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BY SMALL FARMERS IN SUBSAHARAN AFRICA: THE CASE OF NEW
VARIETIES OF COWPEAS AROUND THE AGRICULTURAL RESEARCH
STATION OF CINZANA, MALI

presented by

Ousmane N. Coulibaly

has been accepted towards fulfillment
of the requirements for

Master's degree in Agricultural Economics


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**FACTORS AFFECTING ADOPTION OF AGRICULTURAL TECHNOLOGIES
BY SMALL FARMERS IN SUBSAHARAN AFRICA:
THE CASE OF NEW VARIETIES OF COWPEAS AROUND THE AGRICULTURAL
RESEARCH STATION OF CINZANA, MALI**

by

Ousmane Nafolo Coulibaly

A THESIS

**Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of
Master of Science**

Department of Agricultural Economics

1987

ABSTRACT

**FACTORS AFFECTING ADOPTION OF AGRICULTURAL TECHNOLOGIES
BY SMALL FARMERS IN SUBSAHARAN AFRICA:
THE CASE OF NEW VARIETIES OF COWPEAS AROUND THE AGRICULTURAL
RESEARCH STATION OF CINZANA, MALI**

By

Ousmane Nafolo Coulibaly

Body of Abstract

This study analyzes factors affecting farmers' rapid adoption of new varieties of cowpeas around the agricultural research station of Cinzana, their impact on the farming systems in the area, and how technology generation and diffusion in the area could be improved. Diffusion of the varieties occurred outside of the formal research/pre-extension/extension channel and was backed by a project that supplied inputs and animal traction equipment on credit. The results of the study show that agricultural technology is quickly adopted by farmers if it:

- addresses a major constraint faced by farmers (e.g., early maturing varieties for erratic rainfall conditions).**
- is profitable and backed by appropriate institutions (adequate input supply, credit, remunerative prices, etc.).**

Input-tied credit has been very important in adoption because of the lack of input markets and cash flow, constraints in the area. Access to output markets and remunerative prices will be key factors influencing future adoption.

To the memories of

**Lonia Coulibaly
Harouna Diarra**

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LIST OF ACRONYMS

CGIAR	Consultative Group for International Agricultural Research
CIP	International Potato Center
CILSS	Comité Interétat de Lutte Contre la Secheresse au Sahel
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
DRA	Division de la Recherche Agronomique (IER)
DRSPR	Division de la Recherche sur les Systemes de Production Rurale (IER)
FAO	Food and Agriculture Organization
FED	Fonds Européen de Développement
FDVS	Fonds de Developpement Villageois de Segou
ICARDA	International Center for Arid and Desert Agriculture
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDRC	International Development Research Centre (Canada)
IER	Institut d'Economie Rurale (Mali)
IITA	International Institute for Tropical Agriculture
ILCA	International Livestock Centre for Africa
ILRAD	International Laboratory for Research on Animal Diseases
IRAT	Institut de Recherche Agronomique Tropicale
IRCT	Institut de Recherche sur les Culture Cotonieres
IRHO	Institut de Recherche sur les Huiles et Oleagineux
IRRI	International Rice Research Institute
LDC's	Less Developed Countries
SAFGRAD	Semi-Arid Food Grain Research and Development
OACV	Operation Arachide et Cultures Vivrieres
OHV	Operation Haute Vallee
PAR	Point d'Appui et de Recherche
PEP	Point d'Experimentation Permanent
USAID	United States Agency for International Development

CHAPTER 1

INTRODUCTION

Food deficits have been one of the most important concerns in Subsaharan Africa since the 1970's. Those food shortages are mainly explained by erratic weather fluctuations, poor soils and food crop technologies, and weak agricultural policies (strong extension versus research; bad linkages between research, extension, and farmers; deficient marketing and price policies; and a colonial heritage of a research program heavily focused on cash crops rather than food crops.) In addition to the problem of food supply, hunger and malnutrition are also caused by very low incomes. According to Eicher (1984), hunger and malnutrition occur even in areas where per capita food production is not declining because the poor do not have income to obtain enough food. The solutions to Subsaharan Africa's food deficits will be to increase the supply of food and the purchasing power for its population by increasing their real incomes. To increase food production and incomes in Subsaharan Africa, and especially in the Sahel, where agro-ecological environments are very harsh (World Bank, 1985), adequate technologies have to be generated in a cost-effective way and be sustained by supporting institutions (credit, supply of inputs, markets for outputs, extension services, etc.) compatible with the objectives and socio-economic environments of rural and urban populations. Among the technologies that have been tried are the introduction of hybrid varieties of food crops into the Sahelian farming systems for "transferring green revolution technology to Africa." Such direct transfer of green revolution seeds as sorghum varieties from India to the Sahel has not performed well (Eicher and Baker, 1982).

Steps have been taken to identify, test, and screen some promising local and imported varieties in order to adapt them to the Sahelian agroclimatic environment (poor rainfalls and soils, diseases, weeds, etc.)

In Mali, research efforts on rainfed food crops have been focused on on-station tests of improved local varieties of millet, sorghum, maize and cowpeas. An illustration of such efforts is the creation and funding of the agricultural research station of Cinzana in 1979 by the government of Mali, the Ciba-Geigy Foundation (Switzerland), and ICRISAT Mali/USAID. The research station was established in Central Mali to carry out breeding, screening, and testing of local and imported varieties of millet, sorghum, and cowpeas and to assess yield responses to different agronomic practices. The "successful" on-station results are tested through multilocal researcher-managed trials on farmers' fields by SAFGRAD (Semi-Arid Food Grain Research and Development) and diffused to farmers by extension agencies. Such "top-down" generation and diffusion of technologies in general in Mali has had few impacts on farmers as far as adoption is concerned. Adoption of agricultural technologies generated from research stations has become a very important concern in Malian agricultural development, and this study will analyze the issue by presenting a case study of the adoption of new varieties of cowpeas by farmers in the Cinzana region of Mali.

Problem Statement and Setting

Since 1983 farmers who reside around the agricultural research station of Cinzana, many of whom work part time for the station, have been aware of the early-maturing characteristics of some improved local varieties (new varieties) of cowpeas on tests at the researcher-managed plots on the station. Some of the workers took seeds from the research plots for use on their own fields and tested them. The results confirmed the precocity of the varieties, which is a good characteristic for a semi-arid zone such as Cinzana, where rainfalls are irregular and low (600-700 mm/year). A diffusion process started from the research station to the surrounding villages. This process occurred outside the formal channel of research/pre-extension/extension. Farmers first adopted two varieties of

cowpeas: KNI (Kamboinze no. 1 from Burkina Faso) and TN 8863 (TARNA no. 8863 from Niger) and later Gorom-gorom and TVX 3236 from IITA in Nigeria.

At the research station the improved varieties of cowpeas were tested for yields and environmental stress resistance through a food legume program supported by IDRC (International Development Research Centre of Canada) and the Government of Mali. In 1985, an integrated rural development project to increase cereal production in the Segou area was set up in Cinzana to supply farmers with animal traction equipment, insecticides, and fertilizer on a credit basis, and services such as non-formal adult education, extension, monitoring and evaluation, and health services for both humans and draft animals. This credit program, which aimed to increase food production into the area, played a key role in increasing the rate of adoption of new varieties of cowpeas in villages with access to credit. Particularly important was the provision of insecticides for cowpea treatment, as the new varieties are very sensitive to insects and disease. Thanks to the early maturing characteristic and the supply of a critical input (insecticides) that was not available on the market, the areas cropped in the new varieties in 50 villages around Cinzana increased from 80 ha in 1984 to 1200 ha in 1986. This quick adoption and diffusion of new varieties of cowpeas provide a case study of the key factors affecting adoption of an innovation, which may be useful in shaping technology generation from the research station. This study will examine the reasons for and the constraints to adoption of these new cowpea varieties in order to get a better understanding of farmer behavior toward new technologies.

According to Chapman (1983), a good measure of the degree of success for an innovation or cropping system research program carried out in an area is the extent to which the results are adopted by farmers. The new technologies emerging from a research station may not be appropriate to farm agroclimatic or

socioeconomic conditions or to farmers' objectives or need some institutional support to sustain their adoption. A careful study of farmers' environment, the technology itself and the required institutions to sustain the technology can help avoid mistakes leading to rejection by farmers of the innovation or some components of the proposed packages.

Objectives of The Study

The objectives of the study are:

1. To develop a conceptual framework of factors affecting adoption of agricultural innovations by farmers in low-income countries such as Mali.
2. To understand how improved varieties of cowpeas in test plots on research stations have been adopted and diffused to villages surrounding the research station of Cinzana.
3. To examine the role and importance of institutions such as the credit system, extension, and input and output markets in affecting farmers' decisions to adopt and continue to use improved varieties of cowpeas in the Cinzana area.
4. To carry out an economic analysis of adoption in order to understand the reasons farmers adopted in a given time only some parts of the proposed technological package rather than the total package.
5. To assess the impact of the new varieties of cowpeas on the farming system in the Cinzana area and on farmers' incomes and food security.
6. To make general recommendations for the agricultural research in order to generate more appropriate technologies and for institutional support to meet the needs of farmers in adoption of future innovations.

Organization of the Study

The thesis can be broken down into 8 chapters. Chapter 1 describes the technology generation process that occurs through agricultural research in

Subsaharan Africa and Mali. Chapter 2 is a literature review on the process of adopting technologies by farmers and the factors affecting adoption. In Chapter 3 we describe in detail how the data on which this thesis is based were collected in both 1982-84 and 1986. Chapter 4 gives a summary of findings from the 1982-84 data collection, which is important in understanding the farming systems (constraints) before the advent of the new varieties of cowpeas. In Chapter 5 the process of adoption of new varieties of cowpeas is analyzed, with a focus on factors affecting adoption. Chapter 6 presents an economic analysis of the costs and benefits to farmers of adopting new varieties of cowpeas and illustrates the logic of farmers' not adopting the entire package. Chapter 7 describes the impact of new varieties of cowpeas on the farming systems in the Cinzana. And finally, Chapter 8 presents the conclusions and the recommendations for better technology generation and diffusion in Mali and elsewhere in Subsaharan Africa.

**Agricultural Research and Technological Change
in Subsaharan Africa and Mali**

Access to food is now a tremendous and continuing problem in Subsaharan Africa. According to Oyer, food production is influenced by several factors, including the available physical and biological resources; the milieu for the initiation, development, testing, and delivery of new and improved technology appropriate to a given environment (local research and extension institutions); national government policies relative to incentives for farmers to produce more food (availability and prices of inputs and outputs, storage costs, transportation); and regional and international institutions to facilitate the generation and transfer of technology.

The increase in agricultural productivity is more than a necessity in LDC countries where food production is outstripped by population growth. As Schultz (1964) argues, comparatively few significant inefficiencies exist in traditional agriculture, so that it does not pay to reallocate the factors of production already

existing at the small-farm level or to apply more units of traditional inputs. New technologies (improved varieties of seeds, farm equipment, chemical inputs and new farm management practices) are needed to overcome climatological, physical, and labor constraints at the farm level. These technologies have to be profitable for farmers, compatible with their environment (socioeconomic, cultural, etc.) and sustained by an adequate institutional support for extension, input delivery, infrastructure for transportation and storage and markets for output.

Agricultural Technology and Technological Change

According to CIMMYT, a technology is "... a combination of all the management practices for producing or storing a crop or crop mixture. Each practice is defined by the timing, amount, and type of various technological components such as varieties, land preparation, fertilizer, or weeding."

Agricultural technology can be divided into three main types: biochemical, mechanical, and combinations of the two. Biochemical technologies involve both the chemicals and new plants such as crop varieties. These biochemical technologies have physiological effect in increasing timeliness of operations (Dalrymple). Mechanical technologies involve improved equipment.

Most research in Sub-Saharan Africa has been focused on research stations, where the development of new technologies is done under controlled conditions. Promising technological components are refined and sent to farmers through extension channels. This method of technology generation is often inappropriate because it fails to take into consideration on-farm constraints and objectives as a guide for experiment station research. Steps have been taken by international research centers (IRRI, CIMMYT, ICRISAT, IITA, CIAT, ILCA) and many countries including Mali to move toward more integrated agricultural research at the farm and agricultural station levels in what is called "Farming Systems Research." The technologies generated from this integrated on-farm and station research are

supposed to reflect farmers' reality (physical and socio-economic environment) and be appropriate to them. As CIMMYT found out, "Information from on-farm research aggregated over several regions can help establish broad priorities for the experiment station work." The information on farmers circumstances and the associated risks as well as the types of farmers that would benefit from each technology is important in generating adequate technologies.

Agricultural Research in Sub-Saharan Africa

Agricultural research plays an important role in the overall processes of agricultural production by identifying and providing the limiting element, ingredient, or practice constraining food production. Agricultural research in Sub-Saharan Africa has focused on developing improved varieties of crops; on agronomic practices such as application of chemical fertilizer, fungicides, insecticides; and on mechanical technology, including animal traction and tractor mechanization (Eicher and Baker, 1982). Most of this research has been carried out on station in very controlled situations, with trials designed to evaluate crops' physical performance as measured by yield responses to different levels of inputs, level and stability of yields, and resistance to different environmental stresses (drought, heat, pests, and diseases).

The research is done through two channels: The national agricultural research system and the International Agricultural Research Centers, which operate through bilateral or multilateral cooperation programs with countries or regions.

National Agricultural Research System

Each country has its national agricultural research network, sponsored primarily by the government and to some extent by external donors. One of the main problems in national research systems is the conflict between the research mandate and the amount of physical, financial, and human resources available to

carry out the proposed research program. Most of the research is done at research stations located in different agroclimatic locations and are commodity oriented. Some general problems faced by agricultural research in Sub-Saharan Africa are:

- The scarcity of funding and of well-qualified researchers and the lack of incentives to maintain the few good researchers from leaving agricultural research for other opportunities. Training scientists and giving them incentives to work are necessary for any agricultural research network.
- The poorly designed research system, which often has few linkages with extension and faces severe institutional problems (Evenson, 1986). For example, many research systems lack standards of research conduct and cannot weed out incompetents.
- The over reliance on the "diffusion" or "technology transfer" model of development, which is one reason why research systems in Sub-Saharan Africa have failed to generate a large enough stock of appropriate technology for farmers (Spencer, 1985).
- The lack of political back-up to research and research institutions. Support is often lacking because research results are neither short-term products nor directly "visible", as are "crash food" projects. Most of the efforts are focused on extension, aimed at achieving quick technology transfers. There is also a lack of early, systematic and critical feedback from farmers to breeders (Spencer, 1985; Matlon, 1983).

International Agricultural Research Centers

The International Agricultural Research Centers, such as ICRISAT (India), IRRI (Philippines), IITA (Nigeria), CIAT (Columbia), CIMMYT (Mexico), and ICARDA (Syria), are in the forefront of breeding efforts on world food crops. Others such as ILCA (Ethiopia) and ILRAD (Kenya) carry out research on

livestock.

Each center has a mandate for one or more important food crops, and some have a regional mandate for several crops in a specified geopolitical area (Munger and Coffman). The centers are supported through the Consultative Group for International Agricultural Research (CGIAR). This effort to increase many research centers underscores the desire of donors to provide long-term support for agricultural research in LDC's. Each center has a very well-supported program for breeding and other disciplinary fields. The achievements of two of these centers (IRRI, CIMMYT) have been recognized since the release of new varieties of rice and wheat into the 1960's to start the "Green Revolution" in Asia. Some centers (ICRISAT, IITA) operating in West Africa have done important work on sorghum, cowpea, and bean breeding and collaborative programs with national research institutes, including short and long-term training. Despite these efforts, more collaboration between international and national research centers is necessary. The collaboration will lead to more exchange of knowledge between scientists and to better integration of local conditions (physical, biological, socio-economic) into the generation of appropriate technologies for rural development.

Agricultural Research in Mali

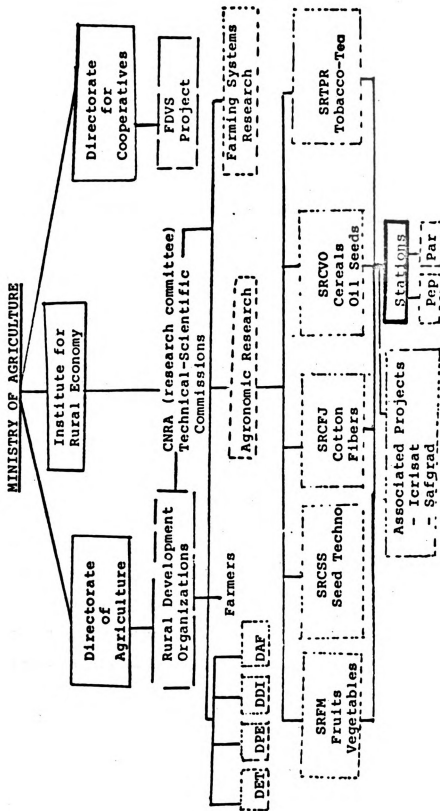
Agriculture is the most important activity in the Malian economy, and more than 85% of the population lives in rural areas. Agriculture and livestock exports provide 75% of the foreign exchange earned by Mali (USAID, 1985). Malian agriculture faces harsh climatic conditions with droughts, poor management of the state organizations involved in agriculture, and other financial crises linked to international and national economic problems. Agricultural research, as in many former colonies, has historically been heavily focused on cash crops for exports (cotton and groundnuts). Until the late 1970's, when the control of all research was taken by Malian researchers and institutions, the research was run mainly by

French research organizations such as IRCT for cotton, IRHO for groundnuts, and IRAT for food crops.

All agricultural research in Mali is conducted under the Institut d'Economie Rurale, created in 1962. IER has seven divisions (See Figure 1.1), of which two are concerned with agronomic and breeding research. The Agronomic Research Division (DRA) is the largest division, accounting for 78% of the entire IER staff, and carries out on-station commodity research. The Farming Systems Division (DRSPR) was created in 1976 to determine productivity, farm incomes, and the level of technology of existing cropping systems in order to assess the impact of new techniques. DRSPR tests new technologies at the research station of Tierouala and on farmers' fields. In 1986 DRSPR extended its activities to the OHV zone of Central Mali.

FIGURE 1-1

ORGANIZATION OF AGRICULTURAL RESEARCH
AND EXTENSION IN MALI



National Agricultural Research

Agricultural research is carried out on commodity-oriented research stations. The main stations, which are shown in Figure 1.2, are: Kogoni (rice, wheat), Mopti (rice), Same (dry and irrigated crops), Sotuba (millet, sorghum, maize, cowpeas), Cinzana (millet, sorghum, cowpeas, groundnut), Dire (wheat), N'tarla (cotton and fibers) and Finkolo (tea). There are many sub-stations where trials are carried out by research on PEP (Permanent Experimental Points) and PAR (Point d'Appui et de Recherche) for multilocal tests under different climatic conditions.

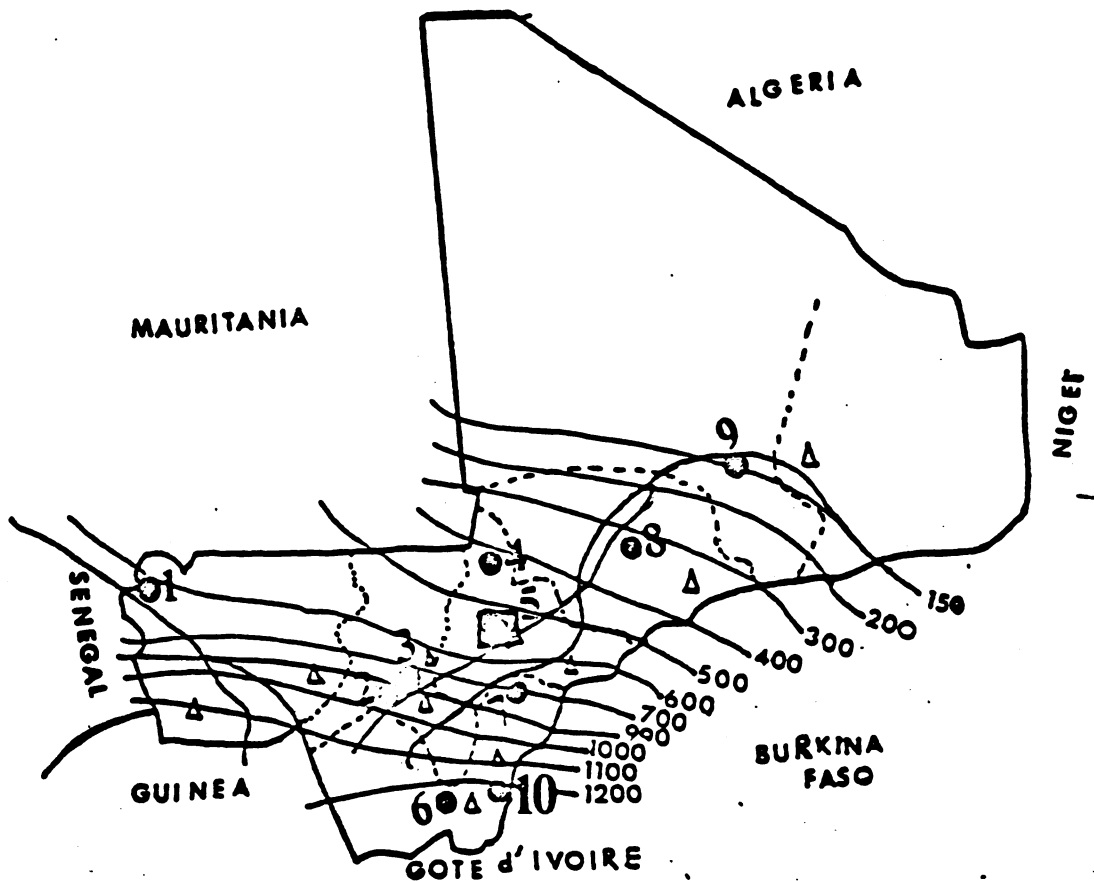
The research programs focus on variety trials for superior yields and for resistance to diseases, drought, and insects. Fertilizer trials are very important on stations and substations, and emphasis has been placed on animal traction and different kinds of cropping techniques.

The national agricultural research programs are backed by international and regional institutions and donor efforts. The leading institutions for this collaborative effort are: ICRISAT (International Crops Research Institute for Semi-Arid Tropics), IDRC, Ciba Geigy Foundation (a Swiss Foundation that co-finances the station at Cinzana); USAID (which sponsors ICRISAT, SAFGRAD, farming systems research in OHV, and other research programs), CILSS (Comité Interétat de Lutte contre La Secheresse au Sahel), FED (Fonds Européen de Développement) France, Canada, and the Netherlands.

