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Resistance of Wild Species of Peanut to an Insect Complex[1]

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ABSTRACT

A complex of insects which can cause moderate to severe crop damage attacks peanuts in the North Carolina-Virginia production area. Wild species representing the seven sections of the genus *Arachis* L. were evaluated for resistance to tobacco thrips (*Frankliniella fusca* Hinds), corn earworm (*Heliothis zea* Bodie), and potato leafhopper (*Empoasca fabae* Harris) during a 3-year field study. Very high levels of resistance for these insects were identified in several species collections. Because collections in section *Arachis* were among the species with the highest resistance levels, utilization of the germplasm resources to improve cultivated peanuts should be possible. In addition to evaluating species collections, 40-chromosome (*A. hypogaea* x wild species) hybrid derivatives were evaluated for resistance to the three insect pests plus southern corn rootworm (*Diabrotica undecimpunctata howardi* Barber). Selections with resistance levels equal to or greater than the cultivar NC 6 were made for corn earworm and southern corn rootworm. Laboratory tests of several *Arachis* species indicated that a mechanism of resistance to *H. zea* is antibiosis. Because the levels of resistance to several insects have been greatly increased in lines of *A. hypogaea*, evidence exists for germplasm introgression from wild to the cultivated species of peanuts.

Key Words: Insect resistance, *Arachis,* Wild species.

Arachis hypogaea L. is attacked by numerous pest species which cause damage ranging from incidental feeding to near total plant destruction and yield loss. Peanuts ranked tenth for the number of pests among the 77 major crops listed by van Emden (15). Smith and Barfield (11) reported peanuts were attacked by more than 360 insect species. Although the damage incurred by insect pests can vary among locations and years, most pests are highly mobile and have a wide distribution.

Among the pests in the Virginia-North Carolina production area are tobacco thrips (*Frankliniella fusca* Hinds), potato leafhopper (*Empoasca fabae* Harris), corn earworm (*Heliothis zea* Bodie), and southern corn rootworm (*Diabrotica undecimpunctata howardi* Barber). Thrips initially move into fields from other cultivated or wild host species early in the growing season and reach peak population levels during the first 30 days after planting (12,14). One thrip per terminal bud can result in 33 to 80% of newly formed leaflets being damaged (4). Thrips extract juices from young leaflets and cause damage ranging from scarring to leaflet abscission. Although damage can appear to be severe and plants can be stunted, Bass and Arant (3), Smith and Sams (12), and Tappan and Gorbet (14) concluded that controlling thrips on peanuts in the USA is not an economical practice. However, Smith and Barfield (11) listed thrips as a key peanut pest in South America. Only a low level of resistance to thrips has been observed in cultivated peanuts (4).

Corn earworm invades peanut fields at peak bloom (4) and can cause severe defoliation as larvae preferentially feed on newly formed leaves in terminal buds (7). Low to moderate resistance has been reported in the cultivar NC 6 and Early Bunch, with antibiosis being a mechanism of resistance in NC 6 (4).

Potato leafhopper populations vary considerably from year to year in the USA as densities may depend greatly on insect migrations proceeding northward from the Gulf Coast region (4). The leafhopper sucks plant juices from the leaves and causes "hopperburn," a typical V-shaped yellowing in the leaf apex which may in time turn necrotic. Campbell *et al.* (3) reported cultivated lines with resistance to the potato leafhopper which they associated with straight trichomes on leaves.

The southern corn rootworm can cause moderate to severe damage to peanuts. Adult insects cause subeconomic damage to foliage, but larvae can destroy pegs and pods (4). Campbell *et al.* (5) released NC 6 as a cultivar with high resistance to the southern corn rootworm.

