PD-AAH-483
40762

Midterm Evaluation of Semi-Arid Tropics Crops Research Phase II ICRISAT/Mali

Prepared under the terms of USAID contract number PDC-1406-I-14-1089-00, Bamako, Mali

Anthony Hall
Brahima Sidibe
Orrin Webster
David Wilcock

November 1983

Development Alternatives, Inc. 624 Ninth Street, N.W. Washington, D.C. 20001

PREFACE

EVALUATION TERMS OF REFERENCE AND REPORTING RESPONSIBILITIES

The ICRISAT/Mali Phase II project paper (USAID, 1981)[1] calls for a mid-project evaluation to be conducted in year three of the project. Since Phase II activities began in July 1981, the evaluation period of October 20-November 11, 1983, falls about midway through the original five-year project life. The project paper specified that the evaluation would be undertaken by a "combined team respresenting GRM/IER, USAID, ICRISAT, and outside consultants." Representative participation in the evaluation process has largely met the spirit if not the letter of this requirement. Specificially the composition of the "evaluation team" which has produced this report is:

- Dr. Anthony Hall, Agronomist
- Dr. Brahima Sidibe, Entomologist and representative of the GRM/IER
- Dr. Orrin Webster, Cereal breeder
- Dr. David Wilcock, Agricultural economist and team leader.

We must quickly add, however, that other parties have been intimately involved in the evaluation process but bear no responsibility for the contents of this report. Dr. S.K. Reddy, USAID project manager, has collaborated very effectively in this process, as have personnel from the USAID/Mali Offices of Agricultural Development and Design and Evaluation. Personnel from GRM/IER, ICRISAT/Mali, and other organizations have given generously of their time both in Bamako and at the research stations at Sotuba, Cinzana, Baramandougou, Koporo-Keniepe, and Tierouala. For a detailed accounting of these contacts the reader is directed to the Schedule of Evaluation Team Activities, included as Annex B. The ICRISAT/Mali researchers are to be commended for their extremely cooperative conduct and ability to facilitate the work of the evaluation team while ensuring the harvesting of their breeding and agronomic trials, which largely occurred during the evaluation period.

ICRISAT/Center (Hyderabad) provided technical assistance on financial management as a part of this project evaluation in the person of Mr. K. Narayana Murty, assistant accounts officer from

---

1 References given in this format are contained in Annex A, Bibliography.

Hyderabad and through a formal accounting audit of ICRISAT/Mali books undertaken by the Dakar office of the firm of Coopers and Lybrand. A report on Mr. Murty's review of project financial management and on the audit will be available separately from this evaluation report. These latter two activities are being undertaken with ICRISAT core funding. The evaluation team specifically requested some ICRISAT/Regional or Center participation in the evaluation process but this did not occur.

The Phase II project paper provides general evaluation terms of reference as follows:

> This evaluation will cover all aspects of the project, including technical, socio-economic, financial, and administrative. Special attention will be focused on the socio-economic feasibility of the ICRISAT strategy, the efficacy of the linkages between ICRISAT and the farmers and the GRM system for getting research results to the farmer, and the feasibility of Malian institutions to continue similar research on their own (USAID, 1981, p. 33).

More detailed terms of reference were provided for the team by USAID/Mali. They are consistent with the general terms above but provide more detailed technical and policy-oriented questions to be addressed by the agronomist, the plant breeder, and the agricultural economist team members. A copy of these more detailed terms of reference is available from either USAID/Mali or USAID/Washington.

The evaluation team felt that one coordinated evaluation report would be the reporting format of greatest utility to different interested parties. We have thus attempted to reach general conclusions and recommendations through a process of consensus. It should be noted however that different team members undertook primary responsibility for particular sections of this report. Specifically, Section III on the ICRISAT/Mali plant breeding program was written principally by Dr. Webster, Sections IV and VI on the agronomy program and the development of Malian research station capacity by Dr. Hall, and the rest of the document by Dr. Wilcock. Due to the drafting of the report in English, Dr. Sidibe's role was to review and amend all sections in draft form and to prepare the draft summary and recommendations in French.

Final typing, translation, and preparation of reports in both French and English were undertaken by personnel in the offices of Development Alternatives, Inc. (DAI) in Washington. Typing of early drafts was provided by ICRISAT/Mali typist Rachel N'Diaye and USAID/Mali secretarial staff, whose efforts the authors greatly appreciate.

TABLE OF CONTENTS

I. SUMMARY OF EVALUATION FINDINGS AND RECOMMENDATIONS

A. GENERAL CONCLUSION AND OVERALL RECOMMENDATION

ICRISAT/Mali has played a steadily expanding role in applied sorghum and millet breeding and related dryland farming agronomy in Mali since 1976. This mid-term evaluation effort has focused specifically on the past two-and-one-half years of this effort under current Phase II USAID bilateral funding. This summary section contains a condensed version of the team's more important findings and 31 specific recommendations. For more complete details see the corresponding sections of this report.

ICRISAT/Mali project activities are closely integrated with, and supporting of, a young but impressive Malian agricultural research system. Building on a strong base developed over the previous four years, Phase II activities have focused on a sorghum and millet breeding component which shows substantial promise of making a significant contribution to the development of improved varieties for a wide belt in West Africa and on a multifaceted agronomy component which has made a major contribution to the development of Malian agronomic research capabilities. The evaluation team concludes that this bilateral funding mechanism has been extremely cost-effective when overall project accomplishments are enumerated and, in fact, the "Mali model" may just prove to be one of the most viable approaches ICRISAT could follow in the development of its African research and training program. Therefore, the evaluation team recommends that:

(1) the ICRISAT/Mali project maintain its overall general course over the remaining two to three years of Phase II but that it should make specific changes as described in the recommendations. If substantial progress can be made in making the mid-course corrections suggested -- particularly in the development of practical improved agricultural technologies for farmers -- then this evaluation team would feel that a very strong base exists for some type of Phase III project funding.

B. PROJECT OBJECTIVES

The overall objectives defined for the ICRISAT/Mali Phase II project were generally sound if overly ambitious for a small team. In hindsight, greater relative emphasis should have been placed in the project paper on the station development and training, which have been both time consuming and highly successful.

ICRISAT/Mali has not developed an adequate practical strategy for meeting the overarching goal of the project: the development and transfer of improved dryland farming technical packages for Mali's major production regions in the semi-arid zone. While it is clear that meeting this goal goes far beyond what can reasonably be expected of a small agronomic research project and demands that the GRM more effectively provide adequate field-level coordination with other research and extension organizations, development of a workable technology transfer strategy is a necessary precondition to fully capitalizing on the accomplishments of the ICRISAT/Mali effort to date.

The evaluation team therefore recommends that:

(2) the logical framework analysis of the project be revised so that it shows a clear, anticipated, logical progression toward achievement of the overall project purpose, and it incorporates changes in project scope and direction which should result from this midterm review;

(3) as part of this restatement of project objectives, a realistic, written agricultural technology development and transfer strategy for semi-arid Mali be elaborated. This could help guide further USAID investment to the ICRISAT/Mali and related agricultural research and development projects and can point up the nature and extent of necesary linkages with GRM Ministry of Agriculture farming systems research and extension organizations. This could be done in preparation for the five-year review of the overall ICRISAT program.

C. SORGHUM AND MILLET BREEDING PROGRAMS

Substantial progress has been made by the sorghum and millet breeding programs toward developing varieties that are adapted to the semi-arid zone of Mali.

The creation of the food technology group within the breeding section has had useful consequences because it is making possible the development of sorghum and millet varieties that are acceptable to consumers. This combination of food technology with plant breeding is unique in West Africa and could benefit the entire region.

The breeding programs of ICRISAT/Mali are well-integrated with the national program. Consequently, the evaluation team recommends that:

(4) the breeding programs continue in essentially the same manner as at present with only minor modifications as indicated in the report;

(5) exchanges of information and visits be increased between millet breeders in the ICRISAT Regional Center, Niamey, and the Malian National Program, and between sorghum breeders at ICRISAT Center, Hyderabad, and the ICRISAT/Mali project;

(6) high priority be given to efforts currently underway to strengthen the food technology group by increasing laboratory space and equipment and by training personnel.

D. THE AGRONOMY PROGRAM

The two major activities of the agronomy program consisted of developing the infrastructure necessary for conducting a broad range of on-station, agronomic research and conducting research on intercropping to determine the management factors and

interactions that have a major influence on these systems. These activities were appropriate at this stage of the project and considerable progress has been made.

The other activities of the agronomy program were diverse, and, for the future, increased focus and definition of research strategies are needed. Consequently, the evaluation team recommends that:

(7) the agronomy program focus on two major objectives: (a) the development of packages of improved management technology for wide-scale on-farm testing by cooperating organizations, and (b) assisting the sorghum and millet breeding programs to develop improved varieties that can benefit from the improved management technology;

(8) improved packages of cultural techniques be developed with emphasis on animal traction, weed control, and surface water management -- this should make possible improved collaboration with the Cellule Technique Culturale and other organizations within the Malian national program;

(9) emphasis be given to sole crops of millet and sorghum, and intercropping systems with cowpea. These studies would be conducted in the area served by Cinzana, Baramandougou, and Koporo-Keniepe in collaboration with organizations conducting research in farming systems.

(10) a senior agronomist be recruited by ICRISAT/Mali as a replacement for the present agronomist who is being transferred to ICRISAT/Niamey. The new agronomist should be encouraged to develop packages of improved cultural techniques as described above;

(11) ICRISAT/Mali recruit an agro-physiologist to work mainly at the Cinzana station under the direction of the sorghum and millet breeders on systems for screening for resistance to drought and diseases;

(12) the project continue to provide modest funding to maintain the potentially very useful botanical observation trials undertaken by Malian researcher A.A. Sow, Senior; and

(13) ICRISAT/Mali finish research on the promising maize/millet intercrop, pigeon peas, Eleusine coracana systems, increase amounts of seed where necessary and encourage other collaborating organizations to conduct wider scale on-farm testing.

E. SOCIO-ECONOMIC FEASIBILITY OF AGRICULTURAL TECHNOLOGY TRANSFER

The development and dissemination of improved agricultural technologies for specific groups of farmers in specific production zones will depend on the simultaneous and coordinated development of applied breeding and agronomic research, relevant and highly focused farming systems investigations, and an adequate yet streamlined agricultural extension mechanism. In many respects this larger process surpasses the scope of the ICRISAT/Mali project but must occur if there is to be a full realization of the potential benefits of a relatively successful agronomic research project.

Until 1982, lack of systematic baseline data collection and a clear understanding of underlying Malian farming systems was a major deficiency in this overall process. Initial efforts to fill this gap should be expanded and intensified. It is the belief of this team that a collaborative, "cross-institutional" approach to the development and transfer of improved dryland farming technologies in Mali is institutionally feasible if not easy to accomplish. To that end the evaluation team recommends that:

(14) analysis of the 1982-83 Cinzana FSR studies be completed as soon as possible and that ICRISAT/Mali staff help design a new set of more focused farm-level investigations for the four Cinzana villages for the 1984 production season;

(15) the GRM/IER should be urged to seek mechanisms to improve coordination among the various research and extension organizations involved in the development and transfer of agricultural technology. Multi-disciplinary task forces with representatives from both research and extension, working on a specific problem in a well-defined geographic area, will be more likely to be effective in developing and transferring improved agricultural technology to farmers than current fragmented approaches;

(16) USAID actively pursue this regional level coordinated approach through the projects it funds so as to maintain a problem-oriented focus; and

(17) with respect to the proposed Farming Systems Research and Extension project:

-- USAID should proceed with a scaled down version of this project, concentrating on building strong reinforcing linkages to the ICRISAT/Mali and GRM/IER/SRCVO agricultural research efforts;

-- the production zones around the Cinzana, Baramandougou, and Korporo research stations be the target areas for a pilot multidimensional approach to technical package development and transfer to Malian farmers; and

-- the FSR & E project should also furnish a streamlined experimental agricultural extension outreach mechanism.

F. DEVELOPMENT OF MALIAN RESEARCH STATIONS

ICRISAT/Mali, the government of Mali, and the Ciba-Geigy Foundation have developed an excellent research station at Cinzana that can make major contributions to the improvement of cereal and legume production in the semi-arid zone of Mali.

However, the evaluation team considers that the equipment and infrastructure of the Koporo-Keniepe and Baramandougou stations will not permit the agronomy and breeding programs to achieve their goals in a timely manner. Consequently, the evaluation team recommends that:

(18) the government of Mali, ICRISAT/Mali, and the ICRISAT Regional Center in Niamey take the actions necessary to ensure the continued development and operation of the Cinzana station. For example, consultants from ICRISAT Regional Center could provide advice concerning station development and management. Further, the government of Mali and ICRISAT/Mali should ensure that at least two senior scientists reside on or near the station to ensure close daily supervision;

(19) land-use plans be developed for the Cinzana and Baramandougou stations, and major drainage-ways be designed and installed on both of these stations to prevent soil erosion;

(20) the initial start in the use of animal traction for station soil preparation be continued and expanded in the reoriented agronomy program described above (greater use of donkey traction and smaller wheeled tool carriers is strongly advised);

(21) the irrigation system at Cinzana be fully developed to attempt to serve the needs of dry season breeding nurseries and the agro-physiological experiments; other strategies for providing for nurseries during the dry season could also be studied;

(22) the Government of Mali and ICRISAT/Mali request funding from USAID, Ciba-Geigy, and other sources to finance the development of infrastructure necessary for executing the research programs proposed for Baramandougou and Koporo-Keniepe (the development of the system for screening for resistance to downy mildew in millet is particularly important); personnel would be needed for this development work, including consultants from the ICRISAT Regional Center in Niamey.

G. TRAINING

Training has been conducted by the ICRISAT/Mali project in several ways: short-term training at ICRISAT Center, Hyderabad; university degree-level training; on-site training of junior scientists and technicians; and training of advanced students from Katibougou in special studies. In all cases the training has been extremely successful The evaluation team recommends that:

(23) these training activities be continued in their current major orientation. It would also suggest some exploration of broadening the options considered under the category of short-term foreign training, particularly in response to practical training opportunities in West Africa. Particular attention should continue to be devoted to the need to provide effective training opportunities to Malian researcher counterparts; and

(24) every effort be made to coordinate the ICRISAT/Mali training component with an overall manpower training strategy as this is developed by the personnel of the GRM/IER.

H. PROJECT ADMINISTRATION AND INSTITUTIONAL RELATIONSHIPS

The administration of the ICRISAT/Mali project is generally seen to be adequate,but some informal procedures are no longer appropriate given the increased size of the project. There has been an escalation in recurrent local personnel and operating expenditures in recent years that points up the need for a more rational budget planning process. This will also help GRM/IER to plan its budget allocations more effectively. Until the past year, the project has received only superficial or sporadic administrative and scientific input, review, and assistance from both USAID and ICRISAT/Center.

In order to promote improved project administration and support, the evaluation team recommends that:

(25) ICRISAT/Center at Hyderabad provide short-term assistance to ICRISAT/Mali in budget planning; certain aspects of this planning should be coordinated more closely with USAID and GRM/IER;

(26) the long-term feasibility of integrating certain ICRISAT/Mali personnel into the Malian civil service be studied. This would apply only to those personnel currently playing critical roles in the operation of Malian research stations and in the conduct of the national agronomic research program;

(27) ICRISAT/Mali develop a prioritized list of short-term technical assistance needs in the areas of research, station development, and project administration for the remainder of current project funding. This list should be part of the improved budget planning process and updated annually. In addition, short-term visits of ICRISAT/Center and Regional personnel should be more systematically planned to provide review and planning assistance to the Mali research program;

(28) ICRISAT/Mali improve its reporting and make its annual reports more complete, with more synthesis and description of project evolution and accomplishments;

(29) because ICRISAT/Mali spends too much time and too many resources looking after teams of scientists from projects funded by USAID, the USAID mission should assume this responsibility;

(30) ICRISAT/Center at Hyderabad and the ICRISAT/Regional program at Niamey provide more systematic administrative assistance to the ICRISAT/Mali project and periodic critical review and planning assistance in Mali to the research program; and

(31) ICRISAT/Mali explore increasing project use of microcomputers for project administration and accounting, for research data processing, and for report preparation. This effort should be carefully planned, facilitated through short-term technical assistance, and coordinated with the provision of microcomputer training to ICRISAT-sponsored Malian students in the United States for advanced study.

II. ICRISAT IN MALI: AN OVERVIEW

A. CHRONOLOGY OF ICRISAT/MALI AGRICULTURAL RESEARCH

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) was established in 1971 to:

(a) improve production of sorghum, millet, pigeon pea, and chick pea (peanut was added later);

(b) develop improved farming systems for the seasonally dry, semi-arid tropics;

(c) identify socio-economic and other constraints to agricultural development and evaluate technological and institutional changes to overcome them; and

(d) assist national and regional research programs through cooperation and support by sponsoring training and extension activities.

Through a grant from the Ford Foundation in 1976, ICRISAT initiated a research project in Mali, in which plant breeder S. Clark began the evaluation of local sorghums and millets and the introduction of exotic materials. The following year, funding was assumed on a one-year renewable basis by USAID/Mali, under the "Operation Mil-Mopti" project as a component of the National Research Program, and agronomist P. Serafini joined the project. Plant breeder J. Scheuring arrived in Mali in 1978 under ICRISAT core funding and replaced S. Clark.

In 1979, USAID provided ICRISAT with a three-year $500,000 grant to continue this work. The purpose of this Phase I project was to develop a series of technical packages on millet, sorghum, and certain grain legumes for the 400-1200 mm rainfall zone of Mali. Research was to include varietal improvement of sorghum and millet and agronomy with emphasis on intercropping, forage production, animal traction, and pigeon pea production. Phase I activities were reviewed by O. Webster of the University of Arizona in November 1980. It was concluded that the project was proceeding as originally planned and the evaluation recommended that it be continued.

Previous Page Blank

In 1981, USAID provided ICRISAT with a five-year $3,750,000 grant to continue this work under Phase II.

B. PHASE II PROJECT PURPOSES

The logical framework analysis in the project paper states that the purpose of Phase II is to develop a series of technical packages with sorghum/millet and certain grain legumes in the 400-1000 mm rainfall zone of Mali and to make them available to small farmers and small herders through the extension service operations and livestock projects and to strengthen the GRM's research capability in the semi-arid rainfall zone.

