Resistance in Eight Peanut Genotypes to Foliar Feeding of Fall Armyworm, Velvetbean Caterpillar, and Corn Earworm

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ABSTRACT

A laboratory feeding bioassay was used to test field-grown foliage of eight peanut (Arachis hypogaea L.) genotypes for foliar feeding resistance to three common species of defoliating caterpillars: velvetbean caterpillar (VBC), *Anticarsia gemmatalis* Hübner; fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith); and corn earworm (CEW), *Helicoverpa zea* Boddie. The eight peanut genotypes studied were: Southern Runner, Florigiant, Curly Leaf, GPNC 343, Robut 33-1, NC 6, Tifton-8, and Florunner. Percent survival of both FAW and VBC was very high (84-100%) when reared on any of the genotypes tested. Development to the pupal stage was slowest for FAW reared on Florunner, NC 6, and Tifton-8, and for VBC reared on Florunner and Tifton-8. Percent survival of CEW larvae was reduced on both NC 6 and Tifton-8 (36% survival). Differences in development to pupation and pupal weight were less distinct for CEW. When CEW larvae were provided ten peanut blooms each 48 hours in addition to unlimited foliage, development to pupation was significantly shorter in Florunner, NC 6, Robut 33-1, GPNC 343, and Curly Leaf than when larvae were fed only foliage. Similarly, CEW pupal weights were heavier in Florunner and GPNC 343 treatments, indicating that feeding on peanut blooms of most peanut genotypes tested was of benefit to CEW. In terms of overall response of the three insect species tested, NC 6 and Tifton-8 appeared to be the most resistant while Robut 33-1, Curly Leaf, and Florigiant appeared to be the most susceptible.

Key Words: Peanut, insect resistance, *Anticarsia gemmatalis, Spodoptera frugiperda, Helicoverpa zea*

Defoliating insects are occasional pests of peanut, *Arachis hypogaea* L. Experiments utilizing mechnical defoliation of plants to simulate insect feeding demonstrated that peanuts can tolerate defoliation fairly well, depending on plant developmental stage, before serious yield reductions are likely to occur (14). However, Leuck *et al.* (10) found that yields decreased significantly with increased insect defoliation among 14 peanut varieties planted in field plots in Georgia, indicating that damage from these pests can be of concern.

Consumption of peanut foliage has been quantified for the more common defoliators such as corn earworm (CEW), *Helicoverpa zea* Boddie (9), fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith) (1, 6), and velvetbean caterpillar (VBC), *Anticarsia gemmatalis* Hübner (12) using the varieties Starr (CEW) or Florunner (VBC, FAW). Limited information is available concerning the suitability of other peanut varieties as a food source for these pests. Leuck *et al.* (10) noted visual differences in foliar feeding by CEW larvae among a number of peanut lines under field conditions. When reared through three generations on foliage of the non-preferred variety Southeastern Runner 56-15, FAW showed an increase in the length of the life cycle compared with FAW reared on the susceptible variety, Starr (11). The peanut variety NC 6, selected for resistance to the southern corn rootworm, *Diabrotica undecimpunctata howardi* Barber, has been shown to have moderate resistance to CEW in laboratory leaf-feeding bioassays (7, 8). Also, high levels of mortality and growth reduction were noted when CEW larvae were fed foliage of several wild *Arachis* species capable of hybridizing with commercial peanut cultivars (4, 15).

Holley *et al.* (7) attempted to develop a laboratory procedure to screen for CEW resistance and to determine the relationship between laboratory and field measurements of resistance. Because of inconsistency in laboratory tests, the relationship between lab and field tests was not highly correlated (7). Two possible reasons for the inconsistency in their results are as follows: (1) the feeding of larvae for the first 48 h (first instar) on Burton diet (2) before switching to peanut foliage for the remainder of the test period could have influenced results, and (2) the use of greenhouse grown plants could produce results different from field grown plants.

The aforementioned and possibly other sources of resistance could be utilized in breeding programs where incorporation of resistance to defoliating pests is an objective. Except for the studies cited above, little is known of the relative susceptibility of the cultivars currently in use to various defoliators. It is possible that some cultivars already possess a higher level of resistance compared with others, and that this resistance would be of value as genetic material in breeding programs, as well as a less susceptible variety in pest management programs. We used a laboratory feeding bioassay utilizing field grown foliage to investigate the relative resistance of eight peanut genotypes to CEW, VBC, and FAW.