In addition to *A. hypogaea* breeding lines, the wild peanut species offer a largely untapped germplasm reservoir for genes conditioning pest resistance in peanuts. *Arachis* species have been reported as resistant to: mite species *Tetranychus tumidellus* Prichard (10) and *T. urticae* Koch (8,9), aphid species *Aphis craccivora* Koch (1), thrip species *F. schultzei* Trybom (1) and *F. fusca* (4), and potato leafhopper (*E. fabae*) (4). The objective of this investigation was to evaluate peanut species in all sections of the genus for resistance to *F. fusca, E. fabae, H. zea,* and *D. undecimpunctata howardi.* Hybrid derivatives between cultivated and wild species were then tested to determine the resistance levels in interspecific hybrids and to make selections for use in a breeding program to improve cultivated peanuts.

Materials and Methods

The species were propagated by seeds or vegetative cuttings from *Arachis* germplasm maintained at North Carolina State University. Five plants each from 49 collections representing all seven sections of the genus were transplanted into single row plots at Lewiston, NC. Two replications were evaluated during 1979 and three replications were tested during 1980 and 1981. The cultivars Florigiant and NC 2 were used as susceptible checks, and NC 6 was used as a resistant check for the insects (16). In addition, triploid F_1 hybrids between *A. hypogaea* x *A. villosa* Benth and *A. hypogaea* x *A. batizocoi* Krap. et Greg. were produced in 1979 and evaluated during 1980 and 1981. Insect damage was evaluated in the plots for thrips in late June as the total number of damaged leaves per plot; potato leafhopper damage was evaluated during early August as the total number of damaged leaves per plot; and corn earworm was evaluated during mid-September as the percentage damaged leaves per plot.

To investigate the mechanism of resistance of peanut species to *H. zea*, a laboratory experiment was conducted during 1981. Four-day-old larvae were weighed and placed into 30-ml jelly cups with leaves of the respective species which had not been exposed to insecticides. Fresh leaves were added daily. Six collections were compared in six replications to NC 2, NC 6, and a control diet for weight gain and larval mortality when larvae were 10 days old.

Three 40-chromosome advanced generation interspecific hybrid combinations - *A. hypogaea* (PI 261942-3) x *A. cardenasii* Krap. et Greg.

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nom. nud. (GKP 10017), *A. hypogaea* (PI 261942-3) x *A. duranensis* Krap. et Greg. *nom. nud.* (K 7988), and *A. hypogaea* (cv. NC 2) x 4x[*A. batizocoi* (GKP 9484) x *A. spegazzinii* Greg. et Greg. *nom. nud.* (GKP 10038)] - were evaluated for tobacco thrips,potato leafhopper, corn earworm, and southern corn rootworm resistances. Southern corn rootworm was tested because it is an important peanut pest and the pods remained attached to plants at harvest time in hybrid derivatives. The lines tested originated from a random sample of 50 plants from each interspecific hybrid population. The plants were then self-pollinated after which progeny from the 50 individuals were grown in rows replicated three times in the field in a split plot design. Tobacco thrips, potato leafhopper, and corn earworm damage were evaluated as previously described. Southern corn rootworm damage was determined at harvest as the percentage of rootworm-penetrated pegs and pods on a three-plant sample per plot.

Results

High levels of resistance approaching immunity were observed in the *Arachis* collections to thrips, potato leafhopper, and corn earworm (Table 1). Seventeen of the species collections did not have thrips damage during the 3-year test. Only one wild species entry, *A. monticola* Krap. et Rig., had as much thrips damage as the cultivated checks. Similar results were observed for potato leafhopper resistance where 21 collections never exhibited leafhopper damage. Eight collections were observed with neither thrips nor leafhopper damage during the 3 years of testing. Corn earworm damage was observed on at least a few plants for all collections tested. However, the level of damage was generally significantly less than for the cultivated checks (Table 1). Twenty collections, including taxa in six of the seven sections, only had 2% or less of their leaves damaged by corn earworm as compared to 14.8% for the cultivar NC 6 and 37.8% for Florigiant.

