Laboratory Bioassay Evaluating Peanut Seedlings for Resistance to the Southern Corn Rootworm, *Diabrotica undecimpunctata howardi* Barber (Coleoptera: Chrysomelidae)

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ABSTRACT

The objective of this study was to develop a laboratory bioassay that consistently distinguishes peanut genotypes (*Arachis hypogaea* L.) based on their potential susceptibility or resistance to the southern corn rootworm (SCR), *Diabrotica undecimpunctata howardi* Barber, a major soil insect pest of peanut in North Carolina, Virginia, and other states. The susceptibility or resistance of a peanut genotype to the SCR was characterized by the survival, development, and mean weight of the pest after feeding for 14 d on seedlings of different peanut genotypes. An initial 14 d seedling bioassay demonstrated the ability of the technique to separate a susceptible cultivar (NC 7) from a resistant cultivar (NC 6) based on the percentage of SCR that survived after 14 d, the percentages and mean weight of surviving SCR in larvae, prepupae, and pupae. Subsequently, two 14 d seedling bioassays evaluated five additional peanut genotypes that were believed to have some resistance to the SCR (N97059N, N92069L, VA 861101, VT 9506114-1, NC-GP WS 9) along with the susceptible (NC 7) and resistant (NC 6) controls. The final two bioassays were modified to test the differences in the percentages of SCR adults that emerged and the time required for adult emergence after feeding as larvae on the susceptible (NC 7) and resistant (NC 6) peanut seedlings. The 14 d seedling bioassay represents an improvement over earlier seedling bioassays because of its consistent ability to distinguish susceptible and resistant peanut genotypes, and because of the diversity of parameters measured. It consistently separated the susceptible (NC 7) and resistant (NC 6) controls, with one or more of the parameters measured. The breeding line N92069L and the germplasm line NC-GP WS 9 were shown to result in significantly lower survival of SCR and to delay development relative to the susceptible control NC 6. A seedling bioassay where eggs were allowed to develop to the adult stage repeatedly separated NC 7 from NC 6 based on the percentages of adults that emerged. Results indicate the seedling bioassay should be a reliable method for screening large numbers of peanut genotypes before committing the time, space, and labor required for field evaluations. In addition, future peanut breeding programs should consider attempting to introduce the resistance expressed in NC-GP WS 9, N92069L, and N97059N into lines with desirable agronomic characteristics.

Key Words: *Arachis hypogaea* L., host plant resistance, species introgression.

The southern corn rootworm (SCR), *Diabrotica undecimpunctata howardi* Barber, is considered a key pest of peanuts (*Arachis hypogaea* L.) in North Carolina and Virginia (Smith and Barfield, 1982; Herbert, 1995). Although adult beetles will feed on foliage of the peanut plant, it is the subterranean larval stage that causes economic damage by boring directly into the pegs and immature pods prior to the hardening of the mesocarp (Fink, 1916). Feeding injuries that do not directly result in pod loss often allow microorganisms to enter, thus causing decay (Grayson and Poos, 1947). In addition, superficial scarring of pods can reduce the value of the crop because virginia-type peanuts are primarily grown for the in-shell market (Brandenburg and Herbert, 1991).

Current control of SCR primarily relies on the preventive application of soil insecticides (e.g., chlorpyrifos, phorate) (Herbert, 1995). Approximately 56% of the peanut acreage in North Carolina in 1995 and 90.4% of the peanut acreage in Virginia in 1990 were treated preventively with soil insecticides. These preventative applications cost more than $3 million annually and represent 158 t of active ingredient combined (Phipps *et al.*, 1992; Toth *et al.*, 1994; Herbert, 1995; Toth and Brandenburg, 1997). Alternative methods of control such as semiochemical baits, trap crops, and entomopathogenic nematodes have been ineffective replacements for traditional insecticide applications (Barbercheck *et al.*, 1995; Barbercheck and Warrick, 1997). The SCR resistant peanut cultivar NC 6 was released in the 1970s, but its seed coat color and yield potential do not compare favorably with currently available cultivars. Recent attempts to predict fields at risk of economic SCR damage have failed to eliminate insecticide applications on most fields because of the low risk tolerance associated with such a potentially devastating pest (Brandenburg *et al.*, 1992; Herbert *et al.*, 1997). Possible restrictions imposed by the Food Quality and Protection Act concerning the use of organophosphate pesticides on peanuts makes future reliance on these chemicals uncertain.

