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A Scale of Reaction Types of Groundnut to *Puccinia arachidis* Speg.

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With 3 figures

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Abstract

A scale of reaction types of groundnut to *Puccinia arachidis* Speg. is proposed based on observations of infected leaves taken from the field. A variety of reaction types was described and ranked in two ways, according to ontogenic development and to host susceptibility. The reaction types thus described were grouped into few classes, and the resulting scale was compared with the widely-used scales of cereal rusts. The application of the proposed typological scale for a quick, qualitative assessment of groundnut varieties for rust resistance is discussed.

Zusammenfassung

Eine Reaktionstypskala für Erdnüsse gegen *Puccinia arachidis* Speg.

Vorgeschlagen wird eine Reaktionstypskala für Erdnüsse gegen *Puccinia arachidis* Speg., die sich auf Beobachtungen von feldgesammelten, infizierten Blättern stützt. Eine Vielfalt von Reaktionstypen wurde beschrieben und nach zwei Gesichtspunkten eingeordnet, nach der ontogenischen Entwicklung und der Wirtsanfälligkeit. Die so beschriebene Reaktionstypen wurden in einigen Klassen zusammengestellt und die daraus gebildete Skala mit der breitangewandten Getreiderostskala verglichen. Diskutiert wird die Anwendung dieser vorgeschlagenen typologischen Skala für eine schnelle, qualitative Beurteilung der Rostresistenz von Erdnußsorten.

The recent outbreaks of groundnut rust caused by *Puccinia arachidis* Speg. throughout the groundnut producing regions in the world, and especially in Asia and Africa, have induced considerable efforts to control this disease, mainly by

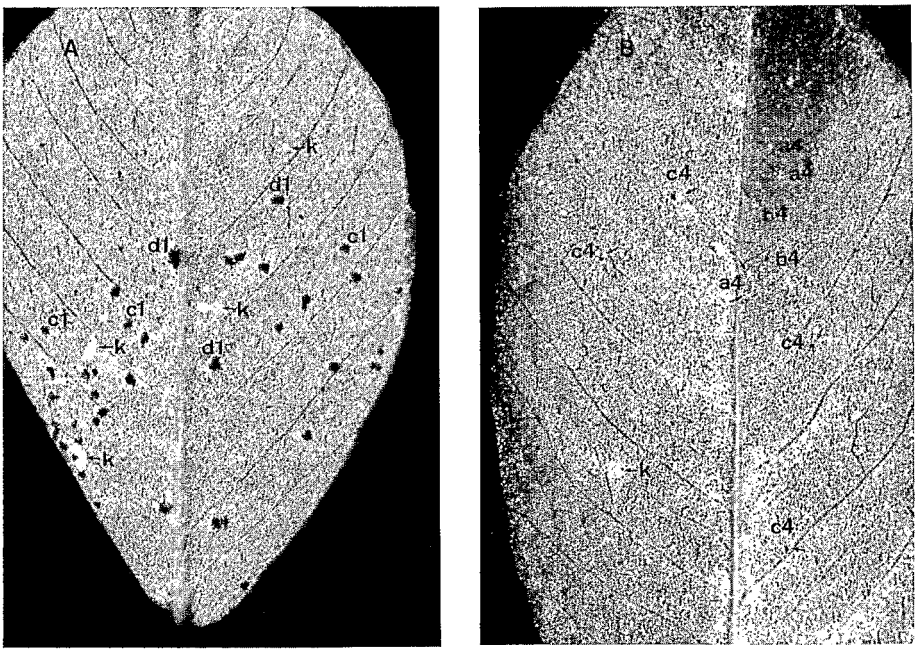

Fig. 1. Rust symptoms on two groundnut varieties showing extreme lesion and reaction types. A: local variety; B: NC Ac 17090. From potted plants, 20 days after inoculation. k: remnants of kaolin used for inoculation, in mixture with rust spores. For other symbols, see legend of Fig. 3, and text

increasing resistance in the host populations (SUBRAHMANYAM *et al.* 1985). Disease assessment is a tool used by plant breeders and epidemiologists to describe the development of the pathogen (LARGE 1966). Assessment of rust severity in the field is based on semi-quantitative (SUBRAHMANYAM *et al.* 1983 a), quantitative (SAVARY 1987) and/or typological scoring systems, based on verbal or pictorial scales.

