International Cooperative Screening for Resistance of Peanut to Rust and Late Leaf Spot

P. SUBRAHMANYAM, Plant Pathologist, Groundnut Improvement Program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru P.O., Andhra Pradesh 502 324, India; R. O. HAMMONS, Supervisory Research Geneticist, U.S. Department of Agriculture, Agricultural Research Service, P.O. Box 748, Tifton, GA 31793; S. N. NIGAM, Plant Breeder, D. McDONALD, Principal Plant Pathologist, and R. W. GIBBONS, Principal Plant Breeder, Groundnut Improvement Program, ICRISAT; and MING-YING FAN and WEI-LIN YEH, Vice-President and Assistant Research Fellow, Industrial Crops Research Institute, Guangdong Academy of Agricultural Sciences, Shipai, Guangzhou, Guangdong, People's Republic of China

ABSTRACT

Subrahmanyam, P., Hammons, R. O., Nigam, S. N., McDonald, D., Gibbons, R. W., Fan, M.-Y., and Yeh, W.-L. 1983. International cooperative screening for resistance of peanut to rust and late leaf spot. Plant Disease 67:1108-1111.

Following preliminary screening at Tifton, Georgia, USA, 23 peanut (*Arachis hypogaea*) germ plasm lines were evaluated at Isabella, Puerto Rico, and 22 of the 23 lines at both Patancheru, Andhra Pradesh, India, and Guangzhou, Guangdong, People's Republic of China, for resistance to *Puccinia arachidis* rust in field trials during 1976–1981. At Patancheru and Guangzhou, the 22 entries were also evaluated for resistance to *Cercosporidium personatum* late leaf spot. Nine entries (PI 215696, PI 259747, PI 315608, PI 341879, PI 350680, PI 381622, PI 393646, PI 405132, PI 407454) were resistant to rust at all three locations. Six entries (PI 215696, PI 259747, PI 341879, PI 350680, PI 381622, PI 405132) were resistant to both rust and late leaf spot in Patancheru and Guangzhou and can be useful in breeding for multiple disease resistance in peanut. Four of these six entries (PI 259747, PI 350680, PI 381622, PI 405132) were previously reported resistant to both rust and late leaf spot.

Additional key word: groundnut

The leaf spots caused by *Cercospora arachidicola* Hori (early leaf spot) and *Cercosporidium personatum* (Berk. & Curt.) Deighton (late leaf spot) are the most important diseases of peanut (*Arachis hypogaea* L.) on a worldwide scale (9,13). Rust of peanut, caused by *Puccinia arachidis* Speg., has become a worldwide problem since 1969 (2,8,13). In countries with advanced agriculture, controlling these diseases by application of fungicides has been a common practice (15). In the semiarid tropics, peanuts are grown mostly by small-scale farmers who can rarely afford crop protection inputs, and under these conditions yield losses in excess of 50% are common (7). The rise in cost of fungicides and the problems limiting their use by small-scale farmers in the developing world have led to increased efforts in the exploitation of host resistance to control these diseases. Sources of resistance to rust and leaf spots have been reported (1–11,13,14, 16–18), and in recent years, efforts have been extended to identify sources of multiple disease resistance in peanut (4,12,14,18).

In this paper, we report the results of screening a number of peanut accessions in four geographical regions—Isabella, Puerto Rico; Tifton, Georgia, USA; Patancheru, Andhra Pradesh, India; and Guangzhou, Guangdong, People's Republic of China—for resistance to rust and late leaf spot during 1976–1981.

Submitted as Journal Article No. 255 by ICRISAT.

Accepted for publication 16 April 1983.

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MATERIALS AND METHODS

Preliminary screening. Thirty-two peanut entries, consisting of 24 accessions collected by L. D. Tripp, H. F. Winters, and R. L. Clark in Peru, Bolivia, Colombia, and Ecuador, five accessions of Tarapoto (PI 259747, PI 341879, PI 350680, PI 381622, PI 405132), two accessions of Israel line 136 (PI 298115, PI 315608), and one accession of DHT 200 (PI 314817), were grown in the USDA/University of Georgia field nursery near Tifton in 1976 in nonreplicated paired row plots (1.8 × 6.1 m) with standard cultural practices. At the beginning of pod maturity, heavily rust-diseased leaves were spread over the test entries for inoculum. Each entry was visually scored for reaction to rust just before harvest using the five-point disease scale (0–4) of Mazzani and Hinojosa (10). Entries were not scored for late leaf spot reaction. As a peanut rust epidemic does not occur in every season in Tifton, advanced screening was carried out initially in Puerto Rico and subsequently in India and in the People's Republic of China.

