MSU International Development Working Papers

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MSU International Development Working Paper No. 43
1994

Department of Agricultural Economics
Department of Economics
MICHIGAN STATE UNIVERSITY
East Lansing, Michigan 48824

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June 1994

This paper is published by the Department of Agricultural Economics and the Department of Economics, Michigan State University (MSU). Funding for this research was provided by the Food Security II Cooperative Agreement (AEP-5459-A-00-2041-00) between MSU and USAID.

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ISSN 0731-3438

Published by the Department of Agricultural Economics, Michigan State University, East Lansing, Michigan 48824-1039, USA.

ACKNOWLEDGMENTS

The authors wish to thank the research staffs of IRA-Cameroon, the Bean/Cowpea CRSP (both its management staff at Michigan State University and the associated research team at Purdue University), and the NCRE project for the considerable support they provided during data collection and in their reviews of this document. In particular, the guidance provided by Doyle Baker, Russ Freed, Jerry Johnson, Mulumba Kamuanga, Lauri Kitch, and John Russell are sincerely appreciated. A heartfelt thanks is also extended to Georges Dimithé and his family. Eric Crawford, Jim Oehmke, and Mary Schultz of the Department of Agricultural Economics, MSU provided many helpful comments in their reviews of earlier drafts of this document.

Funding for this research was provided by the Food Security in Africa Cooperative Agreement between MSU and USAID.

EXECUTIVE SUMMARY

Throughout Africa, per capita food production has been declining since the early 1960s. Cameroon has sought to counter this trend by increasing agricultural productivity through research and extension. In order to establish future investment priorities, policy makers need to know if past agricultural research investments have earned sufficient returns to justify continued funding. Further, national experiences need to be compared to see if returns varied across programs, and in cases where they did, explanations need to be sought to discover why these variations exist.

To address these issues, data were collected in Cameroon and analyzed in order to estimate the benefits and costs of investments in sorghum and cowpea research and extension in northern Cameroon. Specific data that were needed to construct benefit and cost streams included the following: yields of traditional and introduced technologies, area harvested, adoption rates of technological innovations, prices of both inputs and outputs, climatic factors influencing both the research agenda and the returns to this research, and the costs of research and extension efforts. Focussing on the period 1979-87, the analysis addressed three questions: What were the returns to past investments? What factors explained the estimated returns and any variability in returns between the sorghum and cowpea programs? And how did institutions influence these returns and the distribution of their benefits?

Estimated internal rates of returns (RORs) were 15% for cowpea research and extension, and 1% for sorghum research and extension. Note, the ROR is a measure of "profitability" of an investment. An ROR of zero indicates a return sufficient to cover the initial investment, but no more. The ROR must be equal to or greater than the target rate of return (the opportunity cost of capital) in order for the investment to be considered "profitable." In the case of northern Cameroon, an opportunity cost of capital of 10% was assumed, indicating that only cowpea research and extension was "profitable" in economic terms, but that both the sorghum and cowpea research and extension programs were "successful" since they were "able to pay for themselves" in financial terms. Further, extensive sensitivity analyses tested the robustness of these estimated RORs, indicating that the results were relatively stable across a wide range of assumptions about the data used in the benefit and cost streams.

Certain characteristics differed between the sorghum and cowpea programs and these key factors give some indication as to why there were significant differences in their returns. First, the improved cowpea technology represented a completely new farming system, while the introduced sorghum technology was simply a complement to traditional practices. The cowpea technology filled an existing need--an early maturing food crop to relieve hungry season food shortages. On the other hand, under normal rainfall conditions, the sorghum technology (the new variety S35) was just one more variety in a pool of over 1,800 accessions that have been identified in the region. S35 enjoyed some success because it also addressed a need of farmers in the region--a sorghum variety that is extremely drought tolerant. However, this need is not nearly as predictable or regular as the needs met by the cowpea technologies. Second, the development of the cowpea technology focussed entirely on varietal screening. Even the success of the sorghum program depended not on a variety developed by its breeding program but one

identified in screening trials. Both cases imply higher returns were found for screening activities. This conclusion is underscored by two factors: (a) screening programs are cheaper because many of the costs of generating the "improved" variety have already been incurred by other projects and institutions, and (b) the appropriateness of screening versus breeding depends on its timing relative to the region's overall development scheme. Third, the incentives faced by cash crop farmers in northern Cameroon went through an evolution during the period that these technologies were being developed and extended. Because of these changes, cowpea became a viable alternative to cotton, the traditional cash crop. This change undoubtedly contributed to the higher adoption rates for the cowpea technology relative to the sorghum technology. Fourth, the relative difficulty of the problems addressed by the two programs may also explain some of the differences in the returns. Sorghum, relative to cowpea, has presented a formidable problem to researchers throughout West and Central Africa for over thirty years. Low returns to sorghum research, although undesirable, may simply reflect long-term historical trends and the possibility that returns to research and extension may, in part, be dependent upon the research agenda itself.

Analysis of key institutions, and their inter- and intra-relationships partially explain how "successes" were achieved in northern Cameroon. Linkages within and between institutions proved critical to achieving positive rates of return. Three insights were particularly clear from the analyses. First, linkages within the research-extension system were critical. Second, linkages between the system and international research institutions were equally important. And third, government agricultural policies influenced the system's performance. Institutions also influenced the distribution of returns. In general, the technologies probably favored men relative to women, and cotton farmers relative to non-cotton farmers.

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LIST OF ACRONYMS

CRSP	Collaborative Research Support Project
CCCE	*Caisse Centrale de Coopération Economique*
CFDT	*la Campagne Française pour le Développement des Fibres Textiles*
DEAPA	*Division des Enquêtes Agroéconomiques et de la Planification Agricole*
EEC	European Economic Community
FAC	*Fonds d'Aide et Coopération*
fcfa	*franc de la Communauté Financière Africaine*
FONADER	*Fonds National de Développement Rural*
IARC	International Agricultural Research Center
ICRISAT	International Center for Research in Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
IRA	*l'Institut de Recherches Agronomiques*
IRAT	*l'Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières*
IRCT	*l'Institut de Recherche sur le Coton et Fibres Textiles*
MESIRES	*Ministère de l'Enseignement Supérieur, de l'Informatique et de la Recherche Scientifique*
MIDEVIV	*Mission de Développement des Cultures Vivrières, Maraîchères et Fruitiers*
MINAGRI	Ministry of Agriculture, Government of Cameroon
NCRE	National Cereals Research and Extension Project
NCSM	North Cameroon Seed Multiplication Project
ONAREST	*Office National de la Recherche Scientifique et Technique*
PCN	*Projet Centre-Nord*
ROR	Rate of Return
SAFGRAD	Semi-Arid Food Grain Research and Development project
SODECOTON	*Société de Développement du Coton*
TLU	Testing-Liaison Unit
USAID	United States Agency for International Development

1. INTRODUCTION

1.1. Problem Statement

Since the early 1960s, developing countries, assisted by foreign donors, have invested resources to strengthen their agricultural research systems. Agricultural economists have supported this strategy, arguing that technological innovations in agricultural production drive the development of the agricultural sector, which in turn contributes to the development of the general economy (Mellor 1966, Eicher and Staatz 1984). While several studies report a high rate of return to agricultural research in Asia and Latin America, it is considerably less evident as to whether these investments have netted positive returns in Sub-Saharan Africa (Oehmke et al. 1992).

This suggests that additional research is needed to address two critical issues. First, there is a need to determine if past investments in agricultural research in Sub-Saharan Africa have generated sufficient returns to justify continued investments. Second, there exists a need to examine national experiences in implementing agricultural research in order to identify factors that explain variability in the impact of these investments.

1.2. Objectives

Cameroon, like many other countries, has sought to increase agricultural productivity through research and extension of locally developed and/or screened technologies. The general objective of this paper is to assess the impact of the development and extension of improved sorghum and cowpea technologies in northern Cameroon and to describe factors that contributed to the observed impact. The specific objectives are as follows:

(1) estimation of the economic rates of return to cowpea and sorghum research and extension in northern Cameroon, using a cost/benefit approach;

(2) review of the institutional factors, linkages, and characteristics associated with the research-extension system in order to determine how each interacted to complement and/or impede the performance of the cowpea and sorghum subsectors;

(3) discussion of lessons learned from this study, focussing particularly on (a) how and why the returns to research and extension differed between commodities, (b) the choice of criteria for setting research agendas, and (c) the constraints in assessing impact.

2. SORGHUM AND COWPEA AGRICULTURE AND RESEARCH IN CAMEROON

2.1. Overview of Cameroonian Agriculture

Cameroon's agricultural sector is highly diverse, due in part to the wide range of ecological zones found within the country's borders. These zones, and their areas of crop production as a percentage of the national land base, include highlands (27%), savanna (22%), semi-arid plains (19%), equatorial rain forests (18%), and coastal lowlands (14%).[1]

This study focusses on the northern region of the country, which ranges from a wooded, Guinea savanna in southern Adamaoua Province, to Sudanian and Sudan-Sahalian savannas in northern Adamaoua Province, all of the North province and much of the Far North province, to the Sahel region of the Lake Chad area.

2.1.1. Northern Cropping Systems

The three northern provinces are generally subdivided by principal cropping systems and the underlying annual rainfall, which declines from south to north.

Southern Adamaoua is classified as the Maize-Tuber belt and is a sparsely-populated area where maize is the principal cash crop, and maize and tubers are the principal sources of food. Although this area, with an annual average rainfall of 1750 mm, has great agronomic potential, tsetse fly has historically been a constraint to production.

Northern Adamaoua and nearly all of the North Province, with an average annual rainfall of 1100 mm, is classified as the Cotton-Maize Belt. Cotton was first grown north of this zone, but northern Adamaoua now leads the country in cotton production, primarily because the cotton parastatal has shifted its efforts southward into areas of higher and less variable rainfall. Maize has traditionally been a garden/compound crop in this zone, but since the mid-1980s, maize has evolved into an important cash crop. This development has been partially due to the creation of MAISCAM, a private sector maize oil processing plant in Ngaoundéré, the provincial capital of the Adamaoua Province.

The Center-North zone[2]–including the Mayo Louti Department of the North Province and the bulk of the Far North Province south of Waza–is the core of the cotton-sorghum belt. With an average annual rainfall of only 800 mm, this area is also plagued by erratic and uneven rainfall.

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[1] Estimated from data on shares (by province) of total land planted as reported in the 1984 Agricultural Census (National Directorate of the Agricultural Census, Yaoundé). The Southwest and Littoral Provinces were classified as coastal lowlands; the South, 60% of the East, and 50% of the Center were classified as rain forests; the West and Northwest were classified as equatorial highlands; 40% of the East, 50% of the Center, the Adamaoua, and the North were classified as savanna; and the Far North was classified as semi-arid.

[2] This area is referred to as the Center-North zone because of a World Bank rural development project by the same name that targeted this area over the period 1982-87.

Both low total annual rainfall and poor rainfall distribution constrain production and often lead to drought-like conditions during the growing season.

This case study focusses on the low rainfall Center-North zone where the principal cropping patterns are either a cotton-sorghum two-year rotation or a cotton-sorghum-legume three-year rotation. Frequent variations within this general pattern include the intercropping of sorghum with legumes, particularly cowpea but also groundnut and bambara groundnut, the planting of a second crop of sorghum[3] late in the growing season, and the substitution of pearl millet for sorghum in the production cycle. In the Mandara Mountains, an area in the Far North Province but outside the Center-North zone, farmers practice a biennial crop rotation, planting sorghum one year and then intercropping pearl millet and a legume the next year. This rotation has evolved as a strategy for controlling weeds and pests, especially the parasitic weed striga (*Striga Hermonthica*).