A wide range of reaction types can be found in cultivated groundnuts, as illustrated by Fig. 1. The application of a typological scale consisting of standardized reaction types allows a quick, qualitative assessment of cultivar-pathogen compatibility. Such a scoring system could be used in the greenhouse and in the field. The objective of the present report is to propose a scale of reaction types for groundnut rust which is conceptually consistent with those used in cereal rust studies. The analysis of the observations was carried out in three steps, a) the description of symptoms, b) the description of lesion types, and c) the description of reaction types.

Materials and Methods

Six groundnut varieties (NC Ac 17090, PI 259747, NC Ac 17127, PI 381622, 69101, and a local short-season erect bunch cultivar), representing a range of restistance levels to rust, were selected from a routine varietal trial at ORSTOM Experimental Station, Adiopodoumé, Ivory Coast. Leaf (around

20 for each variety) samples were brought to the laboratory for observations. The samples were taken when the plants were two months old, when rust was uniformly established in the spreader rows after spontaneous infection. The leaves were fully expanded but not yet senescing. Care was taken to consider infected leaves with moderate or low lesion density for description of symptoms. The leaves from each variety were observed under a dissecting microscope, and a sketch of typical symptoms was made (Fig. 2) for each variety.

Observations

For each variety, a series of observations were made so that its whole range of lesion types was taken into consideration. The observations are summarized as follows:

A-(Local): Large pustules, all ruptured and profusely sporulating at maturity. No chlorosis or necrosis (Fig. 1, A).

B-(69101): Pustules somewhat smaller than those in A, with less profuse sporulation. Late development of the pustule (from pustule opening onwards) is usually accompanied by the appearance of a more or less extensive chlorotic area around it, even at low pustule density.

C-(PI 381622): Small pustules when mature, some of them with slight peripheral necrosis. Large uredinia covered by unruptured epidermis.

D-(NC Ac 17127): Pustules small when mature with large surrounding chloronemic areas. Numerous unruptured uredinia, some of them with peripheral necrosis.

E- (PI 259747): (Tarapoto) Some ruptured but small pustules. Numerous unruptured uredinia. Most pustules, ruptured or not, surrounded by extensive necrotic areas. Some large necrotic lesions correspond to colonies aborted at a late developmental stage.

F-(NC Ac 17090): Numerous large necrotic lesions, some of them with a small, open, and poorly sporulating uredinium. Some small necrotic lesions, corresponding to colonies aborted at an early developmental stage (Fig. 1, B).

Lesion types

The objective of these observations was not an exhaustive description of the variation in rust lesion aspect for each groundnut variety, but rather to provide information on the range of symptoms found in the groundnut-rust pathosystem. The range of symptoms found (Fig. 2) may be classified into a simplified matrix of lesion types (Fig. 3). In a susceptible variety such as the local cultivar, the development of a groundnut rust colony may be described in four stages (Cook 1980): (a1) primary symptom development: chloronemic fleck, (b1) early pustule development, (c1) pustule rupture, and (d1) pustule enlargement. The third stage (c1) corresponds with the termination of the latency period, which is 10 to 12 days on a susceptible variety under average environmental conditions in Southern Ivory Coast (Savary 1985 b). The last stage (d1) corresponds to a phase of more