Advanced screening. Twenty-three entries selected from the preliminary screening trial at Tifton were further evaluated in the USDA winter nursery in Isabella, Puerto Rico, during 1977–1979 for resistance to rust. Twenty-two of these entries were then evaluated at ICRISAT Center, Patancheru, near Hyderabad, India, during 1979–1981 and at Guangzhou, People's Republic of China, during 1981 for resistance to rust and late leaf spot.

Isabella, Puerto Rico. In 1977, the 23 entries were planted in nonreplicated 1.2 × 15.2 m plots with 2.5-cm drill spacing and alternated with plots of the rust-susceptible cultivar Tifrun. Rust was scored on a 0–4 scale (10) just before harvest.

In 1978, the entries were grown in a randomized design with two replications for further screening evaluation. Plots were 7.6 × 1.2 m with 2.5-cm drill spacing. The nursery was bordered by single rows of the rust-susceptible cultivar Florunner, and numerous rust-susceptible entries occupied both sides of the test area. Rust was scored on a 0–4 scale (10) shortly before harvest.

In 1979, each entry was grown in nonreplicated plots 7.6 × 1.2 m with 2.6-cm drill spacing. In the early stages of crop development, the plots were sprayed with a fungicide (chlorothalonil) that controls both rust and the two leaf spots of peanuts. Spraying was discontinued early enough to facilitate the buildup of rust, however. Each entry was scored for reaction to rust shortly before harvest.

ICRISAT Center, Patancheru, India. Twenty-two of the 23 entries were tested for reaction to rust and late leaf spot under field conditions during the 1979, 1980, and 1981 rainy seasons (June–October) and the 1979–1980 postrainy season (November–April).

In the 1979 rainy season, the entries were grown in nonreplicated 9-m rows, with a large number of cultivars susceptible to rust and late leaf spot growing adjacent to the test material. Rust development was heavy on all rust-susceptible cultivars, and the test entries were scored for damage by rust on a field rust disease 1–9 scale (18) shortly before harvest. Reactions of lines to late leaf spot were not recorded.

Rust and late leaf spot attacks are not severe in Patancheru during the postrainy season because of the hot, dry climatic conditions, so special procedures were adopted in the 1979–1980 postrainy season to ensure adequate disease development. A mixture of two rust-susceptible cultivars, TMV-2 and Robut 33-1, was sown systematically throughout the field as infector rows—one infector row after each five rows of a test entry. Rows were 4 m long and 75 cm apart, and within-row plant spacing was 10 cm. There were three replications of each entry. Rust-susceptible cultivars TMV-2 and Robut 33-1 were also planted in test plots to assess the spread of rust from the infector rows.

At peak flowering the infector rows were inoculated with urediniospore suspensions (0.5×10^5–1×10^5 urediniospores per milliliter) in tap water containing a wetting agent (Tween 80). The inoculations were made after sunset following furrow irrigation. Subsequently, the field was irrigated with overhead sprinklers, on alternate days initially, then at irregular intervals until harvest, to provide conditions conducive for disease development and spread. For additional sources of inoculum, heavily rust-diseased "spreader plants" in 14-cm diameter plastic pots were placed systematically throughout the field.

No inoculations were made with the late leaf spot pathogen in Patancheru, but development of the disease from natural inoculum was good. The entries were rated for both rust and late leaf spot damage on a 1–9 scale (18) just before harvest.

The entries were further tested in the field under natural epiphytotics during the 1980 and 1981 rainy seasons. The planting pattern was similar to that of the 1979–1980 postrainy season trial. Infector rows were incorporated but no inoculum was applied. All the entries were scored for both rust and late leaf spot on a 1–9 scale (18) shortly before harvest.

Guangzhou, People's Republic of China. The 22 entries were tested for reaction to rust and late leaf spot under field conditions during the 1981 spring (March–July) and autumn (August–December) seasons. One infector row of a local cultivar susceptible to rust and late leaf spot was sown after each two-row test entry plot. Rows were 4 m long and 30 cm apart, and within-row plant spacing was 10 cm. There were two replications of each entry. In both seasons, a 1–9 scale (18) was used to score the entries for rust and late leaf spot reactions just before harvest.

