

Executive Summary for NPB Project ID 53 Breeding Peanuts for Resistance to Sclerotinia Blight, Leaf Spot, CBR and TSWV.

This long-term project was initiated to implement simultaneous selection for resistance to four diseases of consistent economic importance in the North Carolina and Virginia: Sclerotinia blight caused by soilborne fungus *Sclerotinia minor*, early leaf spot caused by foliar fungus *Cercospora arachidicola*, Cylindrocladium black rot (CBR) caused by soilborne fungus *Cylindrocladium parasiticum*, and tomato spotted wilt (TSW) caused by the thrips-vectored *Tomato spotted wilt tospovirus*. Each year, agronomically superior parents are crossed with sources of high-level resistance that are often not agronomically desirable in the VC area. We often make an initial cross in the winter then next summer cross the F₁ plants back to the agronomically desirable parent before the hybrid progeny are subjected to an accelerated program of inbreeding and selection as outlined below:

Crosses are made in the greenhouse at the N.C. State University campus in Raleigh, NC. The F₁ or first backcross F₁ (BC₁F₁) hybrid plants from the annual summer crossing program are grown at our Puerto Rico Winter Nursery (PRWN) in Juana Diaz, PR. The F₂ populations are subjected to selection for pod and seed characteristics at the Peanut Belt Research Station (PBRS) at Lewiston, NC, in plots provided a full disease control program. There is no chemical control for TSW, and the plants must be spaced 10 inches or more apart to allow for selection of individual plants, so TSW does contribute to the appearance of plants in the selection nursery. F₃ progeny of F₂ plant selections (F_{2:3} families) are grown at the PRWN that winter. At harvest a single pod is harvested from each plant in an F_{2:3} family to provide a single seed representing that plant in an F_{2:4} selection nursery at PBRS, then the rest of the pods are harvested in bulk to provide seed for replicated testing for resistance to the four diseases at sites specially chosen and managed to promote development of diseases: Sclerotinia blight, leaf spot and CBR on infested fields left untreated with the protectant fungicides used to control them, TSW in a trial in which plants are spaced 20 inches apart and left untreated with insecticides that would reduce the population of the thrips that vector the virus. The F_{2:4} or BC₁F_{2:4} families with the best overall resistance to the four diseases are identified, then we make plant selections in those families in the nursery planted for the purpose at PBRS from the F_{2:4} single-seed descent harvest. Progeny of those selections are sent back to the PRWN for another cycle of inbreeding and selection among and within F_{4:6} and BC₁F_{4:6} families the following summer. F_{6:7} progeny of selected F₆ plants are grown at the PRWN, but harvested only in bulk as we do not make single-plant selections beyond the F₆ generation. The F_{6:8} families, now considered genetically stable breeding lines, are tested for disease reactions and also in replicated preliminary trials for yield and grade at PBRS and another research station on the upper coastal plain near Rocky Mount, NC. The most disease-resistant families are retained for continued evaluation in disease trials; those with the best yields and grades advance into the "conventional" testing program (conducted with disease controls) that leads to cultivar release. There is usually some overlap between the two groups, but highly resistant lines that do not make the grade agronomically are used as parents for another cycle of the program. Any line that survives in the conventional advance yield test series for a second or greater year is also evaluated in disease trials.

Two cultivars have been released from this project: 'Bailey' in 2008 and 'Sugg' in 2009. Certified seed of Bailey was available to growers for the 2011 growing season, as were limited amounts of Sugg. Both have partial resistance to all four diseases and also have excellent yield potential. At federal support prices for peanuts, saving one or two applications of leaf spot fungicide or a single application of Sclerotinia preventives could mean the difference between profit and loss. Reduction of chemical inputs requires improvement of the disease resistance available in virginia-type cultivars. Resistant cultivars will help to maintain peanut production and the peanut seed market in North Carolina. In recent years, we have incorporated greater levels of disease resistance and have advanced only families carrying the University of Florida's high-oleic seed oil gene in our accelerated selection program.