First-generation hybrids between *A. hypogaea* and *A. villosa* or *A. batizocoi* had very few thrips-damaged leaves as compared to NC 6. This indicates dominate genes may be involved which confer resistance to thrips. When either *A. villosa* or *A. batizocoi* was used as a female parent, the level of damage for corn earworm and potato leafhopper was greater than NC 6 (Table 1). The hybrid *A. hypogaea* (cv. NC Ac 18000) x *A. villosa* was evaluated during the 2-year test, and a very high level of resistance, approaching immunity, was observed for potato leafhopper. Differences between *A. villosa* reciprocal hybrids were thus observed for leafhopper and corn earworm (Table 1), which may be caused by maternal or cytoplasmic effects.

To further characterize the resistance of *Arachis* species to *H. zea*, laboratory tests were conducted to investigate the mechanism of resistance. Weight gain in the larvae-fed leaves from wild species was significantly ($P \geq 0.05$) less than the NC 2 cultivated check. The average weight of corn earworm larvae that fed on section *Rhizomatosae* or *Arachis* collections was approximately 75% less than larvae reared on the cultivar NC 6 (Table 2).

There was no mortality among larvae which were fed leaves from cultivars; whereas the average mortality rate ranged from 16.7 to 100% and 50 to 100% for the sections *Arachis* and *Rhizomatosae*, respectively (Table 2). These data indicate that antibiosis is a mechanism of corn earworm resistance in some *Arachis* species.

The objective of this investigation was not only to find sources of insect resistance in *Arachis* species, but to incorporate the germplasm into cultivars. The three interspecific hybrid combinations - *A. hypogaea* x *A. cardenasii*, *A. hypogaea* x *A. duranensis*, and *A. hypogaea* x 4x(*A. batizocoi* x *A. spegazzinii*)- were evaluated for resis-

Table 1. Damage to *Arachis* collections for thrips, potato leafhopper and corn earworm in five-plant plots averaged over 3 years.

