Genotypic Diversity in the Suitability of Cowpea (Rosales: Leguminosae) Pods and Seeds for Cowpea Weevil (Coleoptera: Bruchidae) Oviposition and Development

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J. Econ. Entomol. 78: 806–810 (1985)

ABSTRACT The suitability of cowpea pods for *Callosobruchus maculatus* (F.) oviposition varied significantly among 36 diverse genotypes, among 3 pod maturity stages, and between the first 6 h or remaining 18 h periods of the test. The differences in mean number of eggs laid per pod between the most and least suitable genotypes for dry, yellowing, and mature green pods were 14-, 7-, and 3-fold, respectively, and were clearly sufficient to demonstrate nonpreference resistance of cowpea pods to cowpea weevil oviposition. The oviposition on pods of one stage was not correlated with suitability of a genotype in the other two stages. Cowpea weevils oviposited on all stages of all genotypes and the differences in the suitability were in part a result of oviposition being delayed on some stages or genotypes more than others. The suitability of dry pods for oviposition was not correlated with suitability of that genotype for offspring development. The differences in oviposition between the most and least suitable seeds of these same 36 genotypes was only 2-fold. This may indicate that pods have a more diverse array of oviposition stimuli than seeds and may thus be a richer source of nonpreference resistance.

FIELD INFESTATION of crops by several species of stored-products insects is well established (Hagstrum 1985). Host plant resistance could thus contribute to the management of these storage pests in the field prior to harvest. Messina (1984) found that the cowpea weevil, *Callosobruchus maculatus* (F.), oviposits readily upon green cowpea pods and that offspring hatching from these eggs can complete development even on young developing green pods. Nonpreference resistance of cowpea pods to *C. maculatus* oviposition in the field could thus be as important in reducing infestation as antibiosis in seed (e.g., trypsin inhibitor which prevents larval development on TVu 2027, Gatehouse et al. 1979). Previous attempts to demonstrate nonpreference resistance of cowpea pods to cowpea weevil oviposition have been unsuccessful (Akingbohungbe 1976, Fatunla and Badaru 1983).

We examine here the diversity among cowpea pods and seeds of 36 genotypes in their suitability for *C. maculatus* oviposition. The influence of cowpea pod maturity upon its suitability as an oviposition site and the relationship between suitability of a genotype for oviposition and its suitability for development of offspring are considered.

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Materials and Methods

The cowpea pods and seeds of the 36 diverse genotypes considered in this study were obtained from plants grown at the University of Florida Agronomy Research Farm, 19.3 km (12 mi) northwest of Gainesville. To ensure a continuous supply of pods, three plantings were seeded at 10-day intervals, beginning 10 August 1982. A randomized complete block design was used, with single rows within each planting date used for each genotype.

Test insects were selected from the *C. maculatus* colony maintained at the Insect Attractants, Behavior, and Basic Biology Research Laboratory, Gainesville, Fla. The source colony originally was obtained from infested 'Iron-Clay' and 'Pinkeye Purplehull' cowpeas in storage near Live Oak, Fla., in January 1980. The colony was maintained on 'Iron-Clay' cowpeas in a controlled environment room maintained at 25°C and 60% RH, with a LD 14:10 photoperiod, using a rearing procedure similar to that of Strong et al. (1968). The insects (0–24 h old) were placed in empty 0.5-liter jars to isolate them from seed for 24 h before the start of the bioassay. The isolation period was used to induce a high oviposition propensity among female beetles and thus provide the most rigorous test of a genotype's ability to discourage oviposition.

The bioassays for pods were conducted in 1-liter glass jars using two pods of a particular genotype and five female *C. maculatus* per jar. Green, yellowing, and dry pod maturity stages corresponded