RESULTS

The genotypes entered in the trials were classified as either *Arachis hypogaea* subsp. *hypogaea* var. *hypogaea* or *A. hypogaea* subsp. *fastigiata* var. *fastigiata*. The identity, botanical variety, seed color, and origin or source of each entry were recorded (Table 1). Six entries (PI 259747, PI 298115, PI 314817, PI 350680, PI 381622, PI 405132) were previously reported resistant to rust and/or late leaf spot (3,8,17,18).

Resistance to rust. Reactions to rust were evaluated at all locations (Table 2). Preliminary evaluation was done in Tifton in 1976. The entries that scored less than 2 (0–4 scale) in a preliminary screening were further evaluated for three seasons in Isabella, for four seasons in Patancheru, and for two seasons in Guangzhou. The entries with mean scores of 0–1.5 (0–4 scale) and 1–3.5 (1–9 scale) were grouped as rust resistant; the entries with mean scores of 1.6–2.5 (0–4 scale) and 3.6–5 (1–9 scale) as moderately resistant; and the entries with mean scores greater than 2.5 (0–4 scale) and 5 (1–9 scale) as susceptible (Tables 2 and 3). Nine entries were rust resistant at all three locations. The other 13 entries showed some differences in host reaction between localities, being rust resistant at some and moderately rust resistant at others. Check entries were all highly susceptible to rust (Table 2). The entry (PI 393527) that gave the lowest rust score at Isabella was not included in the trials at Patancheru and Guangzhou (Table 2).

Resistance to late leaf spot. At Patancheru and Guangzhou, all entries were rated for reaction to late leaf spot (1–9 scale) and the mean disease scores were calculated (Table 2). The entries with mean scores of 1–3.5 (1–9 scale) were grouped as resistant; the entries with mean scores of 3.6–5 as moderately resistant; and the entries with mean scores greater than 5 as susceptible (Table 4). Six entries were resistant to late leaf

Table 1. Peanut (*Arachis hypogaea*) entries in international cooperative screening tests for resistance to rust and late leaf spot

Entries		Botanical		
PI no.[b]	ICG no.[c]	variety	Seed color[a]	Origin or source
215696	7881	*fastigiata*	Purple (59A)	Peru
259747	4747	*fastigiata*	Purple (59A)	Peru
298115	4746	*hypogaea*	Off-white (158A)	Israel ex. United States
314817	7882	*fastigiata*	Light tan (179D)	Peru
315608	7883	*hypogaea*	Off-white (159C)	Israel ex. United States
341879	7884	*fastigiata*	Purple (59A)	Peru
350680	6340	*fastigiata*	Purple (59A)	Honduras
381622	7885	*fastigiata*	Purple (79A)	Peru
390593	7886	*fastigiata*	Light tan (173D)	Peru
390595	7887	*fastigiata*	Purple (79A)	Peru
393516	7888	*fastigiata*	White with red blotches (155D/42A)	Peru
393517	7889	*fastigiata*	Off-white (158A)	Peru
393526	7890	*fastigiata*	Purple (79A)	Peru
393527	7891	*hypogaea*	Red (53A)	Peru
393527-B	7892	*hypogaea*	Red (53A)	Peru
393531	7893	*fastigiata*	Tan with purple stripes (174B/79C)	Peru
393641	7894	*fastigiata*	Light tan with purple stripes (174C/79A)	Peru
393643	7895	*fastigiata*	Light tan (173D)	Peru
393646	7896	*fastigiata*	Purple (59B)	Peru
405132	7897	*fastigiata*	Purple (79A)	Peru
407454	7898	*fastigiata*	Tan (174D)	Ecuador
414331	7899	*hypogaea*	Tan (166C)	Honduras
414332	7900	*hypogaea*	Tan (173C)	Honduras
TMV-2[d]	221	*vulgaris*	Tan (173D)	India
Robut 33-1[d]	799	*hypogaea*	Tan (174D)	India
Tifrun[d]	9937	*hypogaea*	Tan (173D)	United States

[a] Royal Horticultural Society Color Chart, Vincent Square, London, U.K.
[b] USDA-ARS plant introduction accession number.
[c] ICRISAT groundnut accession number.
[d] Standard cultivars susceptible to rust and late leaf spot.

spot, one was moderately resistant, and eight were susceptible in both locations. Seven entries had different resistance ratings in the two locations. The most important differences were with PI 393531 and PI 407454, which were susceptible to late leaf spot in Patancheru and resistant in Guangzhou. PI 390593 was moderately resistant to late leaf spot in Patancheru and susceptible in Guangzhou; the actual disease scores for this genotype were not markedly different but did overlap the arbitrary late leaf spot resistance groups of entries (Table 2).

