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Breeding coffee plants with durable resistance to Coffee Leaf Rust, anthracnose and other diseases

Project proposal

Background

1. This document has been submitted by the Coffee Board of India and contains a summary of the revised version of the project proposal for research and development to enhance the genetic endowment of Arabica coffee in the context of disease resistance (Coffee Leaf Rust (CLR) and Anthracnose), together with extracts from the full proposal relating to Intellectual Property Rights. The complete project proposal is available in English on request from the Secretariat.

2. This revised proposal has been re-submitted to the Virtual Screening Committee for assessment and will be re-considered by the Executive Board in May 2006.

Action

The Executive Board is requested to consider this revised proposal and the comments and recommendations of the Virtual Screening Committee and, if appropriate, to recommend approval by the Council.

PROJECT SUMMARY

1. Project title: Breeding coffee plants with durable resistance to coffee leaf rust, anthracnose and other diseases.

2. Duration: Five years.

In this phase the major part of the time will be devoted to the development of materials in all participating countries. Given the long gestation period of a perennial crop like coffee, a duration of five years is sufficient only for the proposed activities on a small scale. A second phase of two years is needed to assess the impact of new genetic materials on cultivation and production.

3. Location: India.
Tanzania, Zimbabwe and Malawi have expressed interest in participation in this project. The ICO/CFC may identify any other countries with whom partnership modalities can be formulated.

4. Nature of the project: Research and development to enhance the genetic endowments of Arabica coffee in the context of disease resistance (CLR and Anthracnose).

5. Brief description: The period between 2000 and 2004 witnessed unprecedented low prices for coffee in the international market, leading many small coffee growers all over the world to abandon coffee cultivation or skip plantation maintenance operations. This has had a cascading effect on the economies of all countries exporting coffee to earn foreign exchange right down to the households producing coffee. In India, the impact of the price crisis led to the large scale re-emergence of the devastating disease leaf rust and the deadly pest white stem borer. At the Central Coffee Research Institute, breeders developed many genotypes combining the genes of Arabica and Robusta coffee to obtain a high degree of resistance to leaf rust. Materials worthy of mention are: Devamachy

Hybrids (spontaneous Robusta-Arabica hybrids) and Robarbica hybrids (artificial Robusta-Arabica hybrids) commercially released as Selection-5 and Selection-6 respectively. These materials manifest a high resistance to rust and can help tide small growers over the impact of the crisis. The present proposal had its origin in this background. In the course of the project work, it is proposed to ascertain the genetic nature of the resistance of these selections to other diseases with special emphasis on those caused by the Anthracnose fungus *Colletotrichum*.

In the present project, efforts will be devoted to stabilizing the observed resistance to CLR as well as anthracnose by integrating marker aided selection. Providing these materials to small growers in India is expected to reduce their input costs in managing the diseases and help tide them over the impact of the price crisis. Providing the materials to participating countries is expected to help in exploiting them for cultivation and/or utilizing them as sources of resistance genes in improving their own materials. These materials add a range of new genes to combat the adversaries through the resistance gene pyramiding approach. The benefit of reduced costs of cultivation through lower disease management costs will be available to the growers in all participating countries. Besides achieving the resistance of plant materials the project also aims to identify cheap, easily accessible botanicals and bio-agents to devise new disease control strategies amenable for small grower practice.

6. Estimated total cost: US$445,378.25

7. Financing sought from the Fund: US$356,302.60

8. Mode of financing: Financing sought as grant

9.	**Co-financing:**	By way of counterpart contribution
10.	**Mode of co-financing:**	By making appropriate financial provision in the Annual Budget of the Division of Botany, CCRI, Coffee Board, India.
11.	**Counterpart contribution:**	US$89,075.65 (equivalent value in Indian Rupees)
12.	**Project Executing Agency:**	CABI-Bioscience, UK
13.	**Supervisory Body:**	International Coffee Organization
14.	**Estimated starting date:**	01.10.2006

INTELLECTUAL PROPERTY RIGHTS (IPRs)

The coffee selections being considered for large-scale distribution are unique varieties developed by the CCRI and registered with the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India. The CCRI is willing to share these materials with participant countries. Any technologies and products that are developed in the course of the project also will be shared equitably.

