COMPARATIVE CONSUMPTION AND UTILIZATION OF FLORIDA BEGGARWEED AND TWO SOYBEAN GENOTYPES BY *PSEUDOPLUSIA INCLUDENS* LARVAE (LEPIDOPTERA: NOCTUIDAE)

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ABSTRACT

Larvae of the soybean looper (SBL), *Pseudoplusia includens* (Walker), were reared on three food types: soybean, *Glycine max* (L.) Merrill, genotypes 'Kirby' (insect susceptible) and GatIR 81-296 (insect resistant), and Florida beggarweed, *(Desmodium tortuosum* (Swartz) de Candolle. Larval development was longest on GatIR 81-296 (16.7 days) followed by beggarweed (15.5 days) and Kirby (14.1 days). Total consumption and relative consumption rate by ultimate (6th) instar SBL were significantly greatest on Kirby with no difference noted in consumption between GatIR 81-296 and beggarweed. However, approximate digestibility and efficiency of conversion of ingested food by ultimate instars were significantly greatest on beggarweed compared with the two soybean genotypes. Ultimate instar weight gain and growth rate were similar for larvae restricted to Kirby and beggarweed, while larvae restricted to GatIR 81-296 had significantly reduced weight gain and growth rate. Pupal weights of individuals reared on GatIR 81-296 also were significantly reduced compared with those in the Kirby and beggarweed treatments. SBL larvae consumed less beggarweed foliage (mg dry weight) than Kirby soybean, yet compensated to some extent by utilizing beggarweed foliage more efficiently. Beggarweed proved to be a better source of larval nutrition for SBL than the insect-resistant soybean genotype GatIR 81-296.

Key Words: Soybean looper, *Pseudoplusia includens*, soybean, beggarweed, host plant resistance, foliage consumption.

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INTRODUCTION

Florida beggarweed, *Desmodium tortuosum* (Swartz) de Candolle, is an annual legume commonly occurring in fields and roadsides in the southern United States (Duncan and Foote 1975, Radford et al. 1978). Although of some value as forage (Duncan and Foote 1975, Jackson et al. 1984), beggarweed is primarily known as a weed pest in various row crops, including soybean, *Glycine max* (L.) Merrill.

Weeds may affect herbivore abundance in cropping systems such as soybean in various ways. The presence of weed species within or surrounding a soybean field can increase the abundance of herbivore natural enemies (Altieri and Todd 1981, Altieri et al. 1981a, 1981b, Shelton and Edwards 1983). Alternatively, the presence of weed species which can be utilized as nectar sources by adult Lepidoptera, can increase reproductive potential of pest species in soybean (Collins and Johnson 1985).

The occurrence of beggarweed in soybean cropping systems may be positive in regard to reducing herbivory on the crop itself. Barber (1937) noted that soybean was less frequently attacked by larvae of the corn earworm, *Heliothis zea* (Boddie) (=*H. obsoleta* in Barber's paper), when heavy stands of beggarweed (=*Meibomia purpurea* in Barber's paper) were available as a food source. The failure of the Mexican bean beetle, *Epilachna varivestis* Mulsant, to be an important pest of soybean in Florida and other areas of the Southeast may be attributed in part to the beetles' utilization of beggarweed as a host (Nong and Sailer 1985). It should also be noted, however, that the late-season availability of beggarweed as a food source for *H. zea* and *H. virescens* (F.) contributes to the overwintering populations of these two important agricultural pests (Jackson and Mitchell 1984).

The soybean looper (SBL), *Pseudoplusia includens* (Walker), may feed on a wide range of cultivated and noncultivated plant species, yet appears to prefer soybean (Martin et al. 1976). Herzog (1980) has compiled a listing of SBL host plants from numerous references; however, beggarweed has apparently not been noted as a host. During SBL outbreaks in certain soybean cropping systems in south Georgia in 1982 (Beach and Todd 1986), we noted occasional feeding on beggarweed by SBL larvae (unpublished observations). In view of the lack of information concerning the suitability of beggarweed as a larval host for SBL, as well as potential interactions of beggarweed with SBL pest management strategies, we compared growth, consumption, and utilization by ultimate (6th) instar SBL larvae fed beggarweed foliage versus foliage from two different soybean genotypes.