Collection no.	Collector*	Species	Section†	PI no.	Damaged leaves/plot Thrips	Potato leafhopper	Corn earworm
					------ No.	------	%
9484	K	A. batizocoi Krap. et Greg.	A	298639	0	2.2	3.6
9530	GKP	A. correntina	"	262808	4.5	0.1	1.6
22585	B	A. villosa Benth.	"	298636	6.3	1.3	3.2
10038 1.1.	GKP	A. spegazzinii Greg. et Greg. nom. nud.	"	262133	9.7	1.4	2.7
10602	GKP	A. chacoense Krap. et Greg. nom. nud.	"	276235	0.7	2.9	1.7
10017	GKP	A. cardenasii Krap. et Greg. nom. nud.	"	262141	1.4	0.1	3.1
--		A. correntina (Benth.) Krap. et Greg. nom. nud.	"	--	1.3	0.4	0.5
7264	K	A. monticola Krap. et Rig.	"	219824	51.5	1.3	5.2
408	HLK	A. stenosperma Greg. Greg. nom. nud.	"	338279	10.0	1.7	1.5
410	HLK	A. stenosperma	"	338280	1.7	2.1	1.9
7988	K	A. duranensis Krap. et Greg. nom. nud.	"	219833	17.4	0	3.8
Manfredi #5		A. villosa-correntina	"	--	1.1	0	2.2
Manfredi #36		A. villosa-correntina	"	--	0	1.0	1.5
565-66	HLKHe	A. sp.	E	338297	0.3	6.0	5.2
9841	GKP	A. sp.	"	262278	0	0.2	1.3
9990	GKP	A. sp.	"	261877	1.2	5.3	2.7
9993	GKP	A. sp.	"	261878	1.4	2.1	2.2
10002	GKP	A. sp.	"	--	2.2	0.4	2.0
10034	GKP	A. rigonii Krap. et Greg.	"	262142	3.0	0	3.9
10573	GK	A. sp.	"	276225	0	2.5	2.0
10576	GK	A. sp.	"	276228	0	0	4.0
11488	KC	A. paraguariensis Chod. et Hassl.	"	--	0	2.3	2.2
14444	KHe	A. sp.	"	338320	0	25.0	4.5
10127	GKP	A. sp.	Ex	276203/ 276309	0	0	2.4
12943	GK	A. sp.	Am	338452	1.3	0	0.5
12946	GK	A. sp.	"	338454	1.0	2.9	0.5
12922	GK	A. pusilla Benth.	T	338449	0	0	0.6
10538	GKP	A. repens Handro	C	276199	0	0.2	0.7
349	HLKO	A. sp.	R	338305	0	0	2.0
486	HL	A. sp.	"	338267	0	0	5.5
568	HLKHe	A. sp.	"	338300	0.3	4.3	4.3
571	HLKHe	A. sp.	"	338265	2.9	0	4.8
1960 #100	--	A. sp.	"	--	1.6	0	4.0
9567 pl. 1	GKP	A. sp.	"	262814	2.9	5.7	5.4
9570	GKP	A. sp.	"	262817	8.0	0.1	9.7
9575	GKP	A. sp.	"	262821	2.7	2.7	9.7
9576 pl. 1	GKP	A. sp.	"		0.4	0.3	8.8
9592	GKP	A. sp.	"	262828	0.5	0	4.8
9645 pl. 1	GKP	A. sp.	"	262841	1.9	0.3	12.3
9649 p. 250	GKP	A. sp.	"	262844	0.1	0.5	2.2
9667	GKP	A. sp.	"	262848	1.8	0	2.4
9813	GKP	A. sp.	"	262793	0	0	1.0
9815	GKP	A. sp.	"	262794	0	0	1.7
9830	GKP	A. sp.	"	262797	0	0.9	3.3
9834 pl. 2	GKP	A. sp.	"	262798	1.0	0	2.2
9882	GKP	A. sp.	"	262286	0.5	0.4	1.6
9893	GKP	A. sp.	"	262287	1.3	0.4	1.3
9935 pl. 1	GKP	A. sp.	"	262301	1.0	1.1	6.3
9966	GKP	A. sp.	"	262306	0.2	0	1.8
10120 pl. 1	GKP	A. sp.	"	276202	0.1	0.7	2.4
10566	GK	A. sp.	"	276223	0.1	0	6.2
10596A	GK	A. sp.	"	276233	0	0	1.3
10596C	GK	A. sp.	"	276233	0.2	0	2.4
A. villosa x NC-Ac 18000-2 F_1			A		10.0	37.2	38.4
A. villosa x B_2-3 F_1			"		8.0	60.3	40.8
NC-Ac 18000 x A. villosa-1 F_1			"		1.3	0	4.4
9484 x B_2-1 F_1					2.2	37.6	35.5
9484 x NC-Ac 18000 F_1			"		0	90.3	46.8
Florigiant		A. hypogaea	"		97.2	68.2	37.8
NC 2		"	"		57.0	86.2	30.6
NC 6		"	"		31.0	22.3	14.8
LSD (.05)					8.2	10.7	8.6
LSD (.01)					10.8	14.0	11.4

*B = Burkart, GK = Gregory-Krapovickas, GKP = Gregory-Krapovickas-Pietrarelli, HL = Hammons-Langford, HLK = Hammons-Langford-Krapovickas, HLKHe = Hammons-Langford-Krapovickas-Hemsy, HLKO = Hammons-Langford-Krapovickas-Ojeda, K = Krapovickas, KC = Krapovickas-Cristobal, KHe = Krapovickas-Hemsy.

†A = Arachis, Am = Ambinervosae, C = Caulorhizae, E = Erectoides, Ex = Extranervosae, R = Rhizomatosae, T = Triseminalae.

Table 2. Reaction of *H. zea* larvae to feeding on leaves of *Arachis* species.

