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FERTILIZER UTILIZATION PRACTICES AND CROP RESPONSE RESEARCH:

RECOMMENDATIONS FOR THE FERTILIZER SUB-SECTOR REFORM PROGRAM OF CAMEROON

OCTOBER 1989

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October 1989

The AMIS Project
The Postharvest Institute for Perishables,
University of Idaho
and
Abt Associates, Inc.
Washington D.C.

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GLOSSARY OF ACRONYMS

GRC - Government of the Republic of Cameroon

USAID - U.S. Agency for International Development

MINAGRI - Ministry of Agriculture

MINPAT - Ministry of Plan and Regional Development

FSSRP - Fertilizer Subsector Reform Program

TSC - Technical Supervisory Committee (of the FSSRP)

FAO - Food and Agriculture Organization of the United Nations

NWCA - North West Cooperative Association

UCCAO - Union Centrale des Cooperatives Agricoles de l'Ouest

IRA - Institut de la Recherche Agronomique

NCRE - National Cereals Research and Extension (USAID Project)

IRAT - Institut de Recherche de l'Agronomie Tropicale (French)

IRCT - Institut de Recherche du Coton et Textiles (French)

IRACHO - Institut de Recherche sur les Cultures Oleagineuses (French)

ORSTOM - Organisation pour la Recherche Scientifique et Technique Outre Mer (French)

MIDENO - Mission du Developpement du Nord Ouest

FED - European Development Fund

IFDC - International Fertilizer Development Center

NFRD - National Fertilizer Response Database

PDRPO - Rural Development Project, Western Plateau

TSP - Triple superphosphate fertilizer

DAP - Diammonium phosphate fertilizer

PREFACE

The Agricultural Marketing Improvement Strategies Project (AMIS), core-funded by the Agency for International Development's Bureau for Science and Technology, is a five-year project designed to assist USAID Missions and developing countries to:

* improve diagnosis of agricultural marketing system constraints, using rapid appraisal techniques,
* conduct in-depth analysis of specific marketing problems identified during rapid appraisal or by other studies,
* identify, design, and monitor appropriate marketing system innovations and improvements,
* build local capacity in both the public and private sector to do marketing systems analysis.

AMIS is also assisting AID/W and USAID Missions in planning new marketing initiatives and projects.

The rationale for the AMIS Project, which began operations in October 1987, was the realization that benefits from increases in agricultural production, often the result of successful AID or other donor-sponsored projects, frequently do not reach farmers and others in the marketing chain because of constraints or bottlenecks in marketing systems. Likewise, inefficient distribution systems for fertilizer and other inputs may result in late deliveries and high cost to farmers. These constraints may be technical, institutional or infrastructural, but they are often the result of government policies with disincentive effects -- policies that discourage private sector participation in marketing. Through analysis and active interventions, AMIS is promoting a better understanding and appreciation of the importance of marketing in the agricultural development process.

The prime contractor for the AMIS Project is Abt Associates, a Cambridge, Massachusetts-based policy research and economic analysis firm, operating through its Washington D.C. area office. Abt is assisted by two subcontractors: The Postharvest Institute for Perishables at the University of Idaho, a research and information center dedicated to improving postharvest handling and marketing of perishable crops, and Deloitte, Haskins & Sells, an accounting, management, and agricultural development consulting firm with special expertise in market liberalization studies.

INTRODUCTION

This report is one of a series devoted to the assessment and monitoring of the Fertilizer Sub-Sector Reform Program of Cameroon. Funded by USAID/Cameroon, the studies are being carried out by the Postharvest Institute for Perishables, University of Idaho, under the Agricultural Marketing Improvement Strategies Project (AMIS).

Previous reports include a first-year assessment of the program (June 1989) and the preliminary design of a monitoring and data collection system (May 1989).

The present report was prepared during a four-week period in July and August 1989 by Nicholas Minot, Agricultural Economist, and Jerry Johnson, Agronomist. It constitutes a follow-on to the second report mentioned above on a system for monitoring and data collection.

The report is divided into two main sections: Fertilizer Utilization Practices, carried out by the Agricultural Economist, and Fertilizer Crop Response Research, by the Agronomist. The following paragraphs describe the conduct of the work by each specialist.

Agricultural Economist

The terms of reference for the Agricultural Economist specified two principal tasks: 1) the preparation of a review of the available literature on the patterns of fertilizer use in Cameroon and 2) the design of several surveys on fertilizer use and the negotiation of research protocols with local institutions to implement these surveys. One survey would cover seven provinces, another the North West Province, and the third the West Province.

The first week and a half was spent in Yaounde collecting and reviewing secondary materials and in discussions with USAID officials. A draft questionnaire and outline protocol was prepared. The following week was spent in the field with Felix Nkonabang, the Ministry of Agriculture representative on the Technical Supervisory Committee of the FSSRP. Two days were spent in Bamenda, North West Province, and three days in Bafoussam, Foumbot, and Dschang in the West Province. The last six work days were spent in Yaounde, meeting with the Directorate of Statistics of the Ministry of Agriculture and finishing the literature review.

These efforts produced the following outputs:
- a review of the literature (Part One of the report)
- a fertilizer survey questionnaire (Appendix A)
- a series of research protocols for carrying out the provincial surveys (Appendix B).

The questionnaire covers coffee and maize production patterns, fertilizer use patterns, opinions regarding the fertilizer distribution system, the level of fertilizer knowledge, and reasons for not using fertilizer. The research protocols are draft agreements between the FSSRP

and the local institutions being contracted to implement the surveys. One protocol is with the Directorate of Statistics in the Ministry of Agriculture to carry out the seven-province survey. Another is with MIDENO to conduct the North West Province survey. The West Province survey involves two protocols: one with the PDRPO project to collect the data and another with the University Center at Dschang to do the data processing and report preparation.