2.1.2. Land in Crop Production

Two data sources report harvested area for Cameroon. First, the Ministry of Agriculture (MINAGRI) reported sorghum and cowpea production and area harvested in northern Cameroon for the period 1972/73 to 1989/90. These time series indicate large year-to-year fluctuations and no discernible trend. Many key informants interviewed in Cameroon cautioned that these data were unreliable because MINAGRI has historically had limited resources for data collection and compilation.

Recognizing the need for more reliable data, the National Directorate of the Agricultural Census (DEAPA), with support from USAID, initiated a project in 1984 with the explicit goal of estimating crop area and yields, based on farmer surveys and in-field measurements. Researchers and other in-country agriculturalists consider these data to be the best available. Yet, given the large year-to-year fluctuations in estimated harvested area and the short (six years) length of the time series, it is impossible to discern historic trends or to project future levels of production and land use from these data.

Sorghum: Sorghum, and to a lesser degree pearl millet, are the region's traditional cereal grains and primary sources of calories. In an average year, sorghum comprises approximately 70% of total land harvested (table 1). While MINAGRI and DEAPA estimates of area planted to sorghum differ considerably in a given year, both data series show that sorghum production is the most important food crop in the Far North Province. For example, over the 1984-89 period,

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[3] Second crop sorghum in northern Cameroon, commonly called "mouskwari," is seeded in small, often irrigated, garden plots and then transplanted to the field late in the growing season. It then matures on residual soil moisture.

DEAPA reports,[4] on average, an estimated 332,000 ha in sorghum (73% of cropped area) while MINAGRI reports an estimated 313,000 ha (54% of cropped area).

As reported in table 1, two crops of sorghum are grown in northern Cameroon. Dry season sorghum (mouskwari) is planted on vertisols late in the growing season, maturing on residual soil moisture. Rainy season sorghum varieties are more heterogeneous relative to mouskwari, differing by a greater degree in stalk length, grain color (usually red or white) and length of growing cycle (short, medium, or long). Farmers' preferences reflect this heterogeneity, with each farmer choosing varieties which have specific traits that he or she desires.

Table 1. Sorghum and Total Harvested Crop Hectares, Far North Province, Cameroon, 1984-89

	Grain Sorghum (Ha)			All Crops	
Year	Rainy Season	Dry Season	Total	Total (Ha)	Sorghum share (%)
1984	135,902	119,502	255,404	383,983	66.5
1985	185,424	135,030	320,454	445,380	72.0
1986	178,777	201,531	380,308	511,352	74.4
1987	95,676	147,856	243,532	335,154	72.7
1988	161,138	224,056	385,194	511,299	75.3
1989	172,313	232,116	404,429	519,143	77.9
mean	155,000	177,000	332,000	451,000	73.1

Source: National Directorate of the Agricultural Census/MINAGRI, 1991.

Although sorghum production dominates the agriculture sector in northern Cameroon, farmers face a host of constraints. Russell (1991) notes the following examples: "poor and erratic rainfall, often disastrously distributed during the growing season; striga, which is increasing in importance as both soil fertility and the length of fallow period decrease; labor constraints at the time of sowing and weeding, which impede improvement in land preparation and weed control; and lack of credit for yield-enhancing inputs such as animal traction, fertilizer, and pesticides." (p. 8) Other constraints include a variety of insects and endemic leaf diseases.

[4] Census data estimate combined sorghum and millet data. Hence, to estimate the sorghum area, the reported data were multiplied by 0.9 to remove pearl millet and the adjusted data are reported. This factor is based on the judgments of key informants involved in agricultural research in northern Cameroon.

Cowpea: Cowpea, the second crop on which this study focusses, accounts for an estimated 5% of the harvested area. Like sorghum, cowpea is a traditional food crop in northern Cameroon. In 1979, Perez, on an International Institute of Tropical Agriculture (IITA) plant exploration tour, collected 396 samples of cowpea while in Cameroon, noting "an impressive wide variability" in cowpea varieties grown by farmers.

Although a relatively minor crop in terms of hectares harvested, several studies (Ta'Ama 1984, Wolfson 1990, Kitch 1990) have found that cowpea contributes significantly to household food security in northern Cameroon. First, because cowpea matures early, households are able to harvest leaves and green pods during the "hungry season" (late June through August) when grain reserves from the previous harvest are depleted and farmers have yet to harvest the current year's crops. Second, cowpea is an important source of protein, especially for the rural poor. Singh and Rachie (1985) estimate that cowpea contains 23% to 30% protein, with variations in content due to varietal differences and environmental factors. Third, as a drought-tolerant crop that matures in 60 to 80 days on as little as 300 mm of rain, cowpea reduces farmers' exposure to risk. Finally, cowpea hay (leaves and stems) is used by limited-resource farmers to feed their livestock during the dry season and to earn cash through sales in local markets.

Time series data for area planted to cowpea are even less reliable than the sorghum estimates. As with sorghum, DEAPA data cover only a six-year period and MINAGRI estimates are considered unreliable. In addition, neither agency reports production figures specifically for cowpea. For example, DEAPA data classify cowpea in the general category of "beans," which includes common beans, kidney beans, and cowpea. Similarly, the MINAGRI time series reports nine years of data for "*haricots doliques*," after which data are reported for "*haricots/niébé*."[5] Finally, since cowpea is generally intercropped, it is extremely difficult to accurately estimate yields, implying that even the DEAPA data are not entirely reliable.

Since cowpea is the only "bean" crop grown on a large scale in the Far North Province, this study assumes that 100% of the quantities reported for this province are for cowpea (table 2). The large amount of year-to-year variability reported in table 2 may be attributable to weather, changes in farming practices, and/or human error in data collection and compilation. Yet, these best available data indicate an average annual harvested area (1984-89) of 23,600 ha, on average, which accounted for 5.3% of the area harvested.

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[5] *Haricots doliques* is a French horticultural term referring to plants of the Dolichos species and/or Vigna species, which would include cowpea. *Haricot/niébé* translates to beans/cowpea.

Table 2. Cowpea and Total Harvested Crop Hectares, Far North Province, Cameroon, 1984-89

	Area Harvested (Ha)		Cowpea Share
Year	Cowpea	All Crops	(%)
1984	23,470	383,983	6.1
1985	30,232	445,380	6.8
1986	24,109	511,352	4.7
1987	16,744	335,154	5.0
1988	29,975	511,299	5.9
1989	16,998	519,143	3.3
mean	23,600	451,000	5.3

Source: National Directorate of the Agricultural Census/MINAGRI, 1991.

2.1.3. Rainfall

In northern Cameroon, virtually all sorghum and cowpea production is rainfed. Rainfall distribution is monomodal, usually beginning in late May, peaking in August, and ending in late October. However, there is a great deal of variability in this distribution, due to late and unpredictable onsets of the rainy season and a highly erratic distribution of rainfall between localities. Russell (1991) notes "that northern Cameroon has suffered from an extended drought episode, that is, a period in which droughty years are more frequent than usual. Farmers tend to think that the current drought episode, which has lasted more than a decade and a half, is due primarily to decreasing rainfall. Nicholson (1986) cites several factors that may have contributed to drought, including overgrazing, overcultivation, and removal of vegetation, but concludes that the fundamental cause of the current drought is meteorological." (p. 2)

In setting the research agenda, agricultural scientists working in northern Cameroon have sought to take into account rainfall patterns. Any evaluation of the research system needs to include some measure of the effects of rainfall on the general state of the agricultural sector of northern Cameroon, and of how rainfall influenced research agendas, the selection of technologies for extension, and ultimately, the returns to research and extension efforts.

2.2. Agricultural Research in Northern Cameroon

In 1974, the Cameroonian government "nationalized" the research system, creating the *Office National de la Recherche Scientifique et Technique* (ONAREST) as a national umbrella organization for agricultural research throughout the country. Since 1974, the government has restructured its research system several times. Currently (1991), agronomic research is conducted by the *Institut de Recherche Agronomique* (IRA) within the *Ministère de l'Enseignement Supérieur, de l'Informatique et de la Recherche Scientifique* (MESIRES).

While the current agricultural research system is organized along major ecological zones, with one research center per zone, budgeting and staffing for these centers are organized on a commodity basis. At the Maroua center, research units[6] have been established to address production constraints for the principal cash and food crops of northern Cameroon–cotton, sorghum, millet, rice, peanuts, and cowpea.

The sorghum and cowpea units primarily screen varieties and test various agronomic and post-harvest technologies. Sources of plant material for screening include both promising local farmers' varieties and foreign varieties. Introduced varieties are distributed regionally for multi-locational evaluation by the International Institute for Tropical Agriculture (IITA), the International Center for Research in Semi-Arid Tropics (ICRISAT), the Semi-Arid Food Grain Research and Development project (SAFGRAD), and the Bean/Cowpea Collaborative Support Project (CRSP). Although a sorghum breeding program was initiated in 1982, none of the developed hybrids were released to farmers and the breeding program was significantly scaled down after 1988. Cowpea research initially focussed on screening local varieties and introduced cultivars. In 1987, this research agenda shifted to identifying improved post-harvest storage technologies and to establishing a breeding program to develop high-yielding cowpea varieties with tolerance to the storage pest bruchids (*Callosobruchus maculatus*).

Historically, a combination of expatriate and host country nationals have staffed the research system. Initially, senior research staff were expatriates, employed by *l'Institut de Recherches Agronomiques Tropicales et des Cultures Vivrières* (IRAT), *l'Institut de Recherche sur le Coton et Fibres Textiles* (IRCT), or donor projects while mid-level staff and hourly workers were Cameroonian. Today, Cameroonians hold many of the senior staff positions due, in part, to resources provided by USAID to train nationals in the U.S. at the master's and doctorate level. Since the mid-1960s, increased state and donor funding and training opportunities have enabled the Maroua center to expand its scientific staff (table 3[7]) and to broaden its disciplinary mix.

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[6] In 1991, the Maroua Center had research units for cotton breeding, cotton entomology, sorghum and pearl millet breeding, sorghum and pearl millet agronomy, cowpea agronomy, peanut breeding and agronomy, rice agronomy, farming systems research and extension, and soil science.

[7] The totals reported in table 3 include researchers directly employed by IRA and those affiliated with IRA through donor projects.

Table 3. Number of Senior Researchers, IRA Research Center, Maroua, Cameroon, Selected Years

Year	Expatriate	Cameroonian	Total
1967	4	0	4
1977	6	3	9
1981	7	4	11
1987	15	15	30
1991	7	19	26

Source: IRAT, 1967; IRAF, 1977; IRA, 1982. The number of researchers in 1987 was compiled from NCRE/IRA and CRS/IRAP documents, from a 1987 IRA memo on pay promotions for all IRA scientists in Cameroon, and from interviewing researchers who were at the IRA-Maroua research station in 1991. The number of senior researchers in 1991 was compiled during field research in Cameroon, and subsequently confirmed in an interview with the IRA director, Mr. Boli.

The research system has been funded jointly by the Cameroonian government and donor projects. In recent years, the Cameroonian government has paid basic operating costs (e.g. electricity, fuel, water), some capital improvements, and salaries for Cameroonian researchers. Donor projects have usually financed equipment, vehicles, capital improvements, staff training, and the salaries of expatriate staff.