Table 1. Oviposition of *C. maculatus* on green cowpea pods

Genotype[a]	Oviposition 1st 6 h on pods					Oviposition next 18 h on pods			
	n	Fraction of pods with eggs	Mean eggs/pod[b]	SD	% 1st 6 h	*n*	Fraction of pods with eggs	Mean eggs/pod[b]	SD
'Big Boy'	6	1	11.7a	5.3	46.4	6	1	13.5gh	9.1
'Acc 794'[c]	12	1	14.9bc	6.3	58.0	12	0.92	10.8e–g	10.6
'Bluegoose'	12	1	16.9a–c	9.2	74.8	12	0.92	5.7a–f	5.1
'TVu 123'[d]	18	1	17.6a–d	10.0	80.7	18	0.78	4.2a–e	3.3
'Victor'	18	1	17.9a–d	8.3	70.5	18	1	7.5a–g	4.7
'Brabham'	12	1	18.0a–d	8.3	83.7	12	0.75	3.5a–c	3.2
'Mississippi Conch'	12	1	18.8a–d	7.5	75.8	12	0.83	6.0a–f	5.1
'Freeze Green'[e]	24	1	19.2a–d	8.7	80.3	24	0.83	4.7a–e	3.4
'New Era'	12	1	19.4a–e	5.7	78.5	12	0.83	5.3a–f	4.1
'TVu 1977-OD (Vita 4)'[d]	12	1	21.6a–d	9.0	76.9	12	1	6.5a–f	5.6
'Iron'	18	1	22.0a–d	10.7	75.1	18	0.78	7.3a–g	7.9
'Macassar Bronco'[d]	12	1	23.7a–e	6.9	83.0	12	0.75	4.8a–e	5.1
'All Season'[c]	6	1	23.8a–e	11.2	73.0	6	1	8.8b–g	4.4
'Fla 589-06'[e]	44	1	24.2a–e	14.3	82.0	44	0.89	5.3a–f	5.3
'CES 41-6'[c]	12	1	24.5a–e	15.4	88.4	12	1	3.2a–c	2.6
'Mississippi Silver'	12	1	25.3a–e	10.0	95.1	12	0.50	1.3a	1.7
'Michigan Favorite'	12	1	27.0b–e	8.8	87.4	12	0.92	3.9a–d	2.5
'Ala 936.8'[e]	12	1	27.1b–e	10.6	92.2	12	0.42	2.3ab	3.3
'794264'[d]	12	1	27.4b–e	13.4	60.0	12	1	18.2h	11.4
'Pinkeye Purplehull'	86	1	28.1b–e	12.4	85.7	86	0.83	4.7a–e	5.3
'Claybuff'	12	1	28.7b–e	8.3	88.1	12	0.67	3.9a–d	4.1
'V-306'[e]	20	1	29.0b–e	15.7	88.7	20	0.75	3.7a–c	4.0
'Zipper Cream'	6	1	29.2b–e	16.3	93.6	6	0.67	2.0ab	2.1
'Serido'[d]	12	1	30.7c–e	10.2	90.9	12	0.75	3.1ab	2.7
'Sadandy'	12	1	31.2c–e	17.5	77.8	12	0.75	8.9b–g	7.5
'CR 17-1-13'[e]	18	1	31.2c–e	13.4	82.3	18	0.83	6.7a–f	4.9
'Colossus'	12	1	31.5c–e	6.6	94.6	12	0.58	1.8a	2.2
'CR 22-2-21'[e]	12	1	31.8de	10.5	88.3	12	0.67	4.2a–e	4.6
'ACC 113'[c]	12	1	31.9de	15.7	78.6	12	0.83	8.7b–g	7.0
'TVX 289-4G'[d]	12	1	32.0de	7.4	75.1	12	0.92	10.6d–g	8.2
'CES 26-12'[c]	12	1	32.3de	16.2	72.7	12	1	12.1fg	8.6
'Calif. Blackeye #5'	18	0.89	36.9e	18.0	85.0	18	0.78	6.5a–f	9.1
'Worthmore'	26	1	37.5e	12.7	83.1	26	0.85	7.6a–g	7.6
'Brown Crowder'	12	1	37.8e	14.8	79.1	12	1	10.0c–g	6.7
'UPLCP1'[c]	12	1	37.9e	8.9	94.5	12	1	2.2ab	2.8
'CES 26-3'[c]	12	1	38.0e	10.9	83.3	12	0.83	7.6a–g	6.1

[a] Other genotypes were obtained from commercial sources or from the USDA-ARS, Regional Plant Introduction Station, Experiment, Ga.

