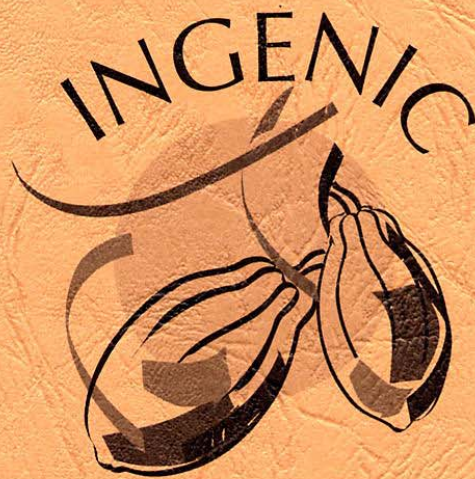


**Proceedings of the
International Workshop
on the Contribution
of Disease Resistance
to Cocoa Variety
Improvement**



**24th-26th November, 1996
Salvador, Bahia, Brazil**

PREFACE

Following the Workshop on Cocoa Breeding Strategies, held in Kuala Lumpur in 1994, INGENIC has taken the endeavour to organize its second International Workshop on the "Contribution of Disease Resistance to Cocoa Variety Improvement" at the occasion of the 12th International Cocoa Conference held in Salvador, Ba, Brazil in November 1996.

Cocoa is affected by several serious diseases. Although useful genetic variation has been identified in relation to most pathogens breeding success for resistance has been limited. Historic restraints on progress include lack of reliable screening methods, incomplete knowledge of the pathogen and of its relationship with the host, as well as lack of a coherent framework for cocoa breeding in dealing with quantitative disease resistance. Other factors than intrinsic resistance alone, such as escape and tree architecture, will influence disease severity in the field. A multidisciplinary approach to cocoa disease problems is required.

The Workshop brought together 88 participants from 21 different countries. Most were breeders and pathologists but also many with more general interest were present. A total of 22 papers were presented and discussed focussing on the five major cocoa diseases: *Phytophthora* pod rot and stem canker, witches' broom, vascular streak die-back, moniliasis and cocoa swollen shoot. The contents of the Proceedings are organized according to these diseases and to the continents where the research was carried out. Questions and answers were added at the end of each article. The authors of papers were requested to review the research results in their area of expertise and present recent research results. The Workshop organizers were glad to receive four additional papers for the Proceedings of scientists that were unable to attend the meeting.

Two external reviews have been commissioned for the Workshop, one on "Phytopathological Aspects of Disease Resistance and Resistance Breeding in Cocoa" and one on "Strategies of Varietal Improvement in Cocoa with Emphasis on Durable Resistance". These were carried out by two scientists with large international experience: Dr. J.C. Zadoks and Dr. H.A.M. van der Vossen. Both have delivered a summary of their findings during the Workshop and the complete reviews have been published by INGENIC in 1997.

INGENIC is now engaged in organizing its third Workshop on the "Potential of Biotechnology in Cocoa Breeding". We hope that the continuing support of the cocoa industry and of other organizations will make that event as successful as the first two Workshops organized by INGENIC.

Frances Bekele
Michelle End
Albertus Eskes
Editors

WORKSHOP CONCLUSIONS AND RECOMMENDATIONS

Economic losses

- There is a need to collect more reliable data on real losses incurred due to cocoa diseases and pests. Such information would guide decision makers and researchers in their search for more efficient methods to control these important production constraints.

Phytopathological aspects related to resistance breeding

- The response of cocoa to its pathogens includes primarily partial, polygenic resistance; it can be measured and exploited by breeders using current techniques including "Components Analysis".
- Early tests for resistance to cocoa diseases have often shown low representativeness, unproven predictiveness and unspecified differential capacity. Nonetheless, the use of such tests, possibly combined with molecular analyses, is imperative to ameliorate progress in resistance breeding.
- International consensus on test protocols and on pre-breeding strategies is required and INGENIC should facilitate discussions leading to such consensus.
- Due to the high variability of pathogens, the use of more than one resistance source in the development of new commercial varieties is recommended.

Information on resistance levels observed in the field and in resistance tests should be made available through the International Cocoa Germplasm Database.