Agronomist

The agronomist was asked to review existing fertilizer response data and identify gaps in understanding which could be addressed by agronomic trials (see Scope of Work in Appendix F). Of particular interest was the identification of potential opportunities for improving the efficiency of fertilizer use.

The agronomist was in Cameroon for one month (24 July to 25 August 1989) and the time was spent in three separate stages.

The first twelve days were spent in Yaounde in introductions and meetings with principal project participants in USAID, the Technical Supervisory Committee (TSC) of the FSSRP, and the Institute of Agronomy Research (IRA).

Eight days were consumed by field visits to Ekona, Bamenda, Bafoussam, Foumbot, and Dschang in the South West, North West, and West Provinces.

During the final ten days in Yaounde, a second round of meetings was held with USAID officials, TSC members, and IRA researchers to discuss observations and receive feedback on recommendations.

The reports from this work include a review of fertilizer research in Cameroon and a series of recommendations (Part Two of the report). Extensive technical appendices dealing with proposals for on-farm fertilizer trials, demonstrations, and creation of a national fertilizer database are also included.

EXECUTIVE SUMMARY

Aggregate fertilizer consumption in Cameroon was around 50,000 metric tons annually in the late 1960s and early 1970s during a FED-financed program to subsidize and promote its use. When it was terminated in 1972, fertilizer consumption fell to around 30,000 metric tons. The following year, the goverment of Cameroon began a similar program aimed at small farmers, particularly coffee growers. Over the next decade, total fertilizer consumption tripled to over 100,000 metric tons per year, 60% of which was subsidized. Among the five types of subsidized fertilizer, there has been a trend away from ammonium sulfate and toward the compound fertilizers (particularly NPK 20-10-10) and, to a lesser degree, urea. Of these five, only urea is commonly imported through unsubsidized channels, the others being relatively expensive sources of the major nutrients.

In the 1980s, studies by Elliot Berg Associates (1983a and 1983b) and by IFDC (1987) identified a number of problems with the fertilizer distribution system: unsustainable fiscal costs of the subsidy, late and unreliable fertilizer delivery, insufficient cost control, excessive use of inappropriate and costly types of fertilizer, and inefficient allocation of fertilizer. To address these problems, the government of Cameroon, supported by USAID, launched the Fertilizer Sub-Sector Reform Program (FSSRP) in 1988.

Fertilizer Utilization Practices

The use of fertilizer varies considerably among provinces. The West, the Littoral, and the three northern provinces represent three quarters of the total fertilizer consumption. The North West Province is also an important consumer of fertilizer. On the other hand, the South and Center Provinces together account for less than 2% of the national total. These differences are less due to the quantities used per farmer than by the number of farmers using fertilizer. Over half the farmers in the West, Littoral, and North West Provinces use fertilizer, while less than 2% of those in the South and Center Provinces do.

To a large degree, these patterns reflect the different crops grown in each province. Cotton, a crop fertilized by 90% of the growers, account for the bulk of the fertilizer use in the northern provinces. Coffee, fertilized by 53% of its producers, helps explain fertilizer use in the Littoral, West, and North West. In the West and North West, fertilizers are also used on food crops. Although nation-wide only 23% of farmers fertilize food crops, this figure varies considerably according to the crop. Maize, vegetables, and potatoes, particularly important in the West and North West Provinces, are probably the most frequently fertilized food crops.

By contrast, cocoa and root crops (other than potatoes), which are the important crops in the South and Center, are rarely fertilized. In the East and South West Provinces, where 10% of the farmers use fertilizer,

fertilizer use seems to be concentrated in pockets of coffee production (East and South West) and highland potato-growing areas (South West).

However, the differences in cropping patterns do not fully explain the differences in fertilizer use among provinces. Even for a given crop, the West, North West, and Littoral Provinces seem to have higher fertilization rates than elsewhere. This may be because greater use of fertilizer in a region helps establish supply lines which, in turn, facilitate fertilizer use among farmers who would not otherwise use it.

It is important to note that the use of fertilizer may vary greatly among farmers within a province. This could be due to differences in purchasing power, cropping patterns, distance to major roads, population density, or the effectiveness of local supply institutions such as cooperatives.

Recommended Research on Utilization Practices

Four topics for further research are identified. These represent types of information which are currently unavailable but would be useful for the operation and evaluation of the FSSRP. First, there is a need for more information on the patterns of food crop fertilization. Second, it is important to study the factors affecting the demand for fertilizer. Third, information is needed on the types of problems faced by farmers in obtaining fertilizer. And lastly, we need to get a clearer idea of the level of fertilizer knowledge among farmers.

To collect this information, a survey questionnaire was designed and a series of research protocols drafted to be used with Cameroon agencies who will carry out the survey work. These items are included in the appendix to this report.

Review of Fertilizer Response Research

The agronomist was asked to review all of the fertilizer research and identify opportunities for improving fertilizer use efficiency. However it was found that the data are spread throughout the country and often not in a form that would permit interpretation (see Bibliography references #4,5,7,8,9). Having worked for four years within IRA in northern Cameroon, the agronomist knew that much more fertilizer response data exists in the field than is ever reported. During the course of the literature review it became obvious that the wealth of unexploited data was not limited to northern Cameroon and that thousands of fertilizer trials have been conducted in the country (3). It also became obvious that efficient use of existing response data and results would require a concentrated effort to collect and analyse all of the outstanding data from throughout the country. This gave rise to the concept of a National Fertilizer Response Database (NFRD). