Resistance of Peanuts to the Potato Leafhopper[1]

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ABSTRACT

More than 700 peanut (**Arachis hypogaea**) lines from the North Carolina germplasm collection were evaluated for resistance to the potato leafhopper, **Empoasca fabae** Harris, from 1961 to 1972. Twelve lines were selected as being highly resistant to the potato leafhopper. The lines represent two diverse sources of germplasm resistant to the potato leafhopper.

A study of the nature of resistance using standard histological techniques revealed leafhopper resistance was associated with a thick epidermis, long trichomes, and with a high percentage of straight trichomes on leaves. Leafhopper susceptible peanuts have leaves with an appressed surface texture.

Additional index words: Arachis hypogaea L., groundnuts, **Empoasca fabae** Harris, host plant resistance to insects, nature insect resistance.

The potato leafhopper, *Empoasca fabae* Harris, has been reared on more than 100 species of plants including peanuts (*Arachis hypogaea L.*) (Poos and Wheeler, 1943). Feeding on peanuts by nymphs and adults results in a characteristic "V" shaped yellowing at the leaf tips. Under high population pressure the entire leaf may yellow and the tip may appear necrotic.

Poos and Batten (1937), Poos et al. (1947), and Arant (1954) reported increased peanut yields when leafhoppers were controlled. Leafhoppers may be controlled with foliar or granular systemic insecticides (Smith, 1973).

Resistance to the potato leafhopper in leguminous crops has been observed and reported. McFarlane and Rieman (1943), Wolfenbarger and Sleesman (1963) and Chalfant (1965) identified various bean varieties possessing resistance to the potato leafhopper. Some alfalfa varieties were reported resistant to the potato leafhopper by Davis and Wilson (1953) and Webster et al. (1968).

Research was initiated in North Carolina in 1961 to determine if resistance to the potato leafhopper could be found within *Arachis hypogaea.*

Materials and Methods

Peanut lines were planted in single rows 9.1 m (30 ft.) long and replicated 3 to 5 times. The susceptibility of lines was determined by 5 or 10 net sweeps for counts of leafhopper adults and nymphs in early August, or by counting the number of leaves with leafhopper yellowing "hopperburn," per 30 row ft., or by a visual estimate of the percent leaf area with leafhopper yellowing per 30 row ft. Entries with the highest level of resistance were selected each year for retesting with commercial peanut cultivars serving as susceptible checks.

Lines that consistently exhibited low leafhopper damage were classified as resistant, and these were used as leafhopper resistant checks. Each year new lines were added to the program and evaluated with previously identified resistant and susceptible checks in order to select for higher levels of leafhopper resistance.

The nature of leafhopper resistance was studied by comparing leaves of leafhopper resistant and susceptible peanuts anatomically and histologically. Leaf pieces measuring approximately 0.6 cm (1/4 in) by 0.9 cm (3/8 in) were killed and fixed in Craf II solution according to Sass (1951). The leaf pieces were dehydrated in an ascending graded series of tertiary butyl alcohol and embedded in tissuemat. Sections were cut 10 microns thick on a Spencer 850 rotary microtome, stained with safranin, and counterstained with fast green.

Measurements were made with an ocular micrometer of thickness of entire leaf, thickness of the epidermis, spongy parenchyma and palisade layers, and the length and characteristics of trichomes.

Results and Discussion

'GP-NC 343', germplasm released for resistance to the larvae of the southern corn rootworm (*Diabrotica undecimpunctata howardi Barber*), exhibited significantly less leafhopper damage at the 95% confidence level than the commercial cultivar 'NC 2' in tests conducted in 1961, 1962, and 1963 (Table 1). GP-NC 343 was then selected as the resistant check in order to select for high resistance. Although Acc 317, an irradiation mutant

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with recurved leaves from 'NC 4', was as resistant as GP-NC 343, it was discarded because of its high susceptibility to tobacco thrips (*Frankliniella fusca* Hinds), another important pest of peanuts.

Table 1. Resistance of peanut accessions to the potato leafhopper. North Carolina. 1961-1963.

N. C. accession	Pedigree*	Avg. % leafhopper damage 1961	Avg. No. leafhopper damaged leaves/ 5 plants 1962	Avg. No. leafhoppers/5 net sweeps 1963
343	C12 X C37	22.0	25.3	6.7
317	Recurved	28.0	7.5	7.3
342	C12 X C37	44.0	17.3	9.0
302	C12 X C37	32.0	40.0	10.0
301	C12 X C37	58.0	36.5	13.3
344	C12 X C37	33.0	18.3	15.3
327	Va 56R	37.0	40.0	20.7
326	Ga 119-20	64.0	31.5	22.3
324	NC 4	51.0	52.0	22.7
323	NC 2	72.0	58.5	29.7
LSD 5%		22.0	30.0	15.3

*C12, C37 = NC Bunch x PI 121067; Recurved = irradiation mutant from NC 4.

