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Proceedings of the

First Regional Workshop On Coffee Berry Disease

19 - 24 July, 1982, Addis Ababa, Ethiopia

Organized by

THE ASSOCIATION FOR THE ADVANCEMENT OF AGRICULTURAL SCIENCES IN AFRICA (AAASA)

THE MINISTRY OF COFFEE AND TEA DEVELOPMENT OF SOCIALIST ETHIOPIA

THE INSTITUTE OF AGRICULTURAL RESEARCH OF SOCIALIST ETHIOPIA

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FOREWORD

It is a special pleasure to present the proceedings of the first regional workshop on "Coffee Berry Disease".

Due to the fact that Mr. Asrat Wendem-Agenehu (The Editor of AAASA Publications) resigned just after ending the workshop, a great delay of publication resulted.

However, through the very cooperative spirit of the Delegation of the **European Economic Comission (EEC)** in Addis Ababa, we could overcome these difficulties and bring the proceedings out. It is my duty and pleasure to stress this point and to thank the **delegation,** especially, Mr. Wallner and Mr. Bosuner, for all efforts done starting with the preparation for this workshop. I, Personally, felt this spirit as I had to intervene during the process and take the responsibility of preparing and printing the proceedings.

One of other reasons for delay is that AAASA had to face some administrative difficulties just started middle 1982. Since problems are now settled, we hope that activities will continue to run smoothly as it was.

The completion of this activity on Coffee Berry Disease by publishing the proceedings is of special interest to AAASA. This was the first activity that AAASA accomplished with sponsorship of EEC. We hope, in spite of all previous difficulties encountered with this excercise, that in the future cooperation with EEC will continue within it's scope of agricultural activities in different parts in Africa.

I sincerely have the feeling that these proceedings still contain valid and important information, which are of interest to those who are producing coffee in Africa or trying through their research efforts to improve it's production.

AAASA wishes to thank the Ministry of Coffee & Tea Development of Socialist Ethiopia and The Institute of Agricultural Research of Socialist Ethiopia for their cooperation in organizing the Workshop and their continuous support and interest.

Thanks are, also, due to Mrs. Hoda M. Kamel, National Information and Documentation Centre (NIDOC), Cairo, for proof reading and Mr. Abdel Wahab A. Abdel-Maguid, AAASA Editorial Secretary, for follow up and supervising typing and printing. I wish, also, to thank AAASA Secretariat Staff in Addis Ababa for their continuous assistance.

Mohamed M. El-Fouly

Hon. Secretary General
and acting
Administrative Secretary General

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- Welcome Addresses & Theme Address
- Resolutions & Recommendations
- List of Participants

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STATEMENT AND WELCOME ADDRESS

By

H.E. Mr. Yehwalashet Girma

Minister of Coffee and Tea Development

Provisional Military Government of Socialist Ethiopia

Mr. Chairman,
distinguished Delegates,
Comrades.

On behalf of the Government of Socialist Ethiopia, the Ministry of Coffee and Tea Development, the Organizing Committee of the CBD Workshop and myself I would like to extend our warm welcome to Socialist Ethiopia to those that have come from other countries and to you all the participants of this CBD Workshop. I hope your stay here would be pleasant and worthwhile..

It gives me and my Ministry particular pleasure to host this CBD Workshop, which is one of the very few technical forums organized in Africa in coffee matters.

Mr. Chairman

As it is known to all of us, agriculture is the backbone of the economy of most of African countries including those represented by their distinguished delegates in this workshop. Agriculture is also a way of life for the majority of our peoples.

The diversified climate, soils and vegetation have enabled our countries to produce a variety of crops for home consumption as well as for export. For many of us, coffee is one of the principal agricultural export commodities.

According to a report published by the Secretariat of the General Agreement on Tariffs and Trade, Coffee's contribution in the form of foreign exchange to some of our countries is the following: for Kenya 26%, Uganda 63%, Burundi 9[illegible]%, Ethiopia 68% and Ivory Coast 31%.

For Ethiopia, coffee not only accounts for over 60% of the total foreign exchange earnings but also provides directly or indirectly for the livelihood of about one-fourth of the population.

Coffee plays such a vital role in the economy of Ethiopia that in recent years it has been given a very high priority in the national development plan. Because of its importance, the Revolutionary Government has up-graded the status of the Coffee Development and Marketing Authority to the Ministry of Coffee and Tea Development. The Ministry is responsible for the Development and Marketing of Coffee and Tea on the country.

Mr. Chairman,

It is true that coffee is very important to the economy of many African countries. It is also true that Africa has given to the World all the commercially known coffee species : Arabica, Robusta and Liberica. The quantity of coffee Liberica's being insignificant (Less than 2%), the two major types of coffee produced in Africa are Robusta and Arabica.

Although Africa was the original home of coffee, it did not have a significant place in the international Coffee trade of this commodity until the 1950s. As statistics show, the contribution of Africa to world coffee production was only 1.3% in the years 1909 to 1914. Then went up to 7.3% in the years 1924 to 1929, having reached about 22% in the 1950s. With the gradual increment of production, currently the continent's share is estimated to be about 25%. Given the availability of large areas in Africa with favourable climate and soils for coffee production, I hope as we improve our methods of production and find solutions to the problems which prevail at production level, the continent's share in the trade will increase further.

Although coffee is an important export commodity in our countries, we know that it has several problems : lack of proper know-how specially at the small farmers level who are the main producers, lack of adequate infrastructures like roads and warehouse, transportation facilities, the rising costs of farm inputs like machineries and agricultural chemicals, drought or excess of rains now and then, pests and diseases etc. These are some of the major constraints which systematically require different and scientific approaches for their solutions. For many of these problems strengthened research programmes and regional cooperation will be of vital importance.

CBD, the subject of this important Workshop is one major problem in the African countries which produce coffee arabica; specially in Kenya, Tanzania and Ethiopia.

As you all know CBD was detected for the first time in Kenya in 1922. By the 1960s it was found in Tanzania, Angola, Uganda and Cameroun, lastly, it was detected in Ethiopia in 1971. Among these countries Kenya, Tanzania and Ethiopia, the main producers of Arabica coffee, are also the most affected by the disease. In these countries, in spite of the control measures being taken, there are times when in humid areas, the loss due to the disease becomes considerable and very serious, reaching the level of 50% or more.

In Ethiopia, since its outbreak in 1971, the spread of the disease has been very fast than has been the case in other countries. It reached most or our coffee areas in a period of less than 8 years causing a considerable loss in many places. Currently, the country's average annual coffee production loss due to CBD is estimated to be 13%. Because of this threatening nature of CBD to our coffee industry, a quick decision was made by the Ethiopia Government to start a research programme on both short and long term control measures.

After chemical trials were conducted by the coffee research station and large adaptation trials by the field staff of the Ministry between 1972 and 1974, chemical control was taken as in interim control means, and to date we are spraying annually a limited hectareage of between 10,000 to 13,000 ha; in those areas where the disease is considered very serious. Among other things, the traditional nature of many coffee farms in Ethiopia and the high cost of the chemicals have limited the scope of spraying.

Thus, on the one hand, by considering the limitation of large scale chemical spraying under the Ethiopian coffee famring conditions, and on the other, by realizing the availability of broad genetic resources of arabica coffee both in the plantation as well as in the forest, a crash research programme was launched in 1973 to find CBD resistant selections in the shortest time possible. As will be explained to you in detail by our experts in the course of this Workshop. The programme so far has been successfull in that many resistant selections have been obtained and are being released to farmers and state coffee farms. Together with these selections, better planting methods and other improved cultural practices are also being introduced as part of our coffee improvement programme.

While the selection programme is still being carried out, a second phase although not fully implemented yet, has been started in a small scale by the coffee Research Station. The main task of this second phase is to carry out breeding programmes in order to obtain coffee cultivars which will be resistant to CBD and to other major diseases, and which will be high yielders and of good quality.

Mr. Chairman,

It is well known that research on CBD and other aspects of coffee has been and is going on in our respective countries, perhaps more in some than in others. However, since we have a common crop, coffee, with the same or similar problems, it would be to our mutual benefit to join our efforts at least at a regional level and share our experience.

As all of you are well aware, there are few opportunities available for our African Scientists to meet and exchange technical findings and informations on our common problems. Even the circulation and distribution of scientific literature within Africa is so limited that very little is known of what is being done in neighbouring countries on similar problems. Although the after effect of centuries of domination and colonization by imperialistic forces have retarded the development of our scientific, human potential and capabilities. Nevertheless, during the last decade of independence we have been able to creat a nucleus of human resources capable of dealing with our basic scientific problems.

This, of course, does not mean that we have achieved our ultimate objectives. However, given the circumstances, we should be able to deal with our basic problems if we consolidate our capabilities and know-hows for solving our common problems.

Although science and technology is said to be free from political influences and is not supposed to be restricted by national boundries, unfortunately because of the commercial and neo-imperialistic objectives and interests of the world at large, science and technology rather than being a mechanism for human welfare have become instruments for domination.

Of course we should not also lose sight of the fact that the world still has some objective scientific individuals who in spite of their countries' prejudices have contributed and are still contributing to human development and welfare. The evidence to this is the presence among us of distinguished scientists from other continents that have done commendable job in our countries.

Hence, the fact remains that with the cooperation of international organizations and of these colleagues, we should be able to create our own scientific capabilities individually and collectively for the welfare of our fellow Africans.

Distinguished Delegates and Comrades

By supporting the Association for Advancement of Agricultural Sciences in Africa and hosting this forum for the exchange of scientific ideas, findings and achievements, we hope we will be able to help to create a tradition for African scientists to meet regularly and consolidate our knowledges and experiences on our common problems such as coffee and other disciplines.

With regards to coffee marketing, African coffee growers have created since 1960 the Inter-African Coffee Organization. Albeit vast problems this Organization has reached a stage of development where it has become a force to reckon with in the world family of coffee producers and consumers. Particularly in the last couple of years IACO has attempted to consolidate its strength to speak in one voice in defending its collective interest. I am pround to say that my country has played a leading role in this important development.

Although coffee is an important export commodity for Africa, more work has been done in breeding, disease control, other cultural practices and in coffee related scientific field in the countries where coffee was introduced than in our continent.

As a result, the rest of the coffee world has advanced more in coffee technologies while ours still remain relatively behind and therefore, our share of the world market has remained lower than it should have been.

Distinguished Delegates,

Today coffee supply in the world market has reached a position of a glut. The coffee producing world today can present to the consumer over 90 million bags of coffee. The demand however has remained around 60 to 70 million bags annually. Of this, the share of Africa is only one third.

When the rest of the world was expanding its coffee production and productivity, we Africans have lagged behind. Hence, today because of over production of coffee in the world, there is a tendency in some circles to restrict us from developing our coffee industry. The irony in this order of things is that it is us Africans that have the largest need for the income from coffee and it is also us that have the largest potential for development and yet we are prevented from developing to a large extent one of our only realised sources of income.

Mr. Chairman

In spite of this difficult situation, however, by improving our productivity and by solving the major problems of our coffee industry mentioned earlier, African would be able to survive in the trade and even increase gradually its share in the international coffee market. But, our individual efforts to modernize our coffee production or to solve the technical problems common to us all, could give, in many cases, better and quicker results by joining our efforts at least at a regional level to share our experience and even to look for possible improvements in our methods of research approaches.

This very important Workshop on Coffee Berry Disease, I would say, is a very good beginning towards a joint approach to regional common problems.

The very presence of delegates from so many countries of the Eastern part of Africa and other eminent scientists from international organizations and institutions outside the continent is in itself a testimony of the awareness in African countries of the need to share experience amongst themselves and with others. It is important that such workshops be prepared periodically in the future to look into other technical problems of coffee production and processing with the participation of scientists from coffee producing countries of Latin America and Asia as well.

In this workshop, you are going to discuss in depth the problems of CBD in our countries, the related research programmes, the results obtained and their application at the farm level. I hope at the end of your deliberations you will come out with useful resolutions and recommendations which will be of great help to our countries and to small holders who earn their livelihood from this commodity.

Finally, may I take this opportunity to thank AAASA for having taken the initiative for organizing the Workshop, European Economic Commission for its financial support, the Institute for Agricultural Research for co-sponsoring it with my Ministry.

Having said this, it is my pleasure and privilege to declare this workshop open and to wish you success in your deliberations.

Thank you.

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WELCOME ADDRESS

By

Worku Taye
General Manager, Institute of Agricultural
Research, Addis Ababa, Ethiopia

The Minister of coffee and Tea Development
and COPWE Central Committee Member,
The Administrative Secretary General of AAASA,
Representatives of International and National Organizations,
African Agricultural Scientists,
Invited Guests and Friends,

It gives me great pleasure to address the participants of this first Inter-African Workshop on Coffee Berry Disease.

First of all, I would like to express my appreciation to the Association for the Advancement of Agricultural Sciences in Africa (AAASA) for the initiative and the successful organization of this Workshop in collaboration with the Ministry of Coffee and Tea Development and the Institute of Agricultural Research. By promoting direct personal contacts and exchange of experience and capabilities among African agricultural scientists, AAASA is best fulfiling its mission of advancing agricultural sciences in Africa.

Distinguished Agricultural Scientists, Ladies and Gentlemen.

It is now universally recognized that agricultural research is the rock foundation for the badly needed increased agricultural production in developing countries. However, various recent surveys of agricultural research services in African countries reveal that the research needs exceed, by far, the research capabilities of each of the countries studied.

At the same time, a radical change of the strength of the national capabilities to meet the felt need for agricultural research does not seem to be in reach in the near future. To be successful, research work requires a good number of well-trained and experienced staff, adequate facilities and sufficient financial outlay.

The lack of such resources is hampering agricultural research in many developing countries, particularly in Africa.

The strategy to overcome this situation is not only to have a critical review to determine high priority resarch programmes and coordinate research activities to avoid duplication of efforts at the national level, but also to coordinate research at regional and sub-regional levels in order to make the most efficient use of the scarce resources available in the region.

Neighbouring countries or these in similar ecologic zones can develop and undertake joint research programmes. Through exchange of information among African countries and by organizing workshops, visits and seminars to exchange capabilities, African countries can make the best use of their research potential.

Distinguished Participants of This Workshop,

It is the realization of this situation that this workshop on Coffee Berry Disease has been organized.

I need not express the role coffee plays in the economy of Ethiopia and in the countries of the scientists reprsented here. This has been brought out sufficiently in the Statement by the Comrade Minister.

In recent years, Coffee Berry disease has remained one of the major constraints of coffee production not only in Ethiopia, but also in other countries of Africa, particularly in East Africa. It is imperative that the researchers in the affected countries come together and exchange experience for a better control of this disease.

When the presence of CBD was ascertained in Ethiopia in 1971, the Institute of Agricultural Research was charged with the responsibility to search for coffee trees resistant to CBD and to study ways and means of controlling the disease.

The IAR then developed short and long-term programmes with the following objectives :

1. The short-term programme was aimed at selecting CBD resistant cultivars to release to formers in the shortest possible time, in view of the rapid spread of the disease.

2. The long-term programme is intended to pursue studies on the genetic background to CBD resistance combined with a comprehensive breeding programme, including other aspects of disease and pest resistance, quality, yield and other desirable agronomic characteristics.

Although the coffee research department of IAR faced an acute shortage of highly trained researchers, the concerted effort to select CBD resistant strains came out successfully in the shortest possible time.

Todate, the IAR has produced over 60 million seeds from more than 15 CBD resistant selections. These have been handed over to the Ministry of Coffee and Tea Development to be planted on thousands of hectares in Ethiopia.

With the limited trained manpower and in view of the severity and urgency of the problem, coffee research work had to be concentrated on the selection of CBD resistant strains and the production of seeds to replace the susceptible trees. We have now come to a point, where we can concentrate on the work relating to the long-term programme, which I have already described above.

Dear Participants of This workshop,

You have come from various agricultural research institutions in our region to exchange experiences, review and discuss research progress in your respective institutions and to draw a strategy to effectively control Coffee Berry Disease, a common threat to our economies.

I hope the pattern of coordination and cooperation evolved in this workshop on Coffee Berry Disease can also be usefully extended to other areas of agricultural research.

Finally, I wish you success in your endeavour to collectively resolve common problems.

Thank you very much

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WELCOME ADDRESS
By
AAASA President

Your Excellency, the Minister of Coffee and Tea Development,
Excellencies,
distinguished Scientists,
Ladies and Gentlemen,

The Association for the Advancement of Agricultural Sciences in Africa has, once again, taken another opportunity - this time at its headquarters here in Addis Ababa - to organize its first regional workshop on coffee berry disease (CBD). It is thus with great pleasure that I welcome you all on behalf of the President, the Executive Committee and all the more than one thousand members of AAASA.

The workshop is co-sponsored by the Ministry of Coffee and Tea Development and the Institute of Agricultural Research, both of socialist Ethiopia. The funding was possible through the support of the European Economic communities (EEC).

Our special thanks and appreciation go to H. E. Comrade Yehualashet Girma, Minister of Coffee and Tea Development and Member of the Central Committee of COPWE for kindly accepting to officially open this workshop and for the close cooperation which

AAASA has received from the staff of this Ministry. I would like also to extend our thanks to Ato Taye Worku, The General Manager of the Institute of Agricultural Research of Socialist Ethiopia for his assistance and the feedback obtained from the scientists of the Institute and for the excellent facilities which are being placed at the disposal of delegates during the workshop.

Our thanks also go to the EEC, particularly to the EEC Delegate for Ethiopia, Mr. Johann Wall[illegible] for all the efforts made in releasing funds for the workshop. Finally AAASA again deeply appreciates the excellent conference facilities which have been provided by the Executive Secretary of the Economic Commission for Africa (ECA).

For a problem of common regional interest like Coffee Berry Disease, it was only appropriate that scientists who have been working for so many years in isolation should come together to exchange ideas and make proposals regarding the best ways of solving this important problem. I am happy that this responsibility fell on AAASA.

Since it was founded by eminent African agricultural scientists and politicians in 1968, AAASA's headquarters has remained in Addis Ababa and its branch office in Dakar, Senegal. For the last 14 years, the Association has rendered services to African agriculture through its participation in training programmes, its scientific publications, conferences and workshops as well as consultancies.

The Association is a non-profit making organization and derives its funds from membership and subscription fees, donations and grants from various governments and organizations. These funds, particularly those from external sources, have lately been drastically reduced to the point where the Association can no longer function smoothly. We hope that with the launching of the Lagos Plan of Action in which top priority has been given to agriculture, the OAU and individual African governments, the Inter-African Coffee Organization, the African Development Bank, the EEC, and other similar organizations will assist AAASA to contribute more effectively to the Lagos Plan.

During this workshop, delegates will present brief reports on the state of CBD in their respective countries. This will be followed by technical papers on the organism which causes the disease, how the problem can be more effectively controlled and the economic impact of such measures on the individual farmers as well as at national level. There will be an open dialogue between the research scientists and representatives of the many chemical companies which have been playing a vital role in the control of CBD. The purpose of such a dialogue is to find the safest but most effective chemicals for the African coffee farmer and his environment.

Your Excellencies,
Ladies and Gentlemen,

Ethiopia happens to be not simply the host of this workshop but also the original home of coffee. The workshop will also give the participants the opportunity of seeing some of the coffee in its natural habitat. Finally at the end of the workshop, delegates will draw up resolutions and recommendations which will guide them in their future programmes when they return to their respective countries. The papers presented at this workshop, with a summary of the discussions, resolutions and recommendations, will then be compiled into proceedings and sent to the participants, concerned government authorities and researchers of the participating countries for implementation.

Once more, on behalf of the Executive Committee and the entire membership of AAASA, I wish to thank all of you, Excellencies and Distinguished invitees for honouring our invitation to the opening ceremony of the first regional workshop on Coffee Berry Disease. We wish you a happy stay in Ethiopia.

Thank You

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THEME ADDRESS

By

M. Maxwell

Team Leader, Coffee Improvement Project, Tanzania

Mr. Chairman,

Coffee production is very important to the economies or many countries. Under the LOME Conventions, several ACP coffee producing states have been fortunate enough to receive assistance from the European Economic community either directly, in the form of specific coffee projects, or indirectly through schemes such as STABEX. It is the EEC's appreciation of the importance of coffee which has led to its participation in this workshop.

Pest and disease control in coffee continues to be a major aspect of production both in terms of finance and labour input. World inflation has resulted in production costs escalating but, unfortunately, apears to have had little effect on market values of coffee. Prices of the chemicals required for control of pests and diseases have risen steadily over the years while, coffee prices have at best remained static. Foreign exchange earnings from coffee have, therefore, declined in real terms, creating serious balance of payment problems in producing countries.

In many countries, there is no adequate alternative crop to coffee and it is of paramount importance, therefore, to have effective and economic control of all coffee pests and diseases within the framework of an efficient farming system. This is doubly important in the case of Coffee Berry Disease and those of us who have witnessed the revages of this disease, will be able to vouch for its ability to destroy a crop very quickly and completely. Without doubt, CBD is the main threat to the coffee industry in the countries in which it has no become established. Those countries fortunate enough to have, so far, avoided this disease should not be complacent; CBD is virulent and devastating.

We are grateful to the Association for the Advancement of Agricultural Sciences in Africa for arranging this workshop. The high calibre of participants and the quality of discussion papers presented already seems to guarantee a successful outcome.

It will be important during the discussions over the next few days to ensure that a permanent foundation is established on which all future research and cooperation in respect of CBD control will be built and, hopefully, this workshop will be the beginning of an on-going regional CBD control development programme.

The papers which have been submitted by delegates cover a wide diversity of subjects relating to CBD control. These will form the basis of discussions which will allow participants to exchange their views and experience on the various aspects of CBD incidence.

Major considerations should include cooperation in the planning and evaluation of plant breeding programmes since resistance or immunity to CBD will possibly be the ultimate answer to the problem. Important collections of many different coffee varieties exist in the participating countries and coordination of the various on-going breeding programmes, utilising these collections, would be an important development.

Similarly, an exchange of views and experience on how CBD behaves under different climatic conditions and the pathogen's reaction to different cultural practices will be of value.

In view of the recent appearance on the market of fake or substandard agricultural chemicals, it will be important to ensure that such products do not find their way into the coffee industry. Some form of regional cooperation in the screening and evaluation of chemicals should therefore be considered.

Mr. Chairman, I am confident that the deliberations of the next few days will result not only in the establishment of meaningful research cooperation on a regional basis, but will also accelerate the development of CBD control measures which will be to the benefit of producing countries and individual coffee growers whose very livelyhood is at present threatened by the scourage of CBD.

Thank You.

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RESOLUTIONS AND RECOMMENDATIONS

INTRODUCTION

The participants at the First Regional workshop on Coffee Berry Disease express deep appreciation to the Provisional Military Government of socialist Ethiopia for hosting the workshop in Addis Ababa and for the inspiring opening address by His Excellency, the Minister of Coffee and Tea Development.

The participants appreciate the financial, moral and technical support rendered by the Ministry of Coffee and Tea Development and the Institute of Agricultural Research of Socialist Ethiopia, for co-sponsoring the workshop with the Association for the Advancement of Agricultural Sciences in Africa.

They further acknowledge with gratitude the financial assistance provided by the European Economic Communities (EEC), the Governments of Socialist ethiopia and the Republic of Kenya for their prompt response in soliciting the funds from the EEC.

RECOMMENDATIONS

After deliberating on the contents of the addresses given and the discussions made during the different sessions of the workshop, the following recommendations were resolved :

THE PATHOGEN

1. Laboratory Techniques : Some reservations were expressed on the use of only the sporulation test to assess fungicides in the laboratory. This test measures sporulation of a wide spectrum of Colletotrichum species, of which most are not pathogenic and also the reduction of sporulation which does not often resemble the situation in the field. Suppression of spore germination is an important part of disease control. The advantage of the sporulation test is that it indicates possible concentrations that can be used directly in the field.

The participants therefore recommend that further research be done on germination and sporulation tests in vitro to augment the present technique with others.

2. Taxonomy of Colletotrichum species : The confused situation on the nomenclature of Colletotrichum species was deeply regretted by participants.

They recommend that a critical review of the nomenclature of the species on Coffea Arabiba should be made. Appropriate contacts should be made with an internationally known taxonomist for his guidance on this matter (Von Arx).

3. Disease recording and its relation to yield and crop losses : The objectives of disease recording and determination of yield losses are four fold, namely :

a. Comparison of the efficacy of fungicides.

b. Evaluation of the economics of fungicide use and impact of the disease on total yield.

c. Assessment of disease resistance.

d. Epidemiological studies.

Regarding comparison of the efficacy of fungicides, participants believe that ranking of treatments is the main aim. They, therefore, recommend that monthly recordings be conducted on well randomly selected coffee branches : provided the sample is representative (direction and position on the tree). To avoid any statistical bias, the branches should be chosen on or after flowering before the onset of the epidemic.

In fungicide trials, yield data should also be collected and compared with the disease records.

On the economic evaluation of fungicide use and the impact of the disease on total yield, this covers mainly trials on farmers' fields. Obviously, the selection of trial areas should be done according to agreed sampling methods. These trials may have the character of preextension trials. In those trials, it is suggested to use the methods to completely control the disease and compare this with the recommended methods and no control.

As regards assessment of disease resistance, participants felt that in this case, it may be required to collect precise data on losses in individual plots. In such cases, it is necessary to determine what part of the total drop of berries is physiological. It is assumed that the material will have already a considerable level of resistance when such assessments are made and thus the magnitude of the physiological drop can be estimated from trees without CBD in the same cultivar. A possible method is published by N.A. Van der Graaff.

On epidemiological studies, detailed recordings at weekly intervals on well chosen pre-marked branches are recommended.

DISEASE CONTROL BY CHEMICALS

1. Goding of chemicals : The participants agreed that all chemical company code numbers should be used in publications

or scientific papers and not the code numbers used by researchers when testing or screening such chemicals. Active ingredients of chemical products need not be included unless required.

2. Testing chemicals : Methods of testing chemicals (new or in use) and the centres for testing the chemicals have already been established in Tanzania and Kenya. The Tropical Pest Research Institute (TPRI) was used as a regional centre for chemical analyses, but now it no longer serves as a regional centre.

The participants therefore recommended that TPRI (Tanzania) and the National Agricultural Laboratory in Nairobi be reinstituted and rehabilitated and modernized with new equipment for necessary chemical analyses. Respective governments, national and international institutions should give due attention to these centres.

3. Shelf-life of chemical : though the date of manufacture of a chemical can be obtained by request using Batch NO. of the product of the manufacturers, the participants strongly recommend that in addition to the batch number, the date of earliest expiry and minimum shelf-life under normal storage conditions of the product be put on every package or container of the product.

DISEASE CONTROL USING RESISTANT CULTIVARS

1. Concerning coffee genetic resources basic collections should be established in Ethiopia and active collections should be kept in all African countries concerned. In this respect, urgent international assistance is necessary to maintain these centres through secondment of technical experts, training of local personal, supply of equipment, etc.

2. To avoid introduction of the pathogen into CBD-free countries during exchange of material, participants recommend the

creation of quarantine facilities at strategic sites in order to enhance a safe exchange of coffee genetic materials; this may include tissue culture and seed preservation practices.

3. It is recommended that the African Plant Genetic Resources Committee (APGRC) which maintains special relations with the International Board of Plant Genetic Resources (IBPGR/FAO), take the initative to follow up recommendations 7 and 8 above, by convening a workshop in Addis Ababa and if appropriate, seek consultations of concerned governments and other institutions.

4. The participants further recommend that research be continued and strengthened in the following areas :

a. Scope of tests presently used in selection for CBD resistance.

b. Establishment of rapid and economically feasible methods of multiplication of selected materials for distribution to farmers.

c. Testing of coffee materials over a wide array of environmental conditions to study their adaptability to different ecologic zones and their resistance to pests and diseases in this areas.

d. Scientific stydy of the origin, evolution and genetics of coffee in order to have a better insaight of the genetic germplasm of this crop.

Proc. 1st Reg. Workshop "Coffee Berry Disease",
Addis Ababa, 19-23 July, 1982, P. 37 - 42.

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PART II

COUNTRY REPORTS

- CBD in Kenya.
- CBD in Ethiopia.
- CBD in Uganda.
- CBD in Tanzania.

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COUNTRY REPORT : KENYA
COFFEE BERRY DISEASE IN KENYA

By

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ABSTRACT

Coffee is the most important product in Kenyan agriculture and is infact the mainstay of the country's economy. Coffee Berry Disease (CBD) an anthracnose of green and ripening berries, has been and indeed continues to be the most serious threat to production of this important crop commodity. Growing Arabica coffee in Kenya, is infact becoming more unprofitable as a result of the escalating costs of production arising mostly from measures to control CBD, coupled with the falling prices on the world coffee market. A tremendous amount of research at the CRS, Ruiru, has been devoted to CBD and indeed, that coffee is still being grown in Kenya at all, is a reflection of the results of this work.

This report gives an account of research undertaken on the Station, aimed at finding the most offectively and yet economic control measures to CBD. The paper traces the history of this disease and the magnitude of crop losses that have occurred arising out of the CBD epidemics. Details regarding the pathogen, its mode of infection, the symptoms

and its epidemiology are given. This is followed by a consideration of control measures, i.e. chemical control and use of disease resistant varieties, as well as the economic implications of such control measures.

It is concluded, that there is need for more judicious use of chemicals at the farm level, and that farmers need more protection against use of inferior chemicals. This, it is suggested, could be achieved by way of Government as well as its research agencies, instituting more strict control regulations on importation and use of chemicals. Furthermore, short-term measures aimed at reducing the cost of controlling CBD by chemical sprays are suggested. The introduction to the coffee growers of disease resistant varieties, which is expected in the near future, is considered in terms of the impact it will have, both on the Coffee industry and the national economy. Finally, the report strongly emphasizes the need for support of continued research, and for international collaboration among research institutions in terms of exchange of information and materials.

INTRODUCTION

Importance of Coffee to Kenya

Coffee is the most important product in Kenyan agriculture and in fact represents the major source of foreign exchange earning. Kenya coffee is produced by two agricultural sectors namely, the plantation (estates) and the cooperative (small-holders) sectors.

The total area under coffee has increased over the years to the current figure of about 153,000 hectares. Total production has also generally increased over the years to the current 99,000 metric tons, with the co-operative sector producing 64.8% as against 34.7% produced by the plantation sector. The value of Kenya coffee fluctuates according to the International coffee market but for 1980/81, it was over K£ 110 million which represents 30% of the total domestic export.

Kenya produces the mild Arabica coffee that is reknown the world over for its fine quality. Coffee in Kenya is grown in areas between 1200 M and 2100 M above sea level. These areas lie on the broad gentle slopes of Mount Kenya and eastern Abaradare Range in the Central Province area, on the slopes of Mount Elgon, bordering Uganda, parts of the Great Rift Valley and some small holdings in the Taita Hills, a short distance from Tanzania.

The importance of coffee to the National Economy convinced the Government at the very early stage, of the need to have a centralised statutory organization which could implement the production and marketing policies in accordance with an Act of Parliament. The Coffee Board of Kenya, which was enacted in 1933, is responsible for the running of the coffee industry, broadly with respect to production, research, marketing, financial and advisory services to the farmers and overseas promotion.

The Coffee Research Foundation at Ruiru is financed by the Board to undertake specialized research into all problems affecting production, portection, processing and quality of the coffee crop.

Coffee Berry Disease

Coffee berry disease (CBD) is an anthracnose of green coffee caused by the fungus Colletotrichum coffeanum Noack sensu Hindort. The disease has been studied extensively in Kenya.

coffee varieties even under weather conditions favourable to the disease and there is some evidence that these scabs may be an indication of a defence reaction ((Masaba and Van der Vossen, 1982).

Dispersal

The conidia of C. coffeanum are hard and firmly attached to the diseased tissue when dry, but when wetted, the spore masses swell up and become slimy and individual spores are quickly dispersed in water. Dispersion within the tree is by water running along branches and dripping through the tree canopy (Waller, 1971). Dispersion from one plantation to a near-by one can be effected by human agency (e.g. when handling and picking). Long range dispersal seems to take place solely by movement of infected plant material, particularly seedlings.

Effect of Climate on Fungus and Host

Rainfall is by far the most important facet of weather which influences CBD. C. coffeanum, the causal agent of CBD require water (rain) for dispersal of spores and subsequent spore germination and penetration of healthy berries leading to development of lesions. In addition, lesion growth and sporulation on both the twig and berry surface is enhanced during wet weather. Meteorological data from within coffee trees (Kirkpatrick, 1935) showed that a saturated atmosphere in the absence of free water was rare. Waller (1971) was able to prevent CBD developing on coffee by sheltering the trees with polythene covers.

The climate experienced in various coffee gowing districts varies slightly. The districts east of the Rift Valley, where most coffee is grown experience two rainy seasons, the long rains (March-May) and the short rains (October-November) interspersed by more

The total area under coffee has increased over the years to the current figure of about 153,000 hectares. Total production has also generally increased over the years to the current 99,000 metric tons, with the co-operative sector producing 64.8% as against 34.7% produced by the plantation sector. The value of Kenya coffee fluctuates according to the International coffee market but for 1980/81, it was over K£ 110 million which represents 30% of the total domestic export.

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Table (I) : Coffee Area Production and Export Value in Kenya

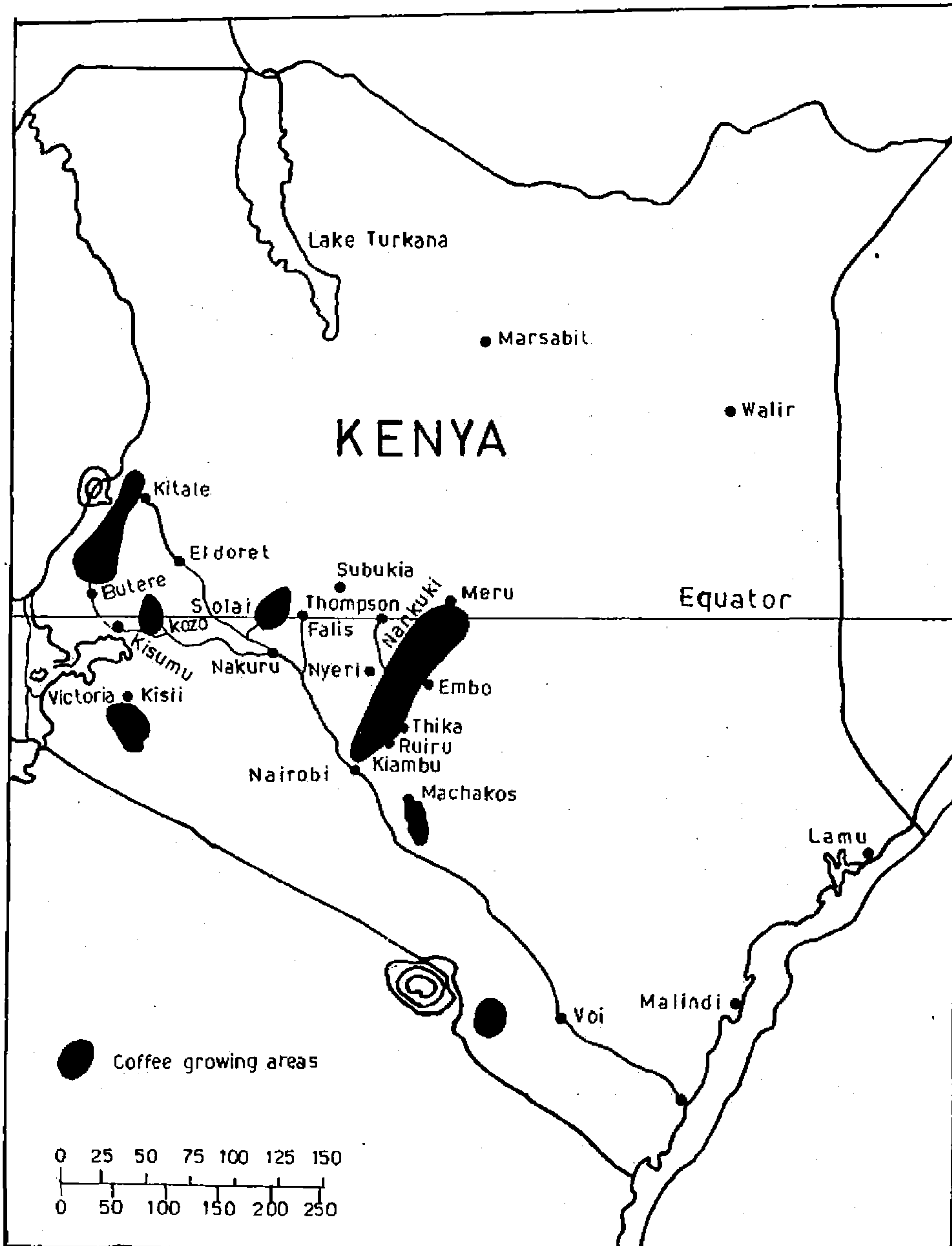
Year	Area under coffee x 1000/1000/ha			Production of clean coffee metric tonnes x 1000			Production per ha in t. clean coffee		Value of coffee		
	Small holders	Estates	Total	Small Holders	Estates	Total	Small Holders	Estates	Mean price per t. K£	total export value K£x10^{6}	% of total domestic exporr
1962/63	28.0 (14.8)	32.0(28.3)	60.0(42.1)	8.9	25.3	34.2	0.6	0.9	204	11.1	25
1963/64	49.2(25.7)	32.6(28.3)	81.8(54.0)	15.4	28.5	43.9	0.6	1.1	350	15.4	33
1964/65	[illegible]	32.4(28.3)	[illegible]	[illegible]	[illegible]	37.2	0.6	0.8	333	14.1	30
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.7	0.8	[illegible]	[illegible]	[illegible]
1966/67	52.5(36.7)	31.9	84.4(68.6)	27.6	25.3	52.9	0.7	0.8	291	15.7	29
1967/68	53.8(49.9)	31.2	85.0(81.1)	20.6	13.3	33.9	0.4	0.4	320	12.8	28
1968/69	55.3(52.3)	30.7	86.0(83.0)	23.3	22.3	45.6	0.5	0.7	308	16.8	32
1969/70	54.1	29.9	84.0	26.3	26.5	52.8	0.5	0.9	373	22.3	37
1970/71	55.6	29.5	85.1	27.3	29.6	56.9	0.5	1.0	314	19.5	32
1971/72	55.7	28.7	84.4	29.4	31.9	61.3	0.5	1.1	375	24.8	27
1972/73	55.3	29.5	84.8	36.0	40.0	76.0	0.6	1.3	463	33.4	28
1973/74	55.6	29.1	84.7	40.6	32.7	73.3	0.7	1.1	510	38.4	24
1974/75	57.8	28.6	86.4	35.5	30.6	66.1	1.6	1.0	477	35.2	21
1975/76	57.8	28.6	86.4	36.5	38.1	74.6	0.6	1.3	1066	84.4	36
1976/77	56.6	27.8	84.4	37.7	49.7	97.4	0.8	1.8	2214	202.7	42
1977/78	65.0	30.6	89.2	47.6	33.7	81.3	0.7	1.1	1553	129.6	34
1978/79	89.2(70.0)	30.0	110.2(92.0)	46.7	27.6	74.3	0.7	0.9	1234	97.3	29
1979/80	90.0(80.0)	30.0	125.0(100.0)	52.0	39.7	91.7	0.7	1.2	1360	118.7	22
1980/81	101.9(84.7)	34.0(32.9)	154.2(135.9)	66.0	34.7	98.7	0.7	1.0	1176	110.9	30

Notes : 1 In brackets actual area in production

2 Heavy crop loss due to CBD in 1968, 1969 and 1979 because of excessive rainfall in 1967, 1968 and 1978

3 In 1980 : 70,000 (+20,000 new planting) ha belong to 153 Co-operative Societies with 568 factories and about 26,500 members.

30,000 ha belong to 740 Estates of which about 74% are now African owned.



KENYA coffee growing areas

History of CBD

Coffee berry disease was first reported in 1922 (Macdonald, 1926) in sotik area and the newly established plantations south of Mount elgon in western Kenya. It is believed to have originated from C. eugenioides, a wild diploid coffee found in high altitude forests in Western Kenya and Eastern Uganda. CBD attacks eventually become so severs that many of the coffee plantations in the West of the rift Valley had to be abandoned. During the following decade, the disease spread to most of the Western districts of Kenya. About 1939, coffee berry disease attacked plantations in the Mount Kenya area, having crossed the Great Rift Valley. In 1951, the disease was reported to have spread to the Central Province area, the main coffee producing area of Kenya. the disease affected plantations above an altitude of 1680 m.

Alarm became general around this time and it was then that research was started in earnest.

During the next few years CBD continued to spread from one plantation to the next, in spite of the efforts to prevent it moving to districts which still remained free from infection, until all the producing districts above 1680 m were eventually attacked.

In 1962, CBD appeared for the first time in the lower (below 1680 m) districts where it soon reached a very high level of intensity.

The disease is currently predominant in all coffee growing areas above 1680 m and occasional severe outbreaks occur in the lower areas during abnormally wet years.

Magnitude of the Disease

Crop losses from CBD in Kenya have increased steadily over the years. Until 1960, only a small part of the growing areas above 1680 m was seriously affected. But during the 1960's epidemics of major proportions occurred. The most disastrous year was 1967, when hardly a grower was unaffected. Many lost their entire crop and overall loss was estimated at not less than 30% (Griffiths, 1969). Control by an annual fungicide spray programme has, however, reduced CBD problem drastically and besides, most of the fungicides used on coffee (e.g. cooper and captafol) have resulted in termendous yield increases which have been not only attributed to the control of the disease but also to the 'tonic' effect these fungicides impart on coffee trees (Griffiths, 1971; Mulinge and Griffiths, 1974).

Coffee Varieties Grown in Kenya

The majority of the older coffee farms are planted with French Mission coffee which is acclaimed to be less susceptible to CBD but in fact quite suscaptible in some years of CBD epidemics. The presently recommended cultivars SL 28 and Sl 34, both of which are very high yielders and produce coffee of remarkably good quality are known to be very susceptible to CBD. Blue Mountain and K 7 which are grown in certain areas in Kenya are partially resistant to CBD. K 7 in addition also shows resistance to rust but only to race 11 of Hemileia vastatrix.

Other Coffee Disease Problems in Kenya

Next in importance to CBD is Coffee Least Rust caused by the fungus Hemileia vastatrix Berk. et Br. coffee leaf rust is especially severe in areas below 1600 m in altitude. Leaf rust is however, adequately controlled by applying well-timed sprays of 50%

copper formulations as well as various organic fungicides such as dithianon (Delan), fentin hydroxide (Du-ter Extra) pyracarbolid (Sicarol) and triadimefon (Bayleton).

Another disease which has gained importance since its seious outbreak in 1974 is Bacterial blight of coffee (BBC), commonly referred to as Elgon/Solai die back, and caused by the bacterium Pseudomonas syringae. Fortunately, this disease has so far, been restricted in its spredad to the coffee areas on the slopes of Mount elgon and in the Solai area in the Rift Valley. Trials carried out since 1975 have proved the effectiveness of 50% copper formulations, in controlling BBC (Okioga, 1977; Kairu 1980 & 1981 unpublished). Work is now in progress on refining the rates and timing of application.

Other coffee diseases are considered of minor importance to the coffee industry in Kenya and have tended to disappear with improved cultural practices.

TEXT

The Pathogen

Colletotrichum coffeanum Noack is an ubiquitous fungus occurring in the mature bark of coffee shoots as a harmless saprophyte. In Kenya, four culturally distinct strains have been distinguished comprising of three saprophytic strains and a pathogenic strain causing CBD (McDonald, 1926; Rayner, 1952; Gibbs, 1969 and Hindorf, 1970). On malt extract agar, the specific strain produces greyish black abundant aerial hypae which bear conidia directly on their branches and not on acervuli. The conidia can cause infection on both green and ripe berries. Cultural isolations made from different parts of the country have been consistently identical in all measureable attributes including pathogenicity (Nutman, 1970; Masaba and van der Wossen, 1980).

Germination and Infection

Nutman and Roberts (1960) determined the conditions necessary for spore germination and infection under laboratory conditions. Conidia require a water film and germination will not proceed in the absence of such a film even when atmospheric humidity is close to 100%. Optimum temperature for germination is about 22°C . At 17°C and 28°C germination is about 40% of the maximum, and below 10°C and above 31°C it is zero. These temperatures with the requiste moisture must persist for a minimum period of about 5 hr. for moderate infection to occur (Waller, 1971 and Cook, 1975).

Conidia germinate into germ-tubes which in turn produce appressoria. The appressoria adhere to the plant cuticles and produce slender infection pegs which penetrate the cuticle to cause infection (Bock, 1956).

Symptoms

Coffee berry disease attacks coffee berries in all stages of growth and occasionally even flowers and leaves. On green berries symptoms first appear as small dark, sunken patches which spread rapidly and may cover the whole berry (Fig. 1). Under wet conditions pinkish mass of spores develop on the lesion surface. Usually, the fungus penetrates the interior and destroys the beans. Eventually, the whole berry dries out and takes the appearance of black mumified bodies resembling 'mbuni' (Fig. 2). Infected berries may also be shed as soon as lesions develop.

A second type of lesion is normally formed under adverse weather conditions. This is normally pale tan in colour, not sunken and usually bears concentric rings of black acervuli (Fig. 3). This type of lesion is normally called 'scab' lesion. Recently, it has been observed that some of the scabs are formed especially on resistant coffee varieties even under weather conditions favourable to the disease and there is some evidence that these scabs may be an indication of a defence reaction ((Masaba and Van der Vossen, 1982).

Dispersal

The conidia of C. coffeanum are hard and firmly attached to the diseased tissue when dry, but when wetted, the spore masses swell up and become slimy and individual spores are quickly dispersed in water. Dispersion within the tree is by water running along branches and dripping through the tree canopy (Waller, 1971). Dispersion from one plantation to a near-by one can be effected by human agency (e.g. when handling and picking). Long range dispersal seems to take place solely by movement of infected plant material, particularly seedlings.

Effect of Climate on Fungus and Host

Rainfall is by far the most important facet of weather which influences CBD. C. coffeanum, the causal agent of CBD require water (rain) for dispersal of spores and subsequent spore germination and penetration of healthy berries leading to development of lesions. In addition, lesion growth and sporulation on both the twig and berry surface is enhanced during wet weather. Meteorological data from within coffee trees (Kirkpatrick, 1935) showed that a saturated atmosphere in the absence of free water was rare. Waller (1971) was able to prevent CBD developing on coffee by sheltering the trees with polythene covers.

The climate experienced in various coffee gowing districts varies slightly. The districts east of the Rift Valley, where most coffee is grown experience two rainy seasons, the long rains (March-May) and the short rains (October-November) - interspersed by more or less dry weather. The districts of the Rift Valley experience more prolonged and widely spread out rains from March to September. The higher altitudes (Above 1600 m) receive more rain than the lower ones, but both experience wide diurnal temperature fluctuations, with low night temperatures and high midday ones. The higher rainfall at the higher, cool altitudes makes the moisture conditions more favourable for invasion and it is in these areas that CBD is most prevalent and severe.

Rainfall also regulates the flowering, and consequently, the cropping of coffee. In areas above 1600 m altitude, where CBD is most serious, the main flowering occurs at the start of the long rains (March-April). The short rains normally induce a second flowering (October), usually of minor importance. The coffee fruit tákes about nine months from flowering to harvest. It is the crop derived from the long rains which is normally most affected by CBD. Aberrant rainfall in other months of the year and overhead irrigationd practised on large scale farms normally induce out of season blossom which results in constant presence of berries on the trees.

Epidemiology

the CBD causing strain of C. coffeanum is most prevalent in the young regions of the stem, where the first phellogen is being produced (Eurtado, 1970). The saprophytic strains, however, occur throughout the eight internodes with maturing bark. Nutman and Roberts (1961) showed that maximum production of conidia occurred on the third or fourth internodes proximal to the one showing the first sign of bark maturation.

Conidia of the CBD strain of C. coffeanum are produced in acervuli on the developing bark of young twigs and on diseased berries. At first, it was considered that conidia from developing bark was the most important source of inoculum (Nutman and Roberts, 1961), but later Gibbs (1969) showed that diseased berries were by far the most important source of inoculum. Griffiths et al. (1971) showed that a single diseased berry can produce more than 50 times as many spores as the whole branch on which it was borne. However, in the absence of diseased berries, inoculum from the bark can initiate an epidemic though subsequent progress of the disease is more dependent on the conidia from the berries which account for most of the inoculum during most of the season. Again, the bimodal annual rainfall distribution in Kenya's major coffee growing areas usually results in two flowerings annually leading to over-lapping crops. Thus, diseased berries from an earlier crop are often present during the early stages of a succeeding crop. In this case, the inoculum from such berries may well mask the effect of inoculum produced from the bark.

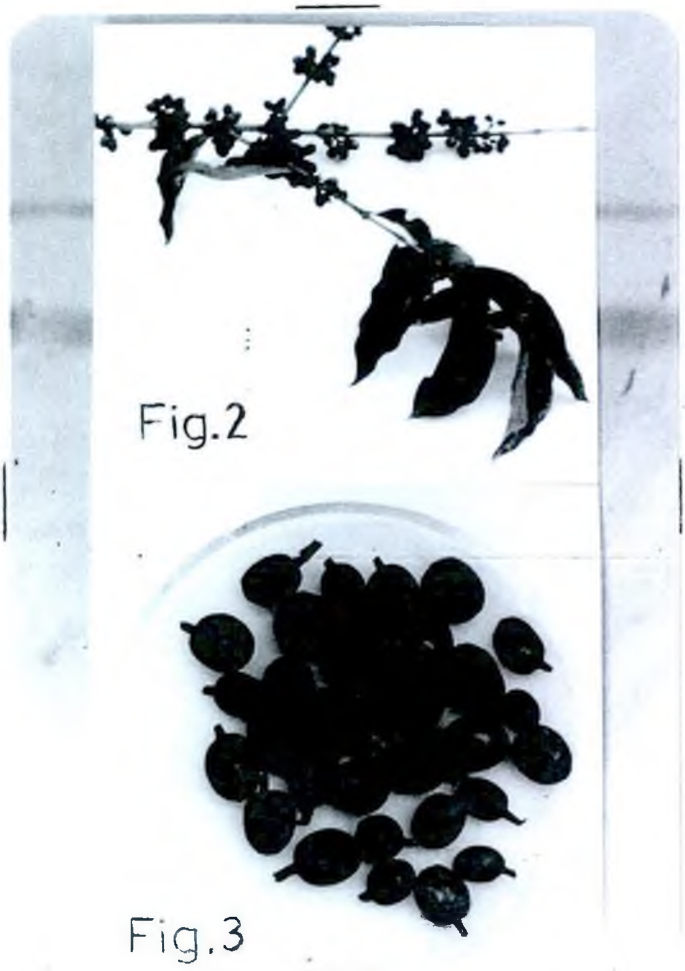
Nutman and Roberts (1960 a&b) showed that mature green berries were resistant to CBD infection. Many other workers have subsequently confirmed that there is little effect of disease on the crop after it is 5 months old until ripening when the berries become very susceptible to infection again. The susceptible stages coincide with the period of berry expansion - between four and fourteen weeks after flowering (Mulinge, 1970).