**Lay Interpretation of Results for NPB Project ID 53
Breeding Peanuts for Resistance to Sclerotinia Blight, Leaf Spot, CBR and TSWV.**

A series of peanut variety releases by N.C. State University gave evidence of a problem in our program. We had separate subprograms of selection for resistance to the four diseases of consistent economic importance in the North Carolina and Virginia: Sclerotinia blight caused by soilborne fungus *Sclerotinia minor*, early leaf spot caused by foliar fungus *Cercospora arachidicola*, Cylindrocladium black rot (CBR) caused by soilborne fungus *Cylindrocladium parasiticum*, and tomato spotted wilt (TSW) caused by the thrips-vectored *Tomato spotted wilt tospovirus*. When we released a variety resistant to one or even two, it often was badly susceptible to another. We needed to select for resistance to all four simultaneously.

Each year, we cross agronomically superior parents with sources of high-level resistance that are often not agronomically desirable in the Virginia-Carolina area, including runner-type sources. After the cross, we use a form of "shuttle" breeding to get to genetically stable inbred lines in three years. Starting the second generation after the cross, we make plant selections for pod and seed characteristics in North Carolina. We use a winter seed nursery in Puerto Rico to grow a second generation each year, then test the selected families for resistance to the four diseases in separate trials, identifying the best families overall and making plant selections within those families. By the sixth generation after the cross, the families are genetically stable breeding lines that have improved disease resistance and then proceed through the multi-year multi-location testing program that eventually leads to variety release. Highly resistant lines that do not measure up agronomically are recycled as parents in the crossing program.

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**QUARTERLY PROGRESS REPORT TO
National Peanut Board
and
North Carolina Peanut Growers Association**

TITLE: Breeding Peanuts for Resistance to Sclerotinia Blight, Early Leafspot, Cylindrocladium Black Rot, and Tomato Spotted Wilt Virus

LEADER: T.G. Isleib

DEPARTMENT: Crop Science

REPORT:

Since the last quarterly report, the disease data were recorded for the 2008 Disease Selection Test (DST) and Disease Advanced Test (DAT) series: Sclerotinia tests with no application of fluazinam were grown at an infested site in Bertie County, NC, CBR tests with no application of metam sodium in an infested field at the Upper Coastal Plain Research Station (UCPRS) in Edgecombe County; early leafspot tests at the Peanut Belt Research Station (PBRs) at Lewiston, NC in plots that received no fungicide application, and tomato spotted wilt virus tests at PBRs in plots that received no insecticide treatment to manage thrips and that were planted at 20" seed spacing to maximize TSWV incidence. Each test had two replications and 240 genetic entries including F₄ progeny of 154 F₂ plant selections (all but one carrying the high-oleic gene, 51 of them high oleic) from 37 crosses made in 2006, F₆ progeny of 36 BC₁F₄ selections (all carrying the high-oleic gene, 28 of them high oleic) from superior F_{2.4} families derived from 9 crosses made in 2005, and F₈ progeny of 43 F₆ selections (all carrying the high-oleic gene, 42 of them high oleic) from superior F_{4.6} families derived from 4 crosses made in 2004. The F_{6.8} families, which will not be subjected to further within-family selection, also were tested in replicated trials (Disease Preliminary Tests) grown at PBRs and UCPRS with full disease control programs to assess yield and grade of those families. For each F_{2.4} and BC₁F_{4.6} family, there was a selection plot at PBRs from which plant selections will be made if that family proves to have superior disease resistance based on performance in the Disease Selection Tests. These tests were planted in May. Stand counts were made in June to permit calculation of disease incidence for CBR, Sclerotinia blight, and TSWV. Few early-season symptoms of TSWV were observed in any of the tests but symptoms developed later. Weather conditions in the early season were conducive to development of CBR and Sclerotinia blight but not leaf spot disease. Leaf spot trials were irrigated to provide sufficient humidity to promote disease development.