In 1964 nine additional lines were identified as resistant to the potato leafhopper (Table 2). The nine lines are all from the cross of C12 x A18, the cross from which commercial cultivar 'NC 5' was selected. C12 is also one of the parents of GP-NC 343. Each selection received two or more recurrent irradiation treatments. Accs. 15729 and 15730 consistently showed low leafhopper damage during tests in 1964-1966.

Table 2. Resistance of peanut accessions to the potato leafhopper. North Carolina. 1964-1966.

N. C. accession	Pedigree*	Avg. no. leafhopper damaged leaves/30 row ft. 1964	1965	1966
15736	(C12 x A18) M_7M_1	1.0	16.7	12.0
15728	(C12 x A18) $M_7M_3M_1$	1.3	20.0	9.7
15730	(C12 x A18) $M_7M_5M_3M_1$	2.7	5.7	6.3
15729	(C12 x A18) $M_7M_5M_3M_1$	3.0	3.3	6.0
15737	(C12 x A18) $M_7M_5M_3M_1$	3.3	21.3	13.3
15727	(C12 x A18) $M_7M_5M_1$	7.0	16.3	---
15732	(C12 x A18) $M_7M_5M_1$	9.0	21.0	9.0
15739	(C12 x A18) $M_7M_5M_1$	9.3	21.0	---
15740	(C12 x A18) $M_7M_5M_1$	11.0	17.3	15.7
343	C12 x C37	---	---	12.0
323	NC 2	41.3	43.7	79.0
LSD 5%		10.4	33.1	29.5

*C12, C37 = NC Bunch x PI 121067; A18 = NC 4 x Spanish 2B.

The highest leafhopper resistance was identified in a group of lines screened during 1966. The best eight lines originated from crosses of sister lines of GP-NC 343 with the irradiation mutant recurved. Thus the high resistance of these lines resulted from crosses involving the two most resistant crosses identified in 1961-1963. Lines identified as resistant during 1966 were all significantly more resistant than GP-NC 343, in the 1967 test (Table 3) when the leafhopper population pressure was very high.

Table 3. Resistance of peanut accessions to the potato leafhopper. North Carolina. 1966-1968.

N. C. accession	Pedigree*	Avg. No. leafhopper damaged leaves/30 row ft. 1966	1967	1968
10211	(C12 x C37) x Recurved	10.0	24.0	9.3
10247	(C12 x C37) x Recurved	4.0	34.3	3.0
10207	Recurved X (C12 x C37)	3.7	42.3	17.0
10223	(C12 x C37) x Recurved	7.7	47.3	14.0
10277	(C12 x C37) x Recurved	6.3	55.7	68.6
10244	(C12 x C37) x Recurved	---	64.0	19.6
10273	Recurved x (C12 x C37)	---	74.0	21.6
10272	(C12 x C37) x Recurved	3.0	77.3	39.0
343	C12 x C37	24.0	155.7	41.0
323	NC 2	75.7	400.3	263.0
LSD 5%		20.0	70.5	55.6

*C12, C37 = NC Bunch x PI 121067; Recurved = irradiation mutant from NC 4.

The best lines from previous tests were grouped and evaluated from 1967-1969 using GP-NC 343 and NC 2 as checks. Results show the level of resistance to the potato leafhopper is high among the selected lines (Table 4).

Table 4. Resistance of peanut accessions to the potato leafhopper. North Carolina. 1967-1969.

accession	Pedigree*	Avg. No. leafhopper damaged leaves/30 row ft. 1967	1968	1969
10247	(C12 x C37) x Recurved	28.3	5.0	5.7
15729	(C12 x A18) $M_7M_5M_3M_1$	19.7	9.6	5.7
15730	(C12 x A18) $M_7M_5M_3M_1$	43.3	12.6	2.7
10207	Recurved x (C12 x C37)	24.0	13.2	4.0
15745	(C12 x A18) $M_7M_5M_1$	37.0	17.3	5.7
10272	(C12 x C37) x Recurved	25.7	24.6	9.3
10277	(C12 x C37) x Recurved	74.3	39.0	8.0
343	C12 x C37	56.0	39.6	21.7
15744	(C12 x A18) $M_7M_5M_1$	61.0	44.3	11.0
15736	(C12 x A18) M_7M_1	64.0	96.6	11.7
323	NC 2	243.0	341.0	89.8
LSD 5%		47.5	32.3	25.7

*C12, C37 = NC Bunch x PI 121067; A18 = NC 4 x Spanish 2B; Recurved = irradiation mutant from NC 4.