CONTROL MEASURES

Cultural Control

Waller (1971) indicated clearly that more C. coffeanum spores are produced in the bark in the top half of trees than in the lower parts. In multiple stem coffee, the upper parts of tall heads have been showen to be severely affected by CBD than the lower parts of the tree (Griffiths et al., 1971). There are probably many reasons

Fig. 1. Symptoms of CBD.



Figs. 2 & 3. Symptoms of CBD.

for this. Whatever the reasons, the presence of infection in the tops of trees is particularly dangerous because the spores are moved by rain downwards to the crop at lower levels. Thus where capping is not practised the early removal of heads when changing cycle is recommended.

It has also been observed that young coffee up to two years of production, tend to be less affected by CBD but the economics of channing cycles more frequently than the current recommended after four or five years or production are still to be studied.

Chemical Control

In Kenya, major investigations on fungicide control of CBD started between 1956 and 1960 (Bock, 1983; Nutman and Roberts, 1960 a&b)though even as far back as 1922 chemical control of CBD was recommended (Rayner, 1952). Of the fungicides then available, only formulations of 50% copper formulations and organo-mercurials gave results of value. The use of the latter was however, discontinued because the sprays gave a cripping zinc deficiency in the plant and also because mercury became absorbed and was translocated to the developing been where it was present in small but significant amounts.

The earlier workers believed that the inoculum from the bark was a key factor in the epidemiology of CBD. From field trials between 1956 and 1960, it was concluded that in order to control CBD in the long-rains crop, the critical period for application of fungicides was from february to April, and furthermore these sprays worked by reducing the amount of inoculum produced by the bark. Fungicidal sprays applied in February, March and April were referred to as early season sprays and these sprays were reasonably effective in controlling CBD during the late 1950's in Kenya (Fig. 4). Farmers adapted this spray timing schedule using 50% Coper at 3.9 kg/ha suspended in 1800-2250 litres of water per hectare.

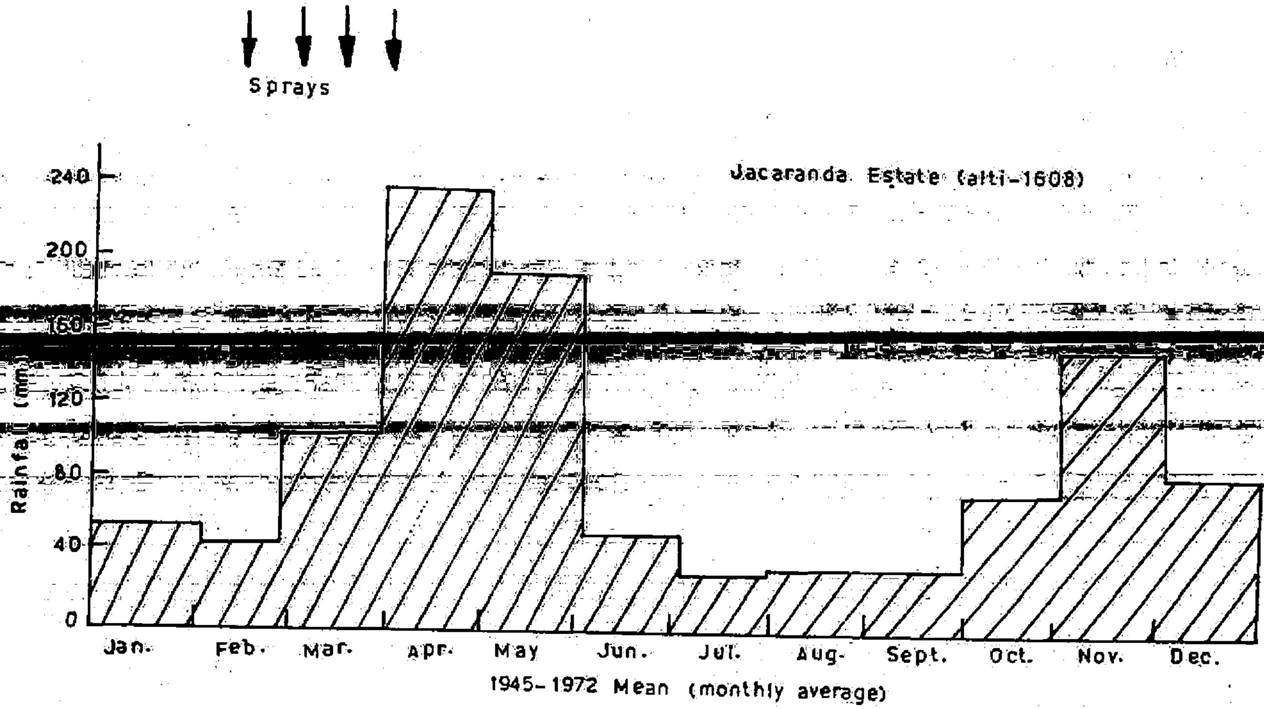


Fig. 4: An early season spray programme (East Rift districts).

In 1986, however, early season sprays proved partially or totally ineffective against CBD and in some cases increased the disease level (Wallis and Firman, 1967; Griffiths and Vine, 1968). As a consequence a re-assessment of earlier work was considered necessary. Gibbs (1969) studied the inoculum sources of CBD and concluded that in the absence of diseased crop, as at the beginning of the rains, the bark remains the primary source of inoculum and there is no doubt that this inoculum can cause severe infection. Thereafter, as soon as diseased berries appear upon a branch, they become the major source of inoculum for any healthy crop remaining on that branch. If climatic and cropping conditions are favourable, secondary spread from disease berries is likely to be of by far greater significance than primary infection. The trials reported by Griffiths et al. (1971) clearly showed that spraying to protect the crop during the rainy season was more successful than sprays aimed at reducing the sporulation of the fungus on the bark. Therefore, monthly spraying to continuously protect the crop during the rainy season and when the barries are most susceptible to CBD infection (4-14) weeks after flowering) has been the standard CBD control schedule in Kenya since 1970 (Fig. 5).

An attempt is being made to develop a flexible spray chedule for CBD control based on the amount of rainfall and crop as compared to the current recommended fixed calender spray programme. Preliminary results have showed that in dry years, the flexible spray schedule could reduce the number of sprays from six to four between February and July, when the crop needs protection against CBD (Javed, unpublished).

It is now fully recognised that CBD can adequately be controlled through efficient application and timely use of tested and recommended chemicals. Since the 1960's screening of fungicides

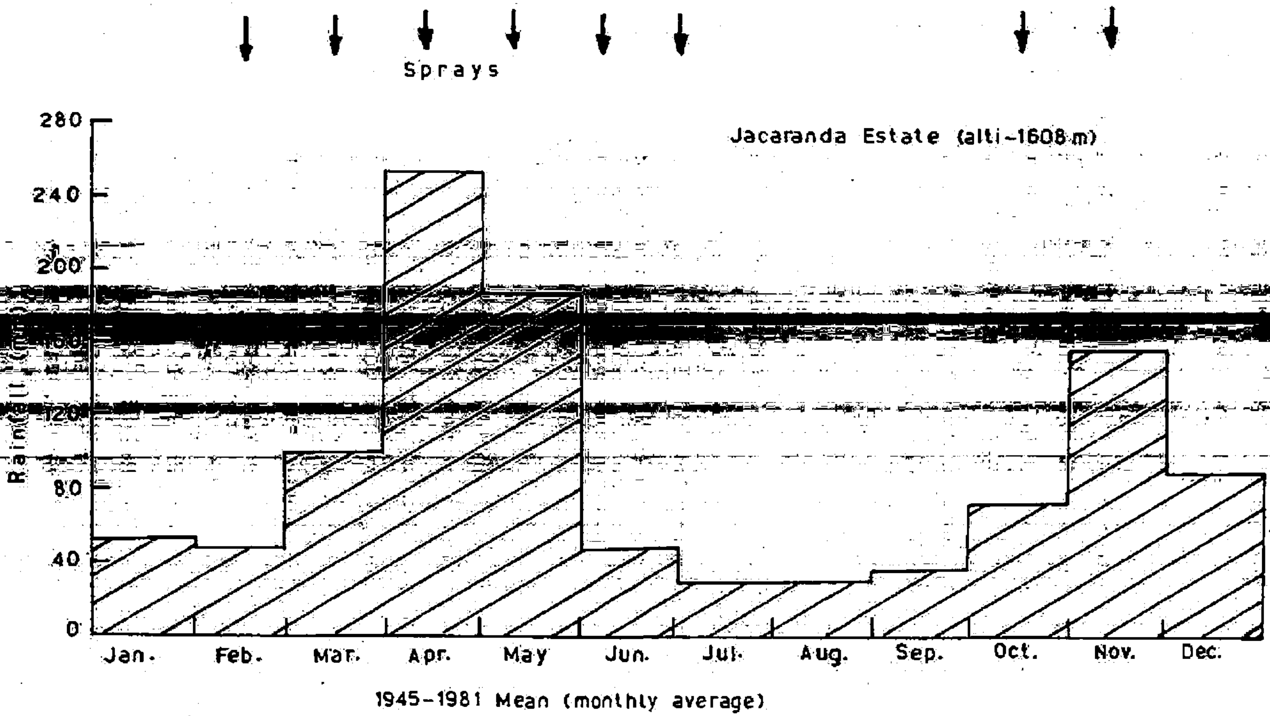


Fig. 5: Current recommended anti C.B.D. spray programme (East Rifts districts)

for control of CBD has been a priority of the protection aspect of coffee research. Many chemicals have been screened for effectiveness against CBD (Vermeulen,1968; Vines et al., 1973; Baker, 1973; Okioga and Mulinge, 1974; Cook 1975; Javed, 1980 and 1981). In Kenya, the use of recommended chemicals is prescribed to farmers through the coffee Research Station technical circulars which specify the chemical to use, the rate, frequency and timing of application. The current recommended chemicals include captafol 80% W.P. (ortho-difolatan), chlorothalonil 75% (Daconil), dithianon 75% W. P. (Delan) and various 50% W. P. copper formulations. Tank mixtures of recommended organic fungicides and copper at half rates have also proved effective against CBD besides, these have been found to be cheaper than individual organic fungicides used on their own.

After recommendation, further trials are still carried out on the recommended chemicals. These trials reveal the effects of long term use of the chemicals recommended and in cases where ill-effects have been observed, the recommended chemicals have been withdrawn from use on coffee. Good examples of this, are the systemic fungicides which were very effective against CBD and recommended for use in the early 1970's (Baker, 1973; Okioga and Mulinge, 1974). Resistant strains of C. coffeanum were observed to haved developed (Cook, 1975 and Okioga, 1976) where the Benzimidozole (MBC) fungicides had been used exclusively, and CBD control was not achieved. After extensive research into the possible combinations and ways of application to safen the use of the MBC fungicides failed, they were withdrawn from use on coffee.

An important aspect of chemical control is the efficient application of fungicides onto the coffee trees. Two major difficulties in efficient application of fungicides are (1) canopy density which seriously affects spray penetration to shoots and (2) the suitability of automated machines for spraying coffee (Kearn et al., 1967).

Growers in Kenya have since the 1960's become well aware of the need to maintain trees in a more open condition through pruning and handling. Tall heads on multiple stem trees, which would be difficult to reach while spraying, have become rare.

considerable strides have also been made in improving the performance of spray machines on coffee. The need for appraisal of factors such as droplet size and spray volume applied per hectare was pointed out by Pereira (1967). Maithia (1981) has devised detailed procedures used in assessing the efficacy of various spray equipment on coffee, and these are currently used to assess the efficiency of the spray machines which are recommended for use on coffee. A list of some spraying machines tested and recommended to the farmers in Kenya has been compiled (Maithia, 1981).

Complete spray cover was earlier recommended for the control of CBD (Lee, 1966; Mapother and Morgan, 1968; Pereira, 1967; Mapother, 1967; and Wallis and Firman, 1967). However, with the adoption of overhead sprayers, which provided cover which was far from complete and yet achieved good control of CBD, the need for complete-spray cover became questionable (Pereira and Mapother, 1972). The effectiveness of CBD control by the overhead method of spraying was found to be due to the good redistribution properties of the fungicides used (Pereira et al., 1973 and Maithia, 1979).

Breeding for Disease Resistance

That coffee is still being grown in Kenya at all, is clearly a reflection on the tremendous amount of work that has been done to develop efficient chemical control measures to CBD. Nonetheless, though most large scale estates may be able to control CBD through the recommended intensive spray programmes, these have become very expensive due to tremendous increase in the cost of fungicides, fuel and machinery over the past few years. At higher altitudes, it is estimated that some estates may spend upto 30-35% of their total production costs on control of CBD alone. But even though, such estates could not prevent considerable crop losses of upto 20-30% during the excessively wet weather conditions in 1977-79.

With the present downward trend in coffee prices and increase in production costs, there is bound to be a drastic decline in profitability of coffee growing by such producers. The majority of the smallholders on the other hand, because of lack of capital are not able to carry out the recommended spray programme. They usually only apply one or two fungicide spray in a year. During the wetter years, they may end up with more severe crop loss due to CBD since it is known that occasional fungicide sprays tend to induce higher levels of CBD than would occur in total absence of fungicides sprays. For the small-holder CBD is therefore a constant threat to his major (and often only) source of cash income.

It is clear from the foregoing that developing disease resistant varieties would be the long-term answer to the present problems. Such a programme has been in progress at the CRS since 1971. Apart from CBD resistance, the programme is also aimed at incorporating rust resistance, inproved yield and quality as well as compact growth in the new varieties.

In order to combine CBD and rust resistance with the other desirable attributes the breeding programme has proceeded along the following stages :

1. Evaluation of existing germplasm collection for CBD and rust resistance followed by single crosses.

2. Multiple crosses to combine in single individual genotypes traits derived from more than one variety.

3. Backcrosses of selected plants from multiple crosses to commercial cultivars mainly o improve on liquor quality.

So far, a number of promising clones selected from among progenies of multiple crosses and backcrosses have been planted out in 5 important ecological zones for coffee in Kenya to evaluate the performance of such genotypes for CBD and rust resistance, yield and quality in widely differing environments.

After considering the more recent results of the breeding programme, it was concluded that the multiplication of new disease resistant varieties could be achieved through hybrid seed thus evading problems inherent in vegetative propagation which initially had been considered to be the only way for large scale multiplication of the new varieties. The breeding programme has thus been reoriented accordingly to ensure that by 1985 large scale production of hybrid seed, for plant material which combines CBD and rust resistance with improved yield and quality as well compact growth, can actively start.

Three subprogrammes of this second phase of the breeding programme have been initiated. These include:

1. The establishment of the seed garden to be used eventually for production of hybrid seed through large scale artificial cross pollination.

2. Progeny testing of crosses between selections of our breeding programme and those from the Catimor materials available on the Station to determine combining ability especially for yield and quality. The best selections within these two sets of parental materials will be the ones to be used for production of hybrid seed.

3. Trials to determine cultural requirements especially for the disease resistant and compact type of varieties.

The progress achieved so far has been due to considerable research that was undertaken in support of the breeding programme. This has included :

1. The development of a reliable preselection test for CBD resistance performed on young seedings and the elucidation of the genetic control of CBD resistance in our main progenitors.

2. The biometrical genetic studies which have provided valuable information to enable efficient selection for yield and quality and

3. Use of the leaf disk inoculation test for screening resistance to coffee rust.

It is expected that by 1987, the first seedlings of the new disease resistant and compact varieties will start being issued to the farmers.

Economic Considerations

The control of CBD is central within the structure of the Pesticide market in Kenya. Coffee in comparison to other crops leads in consumption of Pesticides and within the coffee input market structure fungicides lead (see a paper by SBC Njagi, 1982).

The economics of protection against this disease must of necessity examine the consequence of the presently practiced methods at the farm level, identify divergencies from the recommended methods of control and the reasons within both the estate sector and the smallholder sectors. To justify any protection measures, the expected value of crop gains from employment of control must justify the expenditure leaving the farmer with some profit. At the national level, the improtation of fungicides, the number one within the coffee pesticide market, is a major loss of foreign exchange. with unfavourable balance of payments and rising inflation, any government must examine ways and means to minimise costs to benefit both the farmer and the nation.

CONCLUSION AND RECOMMENDATIONS

Chemical Control

There is need for judicious use of chemicals at farm level. Measures like use of tank mixtures at half rates and reduction in the number of sprays applied by using precise weather observations and cropping would reduce the cost of chemical control in the short term.

There is need for an efficient laboratory to constantly check and confirm the quality of the recommended chemicals. Such checks would include, among others, analysis of the active ingredient, proof on toxicity levels, and residue analysis. This exercise would protect the farmers against chemical swindlers and would assure coffee consumers of the safety of the product.

Control by Use of Disease Resistant Varieties

The eventual replacement of Kenya coffee farms with the new disease resistant cultivars is expected to have a considerable impact on the coffee industry, and the national economy as a whole. There will be a considerable reduction on production costs and improve cash incomes for the small holders while guaranteeing sustained profitability for the large scale farmers. It will also save the national valuable foreign exchange spent on fungicides, fuel and spray machinery. Furthermore, the doubling in yild per unit area through close spacing of the compact varieties will mean drastic reduction of the hectarage of land required to meet the Kenya export quota for coffee. This means that gradually thousands of hectares of high potential land could be directed from the coffee sector to food production.

Importance of Research

It is important to stress that for efficient and economic control of CBD, like all other diseases, continuous research coupled with collaboration with other research Organizations is essential. Exchange of information as well as materials in the past, has strengthened and speeded the control measures which are currently practised in Kenya, and it is our earnest hope that this will continue to the benefit of all the parties invoved.

REFERENCES

Baker, C.J. (1973) Trials with new and recommended fungicides. Kenya Coffee 38 : 185-191.

Bock, K.R. (1963) The control of berry disease in Kenya Emp. J. expl. Agric. 32 : 97-107.

Bock, K.R. (1956) Investigations on Coffee Berry Disease - Laboratory studies, East African Agricultural Journal 29 : 97-103.

Cook, R.T.A. (1975) The effect of weather conditions on infection by Coffee Berry Diusease, Kenya Coffe 40 : 139-44.

Furtado, I. (1970) The effect of copper fungicides upon the bark microflora of Coffea Arabica with particular reference to the Pathogenic strains of Colletotrichum coffeanum. PHD Thesis University of East Africa.

Gibbs, J.N. (1969) Inoculum sources for coffee Berry disease. Annals of applied biology 64 : 515-522.

Griffiths, E. (1971) 'Negative' effects of fungicides in coffee. Proc. 6th Bri. Insectic. Fungic. Conf. 817-825.

Griffiths, e. and Vine, b.H. (1968) 1967 field trials on control of coffee Berry Disease in Kenya. IV Trials conducted by the CBD Research Unit, coffee Research Station. Kenya Coffee 33 :

Griffiths, E. (1969) CBD Kenya's biggest problem Span 12:2.

Griffiths E., Biggs, J.N. and Waller, J.M. (1971) Control of Coffee Berry disease. Annals of applied Biology 67 ; 43-74.

Hindorf, H. (1970) Colletotrichum spp. isolated from Coffee Arabica L. in Kenya. Zeitschrift für Pflanzenkrankheiten, pflanzenpatholgie und pflanzenschutz [illegible] 328-331.

Javed, Z.U.R. (1980) Effectiveness of new and recommended fungicides in controlling CBD in 197[illegible] in 1979 and 1980. Kenya coffee 45 : 177-183 and 29[illegible], Kenya coffee 46 : 209-215.

Javed, Z.U.R. (1981) Field trials with new and recommended fungicides for Leaf rust control during [illegible]78. Kenya Coff. 46 : 19-24.

Kairu, G.M. (1980) The performance of various spray programmes in controlling bacterial [illegible] of coffee (Elgon/Solai die-back) using copper-based bactericides. Kenya Coff 45 : 301-304.

Kairu, G.M. (1981) Evaluation of tank [illegible]tures of copper and Delan (Dithianon) for integrated control of bacterial blight of coffee and coffee berry diseases. Kenya Coff. 46: 325-331.

Kearn, H.G., Mapother, H.R. and Morgan, N.G. (1967) A report on investigations, carried out in Kenya 1967 and 1968. Mimeographs, unpublished.

Kirkpatrick, T.W. (1935) The climate and [illegible]limates of coffee plantations Amani, Memoirs.

Lee, W.C. (1966) Notes on spraying [illegible]ments for CBD control. Tropical Pests Research [illegible] Miscellaneous Report No. 530 Arusa Tanzania.

Maithia, A.S.K. (1979) comparison of Overhead and conventional side boom methods of spray application for the control of Coffee Berry Disease with non-benzimidazole and Benzimidazole fungicides. Kenya coffee [illegible] 25-29.

Maithia, A.S.K. (1981a) Procedures used for assessing the efficacy of spray machinery on coffee. Kenya Coffee 46 : 191-195.

Maithia, A.S.K. (1981b) List of some of the fungicide application equipment tested on coffee. Kenya Coffee 46 : 59-68.

Mapother, R. (1967) the assessment of spray cover by means of fluorescent tracer. Kenya coffee 32 : [illegible]4-196.

Mapother, R. and Morgan, N.G. (1968) Preliminary considerations of spraying techniques for control of Coffee Berry Disease. Kenya Coffee 33 : 141.

Masaba, D.M. and Van der Vossen, H.A.M. ([illegible]80) differential pathogenicity of isolates of the CBD pathogen. Coffee Res. Found. Kenya Ann. Report 1978/79 : P[illegible] 171-172.

Masaba, D.M. and Van der Vossen, (1982) Evidence of cork barrier formation as a resistance mechanism to berry disease (Colletotrichum coffeanum) in arabica coffee. Neth. J.Pl. Path. 88 (2) : 19-32.

McDonald, J. (1926) A preliminary account of a disease of green coffee berry in Kenya. Trans. [illegible] Mycol. soc. 2 : 145-154.

Mulinge, s.K. (1970) Development of coffee berry disease in relation to the stage of growth of the Berry. Ann. Appl. Biol. 65 : 269-276.

Mulinge, S.K. and Griffiths, e. (1974) Effects of fungicides on Leaf rust, berry disease, foliation and yield and coffee. Trans.Bri. Mycol. Soc. 62 (3): 495-507.

Njagi, S.B.C. (1982) Economic aspects of Coffee Berry Disease Control. 1st Regional Workshop on CBD, Addis Ababa 19-24 July 1982

Nutman, F.J.(1970) Coffee berry Disease Pans Vol. 16 (2) : 277-286.

Nutman, F.J. and Roberts, F.M. (1960a) Investigations on a disease of Coffea arabica caused by a form of Colletotrichum coffeanum Noack I. Some factors affecting infection by the pathogen Trans. Bri. Mycol. Soc. 43 : 489-505.

Nutman, F.J. and Roberts, F.M. (1960b) Investigations on a disease of Coffea arabica caused by a form of Colletotrichum coffeanum Noack II. Some factors affecting germination and infection and their relation to disease distribution. Trans. Bri. Mycol. Soc. 43 : 643-659.

Nutman, F.J. and Roberts, F.M. (1961) Investigations on a disease of Coffea arabica caused by a form of Colletotrichum coffeanum Noack III. The relation between infection of bearing wood and disease incidence. Trans Bri. Mycol. Soc. 44 : 411-521.

Okioga, D.M. (1976) Occurrence of strains of Collectorichum coffeanum resistant to benzimidazole-2 - ylcarbonate (Carbendazim) and chemically similar compounds. Annals of Applied Biology 84 : 21-30.

Okioga, D.M. (1977) Status of Bacterial Blight of coffee (Elgon/Solai die back) in Kenya. Kenya coffee 42 : 123-131.

Okioga, D.M. and Mulinge, S.K. (1974) 1973 trials with new and recommended fungicides, Kenya coffee 39 : 319-322.

Pereira, J.L. (1967) Use of fluorescent tracer for assessment of spray efficacy. Kenya Coffee 32 : 461-464.

Pereira, J.L. and Mapother, H.R. (1972) Overhead application of fungicides for control of Coffee Bderry Disease. Exp. agric. 8 : 117-122.

Pereira, J.L., Mapother, H.R.; Cook, B.K. and Griffiths, E. (1973) Redistribution of fungicides in coffee trees. Exp. Agric. 9 : 209-218.

Rayner, R.W. (1952) Coffee Berry Disease. A survey of investigations carried out up to 1950. East African Agricultural Journal 17 : 130-158.

Vermeulen, H. (1968) Screening fungicides for control of coffee Berry Disease in Kenya, Exp. Agric. 4 : 255-261.

Vine, B.H.; Vine, P.A.; Friffiths, e. (1973a) Evaluation of fungicides for the control of Coffee Berry Disease in Kenya. Annals of Applied biology 75 : 359-375.

Waller, J.M. (1971) the incidence of climatical conditions favourable to coffee berry Disease in Kenya Exp. Agric. 7 : 303-314.

Wallis, J.a. and Firman, I.D. (1967) A comparison of fungicides spray volumes for the control of coffee berry disease. Ann. Appl. Biol. 59 : 111-122.

Walyaro, D.J.; Van der Vossen, H.A.M. & Owuor, J.B.O. (1982) Breeding Arabica Coffee in Kenya for Resistance to Coffee Berry Disease. 1st Regional workshop on CBD, Addis Ababa 19-23 July 1982,

Proc. 1st Reg. Workshop " Coffee Berry Disease",
Addis Ababa, 19-23 July, 1982 P. 71 - 95.

COUNTRY REPORT:ETHIOPIA
COFFEE BERRY DISEASE IN ETHIOPIA

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PART I: BACKGROUND TO COFFEE PRODUCTION AND COFFEE BERRY DISEASE IN ETHIOPIA:

INTRODUCTION

Ethiopia lies in the north-eastern part of Africa (Latitude 4° and 18°N; Longi-tude 33° and 48°E) and has an area of 1.22 million Km^2 and a population of 31 million. About 80% or more of the total population are engaged in agricultural activities.

The country, in general mountainous, is characterized by a Central High Plateau (1,500m - 3,000 m.) above sea level. The Plateau disected by gorge and broad valleys covers about 40% of the central and eastern portion of the country. The other important physical feature is the Rift Valley which, with a series of lakes in its southern part, divides the country from northeast to south. As a whole, the topography of this country is variable ranging from below sea level (Dallal Depression)to about 4,500m (Peak of mount Ras Dashen).

The wide variation in altitude, climate and soils of the country has made possible the production of a large variety of crops and livestock. The main crops grown are:cereals (Wheat, barley, teff, sorghum) spices, pulses, sugar, cotton, oil crops, vegetables, coffee etc. Livestocl is another important agricultural activity in the country.

Of these, oil crops, cotton, vegetables, coffee and animal products (mainly hides and skin and meat) are exported. However, coffee is the major foreign exchange earner for the country.

BACKGROUND

Coffee is the single most important crop in the Ethiopian economy contributing over 60% of the nation's foreign exchange earnings. It also contributes more than 30% to the Government's direct revenue. About 25% of the population is engaged in coffee production, processing and marketing.

The total estimated coffee area in the country is 500,000ha. of which about 50,000ha is considered to be forest coffee (2). Nearly 90% of the total coffee is grown in the 5 regions of Kaffa, Sidamo, Wellega, Harrarge and Illubabor. The total number of peasant associations* engaged in coffee farming in these regions are about 3,500with a total of about 1.3 million member farmers. Total production at present is estimated to be 180,000 to 200,000 tons[(2)] with about 98% coming from the peasant sector and the rest from State farms.

Coffee production practices in Ethiopia[(3)]:

Coffee farming practices which are followed by the majority of the Ethiopian coffee farmers are of a traditional nature. Up to now the use of improved cultural practices and farm inputs is very limited, thus in many areas resulting in low yields.

The methods of coffee production in Ethiopia can be grouped as follows[(3)]:

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* All farmers are members of P.A. in Ethiopia

1. Picking coffee from the forest without any additional work. Although such areas still exist in some parts of Kaffa and Illubabor, they are decreasing in size due to new settlement, expansion of farms and the continuous destruction of the forest areas. The coffee obtained from such forests is below 5% of the toal production[(2)].

2. Semi-domestication of the forest coffee. This is also very common in Kaffa and Illubabor. In this type of farming, the forest shade trees are slightly thinned, the gaps left by dead coffee trees are filled with forest coffee seedlings and the weeds are slashed once a year to facilitate coffee picking.

3. Coffee planting following traditional management practices. Weeding is practiced about once a year, natural grown seedlings are used for planting; high density particularly in Kaffa, Wollega, and Illubabor is common usually more than 4,000 trees per hectare. Coffee fields in these regions are generally under heavy shade. Pruning, mulching and fertilizing is used very little. In Sidamo and Harrar, the coffee stand is low about 1,000-1,200 trees per ha but weed control is better.

4. Modern plantation following recommended cultural practices. The bulk of the Ethiopian coffee comes from (2) and (3). It should also be noted that in some areas specially in Kaffa and Illubabor, the combination of either of these systems does exist. However, the intensive extension approach at the peasant sector and the establisment of large farms the state sector is helping the country to have modern farms. With the on-going programme of the rehabilitation of old coffee trees and the relanting and planting of the new CBD resistant selections, improved cultural practices like row planting fertilizing, mulching and pruning are being introduced widely. At the present rate of implementation of this programme at both peasant and state sector, it can be said that the improvement of the country's coffee farms is in good direction.

The Ministry of Coffee and Tea Development :

(MCTD) is the responsible Government institution for coffee and tea industry in the country. Its major responsibility includes the development of coffee and tea production, processing and marketing.

MCTD has five departments at the headquarters in Addis Ababa Development and Co-operatives, Planning and Programming, Public Relations and Training, Inspection and Market Regulation and Administration.

The Development and Co-operative Department which looks after the peasant sector is responsible for the extension service and for the formation of co-operatives in the coffee areas. Under the same Department, there is the Coffee Improvement Project financed by EEC.

The Project's Major Components Are :

Provision of extension services and farm inputs, building of warehouses to co-operatives and construction of rural roads in the Project areas. The Project also provides finance to the Jimma Coffee Research Station* for the selection and propagation of CBD resistant cultivars. The Development Department currently working in 45 coffee districts has a total of 940 senior and other technical staff including those of the Project MCTD has branch offices in 6 Regions, 13 Provinces and extension staff in 72 districts.

Washed Coffee Project (not under the development department) is another Project financed by IDA. Its main task is the construction of pulping stations for co-operatives and rural roads to make the stations accessible.

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* The Station is under the Institute of Agriculture."

MCTD has also two Corporations for coffee and one Enterprise for tea namely Ethiopian Coffee Marketing Corporation, Coffe Plantation Development Corporation and Tea Development Enterprise.

The Ethiopian Coffee Marketing Corporation purchases and exports coffee. Currently it exports about 70% of the country's coffee, while the rest is handled by private exports.

The Corporation has 49 purchasing centres all over the coffee producing areas, 69 stores and 7 warehouses of a total capacity of 50,000 tons and 25,000 tons respectively. In addition, it has 100 coffee hullers[(4)]

The Coffee Plantation Development Corporation is responsible for the management of the state coffee farms. Currently, the total area of coffee state farms is 13,000ha.

The Tea Development Enterprise is relatively new to Ethiopia and the Enterprise which was established in 1979 for the production and marketing of tea currenty has two project areas with only 141ha. The plan is to have a total of 1,000ha under tea for domestic consumption in the coming five to six years.[(5)].

Major Problems of Coffee Production in Ethiopia[(6)]

Historically, Coffee in Ethiopia was growing and bearing fruits under natural conditions in the forest as is testified today by the presence of the remnants of such forests in many parts of South-West coffee growing regions expecially in the viscinty of Tepi, Bebeka, Geisha, etc.

The Exploitation of the forest coffee must have started centuries ago by fruit gathering after acquiring knowledge of the use of coffee. in course of time and as more experience was gained, it must have been followed by relatively more improved practices such as thinning of forest and slashing of weeds to facilitate coffee picking. These practices are followed even today in those areas where forest coffee still exists.

This historical background of the exploitation of coffee in Ethiopia has exerted great influence on the farmers attitude towards coffee culture. The fact that coffee was found growing wild in the forest and bearing fruits without the need of man's interference, has made many coffee farmers of such areas believe for a long time that coffee farming did not need as much work as the other agricultural crops like maize, teff, sorghum etc. Because of this attitude, production methods were and still are in many parts traditional: the use of forest seedlings, irregular spacing, no pruning, mulching or fertilizing, very little weed control etc. This problem, required from the part of MCTD skilful handling and systematic extension approach for the introduction of improved cultural practices. With this approach and the on-going development project, progress is being achieved towards the modernization of the coffee peasant coffee farms. The major coffee development projects for the peasant are: Coffee Improvement Project and Washed Coffee project which receive financial assistance from EEC and the World Bank respectively. Besides, MCTD is developing large scale coffee state farms.

Coffee Berry Disease (CBD) since its outbreak in 1971, has been causing a considerable damage, the loss in some areas exceeding 50%. The overall national loss due to the disease currently is estimated to be about 18% (Tables 1 and 2).

Shortage of trained manpower and in accessibility of some coffee areas are other problems that need to be mentioned.

Prospects for the Improvement of Coffee Production(3)

Ethiopia which has given to the world coffee arabica, has the climate and soil protentialities as well as a very wide variation in genetic composition of coffee types essential for the selection and breeding work to obtain coffee cultivars with desirable agronomic characters such as high yield, resistance to pests and disease, better quality etc. These natural factors potentially place the country in a favourable situation for the improvement and expansion of the coffee industry.

Realising the important role of coffee in the economy of the country and the prevailing favourable growing conditions, the Government has started to give much more attention than any other time to the development and expansion of the coffee sector.

Although limited in magnitude, the results so far obtained on the introduction of improved cultural practices in coffee areas through the extension services of MCTD are very encouraging. Farmers have started to accept stumping for rejuvenation of old coffee trees, applicationn of fertilizers, replanting and planting of selected seedlings in rows with recommended spacings etc.

Since 1979, MCTD has taken the responsibility of operating coffee state farms, the main activities bbeing to modernize the existing 8,000 hectares of old coffee farms and to establish new and modern farms in new areas suitable to coffee. From 1980 up to now, a total of 6,651ha of new coffee has been planted at different sites, 5,000ha being at one site (Bebeka).

The implementation of Coffee Improvement Project (CIP)since 1977 is having a good impact on the modernization of the peasant coffee farms though the introduction of improved cultural practices, provision of inputs like farm tools, agrochemicals and fertilizers; construction of rural roads and warehouses etc. EEC as part of its contribution to CIP is also providing the necessary finace to the Jimma

Research Station for the selection and propagation programme of CBD resistant coffee cultivars. The Coffee Processing Project (CPP) is helping to increase the production of high valued washed coffee by establishing new pulping stations and repairing or repmodeling the old.

Coffee Berry Disease In Ethiopia[7,8,9]

The outbreak of Coffee Berry Disease (CBD) in Ethiopia was confirmed in 1971 in four major coffee growing Regions (Kaffa, Illubabor, Wellega and Sidamo). By 1974, it had widely spread within these regions and by 1978, although the level of the damage varied from place to place, the disease was almost in all important coffee growing areas of importance in the country.

Coffee crop loss caused by CBD In Ethiopia[10]:

Coffee is grown in Ethiopia under different ecological conditions. A high level of genetic variability within farms, locations and regions is also characteristic of Ethiopian coffee. Under these varying conditions, the level of the production loss also varied from place to place.

In order to be able to quantify the crop loss,MCTD after developing a simple assessment method has come evaluating the loss since 1974.

Table I: Average National Crop Loss due to CBD

year	% Loss
1974-75	19.2
1975-76	18.6
1976-77	18.5
1977-78	18.2
1978-79	16.9

Table 2: Percent Crop Loss in Four Major Regions

Region	1974-75	1975-76	1976-77	1977-78
Kaffa	26.0	28.3	27.8	14.3
Sidamo	11.6	27.2	23.4	6.1
Illubabor	50.9	23.2	21.7	28.8
Wollega	24.7	24.2	24.5	31.5

Assessment method of coffee loss followed by MCTD[11]

As mentioned earlier, the spread of CBD in the country was very fast and the level of damage in many localized areas was considred very serious. In order to be able to quantify the loss, MCTD developed a method of assessment in 1974 and this method has been in operation since then.

The objectives of the asessment are, a) to evaluate the magnitude of the annual production loss, and b) to know the level of damage by region and localities for the purpose of planning control measures.

Coverage of the assessment:

The assessment programme covers all the coffee Regions, awrajas (provinces) and Weredas (the smallest administrative unit).

Assessment Method:

Prior to the commencement of the assessment work, sketch maps of the areas are prepared-roads, tracks and trails are litsted. According to road situations, some sections are covered by vehicles and others by mule or by foot. At each section along the roads, tracks or trails, starting points are selected. If the section is to be covered by vehicles, stops for assessment are made at every km from the starting point. If the section is to be covered by mule or by foot, the first point will be where coffee is sighted and thereafter observation will be made at a walking distance of 15 minutes.

A point can be considered effective, half-effective or ineffective. A point will be effective when there are coffee fields at the right and left side of the point within a radius of about 250m. It will be half-effective if there are coffee fields on one side only and ineffective if there are none at either side. If the point is ineffective, no assessment will be done. On the effective or half-effective points, qualitative observation at field and tree level as well as berry counting is carried out.

When the point is effective, two coffee fields at the right and two at the left side (a total of four fields) are taken. Regarding the location of the two fields at each side, one will be the nearest and the second the farthest from the point within the limit of 250 metre radius. If the point is half-effective, there will be only two fields either at right or left side.

After the fields are selected, field observation and berry count assessments are made as follows:

1. Field observation:

The assessment work is done by a team of 2 or 3 extension staff. Each team is assigned to carry out the assessment of given areas. To do the observation, the team will have a good look at the selected coffee field and make judgement of the berry damage level due to CBD and record in the schedules prepared for this purpose. The corresponding information in codes are shown below.

Table 3.

Description	Code	Range of loss
No loss	Record O	
Light	Record L	0 to 10%
Medium	Record M	10 to 30%
Heavy	Record H	30 to 50%
Very heavy	Record VH	50 to 80%
Nearly total	Record T	80 to 100%

2. Berry Count:

Two trees will be selected in each chosen field for berry count. One tree will be selected from the North-East corner and the second from the South Western corner of the field. For the location of the trees, one of the agents will walk ten steps along the length and then 5 steps inside. Then he takes the coffee tree of bearing age which is the nearest to the point reached. These will be the two trees in one field to be selected for the purpose of the berry count. Next, he divides mentally the tree in roughly three equal parts: P, middle and bottom. He will leave out the small fruitless branches at the top.

If the selected tree has many stems, two will be selected, one from the western and the other from the eastern side. On each stem, 3 pairs of branches will be chosen, one in the top another in the middle and the third in the centre of the bottom portion of the tree. If the selected tree has a single stem, then one branch from the western and another from the eastern side will be taken. These will be treatedc as two stems and the above procedures are followed. On each selected branch, damaged and good berries are counted separately and recorded in the schedule. Berries which are damaged by other disease or insects or dried because of die-back are left out of the count altogether.

Sample size:

The total length of roads, tracks and trials covered by the assessment work annually is in the average of about 2,000 kms. The fields for assessment (both effective and half-effective points) reach about 4,500. As two trees are selected in each field, the total number of selected trees is about 9,000 and since there will be 6 berry counts, on each tree the total number of count observation is of the order of 45,000.

Methods of CBD Control Followed in Ethiopia

After studying the experience gained in Kenya, MCTD and IAR agreed that both chemical spraying and the use of resistant cultivars must be considered as short and long term control measures respectively.

Based on this, it was decided for IAR to immediately start trials of chemicals and selection for CBD resistant cultivars and for MCTD to provide the necessary finance for the research work.

Chemical Control

Since the disease was new to this country, by taking advantage of Kenyan experience in the chemical control of CBD, IAR started trials in 1972 at two sites and MCTD in 1974 conducted large scale simple trials at 30 sites under different coffee farm and ecological conditions. The main chemical used in the trials of MCTD was Captafol (Orthodifolatan). Bavistin was also included in the trials but later on was dropped from the spraying programmes because of the resistanc developed by CBD to systemic fungicides as was observed in Kenya[12].

IAR's trials included other chemicals as well.
Dosages used in MCTD's trials:
Captafol: 2.2kg/ha. 3.0 and 4.4 kg/ha per application
Bavisting 0.50 kg/ha 0.750 and 1.0 kg/ha per application
Frequenchy of application was at intervals of 4 weeks.

Results of the trials:

Since Bavistin was discontinued from the spraying programme, mention will be made here only of the results obtained by using Captafol. Effective control was achieved with the dosage of 3.0 kg/ha at an interval of 4 weeks.

As the trials were in different places, the number of sprayings that were sufficient to control the disease per season varied from 5 to 7.

	63.6% of the trials had 6 sprayings
	27.8% of the trials had 7 sprayings
	16.7% of the trials had 5 sprayings
Total:	100.0%

For yield assessment of the trials, qualitative and quantitative assessment observations were made on the effectiveness of the chemical as follows:

1. Qualitative assessment: The extent of loss due to CBD in each plot was observed and recorded by the field staff as judged at the time of harvest. The information of the loss is expressed in codes shown on page 11.

2. Quantitative assessment: Consisted of taking records of the yields taken from treated and control plots.

Although the yields varied from place to place, in the average the increment due to spraying at the rate of 3 kg/ha per application was 276kg clean coffee per hectare.

Pilot Spray Programme [13]

The satisfactory results obtained from the spraying trial led the Ministry to carry out two Pilot Spray Programmes in heavily CBD-affected coffee areas. The first Programme was carried out in 1975 and the second in 1976.

Objectives of the Programme:

1. To train farmers in the use of spraying techniques and associated cultural practices.
2. To encourage farmers to participate in such programmes in the future.
3. To save coffee production to the maximum extent possible under this limited programme.
4. To assess the spraying programme under various field conditions and to make evaluations of the results.
5. To gain experience on logistics of such an Operation.

Coverage and Size of the Programme:

Borth programmes were carried out in the four major coffee regions affected by the disease. In the first Programme (1975), the total area covered was 1,150ha and in the second (1076) 4,100ha.

Organization:

The programme was planned and implemented by MCTD with the active participation of the owners of the farms which had been selected for spraying.

At the headquarters of the Ministry in Addis Ababa, the implementation, the technical control and directives were the responsibility of the Development Department , while the evaluation of the results was carried out by the Planning and Programming Unit.

The representatives of the Ministry at Regional and Provincial level co-ordinated, supervised and gave all the necessary administrative support to the extension agents.

The extension agents on their part were responsible for the selection of the farms, measurement of their areas, for supply of chemicals and sprayers to each farm etc. Also together with the supervisors, they trained selected farmers and the rural youth on the spraying techniques, supervision, car and maintenance of sprayers, handling of chemicals etc.

Criteria for the Selection of Farms to be Sprayed

1. Level of CBD damage during the last 2 years must be heavy 50% or above.
2. They must be in good coffee growing areas.
3. The area must be accessible throughout the duration of the spraying programme.
4. The yield potential of the farms for the year to be sprayed should be high.
5. The coffee trees must be technically suitable for spraying.
6. Water must be available throughout the programme in the farms or near the farms.
7. The farmers should be willing to co-operate with the field staff.

Assessment of the Spraying Programme: In each pilot programme assessment of the spraying result was carried out. The assessment consisted of qualitative and quantitative evaluation.

Each extension agent from amongst the farms under his juridiction (50-75ha) selected at random two coffee fields to carry out simple assessment trials.

For the qualitative assessment of the damage, the sprayed field was compared with the unsprayed field of the previous year as reported by the farmer. Out of the total of 3,885 fields sprayed under the first programme, the qualitative assessment of loss due to CBD was of the order of 60% in 1974 before spraying and 16.7% after spraying. The range of crop loss in the 3,885 fields after spraying was the following:

No incidence	12.4%
Light	46.7%
Medium	24.4%
Heavy	12.7%
Very heavy	3.8%
Total	100.2%
Average loss	16.7%

For the quantitative assessment in the first programme, there were a total of 47 trials for yield comparison between sprayed and unsprayed fields. Response to the spraying resulted in an additional yield of 615 kg/ha clean coffee. The overall yield from the treated plots was 977 kg/ha and from the control 362 kg/ha only.

Although the fields for the experiment were chosen at random, out of the total farms covered by the programme, their relatively high yield was not representatives of many coffee areas in the regions. These plots were very much more closely supervised, sprayed on time etc.

So far, the average increment of yield from the various spraying programmes except those of the trials (Page 14), is between 300 to 400 kg/ha clean coffee.

Large Scale Spraying Programme[14]

Because of the threat of CBD, it became necessary to launch a large scale spraying scheme as an interim crash programme, until resistant cultivars would be available.

Thus, following the experience gained from the previous chemical trials and from the two Pilot Spray Programmes, MCTD after consulting the experts of Research and of other instritutions organized a large scale spraying in 1977. Since then, the programme is in operation.

As was mentioned earlier, the chemical control in Ethiopia under the present coffee farming conditions has limited use for several reasons:

- The high cost of the chemicals compared to the low yields of most of the farms.
- The unsuitable conditions of many coffee farms for spraying because of very tallness of the trees (3 to 4m), the irregular spacing, density etc.
- The concern of MCTD about the possible effect of chemical spraying in large scale on the biological balance in the forest coffee, a balance which has been built up over centuries and is probably unique and which cannot be replaced once disturbed.

It was with serious consideration of the above points that the spraying programme was launched.

Table 4: Coverage and Size of the large scale programme from 1977-1980

Year	Number of Regions	Areas Sprayed
1977	5	12,936
1978	5	9,379
1979	5	12,470
1980	5	11,179

Organization, Criteria for the selection of the farms to be sprayed, and Assessment Methods are the same as those mentioned for th Piolt Programme.

Financing of the Programme

The major costs in the spraying programme are:

1. Cost of the chemical, sprayers and spareparts.
2. Farm labour, which is provided by the farmer themselves.
3. Operating costs-fuel and per diem for the field staff, transportation of material and some sundry expenditures. These costs and the salary of all the field staff involved in the programme were and still are being provided by the Ministry.

For the two Pilot Programmes and the first large scale spraying in 1977, the chemical was supplied free of charge to the farmers. From there on they have come paying part of the cost:up to 1980, 20%, 1981, 25%, and in 1982, 35%, of the actual cost of the chemical. The rest of the chemical cost was and is being provided by the Government in the form of subsidy.

MCTD obtained chemicals and sprayers in the form of a bilateral assistance from friendly nations and the European Economic Commission (EEC). The latter is still providing assistance in the form of chemicals and sprayers as part of its financial contribution to the Coffee Improvement Project.

The Economics of Spraying:

The assessment results obtained from the spraying programme carried out so far, show that farmers get in the average an incremental yield of 300 to 400 kg/ha (Page 17).

The increased production provides employment opportunities in coffee processing, transport, marketing etc. In addition to the direct benefit to the farmers, it contributes to the national economy in form of additional foreign exchange earnings and revenues from the various coffee taxes.

Planting of Resistant Selections to CBD

Because of the limited use of chemical control as mentioned earlier, it became necessary to start research work on the selection of CBD resistant cultivars almost immediately after the outbreak of the disease.

As a result of the big effort made by the Research staff and the availability of very broad genetic diversity of Arabica coffe in the country, the first phase of selection and propagation of CBD resistant materials was successful in a relatively short time. To date, 15 selections have been released for planting since 1977. The technical details will be explained by the Research staff in the course of this Workshop. The total area planted so far with the new selections is about 9,000ha.

REFERENCES

1. The Role of Coffee in the Economy of Ethiopia, MCTD, Publication 7, June (1978).
2. Kohll, D.R., Sample Census of Coffee Farms (1974-75to1976-77) MCTD, July (1981).
3. Yilma, Y.B., Prospects for Improving Coffee and Tea Production in Ethiopia, MCTD, March (1978).
4. Ethiopian Coffee Marketing Corporation (1982).
5. Tea Development Project (Ethiopia) March (1978).
6. Yilma, Y.B., Proposal For the Establishment of Coffee, Tea and Spices Training Centre, Sept. 14 (1981).
7. Dagnachew Yirgu (Dr.) and Yilma .Y.B., CBD in Ethiopia, Augst 11 (1971).
8. Mogk, M., Report on the Coffee Disease Survey in Ethiopia, 10 Sept. to 7 Oct. (1971).
9. Mulinge, S.K. (Dr.), Coffee Berry Disease in Ethiopia January(1972).
10. Planning and Programming Unit, MCTD, Four-Year Chemical spraying Project to control CBD from 1978-1981, January 3, (1977).
11. Planning and Programming Unit, Production Department, MCTD, Assessment of Loss Due to CBD (1974-75).
12. Okioga, D.M., Occurrence of Strains of Colletotrichum coffeanum, Resistant to Systemic Fungicides, Kenya Coffee, April (1975).
13. Porduction Department and Planning Unit MCTD, Pilot Spray Programmes in (1975, 1976).
14. Chemical Spraying Programme to Control CBD, MCTD October 10 (1976).

Bibliography

Gassert, W.L., Research in Coffee Berry Disease in Ethiopia (1979).

Van der Graaff, N.A. (1981) Selection of Arabica Coffee Types Resistant to CBD in Ethiopia.

Vermeulen, H. (1970) Coffee Berry Disease in Kenya.

PART II: RESEARCH ON COFFEE BERRY DISEASE IN ETHIOPIA

INTRODUCTION

Coffee berry disease (CBD) is a fungus disease caused by Colletotrichum coffeanum Noack sensu Hindorf. The fungus attacks all stages of berries but causes severe damage when it attacks green berries. The diseased berries of pin-head stages drop-off but large proportion of matured and diseased green berries, however, remains on the tree as black mummies if the tree is left undisturbed.

CBD was first observed in Kenya in 1922. It then remained confined for nearly 30 years after which it started spreading rapidly to nearly all coffee growing countries of Africa within 12 years period. In Uganda, the disease was noted in 1959, in Tanzania in 1966 and at present CBD is found in Rwanda, Angola, Zaire, Cameroon, and Ethiopia[14].

In Ethiopia, though the presence of C. coffeanum Noack was reported earlier in 1958 and 1959[3], the presence of CBD was not confirmed. Fernie[6], however, indicated by implication that krug[8] suspected the presence of CBD which Fernie at his later visit to Ethiopia refuted.

The epidemicity of CBD was first observed in Jne (1971) at many sistes simultaneously. The following year, the disease was observed in many parts of the coffee growing areas. In Hararge region, however, the epidemicity was confirmed in 1973[3]. A present, all the major coffee growing regions, Sidamo, Kaffa, Illubabor, Wollega and Hararge and the other regions, Shoa and Gamu-Gofa with the exception of the low altitude and isolated pocket areas are affected by CBD.

Coffea arabica L. is the only species of the genus Coffea grown in the country. Its diversity is so enormous that it grows in all regions of Ethiopia. Its genetic variabilities for various agronomic characteristics are also tremendous. Van de Graaff[14] stated that resistance to CBD was quantitative in nature basing his finding on hundreds of selections made for resistance to CBD. Mesfin[10] also after evaluating eight years data from National Coffe Collection randomly collected from different parts of the country for yield and resistance to CBD found high yielding resistant cultivars and the phenotypic variation of the population was continued for yield and resistance to CBD under field conditions.