Because the Disease Selection Tests had 240 entries, only the means for the best ten families of each type and the checks are presented (Table 1). The best ten F_{2.4} families came from four different crosses made in 2006, all of which share ancestry from breeding lines N03078FT, N03079FT, and N03084FT, more disease-resistant sisters of Bailey (tested as N03081T). The best ten F_{4.6} families came from five different backcrosses crosses made in 2005 to move the high-oleic trait into N03073FT, N03076FT, Bailey, N03088T, and N03090T. The best F_{6.8} families came from three crosses made in 2004 between disease-resistant sister lines (N03075FT, N04052FCsMT, and N04070CSmT) and high-oleic parents N00098ol and N02060ol. There were differences in the average level of different diseases observed in the different family types. We expected the F_{6.8} families, *i.e.*, those subjected to the most selection for resistance, to have the greatest average level of disease resistance. However, contrary to expectation, the F_{4.6} families showed a greater average level of resistance than did the F_{6.8} families, probably reflecting the conservation of disease resistance genes in the F_{4.6} families derived by backcrossing to a resistant parent versus the F_{6.8} families with equal ancestry from the resistant and high-oleic parents. In making within-family selections, special attention was paid to the top 5, 10 and 20% of the F_{2.4} and F_{4.6} families. Again, there will be no more selection within the F_{6.8} families; we will simply be identifying the best with respect to diseases, yield, and grade.

The Disease Advanced Test (DAT) series had 81 common entries tested for the four diseases that were measurable in 2008: 15 F_{6.14} families selected from the 2002 Disease Preliminary Test (DPT) for further testing of yield, grade, and disease

resistance; two F_{6:13} families selected from the 2003 DPT; 11 F_{6:12} families selected from the 2004 DPT, six F_{6:11} families selected from the 2005 DPT, 15 F_{6:9} families selected from the 2007 DPT, one line entered upon the request of Dr. Roy Pittman, the USDA-ARS peanut germplasm curator, 14 lines derived from interspecific hybrids developed by Drs. H.T. Stalker and S.P. Tallury, and 16 checks including released cultivars (NC 7, NC-V 11, NC 12C, Gregory, Perry, Phillips, Brantley, VA 98R, Wilson, CHAMPS, and Florida Fancy) and disease-resistant lines (Georgia Green and N96076L). There were also five lines that made their way into the DAT by expressing superior disease resistance after surviving in the conventional cultivar development stream through a second year in the Advanced Yield Test series. Some of these lines originated in the DST program but fell out of the accelerated program because they did not exhibit sufficient resistance to be retained. Such families enter the conventional cultivar development stream that achieves only one generation per year and in which selection and retention in the program are based solely on pod characteristics, yield and grade. Of the 54 experimental lines developed by the breeding program rather than the species program, 23 were also entered in the multiple-location Advanced Yield Test series for broader evaluation of yield and grade, and two were entered in the multiple-location Jumbo Pod Advanced Test (JAT).

Of the 20 best lines for disease resistance, 16 came from the accelerated resistance selection program (Figure 1), 12 of them high-oleic selections from the 2007 and 2008 DPT. Although it is often the case that the most disease-resistant lines are not the highest yielding or have the best grade, many of these selections yielded extremely well. As one would expect for a set of lines yield-tested for the first time, among the 43 selections from the 2008 DPT are several with poor yields. There is not yet any grade data for those selections; it will be obtained in the winter of 2008-2009. The commercial value of these selections cannot be known with certainty until they have passed through a multiple-year multiple-location testing program.

SUMMARY OF EXPENDITURES

Expenditures to date on this project total \$226,526, including \$212,199 for graduate stipend, tuition, and insurance for Crop Science students Susana Milla and Christina Rowe and Plant Pathology students Gabriela Alandia and Damon Smith and \$14,328 in other costs associated with the research plots.

Table 1. Adjusted means from the 2008 Disease Selection Tests: best ten F_{2.4}, F_{4.6} and F_{6.8} families compared with cultivars and checks. Early leafspot tested at PBRS in plots without fungicide; TSWV at PBRS in plots with 20° seed spacing and without insecticide, CBR at UCPRS on infested soil without metam sodium, and Sclerotinia plots at Roxobel in Bertie Co. on infested soil without application of fluazinam or boscalid.

