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 = *Phaeoisariopsis personata* (Berk and Curt.) V. Arx) 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 6330 and USA 63.

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

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 (*Phaeoisariopsis 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.

MATERIALS AND METHODS

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 I. 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 Bavastin(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 I — **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 Ac18091	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
Trial 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	2.3
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**

		Rust score[1]					
Genotype identity	ICG No	1990	1991	Genotype identity	ICG No	1990	1991
PI 476166	10030 A	1 9	1.7	PI476195	10974	2.1	1.7
PI 270806	6330	1.9	2.0	PI 476198	10074	2 2	1.7
PI 476145	10014	2 0	2 3	PI 476189	10064	2.2	1.7
PI 476151	10022 A	2 0	2.0	PI 476192	10068	2.2	2.0
PI 476151	10918	2.0	2 0	PI 476175	10945	2 3	1 3
PI 476179	10048	2.0	1.7	PI 476197	10978	2 3	2 0
PI 476186	10963	2 0	1.7	PI 476169	11080	2.3	2.0
NC Ac 17090	1697	2.0	2.0	PI 476195	11108	2.3	2 0
PI 476160	10928	2.0	1.7	CS 52	–	2.3	1 3
PI 476168	10031	2.0	1.7	PI 476020	11183	2.4	2.0
PI 476183	10053	2.0	3.3	PI 476183	10054	2 4	2 2
PI 476177	10042	2.0	1.7	PI 393643	4826	2 4	2 0
EC 76446 (292)	2716	2 0	2 0	PI 393419	9185A	2.4	2 0
PI 476188	10966	2 1	2 0	PI 476015	11182	2.4	1 7
PI 476149	10020	2 1	2.0	PI 476016	10889	2.4	1.7
PI 393526	7890	2 1	1 7	PI 476172	10939	2.4	1 7
PI 476172	10039	2 1	1.3	PI 476172	10034	2.5	1.7
PI 476168	10935	2.1	1.7	PI 350680	6340	2.6	1.3
PI 476190	10969	2.1	2 0	PI 315608	7883	2.8	2 7
PI 414331	7899	2.1	2 0	NC Ac 2240	5043	3.4	2 0
PI 476149	10021	2.1	2.0	PI 39352B	7892	3.7	2.0
PI 393531	7893	2.1	1 7	NC Ac 17133 (RF)	7013	3.8	2.0
PI 476188	10964	2 1	3.0	NC Ac 17135	1710	4 0	4.0
PI 476180	10051	2 1	2.0	NC Ac 927	6022	4.1	4.0
PI 475981	10884	2.1	1 7	PI 476172	10035	4.2	1 7
PI 476176	10940	2 1	2.3	PI 476168	10936	4 5	4 0
PI 476179	10047	2 1	2 3	WCG 190204/66	7630	4.7	2 7
PI 259747	4747	2.1	2 0	PI 215696	7881	4.7	4.7
PI 405132	7897	2 1	2.3	NC Ac 17132	1707	4 7	5 0
PI 476168	10032	2 1	1.7	PI 476143	10010	4 9	3.3
PI 476166	10933	2.1	2.0				
Checks							
55-437		7.4	8.7				
ICGS 11		7 0	8.0				
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 higly 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 existence 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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RESUME

Sources de résistance aux maladies foliaires de l'arachide et leur stabilité en Afrique occidentale

F WALIYAR, J P. BOSC et S BONKOUNGOU. *Oléagineux*, 1993, **48**, N°6, p. 283-287

Trois agents pathogènes foliaires, les cercosporioses précoce (*Cercospora arachidicola* Hori) et tardive (*Cercosporidium personatum* (Berk et Curt) Deighton = *Phaeoisariopsis personata* (Berk et Curt.) V Arx) et la rouille (*Puccinia arachidis* Speg.) sont une contrainte majeure pour la production de l'arachide (*Arachis hypogaea* L.) en Afrique occidentale, bien que leur importance varie d'une situation à une autre En tout, 424 lignées de matériel génétique ont été étudiées au Niger et au Burkina Faso pour leur résistance vis-à-vis de ces agents pathogènes. Trois lignées résistantes ont été identifiées. Certaines sources de résistance à la cercosporiose précoce signalées en Inde ont présenté un comportement variable en Afrique occidentale. Un comportement différent vis-à-vis de la cercosporiose précoce dans des situations diverses montre qu'il pourrait exister des races physiologiques de cet agent pathogène. Des sources de résistance à la cercosporiose tardive et à la rouille, sélectionnées au Centre ICRISAT (Inde) étaient résistantes en Afrique occidentale également Les lignées ICG 1707, ICG 6330 et USA 63 présentaient des résistances multiples aux maladies.

Mots clés. — *Arachis hypogaea* les cercosporioses précoce et tardive, la rouille, la résistance

RESUMEN

Fuentes de resistencia a las enfermedades foliares del maní y su estabilidad en Africa occidental

F. WALIYAR, J.P BOSC et S. BONKOUNGOU, *Oléagineux*, 1993, **48**, N°6, p 283-287

Tres agentes patogénos foliares, las cercosporiosis temprana (*Cercospora arachidicola Hori*) y tardía (*Cercosporidium personatum* (Berk y Curt.) Deighton = *Phaeosariopsis personata* (Berk y Curt.) V. ARx) y la roya (*Puccinia arachidis Speg.*) son un apremio de mayor importancia para producir maní (*Arachis hypogeo L*) en Africa occidental, aunque su importancia varie de una situación a otra. En total, se estudiaron 424 familías de material genético en Niger y en Burkina Faso para su resistencia frente a los agentes patogénos Se identificaron tres familías resitentes. Algunas fuentes de resistencia a la cercosporiosis temprana señaladas en India presentaron un comportamiento variable en Africa occidental. Un comportamiento differente frente a la cercosporiosis temprana en situaciones varias señala que pueda existir razas fisológicas de este agente patogéno Fuentes de resistencia a la cercosporiosis tardía y a la roya, seleccionadas en el Centro ICRISAT (India) también eran resistentes en Africa occidental Las familías ICG 1707, ICG 6330 y USA 63 presentaban resistencias varias a las enfermedades.

Palabras claves — *Arachis hypogea*, las cercosporiosis temprana y tardía, la roya, la resistencia