Resistant peanut cultivars have the potential to reduce or eliminate the need for pesticides currently used to manage SCR infestations (Campbell and Wynne, 1985). Traditionally, peanuts have been evaluated for resistance through field tests (Fronk, 1950; Bousch and Alexander, 1965; Alexander and Smith, 1966; Chalfant and Mitchell, 1970; Coffelt and Herbert, 1994). Although field tests are considered the most reliable measure of resistance, variable SCR populations and environmental factors require field tests to be repeated a minimum of 3 yr for trends in resistance to be established. The time required to verify the level and stability of resistance has led researchers to develop laboratory and greenhouse methods to screen peanuts for resistance (Chalfant and Mitchell, 1970; Smith, 1970; Smith and Porter, 1971; Petka *et al.*, 1997). Although these previous studies have improved our under-

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standing of host plant resistance and our ability to distinguish susceptible from resistant peanut lines, the limited repeatability of some experiments and the often high SCR mortality on susceptible varieties has left room for improvement upon techniques (Petka *et al.*, 1997). The objective of this study was to develop a laboratory seedling bioassay to consistently distinguish SCR resistance based on survival, development, and weight of larval and pupal SCR.

Materials and Methods

Experiments I, II, and III (14 d Seedling Bioassay). Laboratory bioassays were conducted in 2000 and 2001 at the Dept. of Entomology, North Carolina State Univ., Raleigh, NC, to determine the effects of two peanut cultivars (NC 7 and NC 6) and five breeding lines (NC-GP WS 9, N92069L, N97059N, VA 861101, and VT 9506114-1) on the survival and development of SCR that fed on seedlings. NC 7 was included in the bioassays to serve as the susceptible control because it is a commercially available cultivar with no documented resistance to SCR. NC 6 was included as the resistant control because it was released as a resistant cultivar and has been used as the resistant control in previous studies (Coffelt and Herbert, 1994; Petka *et al.*, 1997). The five breeding lines were tested because earlier field evaluations indicated some level of resistance. Most of the lines included in the study (Table 1) traced their ancestry back to GP-NC 343, a line that has been used as a source of insect resistance in several breeding programs. GP-NC 343 probably derives its insect resistance from PI 121067, which made ancestral contributions to several of the lines through its descendant NC 5 as well as through GP-NC 343. GP-NC WS 9 was included in this study because its resistance is derived from another source: *A. cardenasii* Krapov. and W.C. Gregory (GKP 10017; PI 262141), a diploid ($2n = 2x = 20$) wild peanut species from South America. Peanuts to be tested were treated with Captan {[cis-*N*-(trichloromethyl)thio]-4-cyclohexene-1,2-dicarboximide, Granox®, Chipman Chem. Inc., River Rouge, MI} seed fungicide to control seed decay and disease. Approximately 50 seeds per genotype per experiment were germinated in moist, brown paper towels inside clear, plastic bags and placed onto a lab bench at room temperature (25 C) for 5 d or until the radical was 2 to 4 cm long. The seedlings were then placed in 125 mL of moist vermiculite (Palmetto Vermiculite Co, Inc., Woodruff, SC) (2 parts vermiculite:1 part distilled water) in vertically oriented, clear plastic petri dishes (150 x 25 mm, Fisher Scientific, Pittsburgh, PA). The vermiculite was sterilized with UV light before adding the distilled water, and each petri dish had two holes (1 cm diam., 10 cm apart) located on the top edge for ventilation. Each petri dish contained three seedlings of a single peanut genotype.

SCR eggs in 25 mL of dilute agar were purchased from a commercial source (French Agricultural Research, Lamberton, MN). Nine-inch, borosilicate glass disposable Pasteur pipettes (Fisher Scientific, Pittsburgh, PA) were used to place 15 eggs on pieces of brown seed germination paper (2 x 3 cm). The pieces of paper with eggs were placed onto a 2-cm bed of moist vermiculite inside plastic trays (165 x 305 x 80 mm) and inserted into clear plastic bags to maintain moisture and held at 25 C until the seedlings, moist vermiculite, and petri dishes were assembled. In each petri dish a single piece of paper with eggs was placed on the top edge of the moist vermiculite containing the seedlings.