Typically, donors have given priority to specific commodities. The French, through the *Caisse Centrale de Coopération Economique* (CCCE) and the *Fonds d'Aide et Coopération* (FAC), have supported most of the cotton research. SAFGRAD, the European Economic Community (EEC) Development Fund, the World Bank, and various national governments have funded food crop research. The United States, a major supporter of food crop research, has provided (1979-94) $46.7 million through the National Cereals Research and Extension Project (NCRE), plus an additional $1.97 million (1981-92) through the Bean/Cowpea CRSP.[8]

2.2.1. Sorghum Technologies Extended to Farmers

Grain sorghum has been one of the primary foci of agricultural research in the region for over three decades. Early work (mid-1960s through mid-1970s) conducted by France's IRAT and by the SAFGRAD Joint Project (J.P.) 26 included the collection and classification of local germplasm and the screening of local varieties for desired traits. A short-lived breeding program was also initiated in 1970. In 1974, IRAT terminated its work in Cameroon and in early 1976, the SAFGRAD J.P. 26 came to a close, leaving only the Cameroonian government, through

[8] The NCRE program supports research throughout Cameroon, whereas the CRSP research is conducted only through the Maroua center.

IRA, to fund sorghum research. As a result, over the next several years sorghum research was limited to simply maintaining germplasm and seed stock. In 1979, sorghum agronomy and varietal screening trials were reinstated by the SAFGRAD J.P. No. 31. In 1982, the NCRE project greatly expanded sorghum research through the creation of a sorghum breeding program. In 1986, the NCRE project extended its focus on sorghum, establishing a sorghum agronomy program in Maroua to complement the breeding research.

Throughout its history, sorghum research has focussed on increasing the grain yields of sorghum, given the production constraints of the region. In the mid-1980s, yield stability emerged as a second research objective, as scientists recognized that yield stability across a wide range of environments and varied production constraints was as critical for meeting the needs of farmers as higher yields.

The IRAT and SAFGRAD research programs identified several sorghum varieties (IRAT 55, CE 99, E 35-1, and 38-3) for extension to farmers. However, these varieties were never extended on a large scale, in part due to constraints in both seed multiplication and extension resources. Not until 1986 were "improved" sorghum varieties (NCRE selected varieties S34 and S35) extended across large segments of northern Cameroon.

S35 is unquestionably the sorghum research program's most significant technological output. This variety, originating from India, is a short cycle (90 day), medium height (2.5 m), white-grained sorghum that has some resistance to disease and insects. It was first grown in northern Cameroon in 1982 as one of several hundred varieties screened by the IRA/NCRE sorghum breeding program. From 1983 to 1986, the variety was tested both on-station by the sorghum breeding and cereal agronomy programs and on-farm as part of the SAFGRAD research program. In 1985, the North Cameroon Seed Multiplication (NCSM) Project began multiplying S35 seed, producing 42 metric tons, much of which was extended (purchased and resold to farmers) by the *Société de Développement du Coton* (SODECOTON) in 1986.

2.2.2. Cowpea Technologies Extended to Farmers

In northern Cameroon, cowpea research initially focussed on screening cultivars for high grain yields. Sources of plant material for screening included both local and foreign varieties. In general, foreign varieties were tested as part of a series of regional multi-location variety trials organized by the International Institute of Tropical Agriculture (IITA), the Bean/Cowpea CRSP, and/or SAFGRAD.

The first technology package developed by IRA included the new cowpea variety TVX3236 OG1. This indeterminant, medium cycle (75 to 80 days to maturity) variety was selected from IITA regional screening trials for its high yield potential, grain color, and insect (thrips) tolerance. The extension recommendation was that farmers monocrop the variety on a quarter-hectare plot and, when possible, treat the standing crop with insecticide.

Although TVX3236 was first extended to farmers in 1980 through SAFGRAD's on-farm testing program, SODECOTON did not begin to extend the variety widely until 1984. Widespread extension was facilitated by the North Cameroon Seed Multiplication Project, which produced and sold approximately 20 metric tons of TVX3236 from 1984 to 1986. SODECOTON continued to recommend and extend the "TVX package" through the 1987 growing season. In addition, IRA introduced Ife Brown (a local Nigerian cultivar) and VYA (a local Cameroonian cultivar from the Moutourwa area) in 1985 and 1986-87 respectively. These two varieties were identified for extension by SAFGRAD/CRSP screening trials.

During this period (1980-86), researchers and extension workers documented significant (sometimes total) storage losses due to bruchid infestations. As a result SODECOTON modified its extension recommendation. Foremost, SODECOTON advised farmers to reduce their cowpea area from a quarter to an eighth of a hectare. SODECOTON's contention was that until storage constraints could be met, cowpea should be grown primarily as a garden/compound food crop for the hungry season, not as a commercial grain crop.

In 1987, IRA released two new sister lines[9] with several advantages over TVX3236 including comparable yield, larger grain size, significantly less shattering of seed pods, and most important, greater tolerance to bruchids. These two varieties, BR1 and BR2 (IITA cultivars IT81D-985 and IT81D-994 respectively), were judged sufficiently tolerant to bruchids to allow farmers to store cowpea for an additional month before bruchid damage becomes significant.

Since 1987, researchers have continued to advise farmers to plant cowpea as a monocrop in quarter-hectare plots, sowing BR1 and BR2, and applying 2 to 3 insecticide sprayings. In addition, recognizing the importance of post-harvest losses, the research agenda shifted to give greater priority to developing improved grain storage technologies and to establishing a breeding program directed, in part, at increasing tolerance to storage pests (bruchids). However, as this research initiative is beyond the scope of this study, its costs and impacts are not included in the analysis that follows.

[9] These varieties were developed through IITA's cooperative multilocational trials program.

3. RATE OF RETURN ANALYSES

3.1. General Approach

Cost streams represent estimates of annual research and extension expenditures by donor projects and host country programs. Benefit streams are estimates of the annual dollar value of project benefits, calculated as the market value of the product of land in production, adoption rates, and gains in yield from the improved technologies, minus the value of additional on-farm costs of using the technologies.

Data for the benefit-cost analysis are presented in nominal US dollars, having been converted from the local currency, the *franc de la Communauté Financière Africaine* (fcfa) when necessary. As noted by Pardey and Roseboom (1989), "there is...no option but to convert research expenditures measured in current local currency units into some numéraire currency or unit of measurement." (p. 24) Over the entire period of analysis, the exchange rate between the fcfa and the French franc was fixed at 50 fcfa per one French franc. Thus fluctuations in the value of the fcfa simply reflect changes in the exchange rate between the US dollar and French franc. Although some research (Salinger and Stryker 1991) indicates that the fcfa is overvalued, no effort was made to calculate a shadow exchange rate for the base runs.

A second simplifying assumption about costs and benefits was made regarding the inflation rate applicable to the subsistence economy of northern Cameroon. While inflation rates (IMF and World Bank internal documents) have been calculated for the urban centers of southern Cameroon (Yaoundé and Douala), these data have little applicability to the economy of subsistence farming 800 kilometers to the north. Further, available market prices (MINAGRI Annual Reports; Service Provincial des Etudes et Statistiques Agricoles de l'Extrême-Nord, 1986, 1988, 1988, 1990, 1991; NCRE 1990,1991; and *Office Céréalier* (table 16) and SODECOTON 1977-1990) are extremely limited and indicate no discernible price trends. Also, since weather effects dominate price fluctuations in northern Cameroon, it is impossible to identify short-term inflationary trends in price. Hence, the base runs of the analysis are estimates without any adjustment for inflation.

Cost and benefit streams, and (internal) rates of return (RORs) are presented below, first for sorghum and then for cowpea.[10] The ROR is a measure of "profitability" of an investment. An ROR of zero indicates a return sufficient to cover the initial investment, but no more. The ROR must be equal to or greater than the target rate of return (the opportunity cost of capital) in order for the investment to be considered "profitable."

For this study, the base run RORs for sorghum and cowpea research and extension are calculated from the cost and benefit streams reported in the tables below. Net cost-benefit flows are reported in the appendix (tables 8 and 9).

[10] For a more detailed presentation of these analyses, reference Sterns (1993).

Although a base run ROR is the best-judgment estimate of the returns to research and extension, sensitivity analyses are conducted to test the robustness of each estimate. Further, given that some data used in the analyses are estimates based on informed assumptions and not actual empirical findings, sensitivity analyses are useful in determining how each assumption affects the results.

3.2. Sorghum Research and Extension

3.2.1. Costs

The cost streams for the development of S35 extends from 1979, the first year of the SAFGRAD J.P. 31, to 1986, the first year SODECOTON extended S35 to farmers. For each contributing project/institution, the sorghum share of research and extension investments was calculated as follows: For SAFGRAD JP 31, costs from 1979 to 1983 are estimated to be 30% of total project expenditures. From 1984 to the project's conclusion in 1987, the percentage increased to 60%, reflecting the project's shift in emphasis away from maize and millet.[11] For the NCRE project, costs attributable to the development of S35 were incurred by two research programs–sorghum and millet breeding, and the cereal agronomy. For the breeding unit, 70% of their efforts targeted rainy season sorghum while for the agronomy unit, 30% of their efforts did the same. NCRE cost estimates account for these percentages, which are based on interviews of researchers involved in the NCRE project. As with cowpea, both IRA's contribution (salaries, operating costs, etc.) to the development of S35 and SODECOTON's (a percentage of their food crop extension costs) are included in the cost stream (table 4).

3.2.2. Benefits

The benefit stream associated with sorghum research in northern Cameroon was estimated from data on (1) farmers' yields for local varieties and for S35, both in drought and in normal rainfall conditions; (2) the frequency of drought conditions; (3) annual adoption rates of the improved technology; (4) the land area in sorghum production; and (5) market prices for inputs and outputs.

Sorghum yields are estimated by combining available yield data with qualitative data on rainfall patterns in northern Cameroon. Although data from various sources[12] give an indication of yield potentials, yields in any given year are highly dependent on the quantity,

[11] Estimates of each commodity's percentage shares of total project costs are based on interviews with Owen Gwathmey, Jerry Johnson, and Martin Fobasso, the three principal researchers working on the SAFGRAD project.

[12] Sources include Agricultural Census data, SAFGRAD/NCRE/CRSP on-station and on-farm trial data, and SODECOTON reports.

Table 4. Estimated Total Costs, Nominal $US, Sorghum Research and Extension Programs, Northern Cameroon, 1979-86

Year	SAFGRAD J.P. 31	NCRE	IRA	SODE-COTON	Total Annual Costs
1979	23,881	0	26,542	0	50,423
1980	20,790	0	27,215	0	48,005
1981	18,225	0	21,149	223,603	262,977
1982	18,788	180,536	32,879	215,615	447,818
1983	19,807	174,951	41,889	161,129	397,776
1984	83,799	170,481	45,833	162,767	462,880
1985	91,924	169,646	45,626	222,493	529,689
1986	78,331	178,464	56,077	219,623	532,495
Totals	355,545	874,077	297,210	1,205,230	2,732,062

timing, and dispersion of rainfall in the region. Further, sorghum researchers concede that the improved variety only out-yields local varieties in years when the onset of the rainy season is late and/or total rainfall is below average. Hence, benefits from the development of S35 are limited to drought years.