Methodology to solve the problems of growers

Provide the seeds of new selections to small growers

It is well documented that the majority of coffee growers of India are small growers (98%). In terms of quantities, their production accounts for 60% of the total coffee produced in this country. An important observation is that the lands of these farmers are located in areas where no other crops can be cultivated. Some of these lands are not even amenable for diversification. Because of this, the price crisis of 2000- 2004 took its toll on these growers and they are very badly in need of help. This is because S.795 is the plant stock of their plantations. This material became very susceptible to leaf rust after sustaining in the field for about 30-35 years successfully. Loss of leaves due to rust has led to a high incidence of stem borer and the death of many plants. A preliminary survey of the incidence of white stem borer on different selections has indicated that Sln.5A, Sln.6 and Sln.8 are least affected by the borer. It is proposed that Sln.5A and Sln.6 should be the focus of studies in this project. The surveyed populations are in the age groups between 40-45 years. Other Arabicas in adjoining plots were devastated by the rust and the borer. This means that these selections possess genetic endowments that render them tolerant/resistant to the borer attacks. An important observation is that very few plants in these sections are affected by leaf rust and fewer still are affected to the extent of defoliation. In S.795 leaf rust attacks lead to total defoliation of the plants. Leaf retention by these plants confers a great advantage in that leaves are the site of many biosynthetic processes that lead to the production of a variety of plant constituents like polyphenols, peptides, proteins and enzymes that are involved in plant defense against a vast array of biotic and abiotic adversaries and the overall fitness of the plant. These materials are currently the centre of biochemical and molecular marker studies in the Division of Botany at CCRI. Stable plants in these populations were identified to evolve the next generation (4^{th} generation) that will be utilized in the establishment of demonstration plots for this project. It is possible to supply the seed from the same mother plots to the small growers. This is expected to reduce the burden of costs of cultivation significantly on account of the high inherent, tolerance/resistance of these selections. This, in turn, leads to sustained better incomes from the crop.

The produce of these selections has been subjected to cup quality testing several times since their evolution began in the 1950's. Each of the generations were tested before developing the following generation. Sln.5A and Sln.6 received good Arabica cup ratings. Thus, these selections are not likely to compromise the growers' incomes because of their quality. Sufficient large plots of these selections are available to generate enough seed to be supplied to the small grower sector.

On account of the high inherent resistance of these materials, they do not require high levels of chemical inputs to manage diseases and pests. In turn, this leads to considerable savings on money spent on plant protection chemicals. Lower input of plant protection chemicals is an eco-friendly cultivation practice. This will be rendered much more benign to the environment by the integration of cheap, easily accessible botanicals that will be optimized in the course of the proposed project.

Intellectual Property Rights

Registration status of Indian coffee germplasm

Selection.5A (Devamachy x S.881) is a unique genotype developed in India in the 1960s. The original Devamachy hybrid is a spontaneous Arabica x Robusta hybrid that originated in the Devamachy forest near the Margolly estate in the Kodagu district of Karnataka. This hybrid was collected by the breeders of the CCRI in the early 1950s. It was perceived to be a potential source of new genes for leaf rust (caused by *Hemeleia vasatrix*) resistance and hence was involved in several hybridizations. One of the crosses is Devamachy x Rume Sudan (S.881). Both the parents of this cross manifest a high degree of resistance to leaf rust disease in the field. Devamachy hybrid was stated to be carrying genes for vertical resistance while S.881 (Rume Sudan) was reported to be carrying a degree of horizontal resistance (field resistance) against leaf rust disease. F_1 plants with reproductive balance were taken to F_2 generation and F_3 families were generated from many F_2 plants. This generation is very stable in reproductive behavior and manifests a high resistance to leaf rust disease. Preliminary observations indicated that this selection is less affected by the dreaded white stem borer (*X. quadripes*). Thus this is a unique genotype that can be of great use in the coffee breeding programmes of any Arabica growing country. This genotype is registered with the National Bureau of Plant Genetic Resources (NBPGR) of India (Reg. No. INGR 02009). Thus the CCRI, Coffee Board is the rightful owner of this unique genotype.