Collection no.	Species	Section	Avg wt gain*	H. zea mortality
			mg	%
9484	A. batizocoi	Arachis	0	100.0
Manfredi #5	A. villosa-correntina	"	3.8	83.3
7264	A. monticola	"	11.7	16.7
9645 pl. 1	A. sp.	Rhizomatosae	4.9	50.0
9649 pl. 250	A. sp.	"	3.4	66.6
10596C	A. sp.	"	0	100.0
NC 2	A. hypogaea	Arachis	29.5	0
NC 6	A. hypogaea	"	16.9	0
LSD (.05)			17.4	

*10-day-old larvae.

tance to the insect complex. Southern corn rootworm resistance was also tested in the hybrid derivatives. The range of insect resistance among families of individual hybrid combinations was great. When *A. cardenasii* was hybridized with PI 261942-3, the population mean of damage for the four insect pests was less than the cultivated parent. Furthermore, highly resistant selections were made among families which have potential for immediate utilization of high levels of resistance for potato leafhopper, corn earworm and southern corn rootworm. Resistance to thrips did not appear to be transferred to the interspecific hybrid derivatives (Table 3). *Arachis duranensis* did not originally have as high resistance levels to the insect pests as *A. cardenasii* and the hybrid derivatives had correspondingly less resistance to the four insects. However, selections were also made from several families of the PI 261942-3 x *A. duranensis* population, but none from NC 2 x 4x *(A. batizocoi* x *A. spegazzinii)* hybrids for potato leafhopper and corn earworm resistances. The germplasm developed represents new sources of resistance which have potential in a breeding program for insect resistance.

Table 3. Mean and ranges of damage in advanced generation interspecific hybrids to thrips, potato leafhopper, corn earworm, and southern corn rootworm.

Hybrid	Damaged leaves/plot: Thrips	Damaged leaves/plot: Potato leafhopper	Damaged leaves/plot: Corn earworm	Damaged pegs+pods: Southern corn rootworm
	-------- No.	--------	%	%
A. PI 261942-3 x A. cardenasii-5	38.2 (28.3-50.0)	18.9 (4.0-48.3)	4.6 (1.0-10.7)	5.2 (1.7-14.7)
PI 261942-3	46.7	61.7	38.3	8.0
A. cardenasii	0.0	0.0	2.7	--
Florigiant	41.7	10.0	13.3	49.3
NC 6	20.0	4.0	4.3	15.7
LSD (.05)	12.6	15.1	5.0	8.7
(.01)	18.0	21.6	7.2	12.3
B. PI 261942-3 x A. cardenasii-115M	37.9 (26.7-58.3)	13.0 (1.7-35.0)	4.5 (1.7-10.0)	9.8 (2.0-24.0)
PI 261942-3	60.0	66.7	33.3	25.3
A. cardenasii	1.7	3.0	2.3	--
Florigiant	41.7	5.0	11.3	40.3
NC 6	23.3	7.7	3.7	8.3
LSD (.05)	17.0	12.5	2.9	15.6
(.01)	24.3	17.8	4.1	22.2
C. PI 261942-3 x A. duranensis	57.4 (31.7-70.0)	18.0 (3.3-56.7)	15.3 (5.0-35.0)	6.7 (1.3-13.7)
PI 261942-3	43.3	50.0	31.7	8.3
A. duranensis	10.0	5.0	3.0	--
Florigiant	43.3	4.3	12.3	39.0
NC 6	15.0	2.0	4.5	6.3
LSD (.05)	14.9	13.3	7.6	8.8
(.01)	21.3	19.1	10.8	12.6
D. NC 2 x (A. batizocoi x A. spegazzinii)	36.0 (20.0-51.7)	16.5 (2.0-33.3)	7.0 (2.3-13.3)	25.9 (9.0-38.3)
A. batizocoi	0.0	4.0	3.7	--
A. spegazzinii	1.0	0.0	0.7	--
4x(A. batizocoi x A. spegazzinii)	0.0	2.0	7.0	--
NC 2	31.7	19.9	10.7	9.9
Florigiant	36.7	15.7	13.0	46.7
NC 6	20.0	3.0	3.7	6.7
LSD (.05)	16.7	13.5	5.0	21.0
(.01)	23.8	19.3	7.2	30.1