To prevent emerging larvae from escaping, Parafilm® (American Nat. Can, Menasha, WI) was cut into 250 x 50-mm strips and wrapped around the edges of the petri dishes, and a mixture of petroleum jelly and glycerine was swabbed around the two holes on the top of the petri dishes. After the eggs hatched, the petri dishes were opened, the piece of paper removed, and the number of larvae that emerged was recorded by counting the empty egg cases on the paper with a dissecting microscope. The edges of the petri dishes were resealed with Parafilm®. The petri dishes were then randomly arranged in plastic trays (165 x 305 x 80 mm). Each plastic tray was placed inside of a clear

Table 1. Parentage of lines bioassayed for resistance to SCR.

Line	Parentage	Reference
NC 6	NC Bunch / PI 121067, C12 // C37, NC Bunch / PI 121067, GP-NC 343 / 3 / VA61R	Campbell *et al.*, 1977 Campbell *et al.*, 1971 Alexander and Allison, 1970
NC 7	F334A-3-5-5-1 / Jenkins Jumbo F393-7-47-1-7-1 // NC 5	Hammons *et al.*, 1983 Hammons and Norden, 1979 Emery and Gregory, 1970
N92069L	GP-NC 343 / NC 5	
N97059N	NC 7 / Florigiant, N90004 // GP-NC 343	Wynne *et al.*, 1979 Carver, 1969
VGP 11	Pink-testa selection from NC 6	Coffelt *et al.*, 1998
VT 9506114-1	VA-C 92R / VGP 11	Mozingo *et al.*, 1994
GP-NC WS 9	*A. hypogaea* PI 261942 / *A. cardenasii* Krapov. & W.C. Gregory PI 262141 (GKP 10017)	Stalker and Lynch, 2002

plastic bag to conserve moisture and eliminate the need to water the developing seedlings. To prevent stagnation of air in the petri dishes and the plastic bags, the plastic trays were removed from the bags every other day for 1 hr and then replaced in the bags.

Fourteen days after egg hatch, the vermiculite and seedlings of each petri dish were sorted to recover all surviving insects. The percentages of surviving SCR in the larval, prepupal, and pupal stages, the overall percentage survival, and the mean weights of each life stage were determined for each peanut genotype. The bioassay conducted in August 2000 (Experiment I) tested only two peanut cultivars (NC 7 and NC 6) to determine the technique's ability to distinguish susceptible and resistant genotypes. Experiments conducted in September 2000 (Experiment II) and February 2001 (Experiment III) tested seven genotypes (NC 7, NC 6, N92069L, N97059N, VA 861101, VT 9506114-1, and NC-GP WS 9). In each experiment, each peanut genotype was replicated 11 times in a completely randomized design, with the temperature maintained at 25 C and a photoperiod of 14:10 hr (light:dark) in a growth chamber. Replicates in which all seedlings failed to develop were not included in the analysis. Percentage data were transformed using the angular function ($y = \arcsin\sqrt{x}$) (Steel *et al.*, 1997) and subjected to analysis of variance using PROC GLM (SAS Inst., 1989). The means of untransformed data are reported. Means were separated using Fisher's Protected LSD Test at P = 0.05. Due to the inconsistencies between the two bioassays (Experiments II and III), VT9506114-1 was removed from the data set and the data reanalyzed.

Experiments IV and V (Seedling Bioassay from Egg Hatch to the Adult Stage). Bioassays that allowed the SCR to develop to the adult stage were conducted during February (Experiment IV) and March (Experiment V) 2001. The methods and materials were identical to those used in the 14 d seedling bioassay with the following exceptions. Instead of using a single plastic bag to contain the plastic trays holding the petri dishes, each petri dish was individually placed in a resealable plastic bag (165 x 150 mm). The interval for opening the individual bags to allow the petri dishes to ventilate was shortened from 1 hr to 5 min every other day because the duration of the experiment was longer. Beginning 18 d after egg hatch, each petri dish was monitored for the number of adults that emerged and the day of emergence. Data were analyzed as previously described.

Results

Experiment I. In the initial bioassay comparing NC 7 and NC 6, there were significant differences between the two cultivars in the mean percentage of SCR that survived for 14 d and the mean percentage of survivors in the larval stage. There were no significant differences between the two cultivars in percentages of prepupae or pupae or in larval, prepupal, or pupal weights (Table 2).