The probability of drought conditions–assumed once every three years–is estimated from historic rainfall data and anecdotal evidence provided by IRA and NCRE staff. The annual adoption rates are estimated from historic seed sales and from a 1990 adoption survey conducted by the Testing-Liaison Unit (TLU). These data are fitted to a logistic function, permitting the extrapolation of adoption rates over the entire period of analysis. Estimates of area in production are based on data reported by Cameroon's National Directorate of the Agricultural Census. Prices are estimated from price time series reported by Cameroon's Ministry of Agriculture, NCRE/IRA, and SODECOTON.

Two factors that did not enter into the sorghum benefit stream, but are presented in the cowpea analysis (see below), are stover production and on-farm input costs. Two assumptions were made that led to these exclusions. First, although S35 is a medium height variety, the amount of stover production lost from farmers substituting S35 for "tall" varieties is assumed to be minimal. Second, the level of inputs used by an individual farmer is assumed to be independent of the variety that he or she grows. This implies that S35 farmers are not adopting a complete package of improved seed, seed treatment, fertilizer, etc. Thus, the adoption of these additional technologies is not dependent on the adoption of S35, and a change in variety (eg. from local to S35) does not change on-farm input costs.

Gross benefits from the development and extension of S35 are simply the annual market values of the gains in production, converted to $US (table 5). The time horizon of the benefit stream is fifteen years, beginning in 1984, the first year that S35 was widely tested in on-farm trials. Key informants generally believe that S35 is now part of the "pool" of sorghum varieties from which farmers select each year. Because the variety has been extended widely and has noticeable advantages during drought conditions, the assumption that its benefit stream will continue for another seven years from the time of the analysis (1991) is relatively conservative.

Table 5. Estimated Gross Benefits ($US) from the Development and Extension of the Improved Sorghum Variety S35, Northern Cameroon, 1984-98

Year	Gross Benefits of S35
1984	1,000
1985	0
1986	0
1987	294,000
1988	0
1989	0
1990	601,000
1991	0
1992	0
1993	943,000
1994	0
1995	0
1996	1,119,000
1997	0
1998	0

3.2.3. Sorghum ROR and Sensitivity Analyses

The base run rate of return for sorghum research and extension is 1%, estimated from the cost and benefit streams documented above. To test the robustness of this estimate and the assumptions supporting it, approximately forty alternative sets of assumptions and/or parameter values were tested, and RORs were calculated for each. The reported RORs (appendix, table 11) generally differ only slightly from the base run, suggesting that the ROR estimate is relatively robust. The values of the RORs tend towards zero to slightly positive, indicating that sorghum research and extension was probably "able to pay for itself" in financial terms, but most likely failed to be "profitable" in economic terms (i.e. where the opportunity cost of capital is approximately 10%). Four of these alternative scenarios were particularly insightful.

First, the analysis required that one of two simplifying assumptions be made: either assume that the level of inputs used by an individual farmer is independent of the variety grown or that farmers growing S35 achieve higher yields during normal rainfall years because the adoption of S35 implies a more intensive level of input usage (and thus higher farm-level input costs). The base run used the assumption that the level of input use and the choice of variety grown are independent decisions. When the alternative assumption–S35 adoption implies the adoption of the complete extension package (eg. seed treatments and fertilizer)–was tested, the new ROR was essentially the same as the base run. This increases the confidence in the base run ROR estimate, given that a very different, although plausible, assumption led to virtually the same conclusion: sorghum research, in financial-accounting terms, "broke-even."

Second, some previous ROR studies have excluded extension costs when evaluating the returns to research, simply taking the extension system as given and exogenous to the analysis. To offer results that may be potentially more comparative to other studies, extension costs were excluded from the base run and the resulting ROR was 8%. Although this ROR reflects favorably on the research system, this study concludes that part of the success of S35 research, in terms of farmer adoption, is due to the extension efforts of SODECOTON. Further, given the high degree of collaboration between IRA and SODECOTON and the breadth of SODECOTON's extension program, exclusion of extension costs is suspect because it likely ignores expenditures that were critical to the adoption of the improved variety.

Third, a very critical assumption, from a theoretical point of view, pertains to the frequency of drought conditions in northern Cameroon and its subsequent impact on overall sorghum production. By assuming that the benefits of the improved variety are only achieved in drought years, assumptions about the frequency of drought conditions are fundamental to the base run ROR. Two alternatives were tested–drought conditions once every four years and drought conditions once every two years. The former resulted in an ROR that was just slightly negative, -0.4%, while the latter resulted in an estimated ROR of 8%. Although this ROR is still below the estimated opportunity cost of capital of 10%,[13] these results highlight the competitive advantage of S35 in drought conditions and the potential for high payoffs to research targeted to marginal production conditions.

Fourth, given that some anecdotal evidence in 1991 indicated that the fcfa in Cameroon was overvalued by approximately 40%, an alternative assumption was tested. This alternative assumed that inputs and outputs should be valued at the "true" market exchange rate. This

[13] The estimated 10% opportunity cost of capital is actually more a rule of thumb than an empirically proved value. An 8% return to research and extension approaches this estimate and probably could be considered an "acceptable" return even in economic terms.

alternative assumed that the overvaluation gradually increased to the 40% level during the 1980s. Hence, starting in 1981, an annual 5% incremental increase in the percentage of overvaluation was assumed (i.e. in 1981, the currency is overvalued by 5%, in 1982, by 10%). Thus, a 40% overvaluation is reached in 1988, which is then held constant for the remainder of the analysis (i.e. through 1998). The shadow exchange rate was calculated by multiplying the market exchange rate by a conversion factor (1 plus the foreign exchange premium, where the premium equals the percent of overvaluation divided by 100). The shadow exchange rate was then used to convert the values of all tradable goods within the cost and benefit streams to $US. The resulting ROR is -2.3%. It is lower than the base run ROR because the value of the outputs, when converted to $US, was less after devaluation. The inclusion of a shadow exchange rate was tested and presented in order to provide an estimate of the ROR in the event that the anecdotal evidence of overvaluation is, in fact, correct.

3.3. Cowpea Research and Extension

3.3.1. Costs

Cost streams were compiled for the three donor projects and two host country institutions which financed the cowpea research-extension system responsible for developing and extending the original technology package.[14] Research specific to the development of these technologies began in 1979, was moved to on-farm testing as a technology package in 1981 (for TVX 3236, in 1984 for BR1 and BR2), and was extended to farmers in 1984 (for TVX 3236, in 1987 for BR1 and BR2). Thus, only costs incurred during this nine-year period are included in the cost stream (table 6).

For each contributing project, the cowpea share of research and extension investments was calculated as follows. For SAFGRAD J.P. 31, costs include the 25% of project resources that were targeted towards cowpea research. For the Bean/Cowpea CRSP, all expenditures (as reported by the CRSP Management Office at Michigan State University) supported the

Table 6. Estimated Total Costs (nominal $US) for Cowpea Research and Extension Programs, Far North Province, Cameroon, 1979-87

Year	SAF-GRAD J.P. 31	CRSP	NCRE	IRA	SODE-COTON	Total Annual Costs
1979	19,901	0	0	10,771	0	30,700
1980	17,325	0	0	11,001	0	28,300
1981	15,187	0	0	13,278	15,317	43,800

[14] The package extended to farmers consisted of a recommendation for monocropped, improved varieties with chemical applications (seed treatments and insecticide sprayings).

1982	15,657	131,565	0	33,478	14,769	195,500
1983	16,505	278,689	0	41,847	11,035	348,100
1984	34,916	332,003	0	58,585	11,147	436,700
1985	38,302	298,535	0	55,103	15,239	407,200
1986	32,638	272,893	4,890	26,462	15,043	351,900
1987	26,974	186,452	9,780	84,954	15,688	323,800
Totals	217,405	1,500,137	14,660	335,479	98,238	2,165,919

development of the technologies extended and are included in the cost stream. Since NCRE Project's financial contribution was limited to a two-year buy-in to support on-farm research as SAFGRAD J.P. 31 was being phased out, only these NCRE costs are included. IRA's contribution to the cost of developing the new technologies–including the salaries of host country research staff and unskilled labor, and some operating expenses (eg. fuel, electricity, water, office materials, per diem, temporary hires)–are also included in the cost stream. Finally, as part of its general activities, SODECOTON maintains a large extension network. The adoption of the cowpea package and its subsequent impact is, in part, dependent on SODECOTON's extension and distribution system. Hence, the share of these costs attributable to cowpea extension is included in the analysis.

3.3.2. Benefits

To estimate the cowpea benefit stream, data were needed for (1) yields under three different sets of farming practices (total adoption of the cowpea package, adoption of the package minus insecticide use, and traditional practices[15]); (2) corresponding adoption rates for the new technologies, including adoption ceilings and the life span of the technology; (3) total area harvested; and (4) annual input and output prices.

Yields are estimated from SAFGRAD/CRSP/NCRE on-station and on-farm trial data, from yields reported by farmers in surveys, and from SODECOTON reports. Adoption rates are estimated from adoption survey results reported by the CRSP and the IRA-Maroua TLU and extrapolated into the future, using a logistic function. Area harvested and total number of farmers are estimated from Agricultural Census data provided by DEAPA. Prices are estimated from price time series reported by Cameroon's Ministry of Agriculture, Office Céréalier, NCRE/IRA, and SODECOTON.

[15] Under each farming practice, cowpea yields are needed for grain, leaves for food, and forage for feed. With traditional practices, yield data are also needed for intercropped sorghum (grain and stover).

Gross benefits are determined by summing the changes in production, minus the increases in input costs. For this analysis, gains, reductions, and on-farm input costs are reported in $US (table 7).

Table 7. Estimated Gross Benefits ('000 $US) from the Cowpea Package Extended, Far North Province, Cameroon, 1984-98

Year	Gain in Value of Cowpea Grain Production	Reduced Value of Cowpea Leaf Production	Reduced Value of Cowpea Forage Production	Reduced Value of Sorghum Grain Production	Reduced Value of Sorghum Stover Production	Total Annual On-Farm Input Cost	Gross Benefits from Improved Package
1984	5	-1	0	-2	0	0	2
1985	20	-3	0	-7	0	1	8
1986	53	-7	-1	-20	-1	3	21
1987	110	-15	-1	-42	-1	7	43
1988	449	-63	-6	-171	-5	30	174
1989	499	-70	-6	-189	-5	33	195
1990	1318	-185	-17	-498	-14	87	517
1991	1888	-265	-24	-710	-20	125	744
1992	2030	-285	-26	-761	-21	134	803
1993	2246	-315	-28	-839	-23	148	892
1994	2430	-340	-31	-906	-25	160	967
1995	2437	-341	-31	-908	-25	161	970
1996	2444	-342	-31	-911	-25	161	973
1997	2444	-342	-31	-911	-25	161	973
1998	2444	-342	-31	-911	-25	161	973

Gains are projected to 1998, fifteen years after the original TVX package was extended. This assumption implies that BR1, BR2, and to a lesser degree TVX will continue to be the predominant improved varieties for seven more years. Given the already relatively high degree of adoption (25% in 1990), the timeframe for future benefits is plausible, if not conservative.

The improved package extended to farmers represented a completely new cropping system. Traditionally, cowpea is intercropped with sorghum and grown as much for its leaves as for its grain. The improved package represented a significant increase in grain yields, but required a reduction in the production of other commodities, specifically sorghum grain and stover, and cowpea leaves. With adoption, sorghum production on cowpea acreage is reduced to zero since farmers monocrop improved varieties. Also, for the case of complete adoption, the level of cowpea leaf production for food falls to zero since farmers will not eat the leaves of cowpea treated with insecticide. Further, forage production for feed is reduced with either partial or complete adoption since improved varieties produce less forage.

