Resistance to Early Leaf Spot of Groundnut

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Abstract

*Research on various aspects of early leaf spot (*Cercospora arachidicola*) disease, including evaluation methods of host resistance, is reviewed. Some recent findings from research in India by the International Crops Research Institute for the Semi-Arid Tropics are summarized. Greenhouse and laboratory resistance screening methods have been used to supplement field trials. Future strategies are outlined to identify new sources of resistance to the disease.*

Sumário

***Resistência às Manchas Foliares no Amendoim.** Investigação sobre os vários aspectos da mancha temporã (*Cercospora arachidicola*), incluindo os métodos de avaliação da resistência do hospedeiro, são revistos. Alguns recentes avanços da investigação na India feita pelo ICRISAT (Instituto Internacional para a Investigação de Culturas para o Trópico Semi-Arido) são sumarizados. Métodos de estufa e laboratório para a avaliação de resistência têm sido usados, para complementar ensaios de campo. Futuras estratégias são delineadas para identificar novas fontes de resistência à doença.*

Introduction

Early leaf spot, caused by *Cercospora arachidicola* Hori, is one of the most serious diseases affecting groundnut (*Arachis hypogaea* L.) production worldwide. Leaf spots damage the plant by reducing the leaf area available for photosynthesis and by stimulating leaflet abscission leading to heavy defoliation (McDonald et al. 1985). Early leaf spot and late leaf spot [*Phaeoisariopsis personata* (Berk. & Curt.) v. Arx] together cause groundnut pod yield losses ranging from 10% to 60% in many areas of the world, the loss varying from place to place, and between seasons (Jackson and Bell 1969; McDonald et al. 1985; Cummins and Smith 1973; Ghuge et al. 1981).

More time has been devoted by plant pathologists to the management of early and late leaf spots than to any other groundnut disease problem (Jackson and Bell 1969), and considerable information is available on control with fungicides (Porter 1970; Smith and Crosby 1972; Cummins and Smith 1973; Mercer 1974; Lyle et al. 1977; Mohan and Mathur 1980; Smith and Littrell 1980; Fowler and McDonald 1981; Gorbet et al. 1982). Though fungicidal control of leaf spots is effective and economical in many developed countries, its application is limited in most developing countries by the high costs of application machinery and fungicides and by lack of

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technical skills. Indiscriminate use of fungicides for leaf spots control may result in undesirable effects such as increased severity of sclerotinia blight when chlorothalonil is used against foliar diseases (Smith 1984). It is obvious that the most effective and economical means of leaf spots control would be to grow resistant cultivars.

Screening of groundnut germplasm for resistance to the leaf spots is in progress in research institutions in several countries and genotypes with resistance to early leaf spot or to late leaf spot diseases have been identified (McDonald et al. 1985). However, there has been only limited success in identifying and utilizing resistance to early leaf spot, and the stability of the resistances so far identified has still to be established. This paper discusses various aspects of the identification and evaluation of resistance in groundnut to the early leaf spot pathogen, and summarizes some recent findings from research in India by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

Evaluation of Resistance

A wide range of criteria have been used by different workers to evaluate leaf spot resistance (Sowell et al. 1976; Melouk and Banks 1984; Gobina et al. 1983). Gobina et al. (1983) showed that 'sporulation' was an important criterion when there were no significant differences in lesion numbers, while Anderson (1985) used an index which incorporated necrotic area, latent period, and degree of sporulation. Sowell et al. (1976) evaluated resistance using defoliation and disease-index parameters. Foster et al. (1981) found the number of lesions and percentage defoliation most useful for assessing resistance to early leaf spot. Hassan and Beute (1977) showed that the defoliation ratio and the visual estimation of percentage of leaves with leaf spots were efficient and reliable evaluation criteria, especially when large numbers of entries were tested. Smith and Littrell (1980) reviewed various disease assessment methods and concluded that visual rating on a 1–10 or 1–5 scale to estimate leaf area affected by disease and/or defoliation was less time consuming than the main-stem method. At ICRISAT Center, a visual 9-point scale has been used for preliminary screening of germplasm for early leaf spot resistance, but in recent investigations 'leaf defoliation' has been found to be the most important parameter for estimation of disease resistance, as abscission can be induced in several genotypes by the presence of a single lesion.

Based on the above criteria, effective field and laboratory resistance screening techniques have been developed and used in several countries and a number of sources of resistance to early leaf spot have been reported (Table 1).

The nature of resistance

Resistance has been attributed to various morphological and anatomical characteristics of the host

Table 1. Thirty-six groundnut genotypes identified resistant (elsewhere)[1] to *Cercospora arachidicola* and their performance at ICRISAT Center.