Cooperative Programs for Research

Collaborative efforts to back and strengthen national agricultural research are done by international agencies and donors through cooperative programs by sponsorship of research programs and training of national research staff. An example of this collaborative research is the program of ICRISAT/Mali, which has

**FIGURE 1-2: LOCATION OF AGRICULTURAL RESEARCH STATIONS
IN MALI**



● RESEARCH STATION

▲ SUB STATION

- | | |
|-----------|-------------|
| 1 Same | 6 Tierouala |
| 2 Bamako | 7 NTarla |
| 3 Sotuba | 8 Mopti |
| 4 Kogoni | 9 Dire |
| 5 Cinzana | 10 Finkolo |

SOURCE: adapted from "farming systems research and extension"
Project Paper USAID Mali 1985

been carrying out trials on the introduction to Mali of improved varieties of crops from the ICRISAT Center in Hyderabad, India. This program involves four activities:

- Crop breeding (millet, sorghum) for developing improved varieties.
- Developing improved agronomic techniques (intercropping, improved animal traction techniques, etc.)
- Laboratory analysis and taste tests for the grain quality of improved varieties of millet, sorghum and cowpeas.
- Short-term and long-term training at the ICRISAT Center in India and in the USA.

Other collaborative programs are done with CILSS for Integrated Pest Management, IDRC for cowpea varietal and agronomic practices research at Sotuba and farming systems research in Sikasso. IITA and the ICRISAT Center serve as sources of germ plasm for cowpeas, maize, sorghum, and millet.

Recommendation Process: The research results are discussed and approved by annual national "commissions" and biannual national "Committee for Agricultural Research" on a commodity basis before recommendation to farmers through the extension agencies called ODR (Operaiton de Developpement Rural). The on-station research results are tested on-farm on a multilocal basis by SAFGRAD for performance (yield's resistance to pests and disease, etc.) before final recommendation to ODRs and then to farmers.

CHAPTER 2

REVIEW OF THE LITERATURE ON AGRICULTURAL TECHNOLOGY ADOPTION

Adoption Process of Agricultural Innovations

Interest in the adoption of innovations has been manifested by anthropologists, sociologists, communication specialists, and market researchers. According to Rogers (1974), the crucial elements in the diffusion of new ideas are the innovation itself, the communications channels, the time framework, and the members of the social system who are adopting.

The success of any rural development program depends upon the efficiency with which new ideas are formulated and disseminated to the farmer. Most of the literature on diffusion and adoption of innovations has been summarized by Rogers and Shoemaker (1971). Misra (1968) noted that most of the studies done on diffusion are descriptive and their theoretical value has been questioned seriously. Many diffusion studies do not take into consideration the differing profitability of different innovations and of the same innovation in different circumstances.

Stages in the Adoption Process

Wilkening (1952), Rogers and Shoemaker, Lionberger (1960) and others have described various stages in the adoption process of innovation. Wilkening (1952) was the first to recognize this process in specific terms and defined adoption as "a process composed of learning, deciding, and acting over a period of time. The adoption of a specific practice is not the result of a single decision to act but of a series of actions and thought decisions."

The common stages defined by rural sociologists and communication scientists to analyse adoption process are:

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adoption define?*

Awareness. Awareness or knowledge occurs when an individual is exposed to the innovation's existence and gains some understanding of how it works. Rogers adds that knowing about an innovation is often quite different from using the idea. The reason for knowing and not adopting is linked to the relevance of the innovation to one's situation, to its characteristics and to the socio-economic conditions.

Persuasion or Interest-Information. The individual becomes interested and forms favorable or unfavorable attitudes toward the innovation.

Evaluation-Application Decision. After securing sufficient information about the innovation, the individual evaluates its applicability to his situation and makes the decision to try it or not. He or she makes a cost-benefit analysis (economic, social, and cultural) and looks to the pros and cons of adoption.

Trial. The new practice is used on a small scale to validate its workability on the farmer's own field. After evaluation of the innovation, the individual accepts or rejects it. Most of the time the individual might have already seen the use of the innovation elsewhere.

In the trial stage the farmer is the unique decision maker. Generally a farmer is reluctant to adopt any innovation that has been successful in others' fields without trial experimentation with the innovation himself. According to Misra many farmers can jump from the stage of evaluation to adoption on one condition: the usefulness of the technology is beyond doubt.

Adoption. After successful trials, the farmer commits himself to adopt the innovation and continues to use it if incentives exist. Sometimes adoption can require big changes in a farming system, but most farmers adopt gradually and continue to maintain a balance between the old and the new system.

The process described above is a theoretical ideal. In practice, these stages are difficult to distinguish and can be short or long depending on the farmer. In addition, in practice some steps can be skipped.

Discontinuance. Another stage can be the decision to cease the use of innovation after previously adopting it. Discontinuance has been little investigated despite its importance in diffusion behavior. Some authors such as Leuthord, cited by Rogers and Shoemaker (1971), point out that the rate of discontinuance is just as important as the rate of adoption in determining the level of adoption of an innovation at any time.

The stages of adoption are important for technology designers and extension agencies, which should be aware of this process for a better understanding of farmers' behavior in adopting or rejecting an innovation.

Typologies of Adopters

The adoption of an innovation does not occur at the same time for all farmers. MacDonald (1976) noted that once an innovation is accepted and utilized by some members of a social unit, the users can serve as sources of information for those who have not accepted it. The process of adoption is finished when the maximum number of persons who could use an innovation are effectively doing so.

Farmers can be divided into two groups on the basis of acceptance of the innovation. These groups are called adopters and non-adopters, or users and non-users, according to MacDonald. The two groups can be broken down into subgroups given their willingness to continue adoption or discontinue it. Another typology uses the moment of effective adoption. The idea behind this typology is that the percentage of effective adoption is recorded from the moment of introduction until the innovation has been adopted by the total group of farmers.

Many authors, including Rogers, MacDonald, and Lionberger have set up categories of adopters given the time of adoption. The most widely used classification is from Rogers, which has four categories:

Innovators. According to Rogers, the main characteristic of innovators is their venturesomeness to try new ideas. They are risk bearers and financially powerful

enough to absorb the possible loss due to an unprofitable innovation, and they have the ability to understand and apply complex technical knowledge. Ragaswamy et al., (1972), however, noted that innovators are often so different from the average farmers that they do not serve as a "model" for the majority of later adopters.

Early Adopters. They are ahead of the average adopters. Their adoption behavior is followed by other farmers. They are generally called "the men to check with" before using a new idea and are considered as key persons for changes.

Early Majority and Late Majority. They are average farmers and can be divided into two subgroups: the early majority and the late majority. These classes constitute more than 60% of adopters. Adoption may be both an economic necessity and the answer to increasing social pressure.

Laggards. The laggards are the last portion of farmers to adopt the innovation. They are generally more suspicious about the innovations, the innovators, and the change institutions. They are more risk averse. Their adoption will lag far behind the knowledge of the idea (information or innovation).

Some authors, such as Lionberger, broke down adopters into three categories: Early Adopters, the Majority and the Late Adopters. The adoption curve is typically S-shaped, as illustrated by the adoption pattern for hybrid corn in the United States.

Factors Affecting Adoption of an Agricultural Innovation

The factors affecting the adoption rate of innovations have been widely documented. Among the well-known studies are those done by Ryan and Gross (1943) on the adoption of hybrid seed corn in two Iowa communities, where they found that the profitability of hybrid corn compared to other varieties accounted for its rapid diffusion. Clark and Akinbode (1968) found that economic gains were the main incentives for Western Nigerian farmers' adoption of agricultural innovations. Sinha and Bhasin (1968) found that high costs of resources, lack of

money, and irregular supply of inputs are the main causes of low rates of adoption of innovations. Gerhart (1975) has shown correlations between education, knowledge of credit, availability of inputs, extension visits, and adoption.

The results from these different findings give two key elements as factors affecting the adoption of any innovation:

- The relative advantage of the innovation
- The characteristics of the adopters

The Relative Advantage of the Innovation

Relative advantage includes many factors such as profitability, the characteristics of the innovation itself, the agroclimatic conditions and the institutional support to sustain the innovation.

Profitability

Profitability can derive from better productivity (lower cost per unit), a better quality or a combination of these. Griliches (1957) explained about 30% of the variation in the rate of adoption of hybrid corn on the basis of profitability. Stevens and Jabara (forthcoming) state that "Farmers adopt new technologies and institutional arrangements that are profitable." MacDonald adds socio-psychological benefits such as social benefits or a positive change in status within the social unit and better social opportunities.

The Characteristics of the Innovation Itself

Compatibility. Compatibility refers to the consistency of an innovation with existing ideas and beliefs regarding the farming system of the society. It is the relationship between the innovation, the environment (physical, social, cultural), the farmer experiences, and the needs of members of a social unit (MacDonald). The greater the congruence, the greater will be the adoption of an innovation. Future adopters will have apprehension regarding the innovation if some failure occurred in the past. The compatibility also is measured by the degree to which it

*Economic
aspects*

*Technical
aspects*

meets a need felt by adopters. This criterion is important for our present study on cowpeas.

Complexity. Complexity refers to the degree to which an innovation is perceived as relatively difficult to understand and use, and is negatively correlated to its rate of adoption. This negative relationship has been documented by Kivlin (1960). Innovation technicity should match the technical level of farmers.

Triability or Divisibility. This refers to the possibility of testing an innovation on a small scale in order to assess its results before adopting it on a larger scale. An innovation that is triable is less uncertain for adoption. Varieties of crops are divisible and easier to try on small scale. Ryan and Gross (1943) demonstrated that triability is more important for earlier adopters than late ones. Later adopters will follow if the innovators and earlier adopters succeed.

Observability or Communicability. This refers to the extent to which it is possible to visualize the results of an innovation. The more visible the functioning of an innovation is, the easier its acceptance will be.

Risk. Risk attitudes toward adoption of an innovation have been underlined by many authors, including Wharton (1969) and Walker (1980). Aversion to risk can constitute a serious impediment to adoption. A technology is quickly adopted if less risky, but farmers are considered to be risk averse in LDC's. Norman et al. (1981) in their literature review on semi-arid farm and village production systems, found that attitudes to risk and uncertainty influence both the goals that farmers follow and the different technologies they are likely to adopt. As risk measurement, Norman et al. considered price variability and yield variations as proxies. To minimize risk farmers do mixed cropping or traditional spatial scattering of fields to account for varying soils, insects, and disease conditions.

The Agro-Climatic Conditions

Aspects of the physical environment, including soil types, climate, insect

and diseases existence, etc., are important in decisions to adopt innovations. Bernstein (1980) recognized that few technologies are environmentally neutral. In subsistence agriculture, low resources are also bounded by agro-climatic conditions, where yields are more dependent on rainfall and soil fertility. This factor is especially important for Sahelian countries like Mali, where yields of semi-arid crops are mainly determined by rainfalls. Gladwin (1979) found in Mexico that land quality is important in explaining adoption decisions. The agro-climatic environment is as important as the socioeconomic environment in farmer's decisions to adopt agricultural innovations.

Institutional Support

Adequate institutional support has been recognized as necessary for adoption of agricultural innovations by many researchers. Among these scholars are Tesfai (1975), who came to the conclusion that availability of credit, extension contacts, land ownership, and availability of inputs were important in explaining adoption of new agricultural practices by Ethiopian farmers. The same results were obtained by Gafsi (1976) for Tunisian farmers. Government policies for extension, the credit system, prices and the tax system can be incentives or disincentives for adoption of agricultural innovations by farmers. Credit, availability of inputs, markets for outputs and the level of prices, and extension information are the main components of institutional support.

Credit. Agricultural credit can be available to farmers through non-formal sources such as village moneylenders or through formal credit institutions. The need for credit is important because innovations often require additional investment in equipment, seeds, fertilizers, pesticides, etc. The lack of financial resources may constrain small farms from purchasing these inputs on a cash basis, even if they are available. In many agricultural development projects, inputs are supplied through input-tied credit programs to solve the problems of non-

availability of these resources on the local market. The performance of the credit system is very important and can sustain adoption.

Availability of Inputs. Input availability at the right time and place affects the rate of adoption. Agricultural innovations tend to be embodied in inputs which can be efficiently provided by markets (Timmer, et al, 1984), but the markets do not always exist or need to be strengthened if they do exist.

Markets for Outputs and the Price Level. Lack of access to markets is recognized to be a major barrier to adoption if the increase in output that occurs through technological change is not absorbed by an adequate market. The effective demand for the crop is very important, and the price expectations as well as the reliability and efficiency of the market organization can be a major determinant in production decision making as well (Cleave, 1977). Prices should compensate production efforts and give incentives to farmers to continue adoption. Adoption of productivity-increasing technology (fertilizer, new varieties, etc.) should be sustained by identification of new output markets. Infrastructure for transportation and storage is necessary to facilitate moving the product from the farmgate to consumers without big losses.

Extension Services. Relevant information on the innovation and the extension contacts between farmers and extension agencies are positively related to adoption. Falusi (1973) found lack of sufficient knowledge about fertilizers reduced their adoption of agricultural practices in his Nigerian study. Extension is combined with adult training to facilitate the understanding of the proposed package of technology to farmers.

The Characteristics of the Adopters

According to the literature on the diffusion of innovations, some characteristics and attitudes of farmers have been influential in their adoption behavior. Among the personal characteristics of farmers, formal education, age,

farm size, labor availability, income, extension visits, and contact with the market have been the most frequently cited factors contributing in adoption of innovations.

Many researchers found correlations between these variables and the innovativeness or rate of adoption. Gerhart, in his study of the spread of hybrid maize in Kenya, found formal education, knowledge of credit, availability of inputs, extension visits, farm income, and attendance at training courses were positively and significantly correlated with adoption of innovations by farmers.

Dalrymple has shown that farmers who are more apt to adopt new practices are among the more economically favored. Hodgdon (1974), in his study of Indian farmers, found that situational variables such as size of holdings and availability of productive resources at the farm level are positively associated with adoption. Some researchers also found no significant correlation between these socioeconomic variables and adoption. Among those scholars are Matura (1973), who showed in his study of coffee farmers in Trinidad no relationship between age, education, and adoption of farm practices.

CHAPTER 3

THE RESEARCH METHODOLOGY

The data used in this thesis were collected by the author in two sequences. The first data collection occurred in 1982-84 as part of an effort to collect baseline information in villages around the agricultural research station of Cinzana. This appraisal of the farming techniques, input-output flows, labor allocation to crops from households, etc., was carried out in order to help biological scientists set up the station's research agenda.

The second sequence occurred in 1986 to assess the factors affecting the rapid adoption of new varieties of cowpeas by farmers in the same area (around the Agricultural Research Station of Cinzana). Besides the formal farm survey and trials in 1986, purposive interviews were held with biological scientists working on the station, the staff of the FDVS (Fonds de Developpement Villageois de Segou) project in charge of input supply through credit and extension services, the village-level cooperative members, cowpea traders, and food saleswomen and housewives for more information on cowpea production, marketing, and cooking.

1982-84 Farm Survey

In 1982 a farm survey was initiated by ICRISAT/Mali and executed by the Division d'Etudes Techniques (DET) of the Institut d'Economie Rurale to collect baseline farm level data around the new Agricultural Research Station of Cinzana (Figure 1.2). The results of this survey were summarized in four reports (Coulibaly and Coulibaly, 1982, 1983, 1984). The following data collection procedure was used:

Sample Villages

To choose the sample villages, a presurvey was carried out in 1981 for one month over eleven villages surrounding the new research station site of Cinzana, from one to twenty kilometers from the site. Interviews were held with village

chiefs and randomly with household heads within the villages to collect data on animal traction use, types of crops and soils, etc. A sample of four villages was chosen (Table 3.1) given the criteria of main type of cereal cropped, type of soils, and distance from the research station. These criteria were important for the future programs of the research station, whose main focus is on breeding and agronomic techniques for semi-arid cereals (millet and sorghum) and other semi-arid crops (groundnuts, cowpeas, bambara nuts, etc), and for monitoring of the impact of the research station on the nearby farming systems.

Table 3.1. Characteristics of the Villages in the 1982-84 Sample

Villages	Main Type of Soils	Main Type of Cereal Crop	Distance From the Station Site
Kodian	Tientien* (sandy)	millet	3
Sinebougou	Tientien (sandy)	millet	15
Djambougou	Boua** (clay)	sorghum	16
Samine	Tientien/Boua (sand/clay)	sorghum	25

* Tientien is the local name given by farmers to sandy soils (light).

** Boua is the local name given by farmers to clay soils (heavy).

Sample Farm Households

The farm household was defined as a family with members cropping at least one field together and sharing the same food from this common field. The farm household may be an extended family, with a head who makes the management decisions of the common resources, or a nuclear family (a man plus his wife or wives and children).

A sample of 80 farm households was drawn through a stratified random sampling from the four villages, given the criteria of animal traction equipment ownership (main criterion) and family size (secondary criterion). The commitment of farm household heads to weekly interviews on labor and input use and on grain and livestock transactions was taken into consideration in addition to the

stratified random sampling procedure. Table 3.2 gives the distribution of farm households by the main criterion of selection (animal traction equipment ownership).

Table 3.2. Number of Sample Farm Households With Given Levels of Animal Traction Equipment Ownership (Farm Survey, 1982-84).

Sample Villages	Complete	Average	Low	Non-Equipped	Number of Households	
					Sample	Population
Kodian	1	15	3	6	25	80
Sinebougou	6	8	0	4	18	18
Djambougou	1	6	2	3	12	12
Samine	6	13	3	3	25	110
Total	14	42	8	16	80	220
% of Sample	18	52	10	20	100	

Source: Coulibaly, Ousmane and Aïssata Gologo Coulibaly. Etude socio-économique aux environs de la station de Cinzana: Profil d'unité de production agricole. Bamako: IER, DET, 1982.

Table 3.3. Levels of Animal Traction Ownership in 1982-84 Farm Survey

	Multipurpose ¹ Plow		Plow TM ²	Equipment Seeder		Cart	Oxen
Complete	1	or	1 and	1 and	1 and	2	
Average	1	or	1	0	0	2	
Low	1	or	1	0	0	0	
Non-Equipped	0		0	0	0	0	

¹ The Multipurpose Plow (multiculteur in French) can perform heavy plowing, ridging, light plowing and weeding.

² The Plow TM (Tropical Mali) can only perform the ridging.

Source: Coulibaly, Ousmane and Aïssata Gologo Coulibaly. Etude socio-économique aux environs de la station de Cinzana: Profil d'unité de production agricole. Bamako: IER, DET, 1982.

Notes: A household was defined as completely equipped if it owned a plow, a seeder, a donkey cart, plus at least one pair of oxen. The non-equipped household did not have any animal traction equipment or oxen.

Data Collected

Data were collected on farm size, cropping patterns, inputs and labor allocation among crops, areas, yields, household products and livestock transactions, crop prices, and farmers' suggestions on farm constraints. The baseline data collection was done prior to the introduction of new varieties of cowpeas in 1985.

1986 Data Collection

The quick adoption and diffusion of new varieties of cowpeas motivated the 1986 data collection, which had four components:

The Farm Survey

The farm survey was supposed to cover the four villages initially involved in the 1982-84 farm survey to assess the adoption of new varieties of cowpeas and the impact on their farming systems given the ex-ante evaluation data. Unfortunately, the FDVS project selected only one village among the four to be eligible for its input-tied credit program, which proved very important in the adoption of new varieties of cowpeas. The following procedure was therefore used in choosing the sample villages and households.

Sample Villages

Four villages were chosen purposively as the sample villages (Table 3.3) after a presurvey of one week in July 1986. Two of them, Kodian and Sinebougou, were selected because of their involvement in 1982-84 farm survey and the availability of baseline data before the introduction of new varieties of cowpeas. Also the impact of the FDVS credit program could be easily assessed there because the village of Sinebougou had access to credit and the village of Kodian did not.

The other two villages (Sanogola and Kondogola) were selected because of their access to credit for two years, so that farmers were more knowledgeable

about the new varieties of cowpeas. Also these villages were the first ones to start up adoption of new varieties in 1983 because of the proximity of Sanogola to the station site and the presence in Kondogola of some knowledgeable farmers who were the first to adopt new varieties of cowpeas in the Cinzana area. All of the villages chosen for the sample were around the research station to ensure access by moped and because of the key role played by the station as a starting point for the adoption and diffusion process.

Table 3.4. Village Selection for the 1986 Farm Survey

Villages	Access to FDVS credit	Involved in 1982-84 survey	Sample Size (households)	Distance from Station (km)
Sinebougou	Yes	Yes	18	15
Kodian	No	Yes	20	3
Sanogola	Yes	No	20	1
Kondogola	Yes	No	22	8

Source: Author's Survey, 1986.

Sample Households

After the village selection, an exhaustive inventory of households' animal traction equipment and inputs for the year 1986 was done in collaboration with the extension agents of the FDVS project. As indicated in Table 3.5, a sample of 80 households was chosen given the following criteria:

- The use of new varieties of cowpeas.
- The level of animal traction ownership, as shown in Table 3.6. (Note: A distinction was made between animal traction use and animal traction ownership because farmers often lend or borrow draft animals and equipment among themselves.)

All households in Sinegoubou (18) were included in the sample. Half of the

households in Sangola and 1/4 of those in Kodian and Konogola were chosen and included in the sample households (See Table 3.4).

Table 3.5. Household Sampling from Village Household Population - 1986 Farm Survey

Villages	Sample Households	Total Households within the Village
Sinegougou	18	18
Kodian	10	80
Kondogola	22	90
Sanogola	20	40

Source: Author's survey, Cinzana, 1986

Table 3.6. Levels of Animal Traction Ownership Used in Sample Selection for 1986 Farm Survey

Levels	Multipurpose Plow		Plow TM	Seeder	Cart	Oxen
Complete	1	or	1 and	1 and	1 and	2
Average	1	or	1 and	0	2	
Non-equipped	1	or	1 or	0	0	1

Source: Author's survey, Cinzana, 1986.

The sample households were interviewed using two sets of questionnaires.

- The first was aimed at the head of the household to record the experiences in using animal traction, biochemical inputs, the cropping practices used for cowpeas, their opinions about new varieties of cowpeas compared to local varieties (tastes, yields and forage, resistance to diseases, insects, weeds, etc.) and their views of the formal and informal credit system.
- The second questionnaire was aimed at whomever was in charge of the field (usually the head of the household) to assess labor allocation, the quantities of

inputs, and the yields of cowpeas.

In this study, three categories of animal traction ownership are used instead of four. Both the "low" and "non-equipped" categories are grouped together under the "non-equipped" category because both types of household must to borrow animal traction if they are to use it.

