

Sources of resistance to foliar diseases of groundnut and their stability in West Africa(1)

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Abstract — Three foliar pathogens early (*Cercospora arachidicola* Hori) and late (*Cercosporidium personatum* (Berk and Curt.) Deighton) leaf spots and rust (*Puccinia arachidis* Speg.) are a major constraint to the groundnut (*Arachis hypogaea* L.) production in West Africa although their severities vary from location to location. A total number of 424 germplasm lines have been screened in Niger and Burkina Faso against the three pathogens and resistant lines have been identified. Some sources of resistance to early leaf spot reported in India showed variable reactions in West Africa. Differential reaction to early leaf spot at different locations indicates that there may be physiological races of pathogen. Sources of resistance to late leaf spot and rust selected at ICRISAT Center (India) were also resistant in West Africa. Multiple disease resistance was evident in lines ICG 1707, ICG 6030 and USA 65.

Key words: *Arachis hypogaea*, early and late leaf spots, rust, resistance

MATERIALS AND METHODS

INTRODUCTION

Foliar diseases are a major constraint to groundnut production in West Africa. Early leaf spot caused by *Cercospora arachidicola* Hori, late leaf spot caused by *Cercosporidium personatum* (Berk and Curt.) Deighton (*Phaeosariopsis personata* (Berk and Curt.) V. Arx) and rust caused by *Puccinia arachidis* Speg. are the most common diseases in the region. Severity of these foliar diseases varied from location to location.

All three pathogens are economically important in most countries where groundnuts are grown and damage is more serious when the crop is attacked by more than one pathogen. Pod yield losses due to multiple pathogen attack may range from ten to sixty percent [5, 9, 20]. Although effective chemical control methods are available in many areas of the world, high costs and/or the existence of fungicide tolerant strains of the pathogen limit their use [3, 8]. Consequently there is a need to develop disease resistant cultivars. Screening groundnut germplasm lines for resistance to the foliar pathogens is carried out worldwide and genotypes with resistance or tolerance have been identified [1, 4, 6, 9, 10, 13, 14, 15, 16, 17]. More than 12 000 germplasm accessions have been screened for resistance to late leaf spot and/or rust at ICRISAT Center (India). Several sources of resistance have been identified and used in the breeding program to combine disease resistance with high yield potential in locally adapted cultivars [11, 16]. Screening for resistance to early leaf spot at ICRISAT Center has been less successful due to lack of regular epidemics of the pathogen [17, 18].

The main objectives of this study were

- to identify sources of resistance and check the stability of resistant lines in West Africa,
- to test West African cultivars for their reaction to foliar diseases

Screening trials were planted in selected areas in West Africa where foliar diseases are endemic during the 1989, 1990, 1991 and 1992 cropping seasons. Rust screening was carried out at Niangoloko (near Bobo Dioulasso) Burkina Faso. Trials for early leaf spot were planted at Bengou, Niger, and trials for late leaf spot were conducted in both locations. The number of entries tested at each location are shown in table 1. In all the trials a lattice design with three replications was used. Seeds were treated with a seed protectant chemical (Thioral) at the rate of 3 g kg⁻¹ of seeds. Individual plots consisted of four rows 4m long spaced 50 cm apart.

A 1/9 scale as described by Subrahmanyam *et al.* [13] in which 1 = no disease and 9 = 80–100% diseased foliage was used to evaluate groundnut genotypes for their reaction to foliar pathogens. Although observations were made every 15 days starting from 45 days after sowing until harvest, we report only the last score given. As leaf spot and rust occur together regularly at Niangoloko (Burkina Faso) selective fungicides were used to control either leaf spot or rust as described by Waliyar and McDonald [19]. For rust resistance trials Bavistin^(R) WP (carbendazim) at 500 g in 500 L of water ha⁻¹ was applied to control leaf spot diseases. Calixin^(R) 80% solution (tridemorph) at 150 ml in 500 L of water ha⁻¹ was applied to the late leaf spot screening trial to prevent the establishment of rust. The first spray of either fungicide was applied at 40 days after sowing and treatment continued at 15 day intervals until 30 days before harvest.

TABLE 1 — Number of entries tested in the screening trials.