The high level of resistance and reproducibility of results was evident in the data collected during 1970-1972. Lines with the highest resistance exhibited reduction in leafhopper damage in excess of 90% compared with the NC 2 check (Table 5). There was an apparent correlation between the number of leafhopper damaged leaves and the percent leafhopper damage in 1971. When leafhopper population pressure is low, counting damaged leaves may be the most reliable damage rating system; however, when leafhopper populations are high or a high percentage of the accessions are susceptible, a rating system based on percent damage is appropriate.

Table 5. Resistance of peanut accessions to the potato leafhopper. North Carolina. 1970-1972.

accession	Pedigree*	Avg. no. leafhopper damaged leaves/ 30 row ft. 1970	1971	Avg. % leafhopper damage/30 row ft. 1971	1972
10207	Recurved x (C12 x C37)	5.3	4.0	0.3	3.7
10247	(C12 x C37) x Recurved	---	10.0	1.0	5.0
10211	(C12 x C37) x Recurved	18.0	13.3	0.7	2.3
10277	(C12 x C37) x Recurved	28.3	31.7	2.0	3.7
15729	(C12 x A18) $M_7M_5M_3M_1$	33.0	42.7	4.0	8.7
15730	(C12 x A18) $M_7M_5M_3M_1$	34.3	49.7	3.0	6.7
15745	(C12 x A18) $M_7M_5M_1$	---	69.0	3.3	5.0
15744	(C12 x A18) $M_7M_5M_1$	69.3	84.3	5.3	7.0
15736	(C12 x A18) M_7M_1	35.0	92.9	9.3	7.7
15739	(C12 x A18) $M_7M_5M_1$	78.0	97.3	11.7	11.3
10272	(C12 x C37) x Recurved	43.7	142.7	10.7	15.0
343	C12 x C37	61.0	157.7	15.0	25.0
323	NC 2	423.4	493.0	66.7	63.3
LSD 5%		69.4	43.0	6.1	8.3

*C12, C37 = NC Bunch x PI 121067; A18 = NC 4 x Spanish 2B; Recurved = irradiation mutant from NC 4.

Data collected in 1972 revealed that Accs. 10207, 10247, 10211, 10277, 15729, 15730, 15745, 15736, 15739, and 10272 were significantly more resistant than the resistant check, GP-NC 343. The high LSD values may be partially explained by the fact that more lines were evaluated than those listed. Lines that were more susceptible and more inconsistent in leafhopper resistance across replications were gradually dropped from the evaluation program. By 1971 and 1972 only the best 11 lines and GP-NC 343 remained in the screening program.

Although these 11 resistant lines have C12 as a common parent, the most resistant lines result from crosses made betweeen parents representing two diverse sources of leafhopper resistance. The resistant lines are not acceptable for production in North Carolina. The most resistant lines have been incorporated in a breeding program whose objective is high yield, acceptable pod size and shape, and leafhopper resistance.

More than 700 peanut lines were screened in this study. Although most of the lines evaluated were of the Virginia botanical type (ssp. *hypogaea*), a few Spanish and Valencia (ssp. *fastigiata*) were screened. None of the lines of the ssp. *fastigiata* were found to be resistant.

A study of anatomical differences among leafhopper susceptible and resistant peanuts revealed there were no differences in total leaf thickness, spongy mesophyll, or the palisade cells. Differences were observed in the thickness of the epidermis, especially the abaxial (lower) epidermis. Leafhopper resistant peanuts posses a significantly thicker abaxial epidermis than the susceptible checks except for Acc. 10211 (Table 6).

Table 6. Differences among peanut accessions in thickness of epidermis.