3.3.3. Cowpea ROR and Sensitivity Analysis

The base run ROR for cowpea research and extension is 15%, based on the cost and benefit streams reported above. Over sixty additional estimates of the ROR to cowpea research and extension were calculated by modifying the values of one or more of the model parameters/variables for each of the sixty-plus runs. This analysis identified eight parameters/variables as having a significant influence on the estimated rate of return. In general, when key variables were modified by plus or minus 25%, the RORs varied by less than plus or minus 30% of the base run value, implying an ROR in the range of 10% to 20% (appendix, table 10). There were four exceptions corresponding to increasing or decreasing either grain yield or market price by 25%. Increasing yield or price by 25% resulted in RORs of 25% and 22% respectively. For decreases, the ROR became negative and 3.5% respectively. Although the estimate of the yield of the cowpea package extended to farmers greatly affects the returns to research, key informants within the research-extension system have a high degree of confidence in the expected yield of the technology. Hence, varying its value by 25% is probably excessive, and the resulting negative rate of return is unlikely unless key inputs (eg. insecticides) become unavailable. With respect to cowpea price, trends indicate that the base run prices may be underestimated. Improved storage technologies, developed since 1987, should allow farmers and grain merchants to delay sales to capture higher post-harvest market prices that occur later in the marketing year. Hence, the low rate of return associated with a 25% reduction in cowpea prices is also unlikely.

Another important sensitivity test relaxed the assumption that Cameroon's currency is not overvalued. Given that some anecdotal evidence indicated that the fcfa in Cameroon was overvalued, tradable inputs and outputs were valued at an estimated market exchange rate. The methodology was identical to that used with the sorghum sensitivity analysis. The resulting ROR for cowpea was 11.4%. It is lower than the base run ROR because the value of inputs is more and that of outputs less when converted to $US after devaluation.

4. INSTITUTIONAL INFLUENCES ON THE ROR

Schmid broadly defines "institutions" as "sets of ordered relationships among people that define their rights, their exposure to the rights of others, their privileges, and their responsibilities." (1987, p. 6) In Cameroon, important institutions that affected the productivity of research included the government's system of research and extension (i.e. IRA, MINAGRI), input suppliers like the NCSM Project and SODECOTON, output markets, donor projects, and the government's policies towards food crop marketing (*de facto laissez-faire*).

In the context of impact assessment, institutional analysis examines how institutions affect the benefit and cost streams. In particular, institutional analysis can help identify factors that contributed to the productivity and "success" of a new technology. Quantitative analyses (eg. ROR calculations) simply estimate the financial and/or economic returns to investments. Policy decisions based solely on quantitative results are limited to choices between alternative investments with high, low, or negative returns. Qualitative analyses (eg. institutional analyses) seek to explain *why* an investment had high, low, or negative returns. With these insights, the policy choice set is greatly expanded to include policies that alter the potential returns of investments. For example, an investment which historically has had low returns still may be investment-worthy if institutional constraints that caused the low returns are altered by policy changes. Qualitative analyses may also help to explain *how* returns are distributed. For example, investments with high returns that benefit only a small group may be valued differently from investments with high returns that benefit a much broader constituency. Hence, analysis to identify the beneficiaries of the research and extension system of northern Cameroon is an important complement to calculating the net benefits of the system.

4.1. Key Institutional Linkages

Section 3 estimated the net benefits of cowpea and sorghum research and extension. Using an ROR criterion, the section's conclusions indicate that the development of improved cowpea and sorghum technologies was relatively "successful," particularly for the case of cowpea. Yet, these conclusions do not answer the question, "*Why* were the programs successful?" The discussion that follows addresses this fundamental question.

Analysis of key institutions and their inter- and intra-relationships partially explain how "successes" were achieved in northern Cameroon. Linkages within and between such institutions as IRA, SODECOTON, and donor projects (eg. Bean/Cowpea CRSP, SAFGRAD J.P. 31, NCRE and NCSM projects) proved critical to achieving positive rates of return. The fact that an integrated rural development project, *Projet Centre-Nord* (PCN), was implemented, in part, for the explicit purpose of linking together these institutions seems, in hindsight, especially fortuitous.

Three insights are particularly clear from this analysis: (1) linkages within the research-extension system were critical; (2) linkages between the system and international research institutions were equally important; and (3) government agricultural policies influence the system's performance.

4.1.1. Linkages within the Local System

Numerous efforts were made within the research-extension system to link together all of the "pieces" of the development "puzzle." For example, the PCN made investments to improve IRA's management practices, hiring a coordinator to oversee the agronomy research program. His responsibilities included creating and maintaining links between SODECOTON and IRA staff, which proved essential for the management of off-station research (at research substations and in farmers' fields). The coordinator's efforts facilitated information flows and fostered collaboration between IRA and SODECOTON and among each of IRA-Maroua's commodity-based research units and independent donor projects. Second, regularly scheduled staff meetings, organized by the IRA-Maroua station director, provided an opportunity for interdisciplinary interaction among researchers and staff. A third example was an annual planning meeting at which each research unit presented the previous year's results and the coming year's research agenda. Participants included representatives from SODECOTON, MINAGRI, and various NGO projects, as well as local farmers–all of whom were encouraged to provide their input and evaluation of the planned research agenda.

These linkages among actors involved in the research-extension system enhanced the technology development process in northern Cameroon in two key ways. First, greater information flows served to inform system participants and proved an effective means of identifying farmer constraints and setting the research agenda. For example, as a consequence of this process, the cowpea research agenda shifted from a primary focus on producing high grain yields to addressing post-harvest storage constraints. This shift was significant since post-harvest losses are now considered to be the largest constraint to higher adoption of the already extended improved cowpea varieties. Second, the linking of SODECOTON to the research system proved to be critical in the overall performance of the system. SODECOTON, with its input distribution system and 500 to 1000 extension workers, provided a conduit for both the extension of technologies and feedback from the farm to researchers. In turn, researchers knew that as they developed appropriate technologies, a system was in place, ready to widely diffuse these innovations. Knowing this proved to be an important motivating element for IRA's research staff.

4.1.2. Linkages beyond the Local System

Linkages, via donor projects, between the agricultural research system and international agricultural research centers (IARCs) also enhanced the technology development process in northern Cameroon. Multilocational varietal screening trials were organized at the international level by either IITA, SAFGRAD, ICRISAT, or the Bean/Cowpea CRSP, and then implemented at the local level by either the CRSP, SAFGRAD J.P. 31, or by the NCRE project. These trials became an important source of alternative cultivars. Most of the varieties that were extended to farmers as part of the "improved" technology packages were actually introduced varieties first identified as appropriate for the area through the international varietal screening trials. Hence, IARCs and other international networks (CRSPs and regional projects), by collecting, maintaining, and distributing germplasm, acted as important catalysts for the agricultural development process in northern Cameroon.

Further, donor projects in northern Cameroon had the capacity to access other resources beyond those available to the national system since all of the projects were directly linked to international networks. This access clearly enhanced the performance of the research-extension system. Projects were able to provide, in addition to introduced varieties, links to other research activities in the region, logistic support for on-going research in Cameroon, and access to a network of other researchers who could provide additional feedback relevant to the work being conducted by IRA-Maroua.

4.1.3. Government Policies

From 1979 to 1987, the Cameroonian government played a very limited role in the agricultural sector of northern Cameroon. The ineffectiveness of MIDEVIV, FONADER, *Office Céréalier*, and MINAGRI's extension system are all documented elsewhere (see Sterns 1993). Speculating on how the research-extension system would have performed under a different set of government policies is, at best, difficult. However, one issue merits comment. While farmers connected to SODECOTON's system of extension and input delivery are much more likely to adopt improved technologies, cotton farmers represent perhaps as few as 36% of all farmers in northern Cameroon.[16] Hence, the adoption of technologies is dependent, in part, on which and how many farmers are served by SODECOTON's system. Had the extension and input delivery system served a wider range of clientele, it is likely that the adoption of cowpea and sorghum technologies in northern Cameroon would have been higher. However, it is uncertain whether the benefits from attaining a higher adoption rate would compensate for the additional costs of establishing an extension system which served a broader constituency.

4.2. Distribution of Benefits

There is little documentation on the distribution of benefits from the development and subsequent adoption of improved cowpea and sorghum technologies in northern Cameroon. Two sources that gave some consideration to differentiated impact among groups are data reported by Johnson (1987) on differences between cotton and non-cotton farmers and data reported by Wolfson (1990) on gender differences in cowpea production and storage.

Johnson reports that "cotton sales dominate farm revenues in the Far North. The mean annual revenue for a cotton-growing family is 83,000 fcfa and for a non-cotton-growing family is 26,800 fcfa." (p. 48) He also notes that the only other important sources of income for these farmers are off-farm and livestock revenues. Given the research-extension system's dependency

[16] For the PCN region, the World Bank estimate was 36%, as reported in the 1980 PCN project paper. In 1991, during interviews conducted for this research, key informants estimated that from 40% to 70% of the farmers in northern Cameroon cultivate cotton.

on SODECOTON, many of the benefits of research were probably captured by cotton farmers, particularly early on in the adoption cycle. This indicates that initially the beneficiaries, by income strata, were probably the more affluent farmers in the region. Given the improved cowpea technology's dependency on insecticide usage, this bias may still continue. With sorghum, since the improved technology is an open-pollinated variety that did not depend on a complementary technological package, lower income farmers probably also captured some of the benefits of S35 as the technology was diffused.

In 1989, Wolfson, through work with the Bean/Cowpea CRSP, surveyed 112 households in the principal cowpea growing regions of northern Cameroon. Although it is unclear as to the representativeness of Wolfson's sample of cowpea farmers, her results do indicate distinct gender differences in the production of cowpea. For example, she notes:

> Eighty-seven percent of the farmers produced cowpeas primarily for home consumption. [Yet,] there was an association between the primary purpose of cowpea cultivation in a household and the gender of the producer. When women were responsible for production, the primary purpose was always for home consumption (although some of the crop might get sold). In [the] 17% of the households in which men were involved in production either as sole producer or co-producer, the primary purpose was for sale. . . Women grew their cowpeas intercropped with peanuts or sorghum whereas men more frequently grew their cowpeas in pure stands. (1990, pp. 1-2)

One of Wolfson's conclusions was that since women sell some of their cowpea crop, changes in cowpea technologies could affect women's access to this source of cash income, indicating a need for researchers to be sensitive to this distributional change.

Based on Wolfson's findings, the improved cowpea technologies probably favored men, since the new system required monocropping and the use of insecticides. Wolfson reported that both of these practices were found to be more prevalent with men. On the other hand, cowpea production in general was reported to be more important to women, implying that at least some of the benefits resulting from improvements in cowpea production are likely to be captured by them.

More conclusive discussions on distributions of benefits between income strata and genders are limited, and other distributional issues (eg. differences between rural producers and urban consumers, trade-offs between current and future generations) are not explored due to data constraints. Yet, because cowpea and sorghum are grown in one of the poorest regions of Cameroon, the new technologies have enhanced the welfare of these producers, vis-a-vis farmers in the higher rainfall, more well-endowed regions of the country.