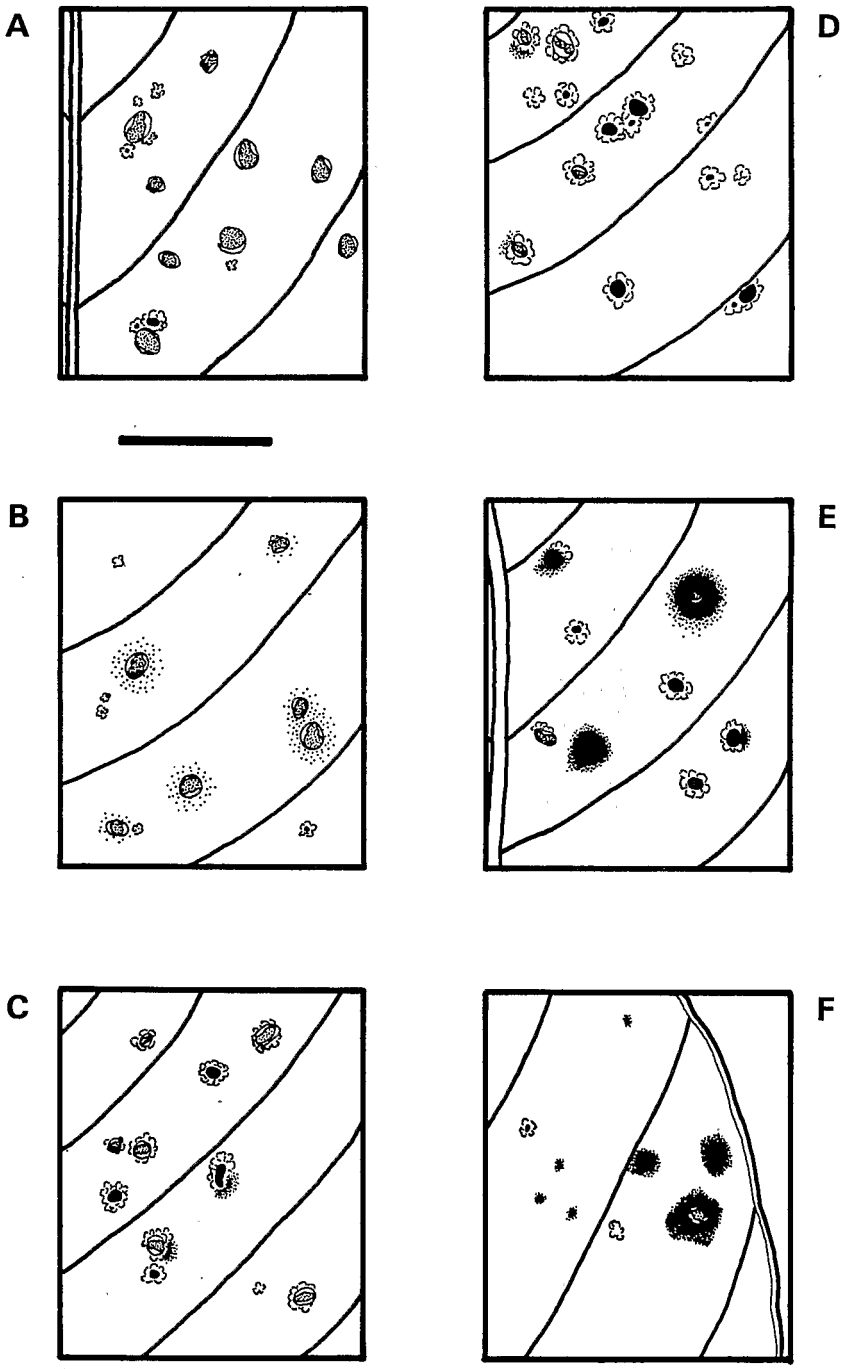

Fig. 2. Typical rust symptoms on abaxial leaf surface in six groundnut varieties.

A: local variety D: NC Ac 17127
B: 69101 E: PI 259747 (Tarapoto)
C: PI 381622 F: NC Ac 17090

The horizontal bar represents 5 mm

intense sporulation of the pustule. Although pustule enlargement implies only radial growth, and not a qualitative change, it is considered as a separate stage because of its epidemiological consequences and because this stage is absent when some host resistance is encountered. At times, this stage is accompanied by the appearance of some chlorosis around the colony (d1 chl). This feature was related to the variety under consideration (69101, B), but chlorosis was also found in the most susceptible variety (local, A) around senescing pustules, or when the lesion density was high. Several environmental factors, such as host nutritional factors, may affect the appearance of chlorosis; this feature should therefore be considered with caution, and only when it obviously differentiates a variety from the susceptible check. The final development stage of the colony, pustule exhaustion, corresponds to the end of the infectious period, which is usually 25 to 40 days after infection in a susceptible variety (SAVARY 1985 b). This stage cannot be assessed by observing the pustule through a hand lense, and therefore it is not considered here.