While VBC and FAW larvae feed mainly on foliage, CEW larvae feed on peanut blooms in addition to foliage. Consumption of peanut blooms by CEW apparently has not been previously investigated, perhaps because bloom feeding is not generally considered of any significance to peanut yields (14). However, such feeding may affect the biology of the insect itself. Thus, our CEW bioassay included blooms as well as foliage.

Materials and Methods

Genotype treatments were: Florunner, Southern Runner, Florigiant, NC 6, Tifton-8, GPNC 343, Robut 33-1, and Curly Leaf. All were planted in field nursery plots located at the Coastal Plain Experiment Station, Tifton, GA. Peanuts were grown using standard agronomic practices with irrigation as needed. No insecticide applications were made during the period when foliage and blooms were used for laboratory bioassays. The bioassays were begun 55 days (FAW and VBC) or 64 days (CEW) after planting.

Larvae of FAW and VBC were obtained from laboratory colonies maintained on artificial diet at the Coastal Plain Experiment Station. Both colonies were established from locally collected specimens from corn

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(FAW) and soybean (VBC). The CEW larvae were obtained from feral moths captured in a light trap at Tifton.

The FAW and VBC bioassays were initiated by placing neonate larvae into individual, 9-cm diam. plastic petri dishes lined with moistened filter paper and containing the field-grown foliage. Replication was 25 per species per peanut genotype (1 replicate = 1 larva). During the first 10 days of development, larvae were provided full-size, but nonexpanded terminal leaves. After 10 days, unfolded leaves located one or two positions down from the terminal were provided. Old foliage was removed every 48 hrs. and replaced with fresh foliage. Petri dishes containing fresh food, and larvae were held in a rearing room at 25 C, 70% RH, and 14:10 (L:D) photoperiod. Parameters measured were larval weight at 10 days of age, total days to pupation, pupal weight at 4 days following pupation, and number surviving to pupation. All weights were taken to the nearest 0.1 mg on an electronic top-loading balance.

Bioassays involving CEW were performed as described for VBC and FAW except that two feeding regimes were provided with each peanut genotype. The first involved feeding field-grown foliage only to CEW larvae as explained above for VBC and FAW. The second feeding regime involved providing fresh peanut blooms from the subject lines in addition to foliage as follows. During the first six days of the CEW bioassay, three fresh hand-picked blooms were added every 48 hrs to dishes containing a CEW larva. After six days, 10 blooms were provided every 48 hrs for the remainder of larval development. Fresh foliage was added every 48 hrs in addition to blooms during the entire duration of the bioassay. Replication was 25 larvae per peanut genotype per feeding regime. Parameters measured for CEW were the same as those described for VBC and FAW.

For each of the three insect species, a resistance index of growth rate was calculated for each of the eight peanut genotypes by dividing pupal weight by the number of days to pupation. This index allows incorporation of two effects often noted in resistance to foliar feeding insects (longer development time and reduced final weight) into a single number for comparison of relative resistance among genotypes. This index was previously used to compare soybean genotypes for resistance to VBC by Rogers and Sullivan (13).

All experiments were analyzed as a completely random design using analysis of variance with means separated by Waller-Duncan K-ratio *t*-test (P< 0.05). Means for the CEW feeding bioassays involving foliage only and foliage + blooms were compared by peanut genotypes using Student' *t*-test(P< 0.05).

Results and Discussion

Larval weights of FAW at day 10 of development ranged from 75.7 mg (Southern Runner) to 26.5 mg (Florunner) (Table 1), indicating a wide diversity of growth responses for the species when reared on various peanut genotypes. Treatments with larvae at the smaller end of the range also exhibited an increased number of days required to develop to the pupal stage. Larvae fed Florunner required an average of 3.7 more days to develop compared with larvae fed Curly Leaf foliage. Less difference was noted in pupal weights among treatments, although FAW reared on Southern Runner and NC 6 developed into siginifantly smaller pupae when compared with five of the remaining six genotypes tested. Percent survival was very high on all peanut genotypes (≥96%).Growth responses of VBC on the various genotypes did not vary as much as FAW (Table 1). However, VBC larvae reared on Florunner were significantly smaller at 10 days and development to the pupal stage was shorter compared with larvae reared on all other genotypes. Larvae reared on Tifton-8 foliage also developed more slowly compared with all other genotypes with the exeption of Florunner. Larvae weighed more at 10 days and developed to the pupal stage faster when reared on Curly Leaf, Southern Runner, and GPNC 343 compared with all other cultivars. The smallest average pupal weight was recorded from Curly Leaf; however, this value was not significantly different from pupal weights on Southern Runner, Robut 33-1, or NC 6.

