



## Selection for resistance to *Phytophthora* pod rot of cocoa (*Theobroma cacao* L.) in Cameroon: Repeatability and reliability of screening tests and field observations

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### ABSTRACT

Phytophthora pod rot (Ppr) disease caused by *Phytophthora megakarya* is the major constraint to cocoa production in Cameroon. The development of resistant varieties requires the use of effective resistance testing methods. The repeatability and reliability of the leaf disc and detached pod tests, as applied in selection activities in Cameroon, were studied. Repeatability of the tests was estimated by calculating the correlation ( $r$ ) between resistance scores of clones, progenies and individuals within progenies in different inoculations rounds of the leaf disc and detached pod tests. Such correlations were generally significant for both tests. For the leaf disc test, as expected, correlations were lower for individuals within seedling progenies than for the average of seedling progenies or of clones. This suggests that a higher number of replicate observations are required for correct evaluation of individual seedlings than for evaluation of the average level of resistance of progenies. Observations carried out 5 or 7 days after inoculation was highly correlated, suggesting that scoring in the leaf disc test may be done only once at 5, 6 or 7 days after inoculation. In one experiment the ranking of leaf disc and detached pod inoculation test results could be compared statistically, with data being significantly correlated ( $r$  0.78). The reliability of the tests was evaluated by the correlations between results of the tests and the level of field infection. These were generally positive and significant, for the leaf disc and detached pod test. A variation between mean scores of 5 and 8 in the detached pod test appeared to be related to a 40% difference in field infection with *P. megakarya* in years with medium disease pressure. However, correlations with field resistance were not always significant, suggesting the influence of uncontrolled environmental factors affecting field observations or the results in the screening tests. It is concluded that the leaf disc and detached pod tests, if applied under standardized conditions, can be of great value to speed up selection for Ppr resistance.

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### 1. Introduction

Increase of cocoa production in Cameroon has been very low over several decades. This stagnation is partly due to high disease and pest incidence and the lack of improved resistant and high yielding varieties. Field performance of the planting material used by the farmers appears unsatisfactory. Traditional varieties had shown often low productivity, and Full sib progenies proposed by the local research stations revealed low vigour and high susceptibility to *Phytophthora* pod rot (Ppr). Progress obtained until the

1970's in breeding for *Phytophthora* pod rot resistance has been relatively limited (Efombagn, 2008, 149 p.).

Before 1995, significant genetic variation for Ppr infection on mature pods has been observed in cocoa breeding trials in different countries (Wood and Lass, 1985, 620 p.; Paulin et al., 1994), including Cameroon (Blaha and Lotodé, 1977). However, a major difficulty in selecting resistant varieties was the lack of reliable early screening tests, the lack of knowledge on the environmental versus genetic factors determining field resistance and on the stability of resistance (interaction between *Phytophthora* isolates and/or species with cocoa genotypes).

Advances in research (INGENIC, 2000) has helped to overcome some of these obstacles. During the current decade, some international collaborative efforts in cocoa breeding have contributed to the enhancement of cocoa collections through the identification of

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relevant sources of resistance against Ppr and mirid insects among local and introduced clones using recently developed selection approaches and methodologies. For Ppr resistance, these were the tests based on leaf disc inoculation (Nyassé et al., 1995) and detached pod inoculation (Iwaro et al., 2000). In Cameroon, several studies were recently undertaken to evaluate the resistance of the local and introduced cocoa germplasm. Clonal and progeny material were assessed using leaf disc (Nyasse et al., 2002, 2003; Efombagn et al., 2004, 2007) and pod tests (Efombagn, unpubl. data).

Most of the clones screened with leaf and pod tests were simultaneously assessed for their resistance to Ppr in the field (Nyassé, 1997, 133 p.; Efombagn et al., 2004; Ndoumbè, 2002). However, reliability studies were carried out to confirm the validity of those screening tests. Therefore, the objective of this paper is to evaluate the repeatability of these Ppr resistance tests (stability of results between inoculations series and between tests), and their reliability (predictive value) to the field incidence of the disease.