MATERIALS AND METHODS

SBL larvae were obtained from a laboratory colony established from local wild populations near Tifton, GA, and had undergone ca. 10 generations prior to testing. Larvae were maintained at 25° C, 14L:10D, and 75% RH on artificial diet similar to that of Greene et al. (1976) except that alfalfa meal was substituted for soybean meal.

Soybean genotypes used were the cultivar 'Kirby' and the Georgia breeding line GatIR 81-296. GatIR 81-296 is the result of a cross between the insect resistant plant introduction PI 229358 and the cultivar 'GaSoy 17' (Baker and Todd 1984). This line has displayed good levels of resistance to soybean defoliators as well as acceptable agronomic characteristics (unpublished data). Foliage from these two genotypes was obtained from small field plantings maintained under standard agronomic practices at the Coastal Plain Experiment Station, Tifton, GA. Plants were in R2-R3 stages of growth (Fehr et al. 1971) during the test period (Aug. 1986). Beggarweed foliage was obtained from plants growing adjacent to the Kirby and GatIR 81-296 plots on tilled but unplanted plot space. Beggarweed plants were blooming throughout the test period. Only fully expanded trifoliates from the middle and upper plant portions of both soybean and beggarweed were utilized for feeding tests.

Neonate SBL larvae were placed in individual plastic petri dishes (25 individuals per foliage treatment) lined with moistened filter paper. Fresh foliage from one of the three treatments (Kirby, GatIR 81-296, or beggarweed) was provided on a daily basis thereafter. All dishes containing larvae and foliage were stacked in a (30 × 60 × 8 cm) wooden box covered with plastic to minimize water loss. Temperature, humidity, and photoperiod were as described previously for colony maintenance.

No measurements of consumption were attempted during the early stadia. However, observations of molts were recorded for each individual until the beginning of the 6th stadium. At that point, 15 larvae were selected at random from each treatment, weighed (all weights were taken on a Mettler AE100 electrobalance accurate to 0.1 mg), and returned to clean dishes with a weighed amount of foliage from their respective treatments. Foliage was replaced at least every 48 hours during the stadium. Larvae were reweighed at the end of the 6th stadium. Remaining foliage was reweighed and subtracted from the amount added to calculate fresh weight consumption. Fresh consumption was corrected for water loss during the stadium by measuring weight loss of foliage maintained in dishes without insects (N=5 per treatment). Control foliage was closely matched to foliage provided to the insects. Corrected fresh weight consumption was calculated as: consumption - (consumption × % water loss of control foliage). The % water loss correction was not applied to the total amount of foliage given to a larva because old foliage was removed periodically with fresh foliage added during the stadium. Thus, the total amount of foliage given was not subject to water loss for the entire duration of the stadium. Percent dry matter of each foliage type was obtained by weighing fresh leaflets (N=10 per treatment), drying at 45°C for 72 hours, and reweighing. Dry weight consumption was then calculated by multiplying fresh weight consumption by % dry matter. Fecal material produced during the 6th instar was collected for each individual, dried at 45°C for 72 hours, and weighed. Extra 6th instars maintained under conditions identical to test insects (N=5 per treatment) were weighed, killed by freezing, dried at 45°C for 96 hours, and reweighed. Dry weights of test larvae were then obtained by multiplying % dry matter of sacrificed larvae by fresh weight of the insect.

Information obtained in the above fashion was used to calculate efficiency of conversion of ingested (ECI) and digested (ECD) food to body substance, approximate digestibility (AD), relative growth rate (RGR), and relative consumption rate (RCR) on a dry weight basis. The terminology and calculations are those of Waldbauer (1968) and Scriber and Slansky (1981). Indices were calculated as follows: ECI = B/I; ECD = B/(I-F); AD = (I-F)/I; RGR = B/($\overline{B}$×T); RCR = I/($\overline{B}$×T), where B = biomass gained during the stadium, I = food ingested, F = feces and T = stadial length in days. Mean larval weight ($\overline{B}$) was calculated as B/ln (final weight of 6th instar/initial weight of 6th instar) (Gordon 1968). Total larval development time (days) and pupal weight (mg fresh wt) were recorded for all individuals.