Research Programmes

Coffee Berry Disease:

Knowing from experience the crop losses due to CBD and its impact on the Nation's economy, assessment of the degree of infection was initiated in 1971 at Wondo-Genet (1830m alt.) and Gera (1900m alt.), simultaneously. The following year, spray trials in the above locations were conducted using Captafol and from these trials, it was concluded that infection was high and six spraying starting in April and five spraying starting in may were most profitable at Gera and Wondo-Genet, respectively[1,2,3,4,5].

The first research programme on the fungus was carried in 1973[7]. The objectives of the programme were to study the spread and progress of CBD, sources of inoculum and ontogenetic changes in the susceptibility of the coffee berries to CBD. The programme was completed in 1975 with the following conclusions:

1. Large scale planting with [illegible] varieties caused rapid spread of CBD with human beings and animals being the vectors.

2. The increase of the disease intensities with the development of the berries of susceptible and less susceptible varieties and differences in the disease intensities at different sections of the trees and exposure of the trees to different directions were reported.

3. Barks of the coffee trees, mummified berries and twigs of the coffee were found to be the major sources of inoculum.

4. The ontogenetic susceptibility of the berries to CBD was established both for field and laboratory conditions.

Selection and Multiplication

In 1973, the Ethiopian Government realizing the danger of the disease and the constraints to coffee production embarked a priority project of selection and multiplication in collaboration with FAO and EEC through MCTD for staff, material and financial assistance. The purpose was to search for genetically stable and long-lasting resistant cultivars from the country.

The Institute of Agricultural Research conducted massive selection programme starting in 1973 and continued through 1975. During this period, 639 mother trees were selected and hundreds of progenies of each mother tree were raised and evaluated for resistance. Of the 639, 213 passed the first test and large progeny plots were planted with the resistant cultivars for further test and seed relase[14,15].

Summary of the major research results from the CBD resistant selection and multiplication programme is given below:

1. Variation for resistance to CBD in the indigenous coffee appears to be of quantitative nature[10,14].
2. Selection thresholds that will establish confidence for seed release were established using combination of different tests[14]
3. Methodologies for seedling inoculation test, detached berry test and field inoculation test were established after modification to fit our condition[14].
4. Chemical control of CBD by different fungicides was studied, and results were made available to the MCTD (Coffee Dpt, progress report 1974-81).
5. Useful studies on resistance to other diseases and pests and to yield potentials, quality and adaptability of the progenies were supplimented to the CBD programme and millions of seeds were issued for planting and replanting[3,14,15].

Breeding:

Two major breeding programmes firstly to study the advantage of hybridization of the CBD resistant cultivars with high yielding resistant cultivars and secondly to study the inheritance of CBD were initiated in 1977-78. The initial result from the first breeding programme was encouraging. Vigour for yield, stem diameter and length of 1st primary branches was expressed, significantly[9]. The initial result from the later programme will be reported in this workshop. It is believed that the combination of the results of the above two programmes has invariably suggested the use of hybrids to maximize production per unit area. This vigour can be exploited in as short a time as possible if the due attention is given to the project which will be submitted to the Min. of Coffee and Tea Development for the hybrid seed production.

Prospect of CBD Control

In consideration of the increasing cost of the chemicals currently in use for the control of CBD it is unlikely that we will make use of the chemical in the near future unless the existing coffee price fluctuation stops and coffee price increases parallel to the increasing cost of the chemicals. The situation becomes more pitiful for countries whose hard currency is dependent on coffee sales, particularly when the cost of the imported chemicals for the control of CBD per unit area exceeds that of the export value of coffee. Such imbalance of cost, may not occur as forseen here but, definitly, one will be abandoned for different other reasons. So we are only left with one indispensable alternative, and the alternative is to look for resistant varieties.

Varietal control is the only long-lasting means of controlling CBD. In this line, major break-through has already been made by identifying number of resistant lines to CBD and thanks to our mother land for offering us such great variabilities for making selection and urgent attention must be given to conserve the variability.Our next task is to study the genetic mechanism of resistance to develop long lasting varieties with broad genetic base to avoid complete break-down of genetic resistance to CBD.

REFERENCES

1. Anonymous (1972 Progress report for the period April 1971-March 1972, 63pp.
2. Anonymouss. (1973) Progress report for the period April 1972-March 1973, 106pp.
3. Anonymous ( ) Progress report for the period covering 1974-1981.
4. Anonymous (1974) Progress report for the period April 1973 to March 1974, 93pp.
5. Anonymous (1982) Coffee Department Research Review. 1981/82. Institute of Agriculttural Research, Addis Ababa.
6. Fernie, L.M. (1966). Some impressions of coffee in Ethiopia. Tanganyika Coffee News of Jan./[illegible] 11pp.
7. Gassert, W.L. (1979). Research on coffee berry disease in Ethiopia. German Agency for Technical cooperation, Federal Republic of Germany, 64pp.
8. Kru, C.A. (1969) World coffee survey. F.A.O. of the U.N., Rome.
9. Mesfin Ameha (1982). Heterosis in crosses of indigenous coffee <u>C. arabica</u> L. selected for yield and resistance to coffee berry disease. I.At first bearing stage (submitted for publication).

10. Mesfin Ameha (1981) Yield assessment of a collection of indigenous coffee C. arabica L. grown at Jimma Research Station. EJAS 2(2) (under publication).
11. Mesfin Ameha. (1981) Summaries of coffee research work in Ethiopia, SINET News letter.
12. Mesfin Ameha. (1978). Report on the spread of CBD and other problems of coffee in Harage. IAR, typed report.
13. Sylvain, P.G. (1958) Ethiopian coffee-Its significance to world coffee problems. Econ. Bot. 12:111-139.
14. Van der Graaff, N.A. (1981) Selection of Arabica coffee types resistant of coffee berry disease in Ethiopia. Mededelingen Landbouwbogeshool, Wageningen, the Netherlands, 110P.
15. White, R.G. (1980) Assignment report on coffee agronomy. Terminal rept. FAO of the U.N., 25pp.

Proc. 1st Reg. Workshop "Coffee Berry Disease"
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COUNTRY REPORT : UGANDA
COFFEE BERRY DISEASE IN UGANDA

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Coffee berry disease CBD caused by Colletotrichum coffeanum Noack is the most serious disease of arabica coffee at high altitude in Uganda. Most arabica coffee is produced between 5,500 ft - 7,500 ft (1,600 m - 2,300 m) in Eastern and Western regions of the country and a smaller area in West Nile. Under the climatic conditions prevailing in these high land areas, the disease can be extremely devastating, if not controlled and makes coffee cultivation unprofitable (Matovu, 1970).

The first confirmed report of CBD in Uganda was in 1959 at an altitude of 1,200 ft (1890 m) on the slopes of Mt. Elgon (Anon, 1959). It made its first apearance in the Western part of the country in 1962 at an altitude of 1,600 m. By the end of 1962, most arabica areas at high altitude were claimed, with the exception of West Nile, at least up to 1976 (Personal observation). The first advance towards low altitude areas was reported in 1972 at the foot of Mt. elgon at Bugusege Coffee Experiment Station (Altitude 1,400 m) (Anon, 1955-1971). Since 1977, the disease has been common on arabica coffee plots during the rainy season, at Kawanda Research Station (Altitude 3 924 ft : 1 196 m-) (Personal observation).

The climatic factors conducive to CBD in these high land areas are temperature and rainfall. Both areas experience heavy bimodal rainfall exceeding 1,500 mm annually. The two rainy periods are separated a comparatively dry period of two to three months, which begin in December to February and from mid June to mid August in the East and West respectively. The main rains come in February to March in the East and from mid-August in the West. The peak period for CBD during the main rainy season occur in April-May and in September-October in the East and West respectively. The minor rains are light and occur in August-September in the East and February-March in the West. During the rainy season, particularly the main rains moisture condition favouring CBD are more than enough. High humidity conditions with frequent mists during morning hours, which clear in the afternoons are common. Heavy downpours lasting sometimes for whole days are also frequent. Average temperature during the rains is 17 C and sometimes temperature can fall below 17 C.

In the lower areas frequent heavy rainfall with increased cloudiness accompanies by misty condition lead to a drop in temperature which is more suitable for CBD so that disease is able to affect these areas (Nutman, 1970).

This has been the case in a number of low altitude areas where arabica coffee is produced in Uganda, which led to the sudden appearance of CBD in areas where once it was not found such as Kawanda Research Station.

Since 1962, a number of CBD surveys have been carried out in the arabica growing areas in Uganda. These surveys however, did not give a comprehensive idea as regards the intensity of the disease. It became necessary to ascertain how much infection there was in the country (Matovu, 1970).

Between 1968 & 1970 another survey was done in the Eastern and Western regions during peak periods for the disease symptoms. This survey revealed that some locations were more heavily affected than others, and also that some areas the disease was widespread but not very serious. Where the disease was serious 73.5% infection was recorded. Where the disease was widespread 14.2% infection was recorded (Matovu, 1970).

The effect of disease on yield was estimated by Matovu (1970) to be 35.4% in the Western region and 50% in the Eastern high land.

There has been no recent yield loss estimates due to a number of factors. It is stressed here that the response in yield may not primarily come from the mere control of CBD. It comes largely from the improvement in the general management of coffee shambas. The general management of coffee shambas has declined. It is difficult to assess the impact of CBD on yield in coffee shambas which are not weeded, pruned or fertilised due to factors beyond the control of the farmers.

The 1969/1970 survey revealed that the incidence of CBD in Uganda was underestimated for a long time. Thus, it became necessary to initiate spray trials to assess the effectiveness of chemicals and to determine a suitable spray schedule. Since all the recommended arabica coffee varieties (SL 28, SL 14, and KP 423) are susceptible to CBD, chemical control measure became the only alternative. Consequently, a number of spray trials were carried out in the CBD areas. Among the chemicals tested Benlate (Benoyml 50% W.P), Captafol 80% W.P, and Perenox 50% performed best. Benlate was found more attractive because of its effectiveness against both CBD and leaf rust. The spray schedule below was also established.

The spraying is done by teams employed by the Department of Agriculture using hand operated hydraulic knapsack sprayers. The chemicals and equipment are purchased by Government. The spray teams are being revived after a period of slackness caused by shortage of chemicals, equipment and transport. These problems made it impossible to adhere strictly to the spray schedule.

Spray Schedule

First spray	At the beginning of the main rains in August-September.	At the beginning of the main rains in Feb-March
Second spray	One month (30 days) from the first spray	One month (30 days)from the first spray.
Third spray	One month (30 days) from the second spray.	One month (30 days)from the second spray.
Fourth spray	At the beginning of minor rains in Feb.-March.	At the beginning of minor rains in Aug.-September.

Name of chemical	Rate of spray Kg/ha	Number of sprays per year
Benlate (Benomyl 50% W.P)	1.0	4
Perenox 50%	5.6	6

As has been indicated earlier, the bulk of Uganda's arabica coffee is grown by the subsistence farmers on small plots ranging in size from about a quarter of an hectare to half an hectare and is normally interplanted with bananas, sometimes beans and peas. Management standards on these plots declined with shortages of inputs like hoes for weeding, pruning saws and fertilizers. Some farmers in spite of all these problems tried to keep good husbandry practices. However, a big improvement is expected soon as most farmers are now getting access to hoes, pruning saws and fertilizers. An increase in acreage of arabica coffee is expected due to the big increase in price of both arabica coffee and robusta coffee by government. Already demand for lanting materials has risen.

In has been of interest to note the CBD incidences on farmers's plots are lower than on a neighbouring government Coffee

Research Station, Buginyanya on the slope of Mt. elong (1,600 m) where there are over 14 hectares of pure stands of arabica coffee. The cultivation of a large acreage of arabica coffee seems to encourag the disease as it spreads very easily. Unlike on small isolated plots interplanted with bananas, probably the spread of the disease is hindered.

We have seen that CBD is wide spread in Uganda and causes appreciable crop loss. The only way of controlling the disease is by use of chemicals. Although acreage of arabica coffee had declined in the recent past, in the Coffee rehabilitation programme now in progress, arabica coffee is to be expanded and the old plots improved.

REFERENCES

Anon, (1955-66) Annual Reports of the Department of Agriculture, Uganda. 27-30 , 34-37.

Anon, (1967-71) Annual Reports of the Department of Agriculture, Uganda. 26-28 , 41-43.

Jameson, J.D. (1970) "Agriculture in Uganda", Oxford University Press,93-99.

Matovu, S. (1970) Annual Report : Coffee Research Unit for 1969/ 1970.

Nutman, F.J. (1970) Coffee Berry Disease. PANS Vol. 16 N° 2, June 1970.

Proc. 1st Reg. Workshop "Coffee Berry Disease",
Addis Ababa, 19-23 July, 1982, P. 103 - 121.

COUNTRY REPORT : TANZANIA
COFFEE BERRY DISEASE IN TANZANIA

By

J. Bujulu* and T. H. M. Kibani**

ABSTRACT

The United Republic of Tanzania with a population of 17.5 million people lies just south of the Equator and from 30° to 40° East. The country is primarily agricultural with 80% of her exports being accounted for by the agricultural sector. Coffee has for quite sometime been ranking number one on foreign exchange earnings but for over 17 years the industry has been hard hit by the most destructive disease to coffee in Africa; Coffee Berry Disease (CBD). The disease which is caused by a fungus Colletotrichum coffeanum has so far been recorded on Coffea arabica, where under favourable conditions it is known to cause more than 90% loss to individual farms. CBD has been found endemic in all Regions in the north eastern parts and one Region in the south, lying between 900 and 2,100 metres above sea level

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and with an average annual rainfall of about 1,700 mm. To date 63% of total hectarage under coffee has been attacked by CBD. This is a great threat to Tanzania's economy which is heavily dependent on agriculture since coffee exports account for over 45%.

Research on the control of CBD has been going on since 1966. Screening fungicides both in the laboratories and in the field has been the main activity for Plant Pathologists while Breeders have been engaged in trying to locate resistant varieties for crosses with high yielding and quality varieties which happen to be very susceptible. Breeding perennial crops like coffee takes a long time and so far little has been achieved in the field of CBD control. On the other hand, however, effective fungicides have been identified and recommend for use in this country. These include Captafol (Orthodifolatan), Dithianon (Delan), Chlorothalonil (Bravo 500), Cupric hydroxide (Kocide 101), Cuprous oxides (Perenox and Copper Nordox) and Copper Oxychloride (Bobox Copper). Since coffee inputs are prohibitively expensive, the government substantially subsidises them to enable all affected farmers to spray recommended fungicides with the right dosages and following proper intervals. This has helped in minimizing crop losses and reasonable yields have been so far maintained. While successful research on fungicides continues, it is recommended that efforts in breeding for resistance be intensified.

History of Coffee in Tanzania

Arabica coffee was first introduced into Tanzania in 1980. The first variety appears to have been Bourbon introduced from the Island of bourbon. It was reputed for having good liquouring but rather susceptible to Hemileia vastatrix the causative fungus of coffee leaf rust. In 1920, a variety known as Kent was introduced from India. This was known for its tolerance to H. vastatrix but it had poor keeping qualities.

Breeding work which followed thereafter revealed promising lines from both Bourbon and Kent varieties. N. 39 was outstanding among the former and KP 423, 162 and 532 from the latter. All four lines were then released to farmers for propagation.

Roubsta coffee (coffea canephora) is indigenous to Uganda North Western Tanzania and other neighbouring countries (Reyner, 1960). This species is until now extensively grown in North Western part of Tanzania-Kagera Region.

Farming System

Both Arabica and Robusta coffee occupy an area of approximately 195,000 ha. of which Arabica species accounts for about 75% (Anon., 1981). Most of this coffee is grown under the small holding system with only 5% on estates. Estate coffee is grown as monoculture with shade trees like Albizzia Maranquensis in between to reduce sunshine intensity. The rest which is grown by small holding farmers is intercropped with bananas (Musa spp.). Although yield per unit area is still very low averaging 319 kg/ha clean coffee, this figure is made worse by the banana coffee mixture which has no proper spacing leading to very low plant population (Table 2).

The United Republic of Tanzania with a population of 17.5 million people (1980) occupies an area of about 939,700 km² of which 2,700 km² are in the islands of Zanzibar and Pemba. The country lies between 1 and 11.5°S and then 30° to 40°E. It is estimated that the population growth rate is about 2.8% per annum while the average economy growth rate is at 4.8% (Anonymous, 1981).

Tanzania is principally an agricultural country with 80% of her total export being accounted for by agricultural commodities (Anonymous, 1977) of these coffee ranks first after cotton (Gossypium hirsutum) sisal (Agave sisalana) tea (Camellia sinensis) tobacco (Nicotiana tabacum) and many others (Table 1). Over the last five years, coffee exports have been contributing an average of 31% of the export total value (Anonymous, 1981). Manifestly, the role played by the coffee industry in Tanzania's development is regarded as unique.

Table (1) : Foreign Exchange Earnings in mill T. Shillings

	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81
Coffee	1282.7	1857.2	1303.3	1357.8	1513.0	1441.9
Sisal	227.0	352.7	333.6	-	-	-
Cotton	627.4	593.4	446.6	-	-	-
Cashew nuts	210.0	273.0	228.8	-	-	-
Tobacco	266.0	215.5	233.0			
Tea	134.5	117.8	168.0	-	-	-
Pyrethrum	23.7	25.1	20.7	-	-	-
Oil Crops	6.8	7.1	33.2			
Livestock	21.7	62.2	29.3	-	-	-
	2799.8	3598.6	2846.0	-	-	-
% Contribution by Coffee	45.8	51.6	45.8	-	-	-

Source : Speech by the Minister for agriculture Mr. J. S. Malecela M. B. while presenting his 1978/1979 Ministerial estimates to the Parliament.

Table (2) : Regional Coffee Production (Metric Tons) for the seasons 1974/75 - 1979/80 (Anon, 1981).

Region	Hactare	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	Mean	Mean Yield kg/ha
Kilimanjaro	65393	19987	20081	16508	17766	11382	13364	16515	253
Arusha	15700	3938	4396	5327	4312	4147	3787	4318	275
Tanga	5973	975	466	768	890	504	314	653	109
Morogoro	2116	608	488	332	430	383	325	438	207
Mbeya	26481	3898	5091	2823	3981	4792	4297	4146	157
Ruvuma	12082	3121	3250	2297	4155	4666	4231	3620	300
Kagera	57012	11808	12585	12911	13862	14873	16401	13740	241
Iringa	144	91	106	36	57	24	31	58	403
Mara Ukerewe	900	266	427	171	165	315	280	271	301
Kigoma	335	39	18	17	35	67	41	36	107
Private Estates	6073	5027	5768	4590	3948	6722	3503	4926	811
Acquired Estates	3305	2333	2683	2901	2288	1758	1294	2210	669
Total	195027	52082	55359	48681	51889	49633	47928	50931	319

Climatic Conditions

Arabica coffee which is susceptible to Coffee Berry Disease CBD thrives well at most of the slopes of famous Tanzania Mountains Like Kilmanjaro, Meru, the Usambaras, etc. Suitable area range between 900 and 1,800 metres above sea level (m.a.s.l.) receiving an average annual rainfall of about 1,700 mm within 125-150 rainy days.

Average air temperature and relative humidity range between 14-28°C and 69-85% respectively. Workable soils within these areas are free draining of lateritic clay or volcanic type with a pH ranging between 5.2-6.2 (optimum) or 4.6-7.5 at extremes.

Importance of Coffee berry Disease and Ecological Aspects

Coffee Berry disease CBD caused by a fungus Colletotrichum coffeanum was first identified in 1964 in a small village (Nyabohansi) of Mara Region along Lake victoria in North Eastern Tanzania (Critchett, 1966). Apart from arousing interest towards research on C. coffeanum which started thereafter, little attention was given to this unfortunate new disease report. It was in 1966 when CBD was reported and confirmed in villages around Mt. Kilimanjaro, and the following year in Arusha Region. Both zones are the most important coffee producers (about 55% of total produce). Thereafter, CBD spread very rapidly covering almost all villages in Kilimanjaro & Arusha regions lying between 1,200 and 2,100 metres a.s.l. (Bujulu, 1976). In 197[illegible], the disease was confirmed in Lushoto District (Tanga Region) and in 1977 it was confirmed in Mbinga District (Ruvuma Region), (Kibani, 1977). All three areas combined account for 63% of the entire coffee area (Table 2).

Colletotrichum coffeanum attacks buds, flowers and berries at any stage of development. It is also known to attack leaves and ripening coffee cherries, a condition known as brown bligh this fungus causes most losses to young expanding cherries of between 6 and 12 weeks after flowering (Muling, 1970). During severe attacks, such cherries rot and fall to the ground. Attacked buds and flowers are also destroyed, thus incredibly reducing yields. Mature cherries which on being attacked remain attached to the branches, become difficult to pulp and their quality becomes poor.

Conditions Favouring Attack

In order for a Colletotrichum coffeanum spore to germinate and infact, it must remain in a film of water for at least five hours during which temperatures must be in the range of 17-26°C (Nutman and Roberts, 1960 a & b). They later (1969) observed that CBD spreads more rapidly and becomes severe with increased rains accompanied by high humidity (Figure 2, Table 3 and 4). Conditions of this nature are very common in north eastern coffee zones of Tanzania between March and June. these months coincide with cherry development, hence high CBD incidence. Rainfall is not only required for spore germination but also for spore dispersal mainly through rain splush. Workers and other animals moving through coffee fields after heavy rains also assist in spore dissemination particularly from upper to lower parts of coffee bushes.

Table (3) : Coffee Berry Disease infection and total rainfall (mm) recorded at the Rombo experimental site (1968 m a.s.l.) Kilimanjaro Region, 1978-1981.

Year	Total Rainfall mm	% CBD infection
1978	2415.00	82.80
1979	2660.50	43.00
1980	1310.30	15.80
1981	2339.80	40.40

Table (4) : L.C. Mean monthly temperatures at 9.00 hrs in °C TPRI, Arusha

Year	Feb.	March	April	May	June	July
* 1975	20.8	20.4	18.9	18.1	16.5	16.0
1979	20.3	20.0	18.6	17.2	15.7	15.3
1980	19.9	20.6	19.8	18.1	16.1	15.7

* In 1975 there was a high CBD incidence (Bujulu, 1975).

Current Status of CBD in Tanzania

The North Eastern Coffee zone which accounts for about 46% of the entire coffee area (Table 2 and Fig. 1) is heavily infected by CBD. <u>C. Coffeanum</u> attacks almost all cultivars of <u>C. arabica</u> although with varying degrees. Both species which are widely grown in Tanzania, Bourbon and Kent, are susceptible to CBD albeit Bourbon suffers more losses.

Prior to 1972/73 when subsidies to coffee inputs were introduced in the CBD striken zones, the control of this disease was far from satisfactory. This was because pesticide prices were too high not only to small holder farmers (who are the majority) but also to Estate owners. Bujulu (1975) estimated losses to individual farms to be higher than 50% and had observed earlier that most peasants were replacing coffee with other crops. Nevertheless, since the economy of Tanzania was very much dependent on coffee, subsidies were quickly introduced to curb coffee abandonment. This programme together with intensified campaigns on better methods of spraying enable farmers to spray according to recommended schedules resulting in reduced crop losses to a more tolerable level.

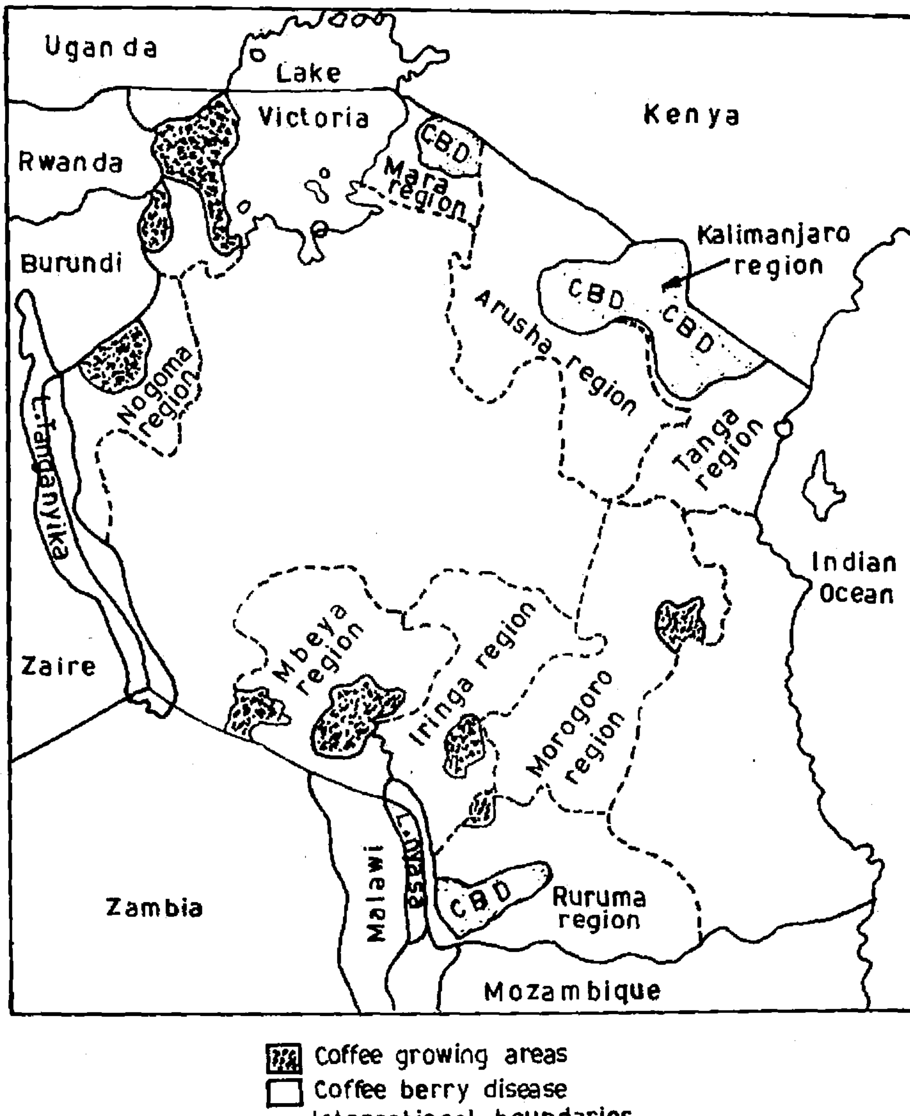

Fig. 1 : Distribution of coffee and CBD infected areas in Tanzania

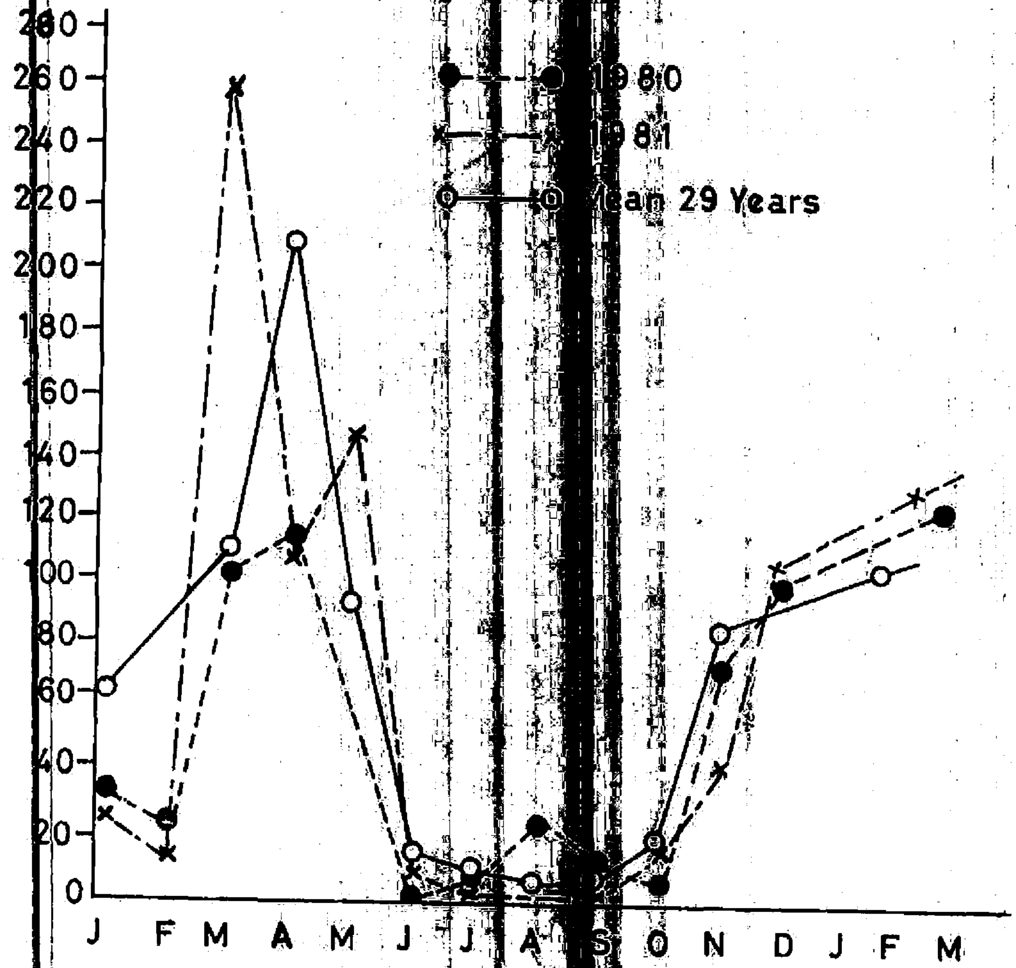

Fig.2. 1980–1981 monthly rainfall and mean for the last 29 years (1953–1981)

The years 1980, 1981 and 1982 received very little rain in form of showers during February and March (Fig. 2). It is during these months when cherries are rapidly expanding and hence very highly susceptible to CBD. Heavy rains starting towards the end of March (1981) find cherries at a stage regarded as partially resistant. Such dry spells have consequently contributed to the present reduced CBD incidence particularly in the medium altitudes (around 1,500 meters a.s.l.). At higher altitude however, (1,800 metres a.s.l.) CBD is still causing considerable losses mainly to farms which are not sprayed following schedule. It is estimated that out of the entire CBD zone, about 31% of the area is apt to heavy CBD infection if not proper measures are taken.

Crop losses caused solely by CBD at a national level is not easy to estimate. This is becuase in Tanzania coffee bushes have many more problems which contribute to reduced yields. These include coffee leaf rust (Hemileia vastatrix) insect pests like Leaf miner (Leucoplera caffeina) Antestia (Antestiopsis spp.) White Borer (Anthores leuconotus) Berry Borer (Hypothenemus Hampei) Berry moth (Prophantis smaragdina) etc. drought, lack of suitable fertilizers and general poor crop husbandry. However, observations made in experimental sites have shown CBD crop losses of varying magintudes (31-68%).

Methods of field Assessment of Losses Due to CBD

a. Experimental field : 20-25 trees per treatment are laid out in a randomised block design with four replicates. threee branches selected at the top, middle and bottom positions of each of the six or nine central trees are labelled for CBD assessment. Each month, total number of cherries and number of diseased berries per branch are counted; not removing diseased berries. Percent CBD infection is then calculated using the equation.

$$\% \text{ CBD} = \frac{\text{Total diseased cherries/18 or 27 branches}}{\text{total cherries/18 or 27 branches}} \times 100$$

All percentages are then analysed statistically. By comparing mean figures of the best treatment to the untreated plots mean per-cent infection within that field is then estimated. At the end of the season when yield figures of the best treatment are compared to those from untreated plots and transformed into yield per hectare crop loss is then determined.

b. Visual field assessment: At least five officers independently walk through a field assessing every 5th or 10th tree (depending on field size) by awarding the tree a percentage the officer deems fit.

At least 20 such awards are made. At the end, each officer totals his figures and divides by the number of awards to get the average. finally, all averages obtained by individual officers are totalled up and divided by the number of officers who took part (5) to give an average CBD infection of that particular field. Given the average actual yield (given by the Farm Manager). Crop loss is worked out by multiplying the normal average yield per ha. times per cent loss obtained by the above officers.

Effects of Farming System and Cultural Practices

Conditions favouring development of C. coffeanum as outlined earlier can be influenced by farming systems and cultural practices. In Tanzania, small holding coffee is planted at low population/ha., while estate coffee is generally planted at 2.74 X 2.74 meters. During early 1970s, farmers realized that they could increase coffee production per unit area by planting their coffee trees at a closer spacing of 1.87 X 3 metres. However, this same innovation had a direct influence on microclimate in favour of C. coffeanum. In addition spraying was made must more cumbersome and ineffective due to much foliage.

Heavy shading by traditional intercropped banana trees practiced by peasants or common shade trees like Grevillea robusta, Albizzia, Acacia and Prunus; species normally found in estates; and unsatisfactory pruning also create favourable microclimate to the CBD fungus.

CBD Control

Chemical Control

Studies on fungicides to control CBD started in mid sixtees mainly in the laboratory to establish effectiveness and dosage rates. Around 1967/68 when CBD gained ground field trials were established. By then researchers in the neighbouring Kenya had recommended copper based fungicides to farmers and were trying a new fungicide. Captafol (Ortho Difolatan). By 1969/70 Cuprous oxide (Perenox) and Captafol had been recommended (Bujulu, 1970). Thereafter, research was intensified including new systematic fungicides like Benomyl (Benlate) Carbendazim (Derosal and Bavistin). Up to 1976, the most effective fungicides were found to be Dersoal and Bavistin (Carbendazim) Red Copper-Perenox (Cuprous oxide) Captafol and to some extent Benlate (Benemyl). In 1977 however, Derosal and Bavistin were withdrawn by the manufactures after C. coffeanum had started building resistance to them (Bujulu, 1977 and Okioga, 1977) several new fungicides were introduced and hitherto CBD in Tanzania is being controlled by spraying fungicides given in Table 5.

Table (5) : Recommended fungicides for use against CBD in Tanzania

Rade Name	Common Name	Rate/ha (product)
Delan 75% w.p.	Dithianon	3.3 kg
Ortho difolatan 80%	Captafol 80	4.4 kg.
Kocide 101,77%	Cupric hydroxide	7.0 kg.
Bravo 500	Chlorothalonil	5.0 1
* Nordox Copper 50%	Cuprous oxide	5.5 kg.
+		
*Cobox Copper 50%	Copper oxychloride	5.5 kg.
Perenox 50%	Cuprous oxide	11.0 kg.

* Both fungicides tankmixed at half the rates.

Criteria for spray recommendation

Spray recommendations depend on spacing, plant morphology and type of fungicides currently in use. Close spacing increases plant population per unit area and therefore requires more spray volume than widely spaced coffee. Coffee plants with large canopies require more spray volumes to insure enough coverage. In Tanzania, the spray volume recommended are about 600 and 1000 litres per hectare for knapsack and tractor mounted sprayers respectively. Dual purpose fungicides are desirable in coffee areas affected by both CBD and leafrust. The frequency of chemical application is determined by the type of fungicide in use and the period between fungicide application and the following shower. Generally, if it doesn't rain immediately after spraying copper based and non-copper fungicides are sprayed at every 21 and 28 days respectively.

Spraying Timing

In Tanzania, CBD spraying commences just before the long rains, i.e. late January to mid February. During this time coffee is at pinhead stage, which is relatively resistant to CBD. Once started spraying continues at the recommended intervals until July. Leaf rust spraying carried out between September and December is always enough to protect coffee against early CBD attack.

Selection and Breeding Programmes

One of the best and most useful germplasm bank is at the Agricultural Research Institute Lyamungu - Moshi. It has three main groups :

i) Variety Collection : This group contains all early introduced varieties from all over the world.

ii) Hybrids : These were obtained from some of the varieties in group (I)

bourbon	X	Timor
Rume	X	Timor
Rume	X	Geisha
Bourbon	X	Kaffa
Bourbon	X	(Bourbon x Geisha) x Timor
Kent	X	Timor
Timor	X	Geisha
Bourbon	X	Rume
Kent H6	X	Timor
(Bourbon	X	Geisha) x Rume
(Bourbon	X	(Bourbon x Geisha) x Kaffa
Bourbon	X	(Bourbon x Timor)
Kent 5	X	(Bourbon x Timor).

iii) Ethiopian collection - over 600 types of C. arabica were collected from Ethiopia and although some types contain less than 10 trees, many of them have shown excellent characteristics. Breeding for resistance is a tedious excercise particularly for perennial crops like coffee. Notwithstanding, with such a useful germplasm, breeding specifically for CBD resistance has a very bright future.

Economics of CBD control

Crop losses caused by CBD are known to be tremendous and have been estimated to be as high as 100% (Okoga, 1978), 90% (Bujulu, 1977) and 80% (Javed, 1980 and Kibani, 1980). Prior to 1972, such high losses were being experienced on both small holding and estate farms because fungicides and other inputs were prohibitively expensive. This trend frightened farmers who then asked the government to subsidize coffee inputs. Realizing coffee's role on the country's economy, the subsidies were granted enabling all farmers within the CBD zone to follow the current recommended schedule.

In Tanzania, fungicides are purchased by the government through tenders. This method somehow reduces costings since manufactuers are forced to compete. However, large sums of money are spent annually on purchasing fungicides (Table 6) but since without spraying losses caused by CBD would be much more than the money spent on fungicides, this exercise will continue.

Reference to Table 1, the possible loss caused by not controlling CBD (Okioga, 1978; Bujulu, 1977; Javed, 1980 and Kibani, 1979) and Table 5, the Government gains more foreign exchange than it spends on buying fungicides.

However, from the farmer's point of view CBD control is a tedious excercise and very expensive. First, inputs which include sprayers and their spare parts (which are normally not available), pruning saws and the subsidized fungicides together are very expensive to the farmers, more so to the majority small holders. Secondly, spraying is difficult since critical spraying months are very wet necessitating spray reapplication if it rains shortly after spraying. Coffee prices are also not very favourable and therefore, farmers think that monetary gains realised from coffee sales are not satisfactory regarding expenditure and their labour.

Conclusion and Recommendations

Since Tanzania's economy is largely dependent on the coffee industry, coffee growing will remain a necessity to this country.

However, apart from other coffee problems like leaf rust and insect pests, CBD and world coffee prices are very demoralizing to coffee growers. There is very little though the Government can do to make coffee prices favourable to farmers, but a lot can be done to help farmers in combating diseases and insect pests. It is believed that the best way of eradicating diseases is breeding for resistance. It is therefore recommended that in addition to the encouraging subsidies, the government is offering to the growers, coffee breeders must be employed as soon as possible to make use of the Lyamungu germplasm in looking for CBD resistant varieties. Probably, an International CBD research Centre should be established to study this problem more efficiently since it will have less difficulties in getting experts and the much needed foreign exchange.

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REFERENCES

Anonymous (1981) Proposed Coffee Industry Development Programme. Coffee Authority of Tanzania, P.O.Box 732, Moshi, Tanzania.

Anonymous (1977) Annual Smut review for crops 1976/77. Kilombero Sugar Company.

Bujulu, J. (1970) CBD control in Northern Tanzania. Zonal Res. Conference for 1970, Lyamungu, Tanzania.

Bujulu, J. (1975) Control of coffee Berry Disease in Northern Tanzania E. Afri. Agric; for J. 42, 39-[illegible]

Bujulu, J. (1977) Chemical Control of Coffee Berry Disease in Northern Tanzania. T.P.R.I. Miscellaneous Report No. 963.

Crichchett, C.I. (1966) Lyamungu annual report for 1966 (unpublished).

Javed, Z.U.R. (1980) Effectiveness of new and recommended fungicides in controlling Coffee Berry Disease during 1979 Kenya Coffee 45. 535: 293-99.

Kibani, T.H.M. (1980) Control of coffee Berry Disease in Tanzania. Paper presented at the Coffee Res. Corrdinating Committee. Meeting Bukoba, Feb. 1981.

Mulinge, S.K. (1970) The Development of coffee Berry disease in Relation to be stage of Berry Growth. Ann. Appl. Biol. 65, 269-279.

Nutman, F.J. and roberts, F.M. (1960a) Investigations on a disease of Coffea arabica caused by a form of Colletotrichum coffeanum Noack I. Some factors affecting infection by the pathogen Trans. Brit. Mycol. Soc., 43, 489-507.

Nutman, F.J. and Roberts, F.M. (1960b) II Some factors affecting germination and infection and their relation to disease distribution I. bid. 43, 643-659.

Okioga, D. (1978) Effectiveness of recommended fungicides in controlling coffee berry disease. Kenya Coffee, 43, 19-24.

Reyner, R.W. (1960) Rust disease of Coffee 2 - spread of the disease. World Crops 12 (5) 18, 222-224.

PART III

TECHNICAL PAPERS

- The pathogen of CBD
- CBD Contorl.
- Economic and Other Considerations

Proc. 1st Reg. Workshop "Coffee Berry Disease",
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SOME MYCOLOGICAL ASPECTS OF THE COFFEE BERRY DISEASE PATHOGEN

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INTRODUCTION

Fungi belonging to the genus Colletotrichum are facultative necrotrophic pathogens or saprophytes commonly found on herbaceous plant material in moist climates. Many are rather week pathogens which can only assume aggressive parasitism of senescent tissuess such as old leaves or ripening fruit. They often persist as saprophytes on the leaf and twig surfaces of tropical plants and this is typical of the Colletotrichem populations occurring world wide on Coffee. Most of these can be regarded as conidial states of the ubiquitous saprophyte Glomerella cingulata (= Collecotrichum gloeosporioides).

The species Colletotrichum coffeanum (Noack, 1901) and Gloeosporium coffeanum (Delacroix, 1897) under which this fungus from coffee was first described are probably both based on C. gloeosporioides; Noack's material came from Brazil where CBD does not exist and coffee leaves were the source of Delacroix's material.

The CBD Pathogen

Some Colletotrichum spp. are readily defined on the basis of their morphologically distinctive conidia or other structures, but the Colletotrichum states of Glomerella cingulata are characterized by a very broad range of their morphological characters and cultural variability. On this basis, the CBD pathogen falls within this broad group, but its distinctive behaviour and cultural distinction of primary isolates on agar are sufficient characteristics to enable it to be clearly separated. Firman and Waller (1977) have reviewed this evidence.

The greenish grey cotton mycelium of fresh CBD isolates was recognised as distinctive by early workers such as McDonald (1926) and Rayner (1948) in Kenya, who coined the term C. coffeanum 'var. virulans'. Subsequently both Gibbs (1969) and Hindorf (1970) showed that the CBD pathogen was very distinctive and could easily be separated from other Colletotrichum isolates obtained from coffee which were not pathogenic to green berries. These characteristic primary isolates of the CBD pathogen are consistent characters from wherever it has been isolated and although forms with darker mycelium have been isolated from coffee in S. America, India and S.E. Asia none of them have the same characteristics as the CBD pathogen and in these areas the disease does not occur.

What is the relationship between the CBD pathogen and other Colletotrichum species? After several subculturings, CBD isolates revert to a white form indistinguishable from saprophytic Colletotrichum isolates, and it is this fact which has caused such confusion about its true taxonomic position. The situation was further confounded by Hocking et al. (1967) who claimed that the CBD form could not be distinguished on a morphological basis and was merely a segregant of Glomerella cingulata. Subsequent work, particularly that of Vermeulen (1970), could not substantiate this and the overwhelming evidence to date is that the CBD pathogen is not an asexual form of Glomerella cingulata, although there may well be an evolutionary link. the change in morphological characteristics of the pathogen when grown in culture are not unusual among fungi. Indeed, even primary cultures, with their floccose mycelium and lack of acervuli have a quite different form from the pathogen on diseased berries where discrete pale pink acervuli are formed. Agar culture media, rich in nutrients and permitting free growth with little physical or biochemical restriction allow the development and proliferation of forms best able to exploit this type of media. This change may occur by the alteration of nuclear ratios in heterokaryotic mycelia, by parasexual recombination of genetic material or by changes in characters determined by cytoplasmic inheritance. It is not necessarily associated with loss of pathogenicity.

Robinson (1974) suggests that the CBD pathogen was present in East/Central Africa, perhaps as a mild pathogen of wild diploid Coffea spp. when Coffee arabica was first grown there. It became important on cultivated Coffee arabica because this had evolved and was selected in the absence of the pathogen and thus lost any resistance to it that ancestral Coffea species may have passed on. CBD therefore represents a type of "re-encounter" disease (Buddenhage, 1977). Nutman and Roberts (1960) considered that the CBD pathogen was a mutation arising from saprophytic Colletotrichum form. In the sense that the CBD pathogen did evolve from a more unspecialized ancestral form during the co-evolution of Coffea and its parasites, there is some truth in this. There is no evidence that the CBD pathogen has been derived from the general Colletotrichum populating through selection pressure imposed by susceptibility to it of Coffea arabica berries, otherwise it would be expected to have occurred in areas where C. arabica had existed for a long time (Ethiopia) or where it has extensively grown (Brazil, S. Asia). Although the Colletotrichum population on coffee from these areas is very variable, none of the variants have shown the cultural and pathogenic characteristics of the CBD pathogen.

Variation in the CBD pathogen

Fungi belonging to the form genus Colletotrichum exhibit substantial morphological variation and even monoconidial isolates show a wide range of form when exposed to different cultural conditions. The CBD pathogen has been regarded as one distinctive type from this range of variability, but because of its originally very restricted geographic distribution cannot be regarded as a type that can be readily selected from the general range of Colletotrichum spp. Its apparently narrow host range and lack of a naturally occurring sexual phase indicate specialization to its particular ecological niche, which limits the need for further variation. Perfect (sexual) states are not known for many parasitic fungi imperfecti and those that are known are often rare or occur only during saprophytic survival periods. On tropical evergreen plants, such a survival stage is not required so that even biotrophic pathogens (e.g. Hemileia vastatrix) can dispense with them.

Necrotrophic pathogens do not require the intimate parasitic contact necessary for the more specialized biotrophic pathogens nor the complex virulence gene system that goes with it. Nevertheless, they do need to overcome active host defence mechanisms which are known to be affected by the physiologic state of the host, age of berry, previous fungicide treatment etc. There is no evidence so far that these host defence mechanisms have been rendered less efficient by increased pathogen aggressiveness. Certain arabica coffee cultivars such as Rume Sudan, Blue Mountain etc. have long been known to have resistance to CBD and there has been no breakdown of this; the Jackson hybrid grown in Rwanda since the 1940's still retains adequate resistance to Coffee Berry Disease. Thus, Robinson (1974) and Van der Graaff (1981) have concluded that resisttant to CBD is horizontal, at least its durability cannot be doubted so far. Will increased use of resistant varieties select more aggressive strains of the CBD fungus? This could happen but there is no reason to expect it. The CBD pathogen still has to survive in coffee bark and compete with other fungi in the colonization of ripe berries. We know this is a critical stage because reducing this microflora competition by using fungicides can increase CBD incidence. It may also be possible through nutritional manipulation of microflora to increase this competition.

One aspect of variation in the CBD pathogen has been its tolerance to fungicides. In common with many other pathogens exposed to the methyl benzimidazole carbamate systemic fungicides, tolerance developed rapidly after intensive use. However, tolerance to these site-specific fungicides, apparently mediated by a simple genetic substitution, should not be confused with the tolerance to host defence mechanisms which act both morphologically and biochemically to restrict pathogen development and its toxic effects.

Conclusion

We need to know much are about the CBD pathogen, particu- ularly its relationship to other Colletotrichum fungi. To what does it owe its peculiar pathogenic habits; is there a toxin or enzyme which can be detected biochemically in culture and used in diagnosis of the pathogen? How is the morphological change in culture related to pathogenicity and is it reversible.? The origin of the CBD pathogen is of special fascination to biologists. Why did it not occur first in the centre of diversity of C. arabica (Ethiopia)? Is this because it is really a primary parasite of some other rubiaceous host in C./E. Africa?.

REFERENCES

Buddenhagen, J.W. (1977) Resistance and Vulnerability of tropical crops in relation to their evolution and breeding. In the Genetic Basis of Epidemics in Agriculture. Ann. N.Y. Acad. Soc. 287 : 309-326.

Delacroix, G. (1897) Espèces parasites nouvelles, Gloeosporium coffeanum Nov. Sp. sur les feuilles vivantes du cafeier. Bull. Soc. Mycol. Fr. 13 : 110.

firman, I.D. and Waller, J.M. (1977) Coffee Berry disease and other Colletotrichum diseases of coffee. Phytopath. Pap. No. 20, C.M.I.

Gibbs, J.N. (1969) Inoculum sources for coffee berry disease. Ann. Appl. Biol. 64, 515-522.

Hindorf, H. (1970) Colletotrichum spp. isolated from Coffea arabica L. in Kenya. Z. Pflanzenkr. Pflanzensch. 77 : 328-331.

Hocking, D.; Johanns, J.C. and & Vermeulen, H. (1967) Ascospore production discharge and infection by Glomerella cingulat causing coffee berry disease. Nature, UK, 214 : 1144-1145.

McDonald, J. (1926) A preliminary account of a disease of green coffee berries in Kenya. Trans. Br. Mycol. Soc. 11 : 145-154.

Noack, F. (1901) Die Krankheiten des Kaffeebaumes in Brasilien. Z. Pflanzenkr. 11, 202.

Nutman, F.J. and roberts, F.M. (1960) Investigations on a disease of Coffea arabica caused by a form of Colletotrichum coffeanum Noack.

Rayner, R.W. (1948) Latent infection in Coffea arabica. Nature, UK 161 : 245-246.

Robinson, R.A. (1974) Terminal Report of the FAO coffee pathologist to the Government of Ethiopia. FAO, Rome. AGO/74/443.

Van der Graaff, N.A. (1981) Selection of arabica coffee types resistant to Coffee Berry Disease in Ethiopia. Med. Landbwhogeschool, Wageningen, 81-11.

Vermeulen, H. (1970) Coffee Berry Disease in Kenya. I & II. Netherlands J. Pl. Path. 76 : 277-284, 285-292.

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THE NATURE OF COFFEE BERRY DISEASE IN TANZANIA

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ABSTRACT

Young green berries with lesions, were studied in vitro. Using the dilution late technique, colonies of different fungal organisms appeared in Malt extract agar medium. These included Colletotrichum coffeanum, Colletotrichum acutatum and Fusarium stiliboides. The diametrical mycellial growth rates of the pure fungi were studied. Colletotrichum coffeanm exhibited fastest growth rate followed by Colletotrichum acutatum and by Fusarium stiliboides.

INTRODUCTION

In the coffee growing areas of Africa, large crop losses caused by diseases like coffee berry disease, leafrust and Armilaria root rot are quite common. In Tanzania, coffee berry disease affects coffee production to a magnitude of up to 90% loss if no control measures are effected (Bujulu, 1977 and Kibani, 1980). The disease affects buds, flowers, young and mature berries. The affected parts show up dark brown or black lesions symptoms.

Earlier studies conducted by Nutman and Roberts (1961) de,cnstrated a number of Colletotrichum species inhabiting coffee twigs. These were identified as Colletotrichum coffeanum; Colletotrichum acutatum; Collectotrichum gloespodioides and Glomerella cingulata, (Hindorf, 1970). Detailed morphological studies of these fungi, were conducted by Hindorf, 1970, 1972 who observed the mycelial and acervular forms of Colletotrichum gloeosporioldes and white mycelial forms of Glomerella cingulata. Colletotrichum gloeospordioides was also identified as conidial stages of C. cingulata (Hindorf, 1970).