Experiments II and III. The results of these two bioassays were initially combined and subjected to analysis of variance. This analysis revealed a highly significant peanut genotype x test date interaction for the overall percentages of surviving SCR, the percentages of survivors in the larval stage, and the percentages of survivors in the prepupal stage. Inspection of the data suggested that the percentage of surviving SCR increased from Experiment II to Experiment III across all genotypes with the exception of VT9506114-1. In addition, the response of SCR to VT9506114-1 was unlike the response to the other six genotypes because of inconsistencies in the percentages of surviving SCR in the larval and prepupal stages from Experiment II to Experiment III (Table 3). In Experiment II, VT9506114-1 was not significantly different ($P \leq 0.05$) from NC 7 with respect to any of the parameters measured. In Experiment III, VT9506114-1 was significantly different ($P \leq 0.05$) from NC 7 with respect to the mean percentage of surviving SCR and the mean percentages of larvae and prepupae. The decreased survival of SCR that fed on VT9506114-1 during Experiment III could be attributed to poor seedling development.

Omitting VT9506114-1 from the analysis removed the interaction between peanut variety and test date for the mean percentages of larvae and prepupae, but did not remove the interaction for the total percentage survival, mean larval weights, and mean prepupal weights. This interaction prevented combining the data from the two bioassays into a single analysis for the mean percentages of SCR surviving, the mean larval weights, and the mean prepupal weights associated with the remaining six genotypes. Due to insufficient numbers of pupae, mean percentages of pupae and their mean pupal weights were not analyzed.

Survival of SCR on NC 7 and N97059N was greater ($P \leq$

Table 2. Mean percentages of surviving SCR and weights after feeding 14 d on seedlings of NC 7 or NC 6 (7/20/00-8/2/00).[a]

Cultivar	Survival	Stage			Weight		
		Larval	Prepupae	Pupae	Larval	Prepupal	Pupal
	%	----------%		----------	---------- g		----------
NC 7	93.9*	23.3*	66.1	10.6	0.015	0.018	0.018
NC 6	79.9	45.1	51.6	3.3	0.012	0.017	0.017

[a]Means within a column followed by an asterisk are significantly different at P = 0.05 by Fisher's Protected LSD.

Table 3. Mean percentages of surviving SCR and weight after feeding 14 d on seedlings of NC 7 or VT9506114-1 during Experiments II and III.[a]

Cultivar	Survival	Stage			Weight		
		Larval	pre-pupae	Pupae	Larval	pre-pupal	Pupal
	%	---------% ----------			----------g----------		
Experiment II							
NC 7	86.1	20.8	67.7	11.5	0.010	0.014	0.014
VT9506114-1	87.8	22.6	73.6	3.8	0.009	0.013	0.017
Experiment III							
NC 7	87.3*	33.0*	65.2*	1.6	0.012	0.014	0.015
VT9506114-1	71.2	64.7	33.5	1.8	0.011	0.014	0.017

[a]Means within a column followed by an asterisk are significantly different at P = 0.05 by Fisher's Protected LSD.

0.05) compared with NC 6, N92069L, and NC-GP WS 9 in Experiment II (Table 4). Survival of SCR on VA 861101 was greater compared with N92069L and NC-GP WS 9, and survival on N92069L was higher compared with NC-GP WS 9 in Experiment II. In Experiment III, survival of SCR on N97059N was again greater than on N92069L and NC-GP WS 9, while survival on NC 7 was only significantly greater than survival on NC-GP WS 9. Survival on NC-GP WS 9 was significantly less than all other genotypes except N92069L in Experiment III.

In Experiment II, mean larval weights on N92069L and NC-GP WS 9 were less compared with all other genotypes. In Experiment III, mean larval weights on NC-GP WS 9 were less compared with all other entries except N92069L. Larval weights on N97059N were greater than on VA 861101 and NC-GP WS 9. The mean prepupal weights on NC 7 were higher compared with N92069L and NC-GP WS 9 in Experiment II. The mean prepupal weights of SCR of N92069L were less compared with all other genotypes except NC-GP WS 9 in Experiment II. No significant differences between mean prepupal weights were observed in Experiment III.

The mean percentages of larvae and prepupae from Experiments II and III were combined into a single analysis because of the absence of an interaction between peanut variety and test date (Table 5). There were several significant differences among genotypes with respect to the mean percentages of larvae and prepupae. NC-GP WS 9 had more larvae and fewer prepupae than did all other genotypes except N97059N. N92069L and NC 6 had more larvae and fewer prepupae compared with VA 861101 and NC 7.