The logical framework analysis also states, however, that the outputs would consist of research results that indicate more efficient agronomic practices and the development of improved sorghum/millet cultivars. It was not shown how these research results and improved cultivars would be put together to form improved technical packages relevant to farming conditions in Mali. Also, it was not stated whether the project would assume this task of assembling and testing technical packages or whether it would be done by a cooperating farming systems research unit. Without a complete strategy, the project purpose may not be achieved. The activities of the ICRISAT/Mali project have been consistent with the logical framework analysis. Research results have been obtained that indicate more efficient possible agronomic practices, and progress has been made towards the development of improved sorghum/millet cultivars. However, these outputs are still a long way from the project purpose, which is to develop improved technical packages for the semi-arid zone of Mali. For more detail on the development of appropriate technical packages see Section V of this report.

The evaluation team recommends that the logical framework analysis of the ICRISAT/Mali project be revised either formally

or informally, so that it shows an anticipated logical progression toward achievement of the project purpose and includes changes in project scope and direction that result from this mid-project review.

C. ICRISAT IN THE STRUCTURE OF THE GRM MINISTRY OF AGRICULTURE

The Ministry of Agriculture in Mali is a large and complex institutional structure. An understanding of certain critical institutional relationships within this ministry is important to fully appreciate ICRISAT/Mali project work and to understand the constraints under which the team has worked in terms of the development of a coherent agricultural technology transfer strategy. This latter topic is covered in Section V below.

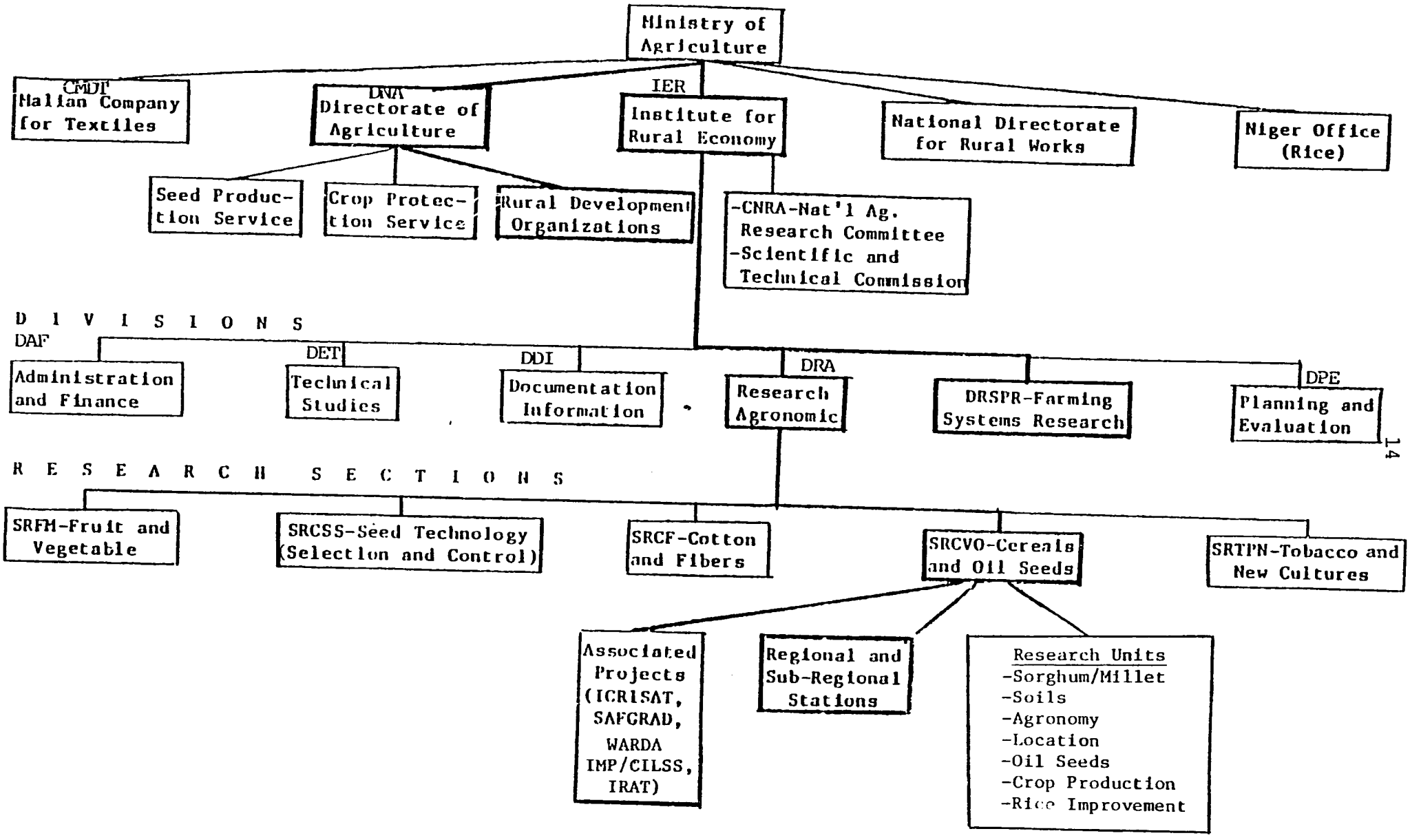
Chart I on the following page presents a fairly complete organizational chart of the GRM Ministry of Agriculture. Note that there are three principle directorates (Directions) in the ministry: Agriculture (which contains the regional extension services or "Operations"), Rural Works, and the Institute of Rural Economy (IER). The institute, under the very capable leadership of Mr. Fatagoma Traore, plays a critical role in virtually all agricultural research conducted in Mali. IER is composed of six divisions: Administration and Finance (DAF), Technical Studies (DET), Documentation and Information (DDI), Agronomic Research (DRA), Farming System Research (DRSPR), and Planning and Evaluation (DPE).

The Agronomic Research Division (DRA) contains a large percentage of the scientific and total staff of the overall IER. It should also be carefully noted that Farming Systems Research (DRSPR) is contained in a separate, parallel division within IER.

As we see in Chart I, within the DRA there are five major research sections, with the most important in personnel and resources being SRCVO. (Section de Recherhe sur les Cultures Vivrieres et Oleagineuses, or, Food and Oil Crops Research

FIGURE 1

ORGANIZATION OF THE MINISTRY OF AGRICULTURE



Section). The ICRISAT/Mali project is located within this section along with other "associated projects" including a SAFGRAD multilocational farm trial project, a WARDA rice project, and a USAID-funded regional IPM project, among others.

SRCVO has seven research units (cellules):

AMS: Sorghum and Millet Improvement (Also includes cowpeas, maize, and minor grains)

AGP: Soils (Agropedology)

TC: Agronomy (Cultural Techniques)

EM: Multilocational Trials

AO: Oil Seed Improvement

DC: Crops Protection (Includes CILSS IPM project)

AR: Rice Production Improvement

The ICRISAT breeding program primarily works within the AMS research unit, which is directed by Malian millet breeder, Dr. Oumar Niangado, who is also the Cinzana station director. As will be explained in the agronomy section of this report, the ICRISAT agronomy program has not been as tightly integrated into the SRCVO structure for a number of reasons. Substantial collaboration has occurred however with the soils (AGP), agronomy (TC), and multilocational trials (EM) units.

SRCVO also has administrative supervision over the Malian national crop research station system. This system is primarily composed of four major research stations and nine substations called "Research Support Points" (Points d'Appui de Recherche). The four major research stations are:

Sotuba Station: Located a few kilometers from Bamako this is the most important national research station. SRCVO headquarters are located here as is a substantial part of the ICRISAT breeding work. About 30 hectares of crop land

are currently in use and more land is apparently available if needed from the surrounding livestock research station.

Cinzana Station: Located about 45 kilometers to the northeast of Segou (second largest city in Mali) on a paved road, the Cinzana station has only formally been in operation since July 1983. The construction, equipping, and develcpment of this station has been an important accomplishment of the ICRISAT project, which is described in Section VI of this report.

Kogoni Station: Locted in the Niger River flood plain area of the Office du Niger, Kogoni station is the oldest research installation in Mali and is focused on research on irrigated rice.

Dire Station: Located about 100 kilometers south of Timbuctou along the Niger River, Dire is supposed to do research on irrigated wheat production. Dire is the least developed of the major Malian research stations.

The research substations are of various origins and generally have fairly limited infrastructure. They are located in: Samanko, Katibougou (also the national agricultural training college), Kita, Sikasso, Baramandougou, Koporo-Keniepe, Bema, Gao, and Massantola (actually the only remaining "experimental point" still in operation).

ICRISAT has conducted trials at many of these PARs and we will focus particularly on work conducted at Baramandougou and Koporo-Keniepe and the role that the development of these two stations might play in future research work to be conducted by the ICRISAT/Mali project (see particularly Sections IV, V, and VI).

There are two additional points to be noted with respect to the structure of the GRM Ministry of Agriculture. One is the location of the agricultural extension services and the farming

systems research unit. The extension services are located in the Direction Nationale d'Agriculture and farming systems (DRSPR) is a separate division within the IER Direction. This is important for coordination and linkage questions to be considered in Section V.

The second point has to do with formal linkage mechanisms built into the ministry organizational plan. In Chart I, the reader will note two "inter-divisional" policy-making, coordinating committees: the Scientific and Technical Commissions and their parent, the National Agronomic Research Committee (CNRA). In February or March of each year, a number of commissions meet to review the research results of the past production season and to plan experimentation for the upcoming season. For the SRCVO and its associated projects, the relevant body is the Technical Commission on Food and Oil Seed Production, which has a very broad membership throughout the Ministry of Agriculture including both the agricultural research units and all the field-level extension units. Proposals hammered out by these commissions are submitted the next month to the more-restricted CNRA, which makes the final decisions concerning the major orientations to be followed in the agronomic research program for the coming season. This is a very laudable mechanism, but the adequacy of this one mechanism to ensure the necessary and sustained field-level coordination of a multidisciplinary approach to the development of improved technology packages and their transfer to farmers will be examined in Section V of this report.

III. THE PLANT BREEDING PROGRAM

A. INTRODUCTION: CHALLENGES TO THE PLANT BREEDER IN THE SAHEL

The plant breeder in West Africa is confronted with numerous constraints which are not problems when working in the temperate zone. It took many years to identify these constraints and new sorghum breeders can take advantage of this information. Dr. Scheuring, the ICRISAT/Mali breeder, has, in a short time, come to grips with the problems involved and been able to move ahead in an effort to develop improved sorghum varieties for Mali.

A few of the constraints to be dealt with include:

(1) A new plant cultivar must fit the season. West Africa has a wet-dry cycle. The farmer must plant at the beginning of the rains to take advantage of the "nitrogen flush," and to avoid early insects that can attack seedlings, such as the central shoot fly. Uneven heading later in the season can create a sorghum midge problem. These insect pests will increase in numbers on the early emerging heads and cause severe damage to the later heads. The plants must not produce grain very long before the end of the rains or the grain will mold and not be fit for human consumption. This factor is most serious in the tropics because of higher temperatures.

(2) Except in the dryer areas, the cultivar must be photoperiod sensitive, which means that regardless of when the crop is planted, heading must take place when the rains normally stop. In other words, the planting dates may vary as much as a month, but heading will take place year to year within a period of a few days.

(3) The cultivar must have a dry stem to resist damage by stem borers. If a borer leaves a hole in a juicy stem, this would permit the entrance of fungi, which multiply rapidly on the

Provided by eGangotri

favorable media thus rotting out the stem. On the other hand, a dry stem will tolerate the presence of stem borers with no yield loss.

(4) The cultivar must have an open head which drys quickly to prevent molding and does not provide places to harbor insects.

(5) The cultivar must be resistant or tolerant to the foliar diseases found in the area. It is for this reason that the best sources of germ plasm available are found in the local sorghums which have evolved over centuries of natural selection.

(6) The grain must thresh from the glumes easily and be flinty in texture. Hard seed will mill better and help in resisting stored grain insects.

(7) In the tropics, when the stalks are used for fencing, house construction, or even for fuel, taller plants are more desired than when the crop is machine-harvested.

The sorghum breeder has two choices to improve his crops: by introductions, either local or exotic; and by breeding.

B. SORGHUM VARIETAL IMPROVEMENT

1. Varietal Introductions

During the past four seasons, several hundred introductions have been evaluated in observation nurseries. With the exception of some local varieties from West African countries, generally they were neither agronomically nor gastronomically adapted to Malian conditions. The West African Guineense sorghums generally grown in Mali have not been used by breeders in the temperate zones because they are photoperiod sensitive and difficult to work with. As a result, introductions from the temperate zones do not have any of the desirable germ plasm of the Guineense sorghums.

The best approach to breeding in Mali is to use a basic stock germ plasm from local sources or from other West African countries. During the past four seasons, 800 Malian sorghums have been evaluated and some of the best have been included in the breeding program. On the basis of 1981 and 1982 yield performance trials, three local varieties from the collection CSM-332, CSM-387 and CSM-388 -- were retained for further yield testing. CSM-388 was increased for multilocation pre-extension testing in 1984. CE-90, derived from a cross between Senegalese and Nigerian local varieties, is grown in Senegal and has performed well in Mali. This variety has been faulted because of poor stand establishment but apparently the problem is due to poor quality seed. In 1983, two derivative varieties from CE-90 were identified and will be yield-tested in comparison with CE-90 in 1984.

Trials with photoperiod-sensitive sorghums are being conducted in the low-rainfall zone. CSM-417 and CSM-419 appear to have excellent yield potential in the Baramandougou area. Some F_1 (first generation) hybrids give a clear advantage over the other entries but grain quality problems preclude their use.

The 1982 test of photoperiod insensitive sorghum for the low rainfall zones included 12 experimental varieties from the ICRISAT programs in Africa. The ISVAT (International Sorghum Variety Adaptation Trial) included 21 experimental varieties from ICRISAT Center program, two F_1 hybrids, and one local check. The performance levels exceeded 4 tons/ha. Unfortunately most of the entries have soft grain, which is not acceptable to most Malian farmers and consumers. They were regrown in the north near Bema where soft grain and relatively compact panicle sorghums are found, but they were found to be susceptible to stalk rot.

2. Breeding

Two methods of breeding are employed: pedigree and population. The former involves the intercrossing of two lines in the anticipation of recombining the desirable traits of both in a progeny. After the cross is made the progenies are grown in pedigree rows for a few generations in anticipation of selecting the desired progeny. Crosses were made in 1981 between a few introduced B-lines[1] and Malian B-lines for the purpose of developing females which could be used in hybrids. The most promising progeny will be crossed into breeding populations. In 1983 a series of short-statured, open panicle, hard-seeded B-lines were identified. This material should provide an excellent base for developing improved varieties and hybrids for this region.

Breeding populations are developed by crossing a number of lines onto a genetic male sterile. The F_1 seed is usually bulked and planted in a plot with some isolation. The male sterile F_2 progeny are identified and are permitted to be outcrossed to all fertiles in the plot. In some cases these plants are hand-fertilized by applying pollen from selected fertile plants. The purpose of this exercise is to recombine the numerous genetic characters found in the parent lines. This mating system is followed for three or four cycles, after which desirable fertile plants are selected and pedigree-tested. These populations can be grown at a number of locations and desirable progeny selected to fit the environment. Using this system a breeder can handle a mass of material with a minimum of effort. F_4 and F_6 lines from populations were grown at four locations in 1983 and panicles were selected from the most promising plants. In the drought year of 1983, Dr. Scheuring was able to select panicles from a number of good agronomic lines which produce hard seed. The next step will be to progeny-test these lines or cross them back into the population. One F_4 family is particularly promising, as it

combines relatively short stature (2m), good tillering, few leaves, and an open and long panicle with hard seed. It will be an excellent parent for future crosses.

Numerous "ready made" exotic populations are available but all have common problems for Mali: disease susceptibility, extreme earliness, chaffy grain, and compact panicles. These populations are useful as a base for inter-crossing the sterile plants with local lines from which plants can be selected to develop "adapted" populations.

Population breeding is the basis for the local Malian program and shows promise of paying good dividends. When one considers that a 10-year period is required to develop a new cultivar, the local breeding program should produce the desired results in a shorter period. This will be a remarkable achievement considering the numerous constraints placed on a new cultivar. The success of this procedure is dependent upon incorporating the desirable germ plasm found in West African sorghums. The present program is already generating entirely new phenotypes which are not found elsewhere.

3. Disease Resistance

Sooty stripe (Ramulispora sorghi) appears to be a major foliar disease in West Africa which can completely defoliate exotic cultivars. There are several other foliar diseases of economic importance such as downy mildew (Sclerospora sorghi), zonate leaf spot (Gloeocercospora sorghi), anthracnose (Colletotrichum gramincola), Helminthosporium (Helminthosporium turcicum), and others (ICRISAT, 1978). Fortunately local sorghums carry good resistance to foliar disease and when crossed with populations should give resistant progeny. The major stalk disease appears to be charcoal rot (Macrophomina phaseolina), which is often associated with drought. In the 1983 nurseries the local Guineense type showed no evidence of lodging due to

charcoal rot. Several of the lines in the 1983 observation nurseries were free of stalk rot at four locations. Unfortunately, we did not visit many farmers' fields to determine the prevalence of kernel smut (Spacelotheca sorghi). There is a question of whether there is resistance to kernel smut in the Guineenses since similar types were found to be susceptible in Nigeria. This disease can be controlled by seed treatment and has been eliminated in the United States since all seed is produced by commercial companies and is treated. Long smut (Tolyposporium ehrenbergii) was very prevalent in the 1983 fields. This is a soil borne organism which is associated with sorghum growing in dry areas of Africa. The percentage of florets which may be infected is so low the yield losses are insignificant. As expected, the highest degree of infection is found on male sterile heads. A comprehensive study should be made of the life cycle of this disease since it does limit the movement of seed between countries because of quarantine restrictions. Head molds are a factor in causing seed weathering and thereby reducing grain quality. Head molds are not a factor when the grain matures during the dry period at the end of the rains. There are reports of genotypes with fair grain quality which are resistant to these molds. If this is correct, such germ plasm could be crossed into the populations. There are many population derivatives in the 1983 nurseries with open panicles and long glumes which appear to tolerate both molds and head bugs. Dr. Scheuring has reported that ergot (Sphacelia sorghi) is not found in Mali. This disease is prevalent in Nigeria and sterile florets are extremely susceptible. This disease would prohibit seed production of sorghum hybrids in Nigeria during the rainy season and would limit it to dry season irrigation.