Table 1. Development and survival of fall armyworm and velvetbean caterpillar reared on field-grown foliage of eight peanut genotypes, Tifton, GA, 1987.

Peanut genotype	Larval[a/b/] wt. (mg)	Days to[b/] pupation	Pupal[b/] wt. (mg)	% Survival
		Fall armyworm		
Southern Runner	75.7a	21.3d	196.7e	96
Florigiant	74.2a	20.9e	214.8bc	100
Curly Leaf	65.1ab	20.7e	225.5ab	96
GPNC 343	53.3bc	21.8c	230.5a	96
Robut 33-1	47.4cd	21.8c	224.0ab	100
NC 6	41.4cd	23.6b	199.7de	100
Tifton-8	38.5de	23.4b	213.3bcd	100
Florunner	26.5e	24.4a	207.4cde	96
		Velvetbean caterpillar		
Southern Runner	111.2ab	16.7ef	247.3bc	92
Florigiant	82.7d	17.6c	269.5a	92
Curly Leaf	116.1a	16.4f	240.3c	84
GPNC 343	103.7abc	16.8e	268.0a	84
Robut 33-1	89.6cd	17.5c	254.9abc	88
NC 6	92.4bcd	17.1c	245.6bc	92
Tifton-8	85.5cd	18.0b	261.4ab	92
Florunner	60.2e	18.4a	263.5ab	96

a/Larvae weighed at day 10 of development.

b/Means followed by the same letter within a column for the same pest are not significantly different, Waller-Duncan K-ratio *t*-test (P<0.05).

Percent survival was high on all peanut genotypes (84-96%).

When reared on foliage only, CEW larvae were smallest at 10 days and development to the pupal stage was longest for GPNC 343, Tifton-8, and NC 6 (Table 2). Southern Runner and Curly Leaf treatments had the largest larvae at 10 days and the shortest development time to the pupal stage when reared on foliage only. No differences were noted in pupal weights among peanut genotypes in the foliage only treatments. Overall, percent survival was lower for CEW fed foliage only compared with percent survival of FAW and VBC. Survival was particularly low (36%) on NC 6 and Tifton-8.

Using the growth rate index method to rank peanut genotypes for FAW resistance (Table 3), the most resistant genotypes were NC 6 and Florunner. Tifton-8 and Southern Runner were intermediate in susceptibility compared to the remaining four genotypes. No significant differences were found when comparing VBC resistance indexes calculated for each peanut cultivar (Table 3).

Using the resistance index method for rating peanut genotypes for foliar feeding resistance to CEW larvae provided foliage only (Table 3), the lowest value was for NC 6. However, this value was significantly lower than index values of other genotypes only in the instance of Curly Leaf and Southern Runner.

When reared on foliage and blooms, CEW larvae were significantly larger at 10 days of development on Southern Runner, Florunner, and Robut 33-1 compared with all other peanut genotypes. Larvae of *H. zea* reared on Florunner provided a diet of foliage and blooms were significantly

Table 2. Development and survival of corn earworm provided either field-grown foliage or foliage + blooms of eight peanut genotypes, Tifton, GA.

Genotype	Larval[a/b/] weight (mg)		Days to[a/] pupation		Pupal[a/] weight (mg)		% Survival	
	F	F + B[c/]	F	F + B[c/]	F	F + B[c/]	F	F + B[c/]
Southern Runner	24.2ab	21.9a	25.7d	24.4c	315.2a	352.5ab	72	56
Florigiant	19.2bc	13.3b	27.4bc	26.4ab	310.9a	332.0b	72	60
Curly Leaf	28.1a	10.8b*	26.5cd	24.5c*	315.4a	347.9ab	84	44
GPNC 343	11.7cd	6.2b	29.5a	27.0a*	302.8a	349.7ab*	60	40
Robut 33-1	19.4ab	25.8a	27.5bc	24.8bc*	311.3a	328.1b	64	72
NC 6	10.8cd	11.2b	28.9ab	26.4ab*	282.1a	311.0b	36	40
Tifton-8	7.0d	6.5b	28.7ab	26.8a	299.9a	330.3b	36	40
Florunner	12.8cd	24.1a*	27.1bcd	24.9bc*	313.2a	373.9a*	56	80

[a/]Means within a column followed by the same letter are not significantly different, Waller-Duncan K-ratio t-test ($P<0.05$). Mean pairs for the two feeding treatments within a genotype are significantly different if followed by an asterisk, t-test ($P<0.05$).