Screening for resistance to	Year		
	1989	1990	1991 and 1992
Early leaf spot	Bengou 144	Bengou 64	Bengou 1991/64
Late leaf spot	Bengou trial 1: 144 trial 2: 36	Bengou trial 1 = 64 trial 2 = 49 trial 3 = 49 Niangoloko 36	Niangoloko 36
Rust		Niangoloko 100	Niangoloko 1991/100

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TABLE II. — Performance of selected groundnut genotypes for resistance to early leaf spot (ELS), Bengou, Niger, rainy seasons 1989, 1990, 1991

Genotype identity	ICG No	ELS score ⁽¹⁾		
		1989	1990	1991
NC Ac 10811A	7878	3.0	2.4	3.6
NC Ac 17500	6284	3.1	3.6	3.0
NC Ac 18045	8298	3.4	3.9	2.9
PI 476033	10900	4.0	3.4	4.0
PI 476180	10954	4.3	3.2	4.9
ICG 7756	7756	4.5	3.8	4.0
NC Ac 18091	8339	4.5	4.3	3.2
ICG 10000	10000	4.9	4.3	3.9
NC Ac 17894	6902	5.2	6.0	3.3
USA 403 Red	9989	5.3	5.0	3.0
PI 215724	10450	5.3	5.0	4.1
10883	10883	5.3	2.6	4.1
10948	10948	5.3	4.0	4.1
NC 5	2711	5.3	5.3	4.5
USA 63	3527	5.4	4.3	-
NA Ac 17124	6280	5.5	4.0	4.6
PI 270806	6330	5.6	5.0	4.1
NC Ac 17132	1707	5.7	4.0	3.6
Checks				
55-437		7.7	8.8	8.6
ICGS 11		8.3	8.2	7.0
SE		±0.68	±0.66	±0.41
Total mean		6.1	5.2	4.9
CV (%)		19	22	15
Lattice efficiency (%)		102	103	113

(1) Scored on a 1-9 scale where 1 = no disease and 9 = 80-100% foliage damage

TABLE III. — Performance of selected groundnut genotypes for resistance to late leaf spot (LLS), Bengou, Niger, rainy seasons 1989, 1990, 1991

Genotype identity	ICG No	LLS score ⁽¹⁾		
		1989	1990	1991
NC Ac 17132	1707	2.0	1.4	3.3
NC Ac 17133 (RF)	7013	2.0	1.6	2.3
PI 215696	7881	2.0	1.7	3.3
PI 476174	10941	2.0	1.9	-
PI 381622	7885	2.0	2.1	-
7756	7756	2.7	2.8	2.0
PI 350680	6340	2.7	1.8	3.7
PI 341879	7784	2.9	4.0	-
NC Ac 927	6022	3.0	1.8	3.7
PI 476168	10936	3.0	1.9	3.0
PI 259747	4747	3.0	3.3	3.3
NC Ac 17135	1710	3.0	3.5	4.3
USA 63	3527	3.1	2.7	3.7
PI 476163	10028	3.3	2.7	3.3
PI 270806	6330	3.3	1.9	4.0
EC 76446 (292)	2716	3.5	1.3	2.3
NC Ac 17506	-	3.6	1.6	-
PI 393516	7888	3.9	2.3	2.0
NC Ac 17056	4995	3.9	3.0	3.7
PI 476195	10975	3.9	1.8	2.7
PI 476172	10039	4.0	1.9	2.0
PI 476178	10949	4.0	2.8	-
NC Ac 10811 A	7878	4.6	2.3	2.7
Checks				
55-437		8.9	9.0	9.0
ICGS 11		7.8	9.0	7.7
SE±		0.66	0.89	0.47
CV (%)		21	37	20
Lattice efficiency (%)		103	103	<100

(1) Scored on a 1-9 scale where 1 = no disease and 9 = 80-100% foliage damage

TABLE IV. — Reaction of selected groundnut genotypes for resistance to late leaf spot (LLS), Niangoloko, Burkina Faso, rainy seasons 1990, 1991