4. Insects

There are three species of stem borers found in West Africa. Fortunately local sorghums are quite tolerant. There are effective insecticides which can be used if required. Central

shoot fly is apparently not an economic factor in sorghum production in Mali. The same is true throughout West Africa since the sorghums in an area are all planted at same time and head at the same time. The problem generally is more acute on an experiment station where varieties of varying maturities are grown or there is a range in planting dates. Sorghum ear worms can be troublesome especially on plant types with compact heads. Open or semi-open panicles are essential for the control of these pests. Head bugs or grain feeding insects can be a problem on early maturing material. This involves a complex of insect species whose life cycles should be studied. Apparently, their cycle is timed with the rains as are other insect pests, and terminates with the beginning of the dry season. Green bugs and aphids are commonly found in most fields.

5. Striga

This parasitic weed is found throughout most of Africa. The plant produces many seeds. The seeds are microscopic in size and may be viable after laying in the soil many years. The seeds are stimulated to germinate in the presence of an exudate from the roots of the host plants. Haustoria attach themselves to the roots of the host plant and a toxin is secreted which may kill the plant. This weed is of major economic importance and numerous international projects have been established to study its behavior and, it is hoped, find a method for its control. Tolerant varieties are available in the Malian collection and their germ plasm is being incorporated into populations. When these populations are constituted, they will be grown on striga-infested sites and tolerant genotypes selected.

6. Cereal Quality Improvement

The ultimate reason for producing seed of the cereals in Mali is for human food. Therefore a prime consideration in the development of new cultivars is a grain quality acceptable to the consumer. This requirement puts a specific restriction on the

breeder. It is relatively easy to produce a productive cultivar with grain suitable for livestock. The breeder in the area where grain of sorghum is used primarily as human food should not discard good productive genotypes because of poor grain quality. It should be possible by a series of backcrosses to a good quality type to transfer the quality required.

Desired grain quality varies from country to country: what is acceptable in Mali may not be acceptable in Upper Volta, primarily because methods of food preparation differ. In all areas however, a flinty, white grain type is generally preferred. In some regions of Africa, red or brown seed is used for making beer or for livestock food.

In the past, the acceptability of the grain for food was not determined until a quantity of grain was available. The most common cereal grain preparations in Mali are tô, couscous, and gruel. Most sorghum can be made into an acceptable couscous but the quality required for making tô is more exacting. A micro-technique has been worked out by ICRISAT/Mali and Texas A & M University which makes it possible to check a small sample of grain for its potential for making tô. Using this procedure the Malian breeders can determine in early breeding generations which selections have good tô making characteristics.

Much of the research conducted on food quality has been initiated by the ICRISAT/Mali breeder who has also been instrumental in the training of two very competent associates, S. Sidibe and A. Kante who are food technology researchers within the AMS (Sorghum/Millet Improvement Unit). While other food technology research units have been established in West Africa, this is the first to be directly involved with a plant breeding organization. The evaluation team strongly commends the work of the food-technology subunit and recommends that increased resources be made available for this important activity.

7. Sorghum Physiology (ICRISAT, 1982)

Dr. Scheuring has been conducting some basic studies on the response of Malian sorghums to photoperiod. Most Malian cultivars are photoperiod sensitive, that is, the time from planting to anthesis is shortened when grown under a day length of less than 12 hours. He has found that there are minor differences in the time period from planting to anthesis of cultivars planted in the north and south. He has also been able to show that different genotypes vary in their response to light intensity. These studies are basic to acquiring a better understanding of the responses of plants to their environment.

Dr. Scheuring has also been able to demonstrate the value of the long glumes of the Guineense sorghums on grain quality. In this type of sorghum the kernel appears out of the glumes 12 days after anthesis, and the grain only remains about 20 percent exposed until the glumes suddenly open obliquely after physiological maturity. On the other hand, kernels of other sorghums begin to appear 8 days after anthesis and are quickly exposed to weathering. When 1/4 of the upper part of the glumes of the Guineense were clipped before anthesis, the developing kernels had more spotting due to weathering than those from unclipped glumes.

Scheuring also has made an interesting observation that the stem cortex cells of E35-1 and CSH-5 are turgid with juice and thus the juice comes from the cortex cells rather than the vascular system. In contrast, the Guineense cortex cells are dry and empty, and no juice was found in any part of the stem. Scheuring suggests that this phenomenon may be responsible for the resistance of Guineenses to charcoal rot. I also suggest that there may be a relationship to tolerance to stem borers. These areas need further investigation.

C. MILLET BREEDING

1. Program Overview

Pearl millet is a major food crop in the Sahel. Production is more assured when planted on sandy soils under low rainfall than is sorghum. The grain is often preferred to sorghum. People living in the area where both crops are grown prefer eating millet during the season of the year when the greatest physical labor is required. They say that it gives greater strength. In areas where both crops are grown, they are planted as sole crops. The common practice in Nigeria is to plant the two in the same field. One farmer on the road to Baramandougou told us that he grew sorghum because the grain stores better than millet. Another reason for growing the two crops is security, because in some years millet is damaged by head caterpillar (Raghuva sp.).

Pearl millet is a cross-pollinated crop, as is maize, and crop improvement follows the same breeding principles. Each collection is the equivalent to a sorghum population or an open pollinated corn variety and no two plants are genetically alike. Populations differ in maturity, plant type, and grain characteristics. The vast reservoir of germ plasm which is available to the millet breeder is intriguing to the sorghum breeder. The appearance of exotic entries in regional millet trials has convinced me that a millet breeder should look no further than in the area where he is working for germ plasm. The genes to accomplish his goals are in the local material but the breeder must isolate and combine them.

The priorities in breeding for improved millet should be resistance to downy mildew, resistance to smut, and resistance to lodging. An improved variety which has these characteristics and is within the maturity range desired for a specific area should be effective. The breeding procedure is recurrent selection, as is practiced for maize improvement.

A number of improved millets have been developed in Senegal, Mali, and Niger. These are being used as a source of germ plasm in the current breeding program. They are M_gD_3 (Late), M_2D_2 (early), and NKK (for use on the Seno Plain).

Pearl millet in West Africa often hybridizes with wild species. These hybrids are termed "chibras." The spikes are small and the seed is shed as soon as it matures. This seed can germinate the following year and become a weed. Chibras are a major problem in fields on the Bandiagara plateau. In 1981, seed of 300 half sib spikes was planted and selfed. From the F_2 segregation, lines were identified which were heterozygous for chibras. With further selfing and selecting a new source of seed was developed for this area which is free of these wild types.

2. Pearl Millet Physiology

Millet is grown as a sole crop on the sandy plains serviced by the station at Koporo. In 1982, a thesis student, Mamadi Diabi, worked on screening techniques for seedling establishment in this area. He conducted two kinds of screenings: for heat and drought tolerance, and for tolerance to sand burial. Charcoal dust was scattered over the nursery rows to elevate the temperature. Sand burial was accomplished by applying 1 cm of sand over the nursery the day of emergence and 4 cm again 7 days later. There were distinct genotypic differences in seedling vigor under the two treatments. This technique will be continued in the future.

3. Pearl Millet Cereal Technology

Certain millets command higher prices in the market place. Studies made in cooperation with Texas A & M University indicate that the grain of these millets has multiple pericarp layers with no starch granules in the mesocarp. Studies have been initiated

to determine the mode of inheritance of thick and thin pericarps. This information will facilitate breeding for improved grain quality.

D. OTHER ASPECTS OF THE BREEDING PROGRAMS

1. Geographical Coverage

The sorghum investigation should be centered at Sotuba, Cinzana, and Baramandougou, with Same as an outreach station. Dr. Scheuring is responsible for the sorghum work at these locations and has trained a group of assistants who are able to carry on the operations with a minimum of supervision.

Dr. O. Niangado is responsible for the pearl millet project. This a Malian project with ICRISAT cooperating. The work is centered at Cinzana, Baramandougou, and Koporo. Like the sorghum program there are well-trained assistants.

Cinzana station is well equipped with machinery for field operations, labs, seed processing, and storage. On the other hand, the stations of Baramandougou and Koporo need to be upgraded.

2. Training of Malian Research Staff

This phase of the responsibility of ICRISAT is described in detail in Section VII of this report. A commendable record has been achieved. I am particularly impressed, as I was in 1980, with the skills achieved and the interest shown by the junior staff. They are dedicated and responsible. The same applies to the trainees who were sent to ICRISAT/Center. The men returning from degree training are assuming responsible positions.

3. Evaluation of Plant Breeding Techniques

Dr. Scheuring is using all of the methods known, introduction, and hybridization. Hybridization includes pedigree breeding, back-crossing, and population breeding. Until recently, population breeding was not used, but in a situation such as we find in Mali, this appears to me to be the most practical and efficient approach. A population of elite West African cultivars was assembled in Puerto Rico in 1970-75. If seed is still available, it may be useful in Mali. This population was originally planned for the development of improved varieties for northern Nigeria.

I would suggest using a recurrent selection program for millet improvement. This would involve selfing and S_1 evaluation, or the S_1s could be checked for combining ability by using a top-cross procedure developed at the Maradi station in Niger several years ago. This method has been used with good success rates in Nigeria. The elite lines would then be combined into a synthetic. Populations should be developed from local materials. Exotic germ plasm should be used only to incorporate specific genes.

Hybrids of both sorghum and millets probably have no place at present in the peasant agriculture of Mali. However, they may be useful in the future. The breeders should, as they develop new lines, check them for their B and R reactions. The B and R lines could then be tested for their combining ability and eventually tested in hybrid combinations. If the benefits of hybrids can be demonstrated to the Malian farmer, he will be receptive if he sees an economic advantage and if seed is available.

4. Evaluation of Varietal Testing Schemes

Varietal tests are for the purpose of obtaining yield data to establish the relative yield potential of a cultivar. If one wants a precise measurement, the trial must be replicated on a fairly uniform field. Stands must be uniform. I am amazed at the high CVs for the Malian trials which are most likely due to non-uniform stands.

These variations may be due to poor seed, poor planting methods, termites, rodents, dry periods after planting. Stand establishment has traditionally been more difficult with hand planting as compared with using some type of machine. To a trained breeder the varieties can best be evaluated by a visual rating since there are so many factors to consider besides yield. Large amounts of material can be given a preliminary visual evaluation if yields are not taken. This method of evaluation was used by Dr. Scheuring in 1983 when he grew a large collection of F_4 and F_6 material at four locations and selected panicles from the best rows. In 1984, the best bulked F_6 families will be yield-tested in comparison with standard local checks. Once a variety is found to yield better than the check, it is passed on to the multilocational trial group, and then on to the SAFGRAD team for on-farm pre-extension testing.

5. Cereal Physiology with Reference to Drought Resistance

Sorghums are considered to have more drought resistance than maize because they have the ability to become partially dormant when soil moisture is in short supply and resume growth with the addition of moisture. This is one of the factors which make this crop well adapted to the semi-arid regions of the world.

The line gradient system which was used for the first time at Cinzana this year to measure the relative drought resistance of cultivars will be discussed in another section.

6. New Plant Introduction

Pigeon peas: This is a new grain legume for West Africa that shows considerable promise in Mali. In 1980 when I saw it growing on the Baramandougou station, I recommended that ICRISAT staff should introduce several varieties for trial on the different stations. This was done with promising results. The seed may be eaten as a green vegetable or as a dry seed. A method has been developed to decorticate easily the dry seeds from their pods. Pigeon peas could become a valuable supplement to the diets of people in regions where animal protein or other legumes are in short supply.

Eleusine coracana (Finger millet): This is an important food crop in India and parts of east Africa. It appears to be well adapted to Mali in areas when rainfall exceeds 1000 mm. The grain does not make a stiff tô but can be blended with tuber flour. The seed is small and can be stored free of insects for a longer period than sorghum. Yields of 1.8 tons/ha were obtained in 1983 test plots. The crop has an added plus in being able to tolerate striga.

ICRISAT should continue to test and encourage the use of these two crops but not become involved in a breeding program.

ICRISAT/Mali breeders have made good progress. Local and exotic collections have been surveyed and two or three local sorghums that appear superior are ready for release. In the meantime, an aggressive breeding program has moved forward, but time will be required to produce new cultivars. ICRISAT has full responsibility for the sorghum breeding program and cooperates with the millet project. At present this is a congenial arrangement. In the future when adequate financial resources become available, the government of Mali is expected to take over full responsibility of both crops. At that time, ICRISAT's role will be reduced to providing advice and assisting in coordinating

the developmental programs on a regional basis. ICRISAT, because of its international programs, will continue to supply not only elite breeding material for millet and sorghum but will be in a position to suggest new crops which may be adapted and will fit into the economy of the country. An example of this activity is the recent introduction of pigeon peas and finger millet.

Cooperation with SAFGRAD and other multilocational testing organizations is an essential first element in getting new varieties to farmers through on-farm testing. The results of these trials determine if seed is to be released to the extension services for multiplication and release.

The work load of the ICRISAT/Mali breeder has been somewhat reduced by the Malian government assuming the direction of the millet program. It is recommended that the millet breeder establish a close working relationship with the ICRISAT regional center in Niamey, Niger. Such a close association will, we hope, give continuity to the project in case of local personnel changes. The same also applies to the sorghum program. The ICRISAT/Center sorghum specialist should keep in close contact with the Malian programs to keep the project on course. Many times a change in local personnel will completely disrupt a program because of a change in concepts or procedures.

The ICRISAT/Mali project is to be highly commended for its training program. The scope of this program is emphasized in another section where actual numbers and names of participants are listed. Trained staff are essential to the continuation of a viable program.

E. CONCLUSIONS AND RECOMMENDATIONS

The sorghum investigation for Mali should be centered at Cinzana, Baramandougou, and Koporo. Project personnel are to be commended for the number of dedicated people trained to assist in the programs.

We recommend that the sorghum work be coordinated with the ICRISAT/Center and that the ICRISAT sorghum research director visit Mali at least once a year not only to give counsel to the local breeder, but also to become completely familiar with the Malian breeding program and local conditions. Likewise there should be a close formal working relationship between the Malian millet breeder and the ICRISAT millet specialist based in Niamey. One or more reciprocal visits should be made each year. These arrangements will not only expedite the Malian programs but will also help to provide continuity to the overall ICRISAT/Mali effort regardless of changes in project personnel.

A number of exotic and local millets and sorghums have been yield-tested. Two or three elite local sorghum varieties have been recommended for advanced yield-testing and possible increase. They will fill a gap until more advanced varieties are developed by the breeding program.

Germ plasm sources for both the sorghum and millet projects should come largely from West African sources. We recommend that the present technique of population breeding in sorghum be continued. It will be the most effective and efficient method to pursue. We recommend that a method of recurrent selection be used to improve the millets. The millet program should continue to place emphasis on resistance to downy mildew, smut, and lodging.

The development of sorghum and millet varieties which are tolerant to striga should be given high priority. ICRISAT/Mali annual reports suggest that tolerance to striga has been identified in Malian varieties of both sorghum and millet. These materials should be used as sources of resistance.

Local sorghums and millets have evolved over centuries by natural selection and are tolerant of many of the pests and diseases of the region. This provides another good reason for using local material as a basis for an improvement program.

Some interesting work in sorghum and millet physiology is under way. This work should be continued.

We recommend that assistance be solicited from ICRISAT/ Niamey and ICRISAT/Center to develop a system for screening for resistance to downy mildew in millet and sorghum.

The evaluation team is strongly impressed with the very innovative work undertaken by the relatively new food technology group associated with the breeding programs. The team recommends that efforts currently underway to strengthen the food technology group by increasing laboratory space and equipment and providing expanded training to Malian personnel be given high priority and fully supported.

NOTE

1 A B-line has the genetic potential for becoming a female parent for hybrids. An R line or Restorer is the male parent.

IV. THE AGRONOMY PROGRAM

A. INTRODUCTION

The ICRISAT/Mali agronomy program initiated on-station experiments in the 1979 cropping season under Phase I. These studies were continued in 1980, and under Phase II in 1981, 1982, and 1983. Seven major areas of research were proposed in the project paper for Phase II: intercropping systems, animal traction equipment and techniques, fallow period management, forage production, rock phosphate utilization, pigeon pea agronomy, and watershed management. All of these research areas, with the possible exception of pigeon pea agronomy, have major importance for the development of improved crop management technologies for the semi-arid zone of Mali. Emphasis was to be placed on sorghum and millet as sole crops and as intercrops with cowpea. These are the major food crops presently cultivated in the semi-arid zone of Mali and they also substantially contribute to forage supplies during the dry season.

The scope of the agronomy program, as described in the project paper, was far too ambitious. It is not reasonable to expect that a single ICRISAT agronomist working with national program staff (who, to a large extent, lacked the necessary training and experience in research) could make major progress in research in all of the proposed areas. The ICRISAT agronomist also had major additional responsibilities as the project team leader and in the development of the Cinzana and other research stations. Consequently major emphasis was given by the agronomy program to *in situ* training of national program staff and provision of adequate working conditions on several experimental sites that would enable them to effectively conduct on-station agronomic experiments. The ICRISAT agronomist stated that the national program staff working for ICRISTAT/Mali have had major responsibilities in the planning and execution of experiments and in the analysis and interpretation of results.

In analyzing the activities of the agronomy program, it should be recognized that: (1) a major goal was the development of staff and conditions, so that multilocation experiments could be conducted in a reasonably effective manner; (2) the many agronomic experiments were mainly conducted by trainees working at several isolated locations under primitive conditions; and (3) the ICRISAT agronomist was heavily involved in the administration and management of the whole ICRISAT/Mali project which is of considerable size and complexity.