5. LESSONS LEARNED

5.1. Comparing Programs

The significant difference in returns to the two commodity-based research programs (15% compared to 1%) leaves unanswered the obvious question, "Why?" Although a definitive answer to that question may not be possible, certain characteristics that differed between the two programs give some indication of possible reasons.

First, the improved cowpea technology extended to farmers represented a completely new farming system, while the improved sorghum technology was simply a complement to traditional practices. Although cowpea is indigenous to northern Cameroon, it has been traditionally grown more as a garden crop, harvested for its leaves as much as for its grain. The improved cowpea technology filled an existing need of farmers in the region–an early maturing food crop to relieve hungry season food shortages. On the other hand, under normal rainfall conditions, S35 is just one more variety in the pool of over 1,800 accessions that have been identified in the region by the NCRE sorghum breeding unit. S35 has enjoyed some success because it also addresses a need of farmers in the region–a sorghum variety that is extremely drought tolerant. However, this need is not nearly as predictable or regular as the needs met by the cowpea technologies. Hence, the most obvious difference between the two programs was that cowpea research generated a technology that netted benefits *every year* while the sorghum technology led to net benefits in *only one out of every three years*.

Second, given that this is a case study, little can be said about the general appropriateness of funding screening programs versus breeding programs within research projects. Yet, higher returns were found with the cowpea program, which focussed entirely on varietal screening to "develop" improved varieties. Even the success of the sorghum program depended not on a variety developed by its breeding program but one identified in screening trials. Both cases imply higher returns were found for screening activities. This conclusion is underscored by two important insights. First, screening programs are cheaper because many of the costs of generating an "improved" variety have already been incurred by other projects and institutions. Second, the appropriateness of screening versus breeding depends on its timing relative to a region's overall development scheme. Screening is most likely to be successful early on in the research horizon. As a first pass at introducing improved technologies, high yielding varieties developed for a wide range of growing conditions (eg. TVX 3236) will likely have positive returns. However, as researchers gain a greater understanding of the constraints faced by farmers within a specific region, breeding programs offer an alternative for potentially greater returns to research (eg. the cowpea breeding program established in 1988, targeting, in part, bruchid tolerance).

Third, cowpea has a competitive advantage in production (drought tolerance) and in consumption (affordable protein source) and can be readily sold in local markets, making it a viable alternative to cotton. In the late 1980s, as SODECOTON cut its price subsidy for cotton, the cowpea market was poised for considerable expansion as cash-crop farmers looked for alternatives. The change in cotton price represented an institutional shift in the incentive structure faced by farmers and consequently in the profitability of the established system, which may explain some of the relative "success" of cowpea technologies and subsequent transformation of the farming system. Hence, changes in the incentives that farmers faced may have had an important influence on the success of the cowpea program.

Fourth, the relative difficulty of the problems addressed by the two research programs may also explain some of the differences in the returns. Sorghum, relative to cowpea, has presented a formidable problem to researchers throughout West and Central Africa for over thirty years. Low returns to sorghum research, although undesirable, may simply reflect long run historical trends.

5.2. Setting the Research Agenda

Several characteristics of the research-extension system of northern Cameroon provide insights on the setting of research agendas. First, the system demonstrated a capacity to incorporate feedback from farmers and extension agents, permitting some redirection of research efforts (i.e. addressing storage losses in cowpea). Examples of these information flows include on-farm testing of promising varieties, an annual planning meeting between researchers, extension agents, development agencies and farmers, and regular contact between village level SODECOTON extension agents and researchers. These flows proved to be an effective means of identifying farmer constraints and for setting the research agenda.

A second factor was the choice of what to research. With cowpea, the research-extension system identified and researched constraints that were critical to expanding the existing farming system. A new crop management system was developed to address the needs of farmers. In contrast, with sorghum, one constraint (vulnerability to drought), although not always limiting, was identified and researched, resulting in modest returns for the investments made.[17] In both cases, one facet of the needs of farmers was identified and researched, although each case differed both in the relative difficulty inherent in the targeted problem and in potential returns. Hence, selecting which constraint to research probably affects any subsequent impacts as much as the actual research that follows.

Third, when setting research agendas, the influence of data availability on the selection of the assessment methodology employed should be noted. In northern Cameroon, data on the research and extension system were obtained primarily from project documents including annual reports and research summaries. When these sources failed to provide sufficient detail for the needs of the analysis, key informants were interviewed–individuals within the research-extension system and the cowpea and sorghum subsectors who were knowledgeable about the data in question. Two issues that surfaced during this data collection process are related to data availability and data reliability.

[17] This constraint, however, has serious food security implications: food shortages in drought years can be lessened with the improved technology, a factor not reflected in the ROR calculation.

5.2.1. Data Availability

In northern Cameroon, the research-extension system historically had not collected and organized data appropriate for the requirements of rate of return analysis. Specific data needs often could not be met since the data simply had never been collected, necessitating the use of proxies and estimates based on the opinions of key informants. Also, data that had been collected were typically not in a form which could be readily transferred into benefit-cost streams.

5.2.2. Data Reliability

Although information gathered during interviews with key informants is critical to this study, the analysis relies heavily on secondary data. The integrity of the study's results then depends, in part, on the reliability of these secondary data. It is difficult to assess the historic quality of the data collection methodologies for such key data as area in production, adoption rates, and market prices. Hence, the study used sensitivity analyses to test the robustness of its conclusions.

Underlying the issues of data availability and reliability is a more fundamental issue concerning the costs and benefits of data. If impact assessment is to be institutionalized within Sub-Saharan NARSs, then financial resources must be committed to generate appropriate data to support these analyses. This study confirms that administrators, plant breeders, and agronomists are not well versed in the methods and scope of data collection necessary for economic analysis. Assessing the economic returns of projects and/or research-extension systems is highly dependent on specific data needs. Historically, these data have not been collected or given a high priority in the research agenda.

APPENDIX

Table 8. Estimated Cost-Benefit Flows (in '000 $US) for the Cowpea Technology Extended, Far North Province, Cameroon, 1979-98

Year	Gross Benefits from Package Extended	Gross Costs of Research & Extension	Net Cost/Benefit Flow
1979	0	-31	-31
1980	0	-28	-28
1981	0	-44	-44
1982	0	-195	-195
1983	0	-348	-348
1984	2	-437	-434
1985	8	-407	-399
1986	21	-352	-331
1987	43	-324	-281
1988	174	0	174
1989	195	0	195
1990	517	0	517
1991	744	0	744
1992	803	0	803
1993	892	0	892
1994	967	0	967
1995	970	0	970
1996	973	0	973
1997	973	0	973
1998	973	0	973

Table 9. Estimated Cost-Benefit Flows (in '000 $US) for the Development and Extension of the Improved Sorghum Variety S35, Northern Cameroon, 1979-98

Year	Gross Benefits of S35	Gross Costs of Research & Extension	Net Benefit Flow
1979	0	-51	-51
1980	0	-48	-48
1981	0	-263	-263
1982	0	-448	-448
1983	0	-398	-398
1984	1	-463	-462
1985	0	-530	-530
1986	0	-530	-530
1987	294	0	294
1988	0	0	0
1989	0	0	0
1990	601	0	601
1991	0	0	0
1992	0	0	0
1993	943	0	943
1994	0	0	0
1995	0	0	0
1996	1,119	0	1,119
1997	0	0	0
1998	0	0	0

Table 10. Sensitivity Analysis, Modifying Values of Key Variables and Subsequent Changes in the ROR for Cowpea Research & Extension, Far North Province, Cameroon, 1979-98

Key Variables	Base Run	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7
Yield (kg/ha):								
cowpea grain, extended pkg.	1000	b[a] ± 10%	b ± 25%	b	b	b	b	b
cowpea grain in intercrop	350	b	b	b ± 25%	b	b	b	b
sorghum grain in intercrop	600	b	b	b	b ± 25%	b	b	b
Price (fcfa/kg):								
cowpea grain	155	b	b	b	b	b ± 25%	b	b
sorghum grain	60	b	b	b	b	b	b ± 25%	b
Area Harvested (ha)	23,600[b]	b	b	b	b	b	b	b ± 25%
Adoption Rate (% farmers adopting)	35.2[c]	b	b	b	b	b	b	b
Total Costs ('000 $)	2,613[d]	b	b	b	b	b	b	b
IRR (%) for:	15.5							
a decrease in value of variable		9.5	-18.0	19.6	18.3	3.5	18.3	11.9
an increase in value of variable		19.9	24.8	10.0	12.1	22.2	12.1	18.5
Change in Value of IRR from:								
a decrease in value of variable		-6.1	-33.5	+4.1	+2.8	-12.0	+2.8	-3.6
an increase in value of variable		+4.4	+ 9.3	-5.5	-3.4	+ 6.7	-3.4	+3.0

[a] "b" represents base run values for the variable.
[b] For the period 1984-89, DEAPA reports that average area harvested is 23,600 ha.
[c] Annual adoption rates are estimated using a logistic function. The adoption ceiling for the base run is 35.2%.
[d] Total cost is an aggregate of the annual cost stream reported in table 1.

Table 10. (cont.) Sensitivity Analysis, Modifying Values of Key Variables and Subsequent Changes in the ROR for Cowpea Research & Extension, Far North Province, Cameroon, 1979-98

Key Variables	Base Run	Run 8	Run 9	Run 10	Run 11	Run 12	Run 13
Yield (kg/ha):							
cowpea grain, extended pkg.	1000	b	b	b - 25%	b	b	b ± 10%
cowpea grain in intercrop	350	b	b	b - 25%	b	b	b
sorghum grain in intercrop	600	b	b	b - 25%	b	b	b
Price (fcfa/kg):							
cowpea grain	155	b	b	b + 50%	b	b	b ± 10%
sorghum grain	60	b	b	b + 50%	b	b	b
Area Harvested (ha)	23,600	b	b	b	39,400[e]	↑ p.a. by 10%[f]	b ± 10%
Adoption Rate (% farmers adopting)	35.2	b ± 25%	b	b	b	b	b ± 10%
Total Costs ('000 $)	2,613	b	b ± 25%	b	b	b	b ± 10%
IRR (%) for:	15.5			20.1	22.5	19.5	
a decrease in value of variable		11.7	19.4				1.3
an increase in value of variable		18.6	12.7				27.0
Change in Value of IRR from:				+4.6	+7.0	+4.0	
a decrease in value of variable		-3.8	+3.9				-14.3
an increase in value of variable		+3.1	-2.8				+11.5

[e] For this run, MINAGRI data for annual cowpea area harvested replaces DEAPA data, otherwise ceteris paribus. MINAGRI data are reported that the average area harvested (1981-90) is 39,400 ha.

[f] For this run, area harvested in 1990 is assumed to be 23,600 ha, after which (1991-98) a 10% per annum increase in area of cowpea harvested is assumed, otherwise ceteris paribus.