The present investigation made on the nature of coffee berry disease in Tanzania demonstrated other associated fungal organisms apart from Colltotrichum coffeanum. These were identified as Coliotrichum acutatum and fusarium stilboids. These organisms were mostly identified on diseased berries with dark brown lesions.

Therefore, the purpose of this study was to observe other causes of disease lesions in arabica coffee berries.

MATERIALS AND METHODS

Thirty diseased young green berries with lesions were randomly collected from five sites of rombo, Moshi and Haidistricts of Kilimanjaro region in Tanzania. These were surface sterilized with mercuric chloride 0.1%, then washed with sterilized distilled water, placed on sterilized moist cotton wool in conical flasks and then incubated at room temperature.

After four days of incubation ten berries per specimen were vigorously shaken in 90 mls sterilized water in conical flasks. 1 ml of spore suspension wasl infused into malt extract agar medium using dilution plate technique.

Pure colonies were grown on malt extract agar and their rate of diametrical mycelial growth was measured.

Results

Results in Table 1 showed the type of fungi isolated from Coffee berry disease lesions. These included Colletotrichum coffeanum, Colletotrichum acutatum and Fusarium stilboides. The latter two fungi were mostly identified on diseased berries with dark brown lesions. Colletotrichum coffeanum was prevalent at all sites, while Colletotrichum acutatum and Fusarium stilboides were aslo widely observed on specimens collected from Rombo and Hai sites respectively.

Results on the rate of diametrical mycelial growth are shown in Fig. 1. Colletotrichum coffeanum exhibited fastest growth rate followed by Colletotrichum acutatum and Fusarium stilboides.

Table (1) : Occurrence and prevalence of the fungi identified on diseased arabica coffee berries.

Sites	Common fungi	Most prevalen fungi
Rombo	Colletotrichum acutatum Colletotrichum coffeanum Fusarium stilboides	Colletotrichum acutatum Colletotrichum coffeanum
Hal	Colletotrichum coffeanum Fusarium stiboides	Colletotrichum coffeanum Fusarium stilboides
	Colletotrichum coffeanum Fusarium stiboides	Colletotrichum coffeanum

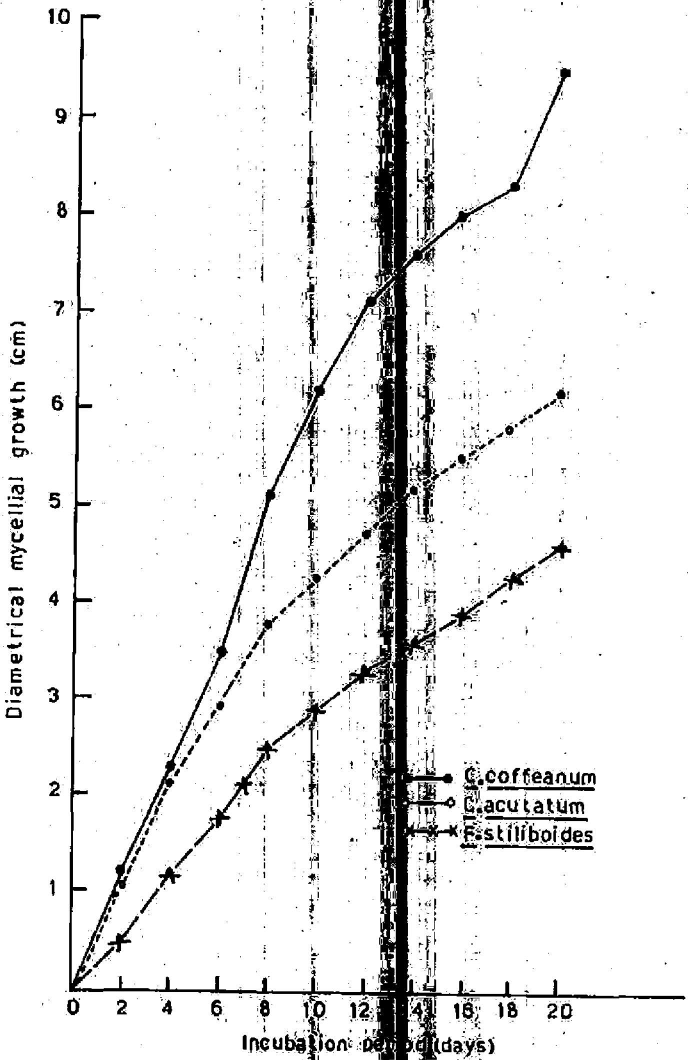

Fig. 1 : Diametrical mycellial growth rate of C. coffenum, C.acutatum and F. stilboides .

Discussion

It has been noted from the results that dark brown or black lesions in diseased arabica coffee berries are probably associated with a number of fungal organisms including Colletotrichum coffeanum, Colletotrichum acutaum and Fusarium stilboides. These fungi though have been found different in their growth habit yet it is believed that both organisms probably affect coffee berries. The magnitude of crop loss caused by these organisms could very depending upon many aspects including growth habit of the fungi, fungal response to chemical treatments applied and variations in weather conditions.

Therefore, the fastest growth rate given by Colletotrichum coffeanum could probably account for its prevalence over the sites. Notably, the other two fungi may sometimes express themselves depending upon their abundance in the coffee bark. This could be illustrated by an epidemiological studies on Colletotrichum coffeanum conducted by Griffiths, Gibb, Zaller (1971). The infection pressure by Colletotrichum coffeanum was also attributed to its abundance in the coffee bark.

Therefore, this successful isolation of fungal organisms from diseased berries could make a bright future for identification of dual purpose fungicides. These findings could also help in the determination of the disease forecasting models.

ACKNOWLEDGEMENT

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REFERENCES

Bujulu, J. (1977 Control of coffee Berry Disease in Northern Tanzania. E.A. Agric. forestry Journal 42 : 427-430.

Griffiths, E. Gibbs, J.N. and Waller, J.M. (1971) Control of Coffee Berry Disease. Ann. Appl. Biol. 67, 45-71.

Hindorf, H. (1970) Collatotrichum spp. isolated from coffea arabica in Kenya. Z. Pflkrankh Pflschtz, 77 : 328-331.

Kibani, T.H.M. (1980) Field evaluation of fengicides for Coffee Berry Disease control in Tanzania, Paper Pres. Annual Coffee Res. Conf. Tanzania.

Nutman, F.J. and Roberts, F.M. (1961) Investigation on a disease of coffea arabica caused by a form of Coll aptrichum coffeanum Noak. The relationship between infection of bearing wood and disease incidence. Trans. Br. My . soc. 44 : 511-521.

In some experimental trials, we saw that this theory was not good in the conditions of Cameroon where preflowering treatment appeared not efficient at all, as it was to expect; on the contrary, postflowering treatments were very efficient.

We studied the problem in Kenya[1] first in 1964 [2] and then in 1967, and we concluded in the paper we wrote at this occasion[3] that Nutman and Roberts had done three very great mistakes:

- firstly, they confound all the **colletotrichum** living in the bark of the branches with the CBD pathogen;

- secondly, they measured the production of spores on the bark in laboratory conditions in humid chamber and not in field conditions;

- thirdly, they completely forgot the role of the diseased berries in the production of spores.

Thanks to our study in Kenya, other studies were done in country by Hindorf and Gibbs; these studies confirmed our opinions:

- the bark of the branches contains mainly at least 5 species of colletotrichum, different from the CBD strain which is found only very scarcely in that tissue and not constantly (see the graph of Gibbs were the scale used for the CBD pathogen is 10 to 20 times greater than the scale used for the other species): in such conditions it is possible to doubt that this fungus is really deeply living in the bark tissue; even if it is true it is of very little importance in epidemiology, comparing with the role of the diseased berries themselves;

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(1) VERMEULENN H. Coffee Berry Disease in Kenya. Thesis, University of Wageningen, Holland, (1979), p. 25 and p. 95.
(2) First specialist meeting on Coffee Research, Nairobi, (1965).
(3) MULLER, R.A.: La lutte contre l'anthracnose des baies du caféier Arabica, due à une forme de collectotrichum coffeanum Noack au Kenya, Café-Cacao-Thé, Vol. XII, n°1, (1968).

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SOME CONSIDERATIONS ON EPIDMIOLOGY OF CBD IN KENYA AND CAMEROON, IMPORTANCE OF THE DISEASE, METHODS OF EVALUATION OF LOSSES

By

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INTRODUCTION

Studies of epidemiology of a disease are very important to definite a policy of treatment in a given country, depending on sources of inoculum, climatic conditions and phenology of the plant.

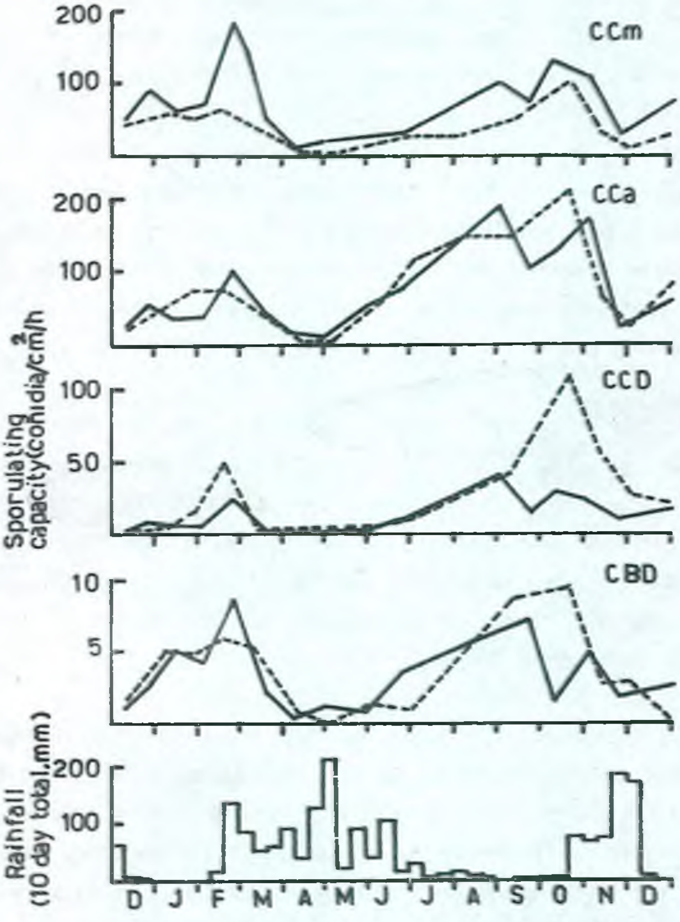
Concerning CBD, we personally studiedd that problem in Cameroon and alo in Kenya.

Sources of Inoculum:

Among the most important factors to be known in epidemiology, are the nature and the efficiency of the sources of inoculum.

Starting our studies in Cameroon in 1958, we were surprised to learn in the Kenyan literature, that, according to Nutman and Roberts "inoculum potential" theory, the main source of primary infection would be the bark of the branches where the parasite would be living without giving any damage but producing spores which infect the berries.

Counting the spores produced by the bark, (number of spores per cm² per hour) there authors gave curves showing that the production of spores was the most important during the dry season. Consequently, they advised the farmers to do chemical treatments during that dry period, before flowering.



After GIBBS (Kenya-1968)

Spores production on branches for the different strains of <u>Colletotrichum</u> on untreated trees——Kamundu 1—— Kamundu 2. The scale used for the CBD strain is 10 or 20 times greater than the others, showing that the production of CBD spores is very few. On the other hand ; the sporulation is maximum during the dry season showing that the observation in laboratory is completely different from the natural phenomenon.

- the diseased berries are the main source of infection during the campaign because they produce a very great number of spores (from 700 to 900 per cm^2 per hour according to Gibbs).

- but, as we explained in 1967, they are also the main source of primary infection in that country due to the fact that there are 2 flowerings (April and November) giving 2 corps (the early and the late ones) which berries are always coexisting on the branches along the year, the early crop being a very efficient source of infection for the late crop and vice versa.

On the other hand, it was shown in Cameroon that, among the possible sources of primary infection, the overlapping berries were a very important one. In Cameroon, due to the tropical climate of the CBD area-one dry season from November to late February, one rainy season from March to October-arabica coffee has only one importat flowering near the first of march and only one important picking period from November to January.

But it happens, all along the year, that some flowers come and give fruits. These fruits are never picked because they reach their maturity out of time, being too few to justify special pickings. It such fruits are not important in terms of production, they play an important role in the epidemiology, being infected by CBD in an important proportion, they are a kind of bridge for the fungus from one campaign to the following one, as it was shown experimentally (Table I). In plots where that overlapping berries were removed before flowering, CBD was slower to develop than in plots where they remained on the trees.

Table 1: Percentages of diseased berries 40 days after flowering

Blocks \ Plots	Plots without overlapping berries	Plots with overlapping berries
A	9,4	21,0
B	3,0	26,0
	6,2(*)	23,5(*)

It was concluded that, in the conditions of Cameroon, and in all countries with similar type of climate giving only one annual economical production, the overlapping berries occurring during the year without any economical importance, had to be removed at the moment of the last tour of picking. It is true that this is not sufficient to control the disease but it appears to be a very good auxiliary of the chemical treatment, by reducing and retarding the development of the primary infection. It is obvious that such recommendation may not be made in countries where, as in Kenya, 2 economical crops exist.

Among the other sources of inoculum, we think that the diseased berries remaining on the branches from one campaign to another, the disease berries fallen and remaining on the soil, the fungus staying in the peducles of the diseased berries remaining on the branches could be important.

We think that it is doubtful that the bark of the branches plays a very significant role-if any-as a source of CBD infection.

Evolution of the Disease in Cameroon

When CBD occurs in the french speaking Cameroon in 1958, study was immediately carried out to know:

- the true levels of the damages due to the disease which was necessary to decide of the opportunity cf fungicide treatments;

(*) Significant at P=0,01.

- the evolution of infection during the year in relation with the climatic conditions and the phenology of the plant.

This study gave some important information:

- quantitatively speaking, the rate of infection and the resulting losses appeared to be very variable from one placed to another during the same year, due to microclimatic conditions and to some other factors as importance of production, and also from one year to another for the same place, according to the annual variations of the climate. The losses may reach 80% or more of the production; considering that it is not possible to know if one year will be very favourable to the disease or not. Due to the fact that the efficient fungicides were only preventive, it was concluded that the disease presented a very high risk and needed to be systematically controlled.

- qualitatively speaking, it was shown that the evolution of the infection was always the same, independently of its amount. Infection (in terms of percentage of diseased berries in relation to the number of total berries at the moment of each observation) has three phases:

1. a phase of quick increase from the 6th to the 22nd week after flowering, corresponding to the expanding stage of the young green berry;

2. a phase of stabilization from the 23rd to the 32nd week after flowering, corresponding to the stage of stabilization of the size of the green berry: during this second phase, new lesions do not occur;

3. a new phase of increase (occurrence of new lesions) later on, during the premature and mature stages of the berries, but at this moment the damages are not important, the pulp of the berry only being rotted.

As a direct consequence, it was shown that the losses due to the diseased took place during the expandiñg stage of the berries. Later on, the losses were not important or of little importance.

According to these observations, it was concluded that the chemical treatments had to be done during the young stages of the berries that means during the first 22 weeks following the flowering and were completely useless later on.

Difficulty To Assess The CBD Losses In Epidemiological Studies:

For studies of epidemiology, we observed weekly a number of populations of berries, recording every time the total number of fruits, and the number of diseased and healthy ones.

It appears, during that studies, that it was not very easy to evaluate the losses due to CBD. This is due to the fact that the phase of main infection-and therefore, the period of main losses-is also the period of main physiological drops of the berries. When we observe-as we did-a given population of berries, it is difficult to know if the berries which disappear between two odbservations, were CBD-free (physiological drop)or not. Even, if the observations are done weekly and branch by branch, comparing the data recorded one week to those recorded the next one, it is impossible to avoid and over-estimation of the losses.

The only way to avoid this error is to mark each diseased berry by putting a little coloured thread around its peduncle with a very great care to avoid wounding or destructing that berries.

But this diffiuculty occurs only when one observes evolution of infection and losses on a previously fixed population of fruits, for epidemiological studies. In trials comparing the effectiveness of fungicides or other human interventions, the problem does not exist. If the plots are homogeneous and the trials with a sufficient number of replications, the results have to be mainly recorded in such cases. In terms of percentages of diseased berries on representative samples pickes montly, and finally in terms of weight of the yield.

Conclusion:

The studies we carried out in Cameroon and in Kenya have shown tat CBD is a disease of the young stages of the berries coniciding with a rainy period which allows the pathogen activity.

The main source of contamination is the diseased berries themselves as secondary sources as well as primary source. Comparing with the berries, the bark does not play a very significant role in the contamination.

A great care has to be done to assess the amount of losses due to CBD in studies of epidemiology because of the concidence of that losses and the physiological drop which affects the young berries at the same moment.

Ethiopia is the centre of origin and the centre of domestication of <u>Coffea arabica</u>. The history of the crop in the country is practically unknown. It was probably domesticated in the south and south-west of the country.

Coffee in Ethiopia occurs between 1,200 and 2,100 metres. Rainfall in the coffee areas varies between 1000 and 200 mm per annum; there is a marked dry season. The coffee occurs under four different systems (Institute of Agricultural Research, 1971) :

a. Forest coffee (60%), which is sometimes referred to as 'wild' coffee, but is exploited for many years. Self sown seedlings have been transplanted to give an irregular, but dominant understorey in the forest, which itself is secondary. The forest is mostly thinned.

b. small holder coffee (37%) plots of varying sizes around dwellings.

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RESISTANCE TO COFFEE BERRY DISEASE IN ETHIOPIA THE CBD PROGRAMME FROM 1972 TO 1979

By

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INTRODUCTION

Arabica coffee is growing on some 400,000 hectares in Ethipia. Main coffee growing areas are located in the south and south-western areas of the country, a relatively small and geographically isolated location exists in the east.

c. Semi-plantation coffee in the forest; seedlings raised in nurseries and planted, more or less regularly, in thinned forest.

d. Plantation coffee: plantations estabilshed on previously cleared land; the seedlings raised in nurseries and regularly planted; shade trees often planted.

Most of the Ethiopian coffee is a low input - low output crop. Due to this, production prices have always been among the lowest in the world. Ethiopian C. arabica is a traditional crop, which is in balance with its indigenous parasites.

In the late 60's, Coffee Berry Disease was introduced in Ethiopia(Muiinge,1973).It spread rapidly over south-western Ethiopia and by 1975 most of the area was probably infested. In 1978, the disease was also found in the eastern area of Harerge. Average losses due to disease amount to some 20 to 25% of the total crop (Van der Graaff, 1981). The losses on individual farms vary considerably; in high rainfall, high altitude areas, losses may reach 100%.

Although chemical control is presently used on a limited scale, it was quickly recognized that under the Ethiopian conditions resistance to CBD should be the main control method and therefore, a programme was begun to select resistant material. In this paper, the realization of the programme is reviewed up to 1979. A full acount of this work can be found in Van Der Graaff (1981).

The CBD Programme

As indicated before, Ethiopia is the gene centre for Coffea arabica. Coffee growing is still very much traditional and there is an enormous genetic variability in the coffee population. Such variability offered possibilities for the selection of resistant coffee types, especially as variability of resistance was already observed elsowhere (McDonald, 1932; Firman, 1964; Van Der Vossen, 1973; Hendrix and Lefevre, 1946).

In Ethiopia, a resistance programme was designed by Robinson (1974), FAO coffee pathologist in Ethiopia in 1973 and 1974, and was reviewed by Person (1974). As all grades of disease intensity were present in the coffee population, the working hypothesis was adopted that resistance was horizontal. Later, the programme was amended to include other diseases and pests, however, its basic structure remained the same. The programme consisted of :

a. Selection of mother trees; Selection of 500 to 600 trees with a very low disease intensity in areas with a high level of disease.

b. Planting of seedlings in nurseries; immediately after selection, seed was collected to obtain a sufficient number of seedlings for the establishment of a 1000 tree progeny block.

c. Observations and tests of mother trees; mother trees were observed for a maximum of four years. During this period notes were taken on CBD, other disease, pests and yield. Whenever possible, quality samples were prepared. The mother trees were inoculated in the field and tests were performed on their seedlings to determine their level of resistance with more accuracy.

d. After an evaluation of the tests and observations, progenies of approved mother trees were planted in progeny blocks of up to 1000 trees on a farm in one of the areas where the CBD intensity was very high. Furthermore, progeny trials were established at other locations in the country.

e. The disease resistance of the progenies was re-evaluated through field observations and tests. Observations on progenies were made through a visual estimation of the percentage of diseased berries and regular counts of diseased and healthy berries. Regularly, tests were performed on detached berries.

f. A separate programme was begun to develop and apply tests for resistance to a vascular wilt caused by Gibbderella xylarioides.

g. In progeny trials, observations were made on the severity of other diseases, pests, yield and quality.

h. A preliminary assessment was made to be able to distribute material. Based on data from the distributed material, the assessment will be updated at regular intervals.

The programme started in 1973 and the first seed distribution begun in early 1978. Funding was obtained from the Ethiopian Government, UNDP and, through the Ethiopian authorities, from EEC. A more detailed description is presented below.

1. Selection for Resistance

Individual trees without or with a low level of, disease were selected from areas where disease intensity was high. At selection, only trees were considered that had an above-average yield prospect and that had a low level of other diseases and pests. In total, 639 trees were selected in the period from 1973 to 1975.

2. Re-assessment of Resistance by Visual Observation

Each mother tree was regularly assessed for its level of CBD, other diseases, pests and yield prospects. Such observations were continued up to a maximum of four years. As a rule, a mother tree was discarded and not observed any more if more than 1% of the berries were diseased at the time of observation. At Gera, a location where many mother trees were selected, the population of mother trees was compared with non-selected trees during three years (Table 1). The disease intensity in the group of selected trees varied. Some trees had consistently more disease than others. The group of non-selected trees always had a much higher disease level than the group of selected trees.

Table (1) : Mother trees, visual disease assessment. Differences between the group of mother trees selected in 1975 and non-selected trees at Gera, one of the selection areas. The percentage of diseased berries per tree was estimated. In the table, the class in which the median observation fell is indicated.

n : number of trees
M : percentage class of the median value

Year of observation	Selected trees		Unselected trees	
	n	M	n	M
1976	57	0.1-1	653	11-50
1977	55	0	560	51-90
1978	55	0.1-1	555	51-90

3. Testing of Resistance of Mother Trees

The resistance of mother trees was further evaluated through inoculations in the field and tests on seedlings.

- Field inoculation tests : In the inoculations in the field, individual branches were sprayed with a conidial suspension. A number of branches on the same tree were used as relications of the experiment. Branches were covered with plastic for 24 hours to ensure the presence of moisture needed for conidial germination and for penetration of the cuticle. The number of berries before inculation and the number of healthy berries three weeks after inoculation were determined. More or less randomly, non-selected trees were chosen in the same area and from those trees, branches that were free of CBD were also inoculated. The experiment was repeated three times during the season; practically all experiments were on fully expanded berries. Some of the results of these experiments are collated in Table 2. As can be seen from the table, there were big differences between the group of selected and non-selected trees. Within the group of selected and non-selected trees, statistically significant differences were also found.

Table (2) : Mother trees, field inoculation tests. Mean responses of three consecutive tests, made on a group of mother trees and randomly chosen non-selected trees in 1976. Data are presented for three selection areas.

- n : number of tested trees
  x : fraction of berries dropped or diseased (angularly transformed).

Location	Mother trees		Non-selected trees	
	n	x	n	x
Gera	77	30	22	61
Jachi (Agaro)	28	31	29	62
Wushwush	13	16	11	37

Table (3) : Mother trees (Gera and coffee types ranging from susceptible to resistant (Jima). Kendall's rank correlations coefficients between field observations and responses in field inoculations, and between field observations and responses in seedling tests. The highest disease intensity in the field in the indicated period and the average response of three consecutive field inoculations were used for the calculations.

Field observation	field inoculation	Seedling test
Gera 1976-78	0.44**	0.27*
Jima 1975-76	0.68**	0.30*

Kendall's rank correlation coefficients between field observations and field inoculation tests are given in Table 3. The correlation between field observations and field inoculations was satisfactory. Certainly, there will be a bias in this correlation : the tests and the field observations were, in part, influenced by the same "site" effects. Thus, differences in the group of elected trees may, in part, be explained by microclimatogical differences between the individual trees. However, these cannot explain the big differences in response between the selected and non-selected trees; these are instead due to genetical differences. Thus, the test served well to discard a number of trees with an unacceptable level of susceptibility.

● Seedling Inoculation Tests : Testing of resistance in young seedlings was based on Cook's inoculation test (Cook, 1973 a,b; Markuru, 1976 and Van der Vossen et al., 1976). The test was adapted to local conditions (Van der Graaff, 1978, 1981) after which seedlings from practically all mother trees were subjected to it. Seedlings of a mother tree were raised in a number of boxes containing up to 100 seedlings per box. Two coffee types were included to serve as a reference. Seedlings were sprayed with a conidial suspension at or just before the unfolding of the cotyledons; a re-inoculation was performed after 48 hours. Boxes were kept closed 48 hours before, in between and 48 hours after the inoculations to maintain a high relative humidity and thus, to ensure infection. After three weeks, individual seedlings were graded according to lesion size and colour. It was soon found that the tests results varied according to the date of inoculation. To circumvent this problem, it was necessary to rearrange the scale from the 12 clases used in Kenya to five classes. In this manner, an acceptable level of additivity was reached, which made correction for the date of inoculation through the use of the reference coffee types possible and also made the data accessible to statistical analysis. Highly significant differences were found among the various mother trees and also among trees included as references. Nevertheless, the correlation between field observations and seedling tests was not very satisfactory (Table 3). The test did not satisfactorily discriminate at the resistant end of the scale, this, I believe, can to a lesser extent also be concluded from results published from Kenya (Van der Vossen et al., 1976).

4. Propagation

Selection thresholds were established through the comparison of the results of field inoculations, seedling tests and field observations. Coffee agronomists from the coffee research station propagated the selected and approved material. Up to 1000 progeny trees were planted per approved mother tree. The progeny blocks were planted at Gera, a farm established in an area where the disease intensity is among the highest in the country. In the period 1975 to 1978, 156 progenies were planted with a total of approximately 120,000 progeny trees. Replicated progeny trials were planted at Gera and at a number of other sites in the country. At least one of the sites is thought to be highly conducive to leaf rust.

5. Appraisal of the Resistance of the Progenies

The progenies were observed and tested to obtain information on the level of resistance and on the homogeneity of the resistance levels among trees within each progeny. The evaluation was made through :

a. Visual estimation at regular intervals of the CBD level of 100 trees of each progeny.

b. Berry countings at three week intervals on marked branches (one branch of each of 25 trees).

c. Tests on detached berries.

To ascertain the presence of the fungus, trees were sprayed with a conidial suspension one year before their first crop. This served to establish the fungus on the bark where it lives as a micro-epiphyte.

The percentage of diseased berries was estimated by visual observations. In many progenies, a small percentage of "off-type" trees could be identified with a high level of disease. In some progenies, these trees had other characters that marked them as "off-trees". These trees are most likely resulting from crosspollination.

In 1978, berry counts were made at three weeks intervals from the start of berry expansion (some six to eight weeks after flowering) to 21 weeks after flowering, when most of the epidemic was over. It was observed that a considerable drop of berries occurred from branches and trees on which no CBD was observed. This drop is probably an adjustment to the physiological status of the plant and is, therefore, termed "physiological drop". This drop, which amounted to an average of 21% in the observation period, varied considerably among progenies. By means of the observations made on branches without disease in each progeny, a correction was made for "physiological" drop. After correction, it was possible to calculate the percentage of damage due to CBD. In 1978, the loss percentage varied between 0 and 36 per cent. Counts made in 1979 revealed that damage was higher in more susceptible progenies, but remained low in those with a high level of resistance while losses were almost complete in unselected material in the same area. Furthermore, the berry counts indicated that relatively low percentage of disease in the visual observation, may already result in serious losses (Table 4 and 5).

Table (4) : The relation between visual assessment and crop losses in 1978. Visual assessment made on 11.8.78. Progenie-s that had their first crop.
Entries: Visual assessment: Percentage diseased berries.
n : number of progenies within class.
Berry counts : Percentage berries diseased and dropped due to CBD

Visual Assessment	n	Berry Counts	
		Average loss	Range
0	18	0.8	0-4
0.1-0-49	23	2.7	0.13
0.5-0.99	10	4.6	0.13
1.0-3.9	5	12.7	6-23
4	5	24.0	9.36

Table (5) : The relation between visual assessment and crop losses in 1979. Visual assessment on progrenies that had their second or third crop. Visual assessment 2nd week September; last berry counts second week August. Further explanations see Table 8. Data from Fekade and Meseret.

Visual Assessment	n	Berry Counts	
		Average loss	range
0	1	0	-
0.1-0.9	4	1.2	0-3
1.0-3.9	5	2.2	0-5
4.0-9.9	2	30.0	18-41
10	3	54.6	29.83

In detached berry tests, berries of progenies were arranged in boxes and inoculated. Boxes were then kept closed to ensure conditions highly conducive to CBD development. Each box contained 50 berries and represented one progeny, replications were made by using three or four boxes per progeny. The number of diseased berries was recorded until nine days after inoculation.

In preliminary experiments, it was determined that the susceptibility of small berries was high and variable, both in resistant and susceptible coffee types. In fully expanded, green berries, susceptibility was lower and less variable.

In the year the progenies had their first crop, detached berry tests were performed on fully expanded green berries at two to three weeks intervals. Susceptibility of the expanded green berries varied according to the testing date; there was a significant interaction between date of testing and coffee progenies. The rank correlation between field data and deached berry tests resulte are shown in Table 6. The correlation coefficients between the progeny means over one season and field observations are shown in Table 7. The correlation coefficients were relatively low, however, it should be realized that the data were derived from pre-selected material in which high levels of susceptibility did not occur. For example, higher rank correlations were obtained in later years, when a range of susceptibilities were used as references in the besting programme.

Criteria for distribution of selected material were determined based on visual field assessments, field observations and detached berry tests. "Off-types" were removed from resistant progenies.

6. Other Diseases and Pests

Arabica coffee was a relatively healthy crop before the introduction of Coffee Berry Disease. This is a condition to be expected from a traditional crop in its centre of domestication. Through farmers' selection, genotypes have been chosen that suffer only minor damage from diseases and pests in that location. Only, when the conditions of cultivation change, new diseases are introduced, or different cultivars with undue susceptibilities are grown, disease and pest outbreaks can be expected.

Table (6) : Progenies at Gera in 1977 and 1978. Kendall's rank correlation coefficients between the results of detached berry tests and disease severity (mean percentage disease from visual estimates) at 26.7.77 and percentage disease (berry counts) in 1978.
T. : date of the detached berry test.
// : Kendall's rank correlation
*, ** : p (T = 0) = 0.05 resp. 0.01

T			
-	-	3.05.78	0.17*
17.05.77	0.38	23.05.78	0.20 *
31.05.77	0.53*		
15.06.77	0.31	13.06.78	0.21
28.06.77	0.60**		
12.07.77	0.42*	4.07.78	0.20*
28.07.77	0.46*	26.07.78	0.34**
10.08.77	0.67**		
24.08.77	0.42*		

Tabel (7) : Progenies at Gera in 1978. Kendall's rank correlation coefficients among disease incidence (number of trees with CBD), disease severity (mean percentage disease from visual estimates), percentage CBD determined through regular berru counts and responses in detached berry tests averaged over a number of consecutive tests. Number of progenies per entry varied between 48 and 57. All correlations were highly significant (P 10^{-3}). Data according to Van der Graaff (1981)

	DBT	Severity (berry counts)
Disease incidence	0.32	0.41
Disease severity (estimates)	0.36	0.42
Disease severity (berry counts)	0.35	-

As disease and pest "pressure" varies from location to location in Ethiopia, it is also to be expected that resistance to those varies. New coffee types will be grown over a wider range of ecological conditions than the populations they were selected from. Furthermore, the cultivars are expected to be managed differently. Although all effects on diseases and pests cannot be foreseen, it is of paramount importance to release only those progenies for distribution that have a good resistance level against other diseases and against pests. Methods to obtain an insight in the disease and pest resistance levels will be indicated in the following sections.

Gibberella xylarioides (vascular wilt) : On Arabian coffee, the disease is only known to occur in Ethiopia. The pathogen causes a typical vascular wilt. The trees die slowly; I estimate that it takes at least a year between initial infection and death. Blackish stroma are formed on the bark at the collar of the tree. Mature ascospores are probably only found on dying or dead trees. Sporulation possibly only occurs at the end of the rainy season. At that time, ascospores can also be found on stumps of trees that have died one or two years earlier. The disease is more severe under modern cultivation. This may be caused by more intensive weeding and subsequent wounding of trees. Wounding either facilitates the direct transport of inoculum from tree to tree or opens venues for infection. Differences in susceptibility to vascular wilt were found in a coffee collection at Jima research station (Van der Graaff and Pieters, 1978). Differences were determined through the use of a grid in which the occurrence of tree death's in groups of four trees of one coffee type was compared with death in groups of four trees in which each tree represented a different coffee type. Based on these observations, two different tests were devised (Pieters and Van der Graaff, 1980). A seedling test was used in which seedlings were inoculated by knicking the seedlings with a knife that had been dipped in a conidial suspension of Fusarium xylarioides. The latent period (e.g., the time between inoculation and death of the first seedling) and percentage of dead seedlings per test were then determined. These data correlated well with field observations. A second test was devised in which the percentage of conidial germination was determined on freshly exposed cambial layers of twigs. Germination correlated well with field data (Table 8 and 9).

In both tests, resistance appeared to be a quantitative character. Differences in horizontal pathogenicity were discovered among various isolates.

Bases on field observations and test results, tentative selection criteria were determined and all material was selected accordingly.

Table (8) : Results of field observations, germination tests and seedling tests. Test results and least significant differences for P = 0.05 were taken from large experience :

Line	Field observation[1]	Germination test[2]	Seedling test: death rate[3]	Seedling test: incubation period[4]
F 24	0	[illegible].84	9.16	211
F 18	3	[illegible].96	14.46	128
F 5	15	[illegible].39	13.95	120
SN 10	18	[illegible].25	30.98	140
SN 4	19	[illegible].19	26.24	90
F 54	25	-0.87	23.02	145
SN 9	29	-0.60	23.37	139
F 9	59	-0.33	35.47	86
LSD		0.48	22.00	29

1. Mean percentage dead trees in collection in the period 1968-1976.
2. Percentage germination in logits.
3. Death rates six months after inoculation, in angular transformation.
4. Number of days between inoculation date and appearance of the first dead seedling.

Table (9) : Correlation between test results and field scores and among test results. (From Pieters and Van der Graaff, 1980).

In parentheses, degrees of freedom
All correlations are significant at P 0.01.

	Field score	Incubation periods	Death rates
Germination test	0.80 (11)	0.67 (12)	0.71 (10)
Death rates after 6 months	0.74 (10)	0.65 (23)	
Incubation periods	0.73 (12)		

- Leaf rust (Hemileia vastatrix), leaf blight and stem dieback (Phoma tarda), blotch leaf miner (predominantly Ceucoptera caffeina), brown eye spot (Cercospora coffeicola):

In trials conducted in various parts of the country, quantitative differences in disease and pest intensity were observed among progenies. They included differences in leaf rust, leaf blight and stem dieback, and in the infestation level by a blotch leaf miner. It was possible to prove that these differences were statistically significant. When the coffee types were grouped according to the provenance of their mother trees, differences were found to exist between provenances (Table 10). These differences can certainly be related to climate, Metu being wetter than Washi and Washi receiving more rain than Agaro and surroundings. This trend can be extended to material from Harerge province, an area with certainly much less rain than any of the three indicated in the table. Coffee types from that area are much more susceptible to leaf rust and leaf blight. At present, the differences in leaf rust intensity are more systematically studied through leaf disk tests (Critchett, pers. comm.), and further field observations.

In the course of studies at Jima Research Station, It was found that statistically significant differences in intensity of attack by Cercospora coffeicola existed among coffee types from Harerge. Coffee types from Western Ethiopia showed a very low level of Cercospora both at Jima and at other locations in Western Ethiopia, thus indicating a sufficient resistance level.

To observations in the progeny trials allowed to discard material with suceptibility to leaf rust, leaf blight and leaf miner.

Table (10) : Susceptibility to diseases and pests and the provenance of mother trees. Data from progeny trials at Metu (leaf rust), Gera (blight) and Agaro (leaf miner). The progenies were visually scored for the percentage of leaves showing symptoms. The data were grouped according to the provenance of mother trees of the progenies; in the table, the mean values per provenance are shown. In each row, data marked with the same letter did not differ significantly. Data according to Van der Graaff (1981).

Disease	Provenance		
	Metu	[illegible]ashi	Agaro
Leaf rust	1.3 a	[illegible].8 a	4.1 b
Blight	0.9 a	2.8 b	1.6 b
Leaf Miner	16.8 a	24.8 b	29.1 b

7. Yield and Quality

I expect others to make statements on the yield and quality aspect of the CBD material. I believe that a pragmatic approach is needed. If one wants to grow coffee in areas where CBD is the limiting factor to production, obviously only the resistant material can be grown.

8. The Nature of the Resistance to CBD

Because coffee is a perennial crop, it is of the utmost importance to obtain an indication of the durability of its resistance. Without doubt, the chance for durability is much greater when resistance is horizontal than when it is vertical. These terms are used here to define the following situations :

Horizontal resistance is quantitative - its expression depends on the conditions for disease development; polygenic or oligogenic - a rather continous variation occurs in the host population between full susceptibility and complete resistance; non-specific-differential interactions between components of the host and of the pathogen populations are at a low level or absent.

Vertical resistance is mostly qualitative - quantitative resistance does occur but it is rare; monogenic or oligogenic - variability in the host population is discontinous specific - interaction between elements of the host and of the pathogen populations is differential, being due to a gene-for-gene relationship.

The proof for the horizontal nature of resistance is elusive and full proof can probably never be given as its definition is negative. Nevertheless, the resistance can be compared with its descriptors.

Quantitativeness; in all tests and observations made in the course of our study on CBD resistance, quantitative results were obtained. Practically, all mother trees showed some disease in the field. For example, out of 55 trees selected in one location, 47 showed some disease in the period 1975-1978. Field inoculations invariably produced disease, though lesions on the more resistant trees often relapsed to inactive "scab" lesions. In seedling inoculation tests, a gradation of disease resistance was observed. Quantitative results were always obtained in detached berry tests on progenies. Where highly resistant mother trees were tested in detached berry, the results were also quantitative.

Specific differential interactions were studiedd in seedling and in detached berry tests. In one case specificity was suspected and special detached berry tests and seedling tests were made to elucidate this. Significant differences were found among coffee types and among inocula, but interactions were not significant. In a detached berry test made with three isolates and 38 resistant progenies of mother trees, differences were not observed among isolates, but considerable differences existed among coffee types. In the latter experiment, differences remained quantitative and no real inversions of resistance occurred. It is likely that the interactions were caused by other confounding factors like differences in homogenity of the growth stage among batches of berries and differences in the genetical homogeneity of the progenies from which the berries were collected. This will result in differences in standard error between coffee types and may thus produce an apparent specific interaction between host and pathogen. Comparable interactions were, for example, found in experiments in which progenies were inoculated with three inocula that differed in conidial concentration.

Studies on the inheritance of CBD resistance have been performed in Kenya. There, the seedling test was used to interpret the results of crosses (Van der Vossen and Walyaro, 1980). It was concluded in those studies that the resistance was caused by a few "major" genes. I, however, have serious doubts about these interpetations and I believe that the authors were seriously confounded by scaling effects. A thorough review of the issue is in press (Van der Graaff, 1982).

In Ethiopia, genetical studies have also started (Mesfin Amha, personal communication). I hope initial results will be presented at this workshop. A preliminary observation should be indicated. In progenies with a satisfactory level of resistance, some susceptible trees were laways observed. Other progenies showed a gradation in disease intensity. The variation in disease internsity within a progeny will, apart from microclimatological variation, depend on the homozygosity of the mother tree and on the frequency of progeny trees derived from naturally cross-pollinated seed. Due to the susceptibility of most of the coffee population, cross pollination will result in an unacceptable level of susceptibility.

Summarizing, resistance is quantitative and little indication of specificity has yet been found. Although some doubts remain, it may be assumed that resistance is horizontal.

CONCLUSIONS

In Table 11, the selection procedure is indicated. While, most selection criteria were arbitrarly, the selection was rather strict which was possible due to the large numbers involved. Seed distribution started in 1978 and I expect that further information on the numbers of seeds and the performance of seedlings will be provided during this workshop.

Much remains to be done. I believe that long term research is needed on the nature and inheritance of CBD resistance. In this respect, I believe that research is needed on the scope of the seedling test. The test is of paramount importance, but I believe that the method should be changed to make comparisons at the lower end of the scale more meaningful.

The material at present distributed in Ethiopia needs a further long term assessment to identify those types that are best adapted to specific local conditions or have a wide adaptability.

Concerning diseases like leaf rust and other leaf diseases, long term field observations are needed to screen out varieties with an undue susceptibility. It may be possible to establish a type of reporting system in this respect. The work on Coffee leaf rust is to be backed up by laboratory work to determine the types of resistance involved.

Further selection of resistant genotypes is needed to identify superior coffee types and conserve the genetical variability.

Although many problems remain and secondary problems are likely to develop, these problems should be measured with the yard-stick of the originally overwhelming problem that brought part of Ethipia's coffee industry to the brink of diseaster. In this light, I believe the decision of the Ethiopian authorities to embark on the crash programme can hardly be overvalued. I am grateful to Ethiopia and my Organization that I have been able to contribute to this programme.

Table (11) : The steps in the selection and testing programme for CBD resistance.

Selection criterium	Fraction discarded
Selection of mother trees :	± 0.995
Discarded/lost/dead before seed was collected	0.31
Observation and testing :	
CBD	0.81
Leaf rust	0.49
Leaf blight	0.44
Vascular wilt	0.40
Blotch leaf miner	0.34
Total observation and testing	0.96

REFERENCES

Cook, R.T.A. (1973a) Work in progress in coffee research. Series III, Part IV. Detecting disease resistance in coffee plants, Kenya Coffee, 38 : 275-277.

Cook, r.T.A. (1973b) Screening coffee plants for CBD resistance, Coffee Res. Found. Kenya Annual Rep., 1972/73 : 66-68.

Cook, R.T.A. (1975) Sccreening coffee lants for resistance to CBD. Coffee Res. Found. Kenya Annu. Rep., 1973/74 : 64.

Firman, I.D. (1964) Screeing of coffee for resistance to Coffee Berry Disease, East Afr. Agric. For. J., 29 : 192-194

Hendrickx, F.L., and Lefevre, P.C. (1946) Observations prèliminaires sur la résistance de lignées de Coffea arabica L. à quelques ennemis, Bull. Agric. Congo, 37 : 783-800.

Institute of Agricultural Research; Jimma Research Station (971) Progress report for the period April 1971 to March 1972, Addis Ababa.

McDonald, J. (1932) Annual report of the Senior Mycologist for 1931, Kenya Dep. Agric. Annu. Rep. 1931 : 118-130.

Mulinge, S.K. (1973) Coffee Berry Disease in Ethiopia, FAO Plant Prot. Bull., 21 : 85-86.

Murakaru, G.N.W. (1976) Influence of age of coffee seedlings on infection by Colletotrichum coffeanum (Noack) (Glomerella cingulata (Stonem.) Spauld & Von Schrenk), Kenya Coffee, 41 : 55.57.

Person, C. (1974) Consultancy report on the Coffee Berry Disease programme at Jimma Research Station, FAO, Rome.

Pieters, R. and Van der Graaff, N.A. (1980) Resistance to Gibberella xylarioides in Coffea arabica : Evaluation of screening method Neth. J. Plant Pathol. 86 : 37-43.

Robinson, R.A. (174) Terminal Report of the FAO Coffee Pathologist to the government of Ethiopia, FAO, rome, AGO/74/443.

Van der Graaff, N.A. (1978) Selection for resistance to Coffee Berry Disease in Arabica coffee in Ethiopia. Evaluation of selection methods, Neth . J. Plant Path., 84 : 205-215.

Van der Graaff, N.A. (1981) Selection of Arabica coffee types resistant to Coffee Berry disease in Ethiopia, Med. Landbouwhogesch, Wageningen, 81-11.

Van der Graaff, N.A. (1950) The principles of scaling and the inheritance of resistance to Coffee Berry Disease in Coffea arabica, Euophytica, 31 in press.

Van der Graaff, N.A. and Pieters, R. (1978) Resistance levels in Coffea arabica to Gibberella Xylarioides and distribution pettern of the disease, Neth. J. Plant Path. 84 : 117-120.

Van Der Vossen, H.A.M. (1973) Plant breeding, Coffee Res. found., Kenya Annu. Rep. 1972/73 : 54-56.

Van der Vossen, H.A.M., Cook, R.T.A., and Murakaru, G.M.W. (1976) Breeding for resistance to Coffee Berry Disease caused by Colletotrichum coffeanum Noack (Sensu Hindorf) in Coffee arabica L. I. Methods of preselection for resistance, Euphytica, 25 : 733-74[illegible].

Van der Vossen, H.A.A., and Walyaro, D.J. (1980) Breeding for resistance to Coffee Berry Disease in Coffea arabica L. II. Inheritance of the resistance, Euphytica [illegible]: 777-791.

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RESISTANCE OF THE F_1 TO COFFEE BERRY DISEASE IN SIX PARENT DIALLEL CROSSES IN COFFEE

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ABSTRACT

The six cultivars of coffee (Coffee arabica L.), R_1 and R_2 (highly resistant and resistant), R_3 (intermediate/fairly resistant), R_4, R_5 and R_6 (susceptible), deliboratelv selected for this study were crossed to produce a complete diallel set of F_1 s for the study of the reaction of the F_1s and inheritance of resistance to coffee berry disease (CBD). Detached berry tests were conducted to compare disease severity.

Differences between treatments were highly significant, where as reciprocal differences of the F_1s for resistance to CBD were not significant ($P = 0.05$). Distributions of percentage susceptibilities were significantly skewed to the resistant direction (Sk_1 = -3.65, -3.70 and -3.28, -3.50 for the 1981 and 1982 data, respectively). Dominance was isodirectional with the favourable gene for resistance being recessive in character. Partial to complete dominance of the susceptible genes to the resistant genes was consistently found and three to five major genes of an additive nature were suspected to be involved in the control of resistance to CBD in the population studied.

INTRODUCTION

Coffee berry disease (CBD) caused by the fungus Colletotrichum coffeanum Noack Hindorf is the major and the most widespread disease of coffee (Coffea arabica L.) affecting coffee production in Ethiopia. The disease can attack all stages of berries causing crop losses of up to 100% in Harar cultivars when the coffee is grown under a climate favourable to CBD.

Since the out-break of CBD in 1971, significant achievement had been made in selecting highly resistant cultivars to CBD. To date, over 15 selections were identified for possessing high levels of resistance to CBD. From these selections, millions of seeds have been released for planting and the level of resistance of their progenies under plantations were as stable as their parents.

The study of inheritance of resistance to a disease is very essential in variety improvement but until 1980 no work had been reported on the inheritance of CBD resistance. Recently, however, Van der Vossen and Walyare in Kenya studied the inheritance of the disease using Rume Sudan and Pretoria as resistant parents. They concluded that Rume Sudan and Pretoria had two resistant genes each. Rume Sudan, however, under our conditions was considered less resistant than our more resistant

Coffee berry disease distribution over the Randomly collected National Coffee Collections was of a quantitative nature indicating the presence of large number of genes for resistance to CBD. Subsequently, it was reported that partial to complete dominance for resistance was observed from the first year detached berry test and field observation data and resistance seemed to be controlled by recessive gene.

Information on the phenotypic variabilities of the F_1 to CBD and the inheritance of the disease at least must be obtained in order to initiate a breeding programme. Our major objectives, therefore, were to see the reaction of the F_1 to CBD and to determinewhether the inheritance of resistance is controlled by dominant or recessive genes while our ultimate objective was based on this work and also the work at Kenya based on the result of the study of heterosis in indigenous coffee, to embark a seed production programme.

Material and Methods

The six cultivars, R_1 and R_2 highly resistant and resistant , R_3 (intermediate/fairly resistant), R_4, R_5 and R_6 (susceptible), deliberately selected for crossing constitutes the population of our indigenous coffee types exhibiting range of resistance to CBD. Complete diallel crosses among the six cultivars and parental selfings were made in February (1978) and the resulting seeds were planted in plastic bags in glasshouse in February (1979). The seedlings were transplanted in July (1979) at two locations, Gera and Melko with a two meter square spacing. Plots consisted of one row with three and two seedlings per plot at Gera and Melko, respectively. The experiment was a randomized complete block design with three and two replications at Gera and Melko, respectively. Only the Gera data were used in the analyses while the Melko plots were used for seed supply. Trees were allowed to grow into one single stem with all suckers removed whenever initiated and all other cultural practices were uniformly applied to all plots.

Each tree was inoculated with CBD' spore suspensions in July and August of 1980 and 1981 to establish the spores on the bark for the following year infection. All data were taken from individual rees except for the detached berry test (DBT) and seedling test where whole plots were used. Green berries and seedling were inoculated with spore suspensions using the method as described by Van der Graaff.

Data obtained included percentage infection of the berries in DBT, field test and seedling test. Only the DBT result is reported here, however, since all tests had essentially the same results. Statistical analyses were made on plot means after the data were transformed into arcsine. For the estimation of the probable number of genes associated with resistance, frequency distributions were ploted for three, four, six and twelve genes after observation were tallied into clases of eqaual intervals but only distributions for four and six genes are reported. Grades 1 to 5 and 1 to 7, 1 being highly resistant and 5 and 7 being highly susceptible, were assigned to four and six gene estimation, respectively. Pearson's First Coefficient of Skewness (Sk_1) was used to see the significance of the distribution.

Statistical analysis was made using Griffing's Method 1 to see the significance of the reciprocal differences. Deviation of the hybrids from the mid-parent (MP) and the susceptible parent (SP) were calculated and significant tests were made using L.S.D. 0.01 and 0.05 on difference between the hybrids and between the hybrids and the theoretical mid-parent values.

Results and Discussion

There were highly significant differences among the treatments for resistance to CBD (Table 1). Differences between reciprocal crosses and between maternal and paternal effects were negligible confirming that the significant treatment differences (which were essentially the interaction between the lines) were a true reflection of the genotypic differences of the lines for resistance to CBD.