B. AGRONOMIC RESEARCH ACTIVITIES AND RESULTS

Major emphasis is given in this evaluation to Phase II activities conducted in the 1981 and 1982 cropping seasons. In addition, some consideration is given to research conducted in 1979 and 1980 under Phase I because this permits an evaluation of the overall strategy of the agronomic research program. It should be recognized that the information provided to the evaluation team in annual reports (1979-82) was not adequate to permit an in-depth and comprehensive analysis of research activities and results. A synthesis of the intercropping experiments had been prepared (Annex by M. Doumbia in ICRISAT/Mali annual report, 1981) which proved to be extremely useful. The project paper stated that a synthesis of work to date would be prepared by ICRISAT for its five-year review by CGIAR in 1983 (p.33). This synthesis would have been extremely useful to the evaluation team. Unfortunately, it had not been prepared because the five-year review of ICRISAT has been delayed until 1984. Activities in the seven areas proposed in the project paper and three additional areas -- toposequence, fertilizer response, and finger millet trials -- are examined.

1. Intercropping Systems

Surveys of farming systems in the Bankass and Koro sectors of the Seno Plain in the Fifth Region of Mali by Cunard (1982), and in the Fourth Region around Cinzana by Coulibaly (1983)

showed that millet/cowpea and sorghum/cowpea intercrops and sole crops of millet and sorghum are practised extensively at this time. The evaluation team also observed these intercropping systems in other areas of Mali but very little research had been conducted on them prior to the initiation of research by ICRISAT in 1977. The government of Mali has asked the agronomy program of ICRISAT/Mali to put major emphasis on intercropping systems and the national agronomy program (Cellule Technique Culturale of SRCVO) does not conduct research in intercropping.

The strategy of ICRISAT/Mali cereal/cowpea intercropping research is to search for systems that maintain the grain yield of the cereal at the same level as a cereal sole crop, while producing the maximum possible yield of cowpea in the intercrop. This approach is considered to be consistent with local practice and it is justified by the importance of millet and sorghum as major food crops in these subsistence farming systems. In earlier years, the agronomy program measured grain yields of cowpeas but they discontinued these measurements during Phase II because they found that in the absence of insecticides, cowpea yields were low and variable and attempting to obtain maximum grain yields compromised efforts to obtain maximum hay yields. Neglecting cowpea grain yields is not completely consistent with current farmer practices. Especially in drier areas, modest yields of cowpea grain are obtained without use of insecticides; in addition, a final harvest of cowpea hay is made. The focus on the cowpea hay by the agronomy program should be considered a practical compromise that was necessitated by the complexity of the system that they were studying and the need to obtain data that would provide a more consistent measure of the performance of these intercropping systems. The decision not to use insecticides is appropriate because it is unlikely that this technology will be available and adopted by farmers for cowpeas for many years.

The agronomy program demonstrated that local varieties of sorghum, millet, and cowpea performed better than selected exotic materials in both intercropping and as sole crops. This showed that the local varieties are reasonably well adapted to the harsh environments in which they are grown.

The sorghum, millet, and cowpea breeding program in Mali are not yet able to provide superior advanced genetic materials for agronomic testing. Consequently, the agronomy team focused on management factors which influence the success of intercropping systems. The results have been summarized by Doumbia (Annex in ICRISAT/Mali, 1981). They have clearly demonstrated that intercropping makes more efficient use of land for the production of cereal grains and cowpea hay than sole cropping. In addition, they have shown that sowing cowpea between the rows of cereals (rather than in the same pocket), increasing cowpea densities up to four times local levels, and delaying sowing of cowpea by two weeks can increase cowpea hay production without reducing cereal grain yields, providing the soil has adequate fertility.

However, further farming systems studies and investigations of animal draft mechanization are needed to determine whether an improved intercropping system can be developed, based on agronomic research results, that is also consistent with farmer conditions. Potential problems are numerous. For example, delayed sowing of cowpea at high densities and between the rows of cereals requires mechanization because it would aggravate the labor bottleneck at first weeding. Millet should not be sown on the flat on sandy soils if sand-covering of emerging seedlings is a problem. Techniques are needed for localized placement of fertilizer and manure and weeding which require less manual labor. On sloping land the system should result in effective management of surface water and prevent soil erosion.

The agronomy program has developed the basic information concerning these cereal/cowpea intercropping systems that could provide the basis for developing improved farming systems, but a focused team effort will be needed to develop improved systems that are consistent with farmer conditions.

In the 1982 season, research was initiated on cereal/cereal intercropping. The basic principle underlying this research is to maximize interception of solar radiation by the two crops in locations where the growing season, as determined by water supplies, is not too short. The yield data for experiments conducted at Cinzana, Sotuba, and Sikasso were presented in the 1982 report but a synthesis was not attempted. The most promising cereal/cereal intercrop for the humid boundary of the semi-arid zone appears to be maize/millet. An early maize and a sanio-type millet would be sown at the same time with low densities of maize to enable the staple food crop --millet -- to give a high yield. The maize is harvested early and provides food during the "hungry season" period (soudure) and the potential for some cash income. In addition to high total yields per growing season in wet years, the system has some built-in security in that, in cases where the maize has failed due to drought or streak virus, the millet has given a substantial yield of grain.

2. Animal Traction Equipment and Techniques

The 1982 annual report devotes less than half a page to this activity and there is no mention of it in the 1981 report. The evaluation team obtained the impression that ICRISAT/Mali has obtained oxen and animal traction equipment for Sotuba, Cinzana, Baramandougou and Koporo-Keniepe, has trained local staff in its use, and has contributed to the training of animal traction and motorized farm equipment operators at the National Center for Agricultural Engineering and on the research stations. Tool carriers (Nikart designed by NIAE, U.K.) and a full range of attachments (e.g. plows, ridgers, disks, cultivators, seeders,

scraper blades, and carts) have been imported from India. They appear to be suitable for effective animal traction mechanization of research station operations but the total price of the system (greater than $1,000 U.S.) would preclude adoption by most farmers in Mali at this time.

ICRISAT/Mali has trained personnel and assembled some of the materials needed for conducting a program of research into improved animal traction methods. The agronomist considered that it was necessary to do this prior to embarking on a program of research on animal traction systems, and there is considerable merit to this decision.

3. Fallow Period Management

The ICRISAT agronomy program was advised by the GRM to de-emphasize this area of activities, and only a modest, low-cost program of research has been conducted. However, the evaluation team was extremely impressed by the activities of A. Sow, Senior, who has been conducting observational experiments on a wide range of local and imported plants to evaluate their potential use during the fallow period. This research has the potential for making substantial contributions to the development of improved systems for fallow period management, but only in the far future. The ICRISAT agronomist is to be complimented for recognizing the talents of A. Sow, Senior, and providing the modest funds required by his research program. A. Sow's knowledge of native plants represents a valuable resource for the government of Mali.

4. Forage Production

The major contribution to forage production was described in the section on intercropping where it was pointed out that the agronomy program has developed several management techniques that have substantial potential for increasing the production of cowpea hay. It was also shown that greater yields of cowpea biomass can be obtained by early harvesting, but since this early

harvest could occur in the rainy season it would require special techniques to prevent spoilage of the hay or ensilage. Present techniques for producing silage do not appear to be practical in Mali due to the need for large pit silos to reduce the proportion of surface losses and to the high power requirement compared with hay production. Experiments conducted with Dolichos lablab as a hay crop indicated that it is substantially inferior to local cowpeas.

5. Rock Phosphate Utilization

Research on rock phosphate utilization was not conducted during Phase II because this area of research became a major responsibility of the SRCVO soils unit (Cellule d'Agropedologie) and IFDC.

6. Pigeon Pea Agronomy

Few pigeon peas are grown in Mali and the objective of this research was to determine whether new varieties and management methods have the potential for contributing to Malian agriculture. Some varieties have been screened both on-station and on farmers' fields, and preliminary agronomic experiments have been conducted. The following tentative conclusions have been reached. Certain short-cycle pigeon pea varieties have greater potential for grain production than cowpea at the wetter boundary of the semi-arid zone when insecticides are not applied. Pigeon pea is less competitive than local cowpea varieties in intercrops with cereals; consequently, cereals may yield more when grown with pigeon pea than with cowpea. The lack of consumer interest in pigeon pea can be overcome by the new decortication technique imported by ICRISAT/Mali. These provisional conclusions appear to be sound but further testing is needed.

7. Watershed Management

While developing the Cinzana Research Station, ICRISAT/Mali has developed parcels of land that would be suitable for future research on the management of surface water and control of soil erosion. In addition, they have assembled the equipment and oxen needed to do experiments involving soil surface modification. During the 1981 season, experiments were conducted comparing ploughing, ridging, and broad ridges with no soil preparation at Cinzana (with maize) and Koporo-Keniepe (with millet). The experiment at Koporo-Keniepe included two dates of sowing to evaluate the negative impact of delayed sowing due to the extra time needed for soil preparation. Unfortunately, these interesting experiments did not give conclusive results and have not been continued.

8. Toposequence and Fertilizer Response Trials

Field plots along toposequences can provide information on crop response to differences in soil type with the plants under similar ambient conditions because they are in the same location. This can provide information on crop responses to factors influenced by differences in soil type such as the level of fertility and drought. In addition, the effectiveness of fertilizer trials can be increased through careful use of toposequences. Experiments conducted at Cinzana in 1981 demonstrated that sorghum is better adapted than millet to the hydromorphic soil, and millet is better adapted to the sandy and sandy-silt soils. Greater yield responses to nitrogen fertilizer were observed on the sandy and sandy-silt soils. Cowpea yielded less hay in the hydromorphic soil and exhibited greater responses to phosphate applications in the sandy soil. In 1982, the toposequences trials were conducted at both Cinzana and Baramandougou. Unfortunately, the experimental design was extremely complex with five soil types, four cowpea varieties, two sowing densities, three levels of phosphate fertilizer, and three times of harvest. A complete interpretation and discussion

of the results was not presented and the complexity of the design may cause this to be a difficult task. Complex factorial experiments are appropriate in the exploratory phase of research where the major variables which influence crop production are not known, and where it is anticipated that important interactions may be present. The experimental design appeared to be sound and may be efficient in this special circumstance where it is not possible to replicate the soils treatment. However, it would have been advisable to reduce the complexity by reducing the number of cowpea varieties (the varieties chosen are not necessarily well-adapted to Mali), and by reducing the number of soil types.

The results in 1981 were useful in that they demonstrated that the crop responses observed on toposequence trials in Upper Volta also apply to Mali. They also demonstrated that the Cinzana station is well suited for evaluations of fertilizer responses (and possibly drought responses) along a toposequence. The value of the data is constrained by the lack of information on soil chemical characteristics, on residual effects of phosphate fertilization (which could only be obtained by a long-term research program on the same plots), and on the economic aspects of fertilization. The choice of single superphosphate rather than Telemsi rock phosphate, which is available locally, in Mali, was not discussed or justified. A potential value of toposequence trials is that, through the use of Landsat satellite data, it is possible to predict the regions in Mali where similar agronomic responses may occur.

In 1981 and 1982, experiments were conducted at Cinzana to evaluate the response of a local sorghum, a single cross hybrid, and a parent of the hybrid to three levels of fertilizer and three planting densities. In 1981, the hybrid sorghum had 40 percent higher yields than the parent sorghum and the local variety. Also the hybrid outyielded the other sorghums at all nitrogen levels and densities. This indicates that substantial

hybrid vigor is present in sorghum even under the low fertility and low densities found in Malian sorghum production areas. In all cases, 45 kg/ha of nitrogen produced a substantial increase in yield, whereas 90 kg/ha of nitrogen only produced the same increase as 45 kg/ha. The results in 1982 were more complex in that drought late in the season caused poor grain filling in the hybrid. Genotypic differences in panicle weight and grain yield responses to fertilizer were similar to the 1981 season. Plants at higher densities responded more strongly to the application of 45 kg/ha of nitrogen.

Studies of this type will be extremely important in the future when the sorghum and millet breeders have developed genetic materials that are clearly superior to the local varieties. The results of these studies can then be used to determine the management practices that will extract the maximum yield or net income from these new varieties.

9. Finger Millet (Eleusine coracana)

Research results on finger millet were reported by the plant breeder in ICRISAT/Mali (1982). Finger millet is very well adapted to areas of Mali with rainfall exceeding 1000 mm. With modest fertility, grain yields in excess of 1 ton/ha have been regularly obtained at Sotuba and Sikasso. And, this crop can be more productive on infertile sandy soils than most other crops. Attempts to introduce finger millet into Mali were stopped because the grain does not make good tô. However, in September 1982, it was learned that in Uganda, finger millet is blended with flour from tubers. They tested this system and found that adding 20-25 percent of flour from yam, sweet potato, rice, or sorghum to finger millet produces a stiff paste with good tô quality.

ICRISAT/Mali is organizing a joint finger millet "pre-introduction" research and farmer trial program with the farming systems group in southern Mali. The evaluation team saw an experimental field of finger millet near Sikasso and it was in excellent condition.

10. Experiments Underway in 1983

The agronomist informed the evaluation team that the following experiments were being conducted in 1983 and several of these experiments were examined in the field.

a) A repeat of the sorghum agronomy experiment conducted in 1981 and 1982: with a local sorghum variety, a hybrid and a parent of the hybrid, at three levels of fertilizer and three plant densities at Baramandougou.

b) A sorghum/cowpea intercropping experiment at Cinzana, Baramandougou, and Sikasso: with three dates of sowing for the cowpea, two plant densities for the cowpea, two levels of fertilization, two sole crop treatments, and four replications.

c) A similar millet/cowpea intercropping experiment at Cinzana, Baramandougou, Sikasso, and Koporo-Keniepe.

d) Toposequence trials at Cinzana and Baramandougou: with a local sorghum and a local millet, five soil types, early and late sowing, three levels of phosphorus, and three levels of nitrogen.

e) A maize/millet intercropping experiment at Sikasso, Cinzana, and Baramandougou: with two dates of planting, and three planting densities for the millet, three levels of nitrogen fertilization, two sole crop treatments, and four replications.

The treatment levels for the cereal/cowpea intercropping experiments in 1983 indicate that the agronomy program is beginning to focus on the most important variables and ranges of these variables. The sorghum agronomy experiment is designed to attempt to confirm the interesting results obtained in 1981. The toposequence trials are focusing on the most important crops for work of this type, sorghum and millet, and the most important variables, phosphorus, and nitrogen. The maize/millet intercropping trials may provide an indication of the adaptive limits of this system: maize was infected by streak virus in Sikasso and has suffered from drought at Baramandougou and Cinzana.

C. LINKAGES WITH OTHER PROGRAMS

The agronomy program has communicated with the sorghum, millet, and cowpea programs. It has also assisted the breeding programs by pointing out weaknesses in exotic materials, such as poor emergence under early drought, susceptibility to lodging and poor grain quality under late drought in sorghum. However, the linkage between the agronomy and breeding programs was constrained by the fact that the breeding programs were not sufficiently advanced to provide improved varieties for agronomic testing.

The ICRISAT/Mali agronomy program has assisted the national agronomy program (Cellule Technique Culturale) by providing oxen, animal traction equipment, and trained personnel for their experiments at Baramandougou and Koporo-Keniepe. However, the linkage has not been strong because they were assigned separate areas of research: ICRISAT/Mali was asked to emphasize intercropping, whereas the Cellule Technique Culturale does not conduct research in this area. The Cellule d'Agropedologie conducted the initial soils analyses for Cinzana but other linkages with ICRISAT/Mali were not apparent. Similarly, strong linkages were not apparent with the national program working on farm agronomic testing (the SAFGRAD program within the Cellule d'Essais Multilocaux). Some

linkages have been established with the socio-economic group (Division d'Etudes Techniques) through contracts for research in villages around Cinzana and cooperation with ICRISAT consultants.

D. ANALYSIS AND RECOMMENDATIONS

The main activities of the agronomy program were developing the research station infrastructure needed for conducting a broad range of agronomic research, and conducting research on intercropping systems to determine the management factors and interactions that have a major influence on the performance of these systems. The evaluation team considers that these activites are important for agricultural development in Mali, they were appropriate at this stage of the project, and substantial progress has been made by the agronomy program.

The agronomy program also was involved in numerous other activities including: development and training with animal traction, watershed management, fallow period management, toposequence and fertilizer response trials, and pigeon pea agronomy. This approach may have been appropriate in the earlier years, as a form of exploratory research and in the development of infrastructure. However, the evaluation team considers that the agronomy program should become more focused and develop more well-defined strategies in the future.

The evaluation team recommends that the agronomy program should actively pursue research designed to develop packages of improved crop management technology that are suitable for wide-scale, on-farm testing by other agencies, and to help the sorghum and millet breeding programs produce improved varieties which benefit from these improved management technologies.

The evaluation team recommends that the agronomy program conduct research to develop improved cultural techniques. The research should emphasize weed control by animal-traction cultivation and herbicides, and surface water management to prevent

soil erosion and increase water-use efficiency. Improved cultural techniques of this type would have tremendous potential for improving agriculture in the semi-arid zone of Mali. The first weeding is frequently the major bottleneck in the whole cycle of crop production. Solving this problem would enable farmers to cultivate a larger proportion of the available land and produce more crops with the labor available to them. Improved cultural techniques could also reduce the effects of drought on the crops and decrease the extent of soil erosion. Drought and soil erosion are also major problems in the semi-arid zone. The interactions of these cultural techniques with soil fertility and fertilizer practices would have to be carefully considered (Breman and de Wit, 1983). In addition, this research would require substantial cooperation with farming systems research so that system interactions and farmer constraints would be clearly understood. Consequently, the agronomic and geographic scope of the research effort should be restricted.

The evaluation team recommends that agronomic research should focus on sole crops of sorghum and millet and intercrops with cowpea, and initially be conducted mainly on the Cinzana and Baramandougou stations and surrounding areas, with possible expansion to Koporo-Keniepe in the Seno Plain.

Defining the geographic area for on-station and on-farm research is part of the important process of defining the recommendation domains for which the technological packages are to be developed. Provision should be made for cooperating agencies to define further recommendation domains for the sorghum and millet producing areas of the semi-arid zone using soil, climatic, and socio-economic data.

Focusing on cultural techniques, with an emphasis on weed control, soil fertility, and surface water management would enable the agronomy program to increase its linkages with Malian national programs, including the SRCVO cellules: Technique Culturale, Agropedologie, and Protection des Cultures, and the

Division of Machinisme Agricole. It is envisaged that substantial effort would be devoted to animal-traction cultivation.

The ICRISAT/Mali project is well-prepared for this project area. In earlier years it gained experience and produced basic agronomic information on cereal/cowpea intercropping systems and on sole cropping of sorghum and millet. It has assembled the oxen, equipment, and trained personnel needed for this type of research. ICRISAT/Center and its regional programs have personnel with experience in animal-traction systems (R. Bansal) and surface water management (G. Perrier) who could provide important back-up assistance.