Table 11. Sensitivity Analysis, Modifying Values of Key Variables and Subsequent Changes in the ROR for Sorghum Research & Extension, Northern Cameroon, 1979-98

Key Variables	Base Run	Run 1	Run 2	Run 3	Run 4	Run 5
Yields in Drought Years (kg/ha):						
sorghum grain, variety S35	650	b[a] ± 25%	b	b	b	b
sorghum grain, local varieties	300	b	b ± 25%	b	b	b
Yields in Normal Years (kg/ha):						
sorghum grain, variety S35	800	b	b	b	b	b
sorghum grain, local varieties	800	b	b	b	b	b
Price in Drought Years (fcfa/kg):						
sorghum grain	130	b	b	b ± 25%	b	b
Area Harvested (ha)	179,800[b]	b	b	b	b ± 25%	b
Frequency of Drought Conditions (years)	triennial	b	b	b	b	b
Extension Costs ('000 $)	1,205[c]	b	b	b	b	zero
Total Costs ('000 $)	2,731[d]	b	b	b	b	b
IRR (%) for:	0.9					7.7
a decrease in value of variable		-5.6	3.0	-2.2	-2.2	
an increase in value of variable		5.2	-1.7	+3.3	3.4	
Change in Value of IRR from:						+6.8
a decrease in value of variable		-4.7	+2.2	-3.0	-3.1	
an increase in value of variable		+4.3	-2.6	+2.5	+2.5	

[a] "b" represents base run values for the variable.
[b] During 1984-89, DEAPA reports that average area harvested is 179,800 ha.
[c] "Extension costs" is an aggregate of the annual cost stream for extension reported in table 3.
[d] "Total costs" is an aggregate of the annual cost stream reported in table 3.

Table 11. (cont.) Sensitivity Analysis, Modifying Values of Key Variables and Subsequent Changes in the ROR for Sorghum Research & Extension, Northern Cameroon, 1979-98

Key Variables	Base Run	Run 6	Run 7	Run 8	Run 9 [f]	Run 10
Yields in Drought Years (kg/ha):						
sorghum grain, variety S35	650	b	b	b	700	b ± 10%
sorghum grain, local varieties	300	b	b	b	b	b ± 10%
Yields in Normal Years (kg/ha):						
sorghum grain, variety S35	800	b	b	b	900	b
sorghum grain, local varieties	800	b	b	b	800	b
Price in Drought Years (fcfa/kg):						
sorghum grain	130	b	b	b	b	b ± 10%
Area Harvested (ha)	179,800[b]	b	214,628[e]	b	b	b ± 10%
Frequency of Drought Conditions (years)	triennial	b	b	biennial/ quadrennial	b	b
Extension Costs ('000 $)	1,205[c]	b	b	b	b	b
Total Costs ('000 $)	2,731[d]	b ± 25%	b	b	b	b ± 10%
IRR (%) for:	0.9		3.9		0.8	
a decrease in value of variable		4.1		-0.4		-5.6
an increase in value of variable		-1.5		7.9		7.0
Change in Value of IRR from:			+3.0		-0.1	
a decrease in value of variable		+3.3		-1.3		-6.5
an increase in value of variable		-2.4		+7.0		+6.2

[e] For this run, MINAGRI data for annual sorghum area harvested replaces DEAPA data, otherwise ceteris paribus. MINAGRI reported that the average annual area harvested (1981-90) is 214,628 ha.

[f] For this run, it is assumed that the adoption of S35 implies the adoption of a complete package, including seed treatment (thioral) and fertilizer (urea) applied at 50 kg/ha. The costs of these inputs are included in the IRR calculation.

YIELD DATA

Numerous sources report cowpea yields for one or more types of farming practices (trial data and annual reports by the SAFGRAD and NCRE projects, the CRSP, SODECOTON, and MINAGRI). Reported yields (table 12) range from 3,158 kg/ha, representing an upper limit achieved in on-station trials, to a low of 10 kg/ha, which was one farmer's response as reported in a survey of cowpea farmers (Ta'Ama 1984 and Kitch 1990 respectively).

Both the CRSP and the IRA/TLU conducted trials for intercropped cowpea and sorghum. Again, results are difficult to compare due to different protocols used across trials. Ranges of sorghum yields reported by researchers are presented in table 15. As noted by key informants, farmers seldom adopt new varieties and chemical treatments (eg. insecticide applications for cowpea and urea for sorghum) without also converting from an intercropped to a monocropped farming practice. Hence, the IRA/TLU on-farm trial data when no chemicals are used are most indicative of actual farm yields for intercropped sorghum.

Numerous sources also report sorghum yields for monocropped sorghum, including trial data reported by the SAFGRAD and NCRE projects, and on-farm yields reported by SODECOTON and MINAGRI. Monocropped systems vary considerably in the degree and breadth of adoption/application of improved technologies, and reported yields (table 13) range from 600 to 1,880 kg/ha. Further, the data in table 15 only indicate yield potentials, with yields in any given year being highly dependent on the quantity, timing, and dispersion of rainfall in the region.

Table 12. Cowpea Yield Estimates, Various Sources, Far North Province, Cameroon, 1983-90

Data Source	Years Reported	Yield Range (kg/ha)	Cropping System
Agricultural census	1984-89	231-1,033	Aggregation over all cropping systems
SODECOTON on-farm production estimates	1986, '87, '91	770-1,200	Monocropped, 2 to 3 insecticide applications, 1/4 ha block plots
CRSP, farmer survey	1990	10-800	Aggregation over all cropping systems
CRSP, on-station research trials	1983-87	262-3,158	Monocropped, insecticide applications, varietal screening trials
CRSP on-station agronomy trials	1983	151-1,292	Monocropped, no insecticide, two dates of planting, variety TVX 3236
CRSP, on-station agronomy trials	1983, '84, '88	67-516	Intercropped, with & w/o insecticide, two dates of planting
IRA/SAFGRAD/ NCRE on-farm trials	1983-87, '89	342-2,500	Monocropped, 2 to 3 insecticide applications, 1/4 ha plots
IRA/SAFGRAD/ NCRE on-farm trials	1989	110-204	Intercropped, no insecticide, varieties BR1 and VYA, 6 sites

Table 13. Sorghum Yield Data, Various Sources, Northern Cameroon, 1983-90

Data Source	Years Reported	Yield Range (kg/ha)	Cropping System
Agricultural census	1984-89	685-1,467	Aggregation over all cropping systems
SODECOTON on-farm production estimates	1985, 87, 89-91	600-1,300	Monocropped, variety S35, with 50 kg urea/ha, seed treatment, seeded in rows, mechanical tillage
SODECOTON on-farm production estimates	1987	650-1,200	Estimates for traditional farming practices and rainy season varieties
IRA/SAFGRAD/ NCRE on-farm trials	1984-87	719-1,825	Traditional varieties, with 50 kg/ha urea, seed treatment, planting in lines
IRA/SAFGRAD/ NCRE on-farm trials	1984-87	1,333-1,888	Monocropped, variety S35, with 50 kg/ha urea, seed treatment, seeded in rows
IRA/TLU/NCRE on-farm trials	1989	448-583	Variety S35, intercropped with two cowpea varieties, no fertilizer, 6 sites
IRA/TLU/NCRE on-farm trials	1990	1,070-1,253	S35 intercropped with VYA, with & w/o 100 kg of urea, 16 sites
CRSP, on-station agronomy trials	1983, '84, '88	736-5,588	S35 and local vars. intercropped with cowpea, with & w/o insecticides and fertilizer, 2 dates of planting

PRICE DATA

MINAGRI, *l'Office Céréalier*, and the TLU collected time series of market price data for farm products. None of these data sets were sufficient to discern price trends, and most key informants, when asked, questioned the validity and representativeness of both the MINAGRI and *l'Office Céréalier* data. However, these data were used as part of the price estimation process, in which key informants were interviewed about market prices, their trends, and upper and lower bounds.

Table 14 presents the prices used in the cost/benefit analyses.

Table 14. Estimated Average Annual Market Prices for Cowpea and Sorghum By-Products, Far North Province, Cameroon, 1984-98

By Products	Market Price fcfa/kg
Cowpea grain	155
Cowpea leaves	35
Cowpea forage	25
Sorghum grain	60-130
Sorghum stover	5

Source: Estimates based on MINAGRI and TLU data and interviews of key information.

Table 15 presents average monthly prices, based on data collected during a two-year period by the TLU. Prices are from six small, rural markets in the Far North Province.

Table 15. Average Monthly Prices in Six Rural Markets, Far North Province, Cameroon, for the Two-Year Period 1989-90

Month	Sorghum (white grain) fcfa/kg	Sorghum (Muskwari) fcfa/kg	Cowpea (grain) fcfa/kg
January	60	56	121
February	55	63	105
March	59	58	113
April	62	62	118
May	59	57	117
June	58	73	171
July	77	74	156
August	99	92	196
September	76	79	175
October	60	61	149
November	56	57	138
December	51	52	101
Average	64	65	138

Source: NCRE 1990 Annual Report.

Table 16 presents two time series of prices from *l'Office Céréalier*. In an effort to moderate extreme price fluctuations, *l'Office Céréalier's* mandate was to purchase and store market surpluses at harvest, and then resell these stores during the annual market short falls that preceed the next year's harvest. However, the agency never was sufficiently funded to have much, if any, regional impact on price.

Table 16. Purchase and Resale Prices for *l'Office Céréalier*, Years 1979/80 to 1989/90, Garoua, Cameroon

Year	Average Purchasing Price for Millet and Sorghum fcfa/kg	Average Resale Price for Millet and Sorghum fcfa/kg
1979/80	49.4	52.7
1980/81	52.4	61.5
1981/82	84.3	72.3
1982/83	63.0	101.9
1983/84	87.1	92.0
1984/85	116.7	114.7
1985/86	76.6	133.6
1986/87	m[1]	65.1
1987/88	67.1	53.0
1988/89	44.0	68.1
1989/90	50.0	73.3
Average	69.1	80.7

Source: Internal documents, *l'Office Céréalier*, Garoua.

[1] "m" implies missing data point.

Table 17. Average Monthly Cowpea Market Prices (fcfa/kg), in Five Regional Markets, Far North Province, Cameroon 1985-90

Period	Maroua	Kaele	Yagoua	Mora	Mokolo
Jul 85	198	281	m	169	m
Aug 85	198	258	m	171	m
Sep 85	198	600	m	182	m
Oct 85	99	173	m	84	149
Nov 85	99	159	m	89	118
Dec 85	99	136	m	81	100
Jan 86	130	124	100	60	125
Feb 86	130	124	90	60	120
Mar 86	130	109	100	60	130
Apr 86	m	228	110	m	m
May 86	m	235	m	m	m
Jun 86	m	243	m	m	m
Jul 86	160	138	190	160	m
Aug 86	160	136	190	160	m
Sep 86	160	m	190	160	m
Oct 86	90	m	150	140	m
Nov 86	90	m	144	120	m
Dec 86	90	100	147	100	m
Jan 87	115	105	m	100	m
Feb 87	115	130	m	100	m
Mar 87	115	185	m	100	m
Apr 87	m	m	m	110	m
May 87	m	m	m	120	m
Jun 87	m	m	m	130	m
Jul 87	m	m	m	m	m
Aug 87	m	m	m	m	m
Sep 87	m	m	m	m	m
Oct 87	m	m	m	m	m
Nov 87	m	m	m	m	m
Dec 87	m	m	m	m	m
Jan 88	m	m	m	m	m
Feb 88	m	m	m	m	m
Mar 88	m	m	m	m	m
Apr 88	m	m	m	m	m
May 88	m	m	m	m	m
Jun 88	m	m	m	m	m
Jul 88	250	185	185	170	165
Aug 88	300	200	200	160	165
Sep 88	220	210	210	160	165
Oct 88	225	135	135	140	100
Nov 88	200	155	155	120	90
Dec 88	190	160	160	120	130

Table 17. (cont.) Average Monthly Cowpea Market Prices (fcfa/kg), in Five Regional Markets, Far North Province, Cameroon 1985-90

Period	Maroua	Kaele	Yagoua	Mora	Mokolo
Jan 89	150	180	200	125	130
Feb 89	105	200	200	125	100
Mar 89	115	205	200	125	95
Apr 89	90	225	225	140	105
May 89	80	235	225	145	105
Jun 89	95	235	225	170	120
Jul 89	165	200	175	110	140
Aug 89	150	200	150	110	145
Sep 89	190	225	160	100	130
Oct 89	125	130	150	100	170
Nov 89	130	140	140	85	80
Dec 89	100	100	140	80	90
Jan 90	90	160	150	80	95
Feb 90	105	180	150	115	100
Mar 90	105	200	175	120	100
Apr 90	125	215	200	130	165
May 90	140	285	210	135	195
Jun 90	150	230	210	150	195

Source: Service Provincial des Etudes et Statistiques Agricoles de l'Extrême-Nord, 1986, 1988, 1990, 1991.

