	–	3.36
P		0.0001	–	0.0001	–	0.0060

* Means within a column not followed by the same letter are significantly different (DMRT, $P < 0.05$). Mortality means were not significantly different.
** Vegetable-type (VG), Grain-type (GR), Resistant control (RC), Susceptible Control (SC).

poor quality foliage. A blacklight trap indicated the major flight period of corn earworm moths began 2 weeks earlier and reached twice the level in 1994 than in 1993. Although larval counts were not made in the field, this was the only evaluation in which insect damaged foliage had to be used.

In the 1993 evaluations of maturity group VII/VIII, all three vegetable-type soybeans, IAC-100, "Tokyo", and N1535-1, had relatively low larval weights, 42 mg or less. However, except for IAC-100, these weights were significantly lower than only one of the two susceptible controls, PIs 417134 (92 mg) and 181565 (52 mg). This group of maturity group VII/VIII soybeans did not appear to include any highly susceptible genotypes.

Table 5. Mean 10-d larval weights (mg) and percent mortality (%M) of corn earworm larvae reared on terminal foliage of maturity groups VII and VIII soybeans, and free sugar content (% wt/wt) of foliage.*

		1993		1994		
Accession	T**	Weight	%M	Weight	%M	Sugar
PI 417134	SC	92 a	0	22 ab	67 abc	0.95 a
PI 181565	SC	52 bc	8	23 ab	58 abc	0.95 a
N1535-1	VG	42 bcd	0	31 a	17 d	0.82 b
PI 187154	VG	54 b	0	19 ab	33 cd	0.94 a
"Gordon"	GR	46 bcd	8	17 ab	25 d	0.94 a
"Tokyo"	VG	42 bcd	8	17 ab	33 dc	0.52 c
"Bragg"	GR	25 ef	0	32 a	33 dc	0.83 ab
PI 229358	RC	37 cde	0	3 b	92 a	0.75 b
PI 417061	RC	31 de	17	2 b	67 abc	0.88 ab
PI 227687	RC	22 ef	8	10 ab	50 bcd	0.86 ab
PI 171451	RC	22 ef	0	8 ab	75 ab	0.86 ab
IAC-100	VG	13 f	8	15 ab	42 bcd	0.86 ab
Mean		40	5	17	49	0.85
F		15.40	–	1.98	3.59	7.18
P		0.0001	–	0.0383	0.0029	0.0001

* Means within a column not followed by the same letter are significantly different (DMRT, $P < 0.05$). Mortality means were not significantly different in 1993.
** Vegetable-type (VG), Grain-type (GR), Resistant control (RC), Susceptible Control (SC).

Moderate to high mean larval weights were common for larvae reared on foliage of vegetable-type soybeans. The most susceptible genotypes in maturity groups III through VI were vegetable-types "Guelph", PI 407820, PI 561291, and "Rokusun", respectively. In addition, mean weights greater than 150 mg were found for larvae reared on the following vegetable-type soybeans: "Kanrich", "Kura", PI 416981, "Camp", N2962, G4032, D71-86, "Hahto", and D71-V89.

Sugar Content of Foliage. Sugar stimulates insect feeding and may be partially responsible for greater larval weights associated with some genotypes. The amount of soluble sugar found in young terminal foliage ranged from 0.50% (PI 416868-B) to 1.04% (PI 561291) of dry weight, and averaged 0.78%. This is less than the 1.0% to 2.9% sugar reported by Antos and Weibold (1984) for upper canopy foliage of R1.5 stage soybeans. The lower values we recorded could be related to the young age of the foliage used in the assays and/or the time of sampling. Sucrose levels in soybean leaves rise dramatically within 1 h after a 12 h dark-period and then increase at a much slower rate the remainder of the light period (Kerr et al. 1985). Our foliage was collected in early to mid-morning (0800 to 1000 EDT).

Although significant differences between means were found within all maturity groups (Tables 1-5), simple linear correlation analysis of the combined maturity groups did not show that leaf sugar content was correlated with corn earworm larval weights. However, after removing maturity groups VII and VIII from the analysis, the remaining maturity groups showed a small but significant positive correlation (r = 0.20; *P* = 0.009). Sugar content appears to be a minor component of resistance at best. Several of the resistant controls had relatively high foliar sugar content, HC-83-46-1 and PI 36906, 0.83% and 0.89%, respectively (Tables 2 and 4). Also, the exceptionally low larval weights found in maturity groups VII and VIII were not due to low sugar levels because mean sugar content (0.85%) was slightly higher than that of the other maturity groups (O.63% to 0.81%).

Larval Mortality. Mortality averaged 2.9% in 1993 and 13.5% in 1994, and was not generally useful in evaluating resistance within maturity groups. Significant differences between means were found only in 1994, in maturity groups IV and VII/VIII. In maturity group IV the two resistant controls had 42 and 50% mortality, greater than all other genotypes (Table 2). Overall mortality in maturity group VII/VIII was 49% in 1994 and accounted for 73% of the mortality in all maturity groups that year (Table 5). The high mortality and low larval weights found in this evaluation may have been related to the quality of the foliage, as previously described. There is also a possibility that the larvae used in this last evaluation may not have been healthy. In July of the following year (1995) the provider of the eggs stopped rearing this *H. zea* colony because of the increasing incidence of a microsporidium disease that affected reproduction (G. Hartley, USDA/ARS, Stoneville, MS, personal communication).

Multiple Insect Pest Resistance. Corn earworm larval weights were positively correlated (*P* = 0.009) with Mexican bean beetle defoliation ratings from a previous field evaluation (Kraemer et al. 1994). Analysis of 42 genotypes common to both studies yielded a relatively low correlation coefficient of 0.39. The correlation was greater when maturity groups VII and VIII were analyzed separately (N = 9; r = 0.84; *P* = 0.004) from the remaining maturity groups (N = 33; r = 0.51; *P* = 0.002).

Two major exceptions to the positive correlation of pest resistance were found. Cultivar Sato (maturity group IV) was highly susceptible to Mexican bean beetle (42% defoliation) but had corn earworm larval weights not significantly different from the resistant controls. Conversely, PI 416981 (maturity group V) was moderately resistant to Mexican bean beetle (15% defoliation) but highly susceptible to corn earworm (150 and 168 mg). The different methods used in the two studies could account for some of these results. The Mexican bean beetle evaluation involved both preference (adult feeding and egg laying) and antibiosis (larval feeding), whereas the corn earworm evaluation only measured larval antibiosis. The overall positive correlation of results from these two studies supports the concept that soybean resistance to defoliating insects is generally broad-based and not species specific.

Petri dish bioassays can be a useful tool to evaluate antibiosis-type resistance to defoliating insects, especially when corn earworm infestations cannot be assured in the field. However, field evaluations should be used to confirm results. The Petri dish bioassay used leaves that were harvested at one moment in time and were not likely to be able to respond to larval feeding by enhancing defenses. In addition, resistance due to non-preference by ovipositing adults was not determined. However, young terminal foliage is important in early corn earworm development and genotypes with greater inherent resistance should have an advantage over those that are more susceptible.

Appearance, taste, and health considerations make seed quality and reduced pesticide use especially important factors for vegetable soybean production. Our evaluations indicated that, whereas, some vegetable-type soybeans have the potential for moderate to good resistance to corn earworm (IAC 100, "Sato", PI 417310, V89-1301, V89-1563, V88-100), others are likely to require additional pest management inputs ("Guelph", "Rokusun", and PI 561291).

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