## 2. Materials and methods

### 2.1. Plant material

Table 1 presents all clones and progenies used in different experiments of the study (eight trials in total). Cocoa clones are vegetatively-propagated genotypes either by grafting or rooted cuttings. Cocoa progenies in our study were all full sib families of the first generation. In total, the progenies considered for correlation studies in different experiments include first generation of respectively four full sib progenies introduced earlier from Côte d'Ivoire and 21 full sib progenies locally selected; 80 farm selections (clones) collected in four sites and planted on-station in Nkolbisson (Centre Cameroon); and 20 locally selected clones and 12 introduced clones available in Collections at the Institute of Agricultural Research for Development (IRAD), Nkoemvone Station (Southern Cameroon).

### 2.2. Screening tests and experimental trials

Resistance to *Phytophthora megakarya* in cocoa genotypes was assessed mainly by inoculating leaf discs taken from nursery plants, and pods harvested on trees in field trials.

A moderately aggressive isolate of *P. megakarya* available in the Plant Pathology Laboratory at the IRAD Nkolbisson Centre (central Cameroon), was used in this study. It was isolated in from a cocoa

plantation situated in the Centre region of the country, and it has been maintained in the laboratory by successive transfers on 1.5% pea-based agar medium. To maintain its aggressiveness, the isolate is periodically inoculated onto cocoa pods.

#### 2.2.1. Leaf disc inoculation test

For each trial, three inoculations series (replicate) were carried out during the wet season and the interval between two inoculation series was 30 days. During each replicate, the leaf discs of each clone or individual full sib seedling were placed upside down in 3 wetted plastic trays, with 10 discs/tray. The covered trays were incubated in darkness overnight at approximately 25 °C. Inoculations were carried out the next morning with a 10 ml suspension of *P. megakarya* zoospores calibrated at 300 000 . Symptoms (disease scores) were observed 5 days after inoculation by using a 5-point scale as described by Nyassé et al. (1995).

The screening method used was as described by Nyassé et al. (1995). Four different trials were conducted to analyze the repeatability within and between tests.

**2.2.1.1. Trial 1.** Four full sib progenies (PA150×T79/501, PA150×T60/887, P7×PA150 and P7×T60/887) introduced from Côte d'Ivoire and known to be resistant to *Phytophthora palmivora* in that country were tested at IRAD together with local control clones (SNK64 and SNK413), two "international" control clones (T60/877 and T79/501), known for their relative low susceptibility to *P. megakarya* (Nyassé et al., 2003), and a local seedling progeny (SNK109×T79/501) of unknown level of resistance.

**2.2.1.2. Trial 2.** leaf discs were used to assess average resistance to Ppr of 20 locally created full sib progenies.

**2.2.1.3. Trial 3.** 80 farm accessions of the traditional variety planted in Southern Cameroon (so-called 'German' cocoa by the farmers) were tested. The trees were grafted on-station and nursery leaves were assessed nine months later for their resistance to Ppr.

**2.2.1.4. Trial 4.** Nursery leaves of 32 introduced and locally selected clones were tested in three inoculation rounds.

#### 2.2.2. Detached pod inoculation test

Two trials were carried out during the study to evaluate the resistance according to the method developed by Iwaro et al. (2000). Half the surface of each inoculated pods were sprayed at

**Table 1**  
Clones and progenies of cocoa used in the different experimental trials.

Trial	Type of experiment	Germplasm	Origin	Collection
1	Leaf disc inoculation	PA150×T79/501; PA150×T60/887 P7×PA150; P7×T60/887 SNK64; SNK413; T79/501; T60/877	Côte d'Ivoire Cameroon Ghana	Divo Nkoemvone Nkoemvone
2	Leaf disc inoculation	See Table 1 in Nyassé et al. 2003	–	–
3	Leaf disc inoculation	TAL 1–20; NSI 1–20; NKI 1–20; GRA 1–20	Cameroon	Nkolbisson
4 & 5	Leaf disc inoculation (Trial 4) and Detached pod inoculation (Trial 5)	SNK10; SNK413; SNK600 series: 600; 602; 603; 607; 608; 611; 613; 614; 615; 619; 620; 622; 624; 625; 630; 633 UPA134; T79/501 ICS1; ICS84	Cameroon Ghana Trinidad	Nkoemvone
6	Detached pod inoculation	SNK10; SNK413; UPA134; T79/501 ICS1; ICS84;	Cameroon Ghana Trinidad	Nkoemvone
7	Field observations	SNK600; 602; 607; 608; 613; 614; 615; 619; 620; 622; 624; 625; 630	Cameroon	Nkoemvone
8	Field observations	SNK10; SNK413 UPA134 ICS84	Cameroon Ghana Trinidad	Nkoemvone and Kumba/Barombi-kang