Resistance to *Phytophthora* pod rot

- Resistance evaluation in West Africa, Latin America, the Caribbean and Asia has resulted in the identification of promising clones with increased resistance and/or escape to the disease. In Brazil, some clones were identified with resistance to more than one *Phytophthora* species.
- The degree of field attack of individual trees is influenced not only by their intrinsic resistance, but also by the level of attack of neighbouring trees, by pod load and by escape phenomena.
- Results from Cameroon, Trinidad and Côte d'Ivoire indicate that the leaf inoculation test is promising as an early screening method for identification of resistance of clones or progenies. Correlations with field resistance were established in Côte d'Ivoire, Cameroon and Trinidad by applying standardised test procedures. More research is required to identify the influence of environment and leaf age on test results.
- Ranking of the general combining ability of a number of genotypes for field disease incidence in Cameroon, Togo and Côte d'Ivoire suggests that field reactions are consistent between countries, despite the different *Phytophthora* species involved. This finding is in line with absence of strong interactions between fungal isolates and cocoa genotypes observed in leaf inoculation tests.
- In Trinidad, a rapid resistance evaluation method was developed involving spray inoculation of detached pods. This test seems promising for application in a pre-breeding programme, such as that already initiated by CRU.
- Test methods differ between countries. More data are being collected in laboratories than in the field and should be compared with field results. Standardization is important to confirm the representativeness of different resistance tests and their use in international collaborative studies.
- Results from Costa Rica and Côte d'Ivoire indicate that significant links between resistance to black pod and molecular markers can be established. QTL studies are being continued in collaborative research programmes.

Resistance to witches' broom disease

- Resistance reactions, evaluated by broom growth, broom death and basidiocarp production can be used to identify useful selections in collections. Isolates differed greatly in aggressiveness, but ranking order remained the same indicating that resistance against one fungal isolate might also be effective in relation to other isolates.
- It is recommended to continue the work related to challenging of promising cocoa genotypes with different fungal isolates outside cocoa-producing countries.
- The Workshop stressed the need for further studies on the reliability of early screening tests for witches' broom disease that are adapted to the breeders' needs of rapid evaluation of clones and progenies. Screening for resistance using cocoa seedlings, as practised in Brazil and Ecuador, has shown a correlation with field resistance and permitted the identification of promising new materials. Further work on alternative methods for identification of individual plant resistance and of clones is to be encouraged.
- Resistance evaluations of collections in Brazil revealed higher resistance in Upper Amazon material than in Lower Amazon material. Other sources of resistance than the well-known Scavina clones were identified in collections in Brazil as well as other countries (Peru, Trinidad, Ecuador). Furthermore, more resistant material was identified in Ecuador in a national survey carried out in farmers fields. These reports suggest that breeders can rely on several different sources of resistance to this disease.
- International collaboration is needed to exchange different sources of resistance, so as to facilitate the accumulation of resistance genes.

Resistance to Vascular Streak Dieback (VSD)

- The *in vitro* dual culture laboratory method was found reliable and could be used for rapid screening of clones or individual trees within progenies as well as for research into the host-pathogen interaction and their application by cocoa breeders.
- Inheritance studies indicated that resistance to VSD is heritable, polygenic and additive. Accumulation of VSD resistance genes is emphasized, together with resistance to *Phytophthora* pod rot.
- International collaboration is required for exchange of material, standardization of resistance test methods and their application in breeding programmes.

Other diseases

- Exchange of clones with resistance to *Moniliophthora* is recommended along with implementation of tests under field conditions. Recent evaluation of collections in Peru indicates the great severity of this disease, but variation in disease incidence between entries was observed. More attention is urgently needed to further develop resistance tests and find additional sources of resistance to this spreading disease.
- Mutation breeding appears to have promise in creating material with resistance to Cocoa Swollen Shoot Virus (CSSV) as well as with variation for other useful traits.
- Resistance to *Ceratocystis* was identified in Venezuela, and this has been incorporated into commercial varieties.

Breeding

- Advances in cocoa breeding are best achieved by (reciprocal) recurrent selection schemes, such as those adopted recently in a number of countries, as such methods can take advantage of the predominantly additive gene action observed for most selection traits in cocoa, and will increase chances of detecting transgressive types. Resistance breeding is to be integrated into such programmes that should simultaneously take into consideration other selection criteria such as yield, bean size, uniform plant type and quality.
- Quick progress can be obtained by fixation of interesting genotypes by clonal selection. Improved methods of vegetative propagation, including micropropagation, have therefore a role to play in the rapid distribution of clones resistant to destructive cocoa diseases.

- Recombination of resistance genes of different origins is expected to allow quick selection progress as it is likely that resistance genes with relatively large effects on partial resistance can be found and efficiently accumulated.
- Good field data obtained under local conditions are the best basis for the start of any breeding effort for increased resistance, but pre-selection tests are essential in obtaining quick progress.
- Consideration should be given to re-designing the cocoa tree architecture in order to not only improve photosynthetic efficiency and harvest index, but, concurrently, to increase the effectiveness of available partial resistance to cocoa diseases.
- Such programmes need breeders who combine expertise in genetics with general knowledge in agronomy and crop protection. In addition, effective team work involving pathologists, entomologists etc., competent field staff for excellent field trial execution, and last but not least, adequate funding are essential.
- Global projects related to germplasm utilization and conservation deserve international support from producer and consumer agencies. Any pre-breeding programme at germplasm centres should be endorsed by national cocoa breeders, who are in the best position to decide on the selection criteria and material to be used in such a programme.