Data were analyzed as a completely random design utilizing a program from SAS (SAS Institute, 1982). Statistics used were analysis of variance (P=0.05) with mean separation by Waller-Duncan K-ratio t-test (P=0.05) (Waller and Duncan 1969).

RESULTS

Dry weight of the younger (but fully expanded) trifoliates of Kirby, GatIR 81-296, and beggarweed averaged 30.3, 26.8 and 19.8%, respectively. Preliminary tests indicated that older foliage from lower areas of beggarweed plants were not preferred by late instar larvae.

Percent water loss control foliage was minimal during the experiment for all three foliage types. Mean (± SEM) % of water loss for 48 hours was 1.2 ±+ 1.1 for Kirby soybean, 3.1 ± 0.9 for GatIR 81-296 soybean, and 3.8 ± 1.2 for beggarweed.

Mortality of SBL larvae restricted to a diet of Kirby soybean foliage was 4% (1/25) while mortality of larvae on GatIR 81-296 soybean and beggarweed was 16%

(4/25). No pupal mortality occurred and adults were observed to emerge normally in all treatments. Of the 15 larvae in each treatment selected for 6th instar consumption tests, two larvae in both the GatIR 81-296 and beggarweed treatments molted to an additional (7th) stadium. However, all four of these individuals died prior to completing the 7th stadium and were not used in calculating growth, consumption, and utilization indices.

Total larval development required only 14.1 days on Kirby compared with 15.5 days on beggarweed and 16.7 days on GatIR 81-296 (Table 1). Final (pupal) weights of SBL fed a diet of Kirby or beggarweed foliage did not differ significantly; however, pupal weights of individuals reared on GatIR 81-296 were reduced.

Total consumption and RCR by ultimate instar SBL were greatest when restricted to Kirby foliage (Tables 1 & 2). No significant differences were noted in either total consumption or RCR between larvae reared on GatIR 81-296 or beggarweed foliage.

Growth of ultimate instar SBL larvae, as measured by weight gain (Table 1) and RGR (Table 2), was reduced in individuals reared on GatIR 81-296 while growth was similar for larvae in the Kirby and beggarweed treatments.

AD and ECI values were greatest for larvae restricted to beggarweed foliage (Table 2). No significant differences were noted in ECD among the three treatments.

DISCUSSION

Dry weight consumption of field-grown Kirby soybean by 6th instar SBL was greater in the present study (332.9 mg) compared with previous studies of SBL consumption (259.5 mg in Kogan and Cope 1974; 208.1 mg in Reid and Greene 1973). However, Kogan and Cope (1974) used greenhouse-grown 'Harosoy 63' soybean foliage, while Reid and Greene (1973) used a leaf area measurement technique from which dry weight consumption of field-grown 'Bragg' soybean foliage was estimated. Thus, results from these studies may not be directly comparable to our results. Dry weight efficiency values (ECI and ECD) in Kogan and Cope (1974) are approximately twice as large as those reported in the present study. However, ECI values based on fresh weight measurements with greenhouse-grown GaSoy 17 soybean foliage (10.5%, Beach and Todd 1988) are similar to results of dry weight measurements with field-grown Kirby foliage (9.2%, Table 2).

Significantly reduced growth and consumption was exhibited by larvae restricted to GatIR 81-296 compared with Kirby. However, ECI, ECD, and AD did not vary significantly between the two foliage types. In the previously mentioned study with greenhouse-grown foliage (Beach and Todd 1988), ECI was significantly reduced for penultimate and ultimate instar SBL restricted to GatIR 81-296 compared with GaSoy 17. Reynolds et al. (1984) found that both ECI and ECD of ultimate instar SBL were reduced when reared on greenhouse-grown foliage of the resistant soybean PI 227687; however, AD was not affected.