Genotype identity	ICG No	LLS score ⁽¹⁾	
		1990	1991
NC Ac 17132	1707	1.0	1.3
NC Ac 17135	1710	1.0	1.7
EC 76446 (292)	2716	1.0	1.0
PI 259747	4747	1.0	1.3
NC Ac 17056	4995	1.0	1.3
PI 270806	6330	1.0	1.0
PI 350680	6340	1.0	1.0
KRAP. ST 16	4790	1.0	1.3
PI 341879	7884	1.0	1.7
PI 381622	7885	1.0	1.7
PI 405132	7897	1.0	1.3
NC Ac 17133 RF	7013	1.0	1.0
WCG 190204/66	7630	1.3	1.3
PI 393516	7888	1.3	1.7
PI 476016	10889	1.3	1.0
PI 476168	10936	1.3	1.0
USA 63	3527	1.3	1.3
PI 476163	10028	2.7	1.7
PI 215696	7881	4.3	1.3
-	6930	4.3	4.3
PI 476172	10039	4.7	3.3
Checks			
55-437		8.3	9.0
PI 476183	10053	7.3	7.7
SE		0.3	0.6
CV (%)		16	36
Lattice efficiency (%)		<100	<100

(1) Scored on a 1-9 scale where 1 = no disease and 9 = 80-100% foliage damage

Analyses of variance were performed on the observation individually for each trial. A combined analysis of variance was performed in 1989 and 1990 because the screening for resistance to late leaf spot was carried out in several separate trials (Table I).

RESULTS

Disease spectrum

Early leaf spot, late leaf spot and rust were present in the region during each year of the experiments, but their severity varied between the two study sites. In Burkina Faso (Niangoloko) rust and late leaf spot were the predominant diseases every year. In Niger (Bengou) both early and late leaf spot diseases were important, but their severity differed each year. For example only early leaf spot was important in 1991 at the Niger site while only late leaf spot was of epidemic importance in 1992.

Resistances to early leaf spot

In 1989, out of the 144 lines screened, seventeen lines had a score of less than six (on a 1 to 9 scale) compared to susceptible checks which had a score of 8. The most resistant lines were ICG 7878, ICG 6284, ICG 8298 and ICG 10900.

In the subsequent years we tested only sixty-four lines, and found the same lines with scores of 5 or less. Among the lines tested in 1990 through 1992, the lines ICG 7878, ICG 6284, ICG 7756 and ICG 10900 which had resistant reaction in 1989, had an average score of less than 4 in all three years (Table II). A variable reaction to early leaf spot was observed on lines such as ICG 6902, ICG 9989 and ICG 1707.

TABLE V — Performance of selected groundnut germplasm and breeding lines for resistance to rust, Bobo-Dioulasso, Burkina Faso, rainy seasons 1990, 1991

Genotype identity	ICG No	Rust score ⁽¹⁾					
		1990	1991	Genotype identity	ICG No	1990	1991
PI 476166	10030 A	19	17	PI476195	10974	21	17
PI 270806	6330	19	20	PI 476198	10074	22	17
PI 476145	10014	20	23	PI 476189	10064	22	17
PI 476151	10022 A	20	20	PI 476192	10068	22	20
PI 476151	10918	20	20	PI 476175	10945	23	13
PI 476179	10048	20	17	PI 476197	10978	23	20
PI 476186	10963	20	17	PI 476169	11080	23	20
NC Ac 17090	1697	20	20	PI 476195	11108	23	20
PI 476160	10928	20	17	CS 52		23	13
PI 476168	10031	20	17	PI 476020	11183	24	20
PI 476183	10053	20	33	PI 476183	10054	24	22
PI 476177	10042	20	17	PI 393643	4826	24	20
EC 76446 (292)	2716	20	20	PI 393419	9185A	24	20
PI 476188	10966	21	20	PI 476015	11182	24	17
PI 476149	10020	21	20	PI 476016	10889	24	17
PI 393526	7890	21	17	PI 476172	10939	24	17
PI 476172	10039	21	13	PI 476172	10034	25	17
PI 476168	10935	21	17	PI 350680	6340	26	13
PI 476190	10969	21	20	PI 315608	7883	28	27
PI 414331	7899	21	20	NC Ac 2240	5043	34	20
PI 476149	10021	21	20	PI 39352B	7892	37	20
PI 393531	7893	21	17	NC Ac 17133 (RF)	7013	38	20
PI 476188	10964	21	30	NC Ac 17135	1710	40	40
PI 476180	10051	21	20	NC Ac 927	6022	41	40
PI 47-981	10884	21	17	PI 476172	10035	42	17
PI 476176	10940	21	23	PI 476168	10936	45	40
PI 476179	10047	21	23	WCG 190204/66	7630	47	27
PI 259747	4747	21	20	PI 215696	7881	47	47
PI 405132	7897	21	23	NC Ac 17132	1707	47	50
PI 476168	10032	21	17	PI 476143	10010	49	33
PI 476166	10933	21	20				
Checks							
55 437		74	87				
ICGS 11		70	80				
SE±		0.27	0.39				
Trial mean		3.33	3.19				
CV (%)		14	21				
Lattice efficiency (%)		125	<100				