Experiments IV and V. There was an interaction between test date and peanut genotype that prevented analyzing the results of Experiments IV and V together. There were differences between NC 7 and NC 6 in Experiments IV and V with respect to mean percentages of adult emergence and the days required from egg hatch to adult emergence (Table 6). NC 7 had more SCR adults emerge compared with NC 6 on both test dates. In Experiment IV, adult SCR emerged in significantly less time after feeding on seedlings of NC 7, while in Experiment V adult SCR emerged in significantly less time after feeding on seedlings of NC 6, although the differences were small for both experiments.

Table 4. Mean percentages of surviving SCR and their mean larval and prepupal weights from Experiments II and III after feeding 14 d on seedlings of different peanut genotypes.

Entry	Survival	Larval weight	Prepupal weight
	%	g	g
	Experiment II[a]		
NC 7	86.1 a	0.010 a	0.014 a
N97059N	82.3 a	0.009 a	0.013 abc
VA861101	75.4 ab	0.010 a	0.014 ab
NC 6	66.4 bc	0.009 a	0.013 ab
N92069L	54.8 c	0.005 b	0.010 c
NC-GP WS 9	21.4 d	0.006 b	0.011 bc
	Experiment III[a]		
NC 7	87.3 ab	0.012 ab	0.014 a
N97059N	90.2 a	0.013 a	0.015 a
VA861101	87.0 ab	0.010 bc	0.013 a
NC 6	83.7 ab	0.012 ab	0.014 a
N92069L	75.2 bc	0.011 abc	0.014 a
NC-GP WS 9	60.5 c	0.010 c	0.015 a

[a]Means within a column followed by an asterisk are significantly different at P = 0.05 by Fisher's Protected LSD. Means are actual percentages but analyses were conducted on arcsin $\sqrt{\%}$ transformed data.

Table 5. Combined mean percentages of larvae, prepupae, and pupae from Experiments II and III after feeding 14 d on seedlings of different peanut genotypes.[a]

Entry	Larval	Prepupal	Pupal
	%	%	%
NC-GP WS 9	92.7 a	7.3 c	0.0
N97059N	86.0 ab	14.0 bc	0.0
N92069L	77.3 b	22.7 b	0.0
NC 6	69.7 b	28.2 b	2.1
VA861101	38.9 c	59.4 a	1.7
NC 7	26.4 c	66.6 a	7.0

[a]Means within a column followed by an asterisk are significantly different at P = 0.05 by Fisher's Protected LSD. Means are actual percentages but analyses were conducted on arcsin $\sqrt{\%}$ transformed data.

Table 6. The mean percentages of adults that emerged and the mean time from egg eclosion until adult emergence after feeding on seedlings of NC 7 or NC 6 during Experiments IV and V (11 replicates/cultivar/experiment).[a]

	Experiment IV		Experiment V	
Entry	Adult	Emergence time	Adult	Emergence time
	%	d	%	d
NC 7	62.6*	28.0*	50.4*	26.6*
NC 6	47.9	29.0	35.1	25.2

[a]Means within each column followed by an asterisk are significantly different at P = 0.05 by Fisher's Protected LSD.

Discussion

A primary objective of our study was to develop a seedling bioassay that consistently distinguishes susceptible from resistant peanut genotypes. Previous research demonstrated a level of resistance was present in the peanut cultivar NC 6 (Wynne *et al.*, 1977; Campbell and Wynne, 1985; Petka *et al.*, 1997). The seedling bioassay used in this study was capable of detecting significant differences between NC 6 and a known susceptible cultivar, NC 7, on several different test dates with respect to more than one parameter. In two out of three 14-d seedling bioassays, significantly fewer SCR survived after feeding on NC 6 as compared to NC 7. In addition, the technique consistently detected significant differences between NC 6 and NC 7 in the

proportion of a SCR cohort that reached the pupal stage after 14 d of feeding on the seedlings.

There are two possible explanations for the differences in the overall survival and development of SCR that fed on different genotypes of peanut seedlings. One explanation could be described as nonpreference that reduces feeding and causes reduced growth and survival. A second explanation is antibiosis, in which a chemical component of the ingested seedling is toxic (Painter, 1951). Whether nonpreference or antibiosis is the mechanism, mortality is only the most extreme result, and sublethal effects retarding the growth and development of the SCR are present. The difference between NC 6 and NC 7 was not great enough to cause significant differences in mean larval and prepupal weights in any of the three 14 d bioassays.