Although previously unreported as a SBL host plant, beggarweed provided the nutrition necessary for SBL larval development in the present study. When compared to the susceptible soybean variety Kirby, insect size and % survival were reduced only slightly; however, total larval development time was increased by ca. 1.1 days. Dry weight consumption of foliage was lower for larvae restricted to beggarweed relative to those on Kirby, yet increased digestibility (AD) and

Table 1. Various consumption and development parameters for soybean looper larvae fed field-grown foliage of Kirby (insect susceptible soybean), GatIR 81-296 (insect resistant soybean), or Florida beggarweed at Tifton, GA, 1986.

	Ultimate Instar				
Foliage Type	Total Consumption (mg dry wt)	Weight Gain (mg dry wt)	Stadial Length (days)	Total Larval Development Time (days)	Pupal Weight (mg fresh wt)
Kirby soybean	332.9 ± 9.6a	30.4 ± 0.7a	4.1 ± 0.1a	14.1 ± 0.1c	296.7 ± 3.7a
Florida beggarweed	256.9 ± 20.9b	29.5 ± 0.8a	4.8 ± 0.1b	15.5 ± 0.2b	277.1 ± 9.8a
GatIR 81-296 soybean	258.8 ± 10.1b	20.4 ± 1.4b	4.8 ± 0.1b	16.7 ± 0.1a	217.1 ± 8.4b

Mean ± SE. Means within a column followed by the same letter are not significantly different at the $P > 0.05$ level (Waller-Duncan K-ratio t-test).

Table 2. Efficiency of conversion of ingested (ECI) and digested (ECD) food, approximate digestibility (AD), relative growth rate (RGR), and relative consumption rate (RCR) calculated on a dry weight basis for ultimate instar soybean looper larvae fed field-grown foliage of Kirby (insect susceptible soybean), GatIR 81-296 (insect resistant soybean), or Florida beggarweed at Tifton, GA, 1986.

Foliage Type	ECI (%)	ECD (%)	AD (%)	RGR (mg/mg/day)	RCR (mg/mg/day)
Kirby soybean	9.2 ± 0.2b	19.6 ± 0.8a	47.2 ± 1.0b	0.28 ± 0.01a	3.08 ± 0.08a
Florida beggarweed	12.2 ± 1.5a	19.8 ± 3.3a	61.5 ± 2.9a	0.26 ± 0.01a	2.25 ± 0.18b
GatIR 81-296 soybean	7.8 ± 0.5b	16.8 ± 1.2a	46.9 ± 1.2b	0.18 ± 0.01b	2.34 ± 0.09b

Mean ± SE. Means within a column followed by the same letter are not significantly different at the $P > 0.05$ level (Waller-Duncan K-ratio t-test).

gross feeding efficiency (ECI) resulted in similar growth for larvae reared on beggarweed compared with Kirby. Such was not the case when larvae were restricted to the resistant breeding line GatIR 81-296. Dry weight consumption and RCR were similar in the beggarweed and GatIR 81-296 treatments; however, RGR and pupal weights were significantly reduced on the resistant soybean genotype. The increased efficiency of SBL larvae on beggarweed relative to Kirby soybean may be due in part to increased leaf water (decreased % dry weight) of beggarweed (see Scriber and Slansky 1981 for a discussion) or could be due to differences in levels of other nutrients not assayed in this study. For larvae restricted to GatIR 81-296 soybean, reduced growth is suspected as being due to allelochemics, although the exact nature of insect resistance is as yet unknown for PI 229358 soybean and lines derived from crosses involving this PI (such as GatIR 81-296).

While SBL larvae apparently can feed on beggarweed, they generally are not found on beggarweed plants in the field. We observed SBL naturally occurring on beggarweed only during 1982, a year characterized by high SBL populations in south Georgia. No reports of SBL feeding on beggarweed in other regions have been published to our knowledge.

The superior performance of SBL larvae on beggarweed compared with the resistant soybean genotype GatIR 81-296 could be of significance in regard to the successful utilization of insect-resistant lines in soybean pest management. If traditional soybean cultivars were replaced to a large extent by resistant soybean genotypes, alternate host plants within the agroecosystem not presently utilized by SBL (such as beggarweed) may then become more desirable as a food source. This could lead to further reductions of SBL larval populations on soybean. In addition, the stability of soybean resistance to SBL could be enhanced due to reduced pressure to adapt to the resistant genotype (Beck and Schoonhoven 1980).

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