(1) Scored on a 1-9 scale where 1 = no disease and 9 = 80-100% foliage damage

Resistances to late leaf spot

In Niger out of 180 lines tested in 1989 twenty three lines had a score of less than 5. Genotypes ICG 1707, ICG 7013, ICG 7881 and ICG 10941 showed a high degree of resistance (scored 2 on 1 to 9 scale) to late leaf spot (Table III) in 1989, 1990 and 1992.

In 1990 and 1991 the screening trial at Niangoloko (Burkina Faso) included lines which had resistant reaction to late leaf spot at ICRISAT Center (India) and susceptible checks. Most of the resistant lines had a very high level of resistance. Some lines such as ICG 6340, ICG 6330, ICG 2716 and ICG 7013 had no symptoms of late leaf spot and were given a score of one in all replications. Others were scored from 2 to 5 compared to 8 and 9 for susceptible check (Table IV).

Screening for resistance to rust

A trial was carried out in Burkina Faso to check the reaction of lines reported resistant to rust at ICRISAT Center (India). One hundred germplasm, breeding lines and interspecific derivatives were tested in field screening trials in 1990 and 1991 rainy seasons. In both years lines that had resistance to rust in India also had high levels of resistance in Burkina Faso. Fifty three lines had scores of less than 4 and eight

lines were scored between 4 and 5. All local lines were susceptible to rust (Table V).

DISCUSSION

Among the lines tested in Niger for resistance to early leaf spot four lines were highly resistant (ICG 7878, ICG 6284, ICG 8298 and ICG 10900). These lines always showed a score of 4 or less in the three years of the test. Results of our early leaf spot screening trials in India (Pantnagar), Nepal (Nawalpur) and Malawi (Lilongwe) indicated that most of the lines reported resistant elsewhere were not resistant [17, 18] at these locations. Among the lines that were reported resistant from ICRISAT Center only ICG 8298, ICG 10900 and ICG 8339 maintained their resistance in West Africa. The genotypes ICG 7878 which had high resistance to early leaf spot in Niger (scored 3) was only moderately resistant (scored 5) in India [17, 18]. Another genotype ICG 6902 reported to be resistant (scored 3) in India was moderately resistant (scored 4-8) in Niger. Some other lines were susceptible in Niger but resistant in India. There may be some variation in virulence or possibly physiological races of early leaf spot in different locations. Research on the variability of

early leaf spot is in progress in France under a collaborative research project between ICRISAT and CIRAD. The results of this work will clarify some of the questions on variability of this pathogen.

In the case of late leaf spot, all the lines resistant to the pathogen in India [13, 14, 15] were also found to be resistant in Niger and Burkina Faso. Although, some differences in varietal reaction to isolates have been reported, there is no evidence of physiological races [12, 21]. Among the lines reported resistant to late leaf spot at ICRISAT Center, ICGs 2716, 6340, 7013, 7741, NC Ac 17132, and NC Ac 17133(RF) showed higher levels of resistance in Burkina Faso.

The highest number of resistant lines have been identified in the case of rust. In Burkina Faso, we were able to identify lines with almost no rust pustules on the leaves. All the lines reported resistant in India maintained their resistance in Burkina Faso. Although, some work has suggested the exist-

ence of physiological races, none has ever been demonstrated [7, 21]. Even in a study carried out with wild *Arachis spp*, it was not possible to separate physiological races [2].

Lines ICG 1707, ICG 6330 and USA 63 (USA 63 had a score of 5.1 for rust) had moderate levels of resistance to both early leaf spot, late leaf spot, and rust. Some other lines were resistant to both late leaf spot and rust. In the latter case, some lines showed high levels of resistance to both pathogens. Identification of such lines is useful for breeding programs as in some West African agroecological zones, more than one disease may cause severe yield losses in a given year.

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