[b/]Larvae weighed at day 10 of development

[c/]F = foliage only, F + B = foliage plus blooms

heavier than those provided foliage only; however, those provided Curly Leaf foliage and blooms were significantly lighter than those fed foliage alone.

Days to pupation were reduced for larvae reared on foliage and blooms of Southern Runner and Curly Leaf compared with larvae reared on foliage and blooms of the other genotypes, except for Robut 33-1 and Florunner. For all genotypes, days to pupation were reduced when CEW larvae were fed foliage and blooms compared with foliage only, although the difference was not statistically significant with Southern Runner, Florigiant, and Tifton-8.

When larvae were fed a combination of foliage and blooms, some differences were noted in pupal weights. Heaviest pupae resulted from Florunner, Southern Runner, GPNC 343, and Curly Leaf treatments. Larvae fed foliage plus blooms resulted in heavier pupae compared with foliage only of all treatments; however, significant differences were observed only in those fed Florunner and GPNC 343. Addition of blooms to the diet did not appear to increase % survival of CEW larvae, except in Florunner treatments (80% on foilage + blooms, 56% on foliage only) and did result in decreased survival where Florigiant, Southern Runner, Curley Leaf and GPNC 343 were fed.

Table 3. Resistance index for fall armyworm and velvetbean caterpillar reared on field-grown foliage, and corn earworm reared on either foliage only or foliage + blooms, of eight peanut genotypes, Tifton GA, 1987.

Genotype	Resistance Index[a/]			
			CEW[b/c/]	
	FAW[b/]	VBC[b/]	Foliage	Foliage + Blooms
Southern Runner	9.2c	14.8a	12.4a	14.5a*
Florigiant	10.3b	15.4a	11.4abc	12.3bc
Curly Leaf	10.9a	14.7a	12.2ab	14.0b*
GPNC 343	10.6ab	16.0a	10.5bc	12.6c*
Robut 33-1	10.3b	15.1a	11.6abc	13.5abc*
NC 6	8.5d	14.6a	9.9c	11.8c*
Tifton-8	9.2c	15.2a	10.5bc	12.2c
Florunner	8.6d	14.9a	11.4abc	15.0a*

[a/]Resistance index = pupal wt./days to pupation; smaller numbers indicate a greater degree of resistance.

[b/]Means followed by the same letter are not significantly different, Waller-Duncan K-ratio t-test ($P<0.05$).

[c/]Mean pairs for the two feeding treatments within a genotype are significantly different if followed by an asterisk, t-test ($P<0.05$).

When the resistance index was calculated for peanut genotypes within the foliage and bloom feeding treatment (Table 3), the relative ranking of the genotypes changed only slightly from rankings based on foliage feeding only. However, for all genotypes except Tifton-8 and Florigiant, the resistance index was significantly lower when larvae were fed foliage only.

The increased performance of CEW larvae in the foliage and blooms feeding treatment for most of the peanut genotypes suggests some nutritional benefit of bloom feeding to the insect. Behavioral observations of CEW feeding within the foliage and blooms treatments also support this conclusion. We observed that CEW larvae fed on blooms first, feeding on foliage only after all blooms were consumed. It is possible that providing more than 10 blooms every 48 hours could have resulted in greater differences between the two treatments.

Summary and Conclusions

In terms of overall resistance to the three defoliators tested, the peanut genotypes NC 6 and Tifton-8 appeared to be the most resistant, while Florigiant, Curly Leaf, and Robut 33-1 appeared to be the most susceptible. Although the resistance exhibited by NC 6 and Tifton-8 was not a very high level in this study; results confirm previous field studies (3, 5). When selecting a peanut genotype, considerations such as yield/quality characters and resistance to other pests would generally outweigh resistance to defoliators. Avoiding the most susceptible genotypes when possible may at least reduce the possibility of sustaining economically significant levels of defoliation in a particular field.

When CEW larvae were provided a limited number of blooms in addition to unlimited amounts of foliage, growth and development were generally improved. As discussed in the introduction, bloom feeding in peanuts is unlikely to directly result in significant yield impact. However, the availability of blooms may be of sufficient benefit to the insect to result in : 1) additional foliage feeding on that crop, 2) enhanced reproductive potential for production of subsequent generations which may remain on that crop or move to surrounding crops, or 3) increased overwintering survival possibly resulting in more severe pest pressure the following season.

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