Trial Data

On-Farm Trials

On-farm trials were carried out on twelve household farms (three farms per village and one farm per level of animal traction equipment). This small size of the sample farms is due to the financial constraints faced by the author in carrying out the research. The selection of the farms within the levels of animal traction was random. The objective of the on-farm trials was to assess the yield responses to different insect control techniques used for cowpea cropping: no insect control, the application of insecticides using tree branches or housecleaning brooms, and the application of insecticides using an ultra-low-volume sprayer. The quantities of labor plus chemicals used were recorded for the farm budgets.

On-Station Trials

Data were collected from trials carried out on station for yield responses to phosphate fertilizer for the cropping season of 1986. Also, on-station researchers were interviewed about the new varieties' resistance to diseases, pests, weeds, drought, and earliness.

Cowpea Traders Survey

In September, 1986, interviews were conducted with a purposive sample of cowpea retailers (15), intermediaries (10), and wholesalers (10) in Bamako, Segou, Koutiala, San, Mopti, Gao and Tombouctou (some main cities in Mali). These marketing agents were interviewed through formal and informal questionnaires to record seasonal cowpea prices, quantities sold, storage problems, export

possibilities, and traders' opinions and perspectives about the future supply and demand for cowpeas.

Cowpea Food Saleswomen and Housewives Survey

Women (8) making cowpea cakes and food for sales in rural and urban market places and housewives (10) using cowpeas as part of family meals were interviewed informally about their opinions of the new varieties of cowpeas versus local ones for characteristics such as ease of cooking, sweetness, consumer demand, etc.

Weaknesses of the Data

Due to budget and time constraints, many relevant data could not be collected for the purpose of this study. Data such as on-farm trials of the new varieties' responses to phosphate fertilizer, other insecticides and cropping techniques would have given a more complete picture of the new technologies in order to help develop appropriate recommendations to farmers. Also, nutritional data and cowpea price series would be worth collecting for a more detailed analysis of cowpea use in Mali.

CHAPTER 4

CHARACTERISTICS OF FARMING SYSTEMS IN THE STUDY AREA

The characteristics of farming systems in Cinzana are important in understanding the general context within which the farm households operate. The physical, agronomic and socio-economic environments that existed in the research area before the introduction of new varieties of cowpeas help explain the quick adoption of the new varieties by farmers.

Results of the Farm Level Survey of 1982-84

To get baseline data on farming systems in the area, a cost-route survey was carried out for almost two years to assess data on soil types, family labor allocation per crop, cropping techniques, farm-level grain sales and purchases, weekly rural market prices, and marketing channels from farm-gate to consumers.

Climate

The Cinzana zone is situated in the 4th administrative region of Segou in Central Mali. The climate is semi-arid with two main seasons: the dry season, from October to June; and the rainy season, from June to September. The mean annual rainfall from 1968 to 1980 was 565 mm. (Figure 1.2)

Soils

According to farmers there are two broad types of soils. The first is locally called "tientien" (sandy soils), which can be subdivided into "tientienble" (red sandy soils) and "tientienfing" (black sandy soils). The "tientien" are light and more appropriate for millet, peanuts, and bambara nuts. The second type is vertisols having heavy clay content (Coulibaly and Coulibaly, 1982). They are called "Boua" and are heavier and more appropriate for sorghum. Soils are generally poor in organic matter and highly erodable.

Cropping Patterns

Land Tenure

Family lands comprise cultivated fields as well as grasslands and fallows. Lands are inherited through lignages, although anyone outside the village can get a piece of land by a simple request to the chief of the village, who will make arrangements with household heads. The land is not subject to any monetary transaction. The distribution of crop fields is uneven between men and women. Eighty-four percent of the total number of fields are owned by men, mostly heads of household, against 16 percent for women. The average size of women's holdings is 0.2 ha, and is used for growing vegetables, groundnuts, and sometimes bambara nuts.

Crops and Acreages

The Cinzana zone covers both Savannah and Sahel areas, with all crops being rainfed. Cereals are the basic crops and accounted for 90% of the area cropped (see Table 4.1). Millet was the most important crop and covered one third of the area. It can be cropped in sole cultivation or in association with cowpeas. The second most important crop was sorghum, accounting for 15 percent of the area. As with millet, sorghum also was grown in mixed cropping with cowpeas. Fonio (*Digitaria exilis*) is another cereal which accounted for 11% of the area cropped. Fonio was the earliest crop to mature before millet, sorghum and other crops (it reached maturity in three months) and was called the "hungry season crop". All farmers reported that fonio can grow on all kinds of soils (clay, sandy or stony soils).

Groundnuts were the cash crop in the area for more than five years and were the main interest of an extension parastatal called "Operation Arachide et Culture Vivrieres" (OACV), which collapsed in 1982. OACV was the only supplier of fertilizer, fungicides, animal traction equipment and groundnut seeds on credit in

Table 4.1: Distribution of Acres per Crop (ha) in Cinzana Before the Introduction of New Varieties of Cowpeas

	Millet	Millet and Cowpeas	Sorghum	Sorghum and Cowpeas	Corn	Fonio Cereals	Total	Groundnuts	Other	Total
Acres/Household	2.8	2.8	.7	1.5	.15	.5	8.45	.5	.4	9.4
Percentage	30	30	7	16	1.5	5	90	5	4	100

Source: Coulibaly, Ousmane and Coulibaly Aissata Gologo. Etude socioeconomique aux environs de la station de Cinzana Rapport^a superficie-rendement-temps de travaux agricoles^a I.E.R.-D.E.T., 1984.

the Cinzana area. Groundnuts still cover 15 percent of the cropping area. At the time of the baseline survey in 1982-84, cowpeas were considered as a secondary crop grown in mixture with cereals.

Cowpeas are very important in the farming systems. Cowpeas fix nitrogen for the other crops and cowpea hay is an important source of food for draft animals during the dry season. Local varieties of cowpeas are rich in fodder and were seldom used for human consumption because of their low seed yields, due to a long cycle, insects, and disease attacks.

Animal Traction Use

Animal traction was the main improved technology used in cropping at the farm level. The farm household level of equipment was determined by ownership of animal traction tools and draft animals (Table 4.2). The first level of equipment, ("completely equipped"), which accounted for 18 percent of the total households referred to households which owned, in addition to a plow and a pair of oxen, a seeder and a cart. The plowing, seeding, weeding, and transportation were done by animal traction. The "average" level equipment represented the most important number of farmers (52% of farm households), meaning that although animal traction was the most popular technology in the semi-arid zone, half of the farm households still possessed only the basic tools to carry out farming tasks (a plow and a pair of oxen). These basic components of animal traction cannot perform tasks such as weeding and light plowing. The low and non-equipped levels (10 and 20 percent of farm households, respectively) used mainly traditional hoes for sowing and weeding. They could buy or trade labor and grain for animal traction services or obtain them from relatives or friends.

The multi-purpose plow ("multiculteur") performs light plowing and weeding in addition to heavy plowing and ridging. The donkey cart is used to carry organic manure to the field, the crops to the granaries, and for transportation of people

and products to the market place.

The levels of animal traction equipment observed during the baseline survey had been fixed for more than three years. The main reason for the lack of expansion of animal traction in the area was the lack of income-generating capacity (cash crops, off-farm activities, etc.) and the lack of a market to supply this equipment. Also, the low yields of food crops (Table 4.2) which could no longer ensure the household yearly food consumption, led to the trade of labor against food and did not permit any investment at the farm level.

Table 4.2. Characteristics of Farm Production in the Cinzana Area by Level of Equipment - 1982-84 Baseline Survey

	Levels of Animal Traction				Total or Average
	Complete	Average	Low	Non-Equipped	
Number of Farm Households	14	42	8	16	80
Size of Farm Household (persons)	26	16	8	7	15
Cropped Area/ Household (ha)	14.0	10.0	4.5	4.4	9.2
Cropped Area/ Person (ha)	.63	.74	.65	.75	.70
Cropped Area/ Crop (ha)					
millet	9.3	5.5	3.2	3	5.6
sorghum	2.6	3.7	.4	.7	2.5
groundnut	1	.8	.1	.2	.7
fonio	.3	.3	.1	.05	.2
Bambara nut (Vouandzou subterranea)	.3	.3	.1	.05	.3
Yields (kg/ha)					
millet	706	682	320	570	620
sorghum	580	614	296	242	500
groundnut	318	309	255	314	300
fonio	281	410	343	483	387

Source: Coulibaly Ousmane and Aïssata Gologo Coulibaly, *Etude socioeconomique aux environs de la station de Cinzana Rapport superficie-rendement-temps de travaux agricoles*, Bamako: I.E.R., 1984. pp. 4-6.

Yields

Yields in the area are determined mainly by the level and timing of rainfalls, the soil fertility, and the cropping techniques used. Soils are poor and less than five percent of the farmers in the sample (3 farmers) were using chemical fertilizers in 1984 before the FDVS project was set up in 1985 and after the departure of OACV in 1982 (Coulibaly and Coulibaly, 1984). Apart from the problem of the lack of availability of fertilizers, few incentives existed to use chemical fertilizer on millet and sorghum given the unfavorable cereal-fertilizer price ratio (IFDC, 1976) and the low physical response of the crops to fertilizer, which in part is due to insufficient soil moisture and the high risk of crop failure from irregular rainfalls. Traditional varieties of cowpeas used in mixed cropping with millet and sorghum have very low seed yields and usually do not significantly contribute to household food consumption or cash income. They did contribute indirectly to family income through their use as feed for draft animals. Yields of millet and sorghum in 1983-84 were low (Table 4.2) compared to yields in years with good weather (1000 kg/ha) and to yields in regions with better soils and weather, such as the southern part of the country (1200 kg/ha).

Labor Supply

The main labor force for farm production is family labor, which generally includes family members from 12 to 55 years old. Farm household size among the sample ranged from 6 to 15 persons. The size of the labor force typically varies with the size and the level of animal traction of the household. Small households (1-5 persons) tend to use 6 to 8 year-old boys or girls in helping with animal traction more than do larger households. There is a positive and significant correlation between the size of the household and the area cropped (Table 4.3). Women perform labor-intensive tasks such as seeding and weeding less often in

households with a "complete" equipment level than in low and non-equipped households.

The farm household could also get help from other farm households through different types of relationships. The first relationship is the extended family. Farm households with the same grandparents often help each other with harvests and commemorate social activities together (births, deaths, marriages, etc.). The second type of relationship between farm households is marriage. The fiance (husband) has to work a couple of days for his in-laws every year and must help in any case of labor constraint (need for extra work or animal traction equipment, which the wife's family is entitled to for free). The third type of relationship is exchange of labor between households during peak labor demand periods (seeding, weeding, harvesting). The fourth type is "work for food." Households facing food problems can work (one or two persons per week) for self-sufficient and food-surplus households for grain (millet and sorghum). The quantity of grain per day of work (the implicit wage) is determined by the ratio of the current cash wage in the zone to the current price of millet or sorghum per kilo.

Table 4.3. Size of Farm Households and Areas Cropped in Cinzana, 1982-84

	Household Size				Correlation Coefficient
	1-5	6-15	16-35	36+	
Frequency (%)	20	50	24	6	
Cropped Area(ha)	5	7	14	29	.7*

Source: Coulibaly, Ousmane and Aïssata Gologo Coulibaly. Etude socioeconomique aux environs de la station de Cinzana "Rapport Profil d'unité de production agricole" Bamako, I.E.R., 1982.

*significant at .05

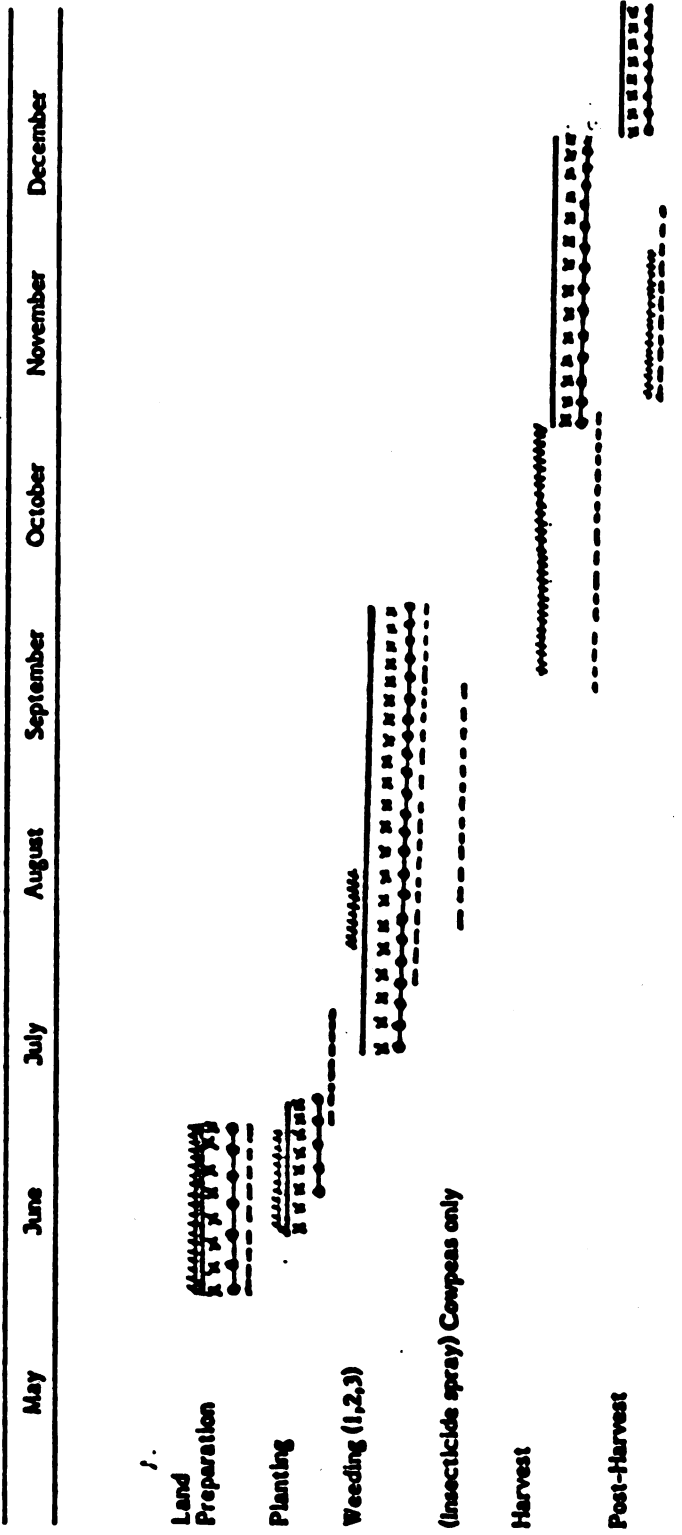
Also, traditional village working groups called tons exist in each village and sometimes in each neighborhood of a village. The ton is comprised of young persons from 11 to 35 years old and has a field called the Ton-foro. The ton can lend its labor services to any household for cash or in-kind payment, which varies from one goat to 50 kg of cereal per day of work for 20-40 persons. The ton services were the main extra-household labor used to overcome peak labor problems. High-income households used more services from the ton compared to low-income households (two or three times per year versus once per year).

Oxen and donkeys are used for animal traction. The feed is produced within the cropping system (grass on fallow land, post-harvest wastes, and cowpea and groundnut hay). The biggest problem for livestock during the survey period was water during the dry season (very deep wells). The desire for animal traction for oxen was very high: 90 percent of the households desired one or two oxen to complete or increase their animal traction sets. This high desire was difficult to meet without a credit system because of high prices of oxen (50,000 FCFA/ox) which were above many households' annual incomes. Donkeys are used mainly for cart transportation and occasionally for plowing.

Labor Demand

The cropping calendar starts in May (bush clearing) and runs to December (transportation of crops to the village granaries). The main tasks are plowing, seeding, weeding, and harvesting which occur from June to November. (Figure 4.1). The cropping peaks are concentrated between June and August for all crops. In 1982-84, weeding accounted for 42 percent of millet labor requirements and 40 percent of sorghum labor requirements. Weeding was the most constraining task of the cropping cycle.

Figure 4-1 Cropping Calendar for Major Crops in Cizana (1986)



Source: Author's Survey, Cizana, 1986.

Marketing of Agricultural Products

Farm households in Cinzana rely on three weekly markets (two for foodgrains and other agricultural products, and one for livestock) where 90 percent of their exchanges occurred.

Table 4.4. Frequency Distribution of Sample Household Sales (percentage) of Agricultural Products and Small Livestock, 1982-83^a

Products	Hungry Season	Harvest	Post-Harvest	Beginning	Total (%)
	Aug - Oct	Nov - Jan	Feb - Apr	Rainy Season May - July	
Millet	2	9	32	7	50
Sorghum	1	17	4	1	23
Fonio	1	1	—	—	2
<u>Total Cereals</u>	4	27	36	8	75
Groundnuts	1	4	19	—	24
Cowpeas	.5	.5	—	—	1
<u>Total Crops</u>	5.5	31.5	55	8	100
Small Ruminants ^b	70	9	15	6	100

Source: Coulibaly, Ousmane and Coulibaly Aïssata Gologo. Etude socioeconomique aux environs de la station de Cinzana: Commercialisation des produits agricoles et animaux et etude de marches hebdomadaires. Bamako: I.E.R., 1984.

Notes:

^aFor agricultural products, the figures in the table refer to the percentage of total annual sales (measured in quantities) that occurred in a particular time period. For example, 2% of the total quantity of crop sales were accounted for by millet sales during the hungry season. For small ruminants, the figures refer to the percentage of the total number of animals that were sold in a particular time period.

^bSmall ruminants sales mostly occurred during the hungry season to purchase food grain.

Household Sales

Household sales consisted of small quantities of grain (5-200 kg/household per market day), sold on the nearest local market place by the household head, his wife, or the first son. Small ruminants (goats or sheep), which are used as savings, were sold for cash to purchase food grain or for specific expenses such as taxes, medicine, or social events. Food grain was the most frequently sold item (75 percent) of the total quantity of household product sales due to the importance of cereals in the cropping system and the lack of a cash crop after the failure of the groundnut parastatal OACV (Table 4.4). The frequency of sales was the highest in the harvest and post-harvest period and accounted for 86 percent of the agricultural product sales. Sales of agricultural products decreased in the rainy season (beginning rainy season and hungry season). These high seasonal fluctuations in market supply are mainly due to the cropping cycle and the poor yields of the crops. Farmers are forced to sell some amount of cereal in the post-harvest period to meet cash needs and to save some for the coming rainy season, which is usually labor intensive and requires a lot of energy. Most of the food-deficit households would eat boiled bambara nuts and sweet potatoes in the dry season to save some cereal for the rainy season, or fill the gap by working for food grain. All the household heads agreed on the need for more food grain consumption in the rainy season to maintain the labor force for hard work. Cowpeas sales were the lowest among agricultural product sales (1.2 kg/household) for the entire survey year.

Household Purchases

Food grain was also the most frequent item purchased by households (Table 4.5). Almost all the food grain purchases occurred in the hungry season (August - October), before the maturity of the crops and when high food grain demand was not met by the households' own production. Grain purchases were low during the

post harvest period, when food is available in most households. Cowpea purchases occurred only at the beginning of the rainy season and was entirely for seeds. Small ruminants were mostly purchased in the post-harvest period as savings after the sales of agricultural products. Farmers did not buy fonio because of its higher price compared to millet or sorghum.

Barter

Barter between households was disappearing but still existed in many villages with the increase of food insecurity that existed in Cinzana since 1975 (Table 4.6).

Table 4.5. Frequency Distribution (percentage) of Sample Household Purchases of Agricultural Products and Small Livestock at Cinzana in 1982-83^a

Products	Hungry Season Aug - Oct	Harvest Nov - Jan	Post-Harvest Feb - Apr	Beginning Rainy Season May - July	Total (%)
Millet	70	6	3	3	82
Sorghum	11	—	—	2	13
Fonio	—	—	—	—	—
<u>Total Cereals</u>	81	6	3	5	95
Cowpeas	—	—	—	5	5
<u>Total Crops</u>	81	6	3	10	100
Small livestock	10	26	60	4	100

Source: Coulibaly, Ousmane and Aïssata Gologo Coulibaly. Etude socio économique aux environs de la station de Cinzana: Commercialisation des produits agricoles et animaux et étude de marchés hebdomadaires. Bamako: I.E.R., 1984.

Note:

^aFor agricultural products, the figures in the table refer to the percentage of total annual purchases (measured in quantities) that occurred in a particular time period. For example, 70% of the total quantity of cereals purchased were accounted for by millet purchases during the hungry season. For small ruminants, the figures refer to the percentage of the total number of animals that were purchased in a particular time period.

Food grain was exchanged against non-agricultural products such as small manual equipment (hoes, knives for harvesting) provided by blacksmiths. Some households bartered sorghum against millet for preference of millet in diet. The exchange of labor against food was the most common way for food deficit households to meet their food needs. Labor for food represented 72 percent of the total quantity of grain bartered. Labor for food had created a vicious circle of poverty and maintained food insecurity. Deficit households worked for self-sufficient ones at peak farming periods and shifted their labor from their own farms to those of others. This shift in labor decreased yields in food deficit households' fields to the benefit of self-sufficient households.

Table 4.6. Frequency Distribution of Sample Household's Barter Out of Cereals 1982-83 (in percent of total cereal bartered out).

Products	Hungry Season Aug - Oct	Harvest Nov - Jan	Post-Harvest Feb - Apr	Rainy Season May - July	Total (%)
<u>Millet against other products</u>	3	—	—	—	3
<u>Sorghum against millet</u>	15	—	—	—	15
<u>Millet-Sorghum against hand tools</u>	10	—	—	—	10
<u>Labor against food</u>	72	—	—	—	72
<u>Total</u>	100	—	—	—	100

Sources: Coulibaly, Ousmane and Aïssata Gologo Coulibaly. Etude socio économique aux environs de la station de Cinzana: Commercialisation de produits agricoles et animaux et étude de marchés hebdomadaires. Bamako: I.E.R., 1984.

Rural Markets

Market agents are farmers (household heads, women and sons) and numerous intermediaries or retailers from the nearest towns who meet in the weekly market place. The channels can be complex, involving social ties as well as business ties. The main weekly market is Cinzana, which is well connected to the city of Segou by a good road. The demand for food grains and the prices were higher on this market than others in more remote markets in the survey area at the same periods of the year (60 FCFA/kg against 40 FCFA on other weekly markets).