a distance of 30 cm using an atomizer containing a zoospore suspension of the same isolate used with leaf inoculation test. For each of the two trials, three replicates were carried out and ten pods were inoculated during each replicate. After four days of incubation, the inoculated pods were assessed based on the frequency and size of the lesions formed. The severity of infection is rated on an eight-point scale as follows: 1 No symptom, highly resistance to penetration; 2 1–5 localized lesions, resistant; 3 6–15 localized lesions, moderately resistant; 4 = > 15 localized lesions, partially resistant/resistant to spread of lesions alone; 5 1–5 expanding lesions, partially resistant/resistant to penetration alone; 6 6–15 expanding lesions, moderately susceptible, 7 = > 15 expanding lesions, susceptible; 8 coalesced lesions, highly susceptible.

**2.2.2.1. Trial 5.** The objective was to evaluate 16 SNK600 clones and to compare results with field observations. The SNK clones had been selected as they had shown relative low infection levels in the field (Nkoemvone collection, see Table 2).

**2.2.2.2. Trial 6.** Detached pod inoculations were carried out on six clones, with well-known levels of field resistance. These clones were used in a previous genetic study (Nyasse et al., 2002)

### 2.3. Field recordings

Field data on the percentage of Ppr-infected pods over the potential pod production of a cocoa tree were recorded over the year.

#### 2.3.1. Trial 7

The percentage of field infection level of 13 SNK clones was recorded in 1996 and 1997 in a clonal trial located at the NKOEM-VONE collection (Table 2).

#### 2.3.2. Trial 8

The percentage of rotten of four clones was recorded for three years (1999, 2000 and 2001) located on-station.

### 2.4. Statistical analysis

Analysis of variance (ANOVA) of the different clones and progenies tested in each of the eight trials was performed with SAS (2000). Separations of means were achieved using the Student Newman-Keuls implemented in the SAS Software. In order to assess the repeatability and reliability of detached pod and leaf

tests as well as field observations, correlations have been calculated based on the results of different trials. Spearman (1904) rank correlation analyses were used in all the comparisons done in the study.

## 3. Results

### 3.1. Leaf disc test

In all trials, there was highly significant variation among the average resistance of the clones and seedling progenies and between individual plants within the progenies (where this was tested).

#### 3.1.1. Repeatability between inoculation series

In trial 1, the coefficients of rank correlation (Spearman, 1904) between the three series of inoculations, carried out at different dates, and the overall means of the four full sib progenies were highly significant ( $r$  0.81 to 0.83). The coefficients of rank correlation between the genotype means of the individual inoculation series were slightly lower, but still significant ( $r$  0.49 to 0.67). This suggests good repeatability over time for the means of full sib progenies. An interesting result from the trial was that the progenies from Côte d'Ivoire were in average more resistant to *P. megakarya* than the control clones and the progeny produced in Cameroon. This shows the potential of the progenies from Côte d'Ivoire for controlling Ppr in Cameroon.

In trial 2, the rank correlation coefficients for the mean scores of the progenies for three replicates (inoculation series) were highly significant ( $r$  0.81 to 0.83). Afterwards, individual seedlings of eight of the more resistant progenies were evaluated in three replications. The rank correlation coefficients for the mean scores of all individual plants in each of the three series of inoculations with the overall mean scores of the same plants were also significant ( $r$  0.54 to 0.80). Between the individual series,  $r$  values are still positive and significant varying from 0.76 to 0.88.

In trial 3, after three inoculation series, coefficients of rank correlation between each series and their overall means were all significant ( $r$  0.73–0.98). However, the coefficients of correlations among the three series varied considerably (0.24–0.96), but were still statistically significant ( $P$  0.03 to 0.0001).

In trial 4, rank correlations coefficients between clone means of individual series and their overall means were highly significant ( $r$  0.75 to 0.90). The rank correlations among inoculation series were lower ( $r$  0.36–0.66), though still significant ( $P$  0.02 to 0.0001).

#### 3.1.2. Correlations between observations carried out at 5 and 7 days after inoculation

In trials 1 and 2 (see above), coefficients of rank correlation for observations 5 and 7 days after inoculation were identical and highly significant ( $r$  0.91). The coefficients of correlation between scores at 5 and 7 days were also highly significant, varying from 0.58 to 0.98 in trial 3 and from 0.88 to 0.98 in trial 4. These results suggest that in the leaf disc test it is sufficient to carry out scoring of Ppr symptoms only once, either at 5, 6 or 7 days after inoculation.

### 3.2. Detached pod test

#### 3.2.1. Repeatability of test results

Table 2 presents the results obtained with the detached pod test after three inoculation series (replicates) of 16 SNK600 clones. Ten pods per clone were used in each replicate and symptoms were observed four days after the inoculations as suggested by the protocol of the pod inoculation test. Average scores of these clones varied from 3.3 to 6.8, although possibly highly resistant

**Table 2**

Evaluation with detached pod inoculations and leaf disc test of 16 SNK600 clones of cocoa selected for field resistance to *Phytophthora* pod rot.

SNK clone number	Replicate 1 (10 pods)	Replicate 2 (10 pods)	Replicate 3 (10 pods)	Means of Pod test	Leaf disc (means)
615	2.2	3.5	4.3	3.3	2.81
614	5.8	1.5	4.3	3.8	2.0
619	4.8	4.0	3.3	4.0	2.59
611	3.3	4.5	5.3	4.3	2.9
613	4.8	4.5	5.0	4.8	2.73
603	3.8	4.8	5.8	4.8	2.81
630	4.3	5.0	5.3	4.8	2.31
608	4.3	4.0	6.3	4.8	3.88
620	4.0	5.5	5.5	5.0	2.77
622	5.0	4.0	6.0	5.0	3.00
625	6.8	4.0	5.8	5.5	2.50
602	5.0	5.8	6.0	5.6	3.19
624	6.5	5.5	5.8	5.9	2.73
600	6.0	5.8	6.3	6.0	3.09
633	6.0	6.3	6.3	6.2	3.03
607	6.8	6.8	6.8	6.8	3.69

(scores 1 and 2) and highly susceptible (scores 7 and 8) genotypes were not represented among the clones tested. Correlations were positive and significant between each of the three replicates and their overall mean ( $r$  0.43–0.63, and  $P$  0.02 to 0.008). The means of the clones for each of the three inoculation series were also positively correlated to each other, with  $r$  0.55–0.65 ( $P$  0.02–0.001).

Table 3 presents the mean disease score of six clones after three replicates of pod inoculations. Ten pods were used in each replicate and symptoms were observed after four days. The replicate means were positively correlated to the overall means with  $r$  varying from 0.87 to 0.90 ( $P$  0.02 to 0.004). Correlations between replicates were also positive varying from 0.60 to 0.89 ( $P$  0.04 to 0.01).

### 3.3. Correlations between leaf disc and detached pod tests

Correlation between the leaf disc and the detached pod test results could be analyzed in the trials presented above that included locally selected and introduced clones. Mean pod test scores of all the 16 SNK600 clones presented in Table 2 were significantly correlated with mean scores in the leaf disc test ( $r = 0.78$ ,  $P$  0.02). A comparison is made for four parental clones used that were screened with the leaf disc and pod inoculation tests (Table 3). All clones were similarly ranked in both tests.

### 3.4. Comparison between results of screening tests and field observations

#### 3.4.1. Comparison of the leaf disc test with field results

In trial 1, the comparison of the leaf disc test results for two international control clones (T79/501 and T60/877) and for the four progenies introduced from Côte d'Ivoire showed a good correlation with field results obtained with the clones involved as parents in the four crosses in Côte d'Ivoire (P7, PA150, T79/501 and T60/877).

Leaf disc test results obtained in trial 4, using nursery leaves from 12 SNK600 clones (cloned  $F_1$  full sib progenies locally selected for resistance to Ppr), were compared to field infection in 1996 and 1997 of the same clones (Table 4) through weekly observations. It should be noted that the field conditions (tree size, overhead shade) were highly variable and the number of trees generally low in the Nkoemvone collection where the observations were made. The rank correlation between the leaf disc results and the 1997 field data were significant with  $r$  0.86 ( $P$  0.02). However, the correlation with the 1996 field data was not significant. The same was observed with the detached pod test (see below), therefore it can be inferred that the 1996 field data were possibly less reliable than the 1997 field data.

In another trial, ten parental clones from the seed gardens used to create progenies released to the farmers were screened with the leaf disc test in three inoculation series using leaves for plant in nurseries. Field Ppr incidence of these clones was also assessed in 1996 and 1997 through weekly observations in the Nkoemvone. Correlation between the leaf disc test and field results was significant in 1997, with  $r$  0.86 ( $P$  0.02). However, in 1997, the correlation was positive ( $r$  0.17) and not significant ( $P$  0.7), showing the highly

**Table 3**

Trial 5: Resistance of clones established in Kumba (Barombi-Kang station of IRAD) assessed with the detached pod test.

Clone	Replicate 1	Replicate 2	Replicate 3	Mean
UPA134	5.3b	4.9 ab	4.5a	4.9a
ICS1	4.3a	4.5a	6.0c	4.9a
T79/501	5.8b	5.2b	4.8 ab	5.3b
SNK413	5.5b	6.2c	6.0c	5.9c
ICS84	6.8c	6.0c	5.7c	6.2c
SNK10	7.8d	8.0d	8.0d	7.9d

**Table 4**

Trial 6: Percentage of field infection level of 13 SNK clones observed in 1996 and 1997, and mean disease scores obtained with the detached pod test and with the leaf disc test.

Clone	Pod rot 1996 (%)	Pod rot 1997 (%)	Pod test	Leaf disc test
SNK615	22	6	3.33	2.81
SNK614	18	2	3.83	2.00
SNK619	9	9	4.0	2.59
SNK613	50	5	4.75	2.73
SNK608	7	10	4.83	3.88
SNK630	49	5	4.83	2.31
SNK620	7	2	5.0	2.77
SNK622	14	12	5.0	3.00
SNK625	8	1	5.5	2.50
SNK602	4	17	5.58	3.19
SNK624	20	15	5.91	2.73
SNK600	15	21	6.0	3.09
SNK607	15	15	6.75	3.69

variable field conditions that made the leaf test and field observations less reliable.

#### 3.4.2. Correlation of the detached pod test and field results

Comparisons from two sets of data could be made to verify the relationship between the detached pod test and the incidence of the Ppr disease in the field. Firstly, the field infection level of 13 SNK600 clones, observed for two years (1996 and 1997) at the IRAD station in Nkoemvone, was compared with results of the detached pod test applied to the same clones (see Table 2). Correlation between the field data for 1997 and the detached pod test results (Table 4) was significant ( $r$  0.59,  $P$  0.03). In contrast, a negative correlation ( $r = -0.16$ ) was obtained between the field data for 1996 and the detached pod test results.

Secondly, field Ppr incidence of four parental clones from the diallel mating design observed in 1999, 2000 and 2001 (Efombagn et al., 2004) was compared to the average results of the detached pod test applied to the same clones (Table 5). Correlations and their probabilities are presented in Table 6. They showed a high level of reliability between field incidence of the disease and the detached pod test. Repeatability of the field performance of all the four clones was good over the years of observations.

## 4. Discussion and conclusion

When the four progenies from Côte d'Ivoire were compared with their parental clones, the highest resistance in the leaf disc test was observed for the cross between the two clones (P7 and PA150) with highest field resistance in Côte d'Ivoire (Nyassé et al., 2003). These comparisons between Côte d'Ivoire and Cameroon suggest reliability of the leaf disc test, even if the *Phytophthora* species present in the two countries are different.

Earlier studies in Cameroon have shown good correlation between leaf disc test results and field results for six parental clones of a diallel mating design planted in Barombi-Kang in 1974 (Nyasse et al., 2002). Correlations between the leaf disc test and field data could be therefore calculated for trial 1 and trial 4. Levels of resistance of the six parental clones of the diallel crossing design, as identified in earlier

**Table 5**

Trial 8: Percentage of field *Phytophthora* pod rot infection, observed for three years, and mean disease scores from the detached pod test obtained with four parental clones of a diallel mating design.

Clone	Pod rot 1999 (%)	Pod rot 2000 (%)	Pod rot 2001 (%)	Pod test (mean)
SNK10	52.7c	69.1d	93.4b	7.9c
ICS84	26.3b	53.5c	80.2a	6.2b
SNK413	25.1b	45.4b	79.6a	5.9b
UPA134	13.2a	19.5a	79.7a	4.9a

**Table 6**

Trial 8: Spearman's rank correlation of four parental clones of the diallel mating design, based on percentage of rotten pods for three years (1999, 2000 and 2001) and mean disease scores from the detached pod test.