Accession	Pedigree*	Leafhopper resistance rating†	Leaf epidermal thickness in microns adaxial	abaxial
15730	(C12 x A18) $M_7M_5M_3M_1$	R	17.4	16.9
15744	(C12 x A18) $M_7M_5M_1$	R	17.1	16.0
10272	(C12 x C37) x Recurved	R	17.4	15.9
10277	(C12 x C37) x Recurved	R	16.4	15.7
15729	(C12 x A18) $M_7M_5M_3M_1$	R	18.3	15.7
10207	(Recurved x (C12 x C37)	R	16.7	15.6
343	C12 x C37	R	17.8	15.4
15736	(C12 x A18) M_7M_1	R	16.5	15.3
10211	(C12 x C37) x Recurved	R	18.0	13.5
333	NC 5	S	18.0	13.0
15717	NC 17	S	17.0	12.5
323	NC 2	S	15.1	12.5
LSD 5%			1.1	1.0

*C12, C37 = NC Bunch x PI 121067; A18 = 4 x Spanish 2B; Recurved = irradiation mutant from NC 4.

†R = resistant; S = susceptible

Leaf trichomes were longer on leafhopper resistant than on leafhopper susceptible peanuts (Table 7). These differences were significant between the NC 2 check and all resistant lines. A high percentage of the trichomes found on resistant lines were straight. Most resistant lines possessed 86% to 99% straight trichomes. Leafhopper susceptible peanuts possessed about 50% curved trichomes. Furthermore, all resistant lines were significantly different from commercial susceptible peanuts for this anatomical character.

Cultivar NC 2 is more susceptible to the potato leafhopper than 'NC 17' which is more susceptible than 'NC 5'. These differences are significant for NC 2 but differences between NC 17 and NC 5 are more subtle.

The shapes of trichomes observed on leafhopper resistant and susceptible peanut leaves are shown in Figure 1. It may be observed that the susceptible lines have appressed trichomes. Even the straight trichomes of susceptible peanuts are nearly parallel with the epidermis and the curved trichomes are all curved inward toward the epider-

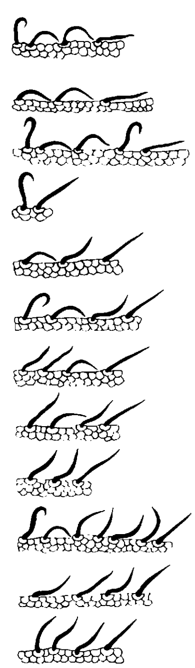
Table 7. Differences among peanut accessions in trichome length and shape.

N. C. accession	Pedigree*	Leafhopper resistance rating[†]	Avg. length trichomes (millimeters)	Avg. % trichomes straight
343	C12 x C37	R	12.7	99.2
10207	Recurved x (C12 x C37)	R	11.2	97.2
10211	(C12 x C37) x Recurved	R	11.4	95.7
10277	(C12 x C37) x Recurved	R	10.6	95.0
15744	(C12 x A18) $M_7M_5M_1$	R	10.8	91.9
15736	(C12 x A18) M_7M_1	R	10.2	88.7
15729	(C12 x A18) $M_7M_5M_3M_1$	R	10.1	87.5
15730	(C12 x A18) $M_7M_5M_3M_1$	R	10.5	85.7
10272	(C12 x C37) x Recurved	R	10.1	77.4
333	NC 5	S	9.8	58.4
15717	NC 17	S	9.6	58.1
323	NC 2	S	8.3	49.4
LSD 5%			1.0	7.4

*C12, C37 = NC Bunch x PI 121067; A18 = NC 4 x Spanish 2B; Recurved = irradiation mutant from 'NC 4'.

[†]R = resistant; S = susceptible

N.C. Accession	Rating (a)	Trichomes % Curved up.	down.	Trichomes Shape
323 (NC_2)	S	0	50·6	
15717 (NC_{17})	S	0	41·8	
333 (NC_5)	S	0	41·2	
343	R	0	0·81	
10272	R	19·3	3·2	
10277	R	2·7	2·7	
10207	R	2·1	0·7	
10211	R	2·6	1·7	
15729	R	12·5	0	
15736	R	8·7	2·6	
15730	R	14·2	0	
15744	R	8·0	1·0	



(a) S — Leafhopper susceptible

R — Leafhopper resistant

Fig. 1. Anatomical differences in trichomes on leaves of leafhopper resistant and susceptible peanuts.

mis. Resistant lines, however, have straight trichomes extending outward from the lower epidermis at approximately a 45° angle. Curved trichomes of resistant lines are mostly curved outward or away from the epidermis.

Lines identified by accession numbers in the ten thousand series possess a recurved leaf and lines identified by accession numbers in the fifteen thousand series possess a normal leaf; therefore, gross anatomical characteristics do not appear to influence leafhopper resistance in peanuts.

Trichome characteristics may serve as a marker to select for higher levels of leafhopper resistance.

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