[b] The analysis of variance for oviposition during first 6 h ($F = 4.99$, df = 34, 543, $P = 0.0001$) and next 18 h ($F = 4.73$, df = 34, 543, $P = 0.0001$) indicated that genotypes differ significantly in their suitability. Means in a column followed by the same letter are not significantly different at $P = 0.05$ level (Duncan's [1951] multiple range test).

[c] Genotypes were obtained from R. Abilay (Inst. of Plant Breeding, College, Laguna, Philippines).

[d] Genotypes were obtained from K. L. Buhr.

[e] Genotypes were obtained from R. L. Fery (USDA-ARS, Vegetable Insects Laboratory, Charleston, S.C.).

to ca. 12–15, 15–20, and >25 days after flowering, respectively. The number of eggs laid on each pod was recorded after 6 and 24 h of exposure to *C. maculatus*. The bioassays for seed were conducted in a similar fashion except 10 seeds were placed in a 25-ml vial with one female and the numbers of eggs laid were recorded after 6 h only. Dry pods were held in 1-liter glass jars at 25°C, 60% RH, and a LD 14:10 photoperiod until adults emerged. Survival was calculated by dividing the number of adults emerging from each pair of pods by the number of eggs laid on those pods.

A completely randomized design was used, with each jar representing one replicate and each of two pods in a jar an experimental unit. The analysis was a nested-factorial incomplete block, with bioassay nested within genotype and maturity stage. Analysis of variance and correlations were done with Statistical Analysis System (SAS Institute Inc. 1982).

Results

The suitability of cowpea pods for *C. maculatus* oviposition varied significantly among genotypes ($F = 4.17$, df = 35, 2,053, $P = 0.0001$), pod maturity stages ($F = 184.78$, df = 2, 2,053, $P = 0.0001$), and between periods of test ($F = 2{,}532.92$, df = 1, 2,053, $P = 0.0001$). The mean numbers of eggs laid on green, yellowing, and dry pods of each of 36 cowpea genotypes during the first 6-h period of the 24-h test and the remaining 18 h are given in Tables 1–3. More eggs were laid (26.6 versus 6.3 for green, 22.1 versus 2.8 for yellowing, and 11.3 versus 4.8 for dry) and eggs were laid on more pods (0.99 versus 0.82 for green, 0.96 versus 0.65