"m" implies data points are missing.

Table 18. Average Monthly White Sorghum Market Prices (fcfa/kg), in Five Regional Markets, Far North Province, Cameroon, 1985-90

Period	Maroua	Kaele	Yagoua	Mora	Mokolo
Jul 85	206	203	m	173	m
Aug 85	206	204	m	178	m
Sep 85	206	176	m	160	m
Oct 85	105	120	m	64	128
Nov 85	105	78	m	67	128
Dec 85	105	61	m	73	123
Jan 86	124	m	50	75	100
Feb 86	124	m	50	75	70
Mar 86	124	m	50	75	80
Apr 86	m	203	56	m	m
May 86	m	207	m	m	m
Jun 86	m	203	m	m	m
Jul 86	80	m	54	53	m
Aug 86	80	m	54	53	m
Sep 86	80	m	54	48	m
Oct 86	55	m	42	42	m
Nov 86	m	m	42	38	m
Dec 86	55	m	42	38	m
Jan 87	40	m	45	38	m
Feb 87	40	m	45	42	m
Mar 87	40	m	45	40	m
Apr 87	m	m	m	40	m
May 87	m	m	m	40	m
Jun 87	m	m	m	42	m
Jul 87	m	m	m	m	m
Aug 87	m	m	m	m	m
Sep 87	m	m	m	m	m
Oct 87	m	m	m	m	m
Nov 87	m	m	m	m	m
Dec 87	m	m	m	m	m
Jan 88	m	m	m	m	m
Feb 88	m	m	m	m	m
Mar 88	m	m	m	m	m
Apr 88	m	m	m	m	m
May 88	m	m	m	m	m
Jun 88	m	m	m	m	m
Jul 88	95	90	95	55	100
Aug 88	110	110	95	40	95
Sep 88	90	95	90	40	110
Oct 88	95	95	80	35	80
Nov 88	70	75	70	35	65
Dec 88	65	60	70	35	55

Table 18. (cont.) Average Monthly White Sorghum Market Prices (fcfa/kg), in Five Regional Markets, Far North Province, Cameroon, 1985-90

Period	Maroua	Kaele	Yagoua	Mora	Mokoloo
Jan 89	50	55	75	40	55
Feb 89	65	60	70	40	65
Mar 89	50	65	80	45	65
Apr 89	55	75	90	45	60
May 89	65	85	95	55	70
Jun 89	65	90	95	60	75
Jul 89	70	80	100	60	80
Aug 89	75	100	100	70	85
Sep 89	65	90	100	60	85
Oct 89	75	80	75	50	90
Nov 89	70	60	70	45	70
Dec 89	65	55	60	45	70
Jan 90	50	55	60	50	65
Feb 90	50	45	50	50	65
Mar 90	45	40	50	45	60
Apr 90	m	m	50	45	60
May 90	m	m	55	55	70
Jun 90	m	m	70	60	70

Source: Service Provincial des Etudes et Statistiques Agricoles de l'Extrême-Nord, 1986, 1988, 1990, 1991.

"m" implies data points are missing.

Table 19. Average Monthly Red Sorghum Market Prices (fcfa/kg), in Five Regional Markets, Far North Province, Cameroon, 1985-90

Period	Maroua	Kaele	Yagoua	Mora	Mokolo
Jul 85	169	194	m	169	m
Aug 85	169	206	m	178	m
Sep 85	170	175	m	160	m
Oct 85	79	92	m	58	101
Nov 85	79	64	m	62	90
Dec 85	79	59	m	62	91
Jan 86	71	58	50	55	75
Feb 86	71	51	45	55	60
Mar 86	71	54	45	55	70
Apr 86	m	192	50	m	m
May 86	m	197	m	m	m
Jun 86	m	200	m	m	m
Jul 86	60	26	67	50	m
Aug 86	60	54	67	50	m
Sep 86	60	46	67	50	m
Oct 86	35	28	47	40	m
Nov 86	35	28	41	32	m
Dec 86	35	27	33	29	m
Jan 87	30	28	34	29	m
Feb 87	30	29	34	36	m
Mar 87	30	35	34	38	m
Apr 87	m	m	m	38	m
May 87	m	m	m	36	m
Jun 87	m	m	m	37	m
Jul 87	m	m	m	m	m
Aug 87	m	m	m	m	m
Sep 87	m	m	m	m	m
Oct 87	m	m	m	m	m
Nov 87	m	m	m	m	m
Dec 87	m	m	m	m	m
Jan 88	m	m	m	m	m
Feb 88	m	m	m	m	m
Mar 88	m	m	m	m	m
Apr 88	m	m	m	m	m
May 88	m	m	m	m	m
Jun 88	m	m	m	m	m
Jul 88	85	85	110	45	85
Aug 88	100	95	110	40	80
Sep 88	75	75	105	35	85
Oct 88	85	70	65	35	65
Nov 88	60	65	65	35	55
Dec 88	35	45	60	35	45

Table 19. (cont.) Average Monthly Red Sorghum Market Prices (fcfa/kg), in Five Regional Markets, Far North Province, Cameroon, 1985-90

Period	Maroua	Kaele	Yagoua	Mora	Mokolo
Jan 89	35	45	60	35	55
Feb 89	45	40	50	35	55
Mar 89	40	55	50	35	50
Apr 89	45	70	65	40	60
May 89	50	75	70	50	60
Jun 89	55	85	80	60	65
Jul 89	65	80	75	60	80
Aug 89	65	90	75	70	80
Sep 89	55	65	75	60	75
Oct 89	45	50	60	55	70
Nov 89	45	40	50	50	60
Dec 89	35	40	50	45	60
Jan 90	45	40	50	50	70
Feb 90	40	45	55	50	65
Mar 90	40	45	50	55	65
Apr 90	50	65	50	45	50
May 90	60	75	50	55	50
Jun 90	65	85	60	65	60

Source: Service Provincial des Etudes et Statistiques Agricoles de l'Extrême-Nord, 1986, 1988, 1990, 1991.

"m" implies data points are missing.

REFERENCES

Eicher, Carl K., and John M. Staatz. 1984. Agricultural Development Ideas in Historical Perspective. In *Agricultural Development in the Third World,* ed. Carl Eicher and John Staatz. Baltimore, MD: John Hopkins University Press.

Johnson, Jerry J. 1987. *Proceedings of the On-Farm Research Workshop Held in Maroua, Cameroon.* Ouagadougou, Burkina Faso: SAFGRAD, Scientific Technical and Research Community, Organization of African Unity.

IRA. 1982. *Programme de Recherches 1981-1982*. Yaoundé, Cameroon: DGRST-IRA.

IRAF. 1977. *Principaux Résultats de Centre des Cultures Textiles et Vivrières de Maroua.* Buea, Cameroon: IRAF.

IRAT. 1967. *L'IRAT au Service du Cameroun, Rapport de Synthèse de l'Année 1967*. Yaoundé, Cameroon: IRAT.

Kitch, Laurie. 1990. *Preliminary Results of a Survey of Cowpea Farmers.* IRA-Maroua Legume Program, Cameroon.

Mellor, J.W. 1966. *The Economics of Agricultural Development*. Ithaca, NY: Cornell University Press.

NCRE. 1989. *Annual Report 1989*. Yaoundé, Cameroon: NCRE.

NCRE. 1990. *Annual Report 1990*. Yaoundé, Cameroon: NCRE.

National Directorate of the Agricultural Census. 1984. *Agricultural Census*. Yaoundé, Cameroon.

National Directorate of the Agricultural Census/MINAGRI. 1991. *Summary of Crop Area, Production and Sales*. *By Year and Crop*. Yaoundé, Cameroon: DEAPA/MINAGRI.

Oehmke, James F., L. Daniels, J. Howard, M. Maredia, and R. Bernsten. 1992. *The Impact of Agricultural Research: A Review of the Ex-Post Assessment Literature with Implications for Africa.* Department of Agricultural Economics Staff Paper No. 92-38. East Lansing, MI: Michigan State University.

Pardey, Philip, and Johannes Roseboom. 1989. *ISNAR Agricultural Research Indicator Series*. Cambridge: Cambridge University Press.

Perez, A.T. 1979. *Plant Exploration in Cameroon, October to December 1979.* Ibadan, Nigeria: IITA.

Russell, John T. 1991. Yield Stability of Pure and Mixed Stands of Sorghum Varieties in Northern Cameroon. PhD dissertation, University of Florida, Gainesville, Florida.

Salinger, B. Lynn, and J. D. Stryker. 1991. *Exchange Rate Policy and Implications for Agricultural Market Integration in West Africa.* Cambridge, Massachusetts: Associates for International Resources and Development.

Schmid, A. A. 1987. *Property, Power, & Public Choice, An Inquiry into Law and Economics.* New York, NY: Praeger Publications.

Service Provincial des Etudes et Statistiques Agricoles de l'Extrême-Nord. 1986. *Annuaire Provincial des Statistiques Agricoles 1985-1986*. Maroua: SPESAEN.

Service Provincial des Etudes et Statistiques Agricoles de l'Extrême-Nord. 1988. *Annuaire Provincial des Statistiques Agricoles 1986-1987*. Maroua: SPESAEN.

Service Provincial des Etudes et Statistiques Agricoles de l'Extrême-Nord. 1990. *Annuaire Provincial des Statistiques Agricoles: Campagne Agricole 1988/1990*. Maroua: SPESAEN.

Service Provincial des Etudes et Statistiques Agricoles de l'Extrême-Nord. 1991. *Annuaire Provincial des Statistiques Agricoles: Exercice 1989/1990*. Maroua: SPESAEN.

Singh, S. R., and K. O. Rachie. 1985. *Cowpea Research, Production and Utilization*. New York: John Wiley and Sons.

SODECOTON. 1977 to 1990. *Compte Rendu Annuel, Campagne 76/77 to Compte Rendu Annuel, Campagne 1989/90*. Garoua, Cameroon.

Sterns, James A. 1993. Ex Post Assessment of Investments in Cameroon's Cowpea and Sorghum Research-Extension Systems. Master's thesis, Michigan State University.

Ta'Ama, Moffi. 1984. *Provisional Report on Cowpea Baseline Data Survey in Northern Cameroon.* IRA-Maroua, Cameroon.

Wolfson, Jane L. 1990. *Analysis of Cowpea Production and Storage Methodologies Used By Small Farmers in Northern Cameroon.* Bean/Cowpea CRSP Project Report. West Lafayette, IN: Department of Entomology, Purdue University.