Entry	Defoliation score	Rank among 240	Cylindrocladium black rot incidence	Rank among 240	Sclerotinia blight incidence	Rank among 240	Tomato spotted wilt virus incidence	Rank among 240	Arithmetic disease index [§]	Rank	
										Over-all	Among families I
	1=none to 9=complete								0=worst to 1=best		
F_{2.4} families											
X06130 (F2-08: F04)	3.96±0.40*	12	-0.091±0.112†	2	-0.005±0.097†	18	0.071±0.118†	13	.909	1	1
X06130 (F2-09: F04)	4.05±0.40*	21	-0.028±0.112†	13	0.028±0.097†	34	0.038±0.118†	5	.884	3	3
X06130 (F2-14: F04)	4.51±0.40	75	0.013±0.112†	31	0.044±0.097†	49	0.000±0.118†	3	.851	5	4
X06130 (F2-15: F04)	4.42±0.40	61	-0.063±0.112†	6	0.104±0.097†	108	0.129±0.118†	32	.818	11	9
X06131 (F2-02: F04)	4.08±0.40**	22	-0.041±0.112†	10	0.090±0.097†	99	0.154±0.118†	43	.829	9	7
X06132 (F2-01: F04)	4.21±0.40**	30	-0.079±0.112†	4	0.074±0.097†	71	0.170±0.118†	58	.834	8	6
X06132 (F2-03: F04)	3.98±0.40*	13	0.029±0.112†	43	-0.093±0.097†	1	0.117±0.118†	27	.897	2	2
X06132 (F2-04: F04)	4.31±0.40**	46	0.062±0.112†	72	-0.026±0.097†	10	0.122±0.118†	30	.841	6	5
X06132 (F2-05: F04)	4.44±0.40	64	0.025±0.112†	38	0.141±0.097†	144	0.000±0.118†	3	.815	12	10
X06258 (F2-01: F04)	4.55±0.40	80	0.012±0.112†	30	0.058±0.097†	54	0.084±0.118†	18	.820	10	8
F_{4.6} families											
X05239 (BC1F1-06-01-S-01: F06)	3.57±0.40†	4	0.145±0.112†	137	0.027±0.097†	33	0.225±0.118*	104	.812	15	3
X05239 (BC1F1-06-01-S-03: F06)	4.19±0.40**	28	0.060±0.112†	68	0.073±0.097†	70	0.208±0.118*	93	.787	30	5
X05242 (BC1F1-02-01-S-02: F06)	3.51±0.40†	2	0.031±0.112†	45	0.090±0.097†	98	0.178±0.118†	65	.835	7	2
X05242 (BC1F1-14-01-S-01: F06)	4.37±0.40	55	0.165±0.112†	153	0.065±0.097†	63	0.163±0.118†	54	.764	50	10
X05249 (BC1F1-07-01-S-01: F06)	4.53±0.40	78	-0.006±0.112†	20	0.144±0.097†	147	0.119±0.118†	28	.783	34	6
X05252 (BC1F1-04-01-S-01: F06)	4.21±0.40**	32	0.068±0.112†	78	0.042±0.097†	48	0.167±0.118†	57	.806	17	4
X05252 (BC1F1-05-02-S-02: F06)	4.30±0.40**	44	0.032±0.112†	47	0.176±0.097*	168	0.139±0.118†	36	.768	47	8
X05252 (BC1F1-05-02-S-03: F06)	3.98±0.40*	17	-0.013±0.112†	16	-0.041±0.097†	6	0.155±0.118†	45	.877	4	1
X05254 (BC1F1-09-02-S-01: F06)	3.53±0.40†	3	0.147±0.112†	140	-0.077±0.097†	4	0.523±0.118	226	.768	48	9