Segregates from the interspecific hybrid derivative populations had significantly higher levels of resistance than their cultivated parents PI 261942-3 or NC 2 for the insect complex. This is evidence for introgression from the wild species *A. cardenasii, A. duranensis, A. batizocoi,* and *A. spegazzinii* into the cultivated genome.

Discussion

The primary step for developing cultivars with insect resistance is to identify sources of resistance. The approach for screening *Arachis* species in this investigation was to evaluate collections under field conditions. Although differences in insect pressure varied among years and locations, we believe the 3-year average presented in Table 1 is a good indication of the relative levels of resistance in *Arachis* species to thrips, corn earworm and potato leafhopper. Many *Arachis* collections were not damaged by thrips or potato leafhopper, and others were highly resistant to corn earworm. Furthermore, several collections had high levels of resistance, approaching immunity, to the entire complex of insects.

The greatest potential for rapid utilization of the germplasm is within section *Arachis* because members of this group will hybridize with cultivated peanuts. Most collections tested had significantly higher levels of resistance than NC 6. Future hybridization programs should utilize *A. batizocoi* (GKP 9484) and *A. chacoense* Krap. et Greg. *nom. nud.* (GKP 10602) as sources of thrips resistance; *A. correntina* (Burk.) Krap. et Greg. *nom. nud.* (GKP 9530 and Manfredi #5 and #36) for potato leafhopper resistance; and *A. correntina* (GKP 9530 and Manfredi #36), *A. chacoense* (GKP 10602) and *A. stenosperma* Greg. et Greg. *nom. nud.* (HLK 408 and 410) as sources of corn earworm resistance. In addition to being resistant to the insects reported here, *A. correntina* (GKP 9548) is also resistant to the twospotted spider mite (9) and *A. chacoense* is highly resistant to *Frankliniella schultzei* and *Aphis craccivora* (1). Although the levels of resistance for corn earworm, thrips and potato leafhopper may be greater in sections other than *Arachis;* for example, in *A. pusilla* Benth (GK 12922) of section *Triseminalae* or *A. repens* Handro (GKP 10538) of section *Caulorhizae,* these species are not cross-compatible with cultivated peanuts (6).

The preliminary results with 40-chromosome hybrid derivatives of *A. hypogaea* x *Arachis* species indicate the potential of introgressing wild species germplasm into cultivars. Segregates in the populations had very high levels of resistance which were comparable to the cultivar NC 6. To obtain higher levels of insect resistance among *A. hypogaea* x wild species hybrids, it may be necessary to select *A. hypogaea* parents with at least moderate levels of resistance rather than a highly susceptible line such as PI 261942-3. However, because PI 261942-3 was highly susceptible to thrips, potato leafhopper and corn earworm, the resistance in hybrids must have been conferred by genes from the *Arachis* species. The selections offer new genetic resources which may be unique from those found in the cultivated species. Stalker *et al.* (13) reported evidence of gene transfer from *A. cardenasii* into *A. hypogaea* for morphological and disease resistance characters. This investigation presents additional evidence for intergenomic transfers and potential utilization of germplasm from wild *Arachis* species.

Hybrid lines so far developed do not have acceptable yields or agronomic characters; however, these hybrid lines represent unique germplasm resources for insect-resistant genes. Since taxa outside the *A. hypogaea* primary gene pool were used in the hybrids, the genetic base of the cultivated species should be significantly broadened, especially for genes conferring insect resistances. A concentrated effort to develop lines which will lead to commercially acceptable peanut cultivars with multiple pest resistance is currently being made.

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