Two kinds of intermediaries connected farmers to wholesalers in Segou, the largest city in the region. The first ones were women retailers who purchased small quantities of grain from farmers (100 - 200 kg/market) and used small plates (equivalent to half, one or two kilos of cereal) for measurement. The number of women retailers varied between 20 - 30 per market after harvest to 10 - 15 in the rainy season. The second category are middlemen, who used scales and were financed by wholesalers settled in Segou. Together they often rented trucks to allow purchases of important quantities, ranging from 4 to 5 tons per market per middleman. Wholesalers own one or more warehouses in Segou and keep stocks. All intermediaries were well informed on prices, supplies, and road situations for the neighboring markets (towns or weekly markets in villages).

Prices

Seasonal prices fluctuated very highly - the highest prices were recorded in the rainy season, when the demand for food grain increases and the supply diminishes (Table 4.7). In 1982-83, prices varied from 40 FCFA to 60 FCFA per kilo for millet and sorghum in the rainy season and decreased after harvest to 25 - 30 FCFA/kg. The seasonal change in prices (almost 90 percent) is linked to the cyclical nature of the crops, the low yields of crops and the lack of income for

farmers. The lack of cash crops and other sources of income pressed farmers to sell their food grains at low prices after harvest to meet cash needs for taxes, social events, and non-agricultural commodities. In the rainy season, farmers were again pressed to purchase food grains for consumption at higher prices or exchange labor against grain.

Table 4.7 Crop Prices in the Rural Market of Cinzana in 1982-83 (FCFA/kg)

Products	Hungry Season	Harvest	Post-Harvest	Beginning of
	Aug-Oct	Nov-Jan	Feb-Apr	Rainy Season May-July
Millet	60	50	40	70
Sorghum	60	50	40	70
Fonio	80	100	110	120
Cowpeas	—	110	125	150

Source: Coulibaly, Ousmane and Aïssata Gologo Coulibaly. Etude socio économique aux environs de la station de Cinzana: Commercialisation de produits agricoles et animaux et étude de marchés hebdomadaires. Bamako: I.E.R., 1984.

Concluding Remarks

The main characteristics of the agro-socioeconomic conditions in Cinzana before the introduction of the new varieties of cowpeas can be summarized as follows:

1. Low rainfalls, which often failed to last until the maturity of local long-cycle crops (millet, sorghum). But late maturing (4 - 5 month) varieties of millet, called Boboni, were still the most popular varieties and were cropped by 70 percent of the farmers because of their taste, which is better than the early maturing varieties called Souna.
2. The poor quality of the soils was recognized by 70 percent of the sample households heads. Chemical fertilizers were not used since 1982 when

the OACV parastatal pulled out of the zone. There were no private markets for chemical inputs. OACV was the only supplier of fertilizer, pesticides, and animal traction equipment to promote groundnut production. Only 15 percent of the area cropped received organic manure, these being the fields near the village. This organically fertilized area was cropped in corn and groundnuts which, according to farmers, are more nutrient-demanding than are millet and sorghum. All farmers agreed on the yield-increasing capacity of chemical fertilizer when there is "enough" moisture, some organic manure in soils, plus good weeding.

3. The main crops were cereals, accounting for 90 percent of the total area cropped. The most widely cropped cereal was millet (60 percent of the total area). Cowpeas were always mixed with millet and grown for fodder since local varieties are very late maturing, have low seed yields, and are rich in forage. Cowpea hay was a major feed for draft animals in the dry season. Fonio (*Digitaria exilis*) was used as a "hungry season crop" because of its early maturing quality, although women complained about the difficulty of hand pounding it. Maize was not often grown (one percent of the area) and does not fit into the agroclimatic environment as well as millet and sorghum. Animal traction equipment such as the multipurpose plow (multiculteur) and draft animals were highly desired (70 percent of farmers desired the first, and 90 percent desired the second). The multi-purpose plow can do light and semi-deep plowing, weeding and mounding.
4. Food insecurity was the most troublesome problem for more than 80 percent of the households, leading to the "labor for food" barter exchange, which in turn created a vicious circle of poverty and ultimately to migration to cities. The main reasons for this food

insecurity were drought, poor soils, lack of cash crops, and few off-farm job opportunities to generate income to purchase food. There was in addition to these more chronic problems a seasonal aspect to food security. There is always a much higher market demand for food grains during the rainy season than at any other time of the year, due to the dwindling stocks left to fill the gap between the two harvests.

CHAPTER 5

ADOPTION OF NEW VARIETIES OF COWPEAS BY FARMERS IN THE CINZANA AREA

Background on Cowpeas

Cowpeas (Vigna unguiculata) or black eye peas (beans) are well known in West Africa and are considered as a secondary crop in mixed cropping with basic cereals (millet, sorghum, corn, etc.). Cowpeas are generally drought tolerant, can be grown under very poor soil conditions, and can also fix nitrogen in the soil (S.R. Singh, 1986). Cowpea production worldwide is not well known, but Rachie (1985) estimated it around 2.5 million tons of dry seeds on 9 million hectares. Traditional varieties of cowpeas in Africa have low yields of dry seed (250-300 kg/ha) compared to yields in Asia and Latin America (400-500 kg/ha) and U.S.A. (600-800 kg/ha) (Singh). The low yields in West Africa are attributed to pest damage, diseases, rain shortages, poor cropping techniques, and poor plant types. Most of the world's cowpeas are produced in Nigeria, Brazil, Niger, Senegal, Mali, and Burkina Faso. Other producing countries in Africa include Togo, Benin, Cameroon, Malawi, and Botswana. In Asia, cowpeas are produced in Bangladesh, Sri Lanka, India, Thailand, and the Philippines. In Latin America, apart from Brazil, cowpeas are also cropped in Nicaragua, Mexico, and Peru.

Research on Cowpeas in West Africa

Research on cowpeas in Africa began seriously with IITA (International Institute for Tropical Agriculture) in Nigeria in the 1970's. IITA concentrated its research on cowpea germ-plasm collection, evaluation, and maintenance. Important parts of IITA's research agenda are breeding for disease and pest resistance, early maturity, improved plant types, and quality seeds (B.B. Singh and Ntare, 1985). After the 1970's, the international donors increased attention to cowpea research. Among the leading institutions is USAID, which created the

Bean Cowpea CRSP (Collaborative Research Support Program), managed by Michigan State University. The CRSP supports research and training through a program of coordinated projects in Africa and Latin America. USAID also funds SAFGRAD (Semi-Arid Food Grains Research and Development), which carries out on-station and on-farm research on cowpea and other tropical crops. IDRC (International Development Research Centre) of Canada sponsors a cowpea research program in many countries, including Mali and Burkina Faso. Other donors, such as the United Nations Development Program, CIDA (Canadian International Development Agency), and some western governments (Italian, British, and West German) sponsor different programs throughout Africa. Most of these international networks have close ties with national research programs in identifying cowpea lines most suited for different agro-climatic environments, and in testing and evaluating improved materials.

In Francophone West Africa, cowpea research began in the 1950's with a modest program of identification of traditional varieties by the French West African Agricultural Research Station at Bambey, Senegal. Research on cowpeas in Senegal is currently carried out by ISRA (Institut Senegalais de Recherche Agricoles) in collaboration with the Bean/Cowpea CRSP, IITA, SAFGRAD, and CILSS for multidisciplinary varietal improvement. In Burkina Faso, cowpea research is supported by IDRC and IITA/SAFGRAD for germplasm screening, hybridization, and selection for resistance to diseases and insects (B.B. Singh and Ntare, 1985). The varieties tested are KNI, Gorom-gorom (Suvita-2) and TVX 3236 (Suvita-4) from IITA.

Cowpea research in Mali is similar to that in Burkina Faso and is supported by IDRC. All the research is carried out by the national research program and is

Table 5.1. Characteristics of Varieties of Cowpeas Cropped in Cinzana, 1986

Characteristics	New Varieties				
	Local	KN1	TN8863	Gorom-gorom	TVX3236
Color of Seeds	white	red-brown	white	red-brown	brown
Length of Seeds	7 mm	4 mm	4 mm	4 mm	4 mm
Growth habit	spreading	semi-spreading	semi-spreading	semi-spreading	erect
Photoperiodism	NA	NA	insensitive	insensitive	insensitive

Source: Author's Survey, Cinzana, 1986.

divided into two components. The agronomy component focuses on station trials for yields; drought, insect, and disease resistance; yield responses to fertilizers; intercropping; etc. The breeding component was initiated in 1980, with introduced varieties from IITA/SAFGRAD and hybridization between these and local varieties. Multi-locational trials are carried out by SAFGRAD to assess the adaptability of tested varieties to different agroclimatic conditions. The varieties commonly tested are KN1, TN8863, Gorom-gorom, TVX 3236, and others (Table 5.1). Local varieties tested are Niban and Choba from Mali.

Cowpea research in West Africa is far behind research on commodities such as cotton, rice, and wheat. The research has mostly focused on physical and biological constraints to yield increase. The socio-economic aspects of cowpea production, marketing, and consumption at the farm level have been neglected. Factors such as input and output prices, the credit system, the availability of inputs at the farm level, extension problems, storage and consumer tastes affect the adoption of promising varieties developed on the research stations. Although to date little research has been done on these aspects, such socio-economic components are as important as agronomic factors in influencing cowpea production decisions by farmers.

Rate of Adoption of New Varieties of Cowpeas by Farmers in Cinzana

To estimate the rate of adoption of a new agricultural variety, the area cropped is the common proxy used. In the research area covered by this study, the area cropped in new varieties of cowpeas increased from 10 ha in 1984 (without any credit program to supply inputs) to an estimated 1200 ha in 1986 after a credit program had been introduced in fifty villages. For villages not covered by the credit program (which supplied insecticides, animal traction equipment, and oxen on credit) the area cropped in new varieties increased only from two to three ha to an estimated 100 ha for twenty villages. The area per farm in cowpeas varied from 1.25 ha for villages with access to credit to .25 ha for the villages without access to the credit program (Table 5.2). The new varieties also diffused from Cinzana to neighboring areas such as Koutiala and Bla covered by the cotton parastatal. Some farmers in these areas started using new varieties as a cash crop due to their early maturity and high yields, as part of their response to the decrease in cotton area due to the fall of cotton prices on the world and Malian markets.

The seeds of the new varieties were multiplied under contract with the Project of Village Development of Segou (FDVS) in 1985 by farmers who already had adopted the new varieties of cowpeas by taking them directly from the research station experimental plots. Seeds were then diffused to second and third generations of adopters on a credit basis by the FDVS project.

The credit program to supply inputs such as insecticides and animal traction equipment began in 1985 and was very important in adoption because of the new varieties' sensitivity to insects and pests. The input-tied credit program is important in Cinzana because the lack of a private market for inputs in general in Mali and the lack of cash incomes for the majority of farmers to purchase the inputs even if they were available on the market. All farm chemical inputs

(fertilizer, insecticides, fungicides, etc.) are supplied to farmers by government extension parastatals. These input-tied credit programs are generally based on a cash crop, which is supposed to generate cash income to repay the credit.

Table 5.2. Areas Planted In New Varieties of Cowpeas in the Cinzana Area

Villages	Area Planted to New Varieties of Cowpeas in Cinzana (ha)		
	1983-84	1985	1986
Kodian (No credit Program)	.5	3	6
Sanogola (Credit Program)	4.0	10	20
Kondogola (Credit Program)	5.0	10	40
Sinebougou (Credit Program)	2.0	12	25
Average Area/ Farm without Credit	.02	.15	.3
Average Area/Farm Households with Credit	.15	.60	1.6
Average Area for the Sample Farms (Credit and Non-credit)	.12	.50	1.5
Total Area for Villages with Credit	10	80	1,100

Source: Author's Survey, Cinzana, 1986.

Table 5.2a. Areas Cropped in New Varieties of Cowpeas per Level of Equipment in Cinzana, 1986.

	Level of Animal Traction			
	Complete	Average	Non-Equipped	Total or Average
Total area per Household	2.5	1.6	.7	1.5
Size of Household	25.0	16.0	8.0	15.0
Area/person	.1	.1	.08	.097*

Source: Author's survey, Cinzana, 1986.

* A two tail t test shows no difference between levels of animal traction for area/person ($\alpha = .05$)

Although household level of animal traction was the basic sampling criterion, the area cropped in new varieties of cowpeas per household was determined by the size of the household. The area per person does not change with the level of animal traction. This is why I have not used the level of animal traction as a basis for analysis in the following section.

Taxonomy of Adopters

Farmers around the agricultural research station of Cinzana can be classified into four categories for the adoption of new varieties of cowpeas (Table 5.3).

Category I: Farmers who use new varieties and would continue to use them.

Category II: Farmers who used new varieties of cowpeas and quit. The main reason for ceasing the use of new varieties is the lack of a credit program to supply inputs (insecticides) to farmers.

Category III: Farmers who never used new varieties but would like to do so if they had access to inputs (insecticides) and animal traction equipment.

Category IV: Farmers who never used new varieties of cowpeas and are not willing to use them.

Table 5.3: Taxonomy of Adopters and Non-Adopters of New Varieties of Cowpeas in the Cinzana Area

Categories		Farmers in Villages With Access to Credit (%)	Farmers in Villages With No Access to Credit (%)
I.	Continuing Adopters	93	10
II.	Adopted & Quit	5	80
III.	Never Tried but Interested in Adopting	2	5
IV.	Never Tried and not Interested in Adopting	—	5
Total		100	100

Source: Author's survey, Cinzana, 1986.

From Table 5.3, it is clear that access to credit makes a major difference in the adoption rate between villages.

Category I

This category is the most important in villages benefiting from the credit program because of the availability of inputs supplied by the FDVS project. The sensitivity of new varieties to insects is very important and requires the use of insecticide two to three times before the maturity of the pods. The non-existence of a market for such chemical inputs and the cash income constraint make the credit program crucial for farmers.

Category II

The number of farmers who quit using new varieties of cowpeas is important in villages with no access to credit (80 percent). The main reason for discontinuing with the use of the varieties is again the lack of inputs, especially insecticides. The small percentage of farmers who continued to use new varieties without access to credit had some relatives in villages with access to credit and could obtain inputs through them. The criteria for village access to the FDVS credit are summarized in Table 5.4:

Table 5.4. Criteria for Village Access to FDVS Credit

-
- | | |
|-----------|--|
| A. | First Criteria for Selection <ul style="list-style-type: none"> • The village has to be in a dryland area with millet, sorghum, peanuts, or cowpeas as major crops. • The village has to be accessible in any season by bikes and cars of the project. • A good rapport among the village people. |
| B. | Final Criteria for Selection <ul style="list-style-type: none"> • No conflicts among village compounds and the existence of a traditional solidarity and self-help among villagers. The existence of a <u>ton</u> (village association) is the proof of such solidarity. • Capacity of the village to pay back the loans. • Management capacity at the village level, as evidenced by the existence of villagers literate in French or Bambara and able to handle the credit management, the village cereal stocks (cereal bank for the village association), etc. |
-

Source: Cheick Kamate. Personal communication, Cinzana, 1987.

A survey is carried out by the project staff to assess these different criteria before the final selection of villages for access to FDVS credit. For individuals within villages with access to credit, the only criterion of eligibility to credit is the ability to pay an advance for each item requested through credit (ten percent of the price of the item).

Category III

Two farmers in the sample did not use new varieties of cowpeas but would like to do so if the credit constraint were solved (availability of inputs through credit or cheaper credit). These two farmers reported that they never tried the new varieties but heard about their sensitivity to diseases from other farmers who were adopters. One farmer lived in the village without access to credit and complained about the non-access to credit. The other one lived in a village with access to credit but did not adopt because of the high cost of the insecticide even on credit. They are generally very risk averse and found the cost of insecticide too high to invest in. Some farmers, including adopters, even suggested to extend the repayment period for the insecticide loan from one year to two years. But this suggestion would be hardly feasible since a current input such as insecticide should pay for itself within a period of one year.

Category IV

One farmer in the sample reported he was not willing to consider adoption even if the credit was available for inputs. The reason given when interviewed was the small size of his household. He heard that new varieties require a lot of labor compared to cereals and would like to focus his small potential of labor (1 to 3 persons) on the basic food crops (millet and sorghum). Another reason was the lack of information about new varieties, as this farmer was in the village with no access to credit and did not have the opportunity to interact with adopters who

were mostly concentrated in the villages with access to credit.

Chronology of Adoption

Diffusion takes time and all farmers do not adopt a new technology at the same moment. Adopters include farmers who are currently using new varieties of cowpeas and are willing to continue to do so. They can be classified into three generations given the time of first adoption (Table 5.5).

Table 5.5. Chronology of Adoption of New Varieties of Cowpea in Cinzana

Chronology	Percentage of Adopters (%)	Year of Adoption
Generation I "Innovators"	16	1983-84
Generation II "Early Adopters"	20	1985
Generation III "Mass Adopters"	64	1986

Source: Author's Survey, Cinzana, 1986.

Generation I or "Innovators" includes farmers who first used new varieties of cowpeas during 1983-84 (16 percent of adopters). These farmers include some of the farmers who were working for the research station and noticed the early maturity of the new varieties of cowpeas. They "pocketed" seeds from the trial plots to try on their own farms. Innovators also include village chiefs, counselors, and knowledgeable persons who travelled abroad, and the heads of some large households. These latter got new varieties from contacts at the research station or were heads of households whose members worked part-time for the research station. The decision to try a new technique was taken by the head of the household, who is the manager of the household assets and responsible for all decisions affecting the household, from farming to consumption and social events.

This first generation of adopters began to contribute to the solution of hunger in the area by adopting early maturing varieties of cowpeas. The cowpeas

were harvested by women from the innovators' households and by many other women from food-deficit households. Women hired by the innovators for harvesting were paid in-kind at the rate of 2-3 kg of cowpeas per day. This daily in-kind wage served as a full dinner for 4 to 5 persons. (Cowpeas are mostly eaten at dinner in the area.)

Generation II or "Early Adopters" adopted new varieties of cowpeas in 1985. They represented 20 percent of the adopters. The early adopters were motivated by the success realized by innovators and encouraged in cropping new varieties of cowpeas by the FDVS (Fonds de Developpement Villageois de Segou) project created in 1985 as an integrated rural development program to address the food problem in rainfed agriculture in the region of Segou. Some innovators and early adopters were subsidized in 1985 for half the costs of inputs supplied by the project in order to increase cowpea seed production for diffusion to other farmers in the area. The second generation, or "early adopters", were more risk averse than the first generation of adopters. Among the "early adopters", 20 percent reported they were not aware of the new varieties before 1985; 80 percent were aware but did not have enough confidence in new varieties before seeing concrete results from the 1983/84 harvest.

Generation III or "Mass Adopters" represented 64 percent of adopters, and are those who adopted new varieties of cowpeas in 1986. The "mass adoption" of new varieties of cowpeas was motivated by two interests:

1. These farmers noticed from "innovators" and "early adopters" some good characteristics about new varieties, such as earliness and high-yields, which are important given uncertainty about rainfall.
2. The farmers perceived the new varieties as a potential cash crop, as groundnuts used to be before 1982, to solve their cash problems. Also with the lack of a private market for inputs, the FDVS project was seen as

important in supplying inputs and animal traction, which have to be paid back in cash.

The year 1986 was very important as a critical year in the trend of adoption in the Cinzana area. The solution to the marketing problem of cowpeas (access to output markets and remunerative prices to farmers) will affect the future trend of adoption of new varieties of cowpeas. If the adoption trend continues, and the farmers who have not adopted the new varieties yet adopt, there will be fourth generation, that of "late adopters."

Factors Affecting Adoption of New Varieties of Cowpea in Cinzana Area

The major factors affecting adoption of new varieties of cowpeas in Cinzana are the characteristics of the new varieties, the agroclimatic and socio-economic environments of Cinzana, and the institutions to sustain the adoption and diffusion of new varieties of cowpeas. All these factors are interrelated and are difficult in real life to separate from one another as we do here for purposes of analysis.

Characteristics of New Varieties of Cowpeas

The two varieties most cropped by farmers are KNI and TN 8863, with KNI being the most widespread (more than 80 percent of the area cropped). Other varieties such as TVX 3236 and Gorom-gorom are cropped by only 3 to 4 farmers in two villages and are newer than KNI and TN 8863. Farmers perceptions of the new varieties are summarized in Tables 5.6 and 5.7.

Early Maturity

Early maturing was the most appreciated characteristic, recognized by 100% of the farmers. It was the main reason cited for adopting new varieties of cowpeas. Eighty percent of the farmers reported that they adopted new varieties of cowpeas because of their early maturing (60 to 65 days compared to 100-120 days for local varieties). Early maturity is an important characteristic in Cinzana, where rainfall is erratic and insufficient at very critical periods in the

crop's development. Cowpeas serve as a "hungry season crop" to fill the gap between the rainy season, when food problems become critical, and the harvest period of basic food crops such as millet and sorghum. The "hungry season crop" or early maturing crop in the area used to be fonio (See Figure 4.1). Labor constraints create conflicts between fonio and cowpea cropping. The two crops are harvested at the same period. As discussed below, farmers who adopted the new cowpea varieties have therefore reduced their production of fonio.

High Yield

The higher yields of new varieties compared to local varieties were the second reason for adopting new varieties of cowpea (40 percent of adopters). Local varieties of have very low yields and are grown for forage rather than for seeds. The average seed yield of the new varieties when treated is 760 kg/ha compared to 50-100 kg for local non-improved and non-treated varieties. The new varieties are cropped in sole cropping for seeds only, while traditional varieties are intercropped with millet and sorghum and used for forage for draft animals in the dry season. Ninety percent of the farmers practiced sole cropping for new varieties and mixed cropping for local varieties.

Table 5.6. Farmers' Perceptions of New and Old Varieties of Cowpeas Regarding Yields

Farmer Responses	Number of Responses (N=60)	Percentage (%)
Use new varieties for seeds and local varieties for forage	54	90
New varieties yield 2 times more seeds than local varieties	20	34
New varieties yield many times more seeds than local varieties	40	66
New and local varieties have the same yields	0	0

Source: Author's Survey, Cinzana, 1986.

Forage

The new varieties of cowpeas are recognized by all farmers as being poor in forage because of the quick senescence of the leaves, which fall before the full maturity of the pods. New variety plants are more erect than local ones, which are of the viny spreading type, with more leaves. The forage problem is an important one for feeding draft animals in the dry season. After harvest, the local variety plants are bundled and stored as fodder to feed cattle (Singh, 1985). Farmers in Cinzana compensated for the poor performance of new varieties by continuing the cropping of local varieties in intercropping with millet and sorghum.