CONTENTS

Preface	7
Welcoming Addresses	9
Workshop Conclusions and Recommendations	13
External Reviews	
Phytopathological Aspects of Disease Resistance and Resistance Breeding in Cocoa: An External Review <i>J.C. Zadoks</i>	17
Strategies of Variety Improvement in Cocoa with Emphasis on Durable Disease Resistance <i>H.A.M. van der Vossen</i>	23
Resistance to Cocoa Pathogens in the Americas	
Genetic Research on Cocoa Diseases at CATIE (1960-1990) <i>G.A. Enriquez and J.V. Soria</i>	33
Studies on Resistance to Black Pod Disease (<i>Phytophthora palmivora</i> Butler (Butler)) at CATIE <i>W. Phillips-Mora</i>	41
Mejoramiento Genético para la Resistencia a <i>Phytophthora</i> en México <i>O. Lopez-Baez, V.G. Fraire y M.J. Cueto</i>	51
Research on Cacao Resistance to Black Pod Disease in Bahia, Brazil - 1980 to 1995 <i>E.D.M.N. Luz, M.M. Yamada, S.D.V.M. Silva, J.L. Pires, U.V. Lopez, L.R.M. Pinto, W.R. Monteiro, J.L. Bezerra, G.R.P. Melo and M.I.B. Brugnerotto</i>	57
Studies on Black Pod Disease in Trinidad <i>A.D. Iwaro, T.N. Sreenivasan and J.A. Spence</i>	67
Reacciones de Cultivares de Cacao a los Principales Patogenos Presentes en Venezuela <i>L. Capriles de Reyes</i>	75
Host-Pathogen Interactions in Witches' Broom Disease of Cocoa <i>B.E.J. Wheeler</i>	83
Cocoa Breeding for Witches' Broom Resistance at CEPEC, Bahia, Brazil <i>J.L. Pires, W.R. Monteiro, E.D.M.N. Luz, S.D.V.M. Silva, L.R.M. Pinto, A. Figueira, K.P. Gramacho, U.V. Lopes, P.S. Beviláquia de Albuquerque, M.M. Yamada, D.E. Ahnert and M.I.B. Brugnerotto</i>	91
A Contribuição das Pesquisas na Amazônia Brasileira para Resistência do Cacaueiro às Doenças <i>S.E. Abud Fonseca, E. Francisco Neto, P. S. Beviláquia de Albuquerque e C.M.V.C. de Almeida</i>	103
Assessing Resistance to <i>Crinipellis pernicios</i> , the Causal Agent of Witches' Broom Disease of <i>Theobroma cacao</i> L., Using Cocoa Sap <i>C. Novais Bastos</i>	107

Studies at CATIE on Moniliasis Resistance (<i>Moniliophthora roreri</i> (Cif.&Par.) Evans <i>et al.</i>) W. Phillips-Mora	111
Monilia Pod Rot Resistance in Ecuador C. Suárez-Capello	119
Recolección y Selección de Cacao Nacional con Resistencia a Enfermedades en Ecuador J. Quiroz , C. Suárez y B. Decazy	123
Mejoramiento Genético para el Control de Enfermedades del Cacao en el Perú E. Arévalo, L. García, U. Krauss, R. Ríos, L. Zúñiga y J. Adriazola	127
Resistance to cocoa pathogens in Africa	
Pathology and Breeding for Resistance to Black Pod in Côte d'Ivoire I.B. Kebé, J.A.K. N'Goran, G. M. Tahi, D. Paulin, D. Clément y A.B. Eskes	135
Update on the Work on Selection of Cocoa for Resistance to <i>Phytophthora</i> spp. in Cameroon S. Nyassé, L. Bidzanga Nomo, G. Blaha, M.H. Flament, D. Berry, C. Cilas, A.B. Eskes and D.Despréaux	141
The Black Pod Resistance Breeding Programme in Ghana A. Abdul-Karimu, Y. Adu-Ampomah, J.D. Amponsah and I.Y. Opoku	149
The Search for <i>Phytophthora</i> Pod Rot Resistance and Escape at the Cocoa Research Institute of Nigeria during the 1960s H. Toxopeus	159
A Review of Breeding Work on Disease Resistance of Cocoa in Nigeria K. Badaru, E.B. Esan and J.A. Williams	167
Breeding for Resistance to the Cocoa Swollen Shoot Virus in Ghana Y. Adu-Ampomah, B. Adomako, G.K. Owusu and L.A.A Ollennu	173
Resistance to cocoa pathogens in Asia	
Disease Resistance Studies and Breeding in Papua New Guinea Y. Efron, M. Faure, J. Saul and G. Blaha	181
Breeding for Resistance to Diseases in Malaysia with Special Reference to Vascular Streak Dieback Disease K. Lamin, T.C. Chong, C.L. Bong , M.T. Lee and P.K. Phua	189
Resistance to Vascular Streak Dieback: Research and Applications in Breeding and Disease Management C.L. Bong and M.T. Lee	195
Disease Resistance Studies and Breeding of Cocoa in Indonesia A. Iswanto, H. Winarno, Sri-Sukanto and S. Mawardi	205
Workshop programme	213
List of participants	215