Selection 6 (Robarbica) is a unique hybrid of *C. arabica* and *C. canephora* developed in India. The first crossing of these species was effected in 1937 with Robusta as the mother parent (♀) and Kents Arabica as the pollinator (♂). The few F_1 hybrids obtained were all found to be triploid and the progeny highly sterile (Sreenivasan, 1987). This F_1 was repeatedly backcrossed to the Arabica parent. Of the three backcross progenies BC-II was found to possess an optimal combination of characters of both parents such as high resistance of Robusta and quality attributes of Arabica. However, the plants of BC-II were still unstable with a variety of cytological and reproductive abnormalities (Sreenivasan, 1987). Self- and open pollinated seed from the selected individual plants of BC-II were utilized to raise succeeding generations. An F_2 descendant line S.2357 (F_2 of BC-II) possessing high resistance to leaf rust and good cluster characters as well as the cup quality characters similar to Arabica was distributed to growers. Two progenies of the third generation derived from S.1156 line of BC-II (S.2827 and S.2828) were also found to be morphologically similar to Arabica carrying the high rust resistance and tight fruit cluster characters similar to Robusta with cup quality character of Arabica. Seed from these lines was also distributed for field trials as Selection-6 and its productivity and quality were assessed over many years. In the course of this time, this selection was adopted by several growers who, in turn, aided its evolution into material suitable for commercial exploitation. A major distinction of this hybrid is the involvement of Robusta as the mother parent in its diploid form. Other Arabica-Robusta hybrids developed in Brazil and the Côte d'Ivoire utilized Arabica as the mother parent and a tetraploid form of Robusta as the male parent. This genotype is registered with the National Bureau of Plant Genetic Resources (NBPGR) of India (Reg. No. INGR 01042). Thus the CCRI, Coffee Board is the rightful owner of this unique genotype.

These genotypes can be provided to research partnerships/commercial exploitation to any of the coffee growing countries, Research Funding/Nodal agencies and other such organizations with the following mutually agreed terms (MATs).

MATs for coffee growing countries

1. The material will be provided to the premier research institute of the country in the form of seeds.
2. The material will be provided on the condition that this material will be utilized for research purposes and the essentially derived varieties (EDVs) involving Sln. 5A and/or Sln.6 of Indian origin will be utilized only in the recipient countries.
3. Any other countries receiving these materials are also bound by the above two agreed terms.

MATs for Funding Agencies/Nodal Agencies

Besides the above terms, the technologies, processes, copyrights and products developed during the course of this project may be protected by patents for the mutual benefit of the PIs, but the ICO and the CFC will be consulted on this matter if or when it arises. According to the CFC Project Preparation Manual, the IPRs of the Project belong to the Fund and the ICO.

Logical Framework

Project Title: Breeding coffee plants with durable resistance to Coffee Leaf Rust, anthracnose and other diseases