Table 2. Field disease ratings of 26 peanut (*Arachis hypogaea*) entries for rust and late leaf spot

Entries	Rust scores			Late leaf spot scores	
	Isabella[a]	Patancheru[b]	Guangzhou[c]	Patancheru[d]	Guangzhou[c]
PI 215696	0.8	3.3	2.8	3.0	2.5
PI 259747[e]	1.2	3.0	3.2	3.3	2.5
PI 298115[e]	1.7	4.0	2.0	7.0	7.0
PI 314817[e]	1.7	3.0	4.5	7.0	4.3
PI 315608	1.3	3.0	2.0	6.7	6.7
PI 341879	1.2	2.5	2.8	2.7	2.4
PI 350680[e]	1.5	3.0	3.3	3.3	2.6
PI 381622[e]	1.5	3.0	3.2	3.0	2.5
PI 390593	1.0	2.8	4.1	5.0	5.4
PI 390595	2.0	3.5	3.3	3.7	2.7
PI 393516	1.5	4.3	3.5	4.0	3.1
PI 393517	1.2	3.3	3.9	7.0	5.5
PI 393526	1.5	4.3	4.2	4.3	4.3
PI 393527	0.7	...[f]	...	...	...
PI 393527-B	1.0	3.0	4.3	7.5	6.4
PI 393531	1.8	3.5	2.9	7.0	3.4
PI 393641	2.5	3.8	2.8	4.0	2.8
PI 393643	1.8	3.0	4.4	6.7	5.7
PI 393646	1.3	2.5	3.4	6.3	5.4
PI 405132[e]	1.3	2.5	2.8	2.7	2.4
PI 407454	1.3	2.8	3.5	6.7	3.5
PI 414331	1.3	2.8	4.1	7.3	7.0
PI 414332	1.3	2.5	4.7	6.3	6.7
TMV-2[g]	...	9.0	9.0	9.0	8.8
Robut 33-1[g]	...	9.0	9.0	9.0	8.3
Tifrun[g]	4.0	...	...	...	...

[a] Mean rust scores of 1977, 1978, and 1979 field screening trials in USDA winter nursery, Isabella, Puerto Rico. Scale 0–4: 0 = no diseased leaves, 1 = less than 25% leaves infected, 2 = 26–50% leaves infected, 3 = 51–75% leaves infected, and 4 = over 75% leaves damaged.

[b] Mean rust scores of 1979, 1979–1980, 1980, and 1981 field screening trials at ICRISAT, Patancheru, Andhra Pradesh, India. Scale 1–9; 1 = no rust pustules, 2 = few small pustules on older leaves, 3 = few poorly sporulating pustules on older leaves, 4 = poorly sporulating pustules on lower or middle leaves, 5 = many moderately sporulating pustules with yellowing and necrosis of lower and middle leaves, 6 = as 5 but heavily sporulating pustules, 7 = plants covered with pustules and lower and middle leaves withering, 8 = as 7 but leaves severely withered, and 9 = more than 50% of foliage withered.

[c] Mean rust and late leaf spot scores (1–9 scales) of 1981 spring and autumn field screening trials at Guangzhou, Guangdong, People's Republic of China.

[d] Mean late leaf spot scores of 1979–1980, 1980, and 1981 field screening trials at ICRISAT, Patancheru, Andhra Pradesh, India. Scale 1–9: 1 = no leaf spot, 2 = few necrotic spots on older leaves, 3 = small, sparsely sporulating spots on older leaves, 4 = many spots on mostly lower and middle leaves, 5 = many moderately sporulating spots on lower and middle leaves with lower ones yellowing and dropping, 6 = as 5 but heavily sporulating spots, 7 = spots on all leaves with defoliation of lower and middle leaves, 8 = as 7 but defoliation more severe, and 9 = more than 50% foliage defoliated.

[e] Previously reported as resistant to rust and/or late leaf spot.

[f] Not included.

[g] Standard cultivars susceptible to rust and late leaf spot.

Multiple disease resistance. In the trials at Patancheru and Guangzhou, six entries—PI 215696, PI 259747, PI 341879, PI 350680, PI 381622, and PI 405132—were resistant to both rust and late leaf spot (Tables 3 and 4). Some entries showed resistance to both diseases in one location but not in the other.