Hybrid and parental mean susceptibilities and per cent susceptibilities of the hybrids over the theoretical mid-parent and

and susceptible parent values for class five and seven are shown in Table 2 and Table 3, respectively. Under class five mean susceptibilities of the hybrids in 1981 and 1982 were 1.72 and 2.17 for resistant x resistant; 2.44 and 2.41 for resistant x intermediate; 4.04 and 4.02 for resistant x susceptible; 4.06 and 4.13 for intermediate x susceptible and 4.17 and 4.60 for susceptible x susceptible. A similar trend of increasing susceptibilities was noted under class seven. The hybrids, resistant x susceptible, were significantly susceptible to their respective mid-parent values except in R_1 x R_6 and R_1 x R_5 in 1981 and 1982, respectively in both classes. Mean deviations of the F_1 S from the susceptible parents were not significant except in R_1 x R_5 in 1982.

Table (1) : Mean squares from the analyses of variance for the F_1 hybrids and parentals over two years.

Source of variation	df	Mean squares 1981	Mean squares 1982
Blocks	2	1675**	1163**
Treatments	35	1187**	1060**
Error	70	129	107
Total	107		

** Significant at the 0.01 probability level.

Results of detached berry tests on individual plots of the hyprids for the 1981 and 1982 seasons are summarized in Figure 1. Distributions were significantly skewed in the resistance direction (SK_1 = -3.65, -3.70 and -3.28, -3.50 for the 1981 and 1982 data, respectively). The modal classes in both years were five and seven. The negative skewness of the distributions under class five were somewht gradual whereas the negative skewness of the distributions under class seven were slightly undulating and the undulation was increasingly pronounced for distribution above class seven. This suggested the absence of major genes above clas seven for resistance to CBD.

Table (2) : Hybrid and parental means susceptibilities to CBD and percentage susceptibilities of the hydribds over the mid-parent (OMP) and susceptible parent (OSP) in 1981 and 1982 in 15 mean of reciprocal crosses after percent susceptibilities were classed and grades one to five were assigned.

Identification	F1 mean value using 5 class		0/0 susceptible			
			CMP		OSP	
	1981	1982	1981	1982	1981	1982
Resist. x resist.						
R1 x R2	1.72	2.17	+34	+39	+29	+30
Resist. x interm.						
R1 x R3	2.39	2.11	+53	+ 9	+26	-14
R2 x R3	2.50	2.72	+55	+32	+32	+11
Resist. x suscep.						
Rs x R4	4.39	4.39	+61**	+41*	+ 4	- 8
R1 x R5	3.73	3.60	+46*	+13	- 4	-27*
R1 x R6	3.61	[illegible].84	+33	+38*	-14	- 7
R2 x R4	4.62	[illegible].22	+66**	+31*	+ 9	-12
R2 x R5	4.95	[illegible].22	+51*	+31*	+ 2	-12
R2 x R6	3.95	[illegible].95	+42*	+37*	- 6	- 4
Interm. x suscep.						
R3 x R4	4.44	[illegible].67	+45*	+29*	+ 5	- 2
R3 x R5	3.89	[illegible].17	+35*	+16	0	-13
R3 x R6	3.89	[illegible].56	+27	+ 9	- 8	-13
Suscep. x suscep.						
R4 x R5	4.34	4.[illegible]4	0	+ 5	/	- 2
R4 x R6	4.23	4.[illegible]7	0	+ 5	0	- 2
R5 x R6	3.94	4.[illegible]8	- 3	+ 7	- 7	0
Parental						
R1	1.22	1.[illegible]4				
R2	1.33	1.67				
R3	1.89	2.[illegible]				
R4	4.22	4.[illegible]				
R5	3.89	4.[illegible]				
R6	4.22	4.[illegible]				

L.S.D. 0.05 and 0.01 = 0.98 and 1.39 for 1981 columns, respectively, and 0.99 and 1.41 for 1982 columns, respectively.

Table (3) : Hybrid and perental mean susceptibilities to CBD and percentage susceptibilities of the hybrids over the mid parent (OMP) and susceptible parent (OSP) in 1981 and 1982 in 15 mean of reciprocal crosses after percent suscptibilities were classed and grades one to seven were assigned.

Identification	F_1 mean value using 7 class		0/0 susceptible OMP		OSP	
	1981	1982	1981	1982	1981	1982
Resist. x resist.						
R1 x R2	2.28	2.61	+28	+30	+21	+12
Resist. x interm.						
R1 x R3	3.34	2.61	+54	+ 4	+37	-22
R2 x R3	3.33	3.61	+62*	+27	+36	+ 8
Resist. x suscep.						
R1 x R4	6.00	5.94	+46**	+42**	- 5	-11
R1 x R5	5.12	4.89	+37*	+17	- 8	-27**
R1 x R6	4.78	5.28	+18	+42*	-23*	- 9
R2 x R4	6.39	5.78	+60**	+28*	+ 1	-13
R2 x R5	5.28	5.84	+46*	+29*	- 5	-12
R2 x R6	5.67	5.39	+44**	+33*	- 9	- 7
Interm. x suscep.						
R3 x R4	6.34	6.45	+44**	+29*	0	- 3
R3 x R5	5.11	5.56	+28	+11	- 8	-17
R3 x R6	5.54	4.67	+26	+ 2	-12	-19
Suscep. x suscep.						
R4 x R5	6.00	6.00	+1	-10	- 5	-10
R4 x R6	5.84	6.51	- 7	+ 4	- 8	- 2
R5 x R6	5.50	6.67	- 7	+ 7	-12	0
Paretal						
R1	1.89	1.67				
R2	1.67	2.34				
R3	2.44	3.33				
R4	6.33	6.67				
R5	5.56	6.67				
R6	6.22	5.78.				

L.S.d. 0.05 and 0.01 = 1.18 and 1.67 for 1981 columns, respectively and 1.19 and 1.70 for 1982 columns, respectively.

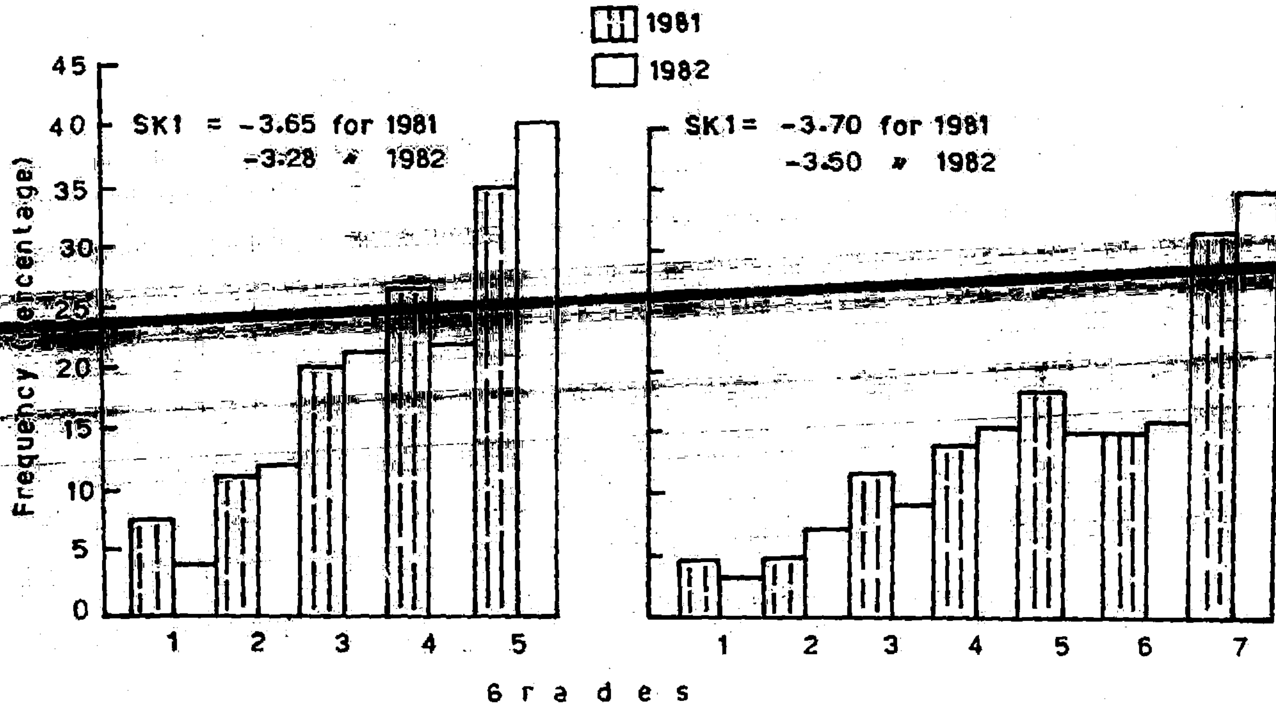

Fig. 1: Frequency distribution of CBD grades for F_1 hybrids in two successive years of detached berry test.

The significant expression of susceptibilities of the resistant x susceptible crosses compared to the theoretical mid-parent values may be due entirely to the expression of the genes rather than to other factors since the berries were tested under controlled environment. This led the authors to believe that partial to complete dominance of the susceptible genes to the resistant genes were present in the population and the favourable character, resistance is controlled by recessive genes.

Results of the frequency distribution of the crosses suggested that phenotypic dominance was isodirectional and the distribution was quite similar to that of the theoretical distributions for three, four and five genes. According to Allare and Falconer when all gene pairs are equally effective, the distribution is isodirectional supporting the conclusion made above. We believe that the resistant lines, R_1 and R_2 were homozygous for resistant genes at most loci and R_5 and R_6 were homozygous for susceptible genes at most loci and R_4 probably heterozygous at some loci. Because susceptible gene was dominant to resistant gene, it was not possible to identify the intermediate lines. R_3 was believed to have homozygous resistant genes at three-fourths of the loci. It is the combination of these lines that produced isoldirectional dominance. The pronounced frequencies of the modal classes may have resulted from the representation of more susceptible lines in the experiment or from the inability of the test to differentiate the level of resistance at the far end of the susceptible scale. Had there been two genes involved, only two classes would have been observed and with more than six genes the distribution could have resembled normal distribution. This interpretation led to the conclusion that three to five major genes of additive nature with some minor genes were probably involved in the inheritance of resistance to CBD.

Implications on Breeding

1. Recurrent backcrossing of resistant genes to the more desirable parent can be made while selection is practiced for resistance being transfered from the donor parent. Selfing, however, is made after every generation of backcrossing to identify the desirable character. Once a tree is identified for resistance with the desirable feature of the commercial variety, the genotype must be multiplied by clonal means. The prospect for the use of recurrent backcross however, is rather limited with coffee mainly because a single sexual generation takes periods varying from three to five years and with the character in question here, it takes six to ten years. Breeding becomes less practical if the disease is controlled by many genes at different loci and heritability is not simple.

2. selection for high yielding cultivars with high cup quality and resistance to CBD is an indespensable alternative to backcrossing.

3. Development of hybrid varieties which depends for superiority on the hybrid vigour or heterosis associated with F_1 hybridas is a necessary step to improve yield. Once a suitable hybrid combination is identified, which has already been achieved here, the parental genotype must be maintained without change so that the same hybrid can be produced repeatedly. This, however should not be the limitation under our condition where we found more than one genotype to nick well and many more genotypes are believed to exist.

Recommendation

To exploit the hybrid vigour discovered, it is strongly recommended that an independent hybrid seed production programme be initiated using the adapted CBD resistant lines for a particular locality as a famale parents and the high yielding lines reported in 7 as pollen parents. The current low production of about five quintals per hectar can easily be tripled with the use of the hybrids.

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REFERENCES

Anonymous (1982) coffee Department research Review 1981/82. Institute of Agricultural Research, Addis Ababa.

Allard, r.W. (1960) "Principles of Plant breeding." John Wiley and Sons, Inc., New York, 485p.

Falconer, d.S. (1960) Introduction to quantitative genetics. The Ronald Press Company, New York, 365p.

Griffing, B. (1956) concept of general and specific combining ability in relation to diallel crossing systems. Australian J. Biol. Sciences, 9 : 463-493.

Mesfin Ameha (1981) Yield assessment of a collection of indigenous coffee C. arabica L. grown at Jimma Research Station. EJAS 2 (2) (under publication).

Mesfin Ameha (1981) Summaries of coffee research work in Ethiopia. SINET News Letter.

Mesfin Ameha (1982) Heterosis in crosses of Indigenous coffee C. arabica L. selected for yield and resistance to Coffee Berry disease. I. At first bearing stage (submitted to EJAS for publication).

Van der Graaff, N.A. (1981) Selection of arabica coffee types resistant to Coffee berry disease in Ethiopia. Mededelingen Landbouwbogeshoul, Wageningen, the Netherlands, 110p.

Van der Vossen, H.A.M. and Walyaro, D.J. (1980) Breeding for resistance to Corree Berry disease in C. arabica L. II. Inhderitance of resistance. Euphytica 29 : 777-791.

Proc. 1st Reg. Workshop "Coffee Berry Disease",
Addis Ababa, 19-23 July, 1982, p. 179 - 188.

SELECTION FOR RESISTANCE TO COFFEE BERRY DISEASE IN UGANDA

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SUMMARY

Individual tree selections from Arabica coffee (Caffea arabica L) varieties Blue Mountain (BM) 71, BM 139 and Jackso 2 (J2), Originally obtained from Rwanda, which showed field resistance to coffee berry disease (CBD) in Western Uganda (S.Kigezi) were planted from seeds in another field trial at three sites in the same district. The variety Kents was included as the susceptible control.

The analysed data over a period of two years indicated that in 1975 at one site, there were highly significant month to month differences in CBD incidence. At one site in 1976, the varieties showed significant differences at 5% level. Variations in varietal reaction to CBD attack from month to month and from site to site was observed. Its significance to field section for CBD resistance is discussed.

INTRODUCTION

Most arabica coffee (Coffea arabica L) in Uganda is produced between 5500ft-7500ft (1600-2300M); though some areas below 5500ft (1600M); like the lower slopes of Mt. Elgon and parts of Western Uganda, produce excellent arabica side by side with robusta coffee (Coffea canephora Pierre) (Jameson, 1970). Smaller areas occur in West Nile, the slopes of Mt. Ruwenzori and other parts of Western Uganda. Arabica forms about 15% of total coffee produced (Jameson, 1970).

Although the arabica acreage is small, the crop is a valuable because of its superior quality compared to robusta and fetches a high price both locally and on the world market. With the recent price increase and under the Coffee Rehabilitation Plan which has just started in Uganda, expansion of arabica is encouraged.

One of the major limiting factors in the production of arabica coffee at high altitudes is Coffee Berry Disease (CBD) caused by a form of Colletrotrichum coffeanum Noack. The first confirmed incidence of CBD in Uganda was in 1959 at an altitude of 6200ft (1890M) on the slopes of Mt. Elgon (Anon. 1959). By the end of 1962 most arabica areas were affected (Anon. 1962). The only area still free from CBD, at least up to 1976 (Personal observation) is West Nile. Since 1977 the disease has been observed at lower altitudes, notably Kawanda Research Station (altitude 3924ft:1196M) on many arabica plots during the rainy seasons.

Chemical control measures have been employed to combat the disease. The cost of chemicals and spray equipment are prohibitively high for the small farmer. The harzardous nature of chemicals is a problem. In times of labour bottlenecks, the subsistence farmer changes the spray schedule giving top priority to growing food crope first. The scarcity of water in many areas is also a hindrance to spray operations. Some of these problems have been minimised by use of spray teams by the Department of Agriculture but this also constitutes a high cost to Government.

Use of resistant/tolerant varieties offer the cheapest and best prospects of control on a long term basis. In view of this varieties known to have resistance to CBD were imported from Rwanda during the late 1960's for trials in Uganda (Butters and Butt, 1964 and Anon.1969) and planted out.

Selections from single trees, which showed resistance were planted in 1971 in South Kigezi in replicated trials for further observation. Any reistant plants were to be used in further breeding programmes. The performance of these selections is described in this paper.

Materials and Method:

Varieties used were Blue Mountain 139 (BM 139), Blue Mountain 71 (BM 71) , Jackson 2 (J2) and Kents (susceptible control). The trial was planted in April 1971 at three sites in South Kigezi (Western Uganda). A randomised complete block design with 6 replicates was used. A spreader row of the susceptible Kents variety was also planted all round the field. Each plot comprised a row of 10 trees for each variety. A spacing of 8 x 8ft (2.4 x 2.4M) was used. The trees were trained on a multiple stem system with two stems.

From seedling establishment to the time of bearing, fertilizers were applied at half the quantity normally applied at full bearing. 200gm of Ammonium Sulphate Nitrate/tree/year, with split application of 100gm at the beginning of each rain or 250gm, of Calcium Ammonium Nitrate (CAN) with split applications of 125gms/tree. At the time of bearing, the full rates of fertilizers were applied. Mulching was done using sorghum stalks throughout the period of experimentation. Spot weeding using hand hose was done when necessary. Insect pests particularly antestia were controlled whenever necessary and when the insecticide was available. Fenitrothion 50 M.L. (Sumithion) was used.

The first CBD assessments were done in 1974. (Assessments were done on four primaries with 6-8 cropping nodes). The primaries were sampled at random from the four quadrants (North, South, East and West) at the time of taking records. This was done once every fortnight.

Percentage infection were transformed to Arcsine before carrying out statistical analyses.

Results:

The results are presented in Tables 1 and 2

In 1975, differences in varietal reaction to CBD at all the three sites were not significant. However, at site I there were highly significant month to month differences in CBD incidence (F = 39.02).Blue Mountain 71 had the most serious attack in August, whereas Jackson 2 was most seriously affected in November. The lowest incidences of disease for BM 71 and Jackson 2 occurred in November and May respectively. At this site, (I), data was collected in May, when the rain was tailing off into the dry period (June/July) so that disease incidence was low.

Generally, all the varieties had the heaviest attack during August compared to the other months.This is an indication that climatic conditions particularly rainfall were favourable for disease development during this month and there was a substantial amount of crop at a susceptible stage already on the trees to be infected. August/September is normally the beginning of the main rains. November is normally drier than August and this is relected in the lower disease incidence for that month. The month x variety interaction was also significant (F = 2.51).

The situation was similar at site III in 1976, where there were significant differences between the varieties (F = 7.22) (Table 2). Blu Mountain 71 and 139 were more resistant than Jackson 2 and the control, Kents.

The month to month differences were also significantly different (F= 2.73). The variety Kents showed the highest level of disease in September, while the lowest level of disease occured in July for all varieties. During February when data was taken, disease level was fairly high with the onset of the second rains. Disease level continued to rise into the month of May, then there was a marked decreased for all varieties with the rains in August and again a drop in December with a reduction in rainfalll (Table 2).

At sites II and III in 1975 and sites I and II in 1976, lower CBD incidences were recorded than at the sites mentioned above. Even, during the expected rainy periods CBD level was low and this gave non-significant results for these sites (Tables 1 and 2), weather conditions were probably unfavourable for disease development at those sites.

Discussion

In these experiments, the months in which data was collected differed from site to site due to labour shortages. Consequently, it was not possible to compare systematically, the site to site difference, or to estimate the combined month to month differences for the three sties.

CBD incidences throughout the two years and for all the sites was also relatively low making it difficult to assess the actual differences in the level of resistance of the test varieties especially when compared to the control. This was further complicated by severe damage on berries caused by Antestiopsis sp. As a result of the latter, few berries were available on the trees for CBD assessment.

In spite of these problems, some useful information has been derived from these experiments.

It is evident from the results that the periods (months) of severest disease incidence was not necessarily the same for all varieties. The results from sits I in 1975 and sites II and III in 1976 illustrate this month to month variations. Tables 1 and 2). Cook (1973) similarly observe these variations in Kenya and reported that the period of greatest susceptibility was not necessarily the same for all selections and that these differences depended on the time of the main flowering

Table (I) : Mean angles 1975

		BM 71	J2	BM 139	Kents
SITE I	MAY	4.23	4.47	4.87	5.61
	AUG.	12.23	10.20	10.26	7.36
	Nov.	1.19	6.16	1.84	2.23
	MEAN	5.88	7.03	5.66	5.07
	S.E.	± 0.67			
		BM 139	J2	BM 71	Kents
SITE II	APRIL	2.36	2.22	4.06	3.81
	MAY	1.01	3.27	1.88	3.96
	NOV.	2.93	1.10	1.02	4.42
	MEAN	2.08	2.28	2.46	4.06
	S.E.	± 0.63.			
		BM 139	BM 71	J2	Kents
SITE III	APRIL	1.83	2.19	2.81	4.14
	JUNE	0.97	1.10	1.04	2.52
	AUG.	2.23	2.08	3.57	2.22
	AUG.	2.23	2.08	3.57	2.22
	NOV.	2.76	2.08	2.96	2.35
	MEAN	2.57	2.48	3.46	3.74
	S.E.	O.53.			

Table (2) : Mean angles 1976.

		BM-139	Kents	BM 71	J2
SITE I	FEB.	3.22	1.57	6.65	7.58
	MAY	6.04	5.12	5.67	5.87
	JULY	3.57	5.08	3.83	5.26
	SEPT.	3.35	3.90	5.66	5.20
	DEC.	7.12	6.64	5.48	7.14
	MEAN	4.66	4.46	5.46	6.21
	S.E.	± 0.68			
		BM 139	Kents	J2	BM 71
SITE II	FEB.	2.63	4.464	1.37	3.68
	MAY	4.18	3.34	3.50	6.45
	JULY	1.76	3.01	4.07	4.17
	SEPT.	3.53	4.46	3.40	3.81
	DEC.	2.63	4.69	6.02	7.87
	MEAN	2.94	3.94	3.69	5.20
	S.E.	± 0.62			
		BM 71	BM 139	Kents	J2
SITE III	FEB.	3.51	3.77	4.09	6.91
	MAY	2.94	3.97	6.72	7.32
	JULY	1.66	1.57	3.82	3.19
	SEPT.	3.34	2.30	7.99	4.75
	DEC.	3.76	3.85	5.69	6.43
	MEAN	3.08	3.12	5.66	5.72
	S.E.	± 0.53			

Table (2) : Performance in terms of growth, yield, quality and disease incidence of Catimor material and progenies of the main breeding programme (Stage 3 : Backcrosses of selected trees from multiple crosses to SL 28 or SL 34), Planted in 1977 at 3333 trees/ha.

		Growth recordings in 1980		Cumulative Yield 1979+ 1980 clean Coffee tonnes/ha	Coffee Quality		Disease Incidence 1979 - 1980	
		Height Cm	Radius Cm		Bean grading AA %	Liquor Quality St (1-7)	CBD %	Rust (0-10)
C. Catimor								
C. Catimor								
(F 3) Progeny	86	149	77	3.2	51	3.0	0	0
Progeny	87	145	80	2.5	26	4.0	0	0
Progeny	88	155	80	3.2	47	3.5	0	0
Progeny	89	151	75	3.5	48	3.2	4.4	0
Progeny	90	143	85	3.6	33	3.3	0	0
M. Progenies of the main								
Breeding Programme (Stage 3)								
SL 28 x B 3.97 = (R.S x SL 28)(B.xH.T)		216	104	3.0	30	3.0	1.6	2.5
SL 28 x B s.116 = (R.S x SL 28)(B.xH.T)		213	103	3.4	31	2.0	0.6	2.0
SL 34 x B 3.87 = R.S x SL 28)(B.xH.T)		223	104	3,0	30	2.5	0.4	1.7
SL 34 x B 3.116 = (R.S x SL 28)(B.xH.T)		244	110	4.1	42	2.0	1.3	1.3
SL 28 x B 3.190 = (R.X x K 7)(H.T x SL 34)		253	112	4.2	36	2.5	2.2	0.2
Sl 28 x B 3.190 = (N 39 x H.T)(SL 4 x R.S)		213	100	3.5	30	2.5	0.0	1.3
SL 28 x B 3.866 = (SL 34 x R.S) x H.T.		249	116	3.3	38	3.0	0.8	0.3
SL 34 x B 3.186 = (R.S.x K-7)(H.T x SL 34)		219	101	3.5	47	3.0	8.1	1.6
SL 28 (Standard)		236	104	2.4	46	2.0	26.0	6.5

See Footnotes Table 1.

Research in Support of the Breeding Programme

That such progress has been so far achieved, is indeed a reflection on the amount of fundamental research that has been undertaken in support of the main breeding programme. For example, selection for CBD resistance was greatly enhanced by the development of a reliable preselection test for resistance performed on 6 week old seedlings (van der Vossen et al., 1976 ; van der Vossen & Waweru, 1976). Moreover, the identification of genes conferring resistance to CBD in the important progenitors, Rume Sudan (2 genes on the R-and K-loci) and Hibrido de Timor (one gene on the T-locus) by van der Vossen and Walyaro(1980), have led to further refinement of the breeding programme to ensure that all the 3 different genes are present in the new material. On the other hand biometrical genetic studies (Walyaro & van der Vossen, 1979: Walyaro, 1980), have provided valuable information on how certain characters in coffee can be used to imporve the efficiency of selection for yield and quality. It has also been possible to screen for rust resistance more effectively by use of the leaf disk inculation test in the laboratory (Owuor, 1980).

Regarding the nature of CBD resistance and its expected stability, no differential pathogenicity among hundreds of isolates of the CBD pathogen tested to date has been found, though differences in agressiveness have been noticed. Van der Graaff (1978) also found the same situation with regard to different isolates collected in Ethiopia. Furthermore, recent histological studies carried out at Ruiru (Masaba and van der Vossen, 1982) have indicated that the defence mechanism in the host, the formation of cork barriers soon after infection, is of a type that may not easily be overcome by changes in the pathogen. Thus, though indications are that the resistance to CBD may be of a stable nature, pyramiding of all the available resistance genes as is being done in our breeding programme, may be one important way of enhancing this stability (Parlevliet & Zadoks, 1977 and Nelson, 1973).

Multiplication of Selected Material

From the breeding scheme already outlined, it is clear that all plants selected within the multiple and backcrosses (stage 3) will be heterozygous for most traits CBD resistance included. As a consequence it was initially assumed that vegetative propagation would be the ultimate solution to large scale multiplication of such material. Indeed, because of encouraging results obtained from some progenies of multiple and backcrosses, clonal propagation of the first 105 promising selections in 1977 was immediately followed by establishment of 7 clonal comparative trials covering 5 important ecological zones for coffee in the country. Though the vegetative propagation techniques developed at the CRS (van der Vossen et al., 1077) could easily cope with multiplication of experimental materials, it became evident that the use of such techniques to provide material on a large scale would require a complete overhaul of the present nursery practices. This we realized would pose such reorganisational problems that the results of the breeding programme would eventually never reach the farmers especially the small holders.

After some careful consideration of the more recent results of the breeding programme, it was found that there was in fact a possibility of producing the new varieties through hybrid seed rather than vegetative propagation. This decision was based on results obtained from evaluation of some Catimor progenies which had been received through an exchange programme with Columbia. It was realized that further selection within these progenies could easily produce plants that would prove useful for hybrid seed production (van der Vossen, 1980). A summary of results on growth, yield quality and disease incidence of some of these progenies is also included in Table 2 (the upper part). As can be seen, the material is productive and the bean size a lot better than was expected. Furthermore, the material is resistant to most rust races and is homozygous for compact growth, a monogenic and dominant character. Many of these plants gave no susceptible segregants in progeny tests during preselection for CBD resistance. The liquor quality, however, is rather poor and the CBD resistance derived from Hibrido de Timor is known to be governed by only a single gene (van der Vossen & Walyaro, 1980).

On the other hand, progenies of backcrosses selected among stage 3 material of the breeding programme (see lower part of Table 2) have benn progeny tested for CBD resistance. Most of them already have 2 or even 3 genes for CBD resistance though in a heterozygous form. The liquor quality is also generally superior to the Catimor progenies and some of the trees are resistant to coffee rust as well. If the best selections among these trees are crossed to selected Catimor trees, they could give progenies of a plant type that fulfills to a large degree the requirements of the Kenyan Coffee Growers. For example, the F_1 hybrids derived from crosses between selections of the main breeding programme with 2 (Rr Kk Tt) or 3 (Rr Kk Tt) resistance genes, and those selected among Catimor material that are homozygous for the T-gene, are expected in priniciple to contain the following genotypes for CBD resistance.

1/4 Rr Kk T;, where T., = TT or Tt
1/4 Rr KK T.
1/4 rr Kk T.
1/4 rr kk T.

Thus 75% of all plants should carry resistance genes on at least 2 loci and in addition, there should be no susceptible plants in all such F_1 progenies. Such a mixed population should probably give adequate protection against CBD epidenics. Table 3 gives results of CBD presdection tests porformed on progenies of such crosses. The mean grade scores and the low % susceptible seedlings in many of the progenies clearly confirm our contention that crosses among combinations of carefully selected trees within the 2 sets of parental materials should give F_1 hybrids that have a sufficient level of CBD resistance. Such hydrid seed can therefore be released immediately to the coffee growers.

An added advantage to the F_1 hybrid material is that Catimor, being homozygously compact the F_1 progenies between Catimor and

Table (3) : summary of data on basis of mean grades for CBD resistance and % Susceptible seedlings in a CBD preselection test performed on progenies of some of the crosses between Catimor trees and progenies of the main breeding programme.

Details of the cross		No. of progenies per cross	Mean Grade (1-12)	Susceptible Seedlings* (%)
(SL34 x (SL34xR.S) x CPR	86	66	4.5	1
(SL34 x (SL34xR.S) x H.T) x CPR	90	135	3.0	1
x CPR	129	137	4.7	7
(SL34 x (N39xH.T)(SL34xR.S) x C.Pr	90	73	3.4	8
x C.Pr	88	106	3.6	5
(SL28 x (SL34xR.S) x H.T x C.Pr	90	92	3.7	3
x C.Pr	90	79	3.0	0
x C.Pr	90	118	4.0	9
x C.Pr	88	74	4.6	5
x C.Pr	88	72	4.0	8
x C.Pr	127	138	5.5	9
x C.Pr	128	117	5.3	8
x C.Pr	124	139	3.6	1
x C.Pr	124	126	4.0	2
x C.Pr	124	123	3.5	0
(SL28 x (R.SxK 7)(H.TxSL28) x C.Pr	90	100	5.1	2
(SL28 x (R.SxSL28)(B.xH.T) x C.Pr	86	101	5.4	9
(SL28 x (R.SxK 7)(H.TxSL34) x C.Pr	119	138	4.1	4
x C.Pr	119	110=	5.8	14
x C.Pr	128	119	5.2	7
x C.Pr	124	122	4.6	4
x C.Pr	124	194	4.7	6
(SL28 x (R.SxSL28)(B.xH.T) x C.Pr	86	101	5.4	9
x C.Pr	90	124	4.3	4
x C.Pr	90	123	4.4	3
SL 28		150	11.9	100
SL 28		150	11.9	100
Rume Sudan		100	4.0	4

* Note :

1. Susceptible seedlings falling in grades 9-12 in the preselection test.
2. C.Pr = Catimor progeny
3. Details of other varieties = See Footnotes Table 1.

the tall genotypes selected in phase I of the breeding programme, will be uniformly compact. In other words the F_1 hybrid seed can be used directly to establish plantations with a high degree of uniformity in plant type. This would normally only be possible with true breeding varieties or clones derived through vegetative propagation.

Before the start of the actual hybrid seed production in 1985, the following subprogrammes are expected to have been carried out:

1) Establishment of seed gardens.
2) Progeny trials of test crosses.
3) Field trials with Catimor and eventually the F_1 hybrids.

Seed Garden

Part of the seed garden is already established having been planted during 1981 with about 9,200 Catimor trees selected from 3 progenies, and about 3,400 plants representing 99 clones of selected progenies of phase 1 of the breeding programme which are the male parents for the hybrid seed production (Fig. 1) Production of hybrid seed will be effected through artificial cross pollination of Catimor trees with pollen from the male parents in this field. Owing to the complexity of such an exercise on the large scales envisaged,a number of investigations are being devoted to practical aspects of large scale emasculation and pollination. It has been estimated (van der Vossen, 1980) that 3 hectares of seed garden would produce between 15-18million seed per year which should probably meet the annual demand by growers for the new hybrids.

Progeny Trials with Testcrosses

The progeny trials with test-crosses referred to earlier, are chiefly aimed at evaluating combining ability of selected male parents with Catimor, especially as regards yield and quality. Such information will be available by 1985, when only the best combining parents among those in the seed garden will be retained for hybrid seed production.

Agronomic Trials

By 1987, when the first seedlings of the hybrids will be ready for field planting, we expect to have available tentative recommendations on spacing, fertilizer requirements, pruning system, tonic sprays and pest control measures for the new disease resistant and compact varieties. To this end advantage has been taken of the fact that Catimor is phenotypically very similar to the new hybrids to establish beforehand a number of trials with this material instead of the actual hybrids.

Conclusion

In conclusion, it appears the coffee breeding programme in Kenya is set to achieve its goal of developing material that is resistant both to CBD and rust and which is also of compact growth type within a remarkably short period of time. It has been stated (Njoroge et al., 1981) that the gradual replanting of Kenya coffee orchards with the new varieties is likely to have considerable impact on the Coffee Industry and the national economy as a whole. Not only will the downward trend in profitability of coffee growing be reversed but the competitiveness and viability of the Kenyan Coffee Industry will be assured. In addition, it will save the country millions of pounds in foreign exchange spent on importation of . fungicides, spray machinery and fuel. Furthermore, there is evidence to suggest that the much closer spacing of compact varieties could easily result in doubling the yield per hectare. However, since the amount of Kenya Coffee that can be sold is restricted under the present ICO quota system, it would be unrealistic to aim at production targets of double the present amount but by producing for example an equivalent of the present Kenya export quota on half the area presently under coffee, it woluld mean releasing the rest of the fertile land under coffee for alternative farm enterprises especially production of food crops. This aspect is of crucial importance both at the farm level, at a time when there is growing demand for more fertile land to grow food crops, and to the nation as a whole in striving to restore self sufficiency in food production.

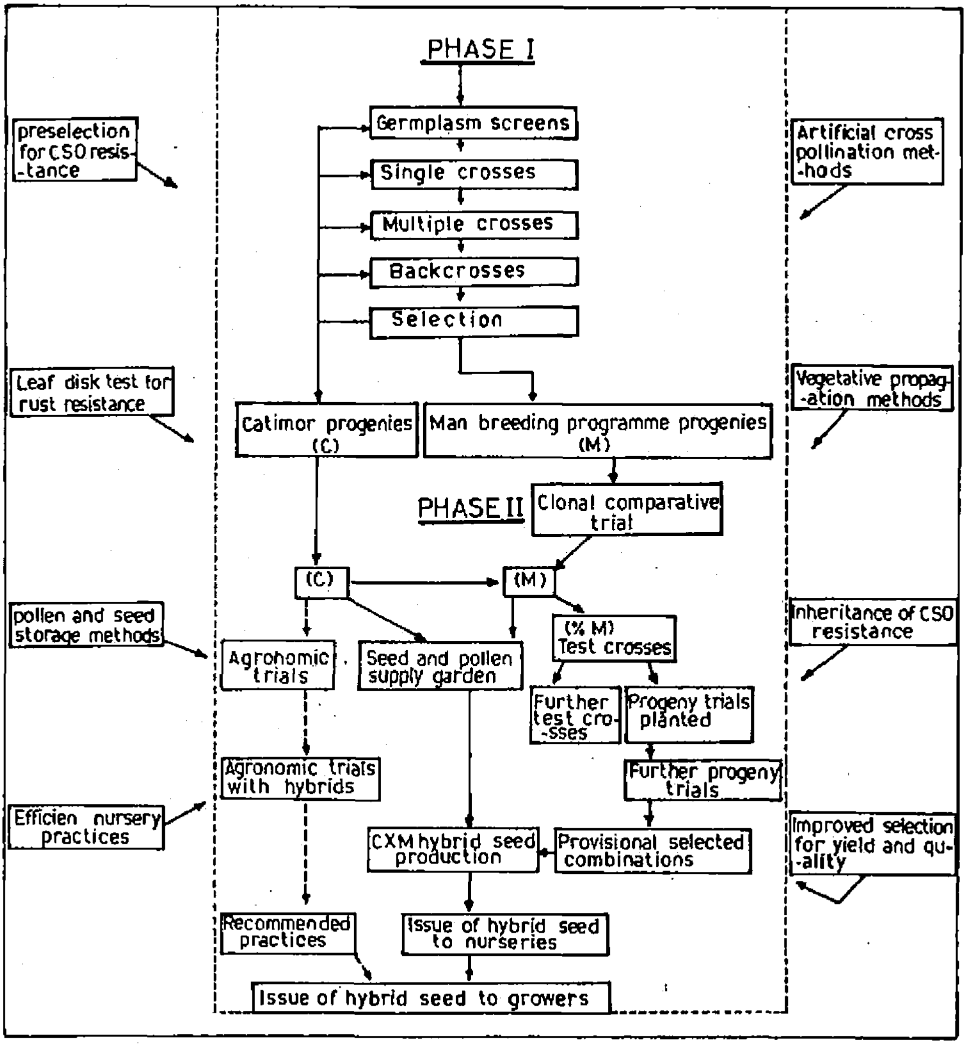

Fig.1: A scheme of the breeding programme for CBD resistance.

REFERENCES

Charrier, A. (1978) Etude de la structure et de la variabilitie genetique des cafeiers: resultas des etudes et des experimentations realises au Cameroun, eh Cote d Ivoire et a Madagascar sur lespece Coffea arabica collectee en Ethiopie par une mission ORSTOIM en 1966. IFCC (Paris), Bulletin no 14 100p.

Masaba, D.M., and van der Vossen H.A.M. (1982) Evidence of cork barrier formation as a resistance mechanism to berry disease (Colletotrichum coffeanum) in arabica coffee. Neth. J. Pl. Path 88:19-32.

Njorge, I.N., Njuguna S.K., Sparnaaij L.D. and van Santen C.E. (1981) Final evaluation of the Coffee Breeding Unit 1971-1981. Mimeo Report 37p+ of annexes.

Nelson, R.R. (1973) Selection for coffee rust using the leaf disk innoculation test. In. Annual Report, Coffee Research Foundation 1979-1980 pp 56-66.

Parlevliet, J.E. and Zadocks J.C. (1977) The integrated concept of disease resistance, a new view including horizontal and vertical resistance in plants. Euphytica 26:5-12

Van der Graaff, N.A. (1978) Selection for resistance to coffee berry disease in arabica coffee in Ethiopia. Evaluation of selection methods. Neth. J. Pl. Path. 84:205-215.

Van der Vossen, H.A.M., Cook R.T.A. and Murakeru, G.N.M. (1976) Breeding for resistanct of Coffee Berry Disease caused by Colletotrichum coffeanum Noack (Sensu Hindarf) in Coffecarabic L.I. Methods of preselection for resistance. Euphytica 25:733-745.

Van der Vossen, H.A.M. and Waweru, J.M. (1976) A temperature controlled room to increase the efficiency of preselection for resistance to Coffee berry disease. Kena Coff. 41:164-167.

Van der Vossen, H.A.M., Op de Laak J. and Waweru, J.M. (1977) Defining optimum conditions and techniques for successfue top working by cleft grafting of Coffeaarabica L. in Kenay. Keny Coffee 42:207-218

Van der Vossen, H.A.M. and Walyaro, D.J. (1980) Breeding for resistance to Coffee berry disease in coffea arabica L. II. Inheritance of the resistance. Euphytica 29:777-791.

Van der Vossen, H.A.M. (1980) Multiplication of disease resistant plant material through the production of hybrid seed. In. Coffee Research Foundation Annual Report 1979/80 pp 62-63.

Van der Vossen, H.A.M. and Walyaro, D.H. (1981) The Coffee Breeding programme in Kenya: A review of the progress made since 1971 and plan of action for the coming years. Kenay Coffee 46:113-130

Walyaro, D.J. and Van der Vossen, H.A.M. (1979) Early determination of vield potentiall in arabica coffee by applying index selection. Euphytica 28: 465-472.

Walyaro, D.J. (1980) Biometrical genetic studies based on a diallel cross between 11 varieties of arabica coffe. In. Coffee Research Foundation. Annual Report 1979/80pp 66-67.

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Addis Ababa, 19-23 July, 1982, P. 203 - 211.

COFFEE GENETIC RESOURCES IN ETHIOPIA CONSERVATION AND UTILIZATION WITH PARTICULAR REFERENCE TO CBD RESISTANCE

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ABSTRACT

It is generally agreed that Ethiopia is the primary centre of diversification of C. arabia and perhaps the only region (covering the area bordering Southern Sudan and part of Uganda) where the species occurs in a spontanous condition in the forest. If there is one characteristic that distinguishes the coffee in Ethiopia, it is the tremendous genetic variability that exists in the few indigenous germplasm collections studied by scientists. Most of these variations are rare and may not be found in other places since the coffee in the rest of the world has a very narrow genetic base. There is still a lot of potential in the existing heterogenous coffee populations, thriving all in some intricate ecosystem, which is not yet explored.

At present, this valuable resource is in real danger of being irretrievably lost due to changes in land use and as a result of expansion of new-uniform genotypes. The National Coffee Imrovement Programme is currently releasing new-developed varieties, selected primarily for resistance to

coffee berry disease (CBD) which is caused by Colletotrichum coffeanum Noack. The disease was first observed in Ethiopia in 1971, and rapidly spread. The traditional farmers (including state farms) are now replacing the present heterogenous coffee population with a limited number of CBD resistant genotypes. There is, therefore, an urgent need for effective measures to conserve and utilize the existing variability which is at present being disasterously eroded.

Three basic approaches are proposed :

1. extensive collection, maintainance and scientific study (with due emphasis on CBD resistance) of coffee materials with the aim of providing useful germplasm for coffee improvement programmes.

2. conservation of the semi-cultivated coffee in areas where the forest coffee occurred spontanously and

3. conservation of certain protected areas where the forest coffee can be maintained in its natural ecosystems - genetic reserve.

The Ethiopian region is situated within the tropical belt extending approximately from 3° to 18°N and from 33° to 48°E. The country posseses an extra ordinary diversity of climatic and geological conditions with altitudes ranging between 100 meters below sea level in the Danakil Depression to peaks above 4000 meters. Much of the country is above the 1000 meter level, most of the agriculture being between 1,500 and 2,600 m altitude.

Ethiopia posseses one of the largest, most complex, self-perpetuating ecosystems comprizing of a large number of diverse and varied plant species which accounts for the enormous diversity of its biological resources. One of the most important of these resources is Coffea arabica L., its great genetic diversity in Ethiopia disignates the country to the primary centre of diversification of the species.[4,6,10]

The existence of such genetic diversity of the arabica species in Ethiopia has great significance for the economy of the country and the rest of the coffee growing areas in the world. It is the leading commercial species accounting for over 80% of the world's coffee production, grown either exclusively or in association with the other species of the crop.[10]

There is tremendous genetic potential in the existing coffee populations which is not probably present in the rest of the world. This could be utilized in selection and breeding for various economically desirable characteristics including yield, quality and disease and pest resistance.[2,5,10]

At present, the existing genetic variability in Ethiopia is endangered by changes in agriculture and/or land use and by the replacement of the semi-wild traditional types with a few genotypes selected primarily for their resistance to coffee berry disease (CBD) caused by CBD.

The purpose of this paper is to describe briefly the situation of the existing indigenous coffee germplasm resources (C. arabica) and propose reasons that should be taken to protect it from genetic erosion.

Origin, Variation and Distribution

The distribution and degree of genetic diversity of C. arabica in Ethiopia is not yet properly studied. Very little is known about its origin and relatively few studies have been carried out on its genetics.

Most of the expeditions made by various scientists were either directed toward specific studies and only the limited germplasm material collected during explorations covering only a fraction of the primary centres of the genetic diversity of the species or were perpheral in nature.

There are many speculations about the origin of C. arabica as a cross between diploid progenitors but they are for the most part inconclusive.[12] Most authorities agree, however, that C. arabica is the only tetraploid species known in the genus Coffea, and is also the only representative of the genus which is self-fertile.[6,12] the mode of reproduction of the species is not yet fully understood but is reported to vary according to region and to the mutant used as a marker.[7]

There is a high level of variability in the C. arabica population within locations but also between regions in Ethiopia. Rama Murthi[9] has for example reported that there was great variation in leaf tip colour and branching nature within the arabica coffee material collected from various regions in Ethiopia. From his data, which included observations on individual plants collected in Kaffa area, it can be concluded that there is variability in leaf tip colour among trees between locations. Various other scientists have described many varieties, types and forms in arabica coffee collections of Ethiopian origin and have recognized that the variations that exist in these types have tremendous breeding value.[9,10] Monaco[9] reported that most of the variation observed in a number of coffee populations in Ethiopia is of a quantitative nature and that, although only a few known major genes could be identified, he was able to record certain new types which he described as "light red pericarp", "chacolate" and "light brown-tiped."

Ethiopia is the only region where C.arabica is found as a wild forest species.[6,10] The forests where coffee is found in its spontanuous condition are located between latitudes 6° and 9°N and longitudes 34° and 40°E.[8] C. arabica extends in Ethiopia from the mountainous forest region in the south through the central plateau to near the northern highlands.[8] The species also occur on the Boma Plateau and may occur another places in Southern Sudan.[7]

In Ethiopia, coffee is grown under the conditions to which it was adapted during millenia, in altitudes ranging between 1,200-2,000 meters mostly in the southern and south-western regions of the country. The areas in these regions are characterized by a well distributed annual rain fall ranging between 1000-2000 mm/year.[6]

Threat of Genetic Erosion

The broad genetic diversity of the indigenous coffee is endangered by changes in land use, i.e. clearance of forest coffee to grow various food and other crops and the replacement of the semi-wild traditional types with a few genotypes selected primarily for their resistance to CBD. In certain areas like Hararge Region, the existing coffee gardens are mainly diminishing due to adverse weather conditions, particularly drought and fluctuations in temperatures.

According to an estimate made by the FAO coffee Mission to Ethiopia,[6] seven-eights of the forest cover of the country had already vanished in 1964. The situation is even worse now as more and more forest areas are being cleared due to the expansion of agriculture and the fast growth of population.

Another factor that endangers the existing variability in arabica coffee in Ethiopia is the adoption of certain genotypes with some degree of resistance to CBD. The disease posses perhaps the greatest single threat to the country's coffee industry, in view of its rapid occupying the same habitat as coffee that are of no immediate economic value yet of great social concern not only as potential, economic sources for the future but for their ecological, social and aethetic value as an essential part of the human environment. These must be protected and conserved within natural communities, in a state of continuing evolution. This could serve as a laboratory in nature where coffee ecology could be studied in a dynamic state.

For this purpose, rainforest areas must be surveyed and mapped and areas for genetic reserve should be selected that contain the maximum representation geographical variants of C. Arabica. Depending on ecological gradient of coffee, a number of locations of appropiate sizes should be protected. The sizes should be based on the degree of coffee germplasm diversity.

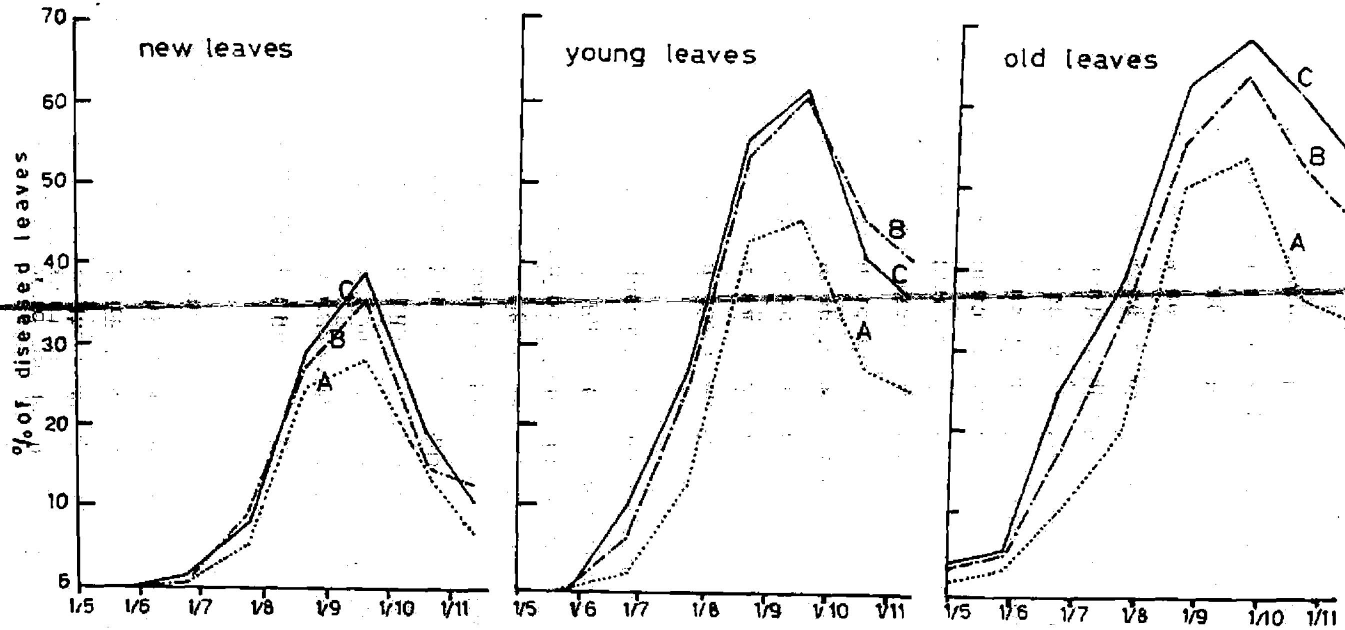
For the survay, it should be possible to indintify areas that are threatened and such areas should be given priority in the establishment of genetic reserves. In the reserves, the total flora and lanna should be protected. That is, the concern for loss of genetic diversity is not limited to crop plants species and their wild relatives or other plants of economic importance but also applies to animals which are endangered with extintion and other plants. Thus, the suggested genetic reserve for plants applies to the conservation of the whole ecosystem.

Finally, there is an urgent need to strengthen the ongoing activities in the collecting and conservation of the indigenous coffee. Special efforts must be made to collect and exploit a wide range of genotypes that show resistance to CBD.

Genetic exploration and conservation and utilization of such enormous resources can be carried out effectively and economically only through cooperation between countries and institutions, shared to mutual advantage with efforts and responsibilities.

REVERENCES

1. Anonymous (1982) coffee Department Research Review (81/82) Institute of Agricultural research, Addis Ababa.
2. Coffee Research Foundation Kenya, Annual Report (1981) Annual Report 1979-80. 64-65.
3. IBPGR (1980) coffee genetic resources. AGP ; IBPGR/80/3. Rome, 6 pp.
4. Mesfin, A. (1981) Yield assessment of a collection of indigenous coffee, C. arabica L. grown at Jimma Research Station. EJAS 2 (2) (under publication).
5. Meyer, F.G. (1968) Further observations on the history and botany of the arabica coffee plant Coffea arabica L. in Ethiopia. In : FAO Coffee Mission to Ethiopia 1964-65, FAO, Rome : 1-5.
6. Monaco, L.C. (1968) Considerations on the genetic variability of Coffea arabica population in Ethiopia. In : FAO Coffee Mission to Ethiopia 1964-65. FAO, Rome : 49-70.
7. Narashimbaswawy, R.L. (1968) Report on a visit to coffee areas in Ethiopia. In : FAO Coffee Mission to Ethiopia 1964-65, FAO, rome : 33-48.
8. Rama Murthy, A. (1968) Observations on the tip leaf colour and branching habit in Ethiopian Arabica coffee collection. In : FAO Coffee Mission to Ethiopia 1964-65, FAO, Rome, appendix IV, 6 pp.
9. Sylvain, P.C. (1955) some observations on Coffee arabica L. in Ethiopia. Turrialba 5 : 37-53.
10. Sylvain, P.C. (1958) Ethiopian coffee - Its significance to world coffee problems. Econ. Bot. 12 : 111-139.
11. Van der Graaff, N.A. (1981) Selection of arabica coffee types resistant to Coffee Berry Disease in Ethiopia. Landbouwhogeschool, waganingen, the Netherlands, 110 pp.
12. Van der Vossen, H.A.M. and Walyaro, D.J. (1980) Breeding for resistance to Coffee Berry Disease in C. arabica L. II. Inheritance of resistance. Euphytica 29 : 777-791.