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Programme goal: The broader objectives a) To improve tolerance/resistance of cultivated Coffea arabica to the main diseases CLR (Coffee Leaf Rust) anthracnose and other diseases causing economically significant crop losses, without compromising quality attributes. b) To optimize disease control measures and render them amenable for practice by small growers. c) To identify socio-economic factors that lead to large disease build-up	Measures of goal achievement a) Increase in the frequency of disease free plants in the population. b) Decrease in disease management costs by the integration of botanicals. c) Beverage quality of new materials. d) Socio-economic index to identify poor farmers who can be the beneficiaries of assistance schemes.	a) Data on field incidence of disease. b) Survey data on disease management cost. c) Socio-economic data collateral to field disease build-up. d) Certificates of residue analysis laboratories.	Concerning long term value of project a) Continued commitment to develop environmentally benign and sustainable disease control strategies for small grower practice. b) Disease resistance built in to new materials is expected to last for a long time. c) Integration of botanicals and optimized disease control is expected to help small growers in the long run.
Project purpose a) To improve genetic endowments of cultivated *C. arabica* for tolerance/resistance to CLR and anthracnose pathogens and to reduce production costs through planting improved materials in participating countries. b) To protect the health of the environment through reduced use of fungicides. c) To ensure beverage quality matches standard norms and render it safe for consumption without residues. d) To identify socio-economic factors leading to non-adoption of recommended disease control measures.	Conditions that will indicate purpose has been achieved: End of project status a) Field incidence of disease by scoring in sizeable populations to prove increased resistance. b) Grower acceptance of new materials – indicated by demand for new seed. c) Liquorers reports on the assessment of beverage quality. d) Residue analysis reports. e) Improved disease control by integration of botanicals- direct benefit to growers.	a) Survey to score field incidence of disease. b) Increased demand for seeds of new materials. c) Certificates of beverage quality from accredited Liquorers.	Affecting purpose to goal link a) Leaf rust continues to be a strong constraint for coffee production in India. b) Maintenance of disease resistance in seed progenies by isolation of seed plots. c) Improved disease control methods withstand climatic vagaries.
Outputs a) Development of seed plots in participating countries. b) Improved planting materials for cultivation from isolated seed plots. c) Development of Marker Assisted Selection (MAS) protocol for seed quality reliability. d) Optimizing disease control measures by integrating botanicals. e) Reduced cost of cultivation by minimizing use of fungicides. f) Assured beverage quality and consumption safety.	Magnitude of outputs necessary and sufficient to achieve purpose a) Increase in seed production based on demand in the respective countries (One kilogram of coffee seed produces about 2,000 seedlings). b) Stabilizing resistance by means of marker assisted selection. Simpler modes of MAS are being developed in India. c) Wide dissemination of knowledge on botanical use in disease control.	a) Detailed analysis of disease resistance levels to understand the behaviour of resistance genes in inheritance. b) Detailed analysis of costs and benefits of cultivating new materials and appraisal by users at the terminal workshop.	Affecting output to purpose link a) New control measures against leaf rust will be effective in conjunction with the built-in resistance and are amenable for small grower practice. b) A complete adoption by growers would be ensured if awareness and training in disease control operations continues post project.
Inputs: Activities and types of resources a) Survey and identification of coffee genotypes with possible resistance to CLR and anthracnose. b) Testing these genetic stocks for resistance against CLR and anthracnose, using the standard tests (leaf disc/attached leaf inoculations for CLR and seedling hypocotyl inoculation for anthracnose) to assess level of resistance. c) Increasing stock by controlled production of additional seeds from resistant mother plants as well as cloning. d) Integration of MAS in seed production. e) Beverage quality assessment by cup tasters. f) Testing for pesticide residues. g) Initiation of on-farm trials in small plots in participating countries.	Level of effort/expenditure for each activity Component 1: To produce enough improved seed for carrying out on-farm demonstration trials in ten demonstration plots in India. US$300,690 Component 2: Optimization of disease control measures currently available. US$60,250. Component 3: Extension and dissemination of project results to farmers and other countries. US$40,000 Component 4: Project Co-ordination (Execution, Monitoring, Financial Administration etc.)	PEA Project Progress Report Annual Progress Reports Participation in advisory committee meetings and terminal dissemination workshop Farm trials of new materials in participation countries Periodic reports and onsite visits to assess progress in implementation	a) Financing from all sources is made on a timely basis in line with proposed activities and annual work plan, budget etc. b) The PEA and collaborative institutions co-ordinate and execute the project efficiently. c) All project participants remain committed to the project purpose. d) Socio-political developments should not prevent effective project implementation.