Effective research on cultural techniques with the primary objective of developing packages of improved management technology would require both on-station and on-farm research. Consequently, it would require substantial linkages with appropriate extension agencies and ultimately with wide-scale on-farm testing organizations such as the SAFGRAD project in the Cellule Essais Multilocaux.

The evaluation team raised some questions concerning weed control that may provide interesting areas for research. Why are not more donkeys used for weeding and would they be more cost effective than oxen? Animal-draft cultivation equipment appears to be either effective and expensive or cheap and much less effective. Would it be possible to develop moderately-priced, effective cultivation equipment? Are effective herbicides available that entail acceptable risks (due to crop damage, soil sterilization, or ineffective weed control) when used by farmers? It is envisaged that the ICRISAT/Mali agronomy program should compare different weed control technologies, including animal traction cultivation, manual hoeing, and the use of carefully selected herbicides.

The research proposed by the evaluation team is more multidisciplinary than earlier agronomic research conducted by ICRISAT/Mali. Consequently, it will require diplomatic leadership and careful planning to encourage and maintain the cooperation that will be needed with several government organizations. In addition, it will be necessary to modify and improve the annual reports so that cooperating and overseeing organizations clearly understand where the project is going. Insufficient time represents a major constraint to effective reporting -- yield data are obtained in December and the annual report is due six weeks later. The ICRISAT/Mali team plans to obtain two microcomputers, and this could partially solve the problem. One computer should be used for data analysis, whereas the other computer should be used for word processing. Ideally, two identical computers should be obtained to provide multiple-use capabilities when one of the computers breaks down.

A more complete analysis of earlier agronomic data would assist future research and personnel working on the agronomy program. The agronomist should be provided with the time needed to develop a synthesis of the agronomic research conducted by ICRISAT/Mali either before or just after his transfer to ICRISAT/Center at Niamey.

The agronomy research that is needed to help the plant breeding programs produce improved varieties that benefit from appropriate improved management technologies appears to be straight forward. The sorghum agronomy research that evaluated the responses of different sorghum genotypes to different fertilizer levels and plant spacings represents effective supportive research. This research will become increasingly important as improved varieties become available from the breeding programs. In addition, genotypic responses to drought could be evaluated at emergence and grain filling. The agronomist might also assist the plant breeder in developing the water supply and misting system needed to screen for downy mildew resistance in millet.

The evaluation team recommends that two agronomists be recruited by ICRISAT/Mali. An experienced agronomist is needed to conduct research aimed at developing improved cultural techniques. A more junior agronomist could be recruited to support the plant breeding program because this research should be guided by the sorghum and millet breeders. Both agronomists should have some experience conducting research in Africa and sufficient breadth to handle the multiple challenges that will certainly occur.

The evaluation team recommends that ICRISAT/Mali continue to provide the modest level of funding to maintain the research program of A. Sow, Senior. His knowledge of native plants will be extremely useful in research on weed control. His enthusiastic approach to natural sciences would also provide inspirational guidance to younger members of the team.

The maize/millet intercrop, pigeon pea, and finger millet appear suitable as themes for more widespread on-farm research with the potential for improving agriculture at the wetter boundary of the semi-arid zone. The evaluation team recommends that ICRISAT/Mali should finish research on these systems, increase amounts of seed where necessary, and encourage other organizations to conduct on-farm testing on a wider scale. ICRISAT/Mali should continue to introduce potentially important food or forage crop species and evaluate them in simple observational nurseries. A. Sow, Senior, could assist in this work.

V. SOCIO-ECONOMIC FEASIBILITY OF IMPROVED AGRICULTURAL TECHNOLOGY TRANSFER IN MALI

A. INTRODUCTION

The virtual lack of success in introducing new packages of grain production technology into traditional dryland farming systems across the Sahel should alert us to the difficulty of the task. In contrast with a few striking cases in cash crops (notably cotton and peanuts) and irrigated production (rice and market gardening), there have been almost no significant advances in Sahelian dryland cereals production. This point cannot be overemphasized; it is the background and challenge to this project.

What is needed is the development of new technological packages (involving some combination of improved biological, mechanical, and chemical components) which can make more efficient use of limiting farmer resources (soil, water, labor, and/or financial capital) than current combinations do. In order to attack this problem we must start with a clear and detailed picture of what different groups of farmers in different target ecological zones are doing, identify critical constraints to higher production, and design appropriate research to attack these critical constraints. Once an improved package has been tested and developed, appropriate institutional means must be found to bring it to the attention of various groups of farmers in similar environmental and socio-economic circumstances (i.e. a similar "recommendation domain" in the language of farming systems). It is the concerted view of this evaluation team that this process will not occur unless there is a simultaneous and interrelated emphasis on applied agronomic research, relevant farming systems investigations, and an adequate agricultural extension mechanism. Investment in one, if the other components are not present, is of little utility to meeting increased food production objectives.

In this section we will examine to what extent the "strategy" in the above paragraph has been followed in the ICRISAT/Mali project and make recommendations accordingly. The overall thrust of this approach is consistent with the ICRISAT mandate and specific project approach, both described in Section II of this report. We should hasten to add that we do not wish to imply that ICRISAT must necessarily do farm level studies or run an extension service. We do insist that somebody must do these things if overall food production objectives are to be met. The GRM/IER has a fairly long history of farming systems work extending back to some initial exploratory efforts by farming-systems pioneer David Norman (1976). The fact that there is a farming systems division in IER on an equal plane to the agronomic research division (see Section II for more detail) is a very encouraging sign. Now the overall challenge is to make these components work together to produce the desired results in terms of improved technology packages for farmers.

B. BASELINE FARM LEVEL DATA AND THE DEFINITION OF RESEARCH OBJECTIVES

Until 1982, there seems to have been almost no formal effort made under ICRISAT sponsorship to define, in a detailed way, the traditional farming systems one would eventually like to modify with the introduction of improved technological packages. The ICRISAT research team members are personally very knowledgeable of Malian traditional farming systems, they work closely with other scientists who have this knowledge as well, and they are aware of other research and development efforts in neighboring countries. This can go a long way toward making good educated guesses about what farm-level problems need to be researched on station, but it cannot replace the need for systematic farm-level data collection. To what extent was this done? To our knowledge it was only done on an occasional and informal basis in the area of the major research stations before 1982. For example, the evaluation team was told of measurements of cowpea planting density in farmers' fields in the Cinzana area to assist in the

design of intercrop trials as part of the agronomy program. The lack of systematic baseline data collection must be considered a major weakness in the ICRISAT/Mali project approach.

After five years of research effort a first attempt was made to begin to systematically define target farming systems in 1982. The ICRISAT team contracted with the Division of Technical Studies (IER/DET) to undertake such a baseline study. Technical assistance was received from ICRISAT/Niamey in the design of study methodology. Data were collected in the field beginning in May 1982 and extended into 1983. As of November 1983, one introductory report (Coulibaly, 1983), was available as well as some preliminary hand tabulations of 1982 baseline village averages. This very promising first effort will be examined in some detail and recommendations offered. It is simply unfortunate that this type of study was not undertaken in 1978 or 1979.

The Cinzana farming systems study began with defining a 25 kilometer radius around the new research station and identifying all the villages in that study area. Meetings were held with farmers in those eleven villages and, through guided discussion, information was gathered which permitted a reasoned choice of four representative study villages which offered fairly great differences in family size, degree of animal traction equipment use, and availability of different types of land. A census was conducted in these four study villages of all agricultural production units ("households" in the common usage of West African farming systems studies, where the critical variables are common major grain fields and common granaries). From this census a sixteen-cell stratification was employed to select a weighted random sample of farmers according to family size and use of animal traction equipment. Eighty households were selected for further detailed study.[1]

From the initial interviews, the preliminary report (Coulibaly, 1983), presents the following information:

- Demographic data (age, sex, breakdowns);
- Level of education of household members;
- An inventory of the number of fields, by "responsible person" and field location in relationship to the village;
- Numbers and types of animal traction equipment sets; and
- Some summary information on the types of sorghums and millets in general use.

In addition to these results which in themselves cannot offer much help to guide the on-station research process, data were also collected in 1982-83 on:

- Animal traction equipment;
- More detailed demographic factors;
- Labor time, collected on a weekly basis, by person and by cultural operation;
- Field acreage and crop yields;
- Marketing: purchase and sale of agricultural products; and
- Market prices on livestock (one local market) and cowpeas and cereals (two local markets).

As is common in this type of study, results have been slow to appear. When detailed data from eighty farmers are tabulated manually, the work is slow. A Radio Shack microcomputer at the DET in Bamako is not in working order. Data have been taken to ICRISAT/Niamey for processing but, to this date, no other results have been forthcoming. Under the DET contract two other reports were called for, one on farm-level production operations (labor time, areas, yields, disposition of production, etc.) and the other on farm-gate marketing and its relationship to price movements in three nearby markets.

On a very informal basis a few broad conclusions concerning possible farm survey inputs into the tighter definition of agronomic trials have been formulated. These include:

Short Cycle Millets: There is substantial farmer interest in availability of shorter cycle millets which may better fit into farming systems coping with perceived trends to lower annual rainfall patterns.

Improved Animal Traction Technology: Given substantial use of traction in the Cinzana area, this presents many opportunities for farm-level investigation focusing on:

- Better adapted equipment;
- More consistent use for weeding;
- Greater attention to negative economic impact of poor animal health and poor animal training; and
- Opportunity to investigate greater use of donkey traction.

Alternative Weeding Technologies: Greater farm-level economic analysis of alternative, feasible weeding technologies including complex labor, cash, and timing trade-offs between manual, mechanical, and chemical technologies.

Fertility maintenance: Indications are coming from farmers on hesitancy to use fertilizer on cereals due to cost, availability, and negative impact through enhanced weed growth.

Regardless of whether or not these very provisional conclusions will hold once the data is finally analyzed, this initial data collection method is only the first step in the kind of close interaction with the ICRISAT agronomy program which the evaluation team feels is important. It is a good first effort and it does provide necessary quantified baseline data. Some

interesting leads have been uncovered that need more focused follow-up investigation. What is missing is an on-going joint effort between farming systems personnel and ICRISAT agronomy personnel to evaluate initial results and plan the next step in farm-level investigations in the four Cinzana study villages.

It is the opinion of the evaluation team agricultural economist that the approach taken by the ICRISAT/Upper Volta farming system unit stressing village level studies in key production zones, coordinated farm-level trials, and above all, close-collaboration between social scientists and agronomists, presents an appropriate model to be followed in Mali. (See Stoop et.al, 1982 for more details.) Also, the beginning of collaborative work between the DRSPR Sikasso Unit, SRCVO, and the CMDT in the Sikasso region indicate that a coordinated approach to the transfer of improved agricultural technology in a well-defined set of production zones is institutionally and practically feasible in Mali, even if this type of practical, "cross-institutional," collaborative approach has not been used very often in recent agricultural development work. This idea is explored in more detail in the following pages.

C. COLLABORATIVE FARMING SYSTEMS RESEARCH OPPORTUNITIES

1. Introduction

As noted above there are positive signs in Mali that the type of collaborative approach to the development of improved technical packages may yet occur. The evaluation team also became aware of some of the institutional and behaviorial impediments to this type of joint effort. It is in this type of situation that opportunities emerge to assess to what extent separate or complementary agricultural development project efforts may be more closely coordinated to concentrate resources in the critical mass needed to make substantial field-level progress in improved package development.

It is useful to examine the kind of working interactions the ICRISAT/Mali team has had with key complementary research and extension groups, particularly DRSPR, SAFGRAD, and the extension operations. Relations with other units within the IER/DRS/SRCVO structure are analyzed elsewhere in this report.

DRSPR is a relatively new division in the IER whose existence is closely linked with Canadian and Dutch experimental funding and technical assistance. Up to this point, activities of this farming systems division have been concentrated in the richer, cotton-producing region of south Mali. The ICRISAT team has had some formal contact with this group in terms of some agronomic trials (maize/millet intercrops) and varietal or observation trials (such as Eleusine coracana plots grown at the Tierouala Station near Sikasso). In addition there are substantial informal contacts between members of the two research groups. However, as of this time there have been few attempts made to work together in a task-oriented approach to problem solving. We will return to this point below.

ICRISAT/Mali relations with the SAFGRAD multilocational testing program have been fairly close over the years. This was due partly to a good working relationship between members of these two projects (for example see Johnson, 1982), which seem to be ongoing. This relationship has been limited by a number of factors, however:

(1) the ICRISAT/Mali breeding program has not had much to be tested in multilocational farm-level trials;

(2) the ICRISAT/Mali agronomy program has been too diversified to produce improved agronomic or cultivation techniques for on-farm testing (see chapter IV for more detail);

(3) SAFGRAD has conducted a very large number of on-farm tests over wide geographical areas, thus limiting the level of supervision and detailed observation which could provide feedback to on-station agronomy experimentation; and

(4) the SAFGRAD/Mali effort has been exclusively focused on multilocational testing so there has been no collection of data on the farming systems into which the tests have been placed. This too could potentially offer important feedback for the refinement of on-station research themes.

ICRISAT/Mali relationships with extension organizations seem to have been fairly limited. For a three-year period, early ICRISAT funding came from the overall USAID funding of the "Operation Mils-Mopti," but this did not seem to result in any collaborative effort with that agency except the indirect facilitation of multilocational trials. More recently, ICRISAT was tied into this operation more directly through a program of jointly applied research activities focused on the upgrading of the Korporo-Keniepe research station and its use to develop improved "themes techniques" for the sandy soils of the Seno plain "millet bowl." This planning process is described in the evaluation report done on the operation just before it was "defunded" by USAID for financial mismanagement (Development Associates, Inc., 1982). This resulted in the loss of $80,000 in planned improvements to the Korporo station.

Relationships with other extension organizations have also been weak or nonexistant. In the Cinzana station area, Operation Arachide et Cultures Vivriers or OACV, has been out of business for a number of years. CMDT efforts in the Fourth Region to introduce jute as a cash crop have collapsed with a declining world market in natural cordage. Further south in the Sikasso area, where ICRISAT has had only modest involvement, CMDT has conducted some of its own agronomic experimentation but this has had to remain semi-secret since research is not part of its mandate. Only in the Bamako area did the team see evidence of some collaboration with an extension organization -- O.H.V. (Operation Haute-Valles) -- on a limited basis involving farm-level tests of pigeon pea, Eleusine, and striga resistance.

How does all this add up? The picture is one of Mali spending substantial resources on various branches of

agricultural research in a loosely coordinated fashion. The people are there, vital facilitating foreign assistance is there, and the institutions are present on the research side, even if weak or nonexistent on the extension side. What is lacking is an adequate mechanism or strategy to put all the pieces together in one geographically defined zone and actually make some progress in developing and moving improved technical packages to farmers' fields.

The coordinating mechanisms which are repeatedly pointed to are the specialized Commissions Techniques and the National Agronomic Research Committee meetings which are described in Section II. It is the opinion of this evaluation team that these mechanisms, while very useful and important to continue, simply are not adequate to promote the kind of field-level, task-force type of attack on food production package development which is needed. Coordinated, continuous working relationships are needed at the field level where farmers' problems are located. Mali seems to be at a watershed point in the development of this approach; all the key components are present or foreseeable, they just need to be put together pragmatically at the regional or field level. As we will argue below, the proposed USAID Farming Systems Research and Extension project and the reorientation of the ICRISAT/Mali agronomy program suggested in Section IV provide the opportunity to make this happen on the ground.

2. Proposed Model

The evaluation team believes that it is possible to put together an experimental model of joint agronomic and farming systems research with a streamlined extension component which can both make progress in technology package development and be consistent with existing GRM/MA structures. We think this could be best done in a elliptically-shaped geographical area which would include the Cinzana, Baramandougou, and Korporo research

stations and the important dryland farming zones they represent. This would involve a coordinated research program including:

(1) an ICRISAT/Mali agronomy program focused explicitly on technical package development, as described in Section IV;

(2) an applied farming systems unit that would continue initial farming systems work in the four study villages around Cinzana and sequentially open two new study/extension zones around the Baramandougou and Korporo-Keniepe stations;

(3) an approach stressing a tightly defined and coordinated set of on-station trials, farm-level tests, and focused data collection/observation with study village farmers;

(4) the working group refining and testing improved sets of technical components (biological, mechanical and/or chemical) so these can be introduced into pilot zones by an experimental extension group attached to the farming system unit;

(5) the entire process being carefully documented and directed by a regional-level working group composed of appropriate respresentatives from DRA/SRCVO/AMS (e.g. the Cinzana station director); DRSPR/Segou (e.g., the farming systems coordinator and the extension training coordinator); ICRISAT/Mali (the senior agronomist); and other organizations which might be directly involved, such as SMECMA or Machinisme Agricole;

(6) this team being headquartered in the Segou/Cinzana area and, once established, expanding operations into the Baramandougou and Korporo areas as basic infrastructure in those stations is improved as suggested in Section VI;

(7) results of such an experimental, multidisciplinary effort being brought to the annual Commission and CNRA meetings for review, analysis, and potential refocusing.

Part of the rationale for this model is to promote the judicious addition of new outside resources to complement and capitalize on existing investments in the Malian national research system and in the Cinzana station. As will be described in the next section, a valuable fledgling institutionhas been created to serve the major dryland cereal production belt of

Mali. Complementary investment will help to ensure some productive outcome from this investment as well as provide the critical mass necessary to make progress in technology package development.

3. Relationship to the Proposed USAID Farming Systems Research and Extension Project

While in Mali for this evaluation, this team briefly examined a 300-page draft project paper which proposed a major ten-year investment in the DRSPR, including technical assistance, construction and operating costs for this period. It is not the intent of this evaluation to review the FSRE project in detail. However, there are some observations we would make that have a direct bearing in the coordinated model we advocate above:

(1) Creation of a DRSPR headquarters at the Sotuba station. If this IER division is going to play a national role it probably does need a national headquarters. The idea of putting this at Sotuba so as to promote linkages with the agronomic research components of DRA is an excellent one.

(2) The related choice of the Second Region (Banako area of the OHV) as the first new area of intervention for the DRSPR team is understandable if not ideal from all points of view.