Insect Resistance

The new varieties of cowpeas need some pest control to avoid insect damage. If no insecticide is used, damage is important on seed yields, forage, and seed quality. Insecticides are therefore a required input to accompany the varieties currently used by farmers (KNI, TN 8863, Gorom-gorom, and TVX 3236). The lack of a private input market in the area to supply insecticide and the lack of cash for many farmers even if the market for insecticide existed explain the non-adoption of new varieties by more than 80 percent of farmers in villages without access to the FDVS credit program.

Many kinds of pests damage cowpeas from the seedling to the harvest and storage. The common species reported by farmers are cowpea aphids (Aphis craccivora), which feed on pods and foliate; and pod bugs (Anoplocnemis curvipes), which attack green pods. In storage, damage is due to bruchids (Callosobruchus maculatus), which multiply after harvest inside the pods and attack the seeds. According to 75 percent of the farmers interviewed, half of the stored seeds can be damaged by bruchids after one year if no precautions are taken.

Farmers could not identify specific diseases for cowpeas, despite their existence, but noted some lesions, necrosis, and yellow leaves on many plants. Local varieties are considered more resistant to pests and diseases by more than 60 percent of the farmers.

Table 5.7. Farmers' Perceptions of the New Varieties (NVC) of Cowpeas' Resistance to Pests

Farmer Responses	Number of Responses (N=60)	Percentage (%)
NVC with Insecticide = NVC without Insecticide	2	3
Yield of NVC with insecticide is 2 times higher than yield of NVC without insecticide	18	30
Yield of NVC with insecticide is many times higher than yield of NVC without insecticide	40	67
TOTAL	60	100

Source: Author's Survey, Cinzana, 1986.

Resistance to Weeds

Weeding is one of the chief constraints in the farming system of the Cinzana area. The weed which may be the greatest threat to cropping in the near future is striga (Striga gesnerioides). Farmers are aware of the striga problem and the sensitivity of the new variety KNI to striga, although they cannot estimate the losses attributed to striga alone. Farmers have, by experience, a clear idea about the parts of their fields where the degree of infestation by striga is important and avoid planting the variety KNI in these areas. They also practice a year-to year rotation of crops to lessen the effect of striga on crops. The users of the variety Suvita 2 (Gorom-gorom) found it more resistant to striga than the other new varieties. The lesser sensitivity of Gorom-gorom to striga has been confirmed by

some researchers (Toure and Dembele, 1986)

Responses of New Varieties of Cowpea to Phosphate Fertilizer

Seventy percent of farmers do not use phosphate fertilizer on cowpeas. The remaining 30 percent use it occasionally on small areas in which the soil is very poor in order to increase the production of those parts of the fields. The few users of chemical fertilizer rarely apply the level recommended by the extension agency. Nonetheless, the users think that chemical fertilizer (phosphate) can double the yields of new varieties if the soils contain "enough" organic matter and "enough" moisture. But all the farmers agree on the low fertility of the soils and their sensitivity to water and wind erosion, as well as the high risk of using fertilizer due to insufficient soil moisture. The reason farmers report for not using fertilizer to the extent recommended by the extension agency is the high risk due to physical and climatic conditions, and the risk associated with the uncertainty of cowpea prices and the market for cowpea products.

Tastes of New Varieties of Cowpeas

All farmers agreed on the sweetness of the new varieties compared to local varieties. Also the farmers agreed that local varieties are easier to cook and to swallow than new varieties of cowpeas.

New varieties have a wrinkled, tightly adhering seed coat (Bressani, 1985) compared to local varieties, which have a loosely adhering one. These differences in seed coat make cooking water absorption easier for local varieties, which make a paste easy to eat when cooked. Over half of the farmers (55 percent) prefer new varieties because of the sweetness which makes their consumption easier over a long period. (Cowpeas may be eaten for dinner every day during the entire hungry season). The remaining 45 percent prefer local varieties, although they do eat new ones.

Saleswomen of cowpea cookies interviewed purposively in weekly market

places found no differences between flours made from the new and local varieties, but think that new varieties such as KNI have a seed coat which is hard to remove by pounding. They suggested that the easiest way to remove the seed coat is to put the cowpeas in water for at least one night before pounding them. This process worked for housewives, who use more of the new varieties of cowpeas than local ones. The second problem faced by housewives and saleswomen is the sensitivity of new varieties in storage to insects. The traditional insect control method used by them is mixing cowpeas with ashes and storing the cowpeas in big earthenware storage jars which are tightly covered. This insect control method works only for small quantities of cowpeas (10 to 50 kg) but cannot solve storage problems for important quantities because of non-availability of enough ash to mix with important quantities of cowpeas. Saleswomen also report that cookies made from new varieties are sweeter than the ones from local varieties and are appreciated by consumers.

Table 5.8: Farmers' Perceptions Regarding the Taste of New Varieties of Cowpea

Farmers Responding	Responses (N=60)	Percentage (%)
New Varieties are Sweeter than Local Varieties	60	100
Local Varieties are Easier to Eat (Swallow) than New Varieties	60	100
Prefer New Varieties (Sweetness)	33	55
Prefer Local Varieties (Easier to Swallow when Cooked)	27	45

Source: Author's Survey, Cinzana, 1986.

Personal and Socio-Economic Characteristics of Farmers

Farmers' Awareness of New Varieties of Cowpeas

In 1986, 90 percent of the farmers in the sample were aware of the existence of the new varieties of cowpeas and 80 percent of the farmers had used them. The main communication channel was interpersonal exchange of information between households in the same village and between neighboring villages around the research station. The information was diffused through friendship, neighborhood ties, family ties, and rural market places, where farmers from surrounding villages meet for sales and purchases and engage in social relationships. This exchange of information was strengthened by direct observations of innovators and early adopters in cowpea fields by other farmers in the same village or in the nearby villages. Similar observations were made by farmers on the research station's plots while working there as part-time workers or just as visitors (chiefs of villages, village counselors, etc.) who have informal ties with station personnel.

The extension agency set up by the FDVS project in 1985 contributed to the dissemination of the information in some villages far from the research station, although it is difficult to evaluate the exact contribution of the formal extension in informing farmers about new varieties of cowpeas.

Experiences with Improved Technologies

Cinzana area farmers had some previous experience with improved technical packages, such as improved groundnut seeds, fertilizers, animal traction, and improved farming practices for groundnuts. These technical packages were diffused in the area by OACV, which collapsed in 1982. OACV also had some adult education programs called alphabetisation fonctionnelle to teach farmers how to use animal traction equipment and improved cropping techniques. Since all the

villages in the sample were covered by OACV extension networks, there are no differences between adopters and non-adopters given farmers previous experiences with improved inputs or techniques. However the previous experiences in using animal traction and inputs such as fertilizers helped adopters in understanding quickly how to seed, weed, and fertilize new varieties of cowpeas. The only new improved technique involved in cultivating the new cowpea varieties was the spraying of insecticide with the ULV (Ultra Low Volume) sprayer. Only 10 percent of farmers had previous experience in using a ULV sprayer. They had learned it outside Cinzana area especially in the cotton zone to the south of Cinzana (Table 5.9).

Table 5.9. Experiences of Adopters with Technical Packages

Experience	% Adopters	% Non-Adopters
Use of Fertilizer	30*	20
Use of Animal Traction	98*	97
Informal Education	45*	50
Use of Insecticide or Spray	6	0

Source: Author's Survey, Cinzana, 1986.

* Chi square tests show no significant difference at .01 percent

Cash Need to Repay Credit

The FDVS project credit line to supply inputs such as animal traction equipment was primarily targeted to promote basic cereals and groundnuts, which are the main crops, and little attention was initially given to cowpeas (local varieties), which were assumed to be grown in association as a secondary crop with millet and sorghum. Cereals and groundnut production were to increase through the use of the improved technologies (inputs and animal traction

equipment, etc.) to ensure food self-sufficiency for farmers. The surplus was to be sold to repay the credit. This view of the FDVS project did not take into consideration many of the constraints facing farmers in the Cinzana area, such as rainfall fluctuations, the low genetic potential of the seeds used, prices, and market problems. The unanticipated diffusion of the new varieties of cowpeas, which was not planned by the project or by any government agency, and the relatively higher market prices of cowpeas (100-150 FCFA/kg) compared to cereals (50-55 FCFA/kg) in 1985 gave a lot of hope to farmers as well as to the FDVS project that farmers could easily pay back the credit. Farmers' perceptions of these input tied credit programs are generally based on a cash crop, which is supposed to generate cash income to pay back the credit.

Cowpeas became very important for farmers, who counted on them as a cash crop to pay back their credit (Table 5.10). The tremendous increase in area cropped in new varieties of cowpeas was made possible by the credit program and motivated by farmers' need to earn cash for credit repayment, social events, and saving.

Table 5.10. Farmers' Perceptions of How to Repay the FDVS Loans for 1986

Farmer Responses	Number (N = 50)	Percentage (%)
Sell cereal (millet, sorghum)	1	2
Sell livestock	4	8
Sell cowpeas and complement revenues with sale of small ruminants if available	20	40
Sell only cowpeas	11	22
Sell cowpeas, but cannot crop enough cowpeas given small size of household	9	18
Don't know exactly what to do	5	10
TOTAL	50	100

Source: Author's Survey, Cinzana, 1986.

Small ruminants also played important roles as savings and as current assets. They frequently are sold to meet cash needs. Farmers who thought that cowpea income would not be enough to pay back credit were often heads of small households, who faced a labor constraint which limited cowpea production.

Sales of cereals were not seen as contributing to credit repayment because of the importance of cereals as providing the basic food for the household, their low prices in the immediate post-harvest period, and the general risk of crop failure due to rainfall deficiencies before the maturity of late varieties of millet and sorghum. All the farmers hoped that the project would buy cowpeas or organize a good marketing system to avoid unsold cowpea stocks and to make enough cash to pay back credit.

Labor Availability

Labor is the main input in the cropping system in the Cinzana area, for both cowpeas and cereals. The new varieties of cowpeas are labor-intensive and require more labor than cereals. This high labor requirement is mainly due to the high-yielding potential of the new varieties and the differing periods of maturity of pods, which require two to three harvests for the same plot. A high correlation exists between the size of the farm household and the acreage cropped in new varieties of cowpeas ($r = .90$). Small sized farm households planted small acreages because of the labor constraint. The harvest of cowpeas is all manual.

Almost all farmers (98 percent) said that new varieties of cowpeas did not decrease their areas cropped in basic cereals and groundnuts. The only crop for which areas declined was fonio. Fonio competes with new varieties of cowpeas for labor during the harvest period in late September. The lack of substitution of labor input between production of cowpeas and the basic crops meant that extra labor was required, which was met by increased effort at the family level. Women

provided 90 percent of the labor for the cowpea harvest in addition to their daily duties. At the harvest time, household men continued to complete the last weeding and the mounding of tied ridges for millet and sorghum (in order to conserve soil moisture and strengthen plants against wind damage) and hence were largely unavailable to help in the cowpea harvest (Figure 4.1).

Institutions to Generate and Sustain Adoption

Institutions to generate new varieties of cowpeas and to sustain them have played important roles in the adoption process. The main institutions involved are the research station; the FDVS project, which provides inputs and animal traction equipment through credit; and the market for cowpeas.

The Agricultural Research Station of Cinzana

The research station was the starting point for the adoption and diffusion of new varieties of cowpeas via tests in research plots. Some farmers among the "innovators" reported that they adopted some on-station cropping techniques, such as maintaining a space of 60 cm between plants, after observing research plots and discussing the techniques with researchers. Other farmers learned how to use the ULV sprayer to spray insecticides just by observing.

Although it is difficult to measure and evaluate the direct impact of the research station on the farming system in the vicinity, interactions between researchers and farmers and those who work on the station part-time were important in that they created a three-way learning process. This process could be more meaningful if the researchers had to carry out on-farm research and learn about agronomic and socio-economic constraints facing farmers.

FDVS Project (Fond de Developpement Villageois de Segou)

The FDVS project was created by the Government of Mali and co-sponsored by IFAD (International Fund for Agricultural Development) to improve the cropping of dryland cereals and other crops in the Segou area through village-

based farmer associations. The main objectives of the project are the following:

- Promotion of community development in villages by supplying credit for animal traction equipment and inputs; extension services; adult literacy; and human and livestock health programs.
- Increased production of the basic crops (millet, sorghum, and groundnuts) to ensure food self-sufficiency and surpluses for investment.
- Training of farmers in taking care of their own development programs, through self-financed investments at the village and the farm level.

The project is supposed to cover 160 villages (60,000 to 75,000 farm households) over a five-year period (1985-89).

The Credit Program

The credit program started in 1985 and supplied farmers in selected villages with basic animal traction equipment (multipurpose plows, plows, seeders, donkey carts, and ULV sprayers) and some cash loans to purchase draft animals. The credit program also provides in-kind inputs such as cowpea and groundnut seeds, insecticides, fertilizers, fungicides, and animal feed salt and veterinary medicine.

The equipment and draft oxen are provided on a four-year credit repayment basis, following a one-year grace period. The ULV sprayer, the insecticide, fungicide, and fertilizer are provided via one-year loans.

Performance of the Credit System. The credit for animal traction equipment and inputs (insecticides, fungicides, etc.) has been necessary for farmers in the Cinzana area, where the lack of income-generating capacity, the poverty of farmers, the government head taxes, the non-availability of markets for inputs, and the low rainfall levels were the main constraints impeding investment for more than 80 percent of farmers. Many farmers thought that credit has played an important role in increasing their farm level of equipment and that they could not afford the plow, seeder, multipurpose plow and draft animals without the FDVS

credit program. Farmers also preferred the formal credit program to informal credit (90 percent of respondents) because of the larger amounts of loans available with the formal program and its longer repayment period for equipment and draft animals (5 year loans). Informal credit between farmers themselves is often used for food (grain loans) during the hungry season and repaid after harvest in grain

Table 5.11. Change in the Use of Informal Loans with the Advent of the FDVS Program and the New Varieties of Cowpeas

Informal Loan Items	1984-85 Percentage of Total Number of Informal Loans	1985-86 Percentage of Total Number of Informal Loans
Food	60	30
Animal traction equipment for cropping	30	10
Donkey cart	5	30
Cash for emergencies	5	20
Miscellaneous items	—	10

Sources: Author's Survey, Cinzana, 1986.

or in labor during the rainy season. In 1984-85, food loans represented 60 percent of the total number of informal loans. But in 1986, thanks to new varieties of cowpeas, the number of food loans dropped to less than 30 percent of the total number of informal loans (Table 5.11).

Loans for animal traction (purchase of plows and draft oxen), which used to represent 30 percent of the total number of informal loans, dropped to less than 10 percent thanks to the formal credit program. However, borrowing for donkey carts remains high (20 percent of the total number of informal loans) because the FDVS Program delivered donkey carts to only a few households, deemed to be solvent. The disadvantages of informal credit according to farmers is the shame and low social prestige that result if one does not repay on time and the non-

availability of large cash loans to purchase animal traction equipment. Formal credit is deemed impersonal and less shameful if one has trouble paying it back and larger loans can be received through the formal credit program than through informal credit. Farmers, however, complained about the yearly repayment amount which they consider high (annual charge for depreciation plus a 10 percent interest rate on the cost of the animal equipment and draft animals). Some complaints were also directed at the FDVS project management that farmers were not informed at the time they took out the loans in 1986 for animal traction equipment that they would be required to pay for the cost of transporting the equipment. (They were billed for this two months after delivery.) According to farmers, the project manager should have had a clear idea of the costs before making any decision concerning extending loans to farmers.

Some farmers (20 percent) thought that the draft animals credit policy should be revised because of complaints about the insurance on the animals' lives. According to farmers, the terms of the insurance are not very clear, and if the animal dies, a very lengthy investigation to establish responsibilities regarding the cause of the death is required before any repayment can be made. The animals' life insurance is a new policy to farmers, who reported themselves to be frustrated by the denial of repayment to some of their colleagues. In general, farmers are satisfied with the quantities of animal traction equipment credit, despite missing spare parts for plows.

If there were no formal credit program, any investment in animal traction equipment and draft animals would take a long time, if it were at all possible given frequent financial problems at the farm and village levels. More than 70 percent of the farmers interviewed reported that the low levels of savings and cash are channeled into food purchases to meet "hungry season" needs, to pay taxes, to pay part of the marriage dowry and other social expenditures rather than

being invested in farm equipment. Formal credit is the major source of important investments (animal traction) for farmers in Cinzana.

Table 5.12 presents data on what farmers said they would like to use the FDVS project credit for in the upcoming 1987 crop year. All farmers intended to use the credit for insecticide, given the necessity of insecticides to grow the new varieties. Half the sample desired credit for draft animals, given the high cost of these and the cash flow constraints faced by farmers. Substantially smaller numbers of the sample wanted to use credit for multipurpose plows and for fertilizers.

Table 5.12. Farmers' Desires for Credit from FDVS Project for the 1987 Crop Year

Farmers Responding	N = 60	Percentage (%)
Insecticide for Cowpea	60	100
Loans for Draft Animals	30	50
Multipurpose Plow	16	27
Phosphate Fertilizer	12	20

Source: Author's Survey, Cinzana, 1986.

Notes: This table shows the percentage of respondents interviewed in 1986 who reported that they would like to borrow from the FDVS credit program in 1987 for the various inputs listed.

Extension

Extension services are provided by the FDVS project to villages eligible for the credit program. The impact of extension on the farming system at Cinzana is difficult to establish since farmers already had some knowledge in using animal traction. The only new technique taught by extension agents has been the spraying of insecticide using ULV sprayers. Demonstration field days are organized in villages to teach this technique. The extension agency has no

connection with the research station of Cinzana and each of them is affiliated with a different government agency. The extension agency is not aware of the research carried out on station and there are no on-farm tests conducted by the researchers in the Cinzana area to inform extension of appropriate technologies to recommend to farmers. The extension agents spend most of their time managing credit and recommending techniques to farmers without any feedback to or from researchers.

An example of the lack of linkage between research and extension in the Cinzana area is the use by farmers of Cypermethrin, an insecticide to control cowpea insects. This insecticide is provided through the in-kind credit program without any on-station or on-farm tests in the area to assess its technical and economic effectiveness. More than 20 percent of the farmers complained about the technical inefficiency of Cypermethrin compared to the former insecticides Decis and Endosulfan used in 1985 by some "innovators". The farming systems and the agricultural research components of the FDVS project, which were supposed to advise the project in technology generation, had not started by 1986 and the main focus of the project seemed to be on extending credit rather than on the other components such as socio-economic monitoring, adult education, etc. The agronomic and socioeconomic constraints faced by farmers are assessed by the socioeconomic monitoring unit, but not yet integrated in the research, extension, and credit process to formulate adequate recommendations to farmers. Also, few linkages exist between the different units of the project.

Non-Formal Adult Literacy Program

The adult literacy program (alphabetisation fonctionnelle) was set up as a unit of the FDVS project to initiate farmers in learning to write in the local language and master basic animal traction techniques and simple management operations, such as computing a farm budget. This type of training was also

promoted as part of integrated rural development projects in the 1970's in Mali through government parastatals (ODRs). In the FDVS project, two farmers from each village are selected and trained for two weeks to serve at the village level as teachers (animateurs) for adult literacy. The FDVS trained 14 animateurs from 1985 to 1986. The main problem faced by this program is the lack of incentives (no salary) for animateurs, who are forced to migrate to cities during the dry season in order to earn money for head taxes, marriage dowries, and to meet other kinds of cash needs.

The training programs also cover routine animal traction techniques already known by most of farmers, who are not very motivated to participate in the program. Farmers do not perceive adult literacy materials as relevant in increasing production of crops such as cowpeas, since the training manuals are sponsored by CMDT and ODIPAC, the cotton and groundnut parastatals, and focus on these crops. Farmers suggested that training materials should focus on cash crops (cowpeas in the Cinzana area) to increase farm incomes. Sixty percent of the sample farmers reported that they were more motivated for adult training when the peanut parastatal was operating in the area before 1982 because of the relevancy of the materials, which were focused on peanuts, the basic cash crop at that time. These materials also helped them learn more about animal traction cropping techniques to increase yields and farm incomes. Because the adult literacy program has not focused on relevant topics to farmers (cowpea cropping techniques, storage, etc.), it has not gained much interest from farmers.

Animal Health Program

Animal health is considered as an important issue by all of the farmers interviewed. They recognized the importance of the 1500 FCFA draft animal health costs included in the five-year loans for draft animals because of the occurrence of common animal diseases such as intestinal worms, trypanosomiasis

and other parasitic diseases. The high cost of draft oxen (60,000 FCFA/animal) and the high frequency of disease are important factors in explaining the farmer high demand for intensive health care of draft animals.

Marketing for New Varieties of Cowpeas

Just as input availability plays an important role in the adoption of new varieties of cowpeas, the prices and market for cowpeas are the most important factors in sustaining and continuing adoption of the new varieties. An ensured market and remunerative prices for new varieties of cowpeas will enhance cowpea production (increase in area cropped and use of yield-increasing inputs, etc.) and help generate income to pay back the loans for animal traction equipment and animals, insecticides, seeds, fertilizer, storage, chemicals, and to purchase spare parts and repair services for the equipment.

All farmers interviewed in 1986 were deeply concerned with the market problem for cowpeas and hoped that the project would find solution by either purchasing the production as it had in 1985, or find private traders to do so. Farmers thought that local weekly markets and even the daily market of Segou, the nearest city, would not be able to purchase all the 1986 cowpea production. Every farmer had a clear plan for the next year's production of cowpeas, which depended on the success or failure of the 1986 cowpea market. All farmers expected to increase the area cropped in new varieties of cowpeas if a market could be found to sell their production at a "reasonable" price (at least 100 FCFA/kg), as had occurred in 1985. (In 1985 the cowpea production has been bought by the FDVS project as seeds to be diffused throughout villages covered by the project). When asked how they could increase cowpeas area without running into a land constraint, farmers suggested the substitution of cowpeas for fonio or bambara nut, in addition to the use of fallow lands. No farmer suggested substituting cowpeas for millet or sorghum production, as they still considered

cereals as basic crops for food self-sufficiency. On the other hand, all farmers stated that they would decrease cowpea acreage to supply only their home consumption level if the prices became depressed by the lack of sufficient markets to buy the 1986 production (See the sensitivity analysis in Chapter 6).

The Cowpea Market in Mali

Our survey of the cowpea markets in some cities in Mali revealed that cowpeas are well known in Malian urban markets except in Gao and Tombouctou, where only two to three traders sell small quantities in the market (200-300 kg/month) during the post-harvest period.