Genotype/ identity	Disease reaction at ICRISAT Center	Genotype/ identity	Disease reaction at ICRISAT Center
NC 5	R[2]	PI 276233	-[2]
NC 3033	S[2]	PI 276235	-
AC 3139	-[2]	PI 109839	-
FESR 5-P2-P1	-	PI 162857	-
NC Ac 3139	-	PI 259679	-
Kanyoma	-	PI 350680	?[2]
Tifton 8	-	PI 259747	S
VGP 2	-	PI 270806	S
VGP 3	-	PI 259639	-
VGP 4	-	PI 468251 (BPZ 56)	-
VGP 5	-	PI 468253 (BPZ 5B)	-
VGP 6	-	PI 468293 (BPZ 96)	-
VGP 7	-	PI 468295 (BPZ 98y)	-
PI 261893	-	PI 475871 (GKPSc 224)	-
PI 306230	-	PI 476029 (SPA 417)	-
PI 270680	-	PI 476034 (SPA 422)	-
PI 196652	-	PI 196604	-
PI 306222	-	PI 196677	-

1. Abdou 1966, Anderson 1985, Foster et al. 1980, Hammons et al. 1980, Hassan and Beute 1977, Kornegay et al. 1980, Melouk and Banks 1978, Sowell et al. 1976.
2. R = Resistant; S = Susceptible; ? = Reaction variable at different locations; - = Not tested at ICRISAT Center.

plant, and to chemical constituents of leaves (Stalker 1984). Hemingway (1957) observed a positive correlation between the size of the stomatal aperture and the susceptibility of groundnuts to *C. arachidicola*, and his observations were confirmed by D'Cruz and Upadhyaya (1961). Gibbons and Bailey (1967) also observed a correlation between resistance in field-grown *Arachis* species and the sizes of their stomatal apertures. Hassan and Beute (1977) considered that while stomatal size changes occurred because of changes in growth environments, decreased stomatal aperture did not appear to be the mechanism for increased resistance in the entries studied. Mazzani et al. (1972) studied the field incidence of leaf spot diseases and concluded that genotypes with greater stomatal length were not more affected by the diseases than those with smaller stomatal lengths. Abdou (1966), working with wild *Arachis* species, found no orientation in the growth of germ tubes toward stomata in immune entries, but he did observe stomata-oriented germ-tube growth on leaf surfaces of susceptible genotypes. He also observed the formation of barriers by cell-wall swelling, thickening, and the deposition of presumed peptic substances to be a response to infection in resistant genotypes.

Miller (1953) found that resistance to leaf spots was related to high riboflavin content of seeds. This point has apparently not been investigated by other workers. A recent study of groundnut phytoalexins by Strange et al. (1985), reported the isolation of an antifungal compound called 'Medicarpin' (3-hydroxy-9 methoxypterocarpan), which accumulates to toxic proportions after infection by either *C. arachidicola* or *Phoma arachidicola*. Phytoalexins are generally believed to play important roles in host resistance (Keen 1986; Strange 1987).

Components of Resistance

An understanding of how the components of resistance operate is required to estimate their relative importance in evaluating the resistance, and to explore means of enhancing it.

The known components of resistance to the early leaf spot pathogen include: number of lesions per leaflet, lesion diameter, latent period, time to leaflet loss, and degree of sporulation. Foster et al. (1980) suggested that latent period could be useful in selection of groundnut lines resistant to early leaf spot. Ricker et al. (1985) emphasized the need to determine which components of the resistant genotypes differ quantitatively from those of susceptible genotypes and whether components are the same for all resistant genotypes. Many authors have studied multiple components of resistance in groundnut (Foster et al. 1981; Melouk and Banks 1984; Nevill 1981); but their studies did not include both field and greenhouse data on components of resistance. Nevill (1981) and Ricker et al. (1985) observed significant genotypic differences in lesion numbers. Ricker et al. (1985) concluded that the lesion number was greatly influenced by environment and therefore an unreliable means to evaluate genotypes in the greenhouse. They observed significant cultivar differences for other parameters, i.e., latent period, time until leaflet loss, and degree of sporulation. They also suggested a previously undescribed, but useful, component of resistance they named MPLS (maximum percentage of lesions sporulating) to be used in selection for resistance in groundnut.

Once the relative importance of the components contributing to the development of epidemics is known, they could possibly be fitted into a dynamic model (Zadoks 1972; Parlevliet 1975; Savary 1986) to predict the progression of epidemics and to evolve disease-management strategies accordingly. Another use for this knowledge would be to breed groundnut varieties for the component having maximum influence on reduction of epidemic buildup.

Recent Research by ICRISAT on Resistance to Early Leaf Spot Disease

At ICRISAT Center, Patancheru, India, early leaf spot is always present but its incidence and severity are usually very low, and the damage it causes is normally masked by the regular and severe epidemics of late leaf spot and rust. Success in identifying resistance to late leaf spot and rust and the incorporation of these resistances into agronomically acceptable cultivars has led to increasing priority being allocated to similar work on early leaf spot. This has necessitated arrangement for field screening facilities at a location in India where early leaf spot occurs regularly and causes severe damage. Pantnagar, in northern India, fulfils this requirement and a field resistance screening project was started there in 1987 in collaboration with the G.B. Pant University of Agriculture and Technology.

During the 1987 rainy season, replicated field trials were carried out at both ICRISAT Center and Pantnagar to screen large numbers of germplasm accessions, breeding lines, and interspecific hybrid derivatives for resistance to foliar diseases. An "infector row" or "spreader row" technique (Melouk and Banks 1984; McDonald et al. 1985) was used, test entries being sown in replicated plots with rows of a susceptible cultivar being arranged systematically throughout the trials to enhance inoculum pressure. The infector row plants were sprayed with a suspension of *C. arachidicola* conidia and sprinkler irrigation was provided as required to maintain conditions conducive to disease buildup.

Early leaf spot appeared at the usual time in Pantnagar and the epidemic built up to a level that permitted effective evaluation of the test entries for resistance to the disease. Unexpectedly, early leaf spot was unusually severe on groundnuts at ICRISAT Center in the 1987 rainy season and the usual attacks of rust and late leaf spot did not materialize, these diseases appearing only very late in the cropping season and doing little damage. Therefore, it was possible to evaluate the trial entries and nearly 3000 genotypes in other experiments on the farm for resistance to the early leaf spot disease.

Several genotypes showed moderate levels of resistance to early leaf spot at both Pantnagar and ICRISAT Center (Table 2), and will again be tested in the 1988 rainy season. Thirty-eight of the lines

Table 2. Reaction to early leaf spot of 14 selected groundnut germplasm and breeding lines for resistance to early leaf spot, Pantnagar and ICRISAT Center, rainy season 1987.

Line	Identity	Reaction to early leaf spot[1] ICRISAT Center	Pantnagar
ICG 1703	NC Ac 77127	4.7	-
ICG 2711	NC 5	4.5	4.6
ICG 6284	NC Ac 17500	5.0	-
ICG 6349	NC Ac 1121	3.6	5.0
ICG 6709	NC Ac 16163	3.6	4.3
ICG 7291	PI 262128	3.0	4.8
ICG 7406	PI 262121	3.0	5.0
ICG 7630	204/66	4.8	4.8
ICG 7878	NC Ac 10811A	5.0	-
ICG 7892	PI 393527-B	4.1	4.0
ICG 9990	US 409 (Flesh)	5.0	4.5
ICG 10040	PI 476176 (SPZ 451)	5.0	-
ICG 10946	PI 476176	5.0	-
ICGV 86690		5.0	5.0
SE[2]		±0.48	-
CV (%)[2]		7.0	-

1. Field disease scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage destroyed.
2. The SE and CV (%) presented represent the values for all genotypes tested.

Table 3. Field reaction of 10 selected groundnut germplasm lines showing multiple resistance to early and late leaf spots and to rust at ICRISAT Center, rainy season 1987.

Line	Identity	Disease reaction[1] Early leaf spot	Late leaf spot	Rust
ICG 1703	NC Ac 17127	4.7	5.0	4.7
ICG 6284	NC Ac 17500	5.0	7.0	3.3
ICG 7340	198/66 Coll. 182	5.7	5.1	2.7
ICG 9294	58-295	5.1	6.0	2.7
ICG 10010	PI 476143	5.7	5.1	4.1
ICG 10040	PI 476176	5.0	4.7	3.7
ICG 10900	PI 476033	5.3	4.7	4.1
ICG 10946	PI 476176	5.0	6.0	4.1
ICG 799	Robut 33-1	8.0	7.0	7.0
ICG 221	TMV 2	8.0	8.0	8.0
SE[2]		±0.48	±0.7	±1.1
CV (%)[2]		7.0	10.7	22.3

1. Field disease scored on a 1-9 scale, where 1 = No disease, and 9 = 50-100% foliage destroyed.
2. The SE and CV (%) presented represent the values for all genotypes.

showing resistance were sent to be tested by the SADCC/ICRISAT Regional Groundnut Improvement Program, Chitedze Research Station, Lilongwe, Malawi, where early leaf spot is consistently a major disease problem.

Eight of the genotypes found to have resistance to early leaf spot are also resistant to rust and late leaf spot diseases (Table 3), and could be useful in breeding for multiple disease resistance.

Because the occurrence of early leaf spot disease at ICRISAT Center is unreliable, greenhouse and laboratory resistance screening methods have been used to supplement field trials. These studies have been carried out on potted plants (greenhouse) and on rooted detached leaves (laboratory) using techniques previously reported (Nevill 1981; Subrahmanyam et al. 1983; McDonald et al. 1985). Similar methods are being used to study components of resistance.

Looking to the future, it is evident that increased efforts are required to identify new sources of resistance to early leaf spot and to integrate these with resistances to rust and late leaf spot and other important diseases and pests into agronomically acceptable and agroecologically adapted groundnut cultivars. Stability of resistance will have to be established, and investigations are required into the possible existence of physiological races of *C. arachidicola*. Integrated disease management procedures will have to be established and the breeding of foliar diseases resistant cultivars should provide the basis for these. It will be necessary for breeders, cytogeneticists, pathologists, and physiologists from different countries to work closely together according to planned strategies to achieve success.

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