Table 3. Rust reactions of peanut (*Arachis hypogaea*) entries at three locations[a]

Entries	Rust nursery locations		
	Isabella	Patancheru	Guangzhou
PI 215696, PI 259747,[b] PI 315608, PI 341879, PI 350680,[b] PI 381622,[b] PI 393646, PI 405132,[b] PI 407454	R[c]	R	R
PI 390593, PI 393517, PI 393527-B, PI 414331, PI 414332	R	R	MR
PI 298115,[b] PI 393641	MR	MR	R
PI 393643, PI 314817[b]	MR	R	MR
PI 393516	R	MR	R
PI 393526	R	MR	MR
PI 390595, PI 393531	MR	R	R

[a] Isabella, Puerto Rico; Patancheru, Andhra Pradesh, India; and Guangzhou, Guangdong, People's Republic of China.

[b] Previously reported as resistant to rust and/or late leaf spot.

[c] R = resistant, MR = moderately resistant.

DISCUSSION

Stability of host resistance to a disease is an important objective for any disease-resistance breeding program and is particularly important for international programs. The stability can be checked by testing genotypes under natural disease epiphytotics in widely separated locations. In the present study, a number of peanut genotypes were screened for resistance to rust in four locations and for resistance to late leaf spot in two locations. Disease pressure, as evidenced by disease scores on the check entries susceptible to rust and late leaf spot, was high in all locations (Table 2). There was little variation in reaction of genotypes to rust between locations, the only changes being from rust resistant to moderately rust resistant or vice versa.

The reaction of entries to late leaf spot was similar for most genotypes in Patancheru and Guangzhou, except for PI 393531 and PI 407454, which were rated susceptible in Patancheru and resistant in Guangzhou. The late leaf spot pathogen is known to be capable of developing strains with tolerance to fungicides (15), and perhaps it could also develop more or less virulent strains. Similar disease resistance screening trials are being carried out in different parts of the world as part of a multilocational international foliar diseases nursery, and results from these trials should provide evidence to support or reject the occurrence of variation in virulence of the pathogens. It is important to note that the majority of the genotypes tested in the different locations maintained constant disease resistance ratings, indicating a considerable degree of stability of resistance.

Several entries tested in this investigation have been examined for reactions to foliar diseases in other locations by various workers (3,5,6,12,14,16–18). Two Tarapoto accessions, PI 259747 and PI 350680, were resistant to early leaf spot in the United States (16) but susceptible in India (*unpublished*) and Brazil (12,14). This difference could be due to pathogen variation in virulence, such as occurrence of different races; to interaction among host, pathogen, and environment; or to heterogeneity of germ plasm. Genotypes of some of the entries in the present

Table 4. Late leaf spot reactions of peanut (*Arachis hypogaea*) entries at two locations[a]

Entries	Late leaf spot nursery locations	
	Patancheru	Guangzhou
PI 215696, PI 259747,[b] PI 341879, PI 350680,[b] PI 381622,[b] PI 405132[b]	R[c]	R
PI 393526	MR	MR
PI 390595, PI 393516, PI 393641	MR	R
PI 393531, PI 407454	S	R
PI 314817[b]	S	MR
PI 390593	MR	S
PI 298115,[b] PI 315608, PI 393517, PI 393527-B, PI 393643, PI 393646, PI 414331, PI 414332	S	S

[a] Patancheru, Andhra Pradesh, India, and Guangzhou, Guangdong, People's Republic of China.
[b] Previously reported as resistant to rust and/or late leaf spot.
[c] R = resistant, MR = moderately resistant, S = susceptible.

investigation may be identical; for example, it has been suggested (8) that PI 259747, PI 341879, PI 350680, PI 381622, and PI 405132 may be accessions of the Tarapoto cultivar. The similarity of disease reactions of these five entries in all locations in the present study supports this suggestion. Confusion of identity probably arises because of extensive dissemination and reintroduction of seed material among countries.

Our data (Tables 2–4) show that some entries have resistance to more than one foliar disease. In addition, PI 259747 and PI 350680 have been reported resistant to peanut scab disease caused by *Sphaceloma arachidis* Bit. & Jenk. in Brazil (12). Observations in Guangzhou indicate that some of the entries resistant to rust and late leaf spot in the international trials may have useful resistance to bacterial wilt caused by *Pseudomonas solanacearum* (E.F.Sm. 1896) Smith 1914. Sources of multiple disease resistance in peanut are of obvious importance to breeding programs.

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