Local varieties of cowpeas are produced and sold on rural markets by farmers who bring small quantities to the market (10-20 kg/farmer/market day) in the post-harvest period. Intermediaries (men or women) between farmers in the rural areas and wholesalers in the cities collect cowpeas and cereals from the weekly markets. Intermediaries can work for wholesalers or borrow money to purchase cowpeas and resell them to wholesalers, who are mostly coarse grain wholesalers. The wholesalers store cowpeas and coarse grains in the same warehouses and resell them.

There are no traders specialized in just cowpea trading, given the scarcity of cowpeas on the market due to low yields (100-200 kg/ha for local varieties). The supply on markets fluctuates following the seasonal pattern of production. The average supply on urban markets varies from one to two tons per week in the immediate post-harvest period to a few kilos in the rainy season. Cowpeas are also sold retail at the warehouse gates by wholesalers as well as by intermediaries. Housewives represent 80 percent of the customers for cowpeas, which are used as ingredients for sauce, cakes, and as basic dinner dish. According to traders, the color, storage quality, and size of cowpeas seeds are very important for customers, who prefer varieties whose seeds are white (local

varieties and one new variety, TN 8863), big, and not attacked by insects. These characteristics result from customers being habituated to local varieties, which have these qualities. New varieties of cowpeas have small, red or white seeds, and are very sensitive to insect attacks if not treated against weevils in storage. But no differences exist between prices of local and new varieties.

Storage and Transportation

All the wholesalers interviewed owned one or more warehouses of 200 tons capacity, where cowpeas and other grains are stored for sale. Wholesalers use chemical insecticides such as HCH (hexachlorocyclohexane) or DDT powder, which are mixed with cowpea seeds before storage in fiber sacks. Traders think that HCH is very efficient in controlling cowpea weevils and can help keep cowpeas in "good condition" (insect free) for at least 4 months. But the HCH and DDT are seriously questioned and not recommended by technicians for seeds destined for human consumption because of their possible health effects. Some traders use ashes, which are mixed with an equal volume of cowpeas and stored in sacks, but this method of storage is traditional and possible with small quantities of cowpeas only (50-100 kg) because of the difficulties in finding large quantities of ashes for larger storage capacity. Some wholesalers do not use any insecticide and speed up the turnover time of cowpea stocks for sale to avoid serious damage by weevils. The FDVS project has introduced storage of cowpeas in polypropylene packs with one tablet of the insecticide Phostoxin per sack of 50 kg. This technique has been very good so far, but has not yet diffused to farmers and traders.

The availability of vehicles to carry cowpeas from rural markets to cities and to neighboring countries for export was not a constraint for traders. Intermediaries rent small pick-up trucks at a cost of 30,000 FCFA per round trip of 40 km to collect cowpeas from rural markets and transport them to the nearest cities. Wholesalers also rent large trucks (semis) for cowpea exports to Cote

Ivoire or Ghana at an average cost of 650,000 FCFA for a round trip from Bamako to Abidjan. Cowpea exports are organized once or twice a year only, due to low supplies of cowpeas, which are collected in small increments from rural markets throughout the year. Small quantities of cowpeas (200-300 kg/week) are collected and sold to wholesalers, who store them until sufficient quantities are raised for export (20-40 tons/trip). [The traders suggested that sales of cowpeas to major Malian cities and exports to neighboring countries could be expanded if reliable supplies could be assured.]

Prices and Margins

Prices fluctuate according to the seasonal patterns of supplies. The cropping year can be broken down into 3 periods: from October to January (harvest), February to May (post-harvest) and from June to September (rainy season). In 1986, producer prices varied from 95 to 165 FCFA/kg on weekly markets and from 120 to 195 FCFA/kg for consumers in urban retail markets. (Table 5.13). The official producer price given by the FDVS project was 100 FCFA in 1985.

Margins vary according to marketing agents. The intermediaries between producers and wholesalers have a gross margin of 10-15 FCFA/kg and a net margin of 5 to 10 FCFA, with a cost of transportation of .125 FCFA/kg/km from weekly markets to the nearest city. Wholesalers have a net margin of 10-25 FCFA kg of cowpeas.

Current and Potential Demand for Cowpeas in Mali

Ninety percent of the sample of cowpea traders, when interviewed, did not know about the new varieties of cowpeas and reported that their customers did not either. The white and big sized seeds of local varieties of cowpeas were the only ones known to anyone. Despite the red color and the small size of new varieties such as KNI, traders thought that customers would like them after a

availability of large cash loans to purchase animal traction equipment. Formal credit is deemed impersonal and less shameful if one has trouble paying it back and larger loans can be received through the formal credit program than through informal credit. Farmers, however, complained about the yearly repayment amount which they consider high (annual charge for depreciation plus a 10 percent interest rate on the cost of the animal equipment and draft animals). Some complaints were also directed at the FDVS project management that farmers were not informed at the time they took out the loans in 1986 for animal traction equipment that they would be required to pay for the cost of transporting the equipment. (They were billed for this two months after delivery.) According to farmers, the project manager should have had a clear idea of the costs before making any decision concerning extending loans to farmers.

Some farmers (20 percent) thought that the draft animals credit policy should be revised because of complaints about the insurance on the animals' lives. According to farmers, the terms of the insurance are not very clear, and if the animal dies, a very lengthy investigation to establish responsibilities regarding the cause of the death is required before any repayment can be made. The animals' life insurance is a new policy to farmers, who reported themselves to be frustrated by the denial of repayment to some of their colleagues. In general, farmers are satisfied with the quantities of animal traction equipment credit, despite missing spare parts for plows.

If there were no formal credit program, any investment in animal traction equipment and draft animals would take a long time, if it were at all possible given frequent financial problems at the farm and village levels. More than 70 percent of the farmers interviewed reported that the low levels of savings and cash are channeled into food purchases to meet "hungry season" needs, to pay taxes, to pay part of the marriage dowry and other social expenditures rather than

being invested in farm equipment. Formal credit is the major source of important investments (animal traction) for farmers in Cinzana.

Table 5.12 presents data on what farmers said they would like to use the FDVS project credit for in the upcoming 1987 crop year. All farmers intended to use the credit for insecticide, given the necessity of insecticides to grow the new varieties. Half the sample desired credit for draft animals, given the high cost of these and the cash flow constraints faced by farmers. Substantially smaller numbers of the sample wanted to use credit for multipurpose plows and for fertilizers.

Table 5.12. Farmers' Desires for Credit from FDVS Project for the 1987 Crop Year

Farmers Responding	N = 60	Percentage (%)
Insecticide for Cowpea	60	100
Loans for Draft Animals	30	50
Multipurpose Plow	16	27
Phosphate Fertilizer	12	20

Source: Author's Survey, Cinzana, 1986.

Note: This table shows the percentage of respondents interviewed in 1986 who reported that they would like to borrow from the FDVS credit program in 1987 for the various inputs listed.

Extension

Extension services are provided by the FDVS project to villages eligible for the credit program. The impact of extension on the farming system at Cinzana is difficult to establish since farmers already had some knowledge in using animal traction. The only new technique taught by extension agents has been the spraying of insecticide using ULV sprayers. Demonstration field days are organized in villages to teach this technique. The extension agency has no

connection with the research station of Cinzana and each of them is affiliated with a different government agency. The extension agency is not aware of the research carried out on station and there are no on-farm tests conducted by the researchers in the Cinzana area to inform extension of appropriate technologies to recommend to farmers. The extension agents spend most of their time managing credit and recommending techniques to farmers without any feedback to or from researchers.

An example of the lack of linkage between research and extension in the Cinzana area is the use by farmers of Cypermethrin, an insecticide to control cowpea insects. This insecticide is provided through the in-kind credit program without any on-station or on-farm tests in the area to assess its technical and economic effectiveness. More than 20 percent of the farmers complained about the technical inefficiency of Cypermethrin compared to the former insecticides Decis and Endosulfan used in 1985 by some "innovators". The farming systems and the agricultural research components of the FDVS project, which were supposed to advise the project in technology generation, had not started by 1986 and the main focus of the project seemed to be on extending credit rather than on the other components such as socio-economic monitoring, adult education, etc. The agronomic and socioeconomic constraints faced by farmers are assessed by the socioeconomic monitoring unit, but not yet integrated in the research, extension, and credit process to formulate adequate recommendations to farmers. Also, few linkages exist between the different units of the project.

Non-Formal Adult Literacy Program

The adult literacy program (alphabetisation fonctionnelle) was set up as a unit of the FDVS project to initiate farmers in learning to write in the local language and master basic animal traction techniques and simple management operations, such as computing a farm budget. This type of training was also

promoted as part of integrated rural development projects in the 1970's in Mali through government parastatals (ODRs). In the FDVS project, two farmers from each village are selected and trained for two weeks to serve at the village level as teachers (animateurs) for adult literacy. The FDVS trained 14 animateurs from 1985 to 1986. The main problem faced by this program is the lack of incentives (no salary) for animateurs, who are forced to migrate to cities during the dry season in order to earn money for head taxes, marriage dowries, and to meet other kinds of cash needs.

The training programs also cover routine animal traction techniques already known by most of farmers, who are not very motivated to participate in the program. Farmers do not perceive adult literacy materials as relevant in increasing production of crops such as cowpeas, since the training manuals are sponsored by CMDT and ODIPAC, the cotton and groundnut parastatals, and focus on these crops. Farmers suggested that training materials should focus on cash crops (cowpeas in the Cinzana area) to increase farm incomes. Sixty percent of the sample farmers reported that they were more motivated for adult training when the peanut parastatal was operating in the area before 1982 because of the relevancy of the materials, which were focused on peanuts, the basic cash crop at that time. These materials also helped them learn more about animal traction cropping techniques to increase yields and farm incomes. Because the adult literacy program has not focused on relevant topics to farmers (cowpea cropping techniques, storage, etc.), it has not gained much interest from farmers.

Animal Health Program

Animal health is considered as an important issue by all of the farmers interviewed. They recognized the importance of the 1500 FCFA draft animal health costs included in the five-year loans for draft animals because of the occurrence of common animal diseases such as intestinal worms, trypanosomiasis

and other parasitic diseases. The high cost of draft oxen (60,000 FCFA/animal) and the high frequency of disease are important factors in explaining the farmer high demand for intensive health care of draft animals.

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Margins vary according to marketing agents. The intermediaries between producers and wholesalers have a gross margin of 10-15 FCFA/kg and a net margin of 5 to 10 FCFA, with a cost of transportation of .125 FCFA/kg/km from weekly markets to the nearest city. Wholesalers have a net margin of 10-25 FCFA kg of cowpeas.

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Ninety percent of the sample of cowpea traders, when interviewed, did not know about the new varieties of cowpeas and reported that their customers did not either. The white and big sized seeds of local varieties of cowpeas were the only ones known to anyone. Despite the red color and the small size of new varieties such as KNI, traders thought that customers would like them after a

Table 5.13. Prices of Cowpeas in Some Cities of Mali, 1985-86 (FCFA/kg)

Cities	Harvest		Post-Harvest		Rainy Season	
	Rural*	Urban**	Rural	Urban	Rural	Urban
San	125	150	135	165	160	165
Mopti	95	150	110	175	115	200
Gao	160	195	160	195	175	200
Tombouctou	90	190	90	190	100	200
Niono	85	135	100	200	100	225
Segou	75	100	85	110	125	150

Source: Author's Survey, Mali, 1986.

*Rural markets are weekly markets around the cities and supply them with cowpeas

**Urban markets are those of the cities mentioned in the table.

period of trial and hesitation. In the short run (one year), it is likely that the variety TN 8863, which is white but has small seeds, will be more easily sold than KNI and Gorom-gorom, which are red.

Traders from different cities suggested also that the FDVS project could purchase and sell to them one to two tons of cowpeas per trader on credit for an introductory period to get consumers used to the new varieties. In Segou and Mopti, four wholesalers reported that they would like to purchase the whole cowpea production of Cinzana area and export it to Cote d'Ivoire and Ghana, where the demand is much higher than Mali, if the government would lower export taxes and alleviate the whole bureaucratic paperwork involved in exporting. Wholesalers who are willing to export found that the main constraints on exports are the high taxes, bribery of custom officials and tedious paperwork, creating disincentives and barriers to exports toward neighboring countries.

Another concern expressed by wholesalers is the storage problem, due to cowpeas' sensitivity to weevils. The use of phostoxin, not yet known to traders, could be a

breakthrough in solving cowpea storage problems and facilitating exports by lowering insect damage that reduces the quality of cowpeas sold.

CHAPTER 6

ECONOMIC ANALYSIS OF ADOPTION OF NEW VARIETIES OF COWPEAS BY FARMERS IN THE CINZANA AREA

Economic Analysis of Cropping Techniques (Insect Control and Fertilizer Use) For New Varieties of Cowpeas

Assessing the costs and benefits of on-farm cropping techniques is important and helps to understand farmer patterns of adoption of technologies and their accompanying inputs. It also helps to make better recommendations to farmers. In Cinzana, the FDVS project extension agency is facing a key problem common in adoption behavior of new technologies by small, poor, and risk-averse farmers: the low rate of adoption of the full package of proposed innovations and accompanying inputs. The new varieties of cowpeas are quickly adopted and well diffused (88 percent of farmers used them in the sample); however, the Ultra-Low Volume (ULV) and the phosphate fertilizer proposed by the extension agency are seldom used by farmers (30 percent of farmers in the sample buy them). For farmers, economic reasons are paramount in explaining such low adoption rates of accompanying inputs and equipment. The budgets and sensitivity analyses presented in this chapter shed some light on understanding the constraints impeding adoption of complementary equipment and inputs by farmers.

In order to develop the budgets and to understand the differences between what extension recommends and what farmers actually do, one needs first to understand what practices are actually carried out in growing cowpeas, both on the farm and on-station.

Identifying Variable Inputs

On-Station Inputs for Cowpeas Trials

Most of the yields of new varieties are higher on station than on farms. The reasons are basically the high levels of inputs applied on trials and the better management of cultural practices on small plots.

Land Preparation

On the station, the land is plowed at the end of the rainy season or after the first rain falls, and the plowing can be followed by a ridging. All the land preparation is done mechanically by a tractor of 20 to 90 HP.

Fertilization

This is done during planting at the rate of 200 kg of Complex cotton (14N-24P-13K-6S-1B), which is the equivalent of 45 kg P_2O_5 per hectare of cowpeas in monoculture.

Planting

The seeds are treated with a fungicide (Thioral) at a rate of 30 g per 10 kg of cowpea seeds before planting. The seeding rate is 25 kg/ha, and after germination the plants are thinned to a density of two plants per planting hill.

Weeding

Weeding is an important operation for cowpeas and is done 10 days after planting. The second weeding is done 15 days after the first one and later weedings are optional depending on the needs of the plant. The sick plants are pulled out before and during the flowering stage to strengthen the others. Weeding is all manual and done by hired labor (farmers from the neighboring villages who work part-time).

Insect and Disease Control

Cowpeas are very sensitive to insects as well as diseases and require pest and disease control. On-station researchers use 2.5 liters/ha each of the

Insecticides Decis (deltramethrin) and Endosulfan (also called Thimul 35) per treatment of cowpeas against pests. The insecticide treatment is repeated two to four times depending on the degree of attacks by pests, at intervals of 10 days. All the insecticide treatments are applied with a ULV sprayer, which is supposed to be more technically efficient in spraying than the Tecnoma 15, an old type of sprayer mostly used in cotton insect control in some parts of the cotton zone. "Thioral vert" is the only fungicide used (75 g/ha).

Harvesting

New varieties of cowpeas are harvested two to three times. The harvest starts when at least 50 percent of the pods are mature. Harvesting is a labor-intensive activity (cf. Table 6.1).

Storage

After shelling, cowpeas seeds are treated with an insecticide (Bromophos or Phostoxin) at a dose of 1 tablet for 50 kg of seed and stored in plastic bags to avoid further contamination.

On-Farm Input Use

Land Preparation

The land preparation is done entirely with animal traction, using the multipurpose plow and a pair of oxen to perform a light plowing. All the land preparation is done after the first rainfall when the soils are softened and easy to work with animal traction.

Planting

Planting is done manually by 70 percent of the farmers and by an animal traction seeder for the remaining 30 percent. The seeding rate is 20 kg/ha, which is less than the 25 kg used on station and recommended by the extension agency. Farmers always crop new varieties of cowpeas in pure stands, in contrast to the local varieties, which are grown in mixed stands with millet and sorghum. The

main reason given for sole cropping is the importance of the new varieties of cowpeas as cash crop, which should be taken care of in a manner similar to other major crops such as millet, sorghum, or peanuts. Another reason for sole cropping is uncertainty about whether the insecticides used would damage the cereals if cereals and cowpeas were intercropped.

Weeding

Weeding is done manually or in combination with animal traction (use of the multipurpose plow to weed), which operates between raised seed rows. In contrast to the research station, 85 percent of the farmers weed only one or two times due to labor constraints at the weeding period between cowpeas and other basic crops such as millet and sorghum. Weeding is one of the main constraints in the cropping calendar because of high labor requirements.

Fertilizer

Fewer than 10 percent of farmers in the sample used organic manure in cowpea fields. The reason for this low rate is the scarcity of organic manure and its preferred use for "home crops" (corn, vegetables, etc.), which are cultivated near the houses and require more nutrients than other crops. Mineral fertilizer was used by only 30 percent of the sample farmers and the levels of application were variable from 20 to 100 kg/ha. Only 25 percent of the farmers who used fertilizer (eight percent of the total sample) applied it at the rate of 65 kg of "Complex coton" per hectare as recommended by the FDVS project extension agency.

Insect and Disease Control

The FDVS project supplies treated cowpeas seeds on a one-year credit basis to farmers. The fungicide used in the treatments of seeds is Thioral. For insect control, Cypermethrin has been used since 1986 in place of the Decis and Endosulfan. Most of the farmers in the first generation who were used to Decis

and Endosulfan found Cypermethrin less efficient. Cypermethrin has been brought to farmers by the FDVS project without any preliminary testing on station or on farm. The application rate of 2.5 liters per hectare is recommended by the manufacturer in Europe. The application is repeated two to three times. The main constraint facing farmers in insect control is the repayment of ULV sprayer loan within one year. Most farmers (90 percent of farmers in the sample) reported they think the ULV sprayer too costly (11,650 FCFA) for a one-year repayment. Fifty-five percent of farmers in the sample used branches or traditional housecleaning brooms (balais) to apply insecticide on cowpeas plants. The Cypermethrin is mixed with water as farmers formerly did with Endosulfan or Decis, poured into a bucket and carried from row to row by hand and applied with branches or a broom.

Technicians believe that Cypermethrin is designed to be sprayed with ULV sprayers only. The remaining 45% farmers who used a ULV sprayer owned it (supplied by the FDVS credit program) or borrowed it from owners for free.

Harvest

Farmers harvest later than researchers and wait until most of the pods are mature and very dry or starting to fall down. One reason for this delay in harvesting is the labor. Women are mostly the ones who harvest cowpeas, in addition to their other duties such as housekeeping, cutting firewood, and vegetable growing. Men do the last weeding for millet and sorghum fields during the cowpea harvest period (September and early October). Although harvest losses are not accurately estimated, they are important and should be on the agenda of research and extension. Harvest requires more than 50 percent of the total labor input for cowpea production.

Table 6.1 Labor Allocation For On-station and On-farm Production of New Varieties of Cowpeas (Person days per ha).

Operations	On-station trials (N=16) (Researcher managed)		On-farm cropping (N=10) (farmer managed)	
	Equipment used	Person days	Equipment used	Person days
<u>Land preparation</u>				
Light plowing	tractor	1	multipurpose plow	5
Ridging	tractor	1	multipurpose plow	5
<u>Fertilization</u>	hoe	2	hoe	1
<u>Planting</u>	hoe	2	hoe	2
<u>Weeding</u>				
first	hoe	6	multipurpose plow and hoe	5
second	hoe	5	hoe	4
<u>Insect Control</u>				
first	ULV sprayer	1	ULV sprayer or Branches/Broom	1 1½
second	ULV sprayer	1	ULV sprayer or Branches/Broom	1 1½
third	ULV sprayer	1	ULV sprayer or Branches/Broom	1 1
<u>Harvest</u>				
first	manually	17		17
second	manually	10		10
third	manually	3		1
Threshing/Winnowing	manually	<u>15</u>		<u>15</u>
<u>Total</u>		65	ULV Branches/Broom	68 68½
Yields (kg/ha)		1225		780
Output (kg)/person day		19		11

Source: Author's survey and the on-station experimental trials, Cinzana 1986.

Storage

Cowpeas are harvested and spread on the ground to dry completely. The dry pods are threshed with sticks and winnowed by women. The seeds are stored in sacks or in big earthenware storage jars.

Less than 20 percent of the farmers interviewed have used Phostoxin, available through the FDVS project, to control weevils in the stored cowpeas. Farmers need more information about conservation techniques to prevent insects from damaging the stored cowpeas.

Economic Reasons for Adopting New Varieties of Cowpeas

Table 6.2 compares the budgets with and without the new varieties of cowpeas, using the different techniques of insect control (no insecticide, insect control with broom application and insect control with the ULV sprayers).

The returns to family labor (incremental returns to labor) are compared to the wages paid by the research station of Cinzana to farmers hired as part-time workers. (Local farmers consider working on the research station as a good opportunity to make some cash). The wages paid by the research station to farmers were 550 FCFA/day in 1986. The "without" situation is the farming system without new varieties of cowpeas, based on data collected in the 1982/84 farm survey.

A few words should be said about how labor is valued in table 6.2. Valuing labor at the on-station wage probably gives an over-estimate of the added labor costs involved in growing the new varieties. It is difficult to come to an exact estimate of the opportunity cost of labor in the area, however. Women harvesting the crop (harvest labor represents most of the additional labor in cropping the new varieties) are paid in kind, at the rate of 2 kg of cowpeas per day. Valued at the market price, this would be the equivalent of 200 FCFA/day. But the women are also typically related to the farmers' whose cowpeas they harvest, and they

usually receive other gifts in addition to their in-kind wage. Given the importance of harvest labor costs in adopting the new varieties, one area for further research is trying to obtain more accurate estimates of the opportunity cost of the labor involved in growing cowpeas.

The results from the budget comparison are summarized as follows:

- Adopting new varieties of cowpeas makes economic sense only when applying insecticide (under the price assumptions of Table 6.2).
- Without any insect control the average returns to family labor and the incremental returns to labor are very low compared to wages paid by the station. Under the current price assumptions, applying insecticide increases the average incremental returns to labor by 176%, making growing new varieties of cowpeas more profitable than working on the research station as workers. Also, a very important point that with no insecticide treatment both average and marginal returns to labor are lower than average returns to labor under the "without" NVC situation (i.e., farmers would earn less per day of labor with the NVC's than without them and take more risk).
- The use of ULV sprayer has slightly higher incremental returns to labor under the current price assumptions than use of brooms or branches for insecticide application. But this is true under the assumption of no cash constraint because the ULV loan is repaid in one year, but amortized in our budget over 4 years.