Table 2. Oviposition of *C. maculatus* on yellowing cowpea pods

Genotype	Oviposition 1st 6 h on pods					Oviposition next 18 h on pods			
	n	Fraction of pods with eggs	Mean eggs/pod[a]	SD	% 1st 6 h	n	Fraction of pods with eggs	Mean eggs/pod[a]	SD
'ACC 794'	6	0.50	5.3a	6.0	100.0	6	0	0a	—
'Sadandy'	12	0.83	10.0ab	8.7	76.3	12	0.42	3.1ab	6.2
'Mississippi Silver'	12	1	11.6a–c	11.3	90.6	12	0.33	1.2a	2.2
'CES 26-3'	6	1	12.7a–d	9.4	84.7	6	0.67	2.3ab	3.1
'CR 17-1-13'	12	0.75	14.4a–d	14.3	75.0	12	0.75	4.8ab	5.5
'V-306'	6	1	15.3a–e	10.9	80.5	6	0.67	3.7ab	4.0
'CR 22-2-21'	12	0.83	15.7a–e	16.3	86.3	12	0.50	2.5ab	3.8
'Victor'	12	1	16.2a–e	6.6	90.0	12	0.67	1.8ab	2.7
'Mississippi Conch'	12	1	17.1a–e	12.1	88.6	12	0.50	2.2ab	3.1
'Colossus'	12	1	18.3a–f	11.8	79.2	12	1	4.8ab	5.3
'Big Boy'	12	1	18.7a–f	11.3	77.3	12	0.75	5.5ab	5.6
'Bluegoose'	12	0.92	18.7a–f	11.6	92.1	12	0.67	1.6ab	1.4
'UPLCP1'	12	1	18.8a–f	6.3	89.5	12	0.67	2.2ab	2.8
'TVX 289-4G'	6	1	19.0a–f	10.2	87.2	6	0.50	2.8ab	3.2
'Fla 589-06'	12	1	19.3a–f	10.2	79.4	12	0.92	5.0ab	2.6
'CES 41-6'	6	1	20.0a–g	12.4	77.8	6	0.67	5.7ab	6.0
'New Era'	6	1	20.7a–g	8.6	95.4	6	0.67	1.0a	0.9
'TVu 123'	12	1	21.1a–g	15.5	81.1	12	0.83	4.9ab	4.9
'TVu 1977-OD (Vita 4)'	12	0.83	21.8a–g	16.7	87.9	12	1	3.0ab	2.4
'Michigan Favorite'	6	1	22.3b–g	6.9	75.3	6	1	7.3b	2.1
'Brown Crowder'	12	1	24.5b–g	10.3	88.4	12	0.75	3.2ab	6.6
'Pinkeye Purplehull'	60	0.93	24.5b–g	13.1	84.8	60	0.67	4.4ab	5.8
'All Season'	6	1	24.8b–g	13.2	91.5	6	0.67	2.3ab	2.9
'Ala 963.8'	12	1	26.0b–g	8.6	90.0	12	0.67	3.0ab	4.3
'Freeze Green'	6	1	26.0b–g	9.4	85.2	6	1	4.5ab	4.1
'CES 26-12'	10	1	26.6b–g	10.0	91.1	10	0.70	2.6ab	2.3
'ACC 113'	6	1	26.7b–g	21.2	97.1	6	0.17	0.8a	2.0
'Worthmore'	18	1	26.7b–g	10.0	90.8	18	0.72	2.7ab	3.4
'Macassar Bronco'	6	1	27.7c–g	4.6	91.7	6	0.33	2.5ab	3.9
'Serido'	6	1	28.3c–g	13.4	98.9	6	0.33	0.3a	0.5
'Claybuff'	12	1	28.7c–g	11.9	92.0	12	0.50	2.5ab	3.5
'794264'	6	1	29.2d–g	15.5	90.7	6	1	3.0ab	1.5
'Zipper Cream'	12	1	32.2e–g	12.5	96.4	12	0.42	1.2a	1.7
'Brabham'	6	1	34.2fg	11.5	99.1	6	0.17	0.3a	0.8
'Iron'	6	1	34.2fg	14.2	96.3	6	0.50	1.3a	2.3
'Calif. Blackeye #5'	6	1	36.8g	12.1	94.8	6	0.83	2.0ab	1.3

[a] The analysis of variance for oviposition during first 6 h ($F = 3.13$, df = 34, 347, $P = 0.0001$) and next 18 h ($F = 1.49$, df = 34, 347, $P = 0.04$) indicated that genotypes differ significantly in their suitability. Means in a column followed by the same letter are not significantly different at the $P = 0.05$ level (Duncan's [1951] multiple range test).

for yellowing, and 0.86 versus 0.72 for dry) during the first 6 h than during the final 18 h. If the unsuitability of a genotype delayed oviposition, the percentage of daily oviposition that occurred during the first 6 h would be reduced. The significant positive correlations for green ($r = 0.5156$, df = 36, $P = 0.0013$), yellowing ($r = 0.4507$, df = 36, $P = 0.0058$), and dry ($r = 0.6332$, df = 36, $P = 0.0001$) pods between the number of eggs laid during the first 6 h and the percentage of the total number of eggs laid per day which this represents, indicate that the less suitable a genotype is the more oviposition is delayed. Oviposition was delayed more on dry (mean = 68% first 6 h) than on yellow (88%) or green (81%) cowpea pods. The significant genotype × maturity ($F = 2.45$, df = 70, 2,053, $P = 0.0001$), genotype × period ($F = 5.49$, df = 35, 2,053, $P = 0.0001$), maturity × period ($F = 224.68$, df = 2, 2,053, $P = 0.0001$) and genotype × maturity × period ($F = 3.39$, df = 70, 2,053, $P = 0.0001$) interactions indicate that oviposition on a genotype during one maturity stage or period was not correlated with oviposition during another. Further, the suitability of the seed for oviposition did not differ significantly among genotypes ($F = 0.71$, df = 35, 396, $P = 0.89$) and the suitability of seed of a particular genotype was not correlated with the suitability of pods of that genotype of oviposition (Table 3). Finally, genotypes differed significantly in suitability for offspring development (Table 3), but suitability for development of offspring was not correlated with the suitability of a genotype for oviposition ($r = -0.2243$ or 0.1815, df = 35, $P = 0.19$ or 0.30 for two periods).