X05254 (BC1F1-09-02-S-04: F06)	4.32±0.40**	49	0.169±0.112†	155	-0.047±0.097†	5	0.292±0.118**	144	.771	43	7
F_{6.8} families											
X04009 (F2-01-S-02-S-02: F08)	5.62±0.40	209	0.000±0.112†	22	-0.014±0.097†	14	0.260±0.118**	122	.739	79	8
X04009 (F2-01-S-02-S-04: F08)	5.71±0.40	212	0.029±0.112†	44	-0.079±0.097†	3	0.115±0.118†	26	.792	26	1
X04009 (F2-02-S-01-S-02: F08)	4.66±0.40	94	0.115±0.112†	115	0.094±0.097†	102	0.202±0.118*	84	.738	80	9
X04009 (F2-02-S-01-S-04: F08)	4.42±0.40	62	-0.022±0.112†	15	0.171±0.097*	164	0.172±0.118†	60	.768	46	3
X04009 (F2-02-S-01-S-05: F08)	4.26±0.40**	38	-0.006±0.112†	19	0.142±0.097†	145	0.308±0.118	153	.746	69	6
X04045 (F2-01-S-01-S-05: F08)	4.92±0.40	139	0.010±0.112†	28	0.033±0.097†	37	0.290±0.118**	138	.750	66	5
X04045 (F2-01-S-01-S-06: F08)	5.23±0.40	176	0.009±0.112†	27	0.075±0.097†	74	0.205±0.118*	86	.741	75	7
X04056 (F2-02-S-04-S-01: F08)	4.86±0.40	129	0.050±0.112†	58	0.078±0.097†	83	0.122±0.118†	30	.773	39	2
X04056 (F2-02-S-06-S-05: F08)	4.40±0.40	59	-0.054±0.112†	8	0.084±0.097†	89	0.446±0.118	215	.733	85	10
X04056 (F2-02-S-06-S-12: F08)	4.31±0.40**	47	0.120±0.112†	120	0.071±0.097†	67	0.244±0.118**	113	.754	59	4
Cultivars											
N03081T (Bailey)	4.20±0.40**	29	0.730±0.112	239	0.011±0.097†	26	0.145±0.118†	39	.646	165	3
Gregory	5.73±0.40	215	0.084±0.112†	92	0.166±0.097*	162	0.156±0.118†	46	.671	141	1
Perry	4.71±0.40	102	0.568±0.112	237	0.179±0.097*	172	0.477±0.118	221	.501	232	6
Phillips	5.00±0.40	156	0.827±0.112	240	0.452±0.097	238	0.563±0.118	233	.286	240	7
GP-NC 343	3.98±0.40*	17	0.211±0.112*	181	0.391±0.097	234	0.350±0.118	174	.596	195	4
VA-C 92R	6.41±0.40	236	0.384±0.112**	229	0.287±0.097	213	0.161±0.118†	50	.503	231	5
N96076L	5.58±0.40	203	0.106±0.112†	111	0.131±0.097†	136	0.256±0.118**	121	.658	156	2
Mean of all entries	4.88		0.138		0.136		0.274		.683	120.5	
Mean of F _{2.4} families	4.97±0.04b		0.126±0.010a		0.138±0.009a		0.263±0.010a		.683	120.5	
Mean of F _{4.6} families	4.33±0.08a		0.130±0.023a		0.103±0.020a		0.270±0.020ab		.730	84.6	
Mean of F _{6.8} families	4.94±0.07b		0.145±0.021a		0.141±0.018a		0.315±0.018b		.664	138.7	
Mean of cultivars	5.09±0.17b		0.416±0.049b		0.231±0.042b		0.301±0.045ab		.551	194.3	
Standard value	3.30		0.000		0.000		0.000				