Depending on the variety under consideration, the early development of the colony may be accompanied by an enlargement of the chloronemic fleck (a2) which may eventually develop a necrotic peripheral area (a3). In some cases, the early abortion in the establishment of the colony is indicated by a small necrotic lesion (a4). The enlargement of the chloronemic fleck may be accompanied by the development of a pustule whose rupture is frequently delayed (b2); the resulting pustule is usually small (c2). In many cases, delay and poor growth of the pustule are accompanied by a partial (b3, c3) or total (b4, c4) necrosis of the surrounding leaf area. The latter lesion types correspond to aborted colonies at medium and late developmental stages, respectively.

Reaction types

Reaction types may be defined as classes of lesion types, each class characterizing an easily recognizable level of host-pathogen compatibility.

In a second phase of the analysis, an attempt was made to identify the lesion types characteristic of a particular reaction type, i. e., of one compatibility level. It should be noticed that the ontogeny of a lesion type characteristic of a given level of incompatibility may involve transitory stages which are common to more compatible reactions (Fig. 3). Such specific lesion types are therefore to be found either in the direction of increasing lesion development (Fig. 3, extreme right), or in the direction of increasing resistance level (Fig. 3, bottom). The reaction types of varities A, B, C, D, E and F were thus defined by the following lesion types [d1], [d1 (chl)], [b3, c3], [b3, c3], [b4, c4], [a4, c4] (Fig. 3).

A third phase of the analysis was to relate these reaction types to published and extensively used reaction type scales (ZADOKS 1961, ROELFS 1985). Using these scales with only slight modifications, the characteristic reaction types, and their corresponding lesion types were classified (Table 1). Two of the reaction types known from cereal rusts (mesothetic, types Y and Z; ROELFS 1984) are missing in our observations. The immune type (*sensu* ROELFS 1984, or reaction type class 0, MACNEAL *et al.* 1971, ZADOKS and SCHEIN 1979) is characterized by

Table 1

A proposed scale of reaction types for the groundnut-rust pathosystem. The reaction classes are derived from CHESTER (1946), ZADOKS (1961), MACNEAL *et al.* (1971), ZADOKS and SCHEIN (1979) and ROELFS (1985) for cereal rusts and are defined by characteristic lesion types (Fig. 3). The host responses 'low resistance' (reaction type LR, index value 4), 'low susceptibility' (reaction types LS, index value 6), and 'moderate susceptibility' (reaction type MS, index value 7) were not found in the present study, but may be encountered in the future

Host response[1] (class)	Reaction type[1]	Index value	Symptoms[1]	Characteristic lesion types[2]	Example[3]
Immune	0	0	No symptoms	—	
Very resistant	VR	1	Necrotic or chlorotic lesions, no pustules	a4	
Resistant	R	2	Few, small uredinia surrounded by a necrosis	a4, b4,c4	F
Moderately resistant	MR	3	Few, small uredinia surrounded by a more or less extensive necrosis	b4, c4	E
Mesothetic (heterogenous)	M	5	Random distribution of variable-sized either ruptured or unruptured uredinia. Some necrosis or chlorosis visible	b3, c3	D, C
Susceptible	S	8	Numerous, medium to large-sized uredinia associated with chlorosis	d1 (chl)	B
Very susceptible	VS	9	No chlorosis, many large and abundantly sporulating pustules	d1	A

[1] From CHESTER (1946), ZADOKS (1961), MACNEAL *et al.* (1971), ZADOKS and SCHEIN (1979), and ROELFS (1985) with slight modifications.
[2] See Figure 3.
[3] See Figure 2.