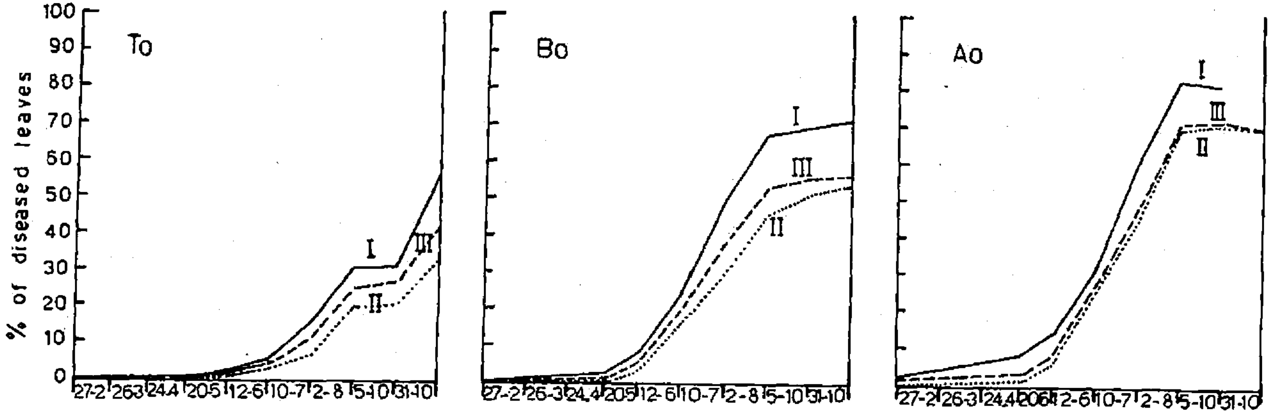


A: Control plot, first rain March, 7.

B: Soil irrigation at January 15 and continuing at 3 weeks intervals.

C: Sprinkler irrigation, and continuing at 3 weeks intervals.

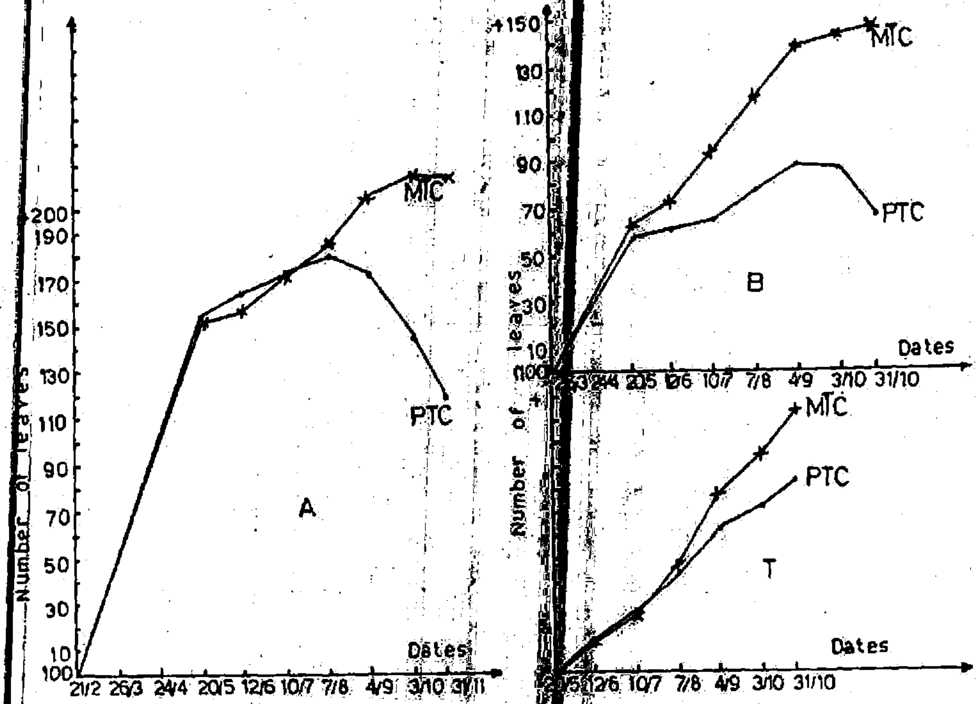
Fig. 2: The effect of irrigation intensity of Hemileia coffeicola on new leaves (developing during campaign), young leaves (soft and light green at beginning campaign), and old leaves (hard and dark green), Data from 1970.



To: no irrigation, first rain on 16th of march,
Bo: early irrigation on 8th of January and continuing at 3 weeks intervals.
Ao: early irrigation on 2nd of February " " " " " .

I: Old leaves (former campaign).
II: New leaves (current campaign).
III: All leaves.

Fig. 3: The effect of irrigation on Hemileia vastatrix and Hemileia coffeicola in 1973.



x———x MTC: with chemical treatments.
•———• PTC: without chemical treatments.

A: Irrigated trees, 1st watering on the 8th of January.
B: " " " " " " " 2nd " February.
T: Unirrigated trees, 1st rain on the 16th of March.

Fig. 4: Number of new leaves with and without chemical treatments in 1973.

However, high leaf rusts infections resulting from irrigation, are very well controlled by three treatments with copper. The fungicide controlled the disease completely; orthodifolatan gave a less satisfactory control.

Early Irrigation, a Factor of High Production for the Next Compaign

It was observed that early irrigation allows the trees ot produce many more new leaves than under natural conditions; therefore, the growth of branches (flower bearing wood for the next year) will be two to three times greater with early irrigation than under natural conditions. This high roduction of bearing wood is a direct function of the precocity of the irrigation (Fig. 4).

CONCLUSION

In conclusion, we can say that early irrigation is a CBD control method, which integrated to cultural practices :

- allows to control the total number of treatments : while treatments are necessary to control CBD and rusts in natural conditions, only three treatments are necessary to control rusts with early irrigation ;
- has a stimulating effect on the growth of branches, that means it gives a greater amount of bearing wood for the next campaign;
- is an insurance to obtain a good flowering : in our experience, we always obtained a complete flowering with irrigation; during two years (in 1970 and 1973) we obtained respectively 2.2 kg and 2.4 kg clean coffee per tree with early irrigation and only 0.2 kg and 0.4 kg clean coffee per tree in natural conditions.

As a good CBD control method and an insurance for a regular high yield early irrigation is recommended in all places where irrigation is possible.

We think that the method, studied in the Cameroon conditions, could be transferred to the conditions of Kenya.

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LABORATORY EVALUATION OF NEW FUNGICIDES AGAINST COFFEE BERRY DISEASE

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ABSTRACT

The standard laboratory screening procedure was applied to four new fungicides A,B,C and D. Fungicides A and D were effective in inhibiting sporulation of Colletotrichum spp. but highly phytotoxic to coffee leaves. Fungicide B failed to inhibit sporulation, while fungicide C was a good antisporulant and was not phytotoxic to coffee leaves. The shortcomings of the method used and the implication of the results obtained have been discussed.

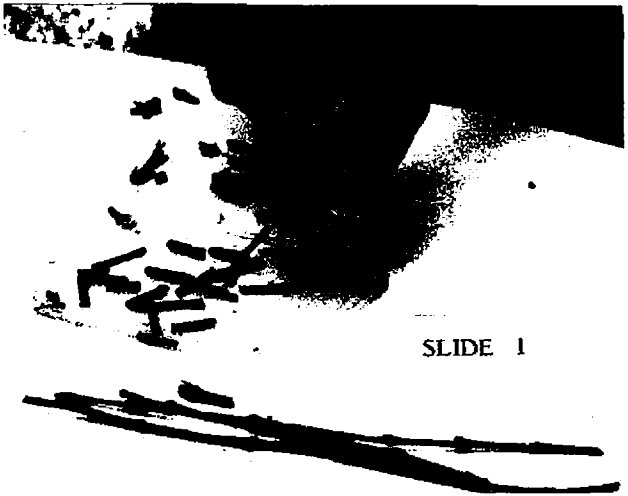
INTRODUCTION

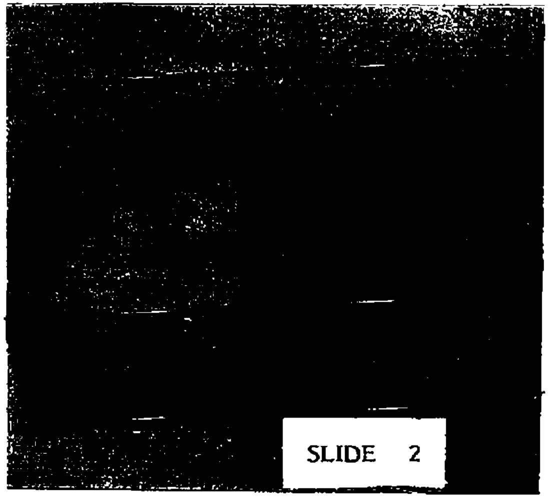
Coffee berry disease (CBD), caused by Colletotrichum coffeanum, is still the major problem for coffee production in Kenya. By 1952,it was known that some degree of control of CBD could be achieved by fungicide sprays (Rayner, 1952). The most effective fungicides were found to be 50% copper formulations and phenyl mercuric acetate though the latter was abandoned at an early stage due to phytotoxic effects (Bock & Rayner, 1956). The use of fungicides has been and still is the only means of controlling CBD in Kenya. In the near future, resistant varieties may play an important role in combating the disease.

An effective method of screening fungicides in the laboratory was required to initially assess these chemicals before field evaluation. The importance of the bark of coffee twigs as a source of inoculum was emphasized (Nutman & Roberts, 1961) and it was then considered that the ability of a fungicide to depress sporulation on the maturing bark was of major importance. In 1967, it became clear that effective control required more prolonged protection of the developing crop during unfavourable weather conditions and this was confirmed in a series of detailed field experiments carried out in 1968 (Griffiths, Gibbs & Waller, 1971). At the same time, many fungicides were evaluated in the laboratory using improved screening techniques and in the field using the extended spray schedule. As a result of these studies, many fungicides are now known that effectively control CBD and moreover much has been learned of the characteristics of fungicides for the control of this disease. Before a new fungicide (new active ingredient or new formulation of a recommended fungicide) is recommended to coffee growers, the Coffee Research Foundation (CRF) ensures that laboratory tests and field trials are carried out to provide conclusive evidence for the efficacy of the chemical against the disease. This paper describes the established laboratory screening procedure applied to 4 new fungicides.

Material And Methods:

Nutman & Roberts (1970) have described a laboratory technique for testing fungicides against CBD on the basis of their effect on sporulating capacity. A somewhat similar method was used by Vine et al. (1973). The same laboratory technique described by Vine et al. (1973) was applied in this study. Coffee twigs with maturing bark, approximately 3-5cm in diameter, were cut into sections of 4 to 5 cm long (slide 1). These sections were washed in a solution of Teepol (100 ppm) to remove any spores present. Twelve sections were laid on moist cellulose wadding in plastic sandwich boxes of approximate dimension 17.5 x 11.5 cm and 4.5 to 5 cm deep (slide 2).





SLIDE 3

Slides 1-6 : A Laboratory Technique for Testing Fungicides Against CBD (After Nutman & Roberts, 1970).

Reduction or stimulation of spore production of sprayed samples was calculated as a percentage of a water sprayed control.

Results:

A summary of results is given in Fig. 1. The majority of the fungicides tested were very effective in inhibiting sporulation of Colletotrichum spp even at very low concentrations.

Fungicide A was very successful in inhibiting sporulation of Colletotrichum spp. and at the rates of 0.2% and 0.4% it gave 72.03% and 73.27% inhibition of sporulation, respectively. The per cent inhibition of sporulation is much higher than 50% obtained using captafol 80% W.P. (chevron), used as a standard, at the rate of 0.4%. Fungicide A was, however, very phytotoxic to coffee leaves even at very low rate (0.1%). The leaf tissue lost the green colouration and tuned blackish (Slide 7). Fungicide B did not perform well in the sporulation inhibition test. The effect of fungicide B on % inhibition of sporulation of Colletotrichum spp. was not very consistent. At the rates of 0.4%, 0.8% and 1.0% the % inhibition of sporulation of Colletotrichum spp. was lower than the immediate preceding rates in this case, 0.3%, 0.7% and 0.9% respectively. At rates 0.9% and 1.0%, fungicide B gave slightly higher level of % inhibition of sporulation compared to captafol 80% W.P. (chevron) at the rate of 0.4%. Fungicide B was not phytotaxic to coffee leaves. Fungicide C was very successful in inhibition of sporulation of Colletotrichum spp. even at the lowest rate of 0.1%. At the rate of 0.4% fungicide C gave 78.65% inhibition of sporulation of Colletotrichum spp. while captafol 80% W.P. (chevron) at 0.4%, used as a standard gave approximately 59%. Fungicide C was not phytotoxic to coffee leaves. Fungicide D was highly effective in inhibiting sporulation of Colletotrichum spp. Th lowest rate (0.1%) of fungicide D gave 80.94% inhibition of sporulation. At rates 0.2% to 0.5% of fungicide D, there was slight decrease in inhibition of sporulation of Colletotrichum spp. but this was still higher than captafol 80% W.P. at similar rates. At the rate of 0.4% fungicide D gave

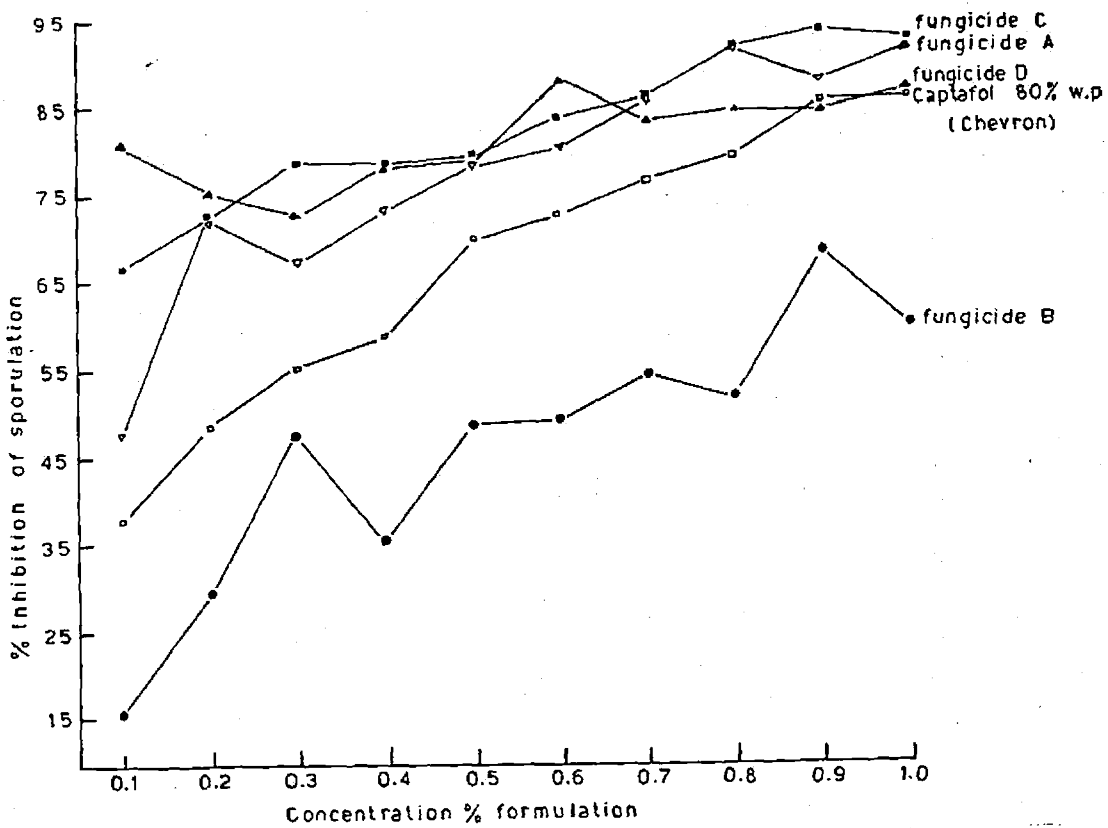


Fig. 1 : Laboratory screening test of fungicides.

78.2% inhibition of sporulation of Colletotrichum spp. compared with captafol 80% W.P.(chevron) at the same rate gave approcimately 59% inhibition of sporulation of Colletotrichum spp. Fungicide D was very phytotoxic to coffee leaves even at the lowest rate (0.1%) tested in the laboratory.

Discussion And Conclusions :

Nutman and Roberts (1970) have described a laboratory technique for testing fungicides against cbd on the basis of their effect on sporulating capacity. A somewhat similar method was used by Vine et al. (1973). Vine et al. (1973) found out that sixteen products giving more than 55% depression of sporulation in the laboratory no fewer than six could be recommended for cammercial use. By contrast out of twelve products in the group that gave 35-55% depression of sporulation only one new product (Delan) proved really successful in the field. In practice, little would have been lost if field testing had been restricted to fungicides giving more that 55% depression of sporulation. However, the fact that some fungicides placed in this group by antisporulation test failed in the field, indicates that some additional tests would be useful in improving the efficiency of the laboratory screening tests. The introduction of a spore germination test by Vine et al. (1973) did not prove to be of any more value.

Fungicides are normally selected for field testing according to their ability of depress sporulation of Colletotrichum spp on the bark of coffee twigs in the laboratory screen test and phytotoxicity on coffee leaves. Fungicide A & D were very effective in inhibiting sproulation of Colletotrichum spp but highly phytotoxic to coffee leaves. Fungicides A and D do not qualify for field testing as they will possibly affect photosynthetic capacity of the coffee trees thus the yield benefits to be accrued from CBD control might not be realized as the dcapacity of the leaves to manufacture assimilates for the berry-filling will be impaired. Fungicide B was not a very good antis-

Slide 7(a,b) : The Effect of Fungicide A on Coffee Leaves.

porulant of *Colletotrichum spp* though it was not phytotoxic to coffee leaves. At high rates (0.9% & 1.0%) fungicide B successfully inhibited sporulation of *Colletotrichum spp*. sompared to captafol 80% W.P.at the rate of 0.4%. If this fungicide is field screened and successfully controls CBD, the most important limiting factor for its use may be its selling price at these high rates. Fungicide C was a very good antisporulant of *Colletotrichum spp*. and was not phytotoxic to coffee leaves. Fungicide C can be field screened against CBD at any rate but considering the economics of fungicide use rates of 0.1% to 0.4% would be preferable.

Vermeulen (1968) screended 43 fungicides using tests to determine reduction of mycelial growth on agar and prevention of conidial germination. Fourteen of those showing the best results were then test results were then tested in field trials. He found that results were variable though captafol was as good as copper. Cook and Pereira (1977) in their studies of *Colletotrichum coffeanum* tolerance to benzimidazole compounds in Kenya, found that CBD lesion growth on green berries was very variable while viability of the spores produced was more sensitive to fungicides than was sporulation. Kirango (1981, unpublished) found that CBD isolates, in mycelial growth and spore germination experiments, were highly sensitive to concentrations of 500 and 1000 ug/ml a.i. of captafol and copper 50% formulation in the laboratory. These rates are far below the recommended field rates of 3200ug/ml a.i. and 3500 ug/ml a.i. of captafol and copper Nordox respectively. However, laboratory screening technique, for testing fungicides against CBD on the basis of their effect on sporulating capacity, developed by Vine et al. (1973) is still use today.

This antisporulant test could be improved on further by including plating method developed by Gibbs (1969). This will help in differentiating the *Colletotrichum spp*. by using cultural characteristics. Thus, the approximate proportions of all *Collerotric hum*, normally found in the maturing coffee twigs can be calculated. Finally, % inhibition of sporulation of C. coffeanum at a given concentration of fungicide, would be calculated. The source of the maturing coffee twigs is also very important. The altitude and type of Coffea arabica cultivar greatly influence the composition of Colletotrichum spp. Mulinge (1971) and Hindorf (1973) found that the relative abundance of the four species of Colletotrichum in young coffee bark varied with the altitude at which the coffee was growing. The proportion of CBD (Colletotrichum coffeanum) and ccp (C. acutatum) increases substantially with altitude and the cca (C. kgloeosporioids) less so. The ccm(C. gloeosporioides) decreases with altitude so that at low altitudes the bark microflora is dominated by ccm and cca with very little C. coffeanum present. Mulinge (1970) found a greater amount of C. coffeanum in the bark of CBD susceptible trees (Harar, SL 28) than in that of resistant trees (Blue Mountain, Rume Sudan).

Further, for protectant fungicides greater emphasis should be place on physical characteristics, particularly persistency and capacity for redistribution if these can be simply and reliably assessed.

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REFERENCES

BOCK, KR. RAYNER, R.W. (1956) Control of coffee berry disease in Kenya. Nature, U.K. 178:217-2[illegible]

COOK, R.T.A., PEREIRA, J. L. (197[illegible]) Strains of Colletotrichum coffeanum, the causal agent of coffee berry disease, tolerant to benzimidazole compounds in Kenya. Kenya Coffee Vol. 42 (No. 491): 63-76.

GIBBS, J.N. (1969) Inoculum sources for coffee berry disease. Annals of Applied Biology 64:515-522.

GRIFFITHS, E.; GIBBS, J.N. and WALLER, J.M. (1971) Control of coffee berry disease. Annals of Applied Biology 67:45-74.

HINDORF, H. (1973) Colletotrichum population on Coffea arabica in Kenya. III. The distribution of Colletotrichum spp. on different parts of the coffee bush. Phytopathologische Z.77: 324-338.

KIRANGU, A.W. (1981) Unpublished.

MULINGE, S.K. (1970) Variations in the level of Colletotrichum coffeanum Noack in the bark of Coffea arabica cultivars. East African Agricultural and Forestry Journal 36:227-230.

MULINGE, S.K. (1971) Effect of altitude on the distribution of the fungus causing coffee berry diseasde in Kenya. Annals of Applied Biology 67: 93-98.

NUTMAN, F.J. and ROBERTS, F.M. (1961) Investigations on a disease of Coffea arabica caused by a form of Colletotrichum coffeanum Nack. III. The relation between infection of bearing wood and disease incidence. Trans. Brit. Mycol. Soc. 44:511-521.

NUTMAN F.J. and ROBERTS, F.M. (1970) A note on a laboratory technique for testing fungicides against coffee berry disease. East African Agricultural and Forestry Journal 35:225-228.

VERMEULEN, H. (1968) Screening of fungicides for control of coffee berry disease in Kenya. Experimental Agriculture 4:255-261.

VINE, B.H.; VINE, P.A.; GRIFFITHS, E. (1973) Evaluation of fungicides for the control of coffee berry disease in Kenya. Annals of Applied Biology 75:359-375.

RAYNER, R.W. (1952) Coffee berry disease. A survey of investigations carried out up to 1950. East African Agricultural Journal 17:130-158.

flowering) are most susceptible to CBD. Under favourable conditions for CBD and in the absence of control measures, the loss of coffee beans caused by this disease may be 80% or more.[1] The use of fungicides is at present the only means of controlling the disease. Newly developed fungicides are screened yearly either in the laboratory or in the field in an attempt to obtain effective, yet comparatively cheaper fungicides than those already recommended for controlling CBD in Kenya.

Assessment of promising fungicides selected from laboratory screening tests and trials in the previous year for control of CBD is normally carried out every year in high and medium altitude coffee growing areas where the disease is normally severe.

During 1981, two field trials to determine the efficacy of six new fungicides and recommended fungicides against CBD were carried out on two different sites namely :

(i) Coffee Research Station (alt. 1608 m) and
(ii)Kentmere Estate (alt. 1935 m. Upper Kiambu).

New products Mk-23 75% WP, Dyrene 50% WP. Dyrene 75% WP. Calirus 50% WP, A 6097 A 25% E.C. and Copcel 50% WP were included in the trials for field evaluation against CBD. Tank mixture of Captafol + Kocide 101 (0.2% + 0.5%) and Delan + Copper oxychloride (0.15% + 0.5%) were also included in the trials for comparison. Dyrene 50% WP (0.55%) and Dyrene 75% WP (0.4%) were found effective against CBD to some extent during 1979/80 but plots treated with these two products gave lower yields compared to the standard product Captafol 80% WP.[2] MK-23 75% WP (0.3) was found effective against CBD during 1977/78 but plots sprayed with MK-23 75% WP gave lower yields compared to the plots sprayed with the standard product Captafol 80% WP.[5] Therefore, MK-23 75%WP was included in the field trials during 1980/81. The results of these trials are reported in this paper.

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EFFECTIVENESS OF NEW AND RECOMMENDED FUNGICIDES IN CONTROLLING COFFEE BERRY DISEASE DURING 1981

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SUMMARY

During 1980/81 field trials, the new fungicides MK-23 75% WP and A 6097 A 25% E.C. were found effective against Coffee Berry Disease (CBD) but both products at the rates tested gave lower yields compared to the standard product Captafol 80% WP (Chevron). Calirus 50% WP was found ineffective against CBD and gave very low yield. Dyrene 50% WP and Dyrene 75% WP gave satisfactory control of CBD and recorded yields as high as the standard product Captafol 80% WP. Copcell 50% WP controlled CBD effectively and gave yield significantly higher than the standard product Captafol 80% WP.

Tank mixtures of Captafol + Kocide 101 and Delan + Copper oxychloride at half rates gave the best overall performance against CBD and increased yields significantly higher than the standard product Captafol 80% WP. Therefore, it is recommended to use these tank mixtures more frequently to control CBD.

INTRODUCTION

Coffee Berry Disease (CBD) caused by the fungus Colletotrichum coffeanum Noack is a serious disease of Coffeaa rabica L. in Kenya. Expanding green berries (4 weeks to 14 weeks after

Orthodifolatan 80 WP gave effective control of the disease at all sites and gave appreciable yields. Also Delan 75 WP (3.3 kg/ha) Bravo 500 (4l/ha) Kocide 101 50 WP (7 kg/ha) and the mixtures of Nordox and Cobox 50 WP (5.5 kg + 5.5 kg) gave good efficacy at all sites over the period under investigation. Other fungicides including Sandoz 269 F 40 WDC, Dusan 540 Perenox 50 WP, (CGA/ 64250/Captafol, Sandoz MZ 50 WP, Benomyl 50 WP and Nordox 50 WP were less consistent over the sites and years of testing. Apart from CBD yield decrease may be caused by the type of fungicide applied. Some fungicides may have growth regulatory effects on coffee plants to an extent of interrupting photosynthetic activities. For example, the continuous use of red copper fungicides at higher rates may have such an effect.

The water dispersible concentrates of copper fungicides including Sandoz 269 F 40 WDC and Nordox 40 OD showed poor storage qualities.

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REFERENCES

Bujulu, J. (1977) Control of Coffee Berry Disease in Northern Tanzania E.A. Agric. For. J. 42 : 427-430.

Critchett, C.L. (1966) Coffee Berry Disease. Lyamungu Research Report : 12-13.

Kibani, T.H.M. (1980) Field Evaluation of fungicides for Coffee Berry Disease control in Tanzania.

Mulinge, S.K. (1970a) Development of Coffee Berry Disease in relation to the stage of growth of the berry. Ann. Appl. Biol. 65: 269-276.

Mulinge, S.K. (1970b) Variations in the level of Colletotrichum coffeanum in the bark of Coffea arabica cultivars. E.Afr. Agric.for.J. 36 : 227-230.

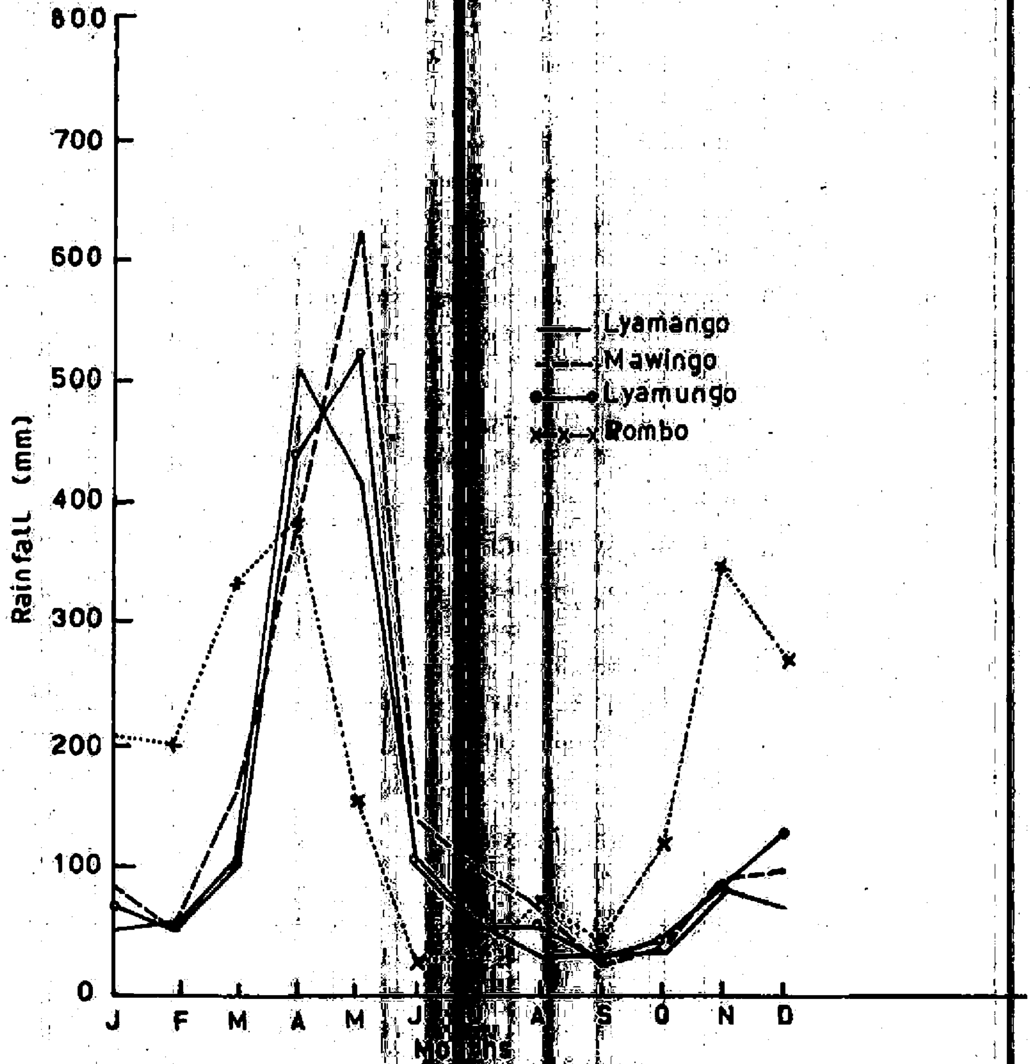

Fig. 1: Mean monthly rainfall recorded at the experimental sites (Lyamungo, Mawingo and Rombo) - 1978 - 1981

of the treatments were as poor as the control. In 1977 and 1979 all sprayed blotsgave significantly lower CBD infection than the control. During 1978, treatments including Sandoz 269 F 40 , Dusan :540 and Perenox 50 WP were inferior to the standard captafol 80 WP. in disease control. All copper fungicides and CGA/64250/Captafol gave low leafrust incidence.

Table 2 shows the performance of fungicides at Mawigno site. In 1977 to 1979, all sprayed plots gave lower CBD infection than the unsprayed. During 1980, treatment Decobre 50 was superior over the standard captafol 80 WP. During the same year, CGA/64250/ Captafol was as poor as the control. Captafol 80 WP and Dusan 540 gave highest yields during 1978. Sandoz 269 F 40 WDC gave poor yields in 1980. Similarly, all copper fungicides gave lower leafrust infection.

The observation trial at Rombo site gave results as indicated in Table 3. The mixtures of Nordox + Cobox, Decobre 500, Bravo 500, Kocide 101 50 WP, Orthodifolatan 80 WP and Dyrene 75 WP gave appreciable yields.

Discussion

During the period under this investigation, Lyamungo, Mawingo and Rombo sites experienced variations in weather conditions (Fig. 1). rombo site a high altitude area experienced highest rainfall from August until March. Mawingo site received highest rainfall in April. The rainfall pattern could account for more CBD infestation observed at Rombo and Mawigno sites as compared to Lyamungu. The coincidence of susceptible expansion stages of berry development and heavy rains between November and April probably resulted in higher CBD infection at Mawingo and Rombo sites (Fig. 1).

Table (3) : The effect of fungicides on CBD (angular transformed) and yield (clean coffee kg/ha) at rombo site.

Trade name	Common name	Appl. rate ha.	Parameter	1977	1978	1979	1980	1981	Mean
1.	Benomyl	1 kg	CBD				34.3		34.3
			L/Rust				20.6		20.6
			Yield				106.60		[illegible]06.60
2. Benlate	Benomyl	1 kg	CBD			35.5	28.8	-16.20	26.83
			L/Rust				25.9		25.9
			Yield			244.45	586.74	272.00	[illegible]67.73
3. Sandoz	Cuprous	4 l	CBD			29.7	14.9	25.20	23.27
			L/Rust				22.2		22.20
			Yield			1360.17	336.00	336.00	677.39
4. Sandoz MZ 50	Cuprous oxide	6 kg	CBD				12.4	12.80	12.80
			L/Rust				10.7		10.70
			Yield				480.06	360.00	420.03
5. Kocide 101 50 WP	Cupric hydroxide	7 kg	CBD			28.2	20.90	10.50	1987
			L/Rust				8.70		8.70
			Yield			444.45	782.12	440.00	[illegible]55.52
6. Bravo 500 F	Chlorothalonil	4 l	CBD			33.7	15.10	11.90	20.83
			L/Rust				19.60		19.60
			Yield			440.00	1031.24	696.00	[illegible]22.41
7. Dusan 540 WP	Cuprous oxide Benomyl	5 kg	CBD			27.5	1.90	20.8	16.73
			L/Rust				27.5		27.5
			Yield			755.57	1075.69	872.00	[illegible]01.09
8. Perenox 50 WP	Cuprous oxide	11 kg	CBD			31.1			31.1
			L/Rust						
			Yield			364.44			[illegible]64.44
9. Nordox 40	Cuprous oxide	4 l	CBD				8.10	19.50	13.80
			L/Rust				29.00		29.00
			Yield				675.64	848.00	[illegible]61.82
10. Nordox 50	Cuprous oxide	11 kg	CBD				5.60	12.30	8.95
			L/Rust				13.80		13.80
			Yield				426.72	288.00	[illegible]57.36
11. Nordox + Cobox	Cuprous oxide + Copper Oxycholoride	5.5+ 5.5kg	CBD				9.20	10.60	9.90
			L/Rust				12.3		12.3
			Yield				1582.42	752.00	11[illegible]7.21
12. Orthodi-folatan 80 WP	Captafol	4.4kg	CBD			35.10	16.20	4.10	[illegible]8.47
			L/Rust				21.5		21.5
			Yield			88.89	1093.45	952.00	7[illegible]1.45
13. Daconil 75 WP	Chlorothalonil	4.4 k	CBD					18.30	[illegible]8.30
			L/Rust						
			Yield					392.00	3[illegible]2.00
14. Delan 75 WP	Dithianon	3.3kg	CBD			28.5		7.80	[illegible]8.15
			L/Rust						
			Yield			444.45		832.00	6[illegible].23
15. Dacobre 500		5 l	CBD					16.30	1[illegible].30
			L/Rust						
			Yield					624.00	62[illegible].00
16. CGA/64250/ Captafol		1.75kg	CBD				12.3	22.8	1[illegible].55
			L/Rust				28.2		[illegible]8.2
			Yield				28.2		[illegible]8.2
17. control			CBD			40.90	28.80	43.40	3[illegible].70
			L/Rust			21.22	52.80		3[illegible].01
			Yield				408.94	250.00	32[illegible].47
		Mean	CBD			32.24	16.04	16.83	
			L/Rust			21.22	22.52		
			Yield			517.80	714.46	586.27	

- Not included/Assessed

Table (2) : the effect of fungicides on CBD (Angular transformed) and yield (clean coffee kg/ha) at Mawingo site.

Trade name	Common name	Appl rate ha	Parameter	1977	1978	1979	1980	1981	Mean
1.	Benomyl	1 kg	CBD			7.35	15.73		11.54
			L/Rust			41.52	36.80		39.16
			Yield			258.62	952.75		605.69
2. Benlate	Benomyl	1 kg	CBD	7.33	11.35	7.42		9.25	4.81
			L/Rust		NA	45.25	73.93		36.06
			Yield		995.77	215.35	905.62	145.63	565.60
3. Sandoz 269 F40	Cuprous oxide	4 l	CBD	6.15	8.10	8.6	14.43	8.43	9.14
			L/Rust			22.37	26.02	12.58	20.32
			Yield		988.43	213.53	737.47	202.46	535.46
4. Sandoz MZ 60	Cuprous oxide	6 kg	CBD		8.3	5.45	13.83	6.05	11.21
			L/Rust			25.70	30.9	13.78	23.46
			Yield		1104.43	124.32	1086.56	264.62	644.98
5. Kocide 101 50 WP	Cupric hydroxide	7 kg	CBD		9.00	9.72	13.20	7.73	10.22
			L/Rust			19.30	13.88	13.88	15.66
			Yield			399.95	998.57	305.47	568.00
6. Bravo 550F	Chlorothalonil	4.1	CBD			5.15	15.45	6.23	8.94
			L/Rust			22.42	36.40	13.20	24.01
			Yield			372.62	988.57	385.39	582.19
7. Dusan 540 WP	Cuprous oxide + Benomyl	5 kg	CBR		8.10	5.95	15.8	10.45	10.08
			L/Rust		NA	30.67	25.9	10.25	22.28
			Yield		1151.54	242.17	1068.80	374.73	709.31
8. Perenox 50 WP	Cuprous oxide	11 kg	CBD	6.60	8.07	9.12			7.93
			L/Rust			13.25			13.25
			Yield		987.10	149.78			618.44
9. Nordox 40 F	Cuprous oxide	4 l	CBD			7.95	15.05	6.60	9.87
			L/Rust			19.60	13.80	18-.18	17.19
			Yield			74.90	1082.58	333.89	497.12
10. Nordox 50	Cuprous pxode	11 kg	CBD			9.20	14.4	5.18	9.59
			L/Rust			12.75	16.5	12.43	13.89
			Yield			294.57	991.32	159.89	481.93
11. Nordox + Cobox	Cuprous oxide + C.	5.5 + 5.5 kg	CBD				17.35	6.63	11.99
			L/Rust				21.50	10.48	15.99
			Yield				1050.57	387.17	718.87
12. Orthodi-folatan	Caaptafol	4.4	CBD	6.00	10.67		17.60	3.68	9.49
			L/Rust				32.29	9.90	21.10
			Yield		1165.54		1053.02	351.65	856.74
13. Dryene 75 WP	Anilazine	4 kg	CBD				13.2	2.60	7.90
			L/Rust				33.00	20.68	26.84
			Yield				913.22	269.95	591.59
14. Delan 75 WP	Dithianon	3.3kg	CBD	4.73	8.82	7.15	16.00		9.18
			L/Rust			33.92	26.7		30.31
			Yield		1007.84	283.19	1120.81		803.95
15. Dacobre 500 F		5 l	CBD				110.58	10.00	10.29
			L/Rust				25.30	12.68	18.99
			Yield				1059.91	447.55	753.73
16. CGA/64250/ Captafol		1.75	CBD				31.4	5.60	18.50
			L/Rust				31.4	3.00	17.20
			Yield				1023.46	300.15	661.81
17. Caprox 50 WP	Cuprous Oxide	11kg	CBD					6.33	6.33
			L/Rust					6.93	6.93
			Yield				127.87	127.87	127.87
18. Control		0	CBD	9.90	18.05	21.63	30.25	22.55	20.48
			L/rust			46.32	51.9	31.55	43.26
			Yield		618.66	117.11	549.4	46.35	
		Mean	CBD	6.79	10.18	8.72	16.75	7.82	
			L/Rust			27.76	29.82	14.23	
			Yield		1002.41	237.17	973.9	273.52	
		LSD P	0.05						
			CBD	4.27	4.47	5.59	5.82	6.82	
			L/Rust			9.42	5.60	8.08	
			Yield		47.77	NS	161.61	NS	

Table (1) : The effect of fungicides on CBD (angular Transformed) and yield (clean coffee kg/ha at Lyamoungo s

Trade name	Common name	Appl Rate Ha.	Parameter	1977	1978	1979	1980	1981	Mean
1.	Benomyl	1 kg	CBD	-	-	4.98	6.25	-	5.61
			L/Rust	-	-	39.10	27.73		33.41
			Yield			298.93	322.04		310.48
2. Benlate 50 WP	Benomyl	1 kg L/Rust	CBD	3.15	9.56	5.78	7.36	2.53	5.6[illegible]
			L/Rust	-	-	34.98	26.70	28.70	30.1[illegible]
			Yield	452.28	306.88	306.66	322.04	786.23	434.8[illegible]
3. Sandoz 269 F 40	Cuprous Oxide	4, l	CBD	4.53	11.57	5.3	7.28	3.70	6.4[illegible]
			L/Rust	-	-	21.77	20.98	19.70	20.8[illegible]
			Yield	327.69	241.33	232.5	423.16	1096.33	464.1[illegible]
4. Sandoz MZ 50	Cuprous Oxide	6 kg	CBD		9.75	8.05	7.40	2.90	7.0[illegible]
			L/Rust			20.07	21.98	26.33	22.9[illegible]
			Yield		280.88	278.57	560.07	775.40	473.7[illegible]
6. Bravo 500F	Chlorothalonil	4 l	CBD			5.08	8.28	4.30	5.[illegible]
			L/Rust			23.75	26.55	27.70	26.0[illegible]
			Yield			304.26	415.60	1296.30	672.0[illegible]
7. Dusan 540 WP	cuprous Xoide + Benomyl	5 kg	CBD		11.02	7.25	9.08	3.15	7.6[illegible]
			L/Rust			23.71	26.18	30.38	26.7[illegible]
			Yield		232.84	226.48	387.38	655.35	375.5[illegible]
8. Perenox 50 WP	cuprous Oxide	11 kg	CBD	5.05	14.05	5.88			8.3[illegible]
			L/Rust	NA	NA	15.75			15.[illegible]5
			Yield	315.91	165.33	276.00			252.4[illegible]
9. Nordox 40F	Cuprous Oxide	4 l	CBD			6.40	9.18	2.18	5.9[illegible]
			L/Rust			21.45	21.55	26.38	23.1[illegible]
			Yield			378.48	410.49	595.49	461.4[illegible]
10. Nordox 50	Curprous Oxide	11 kg	CBD			7.90	8.23	6.25	7.4[illegible]
			L/Rust			18.10	18.10	23.20	491.42
			Yield			273.15	378.93	831.17	491.42
11. Nordox +	Cuprous Oxide	5.5+ 5.5	CBD				7.13	2.18	4.6[illegible]
			L/Rust				16.53	20.15	18.3[illegible]
			Yield				451.17	1153.69	802.4[illegible]
12. Orthodi-folatan 80 WP	Captafol	4.0kg	CBD	3.95	5.45		7.00	2.18	4.6[illegible]
			L/Rust				23.83	25.55	24.6[illegible]
			Yield	416.79	319.06		409.76	1384.75	632.4[illegible]
13. Dyrene	Anilazine	4 kg	CBD				4.30	4.30	3.6[illegible]
			L/Rust				22.59	28.88	25.7[illegible]
			Yield				342.82	984.97	633.50
14. Delon	dithianon	3.3kg	CBD	4.47	6.77	6.75		6.11	
			L/Rust			35.5	27.60		31.[illegible]
			Yield	318.48	289.90	276.88	500.06		346.[illegible]
15. Dacobre 500		5 l	CBD				6.70	3.68	5.[illegible]
			L/Rust				19.68	22.40	21.0[illegible]
			Yield				551.49	1218.34	884.92
16. CGA/64250/ Captafol		1.7kg	CBD				8.90	3.75	6.[illegible]
			L/Rust				20.25	17.70	18.[illegible]
			Yield				387.47	745.21	566.[illegible]
17. Cuprox	Cuprous Oxide	11kg	CBD					2.63	2.[illegible]
			L/Rust					21.73	21.[illegible]
			Yield					765.81	765.[illegible]
18. Control		0	CBD	8.75	17.62	11.63	8.95	10.15	
			L/Rust			45.57	37.93	44.58	42.[illegible]
			Yield	210.77	174.22	150.49	359.15	801.69	337.[illegible]
	Mean		CBD	4.98	10.72	6.78	7.48	3.22	
			L/Rust			26.71	23.70	25.61	
			Yield	338.81	251.31	268.19	422.31	948.51	
	LSD P = 0.05		CBD	3.20	5.27	3.47	NS	NS	
			L/Rust	NA		5.66	8.91	14.65	
			Yield	145.71	NS	NS	NS	NS	

NA = Not included/Assessed.

the expansion stage most susceptible (Mulinge, 1970 b). If not controlled the disease can cause crop loss up to 90%, (Bujulu, 1977 and Kibani, 1980).

The aim of this study was to evaluate and determine the most effective fungicides suitable for control of coffee berry disease in arabica coffee in Tanzania.

Material and Methods

The evaluation programme of fungicides was mainly concerned with annual application of recommended and new products in Arabica coffee growing in Kilimanjaro region. Two sites were chosen for this trial namely Lyamungu (1268 m) and Mawingo (1289 m). Arabica coffee (Bourbon type) spaced at 2.75 X 2.75 m were used for this experiment. An extra site at Rombo (1698 m) was included as an observation trial.

Each plot consisted of 20 trees. Treatments were arranged according to a complete random block design, each treatment was replicated 4 times. Fungicides were applied using a Knapsack sprayer. Copper fungicides were applied 8 times, and non copper fungicides 7 times. Spraying intervals were, respectively, 21 and 28 days. The six central trees of each plot were assessed for disease incidence and their yield was recorded. Percentages disease were regularly transformed; yield data were expressed in Kg of clean coffee/ha.

Tables 1-3 show the effect of fungicides on coffee berry disease, leafrust and yields at Lyamungu, Mawingo and Rombo sites.

Regarding Lyamungu site (Table 1), there were no significant yield difference between treatments since (1978). In 1977, Orthodifolatan 80 WP and Benlate 50 WP outyielded the control. The rest

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EVALUATION OF FUNGICIDES FOR COFFEE BERRY DISEASE CONTROL IN NORTHERN TANZANIA

By

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ABSTRACT

Annual investigations on the effect of fungicides on coffee berry disease in arabica coffee were carried out. Both organic and inorganic fungicides were evaluated. Of all fungicides tested, Orthodifolatan 80 WP (4.4 kg/ha), Bravo 500 (4 l/ha), Delan 75 (3.3 kg/ha), Kocide 101 50 WP (7 kg/ha) and the mixture of Nordox + Cobox 50 WP (5.5 + 5.5 kg/ha) achieved economic control of coffee berry disease. Dusan 450 WP (5 kg/ha), Dacobre 500 (5 l/ha), [illegible]ene 75 WP (4 kg/ha) and Nordox 40 WDC showed great promise. Plots sprayed with copper fungicides experienced low leafrust infection.

INTRODUCTION

Coffee berry disease caused by Colletotrichum coffeanum was described for the first time in Tanzania in 1964 (Critchett, 1966). This notorious disease affects all stages of berry development

Experimental Design

The trials were laid down on the standard randomised complete block design with 11 treatments replicated four times. Individual plot consisted of twently five trees (5 x 5). An unsprayed plot served as a control.

CBD Recording and Assessment

Shortly after flowering two branches of five cropping nodes on each nine central trees were selected using the following random sampling technique. Each tree is arbitrarily divided into 16 positions, 4 quadrants North, South, East and West, and 4 height positions within each quadrant. Using random number tables a position on each tree was denoted and in the field a branch was chosen in the designated area of the tree. A label was affixed to this branch and a plastic covered wire was twisted round the branch proximally and distantly to the nodes to be recorded.

The number of pin heads (immature berries) on five nodes of the labelled branches were first recorded at the time of labelling in March (1981). Therefore, the branches were recorded monthly, distinction being made between pinheads (immature berries) healthy and diseased berries. [6]

Brown Blight Assessment

Disease in ripe berry was determined on a one kg. sample per plot at each harvest or on the total yield when this was less than one kg.

Yield Recording

Ripe cherries were harvested at 10 day intervals and yields recorded at each harvest as fresh weight of cherry and were converted to yield of clean coffee as kg/ha, based on 1330 trees per hectare and assuming that cherry yields one seventh of its weight as clean coffee.[1]

Spraying Equipment

The fungicides were applied with motorised knapsack sprayers at the rate of 80 litres per 100 trees (approximately 800 ml per tree).

Fungicidal sprays were applied at monthly intervals between February and July (1981). Two additional sprays were applied in October and November.

The spraying dates at two sites, the fungicides used and their rates of application are summarised in Table 1.

Results

The long rains during 1981 commenced in the middle of March at both sites and continued until end of May. Kentmere Estate recorded 947 mm rainfall and 54 rainy days between January and June 1981. Coffee Research Station recorded 683 mm rainfall and 52 rainy days between January and June (1981). During these periods favourable conditions for CBD infection occurred with high frequency in March, April and May at both trial sites. Data for rainfall and number of days favourable for CBD infection are shown in Figs. 1, 2 and 3.

CRS Plot 16 CBD Trial I (Jacaranda Estate)

None of the treatments in CRS plot 16 CBD Trial I controlled the CBD significantly (at P = 0.05) better than the unsprayed (control) plots (Fig. 4). New products A 6097 A 25% E.C. (0.3%) and MK-23 75% WP at application rates of 0.2% (2.2 kg/ha.) and 0.3% (3.3

Table (I) : The date of application of various new and recommended fungicides for CBD control on various trial sites during 1980/81 period.