§ Average of three disease scores, each adjusted to a 1 (best) to 0 (worst) scale.

** , * , † Indicate means not significantly different from the standard value at the 1%, 5%, and 10% levels of probability, respectively, by t-test from a standard value.

a,z Denote means not significantly different from the best and worst in the test, respectively, at the 5% level by t-test.

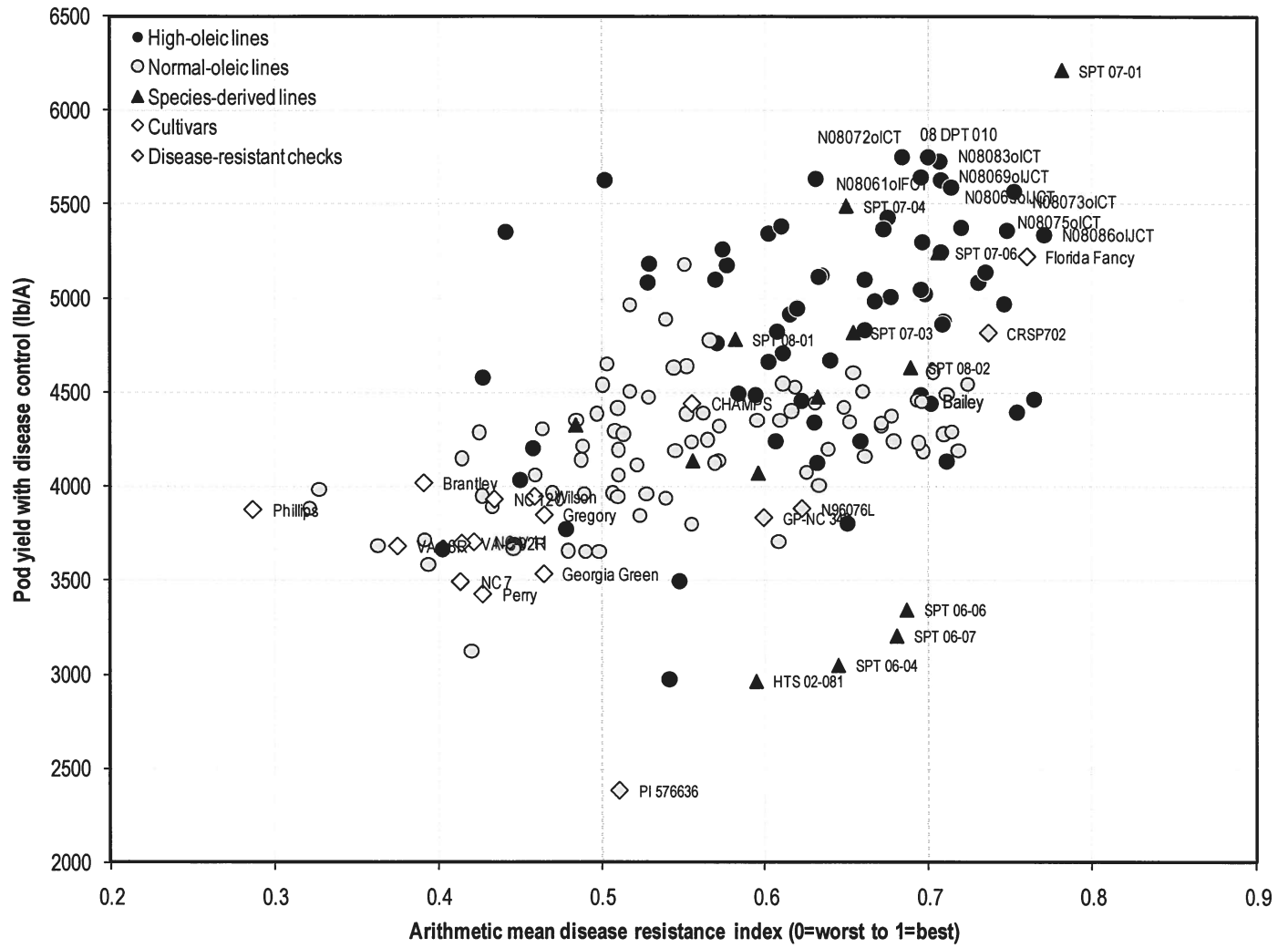


Figure 1. Pod yield with disease control versus arithmetic disease resistance index (mean of three disease scores adjusted to a scale of 0=worst to 1=best).

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IMPACT STATEMENT:

The first cultivar release from this project was initiated in May, 2008: breeding line N03081T was proposed for release under the name "Bailey" in honor of the late Jack E. Bailey. The proposal was approved at the NC Agricultural Research Service and awaits approval by the NCSU Intellectual Properties Committee. Seed multiplication of Bailey is on schedule for distribution to certified seed producers in 2009. Bailey has partial resistance to the four most common economically important diseases of peanut in North Carolina: Early leafspot, *Cylindrocladium* black rot, *Sclerotinia* blight, and tomato spotted wilt virus. With current peanut prices, saving one or two applications of leafspot fungicide or a single application of *Sclerotinia* preventives could mean the difference between profit and loss. Reduction of chemical inputs requires improvement of the disease resistance available in virginia-type cultivars. Resistant cultivars will help to maintain peanut production and the peanut seed market in North Carolina.