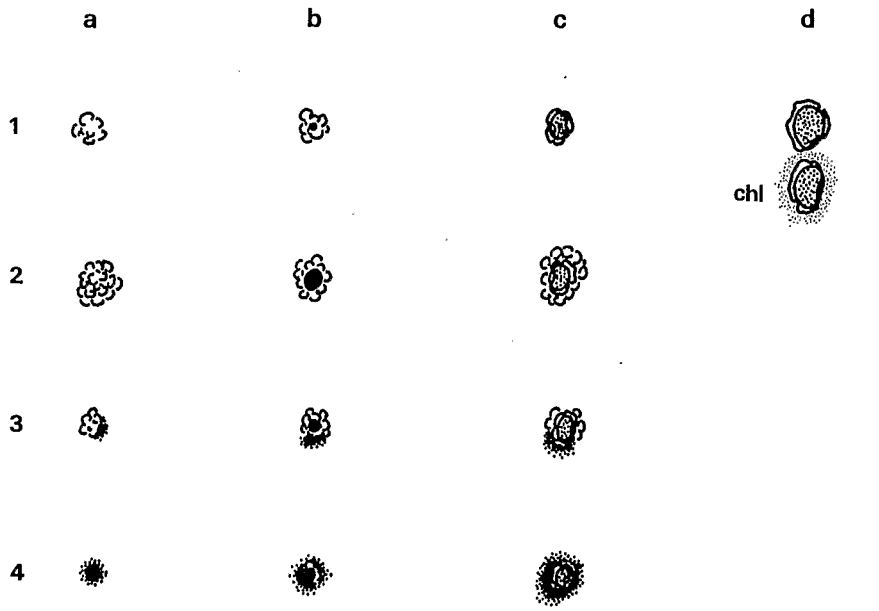

Fig. 3. A simplified classification of lesion types of groundnut rust. The horizontal direction represents colony development. The vertical direction represent increasing host-pathogen incompatibility

the absence of macroscopically visible indication of the disease. It can be found in wild *Arachis* species (SUBBA RAO, unpublished data). In this latter case, however, few, very small necrotic lesions are observed by microscopic examination of the leaf surface. The nearly immune reaction type (*sensu* ROELFS 1984, or very resistant type, *sensu* MACNEAL *et al.* 1971, ZADOKS and SCHEIN 1979; or highly resistant type, *sensu* CHESTER 1946), characterized by the appearance of small necrotic lesions as only symptoms was not found in our investigations. Such a lesion type was only found in combination with large necrotic (more compatible) ones (b4, c4, Fig. 2, F). The nearly immune reaction type might be found in some species of the genus *Arachis* and especially in wild species.

Discussion

CHESTER (1946) suggested three possible reasons to explain the origin of the reaction type M (mesothetic type X with random distribution of variable-sized uredia, ROELFS 1984): a) environmentally-conditioned irregularity, b) genetic instability of fungus or host, and c) merely the result of unrecognized mixture of two or more races in an apparently pure culture. A fourth possibility could be added, which is variation in leaf age and plant developmental stage. The appearence of the reaction type M may therefore reflect in some cases the introduction of an undesirable source of variation. This reaction type does exist and represents a particular level of compatibility between the host and the pathogen, at least in

cereal rusts. In fact, since they were established on field-grown plants, the lesions observed in this study were certainly caused by genetically varying *P. arachidis* populations. Detailed greenhouse and laboratory experiments (SUBBA RAO, SAVARY, unpublished results) confirm, however that such mesothetic (M, Table 1) reaction types do exist in groundnut-rust interactions too.

The objective of this study was to assemble a large range of lesion types and to define their corresponding possible reaction types. Future studies may provide more precise information on the characteristic reaction types of individual combinations of groundnut genotype and rust isolate. This kind of assessments need the following precautions to be taken (CHESTER 1946, ZADOKS and SCHEIN 1979, ROELFS 1985):

a) homogeneous lesion distribution,
b) uniform leaf age and plant developmental stage,
c) avoidance of environmental stresses on the host material (such as water stress),
d) genetic stability of the host material as well as the pathogen populations.

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