Treatments	Active ingredients	% rate of application	Spraying dates CRS Plot 16 CBD Trial I	Spraying dates Kentmere Estate CBD Trial I
Captafol 80% WP	Ortho-difolatan	0.4	12 February, 11 March	10 February, 10 March 9 April, 12 May
Captafol 80% WP + Kocide 101 50%WP	Ortho-difolatan + Cupric hydroxide	0.2 +0.51	10 April, 13 May, 9 June, 2 July, 14 October, 11 November 1981	4 June, 1 July, 13 October and 12 Novermber 1981
MK-23 75% WP	Confidential	0.3	Copcel 50%WP sprays were applied at 3 weeks intervals	Copcel 50WP sprays were applied at 3 weeks intervals
M-23 75% WP	Confiential	0.2		
Dyrene 50% WP	Confidential	0.55		
Dyrene 75% WP	Confidential	0.4		
Calirus 50% WP	Confidential	0.3		
A 6097A 25% E.C.	Confidential	0.3		
Copcel 50% WP	Curprous oxide	1.5		

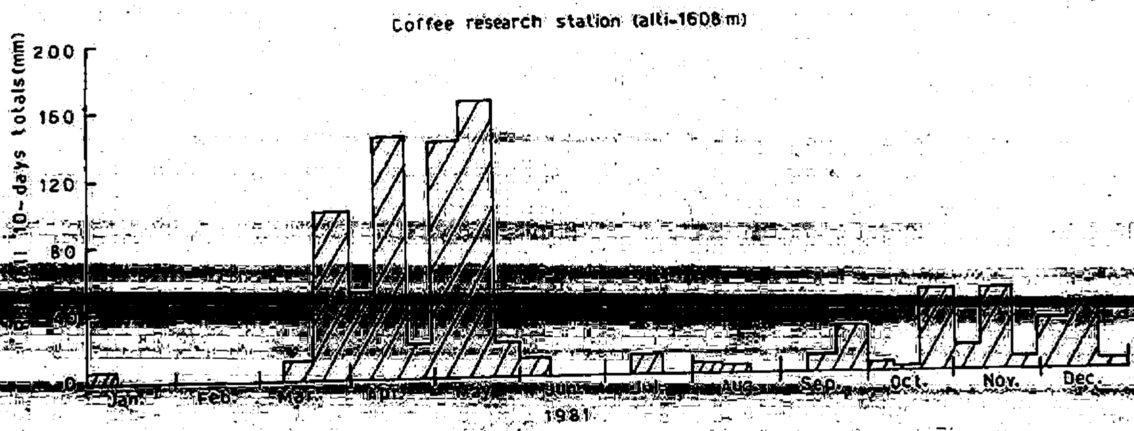

Fig. 1: Rainfall data for Jacaranda Estate for 1981

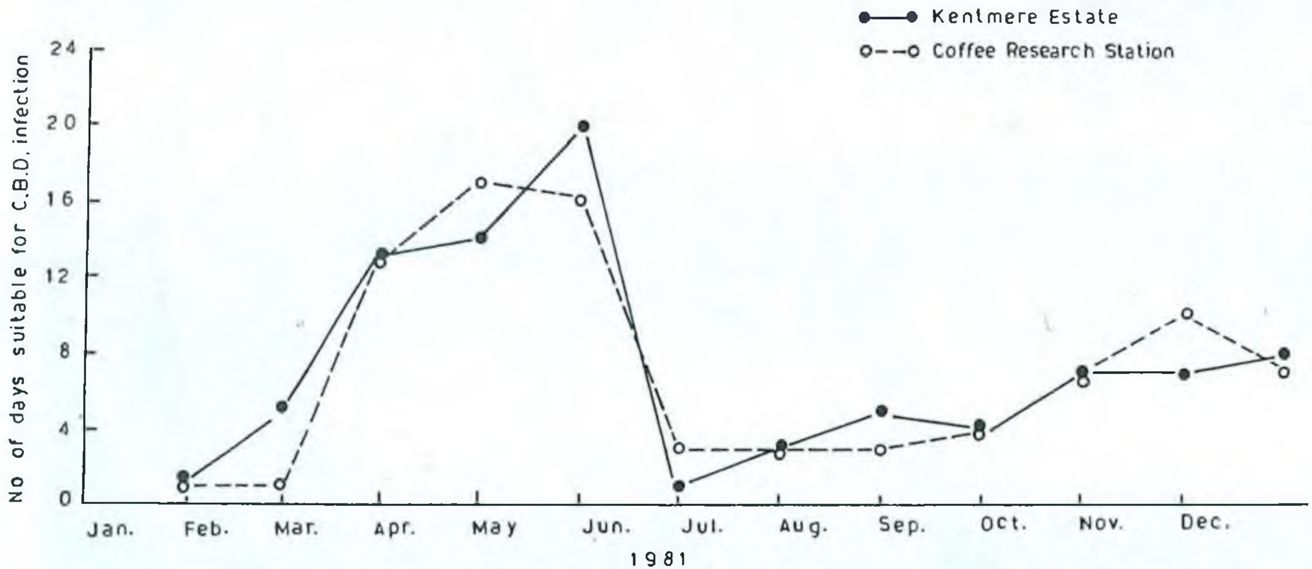

Fig. 2 : Number of days favourable for CBD infection in both trial sites during 1981.

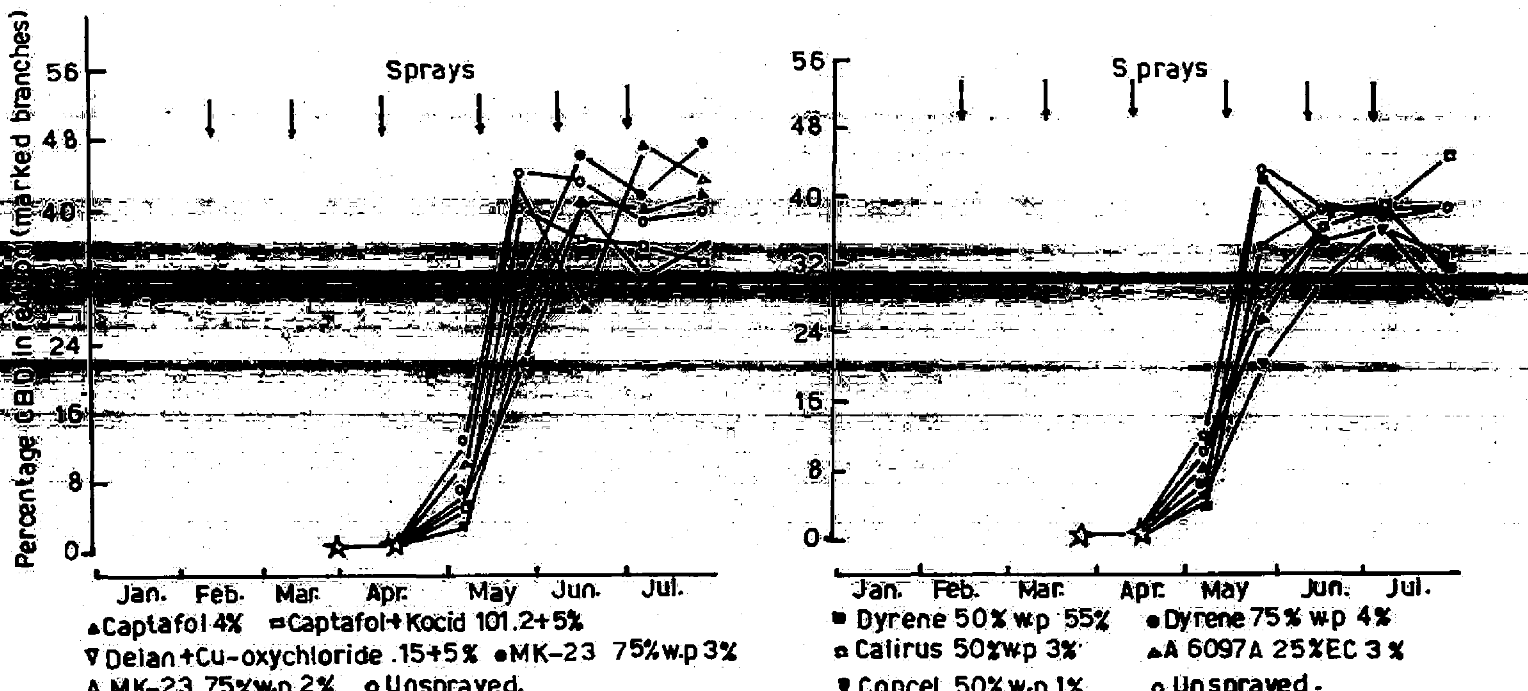

Fig. 3 : Mean percentage C.B.D infection in CRS plot 16 trial 1 on plots sprayed with the new and recommended fungicides.

kg/ha) gave yield lower (not significant at P = 0.05) than the standard product Captafol 80% WP. Plots treated with Dyrene 50% WP (0.55) and Dyrane 75% WP (0.47%) gave yields as high as the standard product Captafol 80% WP. Calirus 50% WP (0.3%) sprayed plots recorded yields lower than unsprayed (control) plots. Concel 50% WP (1.0%) sprayed plots gave yields significantly (P = 0.05) higher than the plots sprayed with the standard product Captafol 80% WP (0.4%).

Plots treated with the tank mix of Delan + Copper oxy-chloride (0.15% + 0.5%) gave the highest yields (significantly higher than the standard treatment). Plots treated with a tank mix of Captafol + Kocide 101 (0.2 + 0.5%) also gave yields higher than the standard treatment Captafol 80% WP but the difference in yield was not significant statistically at P = 0.05. Yields results and % infection in pick (brown blight) are shown in Table 2.

Kentmere CBD Trial

In Kentmere CBD trial I A 6097 A 25% E.C. (0.3%) and MK-23 75% WP (at 0.2%) and C 0.3%) were found effective against CBD (Fig. 2) but plots sorayed with these products gave yield significantly (P = 0.05) lower than the plots sprayed with the standard product Captafol 80% WP (0.4%). Calirus 50% WP (0.3%) was found ineffective against CBD and gave very low yields. Dyrene 50% WP (0-55) controlled CBD effectively and plots sprayed with Dyrene 50% WP gave yields as high as the standard product Captafol 80% WP (0.4%). Although Dyrene 75% WP (0.4%) was significantly inferior in controlling CBD in July 1981 compared to the standard treatment Captafol 80% WP, the plots sprayed with Dyrene 75% WP (0.4%) gave yield as high as the plots sprayed with the standard product Captafol 80% WP. Plots sprayed with Copcel 50% WP (1.0%) gave significant control of CBD and recorded yields higher (not significant at P = 0.05) than the standard product Captafol 80% WP (0.4 %).

Table (2) : Peak CBD infection and yield at Jacaranda estate on plots sprayed with new and recommended products (CRS plot 16 trial I)

Treatment	Rate (%)	% infection in pick(Brown blight) 24.11.81	Peak & CBD infection on marked branches 26.5.81	Clean Coffee yield kg/ha	% increas in yield over standard treatment (Captafol 80% WP)
Captafol 80% WP	0.4	52.2 (46.6)	20.8 (26.6)	642.6	Nil
Captafol + Kocide 101	0.2 + 0.5	31.0 (32.7)	39.6 (38.[illegible])	756.[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	24.9 (29.5)	886.2	+38 (245 kg)
MK-23 7.5% WP	0.3	53.9 (46.7)	30.7 (33.0)	525.1	-18 (118 kg)
MK-23 7.5% WP	0.2	49.7 (45.2	40.8 (39.6)	488.9	-24 (154 kg)
Dyrene 50% WP	0.55	55.1 (47.7)	34.2 (35.5)	645.6	Nil
Dyrene 7.5% WP	0.4	50.0 (45.0)	42.2 (40.2)	623.2	- 3 (20 kg)
Calirus 50% WP	0.3	45.0 (42.0)	28.6 (31.2)	328.2	-49 (315 kg)
A 6097A 25% E.C.	0.3	39.2 (38.5)	25.7 (29.9)	519.1	-19 (124 kg)
Copcel 50% WP	1.0	24.6 (28.6)	20.7 (26.1)	847.4	+32 (204 kg)
Unsprayed (Control)	-	71.6 (58.5)	43.8 (41.1)	427.0	-34 (216 kg).
LDS P = 0.05	-	- NS	- NS	161.82	
CV	-	- 38.68%	- 30.32%	18.44%	

* Figures in parenthesis are transformed percentages (Arcsin %)
One hectare = 1330 trees

The overall performance of tank mixtures of Delan + Copper oxychloride and Captafol + Kocide 101 at half rates in Kentmer CBD Trial 1 was as good as the standard product Captafol 80% WP (0.4%). In fact, both tank mixture gave yields higher than the standard treatment (not significant at P = 0.05) Captafol 80% WP. Yield results and per cent infection in pick (brown blight) are shown in Table 3.

Discussion and Conclusions

MK-23 75% WP at application rates of 0.2% and 0.3% was found effective against CBD (Kentmere Trial I) but gave significantly lower yields than the standard product Captafol 80% WP. In CRS plot 16 Trial I, none of the treatments controlled CBD effectively but MK-23 75% WP treated plots gave lower yields than the standard product Captafol 80% WP. MK-23 75% WP is now being field evaluated against CBD at higher rate (0.4%).

Dyrene 50% WP (0.55%) controlled CBD effectively and gave yield as high as the standard product Captafol 80% WP in both sites during 1980/81. Dyrene 75% WP (0.4%), at one site (Kantmere Trial I) did not give significant control of CBD but plots treated with Dyrene 75% WP at both sites gave yields as high as the standard treatment Captafol 80% WP. During 1979/80. Dyrene 50% WP (0.55%) and Dyrene 75% WP (0.4%) gave significantly (at P = 0.05) lower yields than the standard product Captafol 80% WP. Dyrene 75% WP (0.4%) overall performance against CBD during 1978/79 was inferior to the standard product Captafol 80% WP. It is not easy to explain why Dyrene 50% WP (0.55%) and Dyrene 75% WP (0.4%) did not give consistent performance against CBD. Due to erratic performance against CBD since 1978/79, it has been decided not to field evaluate Dyrene 50% WP or Dyrene 75% WP any more. The failure of all treatments in CRS plot 16 Trial I to control CBD

Table (3) : Peak CBD infection and yield at Kentmere estate on plots sprayed with new and recommended products (Kentmere CBD trial I 1980/81)

	Rate (%)	% infection in pick (Brown blight) 17.12.81	Peak & CBD infection on marked 12.6.81	Clean Coffee yield kg/ha	% increas in yield over standard treatment (Captafol 80% WP)
Captafol 80% WP	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	0.2+0.5	7.8 (16.0)	12.1 (19.1)	823.6	+15 (108 kg)
Delan 7.5% WP+copper oxychloride	0.15+0.5	7.9 (16.3)	14.1 (19.1)	876.2	+22 (160 kg)
MK-23 7.5% WP	0.3	18.3 (24.9)	23.2 (27.9)	435.7	-39 (280 kg)
MK-23 7.5% WP	0.2	15.9 (22.9)	22.5 (27.5)	313.8	-56 (401 kg)
Dyrene 50% WP	0.55	14.6 (22.0)	15.9 (22.9)	717.1	Nil
Dyrene 7.5% WP *	0.4	8.7 (16.9)	17.4 (24.2	761.9	+ 6(46 kg)
Calirus 50% WP	0.3	27.7 (31.5)	30.3 (32.8)	254.9	-64(462 kg)
A 6097A 25% E.C.	0.3	20.9 (26.7)	18.4 (24.5)	421.9	-41 (294 kg)
Copcel 50% WP	1.0	11.5 (19.7)	13.8 (21.7)	803.8	+12(88 kg)
Unsprayed (Control)	-	55.4 (48.6)	33.7 (35.4)	222.3	-69(493 kg).
LSD = P = 0.05	-	- 9.87	- 11.33	220.08	
CV	-	- 28.50%	- 31.84%	26.44%	

* Figures in parenthesis are transformed percentages (Aresin %)

One hectare = 133 trees.

could be attributed to heavy rainfall just after the sprays were applied on 10 April (1981). After the spray in April, 136 mm rainfall was recorded within a week which could have eroded the fungicides from the trees and during the next 3 weeks before the next spray was applied in May CRS recorded 181 mm rainfall with 12 rainy days. The heavy rainfall lead to poor control of CBD in all treated plots but still some treatments gave significantly higher yields compared to the unsprayed plots. The levels of CBD at both sites during 1980/81 were comparatively lower than they were during 1979/80.

Calirus 50% WP was found ineffective against CBD and gave low yields at both sites compared to the standard product Captafol 80% WP. A 6097 A 25% E.C. was effective against CBD in Kentmere Trial I but gave lower yields compared to the standard product Captafol 80% WP. Both Calirus 50% WP and A 6097 A 25% E.C. are new systemic anti-rust fungicides but they were only included in these trials to determine whether or not they will stimulate CBD and affect the yield under the field conditions. Copcel 50% WP (1.0%) controlled CBD effectively in Kentmere Trial 1 and gave yield higher than the standard product Captafol 80% WP. In CRS, Plot 16 Trial I again Copcel 50% WP gave yield significantly (P = 0.05) higher than the standard product Captafol 80% WP.

Tank mixtures of Delan + Copper oxychloride (1.6 kg + 5.5 kg/ha) and Captafol + Kocide 101 (2.2 kg + 5.5 kg/ha) gave the best overall performance against CBD and recorded yields higher than the standard product Captafol 80% WP in both sites during 1980/81. Therefore, growers are advised to use these tank mixtures more frequently than Delan 75% WP or Captafol 80% WP on its own for higher yields. In two successive years, these tank mixtures have performed well against CBD and they are cheeper cost wise compared to the prices of full rates of Captafol 80% WP and Delan 75% WP when sprayed alone to control CBD (Table 4 and Fig. 4).

Table (4) : Current cost of controlling Coffee Berry Disease in Kenya

Fungicides / Tank-Mix	Rate kg/ha	Cost per round (KSHs. 1)	Total cost per season (8 sprays) (KSHs)	% saving over Captafol 80% WP
Captafol 80% WP	4.4	572/-	4,576/-(US$ 436/-)	Nil
Delan 75% WP + Copper oxychloride 50% WP	1.6+5.5	350/-	2,800/-(US$ 267/-)	39
Captafol 80% WP + Kocide 101 50% WP	2.2+5.5	542/-	4,336/-(US$ 413/-)	5
Delan 75% WP	3.3	495/-	3,960/-(US$ 377/-)	13

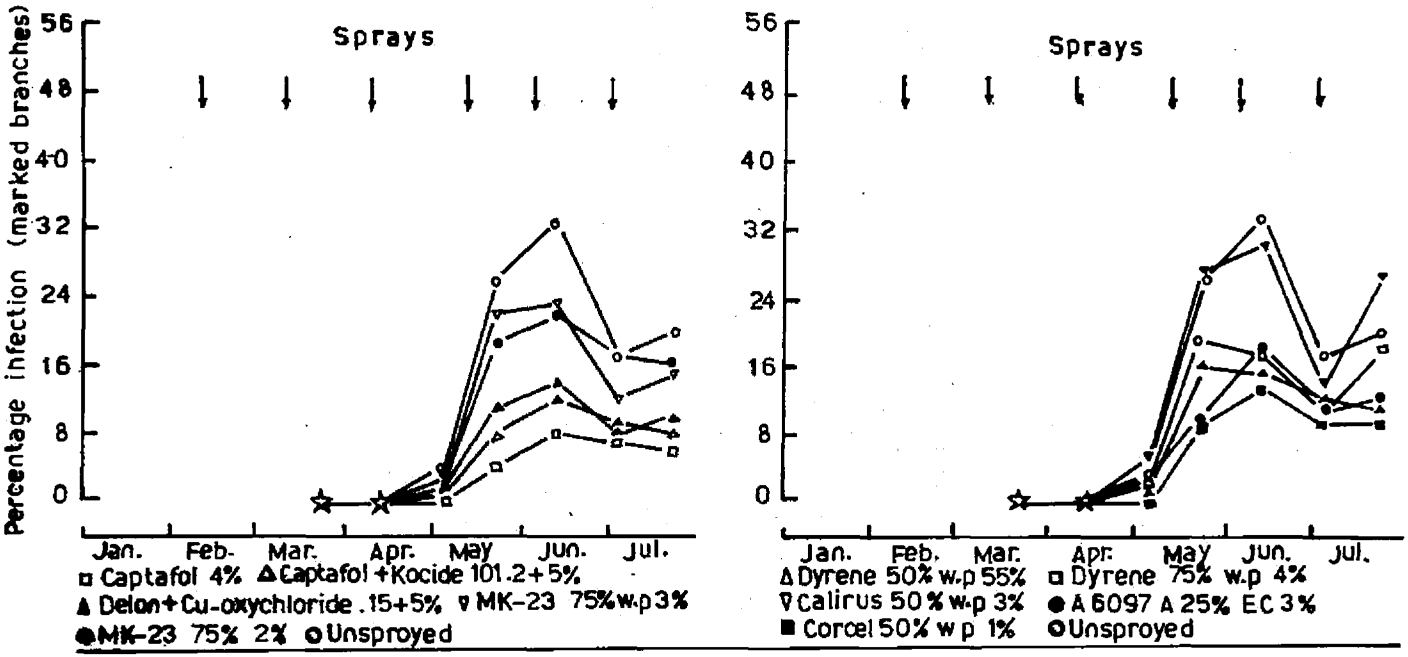

Fig. 4: Mean percentage C B D infection in Kentmere Estate trial I on plots sprayed with new recommended fungicides.

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REFERENCE

Griffiths, E. Gibbs, J.N. and Waller, J.M. (1971) Control of coffee Berry Disease. Ann. appl. Biol. 67 : 45-74.

Javed, Z.U.R. (1981) Effectivness of New and Recommended fungicides in controlling coffee Berry Disease during 1980. Kenya Coffee. 46, 209-216.

Javed, Z.U.R. (1980) Effectivness of new and recommended fungicides in controlling Coffee Berry Disease during 1979. Kenya Coffee, 45 : 293-299.

Mulinge, S.K. (1970) Development of coffee Berry Disease in relation to the stage of berry growth. Ann. appl. Biol. 65 : 296-276.

Okioga, D.M. (1978) Unpublished data.

Vine, B.P., vine, P.A. and Griffiths, E. (1973) Evaluation of fungicides for control of Coffee Berry diseases in Kenya. Ann. appl. Biol. 75 : 359-375.

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A SUMMARY OF RESULTS OF SPRAY TRIALS AGAINST CBD IN ETHIOPIA

BY

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Coffee Berry Disease was identified in Ethiopia in 1971 for the first time. Subsequently, a number of spray trials were conducted by the Institute of Agricultural Research. A short summary of their results over the period 1972 to 1981 is given in the following sections.

Methodology:

Plots normally consisted of 20 trees. Design was RBD with mostly four treatments. Problems in the deliniation of plots were often encountered due to: variability of tree sizes, ages and spacing; the occurrence of dead trees due to Gibberella xylarioides; genetic heterogeneity; and a general lack of pruning and extreme tree height.

Spray machinery consisted of hand-operated knapsack sprayers, if needed, with telescopic lances. For ULV experiments, Micron Ulva 8 sprayers were used.

The volume of application was subject to experimentation (see the separate heading) but was in most trials 960 to 1,120 litres per hectare (standard hectare with 1,600 trees).

The duration of spray intervals was subject to experimentation (see separate heading) but was in normal trials four weeks except for copper formulations where the duration of the intervals was three weeks.

Records were taken by means of regular counting of sample branches and yield measurements. In later trials, it was shown that rapid visual observation was as reliable as the more cumbersome berry counting.

Statistical analysis was improved through the incorporation of within plot replication. Transformations of yield data (gms/fresh cherry/tree) in the range of $X^{0.5}$ to $X^{0.8}$ made the data more suitable for analysis.

Products:

Captafol (80%WP). Various concentrations have been used since the start of the trials in 1972. Concentrations of 0.25 to 0.30% formulation proved superior than lower concentrations and not inferior to higher concentrations (0.4%=4kg/ha). Captafol 98% flowable gave yields comparable to 80% WP at the same concentration of the active ingredient..

Benomyl and Carbendazim (50%WP). Yields did not differ siginificantly from standard Captafol applications at 0.5 to 0.75Kg/ha. Their use was discontinued as the adaptation of the fungus to Benomyl and Carbendazim in Kenya became clear.

Copper formulations: Low copper dosages at threee weeks intervals were less effective than standard Captafol schedules. Copper ('Kocide') at 7.0kg/ha in a four weeks schedule appeared promising.

Other fungicides. Relatively few data are yet available on Daconil, Delan, Dyrene and Bravo.

Daconil, Delan, Dyrene and Bravo.

Daconil 75% WP was tested at 3.4 and 4 kg/ha; yields were slightly lower than the standard Captafol treatment. Delan 75%WP was tested at 3.4 and 4.4 kg per ha and Dyrene 75% WP at 3.1 and 4.0kg/ha. For both Delan and Dyrene, yields were somewhat lower than with Captafol. Bravo, which was tested at 4.5 50% gave a considerably lower yield than the standard Captafol treatment.

Spray Volume:

Spray volumes normally varied between 600 and 700 cc per tree (960 - 1,120 l per standard hectare of 1,600 trees). This corresponds to the point of incepient "run-off". Trials aimed at the reduction of this volume per tree while retaining equivalent Captafol dosages resulted in reduced yields.

ULV was tried in 1981. 33% Captafol 80% WP solutions were tested by overhead application on four year-old trees. As indicated above, Micron Ulva 8 sprayers were used. It was found that trees of up to a maximum of 2 metres could be adequately sprayed. Spray drifting above each tree was found possible and outputs of at little as 9.8 litres/ha were obtained. Yields were comparable to those from standard knapsack sprayers (Table 1).

Timing of Sprays

Flowering of coffee in Ethiopia usually occurs in February or March although earlier flowerings and multiple flowerings may occur. Spraying in trialls generally begun in March or April. Some data are available that indicate that spraying during flowering as against a beginning six weeks after flowering is advantageous.

Table 1 : Captafol ULV Experiment-Gerra 1981

Sprayer	Conc. captafol 80%WP	Col/ha/1600 tree	% CBD(27/8)	%crop loss 23/4-27/8/82	Yield clean coffee / ha	Mean Kg/ha Captafol sprayed
Micron ULVA 8	33.0%	9.8 litres	6.1 b	36.6 b	720.3 a	3 . 3
Holder plants 10	0.4%	685.3 litres	0.4 a	27.4 a	718.6 a	3 . 1
Unsprayed	-	-	29.2 c	62.1 c	417.0 b	-

Design: 3 treatments x 7 replicates (6-tree plots).

Recording: Berry counting: 8 recordings,early April-late September. Yields.

Sepray Schedule: 6 applications, early April-early September.

Site: Gerra Sub-Station, Kaffa Province. (Progenies 7596 and 7598).

Analysis: Two-way ANOVA with replications (6-tree plots).

Spray Application (Micron Ulva 8): Movement of the sprayer directly over each tree top in an arc formation (approx. 3-4 secs/tree).

ntrvals: Captafol, Carbendazim, Benomyl : 4 weeks intervals were clearly superior to 6 or 8 weeks intervals. Three weeks intervals were advantageous with copper formulations but not wil Captafol.

Spraying has usually extended to mid-August (Sometimes early September)?. Little information is yet available on the optimal data of termination of sprayins.

Conclusions:

Despite differences in the system of coffee cultivation between Ethiopia and other African countries, the basic recommendations for the control of CBD also apply in Ethiopia.

Captafol controls CBD well if applied at monthly intervals, at rates of 0.25 to 0.3% and approximately 1,000 litres per standard hectare of 1,600 trees. Benomyl and Carbendazim gave also good control but should be avoided due to an anticipated build up of the fungus.

Daconil, Delan and some other fungicides show promise but further testing is needed.

Results of low volume application warrant cofirmation.

REFERENCES

For More Detailed Results See:

Institute of Agricultural Research: Jimma Research Station, 1973 Progress report for the period April 1972 to March 1973 Addis Ababa 106pp

Progress report for the period April 1973 to March 1974 Addis Ababa 98 pp

Institute of Agricultural Research: Jimma Research Station, 1978. Coffee Department Jimma Station Progress Report. Part I Coffee Research, April 1974 to March 1978 Addis Ababa 125 pp.

Coffee Department Jimma Station Progress Report. Coffee Research, April 1978 to March 1979 Addis Ababa 1980.

Coffee Department Jimma Station Progress Report. Coffee Research, April 1979 to March 1980 Addis Ababa 1981.

Coffee Department Jimma Station Progress Report. Coffee Research, April 1980 to March 1981 Addis Ababa Pending.

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CHEMICAL CONTROL OF CBD

By

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INTRODUCTION

Chemical control of CBD, as well as control of all other fungal diseases, involves a series of elements : timing of spray application, determined by epidemiology of the pathogen, which depends on climatic conditions, sources or primary and secondary inoculum, efficiency of these sources, susceptibility of organs; choice of fungicides according to their efficacy under field conditions, which depends on their type of activity, their ability to control more than one disease, and their physiological effects on the plant; choice of application method : low or high volume and type of machinery; prophylactic measures.

The Beginning of the spraying

In 1958, we began our studies in Cameroon. To our surprise, nutman and Roberts in Kenya considered the bark as the source of inoculum. According to their "inoculum potential" theory, the parasite lives on the bark without any harmful effect but produces the conidia that infect berries.

Nutman and Roberts counted the conidia produced on the bark (number of spores/per cm^2/per hour) and they showed that the conidial production was the highest during the dry season. Therefore, they advised the farmers to treat chemically during the dry season, before flowering.

In Comeroon, the rainy season starts in March and is monomodal. In 1959, we tried to verify the efficiency of Nutman and Roberts, spray schedule for the conditions in Cameroon, in a trial with the six following treatments :

1. 1st spray on 10 January associated with prophylactic measures
2. 1st spray on 10 February or picking the "out of season" berries
3. 1st spray on 10 March at the end of the preceding campaign
4. 1st spray on 10 April and followed by a further 8 to 9 sprays during the season at regular intervals.

5. Prophylactic measures alone, by picking the "Out of Season" berries at the end of precedent campaign.

6. No chemical treatment, no prophylactic measures.

The year 1959 was, exceptionally, characterized by two flowerings :

- The first one on 16 January, resulted from showers in early January (Population A).

- The second one was the most important and corresponded to the normal crop. It occurred on 25 March and resulted from the first rain of the wet season on 18 March (Population B).

The first CBD symptoms were visible on population A on 12 April (at this date the population B was too young to be attacked by the pathogen. Forty-five thousand berries of population A were recorded in early May. In late July, a second series of observations were made on berries of both flowerings (populations A and B) (Table 1).

Table (1) : Percentage of diseased berries in May and July 1959

Treatments	Percentage diseased berries	
	May*	July**
First spray 10.1	0.5 a	2.3 a
First spray 10.2	0.3 a	0.5 a
First spray 10.3	0.9 a	1.1 a
First spray 10.4	5.5 b	1.9 a
Profylactic measures only	6.2 b	39.8 b?
Control	23.4 c	44.5 b

* May Population A (45,000 berries from two replications)
** July Population A + B (119,000 berries from 4 replications).
*** In each column, values marked with the same letter did not differe significantly.

From the data, it was concluded that :

- Control by copper was very effective.
- A late first spray (10.4) did not adequately protect population A but later in the season, the differences between this treatment and those which begun ealier disappeared.

Concerning control recommendations, it was concluded that under normal conditions, the first spray should be applied just after flowering at the start of the rains. In the case of an early crop an extra spray may be applied before the rains.

More generally, it was concluded that pre-flowering treatments were unnecessary and that the only way to protect the berries was through post flower treatments during the rainy season.

Length of spray Intervals

After the determination of the period in which chemical treatments had to be performed and the date of the first spray, we tried to determine the duration of the spray intervals and the minimum number of sprays.

In a series of trials and observations it was shown that treatments had to be performed during the first five months after the flowering. During this period, the main disease increase occurs (see the preceding paper on disease epidemiology). After five months, treatments are not necessary because the berries are not susceptible any more.

As the persistance of fungicides depends on rainfall and as the amount of rainfall increases from March to July, we assumed that intervals between treatments had to be shorter towards that month.

In summary, after many trials with copper fungicides, we recommended in Cameroon the following timing for copper treatments:

1st Spray : 2 weeks after flowering; 2nd spray : 5 weeks after the 1st one; 3rd spray : 4 weeks after the 2nd one; 4th spray : 3 weeks after the 3rd one; 5th spray : 2 weeks after the 4th one; 6th spray : 2 weeks after the 5th one and 7th spray : 2 weeks after the 6th one.

These seven sprays gave the same results as eight or nine sprays and were sufficient but necessary. In the trials, the production of 20 trees was 100 kg fresh berries in the untreated plots and near 200 kg fresh berries in the treated ones.

A comparison with chemical control in Kenya

After a study of the situation in Kenya in 1964 and 1967, we concluded that the same policy would apply to that country but that both early and late crops would need protection.

In fact, we concluded in a paper (La lutte contre l'anthracnose des baies du caféier arabica au Kenya, Café-Cacao-Thé, No. 1, 1968) that the theory of Nutman and Roberts failed to take the following points into consideration :

- In their experiments, the conidial production of all Colletotrichum spp. living in the bark was measured.
- The conidial production was measured under humid conditions in the laboratory but not in the field.
- The conidial production of diseased berries was not taken into consideration.
- Nutman and Roberts indicated that preflowering treatments with copper or captafol during the season would stop the sporulation, howeover, those chemicals normally only inhibit conidial germination.

Hindorf (1973) and Gibbs (1969) later confirmed that at least five taxonomically identifiable Colletotrichums were present on the balk. Bibbs found the CBD causing strain to be relatively rare on the bark. Probably, the pathogen is only living in deeper layers of the bark and its epidemiological importance is likely to be small in comparison with the diseased berries. Gibbs (1969)reported that diseased berries produced from 700 to 900 conidia per cm^2/h.

In Kenya, the two rainy seasons are shorter than the single one in Cameroon and therefore, treatments may be less numerous for both early and late crops. In retrospect, it is very surprising to read in the Kenyan literature that preflowering treatments applied during the dry season (based on Nutman and roberts theory) were efficient until 1967 but lost their efficiency in later years. Obviously, it is not possible to accept a total change in climate that changed the CBD epidemiology. There are no meteorological data to support this idea. The truth is that preflowering treatments were never effective at all. The change in the official recommendations to postflowering treatments in 1968 was only due to our study which showed the failures of Nutman and Roberts theory (see Vermeulen, 1979) and to the results of studies carried out according to our recommendations. As we already explained, these studies confirmed our points of view and lead to the adoption of the spray schedule we recommended for Kenya in accordance with our experiences in Cameroon.

Prophylactic Measures

In a preceding paper, we explained that in Cameroon only one main flowering occurs giving only one crop annually. But some flowers open at other instances giving fruits which are not picked because they reach their maturity out of season and are not numerous enough to justify special pickings. These remain on the trees and, as a large proportion of them is diseased, they ensure survival of the pathogen from one campaign to the next. These berries form a very efficient source of initial inoculum for the new crop. This we demonstrated in some trials. If we compare the data of treatments 5 and 6 in Table 1, we see that the removal of these "out-of-season" berries reduced disease. Therefore, we believe that, in Cameroon, it is a sound practice to remove these "out-of-season" berries during the last picking. Although this will not control the disease, it is a good auxiliary of chemical treatments. It is obvious that this prophylactic measure is impossible in Kenya where there are two important crops per year.

Choice of fungicides

In the CBD affected area of Cameroon, coffee is heavily attacked by leaf rusts, of which Hemileia coffeicola is more serious at high altitude than Hemileia vastatrix. As Hemileia coffeicola can infest up to 50 to 70% of the leaves, treatments against leaf rusts are necessary. The fungus develops during the same period as CBD. As a result, the fungicides used against CBD must also be efficient against leaf rusts. Among all the fungicides we tried, only few were sufficiently polyvalent to be adopted. Therefore, it is recommended to use copper fungicides or captafol. All copper fungicides may be used but there was a range of efficacy :

1. Cuprous oxyde at the concentration of 0.5% of commercial product containing 50% of copper;

2. Copper hydroxyde at the concentration of 0.5% of commercial product containing 56% of copper;

3. Stabilized Bordeaux mixture at the concentration of 0.5% of commercial product containing 24% of copper;

4. Copper oxychloride at the concentration of 0.5% of commercial product containing 50% of copper.

For all these copper fungicides, seven sprays a year are needed.

Captafol 80% WP was the best of all fungicides against CBD, at the concentration of 0.4%. At this concentration, only five sprays are necessary in Cameroon, according to the following schedule : 1st apray : 2 weeks after flowering; 2nd spray : 5 weeks after the first; 3rd spray : 4 weeks after the second; 4th spray : spray : 3 weeks after the third; and 5th spray : 3 weeks after the fourth.

However, Captafol does not control leaf rust as well as copper. Nevertheless, we recommend Captafol because it has a stimulating effect on trees, which results in a better growth of twigs; on the contrary, copper, when applied at the recommended concentration and frequency had a suppressive effect.

Systemic fungicides as benomyl or thiophyanates were not recommended against CBD because they were not effective against rust.

Choice of a Spray Volume and Spray Machinery

Until now, high volume sprays are mored effective than lower volume sprays in Cameroon. As farms are small, manual knapsack sprayers are preferred.

Conclusion and Some Particular Considerations

Concluding, we can say that chemical control is satisfactory. But it is a very hard work for the farmer.

It is obvious that it is necessary to improve the spraying technique to facilitate the work of the farmer and to find new fungicides that combine a good control with easiness of application. We may foresee polyvalent systemic fungicides which have a long life in the plant, and can be applied the soil or the plant by low volume or ultra low volume sprays.

Early irrigation, an insurance for a regular high yield, contributes to the reduction of the number of chemical treatments.

All pathologists must express their results in terms of concentration of fungicide mixture, not in terms of weight per surface unit. It is obvious that it is impossible for a farmer to adjust his fungicide mixture to weight/hectar as this depends on factors like age and size of the trees and planting density. Therefore, the minimum effective concentration of a fungicide should be given and a simple device to measure the necessary amount of product per sprayer should be supplied (for example preweighed quantities for 10 litres or calibrated spoons).

For full references and bibliography, the author can be contacted.

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CHANGES IN SUSCEPTIBILITY OF COFFEE BERRIES DURING THEIR DEVELOPMENT, AND CONSEQUENCIES

By

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The Climate in the CBD Area in Cameroon

The west mountains where arabica is grown in Cameroon present a tropical climate with only one rainy season from march to October and one dry season from November to late February as it is shown in Figure 1. The total annual rainfall is around 2,000 millimeters.

In Figure 1, a curve (in crosses) gives a better idea of the "ambiant humidity" : at the beginning of the rainy season (March to June), if rains are abundant in quantity, they are heavy and short and occur mainly during night or evening, leaving numerous dry and sunny hours in the day. Later on, rains are more and more continuous, the whole day being very wet (August to October).

Phenology of Coffee Trees in the Cameroon CBD Area

In the CBD area, the tropical regime of rains give a particular cycle to coffee trees, with only one flowering and one annual yield as shown in Figure 2 :

- flowering occurs 10 to 15 days after the first rains, that means, as an average, near the 11st of March, with some changes due to the charges of the climatic years;

- expanding stage of the berries is found between the 6th to the 22nd week after flowering (15th of April to late July as an average);

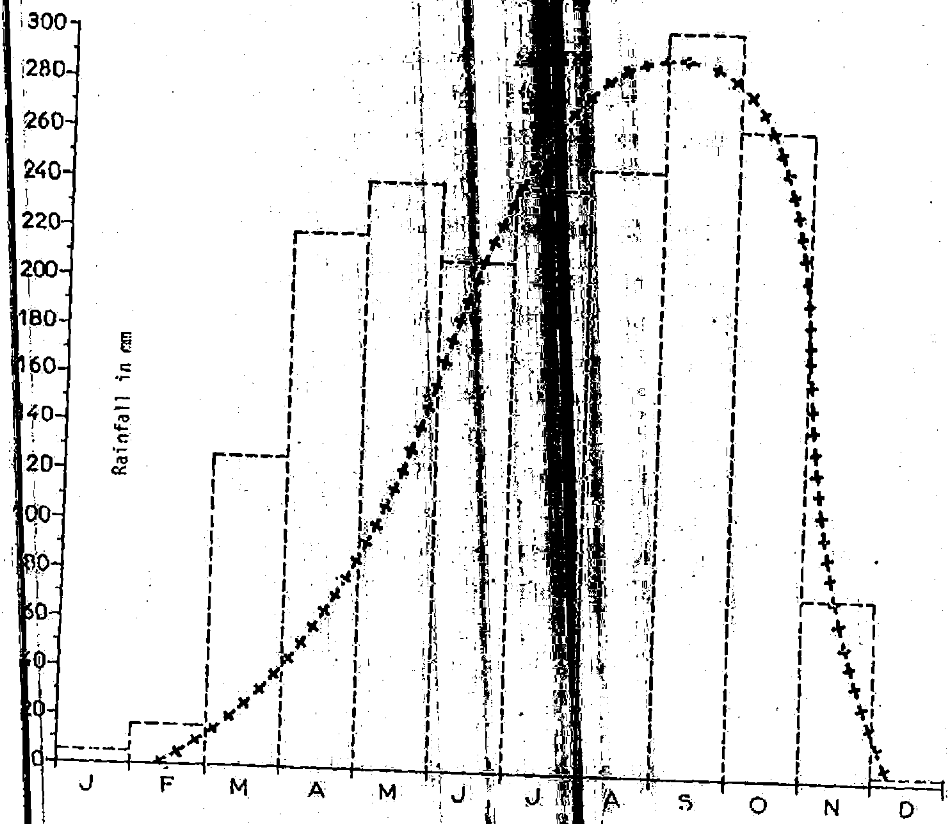

Fig. 1. Average rainfall in Cameroon at 165[illegible] m altitude - The curve ++++ gives an idea of the total ambiant humidity.

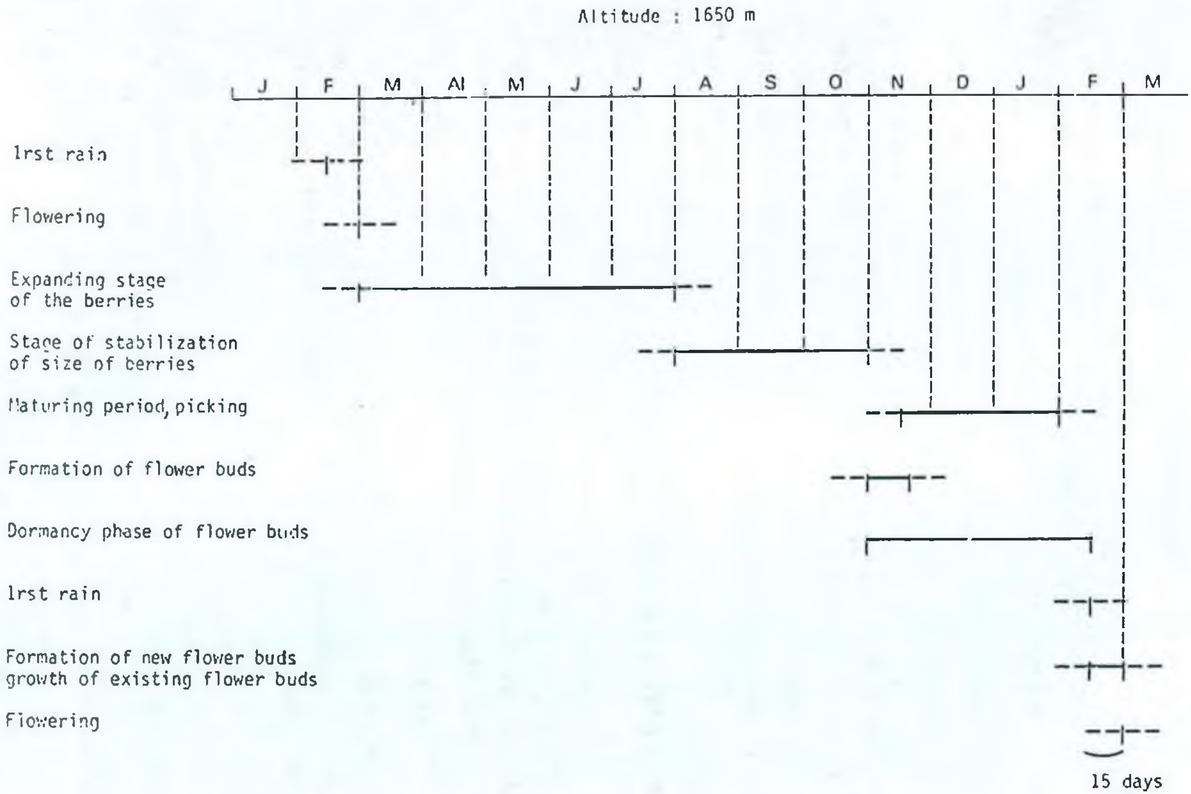

Fig. 2. Phenology of Arabica Coffee, Babadjou-Cameroun.

- phase of stabilization of the green berries - during which the seed becomes hard - between the [illegible] to the 36th week after flowering (August to Late October as on average);

- prematuring, and maturing stages and picking period later on (from November to January);

- the flower buds appear during the last part of the rainy season that means in october-November, and remain dormant during all the following dry season until late February-early March, a period when the new rains allow them to open.

Evolution of CBD in Cameroon

1. Evolution of infection (curve A Figure 3) : Our studies of epidemiology in Cameroon showed that the evolution of infection had every year the same qualitative aspect independently of its intensity that means independently of the climatic conditions. Infection presents three phases :

- a phase of quick increase, from the [illegible] to the 22nd week after flowering, corresponding to the expanding stage of the young berries;

- a phase of stabilization from the 23rd to the 32nd week after flowering, corresponding to the stage of size stabilization of the green berries, during this phase new lestions do not occur.

- a new phase of increase (occurrence of new lesions) later on, during the premature and mature stages (at this moment the lesions concern the pulp only, and therefore damages are not important).

2. Evolution of losses (curve B Figure 3) : In parallel, the evolution of losses is as follows :

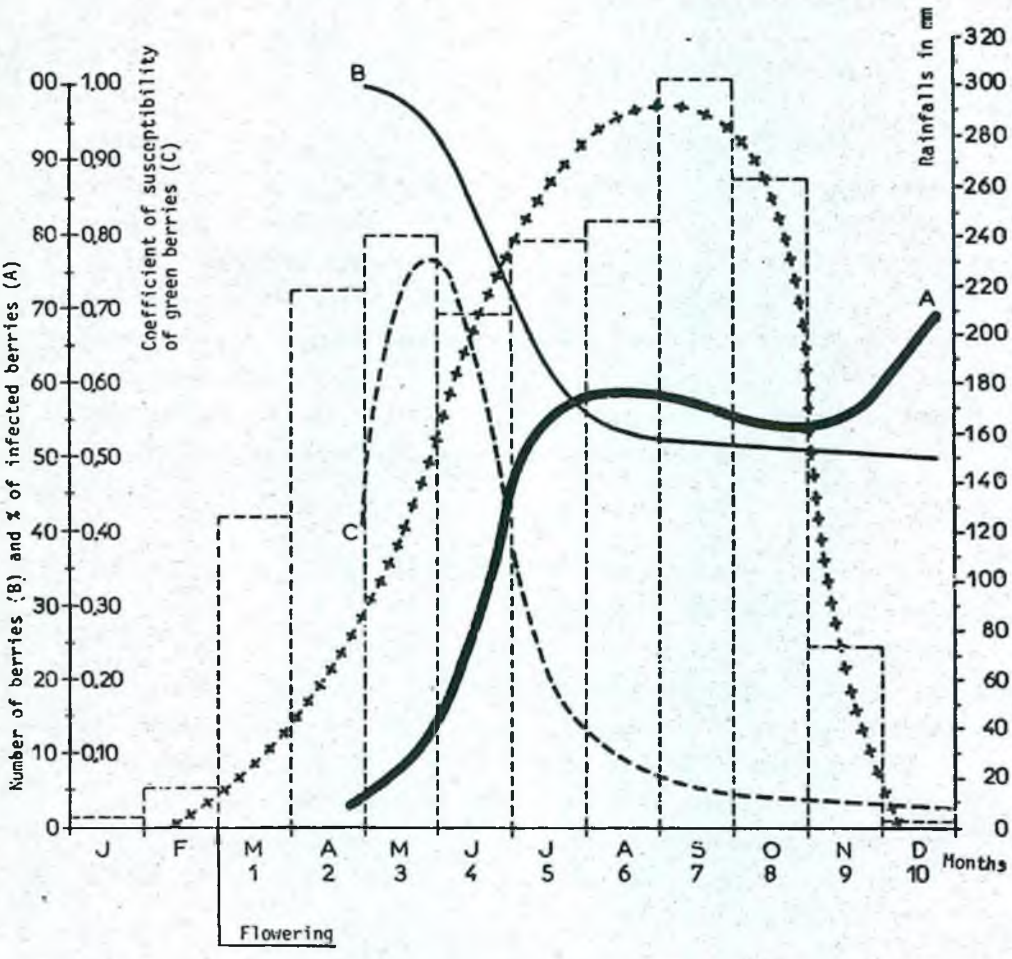

Fig. 3 . Evolution of infection : A
Evolution of the population of berries in observation : B
Evolution of the coefficient of susceptibility of the berries : C

- a period of high losses due to the disease (*) during the first increasing phase of infection;

- then, losses are very few or none.

3. Changes is berry susceptibility : To assess evolution of infection and evolution of losses, our observations were made weekly. We compared, for every week, the number of berries lost between one week (W) and the next one (W + 1), the number of diseased berries observed during the first of these 2 weeks (W); we can see that, for a given number of diseased berries, the losses are not the same along the campaign as it is shown in Figure 4. We had a direct correlation between losses and infection during the young stages of the berries, untill the 20<u>th</u> week after flowering; later on, losses are very few if compared with infection.

This indicates that the susceptibility of the berries to CBD is variable during their development.

We calculated for every week the ratio between the number of berries lost between 2 weeks W and W + 1 and the number of infected berries observed in W. This ratio is the "coefficient of susceptibility" of the green berries; for all sites and all years, this coefficient has high values between the 6<u>th</u> to the 22<u>nd</u> week after flowering (the highest between the 10<u>th</u> and the 18<u>th</u> week), and very low values later on (Figure 3, Curve C).

Our observations lead us to consider that this "coefficient of susceptibility of green berries" was a characteristic of the berries themselves independant of climatic conditions.

(*) CBD losses take place at the moment when the young fruits drop due to physiological causes : nevertheless, it is possibled, thanks to weekly observations done branch by branch, to have a good approximation of CBD losses with a light overestimation.