Based on the low survival of SCR and the preponderance of SCR in the larval stage after feeding 14 d on seedlings, NC-GP WS 9 and N92069L appeared to be the most resistant peanut genotypes evaluated. Additionally, the mean weights of larvae feeding on NC-GP WS 9 and N92069L were significantly less as compared to all other genotypes in Experiment II. NC-GP WS 9 also had a significantly lower mean larval weight than NC 7, N97059N, and NC 6 in Experiment III. The level of resistance demonstrated by NC-GP WS 9 in this laboratory bioassay is consistent with the results of Lynch and Stalker (1997) in a 6 yr field study assessing the percentage of pods damaged by SCR. In their study, the mean percentage of pods damaged by the SCR was 10.5 for NC-GP WS 9, and 28.1 for NC 6. NC-GP WS 9 and N92069L should continue to be considered as sources of resistant germplasm for peanut breeding programs.

Our bioassay technique provided comparisons that would not have been possible if bioassay techniques based strictly on mortality had been used. For example, N97059N had percentages of SCR survive at 14-d that were comparable to or above the percentages in NC 7, the susceptible check. Nevertheless, the mean percentages of surviving SCR in the larval and prepupal stages were intermediate between the two most resistant genotypes evaluated, NC-GP WS 9 and N92069L. The delayed development of the immature SCR under field conditions may result in increased mortality over time due to the effects of natural enemies and abiotic factors, thereby reducing the SCR population that achieves adulthood and subsequently produces offspring capable of damaging developing pods. This potentially valuable resistant genotype merits further study.

There were differences in the results of Experiment II and III that complicated the analyses. The increase in survival of SCR from Experiment II to Experiment III for all but one entry (VT9506114-1) could have been the result of slight differences in moisture or plant health. In Experiment II, VT9506114-1 appears to be as susceptible to SCR as NC 7. The results of Experiment III are much different with VT9506114-1 appearing to be moderately resistant. Considering that the trends in SCR survival were opposite for all other entries except VT9506114-1, one possible explanation would be that excessive fungal growth on the vermiculite in Experiment III adversely affected the health of the seedlings and decreased the ability of VT9506114-1 to serve as a highly susceptible host.

The importance of considering mean larval and prepupal weights is unclear. For example, should the mean weight of larvae that fed on NC-GP WS 9 be considered because it was significantly lower than the mean larval weight associated with other entries? This study did not attempt to distinguish one larval instar from another, although a first instar larva would certainly weigh less than a third instar larva. Since all surviving larvae were grouped in the larval stage and weighed to obtain the mean larval weight, differences in the proportions of instars between peanut entries are reflected in the mean larval weights. Future workers attempting to measure mean larval weights should consider distinguishing the instars.

The percentage of adults that emerged after feeding on NC 6 or NC 7 supports the results of the earlier seedling bioassays with respect to the percentages of immature SCR that survived 14 d. The differences between the percentages of SCR alive after 14 d and the adult SCR that eventually emerge represent additional mortality during pupation. The significant but opposite results of Experiments IV and V with respect to the number of days required for adults to emerge is initially surprising. In the 14 d seedling bioassay, a larger percentage of SCR that fed on seedlings of NC 7 was in the prepupal and pupal stages as compared to those that fed on seedlings of NC 6. Based on this, one might expect that adult SCR would emerge from seedlings of NC 7 before those that fed on seedlings of NC 6. This occurred as expected in Experiment IV, but in Experiment V the opposite was true. The pupal stage could possibly be shortened on a less than optimal host. In both experiments, the adult SCR emerged within 2 d of each other. Nevertheless, the significant differences between the percentages of adults that emerged were similar in magnitude and direction for both Experiment IV and V, further emphasizing the resistance present in NC 6.

In summary, the seedling bioassay used for this study represents an improvement over previous seedling bioassays because of its consistency, its reduced time requirement, and its utility in identifying susceptible or potentially resistant peanut genotypes based on a number of parameters. Future peanut breeding programs may consider attempting to introduce the resistance associated with NC-GP WS 9 and N92069L into genotypes with desirable yield and growth characteristics. Also, large numbers of genotypes can be evaluated using this technique to give a preliminary indication of resistance before extensive field tests begin.

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