(3) Of greatest importance is the choice of the second and third intervention areas. The project paper proposes that the Fifth Region (Mopti) be chosen as the second area for detailed FSR&E work. This team feels that this would be a mistake, both on research and logistical support grounds.

(4) As we suggest above, we feel that the second DRSPR intervention area should be based in the Segou/Cinzana area and concentrate its efforts around the Cinzana station and the Baramandogou and Korporo stations. Further, we believe that IER should devise a regional-level mechanism to promote a tight coordination between DRS/SRCVO actions (including the ICRISAT agronomy program) and those of DRSPR (including an experimental extension education wing in the Segou-Cinzana-Korporo

target area. We feel this makes sense logistically and, more important, greatly increases the probability of success in technology transfer through the appropriate concentration of resources.

(5) The second intervention zone should be set up at the same time as the first in the OHV area. There is no reason to wait since a small team can be based in Segou, Mali's relatively prosperous second city, and continue the promising initial FSR work performed by the IER/DET team.

(6) Two very different sets of technological packages may emerge for the broader mixed-soil valleys of central Mali (represented by Cinzana and Baramandougou conditions) and the particular sandy-soil farming systems of the Seno plain. For example, the latter may involve much more extensive use of improved donkey traction.

(7) The overall point to be stressed here is that USAID/Mali has a unique opportunity to put all the pieces of the technology transfer puzzle together in one sensible, yet important set of dryland production zones. In so doing, it will help to capitalize further on its already cost-effective investment in the ICRISAT/Mali project mechanism.

There remains a very practical question concerning the division of labor between the ICRISAT and FSR funding mechanisms to provide this coordinated approach in the Cinzana-Korporo target area. It is vital that the FSR work conducted in the four Cinzana villages in 1982-83 be continued without interruption. A more focused set of investigations should be conducted during the 1984 rainy season. This will probably have to be conducted by ICRISAT but we hope there will be some design participation by DRSPR in terms of setting the stage for future collaborative work.

Whether all funding and personnel for FSR work in the Cinzana-Koroporo zones would be covered by the FSRE project or whether ICRISAT/Mali should have a role in this collaborative component needs to be debated and further explored. It is feasible to envision ICRISAT/Mali employing an additional senior research person to ensure adequate liason with the FSR team and

to cover the research program in the interim while the FSR project materializes. This needs to be worked out in joint planning sessions with GRM/IER personnel.

D. TOWARD AN ICRISAT/MALI TECHNOLOGY TRANSFER STRATEGY

There is no explicitly defined ICRISAT/Mali strategy that elaborates how improved plant varieties and agronomic practices are to be tested at the farm level and, if proven successful, to be moved to widespread extension to farmers. We have briefly outlined an approach to this process in the preceeding pages. The evaluation team believes that the ICRISAT/Mali project and its USAID patron should examine these suggestions and move to produce a more explicit, written statement of the anticipated transfer process. This can be in the context of the upcoming five-year ICRISAT review or related to the restatement of project objectives recommended in Section II of this report.

E. SUMMARY AND RECOMMENDATIONS

The lack of farm-level data collection and feedback is seen by the evaluation team to be one of the greatest weaknesses in the ICRISAT/Mali project approach. The recent efforts undertaken in 1982-83 by contracted personnel of the IER/DET make substantial progress toward beginning to fill the farming system data and feedback gap.

As a consequence, the evaluation team recommends that substantial effort be made to complete the analysis of 1982-83 Cinzana FSR studies. Further, based on a joint analysis of results, a new set of more focused farm-level investigations should be mounted in the 1984 season in the same Cinzana villages. The ICRISAT/Mali staff should participate more fully in the design process and should seek the collaborative participation of DRSPR in this work.

ICRISAT/Mali has had no explicit statement of how

technologies can be practically tested, refined, and transferred in the Malian agricultural research and extension context. The evaluation team recommends that, as part of a restatement of project objectives suggested in Section II, a realistic technology development and transfer strategy be elaborated that can help guide future USAID investment and point to necessary linkages with FSR and extension organizations. This could be done in preparation for the five-year ICRISAT review scheduled to occur in 1984.

Mali agricultural research and extension is at a watershed in terms of its institutional development. Most of the elements needed to produce improved dryland farming technology packages are present; these elements simply need to be put together in the same place at the same time to produce the critical mass effort required to fully attack the food production problem. The annual meetings of technical commissions and research committees, while very useful, are not sufficient to produce desired results.

The evaluation team therefore recommends that the GRM/IER aggressively seek sustained, field-level solutions to make possible continous coordination among the various Ministry of Agriculture research and extension organizations involved in the development and transfer of agricultural technology. Multidisciplinary task forces with representations from both research and extension, working on specific problem areas in well-defined geographical zones, represent the approach recommended by this team.

There is a unique opportunity to put this strategy to the test and to correctly capitalize on investments already made in the ICRISAT/Mali-led development of the Cinzana research station. This has to do with the correct orientation of the proposed USAID-funded Farming Systems Research and Extension project. Specifically, we recommend that:

(1) USAID proceed with a modestly scaled down version of the FSRE project. Its objectives and general approaches are well designed;

(2) within the context of this project USAID do everything it can to concentrate project resources to reinforce its existing investment in ICRISAT/Mali and the Malian national programs in applied agricultural research and research station development;

(4) the Segou/Cinzana FSR unit should be developed as soon as possible in the life of the project and not delayed for phased implementation; and

(5) under IER leadership, appropriate coordinating mechanisms must be set up to promote the correct functioning and planning of task force activities.

NOTE

1 Initial results of this Etude de Reconnaissance were presented in a yet to be published Rapport Sociologique: Etudes Socio-Economic and Envirions de la Station de Recherche de Cinzana, dated May 1982, which was "unofficially" shown to the evaluation team.

VI. DEVELOPMENT OF MALIAN RESEARCH STATIONS

A. BACKGROUND

The development of improved crop varieties and improved crop and soil management practices requires an integrated network of well-managed research stations. This network must adequately serve major ecological zones and crop production areas. In 1981 there were three major research stations administered by SRCVO at Sotuba, Kogoni, and Dire, and several substations where field research could be conducted. In addition, ICRISAT/Mali had begun the development of a major research station at Cinzana in the semi-arid zone with funding from the Ciby-Geigy Foundation and USAID. A plant breeding laboratory, an agronomy laboratory, and associated offices and out-buildings had been completed. Phase II of the project involves further development that will make Cinzana station fully operational.

B. DEVELOPMENT OF THE CINZANA STATION

Substantial progress has been made in that the Cinzana Research Station was officially inaugurated by the GRM in the summer of 1983. When the evaluation team visited in October 1983, the following additional buildings had been constructed: six houses for senior scientists; a rest house with five rooms; and two housing complexes for junior staff. An electrical generating facility with a back-up generator and an electrical system had been installed. A water supply had been installed, even though conditions were not ideal. Originally, it had been thought that water would be available from wells close to the station, but through test drilling, it was discovered that the aquifers were not suitable. Additional hydrologic surveys were made and a well has now been drilled seven km from the station headquarters, and a pump and pipeline have been installed which can supply 25 m^3 /hour of water to the station. Fortunately, the

Previous Page Blank

seven-km pipeline traverses the length of the station and can provide water for irrigation at several experimental sites on all of the major soil types that are present on the station. Aluminum pipe, valves, risers, and sprinkler heads have been assembled for line-source water application.

The station presently has two pick-ups, a truck for long distance haulage and personnel transportation, a four-wheel drive dump truck, a four-wheel drive tractor, several smaller tractors, oxen (and a supporting herd of cattle), an extensive range of motorized and ox-draft equipment for cultivation and station development, and a maintenance and repair facility.

Aerial photo mosaics and "false color" images which were developed from an IGN aerial survey mission in December 1981 are being used in making soils and topographic maps. The ICRISAT-funded farm manager has extensive cartographic and surveying skills. A soil survey has been completed, and a soils map of 1/5000 scale and a topographic map of similar scale have been made. Soil samples were analyzed for major characteristics at the Agropedologie laboratory in Sotuba. ICRISAT/Mali has taken advantage of their linkage with the Title XII "Trop-Soils" project to obtain additional soil analyses which are presently underway at Texas A & M University. The total area available for field research is approximately 100 ha and a substantial number of experiments were conducted at Cinzana in 1983 on land that has been developed for research.

The design of research projects would be facilitated by a more systematic and detailed understanding of farming systems in the region surrounding Cinzana. To that end, the Division of Technical Studies of GRM agreed in 1981 to conduct four socio-economic studies of representative villages in the region surrounding the Cinzana station, with financial assistance from ICRISAT/Mali. One of these reports, which presents overall demographic and land tenure data on these farming systems, was published in May 1983, and another sociological report has been

prepared. In addition, P. Serafini and his GRM colleagues made informal surveys of cropping systems in the region to determine the appropriate cultural conditions for control treatments in research on the Cinzana station. (For more detail see Section V.)

We were informed that the total costs to date for developing the Cinzana station have been U.S. $1,300,000, with Ciba-Geigy providing $500,000 and ICRISAT/Mali providing $800,000 (these estimates do not include the salaries of the engineer provided by Ciba-Geigy and the agronomist provided by ICRISAT/Mali). In earlier years, operating costs were mainly covered by ICRISAT/Mali. A new agreement has been reached whereby Ciba-Geigy will provide most of the operating costs for the next six years and ICRISAT/Mali will provide fuel.

C. CONTRIBUTIONS TO OTHER STATIONS

The ICRISAT/Mali project has contributed to the development of research capacity in other stations in Mali by training equipment operators, field management personnel, and technicians for conducting field research. This has made possible the effective execution of multilocation experiments without continuous supervision by ICRISAT/Mali senior staff.

The Baramandougou station is staffed by three ICRISAT/Mali personnel. The provision of oxen, animal-traction equipment, and trained personnel has facilitated research on cultural methods at Baramandougou by scientists from the Cellule de Technique Culturale. However, this station does not have sufficient buildings and equipment to conduct agronomic research effectively. In addition, substantial soil erosion was apparent in the center of the experimental land area.

At the Koporo-Keniepe station, ICRISAT/Mali plans to install a system for screening millets for resistance to downy mildew. This system requires misting, and a well has been drilled and pumphouse constructed. Further work is needed to install a generator to provide electricity for the pump and a misting system. Additional buildings, a laboratory, and a refrigerator are needed to make this facility effective for screening for disease resistance.

At the central Sotuba Research Station the ICRISAT/Mali team plans to install a cold room for storing seed. This would appear to be an excellent idea.

D. ANALYSIS AND RECOMMENDATIONS

The ICRISAT/Mali project staff, the government of Mali, and the Ciba-Geigy Foundation have developed an excellent research station at Cinzana which can make major contributions through research to the improvement of crop production in the semi-arid zone of Mali. Prior to this time, GRM did not have a major research station to serve this semi-arid zone. The costs and time required to develop the Cinzana station indicate that the ICRISAT/Mali project staff and the engineer from Ciba-Geigy have been efficient and effective.

The siting of the Cinzana station is excellent. It has a semi-arid tropical climate with 600-800 mm of annual rainfall. The headquarters is situated on a lateritic plateau on the northern boundary. The station has a range of soils along the north-to-south transect with sandy-silt soils on the edge of the plateau, then alluvial silty soils, and hydromorphic clayey soils at the southern boundary. Collaboration with the PIRT/TAMS project, using Landsat imagery, has established that the soils and climate are representative of major rainfed crop production areas in the semi-arid zone of Mali, and it is particularly

suitable for research on millet, sorghum, and cowpea production systems. Its central location facilitates interaction and communication with other stations where substantial research is conducted by the ICRISAT/Mali team and the Malian national program. Sotuba and the capital city of Bamako are only three hours drive to the east on an all-weather road. The important drier semi-arid zone substations of Baramandougou and Koporo-Keniepe are in major millet producing areas, and are located three to five hours drive to the northeast. The research station at Sikasso is located in the wetter sub-humid boundary of the semi-arid zone, and is only three hours drive to the south.

The ICRISAT/Mali team considers that further development work is needed on the Cinzana, Baramandougou, and Koporo-Keniepe stations. The evaluation team agrees with this assessment, has reviewed the suggestions made by the ICRISAT/Mali team, and recommends that the following activities should be given high priority:

(1) At least one ICRISAT/Mali scientist and one GRM scientist should reside near the Cinzana station during the next three years to supervise research and the final stages of stage development (at this time the director of the station, Dr. O. Niangado, and Dr. M. O'Neil, a post doctoral scientist, reside near the station). Short-wave radios should be installed at Cinzana, Baramandougou, Koporo-Keniepe, and Sotuba to facilitate communication and for emergencies.

(2) An overall land-use plan should be developed for Cinzana and Baramandougou. This should include the design and installation of a series of major drainage-ways for managing surface water and controlling soil erosion. These drainage-ways should terminate in reservoirs at the southern end of the stations to provide water for cattle and irrigation, if there is sufficient rainfall/runoff. Station development experts from ICRISAT, such as E. Nunns, G. Perrier, and P. Serafini, should be brought in to assist with this work. This work may also provide

subject matter for theses by students from the National Engineering Institute under the guidance of the ICRISAT personnel.

(3) Specific areas of sloping land between the major drainage-ways at Cinzana should be used to test and demonstrate methods for managing surface water and controlling soil erosion that can be appropriately used by farmers in the region around Cinzana. This work could be one of the responsibilities of the new ICRISAT/Mali agronomists. Work of this type has already been initiated.

(4) In research and station development, substantial use should be made of equipment pulled by oxen and donkeys to assist the ICRISAT/Mali personnel to develop improved animal-draft systems. To date no work has been conducted with donkey traction equipment at Cinzana and this should certainly be undertaken.

(5) ICRISAT/Mali and GRM should seek assistance from USAID to complete the development of Koporo-Keniepe, including installing the misting system and constructing and equipping a laboratory, office, and house, and to construct buildings and provide equipment for Baramandougou.

(6) The irrigation system should be developed for experimental use to assist the sorghum/millet breeding programs (e.g. for irrigating dry season nurseries to advance generations and bulk seed, for screening for resistance to downy mildew in millet and possibly grain mold, and for screening for resistance to drought during emergence and grain filling).

Initially, the line-source irrigation system could be used for screening for tolerance to drought during emergence. The line-source system would be inefficient for screening for resistance to drought during the main growing season due to interference by rain. Its use during the dry season would be

constrained by the abnormal flowering responses due to differences in photoperiod. Line-source systems also suffer from extreme variability and difficulties in the statistical treatment of data.

A uniform overhead irrigation system would be more versatile and effective than the line-source irrigation system that is presently being installed. The change to the uniform system would only require new sprinkler nozzles and would be simple and cheap. The capacity and flexibility of the irrigation system could be substantially increased by making reservoirs to store pumped water when the irrigation system is not being used and surface run-off from the drainage-ways, and by installing booster pumps at the reservoirs. ICRISAT personnel, such as P. Serafini and E. Nunns, should be brought in to plan a water-supply and irrigation system which will most effectively use the limited water supply that is available.

(7) Some further training is needed for personnel who maintain, repair, and construct equipment. ICRISAT personnel such as P. Serafini, R. Bansal, and E. Nunns could assist with this task when they visit on short-term assignments to assist in the development of other aspects of the Cinzana station.

(8) The station manager at Cinzana should be given more responsibility so that the director of the station is able to devote more time to research.

In sum, the personnel of ICRISAT/Mali and the Ciba-Geigy Foundation are to be commended for their excellent work in developing the Cinzana Research Station. The evaluation team recommends that ICRISAT/Center, GRM, and USAID provide full assistance to the ICRISAT/Mali team in completing the development of the Cinzana Research Station and in ensuring its continued operation because it is vital to the development of improved crop varieties and improved crop and soil management practices for rainfed production in the semi-arid zone of Mali.

VII. THE TRAINING OF MALIAN PERSONNEL

In the development of an applied research system focused on meeting critical farm-level food production needs, the appropriate training of national staff at all levels is a vital task. The Phase II ICRISAT project has undertaken four types of training which will be reviewed in this section.

It is the clear and unanimous view of this evaluation team that training has been one of the major accomplishments and successes of the ICRISAT/Mali effort. These training efforts date back to 1977 in some cases and it is thus difficult to limit our examination to only the past two years.

A. LONG-TERM DEGREE TRAINING

ICRISAT/Mali Phase II funds are, or soon will be, supporting five Malian students abroad for higher degree training, four in the United States and one in India. One should also note that the ICRISAT team has been involved with other Malian personnel sent for long-term training but with scholarships from other sources. The students supported by ICRISAT/Mali are as follows:

Moussa Traore: former director of the Division of Agronomic research, who is pursuing a Ph.D. in plant physiology at the University of Nebraska. He began this degree program in the fall of 1982.

Mamadou Doumbia: former ICRISAT agronomy trials supervisor, who is working on a M.S. degree in agronomy and statistics at Texas A & M University. He began his program of studies also in the fall of 1982 (Mr. Doubia also received short term in-service training at ICRISAT/Center).

Samba Traore: former Koporo-Keniepe station director, who is working on a M.S. degree in agronomy and soils at North

Previous Page Blank

Carolina State University. This education began in January of 1983 (Mr. Traore had also received in-service training at Hyderabad).

Dielimoussa Soumano: began work in August, 1983 at Andhra Pradesh Agricultural University in India on a M.S. in groundnut breeding.

Ousmane Coulibaly: currently of the IER/DRA Division of Technical Studies, has been identified to begin M.S. training in Agricultural Economics in January 1984. This training will most likely be done at Michigan State University after language training at the University of Colorado Economics Institute. (Mr. Coulibaly was one of the principle investigators in the 1982-83 DET socio-economic studies described in Section V of this report).

Overall this long-term training component seems to be filling critical needs in higher level scientific manpower. This is being done in a careful manner and there is a legitimate concern on behalf of the ICRISAT project team not to contribute overly much to depleting the ranks of national research units through long-term training.

Attending to the U.S. needs of ICRISAT trainees has been a time consuming task for the ICRISAT/Mali team. Recent reorganization efforts with ICRISAT/Center may be improving this situation; if not, the evaluation team would certainly recommend exploring sub-contractual arrangements in the United States to handle the trainees' support while in the U.S. In addition, some consideration might be given to mechanisms that would allow a closer coordination between the trainee's U.S. program and research activities and training needs in the Malian program. An annual meeting in the United States of ICRISAT-sponsored students with a representative of the ICRISAT/Mali team to review the training program and discuss relations with the evolving

national research program might be one example of such mechanisms. Coordinated training and use of microcomputers in the United States and Mali might be another.