Methods compared	Field 1999 (%Ppr)	Field 2000 (%Ppr)	Field 2001 (%Ppr)	Pod test (mean scores)
Field 1999	–	0.91 <sup>a</sup> (0.08) <sup>b</sup>	0.95 (0.04)	0.99 (0.007)
Field 2000		–	0.76 (0.23)	0.95 (0.04)
Field 2001			–	0.92 (0.07)
Pod test				

<sup>a</sup> coefficient of rank correlation.

<sup>b</sup> review: probability at 5% level.

studies with inoculation of attached wounded pods Nyassé et al. (1995) and leaf discs (Nyasse et al., 2002) by means of leaf disc inoculations, were confirmed with the detached pod test used in the present study. A comparison made for four of the six parental clones used in the diallel mating design showed that these clones were similarly ranked in both leaf and pod tests. Earlier studies (Nyassé et al., 1995; Nyassé, 1997, 133 p.) had already shown similar ranking between leaf disc and attached pod test results for all six parental clones (SNK10, SNK413, ICS84, ICS95, IMC67 and UPA134).

In the repeatability between inoculation series, results indicate that genotypes tested in individual inoculation series are highly correlated with the means of the all inoculation series. However, the correlations among individual series are lower and vary more substantially. This may be ascribed to variations in factors that may affect the resistance of cocoa leaves, such as in leaf development stage and light intensity (Tahi, 2003, 133 p.). From our results, we estimate that a minimum of two inoculation series should be carried out to assess average resistance of clones or of seedling progenies, and at least three inoculation series need to be done to estimate resistance of individual seedlings. However, if the correlations among series are low, more inoculation series will need to be carried out to obtain a reliable estimate of the resistance.

The level of repeatability of the test results influences the number of replicates that have to be carried out in order to obtain reliable results. In our studies, progeny or clone means were significantly correlated between replicates for both test methods. From our experience, two replicates are considered enough to estimate the average susceptibility of clones or seedling progenies when the correlation between the replicates is high. However, for evaluation of individual plants within progenies with the leaf disc test, the correlations among replicates for the same individual plant were low and less significant. This can be ascribed to the relatively low number of leaf discs tested for each individual seedling in each replicate and also because leaves of individual plants are not always in the right development stage. Therefore we estimate that at least three replicates are required for evaluation of individual seedlings. In the case that the correlations between inoculation series are low, this would mean that some of the factors that affect the reactions of the tissue in the tests have not been sufficiently uniform (e.g. leaf development stage and light intensity, see Tahi, 2003., 133 p.). In such cases, an effort should be made to harvest leaves at a uniform stage and light exposure, and to conduct the experiment in standardized conditions both for evaluation of average resistance of progenies or clones and for individual seedlings, until correlations between replicates become significant.

Sometimes we have observed that the result of one replicate does not correlate well with the overall means, nor with the other replicates. It may then be wise to eliminate the results of such a replicate from the analyses. This has happened in the trial 1 (see above under leaf disc test results). Leaves of the local control progeny SNK109×T79/501 were obtained in the first inoculation

round from a different, more shaded, nursery than the leaves of the other genotypes. The results of the first inoculation round showed higher resistance of this progeny than that of the resistant progenies introduced from Côte d'Ivoire. The seedlings of the SNK109×T79/501 progeny were then placed in the same nursery as all the other varieties. The following inoculation series, carried out two months later, showed that the introduced progenies were much more resistant than the local progeny SNK109×T79/501. The results of the first inoculation round were discarded because the relatively higher resistance of the SNK109×T79/501 progeny was likely induced by the higher shade levels in the nursery where it was growing when the first replicate was carried out.

Highly significant effects of full sib progenies, clones and of plants within progenies for resistance to *P. megakarya* were detected with the leaf disc and detached pod test. Such large genetic variation agrees with results of other authors, e.g. Blaha and Lotodé (1977), Nyassé et al. (1994) and Iwaro et al. (1997), and can apparently be correlated with field results (this article, Tahi et al., 2000; Iwaro et al., 2005). For example, a variation of 5–8 on the 8-point assessment scale used in the detached pod test, may mean a difference of 20–60% infection in the field with *P. megakarya* (Table 5) in years with average disease incidence (1999 and 2000). Tahi et al. (2000) have shown that a 1 point scale difference in the leaf disc test may mean a 10% difference of field infection in the case of *P. palmivora* in Côte d'Ivoire. Therefore, efficient and rapid selection of cocoa genotypes with the leaf disc and detached pod tests seem feasible, at least when the conditions under which these tests are carried out are sufficiently standardized.

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