Discussion

Suitability of cowpeas for *C. maculatus* oviposition is known to be influenced by curvature (Av-

Table 3. Oviposition and survival of *C. maculatus* on dry cowpea pods or seed

Genotype	Oviposition 1st 6 h on pods					Oviposition 1st 6 h on seeds		Oviposition next 18 h on pods				% Survival when eggs laid on pods[a]		
	n	Fraction of pods with eggs	Mean eggs/pod[a]	SD	% 1st 6 h	Mean eggs/10 seeds	SD	*n*	Fraction of pods with eggs	Mean eggs/pod[a]	SD	*n*	Mean	SD
'All Season'	12	0.42	1.7a	4.0	34.0	5.1	5.0	12	0.58	3.3a–c	3.5	5	0.7a	1.5
'Sadandy'	18	0.39	2.5ab	3.9	31.6	6.4	9.6	18	0.67	5.4a–c	7.0	6	2.8a	3.9
'CR 22-2-21'	18	0.56	3.8a–c	4.7	34.5	4.4	4.1	18	0.56	7.2a–c	13.2	3	48.0c	19.7
'Calif. Blackeye #5'	12	0.33	4.4a–d	12.4	54.3	4.9	5.0	12	0.67	3.7a–c	4.9	5	49.7c	12.3
'ACC 794'	18	0.67	5.1a–d	8.1	66.7	7.1	4.0	18	0.61	2.5ab	4.0	6	0	—
'UPLCP1'	12	0.83	5.5a–e	8.7	74.3	5.6	4.1	12	0.67	1.9ab	2.4	6	0.3a	0.7
'Ala 963.8'	12	0.92	5.6a–e	4.9	55.4	3.7	4.0	12	0.75	4.5a–c	5.0	3	11.4a	6.6
'Freeze Green'	12	0.92	5.9a–e	7.6	41.8	5.7	4.9	12	0.92	8.2a–c	8.2	6	5.8a	7.4
'Acc 113'	6	0.83	7.0a–e	6.9	80.5	6.0	3.9	6	0.50	1.7a	2.3	3	6.7a	11.5
'Serido'	12	0.58	7.2a–e	10.2	71.3	4.7	4.6	12	0.50	2.9a–c	4.4	3	1.3a	2.3
'Macassar Bronco'	12	0.92	7.3a–e	4.4	58.4	8.2	11.9	12	0.83	5.2a–c	3.8	6	1.4a	2.2
'Fla 589-06'	12	0.67	7.7a–e	8.1	76.5	3.7	3.6	12	0.67	2.4ab	3.6	6	26.0b	22.1
'Zipper Cream'	6	1	9.3a–f	3.9	66.0	4.9	4.3	6	0.67	4.8a–c	5.7	0	—	—
'Mississippi Conch'	11	1	9.5a–g	18.2	51.3	4.1	3.7	11	0.90	9.0a–c	7.1	6	30.8b	25.1
'New Era'	10	1	9.9a–g	7.6	75.0	6.2	2.8	10	1	3.3a–c	1.7	2	1.6a	2.3
'V-306'	12	1	10.8a–h	5.8	77.7	6.2	5.5	12	0.67	3.1a–c	3.1	6	2.3a	3.3
'CR 17-1-13'	18	0.94	10.8a–h	8.8	59.0	6.9	4.1	18	0.89	7.5a–c	6.1	6	1.9a	2.9
'Pinkeye Purplehull'	48	0.90	11.0a–h	9.5	70.5	5.0	3.3	48	0.73	4.6a–c	5.1	20	5.4a	5.4
'TVX 289-4G'	12	1	11.3a–h	11.3	71.3	4.6	4.5	12	0.92	4.5a–c	3.4	6	7.1a	6.7
'CES 26-3'	18	0.89	11.5a–h	11.0	78.8	6.7	6.3	18	0.61	3.1a–c	3.9	6	2.6a	2.1
'CES 41-6'	12	1	11.7a–h	11.7	74.2	4.3	5.3	12	0.83	4.1a–c	3.0	6	1.4a	2.5
'Colossus'	4	1	12.3a–h	5.0	81.3	5.6	4.5	4	0.50	2.8a–c	4.9	2	13.1a	2.9
'Brabham'	12	1	12.6a–h	7.1	82.9	4.7	5.8	12	0.67	2.6ab	3.3	6	0.8a	1.3
'TVu 1977-OD (Vita 4)'	12	0.83	12.8a–h	8.3	70.3	5.9	4.0	12	0.75	5.4a–c	5.3	5	6.0a	4.2
'CES 26-12'	12	1	13.0a–h	8.7	67.7	6.1	4.2	12	0.67	6.2a–c	10.7	6	1.8a	4.4
'TVu 123'	12	1	13.5a–h	7.6	86.0	3.9	4.1	12	0.67	2.2ab	2.2	6	5.2a	3.7
'Michigan Favorite'	10	1	14.6b–h	9.2	67.9	7.7	2.5	10	0.70	6.9a–c	8.1	2	1.8a	2.6
'Worthmore'	12	1	14.8b–h	9.7	63.2	8.2	4.3	12	1	8.6a–c	8.0	3	7.3a	2.2
'Iron'	12	1	15.3b–h	9.5	89.0	7.3	5.4	12	0.42	1.9ab	2.6	6	1.0a	1.5
'Big Boy'	10	1	16.4c–h	13.4	71.6	5.7	4.2	10	0.70	6.5a–c	7.9	5	29.5b	28.4
'794264'	12	1	16.9d–h	16.9	91.3	5.7	3.5	12	0.50	1.6a	2.0	6	8.2a	6.2
'Claybuff'	12	1	18.1e–h	8.4	64.9	5.1	4.5	12	1	9.8bc	4.4	6	2.4a	2.8
'Victor'	12	1	21.3f–h	9.5	86.2	6.4	3.6	12	0.75	3.4a–c	2.9	6	1.0a	1.3
'Bluegoose'	12	1	21.6f–h	10.3	83.1	4.7	3.0	12	0.75	4.4a–c	4.3	6	3.4a	6.3
'Mississippi Silver'	12	1	22.3gh	9.0	67.9	5.3	4.4	12	0.92	10.5c	8.7	5	6.1a	2.4
'Brown Crowder'	10	1	23.2h	12.6	80.6	4.7	2.7	10	0.70	5.6a–c	6.4	5	8.9a	6.0