B. SHORT-TERM FOREIGN TRAINING

Over the past six years, approximately 30 Malian agricultural research personnel have participated in a nine month in-service training program on agronomic and plant breeding research techniques at ICRISAT/Center in Hyderabad. A listing of the trainees and their current positions in Mali is contained in Annex C. Of the 21 persons send to India under this arrangement in the past three or so years (9-29 on the list), 12 seem to have been funded at least partially by ICRISAT/Mali funds, five by the SAFGRAD multilocational trials project, and four by the Sahelian Institute. The ICRISAT/Mali team leader estimates that overall, 70 percent of the cost of ICRISAT/Mali trainees is borne by the project, 30 percent by ICRISAT/Center.

Even though the project has not paid for all trainees, it has handled their administrative backstopping in Bamako. The ICRISAT/Mali administrator, Seydou Toure, has handled all matters involving passports, official detachments from civil service, travel arrangements, etc.

As the information in Annex C attests, virtually all personnel trained in India are still involved in responsible positions in agricultural research or extension. Of the 29 ex-trainees, 20 are located at Malian agricultural research stations, nine at the Sotuba station and 11 scattered at other stations and substations. Of the nine remaining trainees, three work in agricultural extension, three in multilocational trials work, two are in the U.S. in graduate school (two others have also completed degree work in the United States and are now back in Mali) and one is an agroclimatologist in Bamako. This is indeed an enviable result and the tangible evidence of this and

other training efforts was visible to the evaluation team in the field in terms of technically-trained staff able to carry out on-station trials.

With such an impressive record, one is hesitant to make any suggestions for program modification. However, the ICRISAT/Mali team might wish to consider using some of its training funds to finance other short-term, in-service training options such as training practicums with scientists in other research programs in West Africa. For example, the Sotuba station cowpea breeder might benefit from spending some time with the relatively advanced cowpea breeding and agronomic experimentation program in ISRA, Senegal. Similar collaborative training in West Africa might possibly assist in the acquisition of microcomputer data manipulation skills. Some of these short-term possibilities might offer cost-effective career development incentives to more senior ICRISAT counterparts.

C. STUDENT THESIS SUPERVISION

Since 1977, ICRISAT/Mali personnel have been involved in the supervision of 19 B.S. level theses of Malian university students, mostly from the Katibougou Rural Polytechnical Institute, the principal training grounds for GRM agricultural personnel. Fourteen of these have been finished or begun in the past three years during the current Phase II of the ICRISAT/Mali project. A complete listing of these theses is contained in the attached Annex D. Sixteen of the theses were written by students finishing degrees at Katibougou, two at the Superior Normal School in Bamako, and one from the National Engineering School in Bamako.

A brief examination of these studies shows them to fall into the following rather arbitrary categories:

- Sorghum studies 5
- Millet studies 3
- Studies of sorghum and millet as intercrops 3
- Studies of sorghum and millet disease resistance screening techniques 2
- Food technology studies 2
- Others (one each:) 4
  - Weeding methods
  - Northern Mali wild food grains
  - Introduction of Eleusine corocana in southern Mali
  - Hydrology study of the Cinzana station area

TOTAL 19

Annex D also indicates that a majority of these students have gone on to play vital roles in the development of Malian agricultural research capacity.

D. ON-THE-JOB TRAINING

Much of the true role of effective technical assistance comes in the provision of on-the-job training and experiences which help to increase local capacity. This may come from actual instruction, productive interaction, or the demonstration of appropriate role models. The evaluation team feels that the ICRISAT/Mali team has shown creativity and demonstrated considerable success in this area of training.

The local training undertaken under this project can be grouped into two major areas: training for technical specialists

and training provided to junior scientists who have been in more collegial or counterpart positions. In the first category substantial effort was made, particularly by the ICRISAT/Mali agronomist, in the training of the personnel needed to make the research stations run. Here we can point to the training and supervision of mechanics, motorized equipment operators, blacksmiths, and animal traction specialists (two training programs have been organized for animal traction personnel at the National Center for Agricultural Mechanization outside of Bamako). In addition, moniteur-level field trials supervisors have also received substantial, effective on-the-job training inputs.

The second level of higher level counterpart training is also an area of significant accomplishment. Both the breeder and the agronomist can point with pride to long-term associations with four or five junior Malian scientists who are emerging as future research leaders who can effectively design, execute, and interpret research results. Some have already moved into responsible positions as research station directors; some are currently abroad for advanced degree training. The fact that the ICRISAT/Mali technical assistance team members have been in the country for five and six years permits them to have had continuous training relationships with a broader number of counterparts and to interact with them throughout both formal and on-the-job training phases. The evaluation team concludes that, in general, on-the-job counterpart training has been effective.

E. CONCLUDING RECOMMENDATIONS

The evaluation team is greatly impressed by the breadth and broad-based success of the ICRISAT/Mali training component. It therefore recommends that these activities be continued in their current major orientation. It would suggest some exploration of the broadening of options considered under the category of short-term foreign training, particularly in response to practical

training opportunities in West Africa. Particular attention should continue to be devoted to the need to provide effective training opportunities for Malian researcher counterparts.

Finally, the evaluation team recommends that every effort be made to coor'inate the ICRISAT/Mali training component with an overall manpower training strategy as this is developed by the personnel of the GRM/IER.

VIII. PROJECT ADMINISTRATION AND INSTITUTIONAL RELATIONSHIPS

A. INTRODUCTION

Administration is the lifeblood of any project, since it provides an environment permitting substantive work to be accomplished. This administrative component often can be quite time consuming, particularly in a project such as ICRISAT/Mali Phase II, which has had heavy construction, equipment, local personnel, and operating components.

The evaluation team has a very favorable impression of the overall picture of ICRISAT project administration. Both the agronomist, who also served as chief of party/project administrator until May 1983, and the breeder, who has handled those responsibilities since that time, seem to have been able to conduct significant amounts of substantive work while also handling time-consuming administrative details. This is partly due to their dedication and long hours and partly to an availability of qualified Malian assistants who can handle many of the routine tasks.

It is not the intent of this report to delve deeply into project accounting and administrative procedures. These points are being covered in separate reports by the ICRISAT financial management specialist, Mr. Murty, and by the Coopers and Lybrand audit agency. We hope that this is a positive sign of greater future involvement by ICRISAT/Center in project management and support which will help project scientists devote more time to their research program.

What we wish to comment on here are larger, policy-oriented project administration issues which may have a significant impact on the long-run success of the grant team in reaching stated research development objectives. Many ICRISAT/Mali administrative procedures have evolved unanalyzed as project

Previous Page Blank

funding and functions grew over the years since 1977. Even the initial two years of Phase II have seen a significant growth in the local support and personnel administrative functions. Since project involvement has grown in an evolutionary manner, many informal administrative procedures have become increasingly inadequate for the larger project. The evaluation team regards it as a positive sign that measures to correct these tendencies are being undertaken.

B. BUDGET PLANNING AND LOCAL CURRENCY EXPENDITURE PATTERNS

Within the constraints of the major line items of the grant agreement, the ICRISAT team has had substantial autonomy in budget planning. While this independence has generally produced good results, certain expenditure categories -- notably "training" "travel and transport," and "research operation and supplies" could have benefitted from more systematic advanced planning. To the extent that these expenditure categories affect Malian research station operations, the conduct of the national research program and the availability of Malians for short- and long-term training, advance ICRISAT budget planning will help IER personnel plan GRM resource allocation in a more coherent fashion.

One of the most striking areas of ad hoc budget allocation is in the area of research station operating expenses. This is particularly true at the new Cinzana Research Station where the Ciba-Geigy Foundation and ICRISAT/Mali are covering virtually all recurrent costs. The planning of these expenditures seems to primarily involve negotiation between these two outside projects. Through 1983 ICRISAT will have covered 80-90 percent of Cinzana operating costs. With the signing of a new agreement between Ciba-Geigy and the GRM, Ciba-Geigy will provide increased recurrent cost support at Cinzana for a six-year period. In 1984 Ciba will cover about 70 percent of total station costs and ICRISAT 30 percent (which will consist almost entirely of the purchase of fuel).

The project paper indicates that the ICRISAT team was to keep detailed records on Cinzana station expenses so that an analytical report could be prepared for discussion with the GRM. This report has not yet been prepared and the evaluation team suggests that this be completed within the next year so that the implications for eventual GRM/IER assumption of some or all of these costs can be debated. Even if the possibilities of recurrent cost assumption are very low, the situation should be examined openly and clearly in a country desperately short of financial resources. This is particularly true since the GRM has met its obligation for local funding of counterpart and support personnel only under the most generous interpretation.

The evaluation team recommends that ICRISAT/Center provide, from core funding, short-term technical assistance in advance project budget planning. Where appropriate, certain aspects of this planning must be conducted in consultation with appropriate, GRM/IER officials and with USAID project management staff.

C. LOCAL PERSONNEL AND GRM ALLOWANCES

ICRISAT/Mali has two kinds of local personnel budget expenditures: payment of monthly bonuses and allowances to GRM/IER personnel, and the hiring of local contract staff. The monthly payments to GRM personnel (indemnites de responsabilite, indemnites de monture, and local travel per diem) are allowed under the terms of the grant agreement and follow long-established traditions in the Malian agriculture research community. The sum of the two basic allowances may more than double the take-home pay of some research personnel but are fairly easily justified when one considers the fact that doctoral level senior Malian researchers can receive base salaries of only $1,500 per annum. Approximately 20 Malian research staff at Cinzana and Sotuba receive allowances paid by the ICRISAT project and these payments now amount to a total of approximately $14,000 per year.[1] The evaluation team feels that this is a worthwhile and cost-effective use of project resources but would suggest

that some means be found to limit the continual growth of the number of persons receiving payments. This might involve a more systematic identification of research counterparts and close collaborators.

Local ICRISAT contract personnel include 16 persons at the Cinzana station (up to 130 seasonal laborers have also been paid through 1983), 14 persons at the Sotuba research station and three at the Baramandougou substation (including the only senior research technicians at that station).[2]

The ICRISAT Sotuba staff also includes a very necessary, highly qualified bilingual secretary, Mme. Rachel N'Diaye, and a senior administrator, Mr. Seydou Toure, who is provided by the Malian government. The addition of these staff members has made a major contribution to the smooth functioning of the ICRISAT/Mali project and to minimizing some of the inevitable administrative burden.

The evaluation team suggests that ICRISAT/Mali examine its research station contract employee list and determine which employees are (a) necessary due to USAID or ICRISAT administrative or reporting requirements or who are required to directly support the ICRISAT project in Mali and (b) those who are mainly functioning as part of the national crop breeding and agronomic research programs and/or who are critical to the continued, long-term functioning of the system of Malian national research stations. The long-term budget implication of this analysis should be discussed with GRM/IER officials.

The evaluation team recommends that plans be developed for the possible eventual integration into the Malian civil service of those current ICRISAT contract employees whose work is critical to either the national research program or the continued correct functioning of the national agronomic research stations.

D. SHORT-TERM TECHNICAL ASSISTANCE

From information provided by ICRISAT/Mali personnel (Annex F: Short-Term Technical Assistance and Visits by Other ICRISAT Personnel) it seems that most short-term consulting assistance acquired through project funds has been obtained locally in Mali. Virtually all of this assistance has focused on the Cinzana station: hydrological surveys and water prospecting, soil surveys, initial socio-economic surveys of the surrounding villages (reviewed in Section V), and installation andoperation of the line-source irrigation system. In addition, some computer data processing has been undertaken in the United States at Texas A & M University by students who had worked with the ICRISAT team in Mali.

No project funds seem to have been used to provide technical assistance in the design and review of the research program, except for the current mid-term evaluation. This function seems to have been assumed to some extent by periodic visits by other ICRISAT personnel, primarily from Hyderabad, but also from the neighboring Sahelian programs (see part 2, Annex F). It is somewhat difficult for the evaluation team to evaluate fully the utility of these visits by ICRISAT personnel since we have only seen one trip report (September, 1983 evaluation of the Millet program by D. J. Andrews, which is judged to be highly useful) and several related documents by W. Stoop dealing with toposequence work and general agronomic work in the West African Sahel. We have, however, formed some impressions. While some visits seem to have been very useful in specific areas (e.g. animal traction machinery, millet and sorghum physiology, toposequence trials), there seems to have been little direct review and guidance to the overall research program in Mali. A more systematic use of periodic ICRISAT visits toward those ends seems to be warranted. In addition, it should be kept in mind that the care and feeding of visiting scientific personnel can be quite time consuming. The evaluation team concludes that better

use can be made of short-term consultants and visiting scientists to systematically and constructively interact and support the ICRISAT research program in Mali.

We recommend that ICRISAT/Mali develop a prioritized list of short-term technical assistance needs in the areas of research, station development, and project administration for the remainder of current project funding. This list should then be incorporated into the budget planning process and should be revised and updated on an annual basis, taking into account work completed and changing conditions. We further recommend that the visits of ICRISAT/Center and Regional personnel be more systematically planned to provide review and planning assistance to the Mali research program.

E. PROJECT REPORTING

While the annual ICRISAT/Mali reports have provided substantial reporting of the crop breeding and agronomy programs, reporting to ICRISAT and USAID concerning training, station development, project administration, and relations with other research and development efforts has been nonexistent or incomplete. This has complicated project evaluation and has obscured project accomplishments of which the ICRISAT team can be justifiably proud. Much of the information contained in this report and its annexes concerning important non-research areas should be more readily available. In addition, the project paper mentions production of a briefing book on the ICRISAT/Mali project and its research program at the various research stations. This document has not been prepared, and the evaluation team believes that it might be a useful exercise, if only so it can be given to the seemingly endless stream of development specialists who appear in Sahelian capitals.

The evaluation team recommends that ICRISAT/Mali provide a more complete reporting of project accomplishments. This should

either be included in the existing annual report, or preferably, be in the form of an annual supplementary report directed primarily to USAID and ICRISAT but available to other interested parties as well. This will greatly facilitate future project evaluations.

F. PROJECT SUPPORT BY USAID AND ICRISAT

USAID/Mali has provided consistent and positive support to the ICRISAT/Mali team since 1977, and the grant agreement mechanism has proven to be a highly cost-effective bilateral development assistance mechanism. However, until the arrival of Dr. S. K. Reddy as project manager in 1982, substantive project review and constructive feedback to project personnel was weak or lacking. Further, lack of mission support of AID-funded Title XII and other exploratory research team visits to Mali greatly added to the ICRISAT/Mali workload at critical points in project history.

The evaluation team recommends that appropriate USAID/Bamako offices provide adequate in-country support for AID-sponsored agricultural research projects and coordinate their contacts with appropriate GRM/IER personnel.

Until very recently, both administrative and technical support of the ICRISAT/Mali project by ICRISAT/Center or by other West African ICRISAT personnel has been sporadic and inadequate, with a few notable exceptions. Similarly, as described above, no systematic review of the ICRISAT/Mali research program has taken place in country. Review of research results and planning in Hyderabad seems to have been useful in some specific areas but the overall annual review is not long enough to provide the kind of in-depth understanding of research problems that can be accomplished most effectively in the field in Mali.

The evaluation team recommends that both ICRISAT/Center and ICRISAT/Niamey provide more systematic administrative support and research review and feedback to the Mali team.

Specifically, the evaluation team strongly supports current efforts to streamline and rationalize administrative procedures and endorses the concept of providing additional short-term in-country training in accounting and project administration to current local support personnel. Additional future backstopping by the ICRISAT/Niamey administrative officer should be explored.

The evaluation team recommends that greater ICRISAT/Center and Regional assistance should be provided in Mali in terms of research review and planning.

G. USE OF MICROCOMPUTERS

The ICRISAT/Mali team has made some effort to begin to use microcomputers in project administration and research activities; these efforts need to be expanded systematically.

In terms of administration, there is no doubt that the biggest gains can be made through microcomputer use in word processing for report preparation. In addition, advance budget planning can be greatly facilitated through the use of electronic spread-sheet software. Local currency accounting, payroll preparation, and agronomic input inventory control are more complex tasks which can be approached once a viable operational office computer system in place. A fairly powerful data base management system (such as "D-Base II") might be able to handle many routine inventory and list-filing (sortable by multiple criteria for reporting) tasks as well as handle access to small scientific data sets.

Use of microcomputers in the storage and analysis of extensive field trials data could produce major increases in staff productivity and in the timeliness of reporting. What seems to be called for is an agronomic statistical analysis

software package (such as "M-Stat" soon to be released by Michigan State University) which contains provision for rapid data entry, flexible file manipulation, basic analysis of variance statistical capabilities, ability to produce cross-tabulation with prior multiple file sorts, and (optionally) standard graphical capabilities such as scattergrams, histograms, etc.

The evaluation team recommends that:

(a) ICRISAT/Mali explore increasing project use of microcomputers for project administration and accounting, research data processing, and report preparation;

(b) this effort be coordinated through short-term technical assistance to be provided through the ICRISAT/Mali project budget; and

(c) this effort in Mali be coordinated with provision of microcomputer training to ICRISAT-sponsored Malian students in the United States for advanced study.

NOTES

1 At an exchange rate of 795 FM = $1(U.S.)

2 A list of local employees, including their location and function, is attached as Annex E to this report.

ANNEX A

BIBLIOGRAPHY

ANNEX A

Bibliography: Listing of Principle Documents Reviewed in Evaluation

1. Breman, H. and C. T. de Wit (1983), "Rangeland Productivity and Exploitation in the Sahel," Science 221 (4618): 1341-1347.

2. Burton, Glenn (1982), "Comments for the Mali Millet Breeders," ICRISAT, Bamako.

3. Comite Nationale de Recherche Agronomique (1981), "Rapport de Synthese, Section Agronomie," GRM/MA/IER, Bamako.

4. _____(1982a), "Rapport de la Commission Technique Specialisee des Productions Vivrieres et Oleagineuses," GRM/MA/IER, Bamako.

5. _____(1982b), "Compte-Rendu des Seances," GRM/MA/IER, Bamako.

6. _____(1982c), "Recommendations de la 22eme Session du CNRA," GRM/MA/IER, Bamako.