Table 6.3 and Figures 6.1 and 6.2 present sensitivity analyses, which were carried out to assess the impact of changes in cowpea prices and insecticide prices on the returns to cowpea cropping. The results are as follows:

- A decrease in cowpea prices would affect adoption of new varieties of cowpeas. At 75 FCFA/Kg, farmers can still crop new varieties and have higher returns compared to wages paid by the research station (Table 6-2

but this price would be the lowest to keep cowpeas cropping more profitable than working on the research station.

- A decrease in cowpea price to 60 FCFA per kg and below would create disincentives for cowpea cropping. At 50 FCFA/kg the incremental return to labor for cowpea cropping is lower than the average returns to daily family labor without new varieties of cowpeas. Cowpea prices are very important in adopting and in continuing adoption of new varieties of cowpeas.
- An increase in insecticide prices can affect incentives to adopt or continue to use new varieties of cowpeas. But the returns are less sensitive to increases in insecticide prices than to decreases in cowpea prices.

To lower average incremental returns to labor to the level of wages paid at the research station the increase in insecticide prices has to reach 130% (3500 FCFA per liter). An increase of insecticide price to 5500 FCFA/liter would lower average incremental returns to labor to 290 FCFA per person day, below the average returns to family labor without new varieties of cowpeas (335 FCFA/day).

These figures are indicative and reflect changes only in average incremental returns. They do not take into consideration the risks involved in making decisions by farmers given the different changes in output and insecticide prices.

Table 6.2. Average Farm Crop Production Budgets With and Without New Varieties of Cowpeas (NVC) in Cinzana - 1986

ITEM	Without Insect Control		With Insect Control & NVC	
	Without NVC	With NVC	Broom/branches Insect. application	ULV Appli
<u>Average adjusted yields (kg/ha)</u>				
Millet	620	620	620	620
Sorghum	500	500	500	500
Groundnuts	380	380	380	380
Cowpeas (New Varieties) in Pure stand	0	240	667	703
Cowpeas (Local varieties) intercropped with millet and sorghum	80	80	80	80
Fonio	600	0	0	0
<u>Average areas (Ha/Farm)</u>				
Millet (intercropped with local varieties of cowpeas)	5.6	5.6	5.6	5.6
Sorghum (intercropped with local varieties of cowpeas)	2.5	2.5	2.5	2.5
Groundnuts	.6	.6	.6	.6
Cowpeas (new varieties)	0	1.5	1.5	1.5
Fonio	.22	0	0	0
<u>Total Output (yield x area)</u>				
Millet	3,472	3,472	3,472	3,472
Sorghum	1,250	1,250	1,250	1,250
Groundnuts	228	228	228	228
Cowpeas (NVCs)	0	360	1,000	1,054
Fonio	132	0	0	0
Cowpeas (local varieties)	648	648	648	648

Table 6.2. (continued)

ITEM	Without Insect Control		With Insect Control & NVC	
	Without NVC	With NVC	Broom/branches Insect. application	ULV Appli
Gross Benefit (FCFA/Farm)				
Millet	104,160	104,160	104,160	104,160
Sorghum	37,500	37,500	37,500	37,500
Groundnut	11,400	11,400	11,400	11,400
Cowpeas (New varieties)	0	36,000	100,050	105,450
Ponio	6,600	0	0	0
Cowpeas (Local varieties)	<u>64,300*</u>	<u>64,300</u>	<u>64,300</u>	<u>64,300</u>
Total Gross Benefit	224,460	253,360	317,910	323,310
Fixed Plus Variable Costs (FCFA/Farm)				
Animal traction equipment annual charge	20,000	20,000	20,000	20,000
Animal traction animals annual charge	15,000	15,000	15,000	15,000
ULV sprayer annual charge	0	0	0	5,000
insecticide	0	0	18,000	16,375
seeds	3,105	6,105	6,105	6,105
fungicides	560	560	560	560
labor input (person-days)	550	632	635	635
Incremental labor input	0	82	85	85
Total Costs	38,665	41,665	39,665	63,540
Returns				
Total return to family labor input (FCFA)	185,795	212,195	258,245	259,770
Average return to family labor (FCFA/day)	338	336	405	410
Total incremental return to family labor (FCFA)	—	26,400	72,450	73,975
Average incremental Return Incremental Labor (FCFA/day)	—	332	850	870

Source: The data are based on both the 1982-84 farm level survey and the 1986 farm data collection (for the "Without NVC" option).

Price Assumptions Used in Table 6.2**Outputs**

Millet:	30 FCFA/kg
Sorghum:	30 FCFA/kg
Groundnuts:	50 FCFA/kg
Cowpeas:	100 FCFA/kg
Fonio:	50 FCFA/kg

Variable Inputs

Annual cost of ULV:	5000 FCFA/year
Insecticide:	1500 FCFA/liter

*The value of cowpeas (local varieties) may be overvalued because of big sizes of millet and sorghum intercropped with local varieties of cowpeas. But this value can also include hay since cowpeas hay is not valued here but important for livestock feeding in dry season. As mentioned earlier, local varieties of cowpeas are cropped basically for cowpea hay.

Table 6.3. Sensitivity Analyses: Impact of Changes in Cowpea Prices and Insecticide Prices on Incremental Returns to Labor.

Cowpea Prices (PCFA/kg)	Broom Application of Insecticide	ULV Application of In Insecticide
A. Change in Cowpea Price		
100 (Base run)	850	870
75	565	570
65	440	435
60	395	390
50	280	270
40	170	150
35	110	90
30	55	30
B. Change in insecticide prices		
1,500	850	870
2,000	780	805
2,500	710	740
3,000	640	670
3,500	570	605
4,000	500	540
4,500	430	470
5,000	360	405
5,500	290	340

Source: Author's survey - Cinzana 1986.

FIGURE 6.1 Sensitivity Analysis: output price

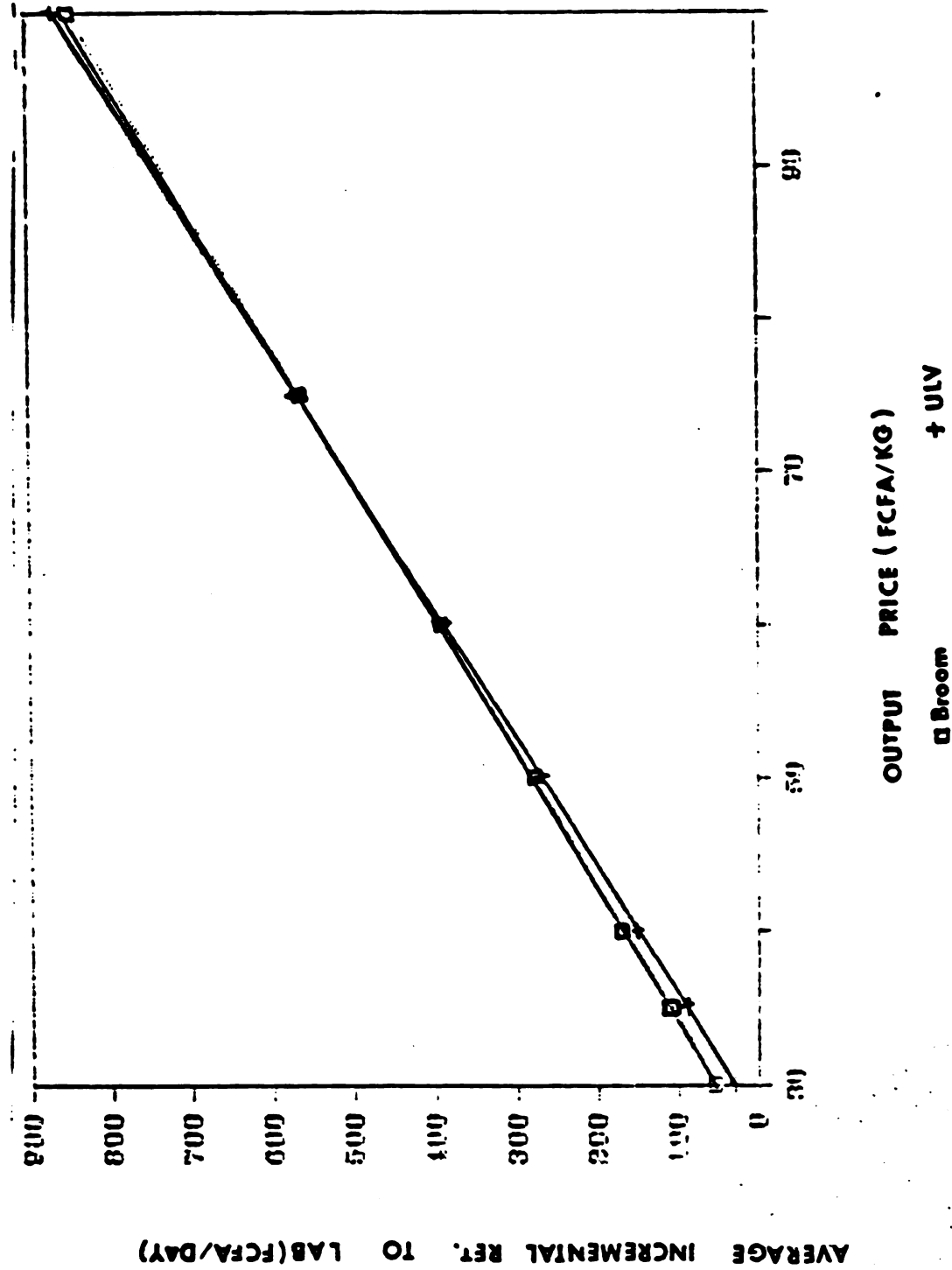
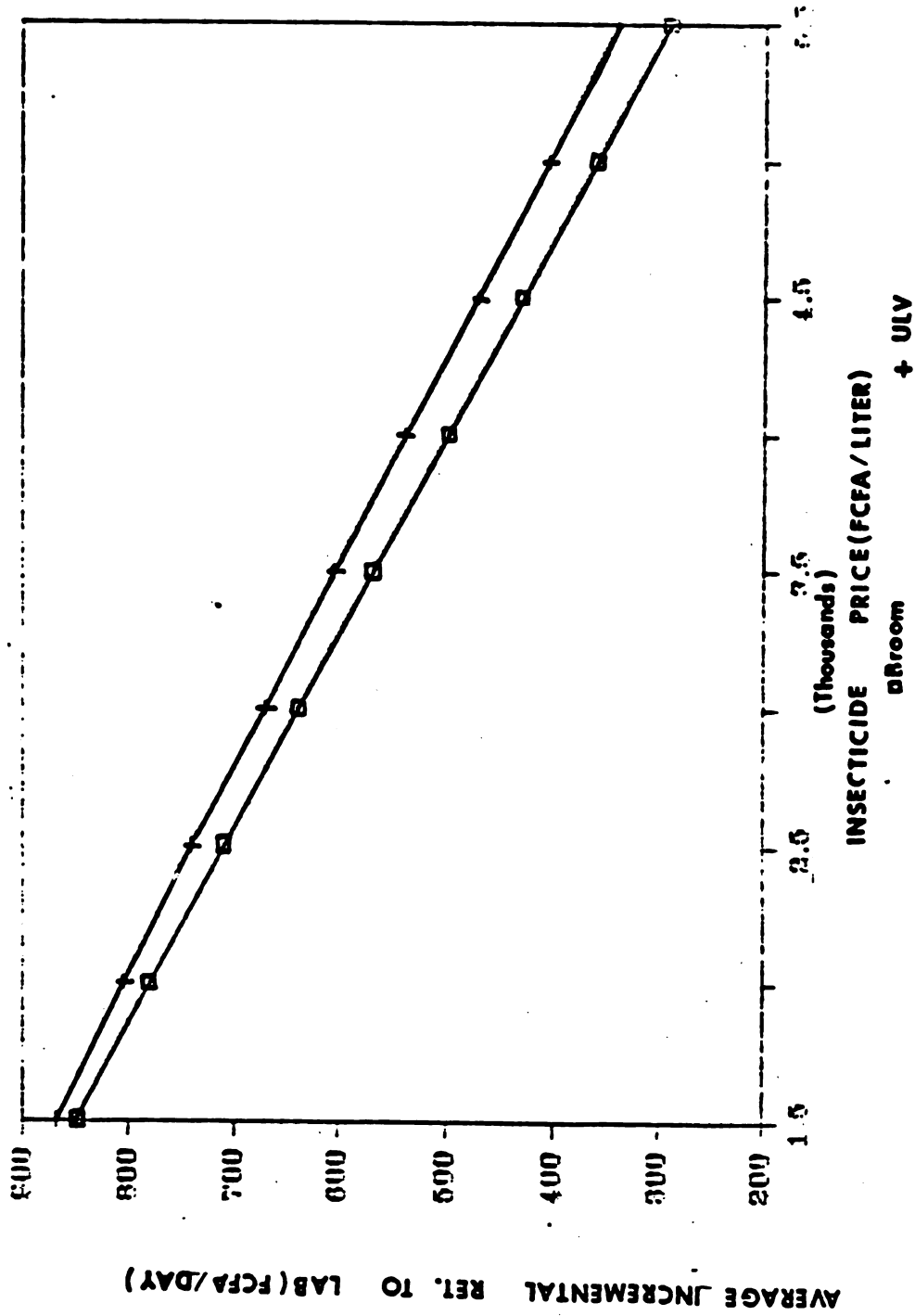


FIGURE 6-2 Sensitivity Analysis: insecticide price



Partial Budget for On-Farm Insect Control Techniques

As shown in Table 6.2 insect control is essential for cropping new varieties of cowpeas. According to farmers interviewed the use of brooms or tree branches to spray insecticide is widespread because of its low cost.

The partial budget (Table 6.4) confirms this perception of farmers under the the current prices for cowpeas, insecticides, and the ULV sprayer. The broom spray technique of applying insecticide has the advantage of no investment in the ULV sprayer, which is supplied by the FDVS credit program on a one-year repayment basis. Cash-flow constraints to payback the ULV sprayer and the insecticide within one year, in addition to higher returns and low costs, explain the use of broom more than the ULV sprayer in applying insecticide to new varieties of cowpeas.

But farmers report that the ULV sprayer is more convenient in spraying insecticide on large cowpea fields (more than 2 ha) because it is less tiresome than broom or tree branches.

Table 6.4 Partial Budget for On-farm Insect Control Techniques for New Varieties of Cowpeas (costs/ha).

Variable	No Insect Control (N = 7)	Insect Control with ULV Sprayer (N = 8)	Insect Control with Tree Branches or Broom (N = 9)
Average Yield (kg/ha) ^a (standard deviation)	264 (90)	781 (112)	740 (114)
Adjusted Yield (kg/ha) (-10% losses) ^b	240	703	667
<u>Gross Benefit</u> (FCFA/ha)	24,000	70,300	66,700
<u>Variable Costs</u>			
- Quantity of Cypermethrin (liters)	0	7.5	8
- Cost of Insecticide	0	11,250	12,000
- ULV Annual Charges ^c	0	5000	0
Total Cash Costs (for insect control)	0	16,250	12,000
<u>Variable Opportunity Costs for Labor</u>			
- Labor Cost for Insect Control ^d	0	1,650	1,925
- Additional Harvest Cost ^d	0	9,720	8,980
Total Opportunity Costs	0	11,370	10,905
<u>Variable Costs for Insect Control</u>		27,620	22,905
<u>Net Benefit</u>	24,000	42,680	43,795
<u>Incremental Net Benefit</u>	0	18,680	19,795
<u>Marginal Rate of Return (%)^e</u> (no insect control to insect control)		68	86
<u>Marginal Rate of Return</u> (from preceding to following)		(dominated) ^f	

Source: Author's survey, Cinzana 1986.

Footnotes

- a/ The variety KNI is used in the analysis because of its widespread adoption in the area.
- b/ Losses are not accurately measured by the extension of research. The figure of 10 percent for losses is approximate and is based on discussions with farmers and extension agents.
- c/ The ULV sprayer is supplied to farmers on a one-year repayment credit basis. But for the purpose of this analysis the ULV sprayer is assumed to be amortized over 4 years. The annual charge also includes the cost of batteries.
- d/ Evaluated by valuing labor at the daily wage paid to workers at the research station (550 FCFA/person day). This wage is assumed to be a high opportunity cost for labor.

$$\text{e/ Marginal Rate of Return: } \frac{\text{Marginal Net Benefit (incremental)}}{\text{Marginal Cost (incremental)}} \times 100$$

- 1/ An experiment is dominated if there is another alternative with a higher net benefit and equal or lower variable cost.

Partial Budget for On-station Cowpea Phosphate Fertilizer Trials

Low soil fertility and poor water retention, added to unpredictable rainfall, are the main physical constraints in farming at Cinzana. The responses to chemical fertilizers are highly dependent on water availability and can be very risky. Nonetheless, fertilizer use for cowpeas is highly recommended by the extension agency.

No on-farm trials were made to evaluate the profitability of the different levels of fertilizer use at Cinzana. The only data available are the on-station experiment trials for cowpea response to phosphate fertilizer.

The on-station trials are used in our analysis to assess the profitability of the response of cowpeas to phosphate fertilizer. The results shown in tables 6.5 and 6.6 can help to explain why fertilizers are not used much by farmers for cowpeas, and the need for researchers to carry out economic analysis of on-farm trials before making recommendations to farmers through extension.

The marginal analysis shows low returns for phosphate fertilizer compared to insecticide. Increasing fertilizer use from 0 to 200 kg of "complex coton" (45 kg P_2O_5) which is used very often on station, has a very low marginal rate of return (15 percent) far below the returns from 0 to 15 kg P_2O_5 . On-station trials show a 40 percent marginal rate of returns from moving from no fertilization to 67 kg of "complex coton" (15 kg P_2O_5) which is the highest rate of return among all treatments, given a cowpea price of 100 FCFA/kg. It must be stressed that these station results are based on small sample sizes, and that more studies, especially on the total cost of capital (interest rate for borrowing, risk premium

due to climatic and soils conditions, services charges, etc.) and on-farm trials will allow researchers to develop better fertilizer recommendations for farmers.

The rate of return of 40 percent is also low when we refer to other studies done in the Sahel, especially in Senegal (Crawford and Kamuanga, 1986). Crawford and Kamuanga argued that Senegalese rice farmers would be unlikely to adopt fertilizer use unless the marginal rate of return to fertilizer was at least 50% and that a marginal rate of return of 100% would probably be necessary to secure widespread adoption.

But the returns vary with crops, environments, prices, etc. Further research on on-farm trials of fertilizer use by farmers will be important in analyzing adoption of fertilizer in cowpea cropping.

A sensitivity analysis on returns to fertilizer use on station by changing fertilizer and cowpea prices indicates very low marginal returns to fertilizer use if fertilizer price increased from 150 FCFA/kg to 175 FCFA or above (Table 6.6).

Table 6.3. Partial Budget For On-station Response of Cowpea Variety KNI to Phosphate Fertilizer - Station of Cinzana, 1986

Variable	FARM	ON-STATION TRIALS			
	N = 10	N = 6	N = 6	N = 6	N = 6
Fertilizer Level (Kg P_2O_5 /ha)	0	0	15	30	45
Average Yield (kg/ha) (Cowpea seeds)	781	760	952	1030	1,225
Adjusted Yield (-10% losses)	703	684	857	927	1,103
<u>Gross Benefit</u> (FCFA/ha)	70,300	68,400	85,700	92,700	110,300
<u>Variable Costs</u> (FCFA/ha)					
- quantity of fertilizer (kg/ha)	0	0	65	125	200
- price of fertilizer (FCFA/kg)	—	—	150	150	150
- Cost of fertilizer	0	0	9,750	18,750	30,000
Cost of labor (FCFA/day)	550	550	550	550	550
Cost of labor for fertilization	—	—	550	825	1,100
Added cost for harvest	0	0	2,000	2,900	5,300
<u>Total variable cost</u> (FCFA/ha)	0	0	12,300	22,475	36,400
<u>Net benefit</u> (FCFA/ha)	70,300	68,400	73,400	70,225	73,900
<u>Incremental net benefit</u>		—	5,000	(-3,175)	3,675
Marginal rate of return (%) (from 0 P_2O_5 to each dose)			40	8	15
Marginal rate of return (from preceding to following experiment)		—	40	(dominated)	26

Sources: Author's Farm Survey, Cinzana, 1986.

Table 6.6. Sensitivity Analysis to Assess Changes in Cowpea and Fertilizer Prices on the Returns to Fertilizer Use

Treatments	Net Benefit	Variable Costs	Marginal Net Benefit	Marginal Cost	Marginal Rate of Return (%)
Case I: Increase in fertilizer price from 150 FCFA/kg					
a) Price of fertilizer = 175 FCFA/kg					
1. 0 kg P ₂ O ₅	68,400	0			
2. 15 kg P ₂ O ₅	71,775	13,925	3,375	13,925	24
3. 30 kg P ₂ O ₅	67,100	25,600	4,675	11,675	(dominated)
4. 45 kg P ₂ O ₅	68,900	41,400	1,800	15,800	11
b) Price of fertilizer = 200 FCFA/kg					
1. 0 kg P ₂ O ₅	68,400	0	—	—	—
2. 15 kg P ₂ O ₅	70,150	15,550	1,750	15,550	11
3. 30 kg P ₂ O ₅	63,975	28,725	-6,175	13,175	(dominated)
4. 45 kg P ₂ O ₅	63,900	46,400	-75	17,675	(dominated)
Case II: Decrease in cowpea price from 100 FCFA/kg					
a) Price of Cowpeas = 75 FCFA/kg					
1. 0 kg P ₂ O ₅	51,300	0	—	—	—
2. 15 kg P ₂ O ₅	51,975	12,300	675	12,300	5
3. 30 kg P ₂ O ₅	47,050	22,475	-4,925	10,175	(dominated)
4. 45 kg P ₂ O ₅	46,325	36,400	-725	13,925	(dominated)
b) Price of cowpeas = 50 FCFA/kg					
1. 0 kg P ₂ O ₅	43,200	0	—	—	—
2. 15 kg P ₂ O ₅	30,550	12,300	-12,560	12,300	(dominated)
3. 30 kg P ₂ O ₅	23,875	22,475	-6,675	10,175	(dominated)
4. 45 kg P ₂ O ₅	18,750	36,400	-5,125	13,925	(dominated)
Case III: Decrease in fertilizer price from 150 FCFA/kg					
a) Price of fertilizer = 100 FCFA/kg					
1. 0 kg P ₂ O ₅	68,400	0	—	—	—
2. 15 kg P ₂ O ₅	76,650	9,050	8,250	9,050	90
3. 30 kg P ₂ O ₅	76,475	16,225	-175	7,175	(dominated)
4. 45 kg P ₂ O ₅	83,900	26,400	7,425	10,175	73
b) Price of fertilizer = 80 FCFA/kg					
1. 0 kg P ₂ O ₅	68,400	0	—	—	—
2. 15 kg P ₂ O ₅	77,950	7,750	9,550	7,750	123
3. 30 kg P ₂ O ₅	78,975	13,725	1,025	5,975	17
4. 45 kg P ₂ O ₅	87,900	22,400	8,925	8,675	102

Source: Agricultural Research Station of Cinzana, experimental trials and Author's Survey, 1986.