[a] The analysis of variance for oviposition during the first 6 h ($F = 4.32$, df = 34, 422, $P = 0.0001$) and next 18 h ($F = 2.09$, df = 34, 422, $P = 0.0004$) and survival ($F = 11.46$, df = 34, 422, $P = 0.0001$) indicate that genotypes differ significantly in their suitability. Means in a column followed by the same letter are not significantly different at $P = 0.05$ level (Duncan's [1951] multiple range test).

idov et al. 1965), texture (Nwanze and Horber 1976), or oviposition markers (Wasserman 1981) and may also be influenced by hydration. Messina (1984) demonstrated that *C. maculatus* preferred moist green over dry pods for oviposition when both were present and females laid more eggs on green than on dry pods (32.9 versus 16.1) in the present study. Cowpea weevils oviposited on all stages of all genotypes and the differences in the suitability were in part a result of oviposition being delayed more on some genotypes or stages than on others.

Clearly, the 14-, 7-, and 3-fold differences in oviposition between genotypes for dry, yellowing, and green pods, respectively, were sufficient to demonstrate nonpreference resistance of cowpea pods to cowpea weevil oviposition. Oviposition was among the lowest on 'Sadandy' and 'Freeze Green' in two of the three stages and on 'ACC 794' in all three (Table 4). Oviposition was among the highest on 'California Blackeye #5' and 'Brown Crowder' in two of three stages. For some genotypes, like 'Bluegoose,' 'Victor,' and 'Brabham,' green pods were among the least suitable, but dry pods were among the most suitable. For other genotypes suoh as 'California Blackeye #5' and 'UPLCP1' this was reversed. This unpredictable variation in the suitability of a genotype with maturity means that the assays for nonpreference resistance cannot be limited to one stage.