7. Coulibaly, Ousmane N., Mme. Coulibaly, and A. Colozo (1983), "Rapport 'Profile d'Unite de Production Agricole,'" second report in Etude Socio-Economique aux Environs de la Station de Recherche Agronomique de Cinzana, GRM/MA/IER/DET, Bamako.

8. Cunard, A.C. (1982a), "Evaluation of Technical Themes," USAID, Bamako.

9. _____(1982b), "Reconnaissance FSR & D Survey in the Bankass/Koro Sections of the Gondo Seno, Fifth Region of Mali," Pragma Corporation, Falls Church, Virginia.

10. _____(1982c), "Review of Research Effort by ICRISAT/SAFGRAD in Mali," Pragma Corporation, Falls Church, Virginia.

11. Development Associates, Inc. (1982), Evaluation Report - Operations Mils-Mopti, Arlington, Virginia.

12. Erickson, J.H. (1982), "The Malian Food Sector Strategy: A Review of Its Contents in Relation to the USAID Development Program in Mali," Pragma Corporation, Falls Church, Virginia.

13. ICRISAT (1978), "Manual d'Identification des Maladies du Sorgho et du Mil," ICRISAT Bulletin d'Information No. 2, Hyderabad, India.

14. ICRISAT/Mali (1979), "Report of the 1979 Season," Bamako.

15. _____(1980), "Annual Report of the Republic of Mali Cooperative Program," Bamako.

16. _____(1981), "ICRISAT Mali Preliminary Report for the 1981 Season," Bamako.

17. _____(1982), "ICRISAT Mali Report for the 1982 Season," Bamako.

18. Johnson, Jerry (1982), "SAFGRAD Project in Mali, September 1978-September 1982, Final Report," REDSO, Abidjan.

19. Norman, D.W. (1976), "Farming Systems Research in the Context of Mali," Bamako.

20. SAFGRAD (1982), "Rapport de la Campagne 1982", GRM/MA/IER/DRA/SRCVO, Bamako.

21. Scheuring, J.F., S. Sidibe, and A. Kante (1981), "Sorghum Alkali Tô: Quality Considerations," Proceedings of the International Symposium on Sorghum Grain Quality, October, 1981, Patancheru, A.P., India, ICRISAT, India.

22. Scheuring, J.F., S. Sidibe, L.W. Rooney, and C.F. Earp (1982), "Sorghum Pericarp Thickness and Its Relation to Decortication in a Wooden Mortar and Pestle," Cereal Chemistry, vol. 60, no. 1, pp. 86-89.

23. Serafini, P. G. et. al. (1982), "Bilan de 5 Ans de Recherche Sur les Cultures Associees," GRM/MA/IER/DRA/SRCVO, Bamako.

24. Shulman, Robert (1979), "Strategy for the Advancement of Animal Traction in Mali," USAID, Bamako.

25. Sidibe, S., M. Diarra, and J.F. Scheuring (1981), "Sorghum Couscous: Quality Considerations", Proceedings of the International Symposium on Sorghum Grain Quality, October, 1981, Patancheru, A.P. India, ICRISAT, India.

26. Stoop, W.A., C.M. Pattanayak, P.J. Matlon, and W.R. Root (1982), "Strategie pour Augmenter la Productivite de l'Agriculture de Subsistance dans les Zones Tropicales Semi-Arides de l'Afrique de l'Ouest," Programme de Cooperation Internationale, Article Occasional No. 1, ICRISAT, Hyderabad India.

27. USAID/Mali (1979), Semi-Arid Tropics Research (Phase I) Project Paper, Bamako.

28. _____(1981a), Semi-Arid Tropics Research (Phase II) Project Paper, Bamako.

29. _____(1981b), Semi-Arid Tropics Research (Phase II) Grant Agreement, Bamako.

30. _____(1983), Country Development Strategy Statement, FY 85 (MALI), Washington, D.C.

31. Webster, Orrin (1980), "Project Evaluation, ICRISAT/Mali," USAID, Bamako.

ANNEX B

SCHEDULE OF EVALUATION TEAM ACTIVITIES

ANNEX B

Schedule of Evaluation Team Activities in Mali
October 20-November 12, 1983

Date	Activity	Persons Encountered
10/20	-Wilcock, Hall arrive Bamako -Briefing with USAID personnel	Rollo Ehrich, ADO Gerald Cashion, DEO Michael Foster, DEO Dr. S.K. Reddy, project manager
10/21	-Review of documents -USAID administrative details -Briefing with USAID project manager	Dr. S.K. Reddy
10/22	-Review of documents	
10/23	-Briefing by Texas A&M, INTSORMIL team	Dr. Darrell Rosenow, sorghum breeder Dr. Lloyd Rooney, food scientist
10/24	-First meeting with GRM/IER staff	Mr. Adams Coulibaly, IER/DET ZanaSanogo, IER/DRA Moussa Traove, IRE/DPE Yacouba Doumbia, SRCVO Brahima Sidibe, SRCVO
	-First formal meeting with ICRISAT/ Mali	Dr. John Scheuring Mr. Philip Serafini
10/25	-Evaluation team interviews ICRISAT/ Mali team	
10/26	-Tour of Sotuba station and exp. fields -Meet with SRCVO Defense des Cultures	M. Doumbia M. Bonzi
	-SRCVO/AMS Niebe breeding	M. Toure
10/27	-Sotuba: meet with SRCVO head factory	M. Panganignon,
	- Bancoumana: In OHU, visit to on-farm pigeon-pea trial	
10/28	-Travel to Cinzana station and Segou -Tour of Cinzana station	ICRISAT/Cinzana staff (See list in Annex E)

Date	Activity	Persons Encountered
10/29	-Sotuba station: minor species work -PIRT satellite imagery -Visit to SMECMA animal traction factory	M. A.A. Sow
10/30	-Hall visits pigeon-pea trials on farm at Kalifaborgou	
10/31	-Sotuba: Food Technology "sub-cell" : SRCVO/Cellule Techniques Culturales -Webster arrives Bamako	Mlle. Assakante M. Simpara Manadou
11/1	-Trip to Sikasso -Visit Tierouala station DRSPR -Visit with IDRC/FSR project Sikasso	Tony Johnson
11/2	-Sikasso: Informal group meeting with DRSPR staff -Collection of wild pigeon-peas -Visit Baramandougou substation -Arrive Mopti -Webster visits Cinzana station	M. Diabate, M. Tramale M. Sanogo or other colleagues ICRISAT/Baramandougou staff (Annex E)
11/3	-Mopoti to Bandiagara to Koporo-Keniepe substation -Webster visits Baramandougou substation	
11/4	-Mopti -Visit Cinzana, reexamine line-source -Return to Bamako	Michael O'Neil, ICRISAT post doc
11/5	-Report writing	
11/6	-Report writing	
11/7	-Meet with DET/FSR study groups -Meet with U.S. ambassador	M. Ousmane M. Coulibaly
11/8	-Meet with Cinzana station director -Draft summary and conclusions in French	M. Oumar Niangado
11/9	-Report writing	

Date	Activity	Persons Encountered
11/10	-Debriefing with USAID/Bamako staff	M. Wilson M. Day M. Ehrich M. Cashion M. Foster M. Reddy
	-Debriefing with GRM/IER	M. Coulibaly M. Dolo M. Zana
11/11	-Report writing	
11/12	-Report photocopying -Team departs Bamako	

ANNEX C

MALIAN IN-SERVICE TRAINEES AT ICRISAT/HYDERABAD, 1977-1982 AND THEIR CURRENT POSITIONS

ANNEX C

MALIAN IN-SERVICE TRAINEES AT ICRISAT/HYDERABAD, 1977-1982 AND THEIR CURRENT POSITIONS

	NAME	CURRENT POSITION
1.	Tigana Lassana	Plant Pathology, Sotuba Station
2.	Adama Coulibaly	Agronomist, WARDA Mopti (B.S. Cal Poly)
3.	Keita Bassirou	Soil Physics, Sotuba Station
4.	Mamadou Doumbia	M.S. Agronomy student, Texas A & M University
5.	Salif Kanoute	Agricultural Extension
6.	Moriba Konate	Sorghum Breeder, Sotuba Station (M.S. Oklahoma State University
7.	Samba Traore	M.S. Agronomy student, North Carolina State University
8.	Issa Diakite	Extension Regional Director
9.	Moussa Traore	Field Trials Officer, Sahel Institute
10.	Bakary Naba	Entomology, Technician, Sotuba
11.	Brahima Karibanta	Cowpea Program, Sotuba
12.	Adama Diarra	Extension Research Liaison Officer, Haute Vallee Bamako
13.	Moumouny Traore	Agronomist, Bema Station
14.	Sibene Dena	ICRISAT/Mali technician, Sotuba
15.	Y. Coulibaly	Extension Regional Director, Kolokani
16.	Jean M. Togo	Ag. Machinery specialist, Samanko
17.	Mama Konate	Agroclimatologoist, Bamako
18.	Seydou Toure	Director, Dire Research Station
19.	Dede Kone	Technician, Dire Station
20.	Baladji Keita	Director, Baramandougou Station

21. Kalifa Diakite	Director, Bema Research Station
22. Kalifa Yattara	Technician, Cinzana Station
23. Aliou Konate	Head, Multilocational trials Unit, Sotuba
24. Hassane Daou	SAFGRAD Pre-extension testing program
25. Bonkana Toure	ICRISAT/Mali technician
26. Djibril Tangara	Station Director, Koporo-Keniepe
27. Sda Sow	Sorghum Breeding, Sotuba
28. Seydou Bocar	Millet Breeding, Koporo
29. Niaba Teme	Sorghum Breeding, Cinzana

Source: ICRISAT/Center Computer Printout and J. Scheuring.

ANNEX D

MALIAN UNIVERSITY STUDENT THESES SUPERVISED BY ICRISAT PERSONNEL

ANNEX D

MALIAN UNIVERSITY STUDENT THESES SUPERVISED BY ICRISAT PERSONNEL

Year	Student	Thesis Title	Later Experience
1. 77	Baladji Keita	Etude de cultures associees au Mali - Experimentaion sur les associations Mil-Niebe, Sorgho-Niebe	ICRISAT CENTRE training 1981 Director Baramandougou Station
2. 79	Seydou Toure	Etude de la prospection 1978-1979 des sorghos cultives au Mali - Observations sur quelques caracteres genetiques et leur variabilite	ICRISAT CENTRE training 1981 Director Dire station
3. 80	Abdoul Abdoulaye Sow	Recherche sur les cultures associees	ICRISAT/Mali Agronomist
4. 80	Mamoutou Sanogo	Contribution a l'identification des groupes de "Souna" et de "Sanio" cultives au Mali	Extension, Kalana
5. 80	Salimata Sidibe	Acceptabilite culinaire comme un des criteres de selection au Mali	Responsable for the cereal Technology Unit, Sotuba
6. 81	Aboubacar Toure	Etude de l'effet heterosis chez le sorgho au Mali	Responsable for sorghum improvement, Sotube MS Training, Bordeaux, France
7. 82	Magnan Diarra	Amelioration du sorgho - Etabslissement d'une methodologie de criblage des varietes resistantes a la secheresse pendant la levee	Biology teacher, Bamako
8. 82	Laye Bagayogo	Contribution a l'etude technique et economique des cultures associees	Extension
9. 82	Ousmane Cissoko	Etude de quelques unes de possibilites d'intensification de la culture du mil. Comparaison de deux phenotypes (mil nain - mil local) sous differentes conditions de densite et de fertilisation	Recently assigned to Agronomic Research
10. 82	Mady Cissoko	L'impact de plusieurs methodes de sarclage	Recently assigned to Agronomic Research

11. 82	Mamadi Diabi	Criteres de selection sur le petit mil	Recently assigned to Agronomic Research, millet breeding
12. 81	Assa Kante	Conservation et coloration du tô comme critere de selection du sorgho	Cereal Technology Unit, Sotuba
13. 82	Mamourou Diourte	Etudes sur la couche brune des graines de sorgho - Consideration sur des sorghos maliens	Responsable for millet improvement, Sotuba. IITA training
14. 83	Karim Tracre	Caracterisation des sorgho guineese	Recently assigned to Agronomic Resarch, Sorghum
15. 83	Youssouf Bore	Recensement des graminees sauvages alimentaires (cereales mineures) utilisees en 5e, 6e, et 7e regions	Biology Teacher
16. 83	Aliou Hamadou Cisse	Evaluation du progres realise en amelioration des populations. Comparaison de differentes generations	Now in training, Sotuba
17. 83	Kassambara Moussa	Perspectives sur l'introduction de l'Eleusine corocana dans les zones Sud du Mali	Now in training, Tierouala
18. 83	Djibi Diakite	Le criblage du sorgho et du mil avec l'application d'un gradient d'irrigation	Now in training, Cinzana
19. 83	Ousamane S. Diallo	Contribution a l'etude de recherche varietale du mil et du sorgho en zone semi-aride, application au perimetre experimental de Cinzana (Region de Segou)	Hydrologist, Vallee de Kou, Upper Volta

ANNEX E

ICRISAT/MALI LOCAL CONTRACT PERSONNEL, THEIR LOCATION AND FUNCTIONS, AS OF OCTOBER 1983

ANNEX E

ICRISAT/MALI LOCAL CONTRACT PERSONNEL, THEIR LOCATION AND FUNCTIONS, AS OF OCTOBER 1983

	NAME		LOCATION	FUNCTION
1	Famougoury	Diarra	Baremandougou	Tech. assistant
2	Kenegue	Traore	Baramandougou	Labourer
3	Bakary	Diarra	Baramandougou	Tech. assistant
4	Moussa	Doumbia N.2	Cinzana	Tech. assistant
5	Salif	Kebe	Cinzana	Tech. assistant
6	Bamoussa	Traore	Cinzana	Technician
7	Madany	Samake	Cinzana	Labourer
8	Moussa	Samaoro	Cinzana	Labourer
9	Soumaila	Dagnon	Cinzana	Labourer
10	Mory	Camara	Cinzana	Foreman
11	Kassim	Traore	Cinzana	Tech. assistant
12	Adrien	Diarra	Cinzana	Driver
13	Souleymane	Sidibe	Cinzana	Mechanic
14	Pierre	Coulibaly	Cinzana	Mechanic
15	Mamadou	Diarra	Cinzana	Tractor driver
16	Dourama	Coulibaly	Cinzana	Labourer
17	Modibo	Djire	Cinzana	Tractor driver
18	Sada	Diawara	Cinzana	Tractor driver
19	Aliou	Dembele	Cinzana	Foreman-assistant
20	Baba	Traore	Sotuba	Tech. assistant
21	Aissata	Dembele	Sotuba	Typist
22	Bourama	Diarra	Sotuba	Labourer
23	Abdoulaye	Doumbia	Sotuba	Accountant-clerk
24	Zan	Traore	Sotuba	Driver
25	Bakary	Sogoba	Sotuba	Accountant
26	Kalifa	Bagayoko	Sotuba	Driver
27	Zoumana	Coulibaly	Sotuba	Labourer
28	Guedouma	Traore	Sotuba	Guardian
29	Moridie	Doumbia	Sotuba	Labourer
30	Moussa Doumbia N.1		Sotuba	Labourer
31	Mory	Traore	Sotuba	Tech. assistant
32	Abdoulaye	Traore	Sotuba	Tech. assistant

ANNEX F

SHORT-TERM TECHNICAL ASSISTANCE AND VISITS By Other ICRISAT Personnel

ANNEX F

SHORT-TERM TECHNICAL ASSISTANCE AND VISITS
By Other ICRISAT Personnel

Part 1. Consulting Services Acquired Phase II with ICRISAT/Mali Funds

PERSONS	DATE	ACTIVITY
a. Buri & Associates	Jan. 1982	Extensive hydrological surveys of region surrounding the Cinzana Station. They located the Douna well site.
b. Bassirou Keita & Associates (Bamako)	Apr. 82 to Dec. 82	Soil survey and soil characterization of the Cinzana station.
c. Bassirou Keita & Associates (Bamako)	Oct. 81 to Dec. 81	Extensive hydrological survey of static well levels in villages surrounding the Cinzana station
d. DET - Ousmane Coulibaly	June 82 to Nov. 83	Village level socio-economic surveys of villages surrounding the Cinzana station
e. Trey Richardson & Mamadou Doumbia	Jan. 83 to Oct. 83	Data processing and computer analysis analysis of ICRISAT/Mali agronomic data
f. Michael O'Neill (IC/Mali covers local expenses)	Dec. 82 to Dec. 83	Post-doctoral appointment, Installation and calibration of irrigated line source gradent fields at the Cinzana station.

Part 2. Backstopping and visits by ICRISAT/Centre and Regional Scientists

PERSONS	DATE	ACTIVITY
1. Dr. R.K. Bansal (I/C)	Jan.-Feb. 81 Aug. 82	Animal traction, Machinery design and adaptation. for Mali.
2. B.K. Sharma (1/C)	July 81	Early Station planning of Cinzana Station.
3. Anand Kumer (I/N) and Sc. Gupta (I/S)	Sept. 80 Sept. 83	Evaluation of millet program and exchange of materials.
4. J. Peacock (I/C)	Sept. 80 Sept. 83	Evaluation of millet and sorghum physiology work.
5. D.N. Andrews (I/C)	Sept. 80 Sept. 83	Evaluation of millet program.
6. H. Veirich (I/UV)	Oct. 83	Farmer level interviews with farmers growing Eleusine corocana for the first time.
7. W. Stoop (Dutch Royal Tropical Institute)	Sept. 80 Sept. 81 Sept. 82	Technical support to the agronomy program.
8. C.R. Jackson (I/C)	Aug. 83	Provided review of ICRISAT/Mali and helped solve management questions.
9. K.N. Murty (I/C)	Nov. 83	Provided support in streamlining financial and management procedures.
10. B. Gilliver (I/C)	Apr. 81 Apr. 82 Sept. 83	Provided statistical backstopping to the ICRISAT/Mali program and to the SRCVO programs.
11. J. McIntire (I/N)	Fall 82	Helped in conceptualization of farm-level socio-economic surveys, data analysis in Niamey.

GEOGRAPHIC CODE:

I/C: ICRISAT Center, Hyderabad
I/N: ICRISAT Regional Center, Niamey (Sahelian Center)
I/S: ICRISAT, Senegal
I/UV: ICRISAT, Upper Volta