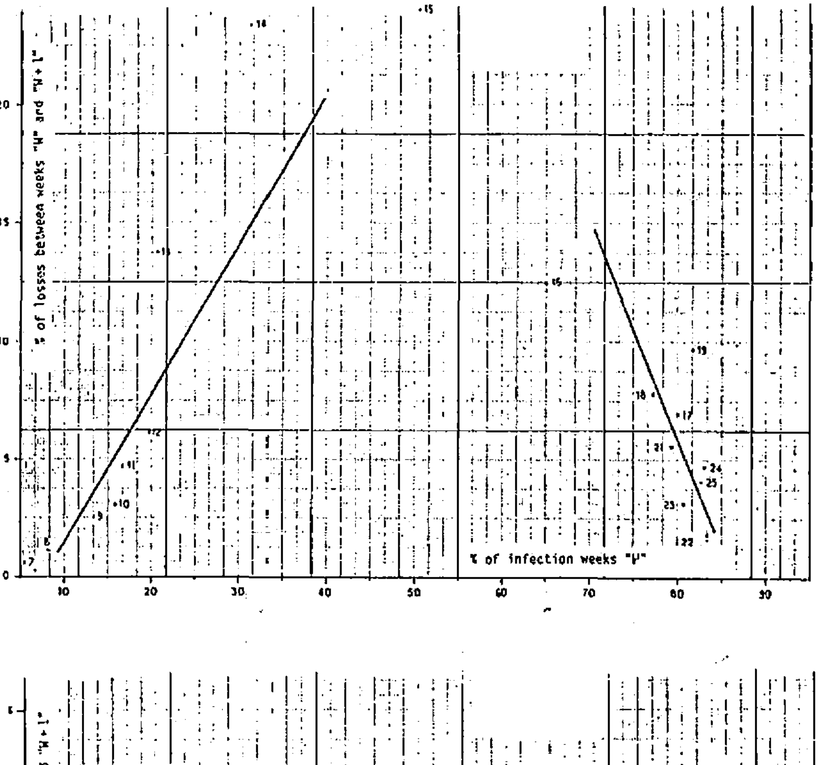

Fig. 4. Correlation between % of infected berries every week "W" and % of losses between "W" and the next week "W+1"

In fact, if we understand well why there is a phase of quick increase of infection during the first 22nd weeks of development of the berries, because rainfalls are sufficient to allow dissemination and germination of spores, we do not understand why there is a phase of stabilization of infection during the next period when the climate is very humid and therefore, very favourable to a high parasitic activity.

The only explanation is found if we consider that, during this period, the berries have lost their susceptibility : this is shown by the fact that the existing lesions do not develop and that it is possible to see some lesions (mainly of scab type) disappearing progressively by desquamation of necrotic tissues.

On the other hand, it is not very easy to understand why new lesions appear during the premature and mature phases, when the weather is dry and therefore, not favourable to infection. This is understandable if, at this moment, the pulp of the fruit becomes susceptible again. We can think that the new lesions which appear during this period result from infections taking place late in the first stage (near the 22nd week after flowering). The fungus remaining dormant in the tissues during the non-susceptible stage of the berry and giving lesions only when the pulp, becoming more hydrated and rich in sugar, allows it to develop.

In summary, our observations lead us to conclude that the susceptibility of the berries is variable during their development, and that this change in susceptibility explains the evolution of the disease along the year.

Consequencies of Changes in Berry Susceptibility

The consequencies of changes in berry susceptibility are numerous :

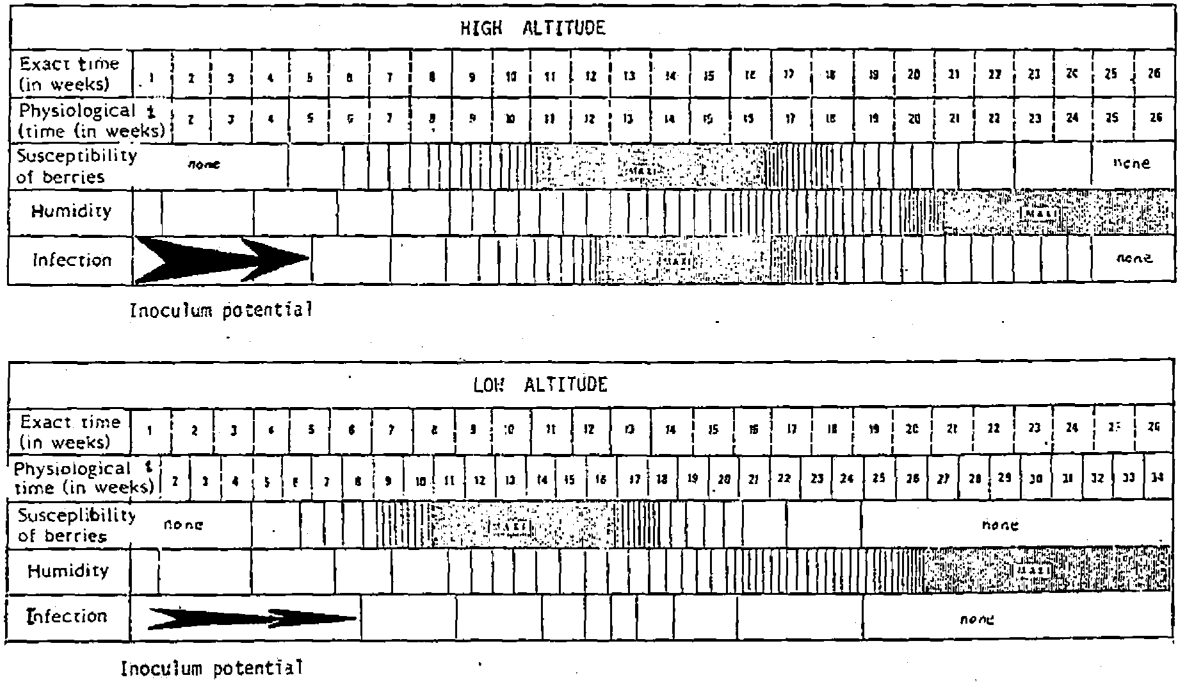

Fig. 5. Comparative Evolution of Arabica Coffee Berries in High and Llow Altitude

- The first one concerns the timing of spray. The young berries being the susceptible ones and coexisting with a humid weather favourable to the fungus. Treatments have to be done during the first 5 months of development of the berries.

- The second one concerns the selection of resistant cultivars. All observations in the field, and all tests of resistance by experimental inoculations have to be done during the period of high berry susceptibility that means during the first 5 months after flowering for the observations in the field and from the second to the fourth months for experimental inoculations.

- For resistant varieties selection, it is important to take in account the speed of growth of the berries infection as a direct function of the duration of the susceptible stage of the berry.

- It is possible in one country free of CBD to know if, in case of introduction of the pathogen, the disease would be severe or not. This was shown in Cameroon where it was possible to see that, if CBD exists in high altitude and not in low altitude where the pathogen is known to exist. This is not due to a direct effect of temperature on the fungus, but to its indirect effect on growth of berries.In hign altitude,the time between flowering and maturing is, as an average, 42 weeks, and only 32 weeks in low altitude. If we compare the temperatures in both areas, it is obvious that they are, in low altitude, as favourable to the pathogen as in high altitude; but the speed of growth of the berries in high altitude is slower than in low altitude. The time between flowering and maturity being 42 weeks in high altitude and only 32 weeks in low altitudeIn such conditions, the duration of young susceptible stages of berries is sufficient to allow the fungus to have an epidemic development, but not in low altitude where the duration of that stages is very much shorter (Figure 5).

- The last one concerns with a cultural method for the control of CBD, the early irrigation.

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ECONOMIC ASPECTS OF COFFEE BERRY DISEASE CONTROL IN KENYA

By

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ABSTRACT

Coffee Berry Disease can cause a considerable loss of yield in coffee. The annual loss is variable over time and space and from documentary evidence it can range from 20%-90% of potential harvest. Despite the economic importance of this disease, the present high cost recommendations continue to be based purely on the efficacy of the fungicide used to control and not on the profitability of the protective measures. The paper attempts an ex-post evaluation of CBD control measures using historic yields from experiments and farms. A - review of the divergence between the farmer practices and recommendations is presented. The analysis herein lands support for urgent need in the short run to recommend reduced but well timed spray rounds and a move to fungicide mixtures. In the long run, the adoption of resistant varieties provide the answer to the CBD problem and input subsidies with support credit systems would enhance rapid uptake of the technology especially within the small holder sector, thereby, reducing farm costs and improving profitability and farmer income.

General Overview

In 1981, the world pesticide market was valued at approximately US$ 13.000 M and of this expenditure about 20% was on fungicides. In contrast, fungicides accounted for nearly 60% of the Kenya pesticide market, valued at approximately US$ 22 M in 1981 (Table 1).

In Table 2, the broad structure of pesticide usage in Kenya is given. From this table, it is clear that coffee dominates the overall market structure accounting for nearly 65% of pesticide usage.

Table (1) : the Structure of world and Kenya Pesticide Markets*

	World Market %	Kenya Market %
Herbicide	[illegible]	21
Insecticide	[illegible]	17
Fungicide	[illegible]	56
Others	[illegible]	6
Total	100	100

Table (2) : Structure and Crop Share of Kenya Pesticide Market, 1979.*

Crop	Approximate Value K£'000	% Share
Coffee	6200	65
Tea	140	2
Maize	290	3
Cotton	410	4
Cereals	300	3
Sugar	390	4
Vegetables	1 510	16
Others	290	3
Total	9 530	100

* source: Kenya Pesticide Association

Within the coffee market, fungicide usage predominates and accounts. for approximately 70% of the total pesticide expenditure on the crop (Table 3).

Of the two major diseases in coffee, Rust and CBD, the latter probably accounts for some 80% of the total expenditure on fungicides, which shows how important the control of CBD is in Kenya.

Table (3) : Structure of Kenya Pesticide Market in Coffee.

% Share of coffee market accounted by				
Fungicide	Insecticide	Herbicide	Others	Total
70	11	13	6	100

Source : Kenya Pesticide Association

The economics of CBD control can be dealt with from both the farmer and the national point of view, in terms of farm level economics, the relevant issues would be the exploration of alternative control measures open to the famer thier costs and benefits, existing Practices that he currently employes with supporting explanatory reasons for their adoption, and the likely future practices taking into account the trends in output and input prices.

At the national level, the economics of CBD control would address itself to the impact of the currently practised control measures on the national level, their costs in terms of foreign exchange, the consequence of alternative practices and the options open to the Government to minimise national costs and maximise benefits.

Farm Level Economics

1. Alternative courses of action

It is fully recognised today that Coffee Berry Disease (CBD) can adequately be controlled at the farm level through efficient application and timely use of tested and approved fungicides. In Kenya, the use of these fungicides is prescribed to farmers through Coffee Research Station CRS Technical Circulars. These circulars specify the fungicide to use, the rate, frequently and timing of application. However, the economics of these protection measures is often silent despite its central role in determining the worthwhileness of the measures.

In the context of farm economics, the question of CBD control hinges upon the alternatives open to the farmer and his free will to choose amongst them. In exercising his free will to choose, he will be doubt evaluate the options either subjectively or formally taking into account the costs and the benefits of each, their resource requirements against availability to enable execution of any chose alternative.

To a coffee farmer, being an estate owner, a manager or a smallscale operator, the alternative courses of action with regard to CBD control are in the short run :

a. Not to spray at all

b. To spray for protection,

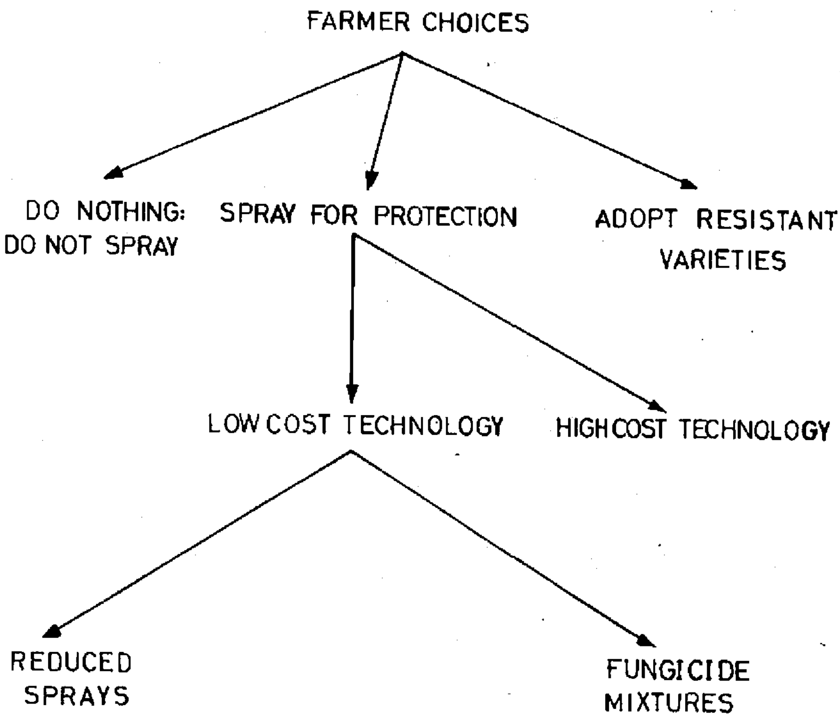
In the long run however, a third alternative exists i.e. adopting the CBD resistant varieties (Fig. 1).

To evaluate among these alternative measures, a farmer will consider each option in terms of :

a. Contribution to increased productivity or reduced crop losses.

b. Justification of the measures in terms of costs and benefits.

FIG.I. FARMER CHOICES FOR CBD CONTROL



It follows therefore that any economic evaluation must start with the assessment of the possible magnitude of crop losses from not controlling CBD or crop gains accruing from control measures. In practice, this is a management function through the corpping cycle to perform repeated and periodic checks on the cropping level, the magnitude of the disease, and the likely damage if control measures are not implemented.

2. Likely benefits from alternatives : Experimental Evidence

Although difficulties have been voiced regarding the conclusive establishment of crop losses from CBD (Griffiths and Gibbs, 1969; Bock, 1963; Huxley and Ismail, 1970) various opinions on the subject have been recorded. Rayner (1952) reported that in 1930's the crop losses due to CBD in the West of Rift Valley coffee growing area were in the region of 25% of the expected. Nutman and Roberts (1962) ascribe a crop loss of 440 kg/ha per annum as a reasonable figure. Bock (1963) showed a variable crop loss between more susceptible Scott Laboratories (SL) varieties and more resistant Blue Mountain. He showed a crop loss of 24% on Blue Mountain and between 84-94% loss on SL 34 and 28. He also argued that in Central Province the yields were 75-80% of normal yields after 1951. Griffiths et al. (1971) has also shown that few and mistimed early spray will not only fail to control the disease but will result in substantial crop losses.

An early spray timing trial at Meru in Kenya (Table 4) shows that at today's prices of coffee and costs of inputs, a farmer is likely to obtain in flush years a benefit of four times the cost of controlling CBD by spraying both in short and long rains. A look at the cost benefit variability over the period of experimentation shows that in a poor crop year a lower cost programme of spraying either during the short or long rains is favourable. The choice of when to spray must obviously be dictated by the cropping level and the disease magnitude and the variability of the two over time and space.

Table (4) : Spray timing treatment in meru & the likely profitability

	1962			1963			1964		
	kg/ha	Gain	Cost Benefit Ratio	kg/ha	Gain	Cost Benefit Ratio	kg/ha	Cost Gain	Cost Benefit Ratio
T_I	1003	265	1:3.75	603	275	1:3.48	591	106	1:3.40
T_2	846	105	1:1.33	385	255	1;3.23	571	86	1:1.09
$T_1 + T_2$	1191	630	1:4.01	678	350	1:2.23	824	339	1:2.16
Control	741	-	-	328	-	-	485	-	-

Legend

T_1 Four sprays applied in the short rains, T_2 Four sprays applied in the long rains.

A comparison of the recommended fixed calender and a flexible spray programme also provides insights into farm level economics of choice. At both, the high, medium and low altitudes estates, the cost-benefit payoff strongly favours reduced but well timed sprays and fungicides mixtures. The payoff is between 4 and 6 times the cost of control measures. Although experimentally four well timed sprays have worked, the data reported relates to a single year and it may well be that four sprays may not adequately protect the crop in very servers CBD years (Tables 5-7).

All that said, we must add a caveat on the raliance of experimental results to portray the likely responses and hence payoff on the farms. Variability between responses on controlled experiments and that on the farms has been observed where rescure use intensity is dissimilar (Davidson & Martin, 1955) and where constraints and risk reducing strategies are major management variables (Bomez, 1977). The dynamic nature of coffee production, the effect of management strategies, interaction between CBD control treatments and the level of non-treatment variables, all go to increase the divergence between experimental responses and that on the adopting farms.

3. <u>Current CBD control measures within estate & their likely profitability</u>

Our survey of the large scale estates reveals that the vast majority spray for CBD protection and very few indeed do not spray. For the purpose of our example, the yields of two non-spraying estates (Farran & Kituamba) have been averaged and compared with the CRS Rukera Farm.

An examination of the estate practices reveals that farmers apply a minimum of eight recommended spray rounds a year and in particular severe CBD years they undertake a extended programme for crop insurance adding up to 12-14 sprays. The fungicides used range from single to fungicide mixtures depending on availability and

Table (5) : High level management of CBD control - Kibubuti estate.

	NO Sprays	Captafol full rate programme	Captafol reduced spray rounds	Reduced spray rounds mixtures
Furglcide	-	Captafol	Captafol	Captafol+ Perenox
Spray rounds	-	6	4	4
Yield kg/ha	232	676	633	804
Incremental yield above control kg/ha	-	444	401	572
Benefit from programme k£	170	444	401	572
Cost of programme k£	444	170	114	85
Cost benefit ratio	1:0.38	1:2.61	1:3.52	1:6.73

Table (6): High level management of CBD control-Jacaranda estate

	NO sprays	Captafol full rate programme	Reduced spray rounds	Redcuced spray round in mixtures
fungicde	-	Captafol	Captafol	Captafol + perenox
Number of sprays	-	6	4	4
Yield kg/ha	382	1082	1057	942
Incremental yield above control kg/ha	-	700	675	560
Benefit from programme k£	170	700	675	560
Cost of Programme k£	700	170	114	85
Cost benefit ratio	1:0.24	1:4.12	1:5.92	1.659

Table (7) : High level management of CBD control - Magagoni estate

	No sprays	Captafol full rate programme	Reduced rounds	Reduced rounds in mixture
Fungicide		Captafol	Captafol	Captafol + perenox
Spray roundcs	-	8	3	3
Yield kg/ha	394	606	598	707
Incremental yield above control kg/ha	-	212	204	313
Benefit from programme k£	277	212	204	313
Cost of programme k£	212	227	85	64
Cost-benefit ratio	1:1.07	1:0.93	1:2.40	1:4.89

individual estate policy. Coupled with these high cost programmes are good cultural practices emphasising pruning, fertilization and reasonable spacing.

The reasons for adoption of the high cost technology are high resource endownment, minimal constrains on cash flow, dominance of profit motivation in farm management and less emphasis on risk in decision making.

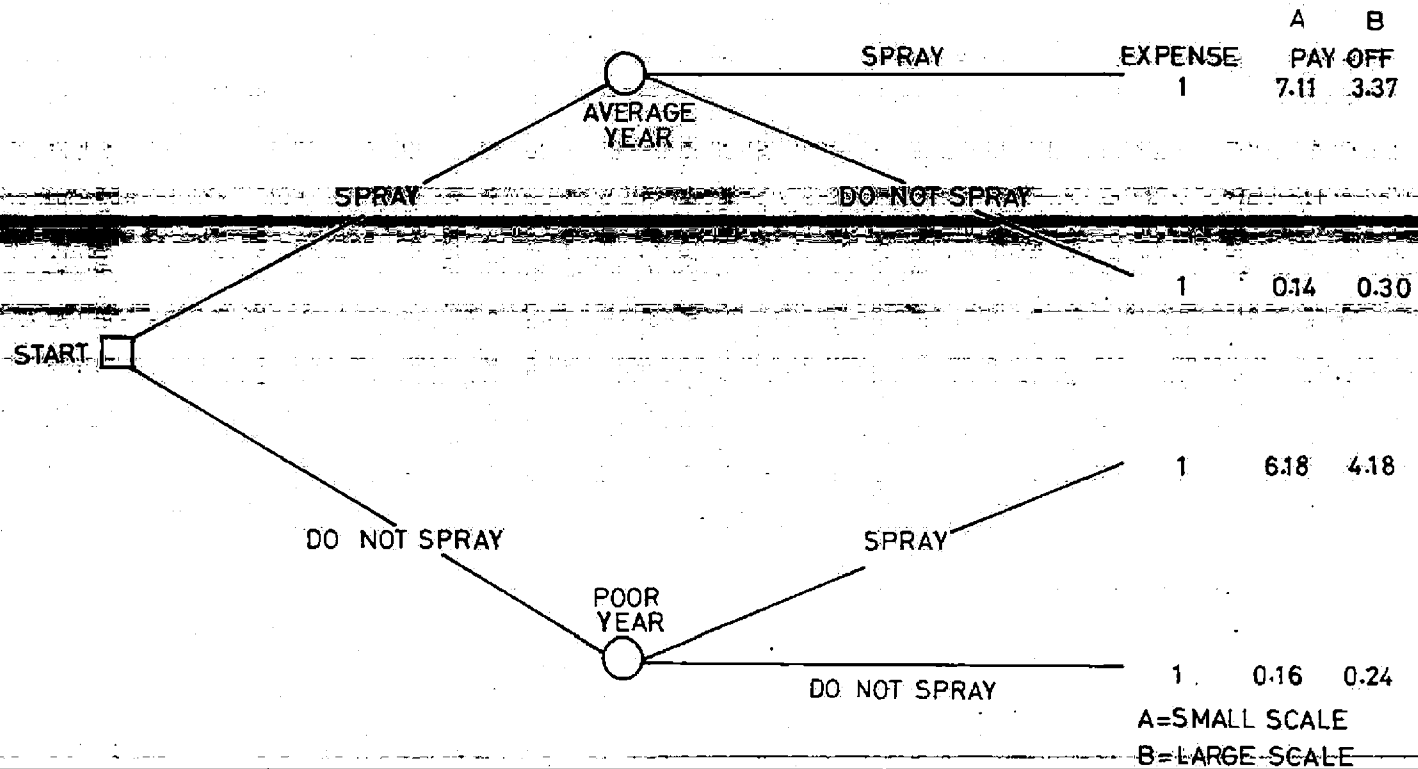
To show a comparison between the non-spraying and well sprayed farms, evidence was obtained from Farran and Kituamba estates and the average yields from these estates compared with the Coffee Reseach Station Rukera Farm. Farran and Kituamba did not use to spray up to 1972. The average yield for a five year production period for the two non-spraying estates was 1312 kg/ha clean coffee with the worst two years averaging 400 kg/ha. On the other hand, rukera farm on average yielded 1480 kg/ha of clean coffee with the average of the worst two years being 1350 kg/ha. The comparison in yields relates to the same period.

In calculating the payoff from various decisions, the value of crop losses from not spraying was taken as the relevant cost of that programme and the saving on the spray costs as the benefit accruing. On the other hand, the value of incremental response above unsprayed was considered as the appropriate benefit from the programme and the investment in annual sprays as the relevant costs, in average and poor years analysis shows that the farmer who does not spray for protection loses. On the other hand, the farmer who sprays more than pays off his investment (Fig. 2).

4. Current CBD control measures within smallholdings & their likely profitability

Within the smalholder coffee producing community the recommendations issued by the CRS are highly compromised. Specifically in

FIG.II. DECISIONS TO SPRAY AT THE FARM LEVEL



relation to CBD control, the current practices range from non-application of any control measures to application of 4-5 spray rounds in a year concentrated in the long rains. This is in contrast to the eight recommended rounds per annum. The main fungicides used are Captafol (Ortho-difolatan 80% W.P) and copper (50% W.D.) with the latter predominating (Table 8).

The main reasons accounting for the observed practices are low profitability and saving, poor farmer liquidity, fungicide availability, inadequate support credit, discouraging loan repayment system, and the farmer strategies to minimise production constrains and risks (Njagi & Kamau, 1981).

Low savings and low farm incomes mean in effect that the majority of the small farmers will have to rely more heavily on credit provision for the purchase of required protection chemicals. Nevertheless, their low productivity due to production constraints in consequence reduces their creditworth and as a result receive less credit than that necessary to cover the full cost of control.

To enable farm level comparison of the spraying and non-spraying farmers, yield data were obtained for five farmers in each group for a consecutive period of five years. In poor years, the spraying farmers averaged a yield of 630 kg/ha clean coffee while on an average year they obtained a yield of 860 kg/ha. Conversely, the non-spraying farmers obtained 140 kg/ha clean coffee in poor years and 300 kg/ha in average years. Applying the current prices to the yield data and the costs of the programmes employed the results show that the farmers who spray receive a benefit of between six to seven times the cost of annual programmes while the non-spraying farmer is shown not to break even.

Obviously, one can not escape to mention the difficulties involved in obtaining accurate data for farm level responses due to

Table (8) : Cost of fungicide use & the CBD control on small scale farms

District	Coffee hectares sampled	Annual fungicide use		Annual Cost of Fungicide KSHs/ha	Brak even response
		Difolatan kg/ha	Copper kg/ha		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Meru	25.67	13.07	7.25	1875.50	78.13
Embu	17.00	10.43	23.32	1951	81.33
Kirinyaga	25.95	4.04	17.18	947.30	40.60
Nyeri	20.93	9.26	19.88	1711.40	71.31
Muranga	9.39	6.69	40.07	1904.80	79.37
Kiambu	20.36	5.80	13.04	1087.25	45.30
Kisii	6.32	0.79	12.74	433.15	18.05

CBD control. With compromises made virtually on all specific recommendations, interfarm variability with regard to timing and the level of such compromises, one must admit difficulty in separating the relevant responses due to CBD control and the losses due to the neglect of other recommended practices.

5. Break even responses to implementing the spray programme

The farmer alternatives within the spray programmes are to use either straight or combinations of fungicides. Table 9 shows the recommended spray programmes for CBD control. Programme 1 is designed for use in areas where CBD is severe but Leaf rust if not a significant problem. Programme II is an alternative to programme I using copper instead of Captafol, Daconil or Deian. The programme can control Leaf rust in addition to CBD. Programme II on the other hand is designed for areas where both CBD and Leaf rust are major problems.

With current prices ot fungicides, the annual cost per hectare of implementing programme I ranges from K£-227. This in consequence would require a response of between 140-190 kg of clean coffee from the same production area to cover the cost of protection. The use of programme II would cost K£ 157 per hectare at current prices and would require a response of 130 kg/ha of clean coffee to break even. Programme III is more diversified and the annual cost of implementation ranges from K£ 130-290. This means that a farmer will have to salvage a crop loss between 110-245 kg/ha of clean coffee to cover his costs (Table 10 a & b).

The implication of the above observations is that a farmer will have to tailor his expenditure on control measures to his best estimate of the potential crop losses being salvaged by spraying.

Table (9) : The recommended spray programmes for CBD control

Programme	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
II		0	0	0	0	0	0			0	0	
III a		x	x	[illegible]	[illegible]	[illegible]	[illegible]			x	x	
III b		x	x	x	x	x	x			x	x	

* Captafol 4.4 kg/ha Delan 3.3 kg/ha Dac onil 4.4 kg/ha

0 Copper formulation II kg/ha

x Captafol 2.2 kg/ha or daconil 2.2 kg/ha plus 5.5 kg/ha of 50% copper formulation or delan 3.3 kg/ha.

Table (10a) : The annual cost of CBD control the recommended programmes

Programme	Fungicide Alternatives	Rate per hectare Kg	Applications per annum	Cost of Fungicide	Preak even response hectare Kg
I	Captafol	4.4	8	4540.80	189.20
	Delan	3.3	8	3616.80	150.20
	Dconil	4.4	8	3308.80	137.87
II	Copper	11.0	11	3146.00	131.87
III	Captafol + Copper	2.2 5.5	8 8	3414.40	142.27
	Captafol + Celan	2.2 3.3	8 8	5887.20	245.30
	Daconil + Copper	2.2 5.5	8 8	2798.20	116.60
	Caconil + Delan	2.2 3.3	8 8	5271.20	219.63

Table (10b) : The annual cost of imple,enting programme III (a)

Qltermative	Fungicide combination	Quantity kg/ha	Cost of annual fungicide	Break even response kg/ha
1	Captafol	26.4	977.60	165.73
	Copper	22.0		
2	Captafol	8.8	515.60	146.43
	Copper	22.0		
	Delan	13.2		
3	Captafol	8.8	361.60	140.07
	Copper	22.0		
	Daconil	17.6		
4	Captafol	26.4	214.00	217.26
	Delan	13.2		
5	Captafol	8.8	752.00	198.00
	Delan	26.4		
6	Capafol	8.8	4598.00	198.00
	Delan	13.2		
	Daconil	17.6		
7	Daconil	8.8	3102.00	129.25
	Copper	22.0		
	Captafol	13.2		
8	Daconil	8.8	3207.60	133.65
	Copper	22.0		
	Delan	13.2		
9	Daconil	22.0	2640.00	110.00
	Copper	22.0		
10	Daconil	8.8	4906.00	204.42
	Delan	13.2		
	Captafol	17.6		
11	Daconil	8.8	4444.00	185.17
	Delan	26.4		
12	Daconil	26.4	4290.00	178.75
	Delan	13.2		

In so doing the farmer will have no benefit of advance quantitative knowledge, as relied on in his paper, of the actual damage caused by the CBD in a particular period of production. He therefore has to exercise his every best judgement and experience to forcast the magintude of the crop requiring protection, the likelihood of bad weather causing severe CBD as well as the timing of the decision to spray relative to the expected losses and how well these harmonise with the resources at hand.

6. Future practices

With annual inflation in the fungicide market (6% for Copper over 20% for Captafol) as shown in Table 11 and the coffee price margin to the farmer dwidling, there is increasing economic rationale to shift from high cost technology to low cost methods of control. In the short term, the low cost methods will be :

a. Shifting to chemical mixtures.

b. Refining the use of spraying by relating the programme more rigidly to rainfall pattern.

c. Increase use of cultural methods of control.

In the long run, however, the answer to the CBD problem will be increased adoption of resistant varieties. Due to greater acquintance with the close-spacing component of the CBD resistant varieties, and less constraint on Capital, the estate will be early adopters of the technology. Within the samllholder sector however, adoption will be slower due to rising investment costs and falling profitability due to market squeeze.

A comparison of likely profitability of the CBD resistant varieties and the susceptible varieties would payoff his investment and annual maintenance costs to the ratio of 1:2. For the same period, the farmer who does not uproot to replant will have a benefit of 2.7

Table (11) : Price trend in major coffee fungicides 1979-1982

		1979		1980	1981	1982	Av. Annual inflation
		Shs	Shs	Shs	Shs	Shs	%
	[illegible] WP	25kg	1900.00	2690.00	2850.00	3225.00	22.95
	Copper oxychloride	25kg	400.00	456.00	472.00	472.00	6.00
Fungicides	Copper Sandoz	50kg	1410.00	1410.00	1410.00	1500.00	2.13
	Nordox	25kg	700.00	750.00	800.00	800.00	4.76
	Delan	25kg	2222.50	2478.75	3416.25	3416.25	17.90
	Kocide 101	10kg	296.00	340.20	296.00	330.00	3.83

over his costs. In longer period of comparison, the farmer adopting the new varieties would stand to benfit more. (Table 12).

Table (12) : Comparison of Benefit from Susceptible & Resistant Varieties

	SL Varieties	Resistant Varieties
Total Yield Over 1st Cycle Tonnes/ha	2	4
Prize to Small Scale Farmer K£	780	780
Total Income 1st Cycle	1560	3120
Replanting Cost	-	859
Maintenance in Zero Income Period	165	213
Maintenance of Productive Estate	405	555
Total Cost 1st Cycle	570	1627
Cost benefit ratio for 1st cycle	1:2.74	1:1.92

National Level Economics

A definite consequence of poor CBD control practices especially within the smallholdings is a loss of national yield. The aggregation of this crop loss and its valuation into a national figure is impossible due to variability in CBD control practices and the compounding losses due to compromises in other recommendations, e.g. fertilization, pruning, weeding.

In terms of foreign exchange, the importation of fungicides presents a drain in national monetary reserves with the share of coffee being nearly K£ 12 M today. Considering the unfavourable balance of payments and increasing disparity between the unit prices for agricultural exports against those of manufactured imports, it is imperative that the Government should examine ways and means to minimise costs at the national level and maximise benefits.

In the short term local formulation and manufacture of CBD protection chemicals presents an alternative. Nevertheless, this would be both technically and economically infeasible due to shortage of raw materials and investment capital and in any case such an investment would in the long-term be undermined by the new resistant varieties. In terms of feasible practical alternative, encouragement of good spray practices with support credit system present a practical and realistic alternative. Equally, encouragement of research into low cost rapid uptake technology based on improved cultural practices would result in increased farmer and national benefits both financially and real terms.

In the long term the resistant varieties are the ultimate answer to the CBD problem but the investment costs mitigate against rapid uptake relative to other farmer alternatives. Subsidization schemes would be a major contribution to increased uptake of this technology particularly within the smallholder sector which currently dominates the total national production.

Nationally the implication of adopting the CBD resistant varieties is the reduction in annual fungicide importation costs by approximately 85% and a saving in foreign exchange valued at nearly K£ 10 M. Secondly, the uptake of the recistant varieties promises any target production relative to the ruling national quota from a smaller area than currently would be the case, thereby, enabling land to be released for food crops through the close spacing component of this technology. This is very much in keeping with the Kenya National food policy. At the farm level, the lowering in costs would translate into improved profitability and farmer incomes.

REFERENCES

bock, K.R. (1963) The control of Coffee Berry Diseases in Kenya. Emp. Journ. Exp. Agric. 31, 97-101.

Davidson, B.R. and artin, B.R. (1966) The relationship between yields on farms and in Experiments. Australian Journ. Agric. Econ, 9, 129-40

Gomez, K.A. (1977) On farm Assessment of yield constraints : Methological Problems. International Rice Research Institute, Los Banos.

Griffiths, E. (1971) 'Negative' Effects of fungicides in Coffee. Proc. 6th Br. Insectic. fungic. Cong, 817-825

Griffiths, E. and Gibbs, J.N. (1969) Early sprays for the Control of Coffee Berry Disease. Ann. Appl. Biol., 64, 523-32.

Griffiths, E.; Gibbs, J.N. and Waller, J.M. (1971) Control of coffee Berry disease. Kenya Coffee, Nov., 1-20.

Huxley, P.A. and Ismail; S.A.H. (1970) Flora atrophy and Fruit set in Arabica coffee in Kenya, Kenya coffee, March 1-10.

Nutman, F.J. and roberts, F.M. (1962) coffee Berry disease and Leaf Rust Research. Kenya Coffee 27, 13-17.

Njagi, S.B.C. and Kamau, P.C. (1981) Variance between Farmer Practices and the CRS Technical recommendations : What can be done? Kenya Coffee, July, 217-226.

Rayner, R.W. (1952) Coffee berry Disease. A Survey of investigations carried out upto 1950. E. Afr. Agric.J. 17, 130-58.

PART IV

GENERAL PAPERS

Proc. 1st reg. Workshop "Coffee Berry Disease",
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THE HARMFUL EFFECTS OF INSECTS AND PATHOGENIC AGENTS ON PRODUCTION EXPORT AND IMPORT OF GREEN COFFEE

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Harmful Effects of Insects and Pathogenic Agents:

It is not the intension to give the full report but only to mention the most essential points. Although all the contries here are not cited in his study, we feel the list in Annex 1 gives the most common parasites and mould encountered in coffee plantations. The classification by areas attacked on the plant according to this Annex allows us to specify the type of damage of the agents which could cause:

- weighted loss due to reduced formation of chlorophll because of leaf attack,
- quality loss due to the quality deterioration of the fruit as in the case of the Coffee Berry Disease caused by Colletotrichum coffeanum,
- quality and quantity loss in more serious cases.

According to the same study and Annex 2, the numerical importance of attacks in descending order is as follows: leaves, trunk and branches, herries, leaves and berries. Although simultaneous attacks on leaves and berries are numerically lower, they can sometimes cause the highest loss in quality and quantity.

Attack on Leaves:

In the group of leaf parasites, the most dangerous comes on the one hand from Lepidoptera which in record time could devour leaves preventing the formation of chlorophyll and on the other hand, the Hemiptera which because of their number could hinder the upkeep of the plantation and make harvesting difficult.

Attack on Berries:

Although this causes considerable loss in quantity, more attention should be paid to the deterioration of the quality of the bean which could be rejected or heavily restricted on some markets.

The most dangerous diseases in this group are the Cofffee Berry Disease, Botytis cinerea, Ahtestiopsis spp, Stigmatomycose, Stephanoderes hampei, Antestia bugs and the Trypetidae.

Attack on Trunk and Branches:

This sometimes causes death to the plant. The most dangerous diseases are found in nurseries: Root Rot, Fusaria (Bark Disease) and Borers. Their presence could make the coffee farmer reconvert his plantation.

Reaction on Production, Export and Import:

a) **Production**

In general, phytosanitary intervention either at the preventive or curative stage can seriously increase production costs and curtail the farmer's profit. The financial needs in this phase of production are mainly for:

- The organisation of an intervention structure and preparation of its instructions.
- continued tests to detect and determine periods of intervention,

- choice, purchase and distribution of phytosanitary products and material,
- payment of salaries for the intervention and extension services'teams,
- accident at work; like intoxications which need medical care and in some cases, indemnities to victims.

Although phytosanitary intervention is not to improve quality, it should provide ways to maintain it by avoiding any possible contact with the fruit and the parasite. Therefore, if we are to minimise costs to safeguard the profit to the farmer, our attention should first turn to prevention which is divided into two phases:

1) respecting the sanitary cropping after each harvest to eradicate nests of infection, and
2) regular detection tests to exterminate infection before it spreads.

The quality and quantity loss suffered by plantations not treated for parasites like the Coffee Berry Disease exceed the cost of phytosanitary intervention and this alone should make us take every effort to fight them.

b) Export:

Most producing countries have adopted a national table of defects to classify marketable coffee. Annex 3 gives some examples through which we calculated the percentage of defects caused by parasistes vis-a-vis the whole table. The last Column in this Annex shows that different producing countries do not give the same value to the same defects. Cameroon, Ivory Coast and Madagascar for example, noted for a high level of farmer production for Robusta attach a lot of importance to sting beans or those affected by insects. Arabica producers give more importance to the presence of foreign matter as stink beans. It is obvious that in the latter case sting beans are eliminated when floating the fresh cherries. In both cases, the elimination of sting beans is only efficiently done by electric sorters. Some examples of classification by defects are:

Angola:

1 st quality	71 to 111 defects
2 AA	112 to 150 defects
2 BB	151 to 220 defects
2 CC	221 to 340 defects
3 DD	341 to 480 defects

The conditions required for exportable coffee are:

- not to contain odour nor have disagreeable taste
- not to exceed 13% humidity
- colour, should be normal and not contain more than 50% of foreign matter, nor more than 2% dry cherries and husks.

Ivory Coast:

Extra-prima -	less than 15 defects with a maximum of 5 broken beans by sample
prima -	less than 30 defects with a maximum of 5 broken beans by sample
superior -	not more than 60 defects with a maximum of 10 broken beans by sample
regular -	not more than 90 defects with a maximum of 10 broken beans by sample

The conditions for export are:

- humidity not in excess of 13%
- sound and free from mould and decay.
- not contain more than 1% foreign matter.

Ethiopia:

Grade 1	0 – 3 defects
2	4 – 12 defects
3	13 – 25 defects
4	26 – 45 defects
5	46 – 100 defects
6	101 – 153 defects
7	154 – 340 defects
8	more than 340 defects

only Grades 1 to 5 are exportable.

The conditions for export are:

- humidity not in excess of 11.5%
- no mould, harmful fermentation or other defects.

These examples show the importance of defects in the classification of coffee for export where parasites play an important role.

C) Import

Just like producers, consumers have national regulations governing conditions for importing green coffee. Here are some examples of Italy, France and the United States.

Italy:

1) Regulations: The law of 16th February (1973) regulates the hygienic and health aspects of the trade in coffee and its derivatives. Some of these regulations will have to be modified following the recent EEC directives on labelling and coffee extracts.

Coffee imports require according to Article 3 that:

- Green coffee must meet the stipulations of Article 5 of law no. 285 of 30th April (1962) and furthermore must:
  - be free from microtoxins within certain tolerances established by the Ministry of Health on the advice of the Health Council,
  - not give off any unpleasant smell foreign to coffee or be contaminated in any way which cannot be corrected by roasting, decaffeination or solubilisation,
  - not contain over 13% by weight of water. Other impurities or defects are allowed within the limits given below.

2) Limit by Weight of Impurities and Defects Allowed in Green Coffee:

- Impurities of animal or mineral origin: may not exceed 1%,
- the following impurities may not exceed 5%:

  a) vegetable impurities.

b) dry cherries and husks
c) parchment
d) black beans, smaller than average beans, wrinkled beans which on roasting swell, turn grey and retain the silverskin,
e) narrow, long and bowed beans with adhering silverskin, coloured pale green to green and brown which on reasting remain a light colour with a wrinkled surface (dry beans),
f) beans with a transparent surface, coloured pale green to reddish or brownish yellow depending on the variety, usually without a silverskin and sometimes giving off an unpleasant smell (waxy or fermented beans),
g) bean fragments,

- may not exceed 10%: beans damaged by stephanoderes and Araeocerus.

Coffee not meeting the conditions mentioned above and the terms of Article 3 must be reconditioned at the cost of the importer and if the coffee is refused entry the importer must ship it abroad.

France

1) Regulations:

They are contained in the decree of 3rd September (1965)which replaces that of 1948. Requirements for imported coffee are:

- must belong to the Coffee species, be materially unaltered and free from contamination by rot or mould,
- may not have any bad smell foreign to coffee or contain more than 120 defects in a 300 gram sample in accordance with the officially recognised scale of defects,
- must be retained by mesh 12 with a tolerance of 6% of beans retained by mesh 10,
- water content may not exceed 12.5%.

These strict regulations will no doubt be made more flexible if there are EEC negotiations to establish Community regulations.

2) Requirements of Green Coffee Traders:

They demand that:

- the final beverage be pleasant,
- cup quality be the main considerations: so far only Arabica is cup tasted,
- it is important to prevent the export of nasty and unpleasant tasting coffee whatever the grade,
- coffee of good appearance may be graded last if its cup flavour is poor,
- the main defect to avoid is stinker beans,
- producers should take care to prevent stinker beans and other defects which can jeopardise a good roast,
- there is a correlation between certain green coffee defects and cup defects,
- defects in green coffee should be eliminated before export; some, such as broken and small beans are less important if they do not spoil the flavour,
- humidity content is important and it is vital to prevent fermentation during transport and storage,
- the judgement of those examining green coffee for export should be realistic in accordance with the grading system of the country.

United States:

1) Regulations:

Green coffee may not be legally imported in the US unless it meets the regulations of the Food and Drug Administration. The regulations contain quantitative limits on contaminants such as insects, bird excreta, rodent excreta or urine, traces of insecticides in excess of certain thresholds, coffee waste and other foreign matter. Coffee may be contaminated by the incorrect or excessive use of chemical insecticides or insanitary conditions in warehouses in producing countries, ships, ports, rolling stock or warehouses in importing countries, Coffee may be reconditioned to be made acceptable for import into the United States. This is a costly operation for which the exporter must pay. If contaminated coffee is not reconditioned it must be reexported or destroyed. American citizens responsible for contamination are answerable in law.

The FDA controls are not intended to prevent the entry of coffee into the United States but to protect consumers from harm. The controls are based on sampling and books of Companies may also be investigated. A roaster receiving faulty coffee must report to the FDA which decides whether it should be rejected or reconditioned.

2) Requirements of Roasters:

These requirements mainly concern cup quality and vary from roaster to roaster, but in most cases there is a "no pass no sale" clause related to samples.

Cup taste is important because a good appearance may have poor flavour, fermentation, the taste of phenol and other such flavours can only be determined by tasting because appearance gives no hint of them. Flavour varies by origin and preference, may be subjective: what suits Nestlé may not suit General Foods.

When there is a shortage, all types of coffee are sold at higher prices and force roasters to alter their requirements and blends to take account of supply. When there is abundant supply better quality coffees sell at a premium and lower grades at a discount.

The efforts made to improve the quality of Robusta are few in comparison with those dedicated to improving Arabica. Buyers are prepared to pay a premium for good coffee although it is difficult to know the amount in advance.

Annex (1) : Classification of insects and parasites by zone of attack on coffee tree according to study by Dr. E.J.E. Buychx on burundi, Rwanda and Zaire

Type of Insect/Parasite	Leaf	Fruit	Trunk/Branch	Observations
Armillariella mellea (Vahl Pat)			+ A + R	not very important damage
Rosellinia bunodes (Berk & Br) Rosellinia necatrix (Hart Berk)			+ A	not very important damage
Fomes lygnosus (Klot Bres)			+ A	not very important damage
Fomes noxius (Corner)			+ A + R	not very important damage
Fusarium xylarioides (Stey)			+ R	dangerous disease causing serious damage in Central Africa
Corticium salmonicolor (Berk and Br)	+ R + A	+ R + A	+ R + A	slight damage generally, but can be serious in wet season
Corticium koleroga (Cke von Höhnel)	+ R			slight damage
Marasmius spp. (Corticium spp.)	+ R			hardly serious damage
Hemileia vastatrix (Berk and Br)	+ A + R			benign in some areas, dangerous in others

Annex I (Continue)

Type of Insect/Parasite	Leaf	Fruit	Trunk/Branch	Observations
Cercospora coffeicola (Berk and Cke)	+ A + R	+ A + R		hardly serious damage
Colletotrichum coffeanum (Noack)	+ R + A	+ R + A	+ R + A	minor parasite causing much damage on Arabica fruit at each stage of development
Cephaleuros virescens (Kunze) striguia spp.	+ A + R			limited damage, sometimes serious in wet areas
Rhizoctonia solani (Kuhn)			+ R + A	[illegible] in nurseries
Pestalozzia spp.			+ R + A	slows growth in nurseries
Loranthus incanus (Schum and Thom)			+ A + R	phanerogamic parasite
Loranthus ogowensis (Engl)			+ A + R	phanerogamic parasite
Loranthus buvumae (Rendle)			+ A + R	phanerogamic parasite
Texoptera aurantii (B of F)	+ R + A		+ R + A	yellowing and rolling of leaves
Brown Scales	+ R + A	+ R + A	+ R + A	stunted growth and serious damage, production of honey dew attracting ants

Annex I (Continue)

Type of Insect/Parasite	Leaf	Fruit	Trunk/Branch	Observation
Habrochila ghesquierei (Schout)	+ A + R			spots on the undersides of leaves
Antestia coffee bugs	+ R	+ R		necrosis of buds,shoots and leaves
Cephono des Hylash.	+ A + R			serious damage in nurseries
Epicampoptera spp.	+ A + R			serious damage on foliage
Parasa vivida (Wlk)	+ A			same as epicampoptera
Dichocrocis crocodera (Meyrick)	+ R			consequential damage
Leaf borer	+ A + R			no heavy damage
Anthores Aeuconotus pasc.			+ A	ravager of Arabica
Botrytis cinerea f. coffeae (Hendr.)	+ A			limited damage but sometimes causes quality loss for import
Septobasidium bogoriense (Pat)			+ A	useful fungus but attracts other parasites
Bacterial Disease		+ A		potatoe taste in coffee bean

Annex I (Continue)

Type of Insect/Parasite	Leaf	Fruit	Tr[illegible]k/Branch	Observation
Hoplandrothrips bredoi (Priesn) Panchaeothrips noxius (Priesn) Diarthrothrips coffeae (Williams)	+ A	+ A		suck sap from leaves, fruit or young shoots, cocooning in distal part of leaves
Antestiopsis lineaticollis ghesquierei (Car) Antestiopsis lineaticollis intricata (Ghesquierei & Car) Antestia [illegible]		+ A		suck sap of vegetal tissues and fruits in particular
Nematospora coryli (Pegl)	+ A	+ A		production of black or sting beans, attacks buds blossoms green branches and young leaves
Lygus coffeae (China)	+ A			serious damage castrating flowers, biting buds and young leaves
Volumnus obscurus popp	+ A			same damage as Lygus
Planococcus kenyae (Le Pelley)	+ A + R	+ A + R		sporadic attack
Stigmatomycose Nematospora coryli (Pegl)	+ A			internal rotting of fruit
Thliptoceras octoguttale (Feld)		+ A + R		attack clusters of fruit which die when ripe
Virachola bimaculata (Hex)		+ R		same as Thliptoceras octoguttale

Annex I (Continue)

Type of Insect/Parasite	Leaf	Fruit	Trunk/Branch	Observation
Leucoplema domertyi (Warr)	+ R + A			same as the Epicampoptera
Dasus simples (F)		+ A + R	+ A + R	sever fruit peduncle, eat into bark and stem
Bixadus sierricola (White)			+ R + A	attack branches
Apate monacka (F)			+ R + A	bore holes in trunk
Dyrphia princeps (Jordan)			+ A + R	branch borer
Sophronica ventralis (Auriv)		+ A		less damage than Stephanodores
Leucoptera coma (Ghasquiere)	+ R + A			burrows in leaf blades
Stephanoderes hampei (Ferr)		+ R + A		important damage to fruit
Pseudotrochalus spp. Anomala spp.	+ R			extensive damage
Trypedidae		+ A + R		fruit shedding
Atopomyrmex mocquerysi (E. André)			+ R	biting buds, digging hollows in trunk, nuisance to cultivation and harvest

Annex I (Continue)

Type of Insect/Parasite	Leaf	Fruit	Trunk/Branch	Observation
Crematogastrini	+ R		+ R	same as Atopomyrmex mocquerysi
Oecophylla smaragdina (F)	+ R			weave small webs for nests in leaves
Macromischoides aculeatus (Mayr)	+ R			nest in underside of leaves making harvest difficult
Macromischoides [illegible]	+ R			renders plantation upkeep and harvesting difficult
Polyporus coffeae (Wakef) Panococcus citri (Risso)			+ A + R	occassional disease
Capnodium coffeae (Pat) Capnodium brasiliense (Puttem)	+ R	+ A		sporadic disease hindering chlorophyll formation and respiration
Die – back	+ R + A	+ R + A	+ R + A	physiological problems
Chlorosis	+ A			yellowing and decaying of leaves
Blight	+ A	+ A	+ A	frozen aspect, stunted and less productive, blackening of shoots, blossoms and young fruits

NB: + A = Arabica
+ R = Robusta

Annex (2) : Numerical distribution of attack by insects and parasites based on the study by Dr. E.J.E. buyckx

Area	Arabica	Robusta	Total
Leaves	17	25	42
Trunk & Branches	16	21	37
Berries	15	11	26
Leaves & Berries	5	7	12
Total	53	64	117

Annex (3) : Percentage of defects caused by parasites according to the scale of defects.

Pays	Total value of defects	Value of defects of parasites and pathogens	(2)/(1) x 100
	(1)	(2)	
Angola	22,999	2,664	11,58
Cameroon	11,466	5,70	49,71
Ivory Coast	9,366	3,80	40,57
Ethiopia	80,8	2,50	3,1
Madagascar	9,466	3,50	36,97
Brazil(Glass Int.)	20,766	1,20	5,78
Brazil (Santos)	28,766	3,033	10,54
Colombie (no)	13,598	2,033	14,95
Countries	Total assesment of defects	Assesment of. defects caused by insects & parasites	

CONCLUSION

Through this paper, we hope to have drawn your attention to the campaign for the quality of this product from its cultivation.

In conclusion, it is necessary to recall that in coffee production, quality starts in the plantation. To obtain this, the following is absolutely necessary:

- respect the anti-disease campaign calendar as well as those cultivation technics which ar baneful to parasitic development such as height, use of resistant clones, sanitary cropping, etc., and
- choice of effective phytosanitary products with large spheres of action.

Such a programme presupposes a highly efficient extension service department.