The decrease of phosphate fertilizer prices from 150 FCFA to 100 FCFA and 80 FCFA give better marginal returns for the dose of 15 kg of P_2O_5 per ha (90 % and 123%). On-farm trials are again needed for better recommendations to farmers given the alternative of a decrease in fertilizer price. The returns to fertilizer use are also very sensitive to decreases in cowpea prices. A change in cowpea price from 100 FCFA to 75 FCFA gives very poor returns making fertilizer use not profitable at all. The results from the economic analysis of adoption of new varieties of cowpeas can be summarized as follows:

- The adoption of new varieties of cowpeas is profitable under the assumptions cited earlier and with the use of insecticide.
- The insect control is a needed technique in cropping new varieties of cowpeas because of the sensitivity to pests. Without insecticide, the returns from new varieties are lower than the situation without new varieties of cowpeas.
- The returns to new varieties of cowpeas are very sensitive to changes in cowpea prices, more so than to changes in insecticide prices. Cowpea prices are very important for the profitability of new varieties of cowpeas.
- The returns to fertilizer (phosphate) are low compared to the returns from insecticide. But on-farm fertilizer trials are necessary for assessing the profitability of fertilizer levels proposed by the extension agency to farmers.

Any fertilizer recommendation to farmers in Cinzana has to take into consideration the cost of fertilizer, the response of cowpeas to fertilizer, the price of output and the risks involved in using fertilizer under erratic rainfall fluctuations.

According to Roy and McClellan (1985) direct application of finely ground phosphate rock may be one of the cheapest ways to supply phosphorus to crops grown in the tropics and subtropics. But on-farm trials of cowpea responses to rock phosphate are necessary for recommendations of optimal doses of phosphate to farmers.

CHAPTER 7

IMPACT OF NEW VARIETIES OF COWPEAS ON THE FARMING SYSTEMS IN THE CINZANA AREA

Impact on the Food Deficit

The food deficit was an important concern in the Cinzana area before the spread of new varieties of cowpeas in 1985. In 1984, more than 79 percent of the farmers were facing a food deficit due to insufficient farm food production to cover the household yearly consumption and lack of adequate income to purchase enough food (Coulibaly and Coulibaly, 1983). In 1985, the food deficit decreased thanks to better rainfalls which were well spread out over the cropping season in the area. In 1985, fifty percent of the farmers interviewed were food self-sufficient and did not buy any food grain from the market or from any other household. Forty-five percent reported that they were food deficit with regard to their own food production, but half of these deficit farmers could purchase food with off-farm incomes, mainly from wages earned at the agricultural research station. Other sources of income were craft sales (hoes, mats, etc.) and petty commerce.

In 1986, 30 percent of the households reported that new varieties of cowpeas helped them reduce the food deficit. Only 15 percent of the farm households, however, reported the new varieties of cowpeas completely eliminated the food deficit, either through on-farm consumption of cowpeas during the hungry season or through sales of cowpeas to buy other food. The new varieties of cowpeas helped to alleviate food problems even in households which did not crop them because of the use of cowpeas as wages for women who were hired for the harvest. The daily wage is two kg of cowpea seed per day per woman. This food for labor was important in alleviating food problems in neighboring villages, from whence the women came to work in villages where new varieties were adopted.

Impact of New Varieties of Cowpeas on Farm Incomes

Farm income from cowpea production was very low in 1985/86 because of the small acreages cropped in new varieties of cowpeas (.50 ha per farm household). The FDVS project started in 1985 and subsidized the "innovators" for half of the cost of inputs used in cowpeas, but farmers were unwilling to take the risk of planting large acreages to these new, largely unknown varieties. The average net farm income from cowpeas varied from 20,000 FCFA to 40,000 FCFA in addition to the family consumption of cowpeas, the in-kind wages and the gifts to the other households (relatives and poor households who receive the Djaka, which is a Muslim in-kind tax on wealth or production to be given to poor). Cowpeas sold to other farmers were used as seeds. The income from cowpeas was expected to be more important in 1986/87, given the expected 1000 tons of cowpea production from the 50 villages involved in the FDVS project (see Table 6.1). The income will also be a function of the prices paid to farmers, which depends on the demand for cowpeas by traders.

The cash need is very important to pay back the FDVS credit and to pay for other expenses such as head taxes, non-agricultural goods for consumption (salt, cola nut, tobacco), payments on dowries for marriage (Table 7.1). Only a few farmers used some part of cowpea income to purchase small ruminants.

Table 7.1. Allocation of Sample Farm Gross Cash Income from Cowpeas in 1985

Items	Percentage of farm cowpea income (%)
Pay back insecticide loans to FDVS credit program	60
Down payment for animal traction equipment or animal loans (first year)	9
Non-agricultural consumer goods (salt, cola nut, tobacco)	10
Payment on marriage doweries	5
Purchase of small ruminants (saving)	16
TOTAL	100

Source: Author's survey - Cinzana, 1986

Impact on Livestock

Livestock play a key role in the village economy as savings, assets, and power for animal traction. Crops are sold to pay for taxes, family consumption of manufactured goods and social events; and the remaining cash, if any, is used to buy goats or sheep for savings. Sheep and goats are sold to buy cattle or to meet current cash needs.

The impact of cowpeas on livestock in the Cinzana area is twofold:

- Earnings from cowpeas are invested in small ruminants.
- Cowpea leaves and pods provide an important source of forage to draft animals in the dry season.

Because cowpea income in 1985 was low, only 18 of the 60 sample farmers used cowpea income to purchase sheep or goats. All farmers expect to use more income from cowpeas in the coming years to purchase more small ruminants and even cattle.

Despite the low forage-yielding capacity of new varieties of cowpeas, they are used in feeding the draft animals in combination with local varieties, which

are richer in fodder. The cowpea pods are recognized to be very nourishing in the dry season when the pastures dry out.

Impact on Fallow Lands

The introduction of new varieties of cowpeas did not affect the areas cropped in basic crops such as millet, sorghum, and groundnuts, but decreased the area of fonio, which competes with cowpeas for harvest labor. Some 30 percent of the farmers interviewed reported that they also used some of their fallow land to crop cowpeas. The use of fallow land without further techniques to improve the fertility of the soils can be a serious problem for farming in Cinzana, where soils are already very poor. Fallowing is the common way to sustain the fertility of the soils; fallows last for five to seven years.

One way to address this problem would be to carry out research on station in collaboration with the FDVS project on crop rotations, soil management practices (incorporation of organic manures, intercropping, use of chemical fertilizer, water retention, etc.) in order to address the future land problem in the area. Farmers are already aware of this future land constraint, as well as the soil's low potential, fragility, low water retention capacity, and the need to overcome these problems. They therefore would likely be very receptive to promising techniques aimed at maintaining soil fertility.

Impact on Family Labor Migration

Family labor is an important factor in farm production. The migration of family labor is higher at the end of the rainy season and involves, on average, one to three persons (men or girls) per farm household who move to urban centers (Segou, Koutiala, Bamako) and Côte d'Ivoire. The migration is seasonal for more than 80 percent of the migrants, who come back at the beginning of the rainy season.

The incomes generated from migration are used mainly for taxes and social

events such as marriage. Seventy percent of the respondents believed that cowpeas have the potential to play an important role in the income-generating capacity of the household and could contribute to decrease the migration. Off-farm activities such as building storage granaries, transportation to the markets, and drying and storing cowpea foods in silos for draft animals are some of the activities that could keep young people busy in the dry season if cowpea cropping became very important.

Impact on Intrahousehold Ties

The 1982-84 farm survey revealed that one of the main reasons for the break-up of extended families into nuclear households was food deficits. All the household heads agreed on food security as a cement to strengthen intrahousehold ties among the members. According to the village heads, hunger has been a source of tension between household members since 1972.

Thirty percent of the heads of extended families think that food security brought by new varieties of cowpeas has contributed to strengthening ties between household members by impeding family break-up. But 10 percent of household heads fear that increasing cash income from cowpeas could develop "individualism" among members and lead to new sources of tension in extended families.

CHAPTER 8

CONCLUSIONS

Summary of Findings

It is too early to draw definitive conclusions about farmers' behavior with respect to adoption of new technologies, but our findings indicate major factors affecting adoption of new varieties of cowpeas in Cinzana. These factors are agroclimatic conditions, the characteristics of the varieties, the institutional setting to sustain adoption and the experiences of farmers in using similar technologies or accompanying inputs.

Agroclimatic Conditions

The poor and erratic rainfall patterns have been very important as constraints in dryland agriculture in Cinzana and therefore favored the quick adoption of new varieties of cowpeas, which mature early. The local varieties of millet, sorghum and cowpeas used by farmers are late-maturing and face the risk of shortages in rainfall before reaching maturity.

Characteristics of the Technology

The characteristics of the technology played a key role in adoption. The early maturing and high yielding characteristics are important factors in adoption of new varieties of cowpeas by farmers. Also, the new varieties of cowpeas are not complicated to use and do not require accompanying inputs unfamiliar to Cinzana farmers, who are used to new varieties of groundnuts supplied by the extension-credit parastatal OACV. The sensitivity of new varieties to pests was important as a constraint to adoption for villages without access to the FDVS credit program and therefore to insecticides.

Personal Characteristics of Farmers

Farmers' experiences with animal traction use made cowpea cropping easier. Also, the innovators who were to adopt new varieties of cowpeas had

information on the existence of the new varieties of cowpeas before the other adopters. They were chiefs of the villages, the chiefs' counselors and the farmers who worked part-time on the research station. But variables such as education did not played an important role in adoption, contrary to what some of the literature review on adoption would suggest (Chapter 3).

Institutional Setting

Institutions such as the research station, from where varieties were taken; and the FDVS, which supplied credit for animal traction equipment and inputs such as insecticide and seeds, and bought cowpeas from farmers in 1985, were very important in affecting adoption by farmers. Farmers who did not have access to insecticide on credit quit or did not adopt the new varieties of cowpeas. Most of these non-adopters were willing to adopt if they could secure access to credit for inputs, especially insecticide.

The returns to cowpeas are also very sensitive to changes in the output price. The profitability of new varieties has been very important in adoption. As the sensitivity analysis in Chapter 6 indicated, higher returns to cowpeas are linked to prices of output and inputs. The higher returns from cowpeas, compared to other crops in the area, were due mainly to higher yield responses with insecticide and higher prices. Profitability as a key factor in adoption of new technologies has been also recognized by many authors (Chapter 3).

Implications for Action

The study revealed that the proximity of the research station facilitated the flow of information on new varieties of cowpeas to surrounding farmers, who took advantage of it. When new varieties of cowpeas were adopted by farmers, the creation of an institution to supply inputs on credit, especially insecticides and animal traction equipment, and to purchase cowpeas in 1985 helped sustain the adoption. To solve constraints linked to adoption and sustainability of adoption of

the new varieties of cowpeas, emphasis has to be put on following factors:

Agricultural Research

Efforts on agricultural research and especially at the agricultural research station of Cinzana, should focus on:

Breeding

The resistance to pests is the most critical issue in new varieties of cowpeas. Since the new varieties are sensitive to pests, breeding for resistance will decrease the use of insecticide and therefore the cost of production of cowpeas, so long as yields of resistant varieties are not so much lower as to offset the savings due to lower insecticide use.

But any research effort should be preceded by socioeconomic surveys at the consumer, farmer and trader levels to determine tastes and constraints, which can serve as research goals. The research results should be tested on the farm level to assess their compatibility to the agroclimatic, socioeconomic, and cultural conditions of farmers and consumers before the release of new varieties to extension and then to farmers.

Cropping Practices

The sustainability of cowpea cropping within the farming systems needs to be researched because of the poverty of the soils, their erodability and the damages to new varieties of cowpeas by pests, diseases and weeds. The main on-farm cropping practices to consider for research are intercropping; organic and chemical fertilizer use; and weed, pest and erosion controls. Intercropping is important because of future land constraints in the area, the benefit of nitrogen fixed by cowpeas to cereals in intercropping and the labor constraint to expand crop areas. Organic and chemical fertilizer will also need to be researched for appropriate recommendations to farmers (compatible with agronomic and socioeconomic conditions). On-farm research for weed, insect, disease and

erosion control is necessary to decrease yield losses due to these environmental constraints and to increase yield stability.

Toxicology of Insecticides

Research is needed on the possible toxicological impact of the insecticide used on cowpeas on humans and animals who consume cowpea seeds and forage. The results of such studies will help determine the precautions that should be taken by farmers in using insecticide to treat cowpeas (e.g., minimum number of days after treatment before human consumption of seeds and animal consumption of fodder is safe, cleaning practices for the ULV sprayer and other equipment involved in insecticide application, etc). These studies need collaboration between the FDVS project extension and research units, the agricultural research station of Cinzana, and the Ministries of Health and Livestock.

Linkage Between the Agricultural Research Station and the FDVS Project

Improving linkages between the agricultural research station of Cinzana and the FDVS credit, extension, research and socioeconomic units is very important in order to sustain adoption of new varieties of cowpeas and the overall improvement of farm practices in the area. The lack of strong linkages between the research station and the FDVS project reflects the institutional and technical separation between agricultural research and extension in most Subsaharan African countries.

In addition to this separation, each activity has many weaknesses. Agricultural research in Mali has been neglected when compared to extension agencies for funding and political support. The underinvestment in agricultural research is reflected in the lack of adequate financial and human resources as well as the lack of incentives to researchers and the failure to maintain research facilities. Few researchers are trained at the Masters and Ph.D levels to conceive, design and carry out research programs. The biggest mistake in Malian

agricultural research has been the consideration of agronomic and climatic factors as the only constraints explaining the poor performance of the crops. The factors commonly evaluated are only physical responses to variety improvement, fertilization, intercropping, plant population at different seeding rates, pests and diseases. Farm-level constraints such as farmers' endowments of factors of production, input and output prices, and access to resources are seldom taken into account in the design of agricultural research. The on-station researchers are not involved in on-farm trials carried out by SAFGRAD in different agroclimatic zones and do not get any feedback from the farmers who use the proposed technologies. Another weakness in Malian agricultural research is the lack of coordination between IER divisions. Socioeconomic data are collected in two divisions (DET and DPE) in addition to the farming system division, which are not supposed to carry out agronomic research. Agronomists are rarely aware of these socioeconomic data, which are collected mainly for project design or to evaluate ODRs.

Despite some good physical responses of on-station generated technologies, many problems remain for the adoption of many of them because of their incompatibility with farmers' goals, tastes or socioeconomic environment. A close collaboration between agricultural research and extension is required to bridge the gap between the agricultural research station of Cinzana and the FDVS project which is actually basically managing credit and extension without agricultural research, even though research was supposed to be included in its mandate.

Agricultural extension has been the main focus of agricultural development in Mali since the independence of the country in 1960. But extension has been facing many problems, such as overstaffing, top-down extension policy from extension agents to farmers without any feedback, management-oriented work to supply inputs and recover credit, and heavy bureaucracy. The extension agents

have a very low level of technical training and their supervisors, who are better trained (BS level), are burdened with administrative duties and cannot follow up with field work.

The Cinzana station could serve as an opportunity for the FDVS project and the research system to match efforts for appropriate technology design and use by farmers. The scope for collaboration between the two institutions can be outlined as follows:

- Accumulate information on farmers' and consumers' circumstances to set up guidelines for on-station breeders and agronomists to design technologies (varieties and cultural practices) compatible with farmers' and consumers' socioeconomic conditions. Farmers and consumers perceptions can be known by organizing surveys at the farm, rural, and urban markets and traders' levels. Housewives use of cowpeas can be surveyed also for more information on cooking characteristics of new varieties.
- Test varieties and cultural practices both on station and on-farm that were generated by the research station and gather feedback from farmers for corrections before final recommendations regarding the technologies are made to farmers via the extension service.
- Test natural rock phosphate of Tilemsi on farm for an assessment of its technical and economic efficiency before making recommendations to farmers.
- Meetings and workshops between researchers, extension, and credit monitoring units of the FDVS project to define problems for the research and extension and collaborative actions to undertake to achieve workable solutions.

Marketing

Output Markets

The lack of an adequate and ensured market for cowpeas is one of the most important constraints on cowpea production and therefore in the whole adoption process of new varieties of cowpeas. The marketing issue for cowpeas can be addressed by following recommendations:

In the Short Term

- Set up a marketing information cell inside the FDVS project, which would make arrangements between cowpea traders in major cities and the village association, which is responsible for the credit management and the marketing of cowpeas. Market information was revealed to be very important, as traders did not know about the cowpea production in Cinzana until our trip in September to inform them.
- Increase the incentives for traders to export cowpeas to neighboring countries such as Côte d'Ivoire, Ghana, etc., by decreasing export taxes.
- Quick extension of phostoxin treatment to farmers and traders to store cowpeas in better condition.

In the Long-Term

- Carry out marketing studies on cowpeas to formulate a marketing policy to sustain cowpea cropping in Mali, and the Sahel region for interregional exchanges. The studies would address the demand for cowpeas by domestic traders as well as traders in neighboring countries and the sources of supply to meet this demand.
- Train members of village associations in carrying out basic marketing tasks (weighing, storing, grading, etc.) to handle village cowpea stocks for

sales to traders and to manage the funds. Some credit lines could be opened for these village associations to market cowpeas.

—Research on storage problems to handle cowpea stocks at the village and traders' level.

—Research on viability of the credit programs (rate of recovery, constraints, linkage between credit and repayment possibilities) is important to carry out or to sustain the credit.)

Input Markets

Markets for inputs (animals, equipment, insecticides, good quality seeds, fungicides, and fertilizer) are very important. The following measures would be important in order to improve input supply:

Short Term

—Extend the credit system (at least for insecticides) to villages in the Cinzana area that do not have access to credit. These villages would like to have access to these inputs but lack cash to purchase them because of poverty and the lack of a private market for biochemical inputs.

—Supply credit for blacksmiths in villages covered by the project to obtain small mechanical equipment and raw materials (iron) to make plows and spare parts for animal traction. Many blacksmiths are well qualified to make multipurpose plows but lack equipment to make them. Credit to blacksmiths would foster local production of spare parts for plows designed for local soil conditions.

—Carry out technical, financial and economic studies on the use of rock phosphate from Tilemsi at the farm level to assess the possibilities of its use by farmers.

Long Term

- Carry out studies on input delivery systems and involvement of private traders in the input supply.**
- Collaboration between the research and the extension networks to design and recommend technologies which are cost effective, and easily available on time to farmers.**

Some General Recommendations for Agricultural Research in Mali

Some of the weaknesses in agricultural research need to be corrected in order to increase the adoption rate of proposed technologies to farmers from the research:

- Train researchers in both the social sciences and the biological sciences to M.S. and Ph.D levels for agricultural research and develop multidisciplinary research teams on research stations. Biological scientists should also receive short-term training in basic agricultural economics on topics such as simple cost-benefit analysis of technological packages and how to use survey data as a guideline for research programs. A multidisciplinary team on station would include agronomists, soil scientists, entomologists, and economists. The teams would carry out on-farm research as well as on-station research. This would solve the problem of the lack of social scientists on biological research stations.**
- Take into consideration farm-level constraints such as input and output prices and input supply problems in addition to soils, weeds, insects and labor constraints in order to decrease the gap between research stations and farmers (yields, priorities in problems to be researched). The costs and benefits of technologies have to be considered before any recommendations can be made to farmers.**
- Establish more linkages between the researchers at IER and the extension**

personnel at the ODRs by organizing workshops, visits and exchanges of information beside the formal annual meetings to discuss research results.

→Encourage research on key issues such as credit, marketing of agricultural products, and integration of livestock and agriculture at the farm level, to inform policy makers for better policy decisions.

Conclusions From This Case Study About the Process of Technology Development and Adoption in Sub-Saharan Africa

Technology development and adoption in Sub-Saharan Africa, especially in Francophone countries, have suffered from an imbalance between research and extension and isolation of on-station biological researchers from feedback from farmers about their technologies. The technology to be adopted needs to be compatible with or solve agro-climatic constraints, e.g., possess early maturity or resistance to pests, characteristics important in an environment where rainfall shortages or diseases are the main constraints. The technology also needs to be profitable and easy use by the target population. The technology requires an institutional backing (input and output markets, extension services, and credit if necessary) to be adopted and sustained in Sub-Saharan African countries, where the input markets rarely exist and where agricultural products face many marketing problems, such as transportation, storage, pricing and access to market information.

Conclusions From this Case Study Concerning the Validity of the Theoretical Literature

The decision process regarding the adoption of new technology by farmers involves awareness, persuasion, evaluation, application decision, trial and finally adoption, but these steps cannot be isolated or followed in this order by farmers. The discontinuance of adoption is explained in our case by the lack of institutional backing to supply inputs necessary for the technology.

Discontinuance is very important to investigate, but little research has been **done** on this side, compared to factors behind success in adoption. In the **literature** a lot of studies have focused on farmers' personal characteristics as the **main** factors influencing adoption of agricultural technologies. In our case study the **key** factor behind the quick adoption of new varieties of cowpeas by farmers in **Cinzana** was not personal characteristics of farmers but the ability of the **technology** to address a major problem faced by farmers, namely the need for **early** maturing varieties to deal with erratic rainfalls. Factors such as **profitability** (higher yields and returns) also played an important role in adoption, **as found** in many previous studies of adoption.

Institutional support (credit, extension, input and output markets) as a factor **to sustain** adoption was very important in our case study, as reported in many **other** adoption studies in developing countries where capital and marketing **constraints** are critical in the whole agricultural development process. The **typology** of adopters and chronology of adoption in our study indicates that **adoption** of an innovation does not occur at the same time for all farmers, or for **all** components of the innovation. Adoption is sequential and the success or **failure** for the farmers who adopted first is critical in the decision to adopt the **innovation** by the farmers who were not among the first to try the innovation.

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