The suitability of pods for offspring development was apparently unrelated to their suitability for oviposition. For these same genotypes, the difference in oviposition between the most and least

Table 4. Comparison of extremes in suitability of genotypes for *C. maculatus* oviposition across maturity stages

Green		Yellow		Dry	
Genotype	Mean eggs/pod	Genotype	Mean eggs/pod	Genotype	Mean eggs/pod
'Big Boy'	11.7	'ACC 794'	5.3	'All Season'	1.7
'Acc 794'	14.9	'Sadandy'	10.0	'Sadandy'	2.5
'Bluegoose'*	16.9	'Mississippi Silver'*	11.6	'CR 22-2-21'	3.8
'TVu 123'	17.6	'CES 26-3'*	12.7	'Calif. Blackeye #5'*	4.4
'Victor'*	17.9	'CR 17-1-13'	14.4	'ACC 794'	5.1
'Brabham'*	18.0			'UPLCP1'*	5.5
'Mississippi Conch'	18.8			'Ala 963.8'	5.6
'Freeze Green'	19.2			'Freeze Green'	5.9
'Calif. Blackeye #5'*	36.9	'Zipper Cream'	32.2	'Claybuff'	18.1
'Worthmore'	37.5	'Brabham'*	34.2	'Victor'*	21.3
'Brown Crowder'	37.8	'Iron'	34.2	'Bluegoose'*	21.6
'UPLCP1'*	37.9	'Calif. Blackeye #5'*	36.8	'Mississippi Silver'*	22.3
'CES 26-3'*	38.0			'Brown Crowder'	23.2

Underlined genotypes had consistently high or low oviposition in more than one maturity stage, but those marked with asterisk had high oviposition in one maturity stage and low oviposition in another.

suitable seed was only 2-fold. This may indicate that pods have a more diverse array of oviposition stimuli than seed and may thus be a richer source of nonpreference resistance of cowpea to cowpea weevil oviposition. The general lack of correlation between the suitability of pods and the suitability of seed, or between suitability for oviposition and suitability for offspring development and the changes in suitability as pods mature suggest that genes at a number of independent loci must be selected to obtain full resistance.

Acknowledgment

This article is part of a thesis submitted by M.S.F. in partial fulfillment of the M.S. degree.

References Cited

Akingbohungbe, A. E. 1976. A note on the relative susceptibility of unshelled cowpeas to the cowpea weevil (*Callosobruchus maculatus*). Trop. Grain Legume Bull. 5: 11–13.

Avidov, Z., M. J. Berlinger, and S. W. Applebaum. 1965. Physiological aspects of host specificity in the Bruchidae III. Effects of curvature and surface area on oviposition of *Callosobruchus chinensis* L. Anim. Behav. 13: 178–180.

Fatunla, T., and K. Badaru. 1983. Resistance of cowpea pods to *Callosobruchus maculatus*. J. Agric. Sci., Camb. 100: 205–209.

Gatehouse, A. M. R., J. A. Gatehouse, P. Dobie, A. M. Kilminster, and D. Boulter. 1979. Biochemical basis of insect resistance in *Vigna unguiculata*. J. Sci. Food Agric. 30: 948–958.

Hagstrum, D. W. 1985. Preharvest infestation of cowpeas by the cowpea weevil (Coleoptera: Bruchidae) and population trends during storage. J. Econ. Entomol. 78: 358–361.

Messina, F. J. 1984. Influences of cowpea pod maturity on the oviposition choices and larval survival of a bruchid beetle *Callosobruchus maculatus*. Entomol. Exp. Appl. 35: 241–248.

Nwanze, K. F., and E. Horber. 1976. Seed coats of cowpeas affect oviposition and larval development of *Callosobruchus maculatus*. Environ. Entomol. 5: 213–218.

SAS Institute, Inc. 1982. SAS user's guide: statistics, 1982 edition. SAS Institute, Inc., Cary, N.C.

Strong, R. G., G. J. Partida, and D. N. Warner. 1968. Rearing stored-product insects for laboratory studies: bean and cowpea weevils. J. Econ. Entomol. 61: 747–751.

Wasserman, S. S. 1981. Host-induced oviposition preferences and oviposition markers in the cowpea weevil, *Callosobruchus maculatus*. Ann. Entomol. Soc. Am. 74: 242–245.

Received for publication 12 February 1985; accepted 8 April 1985.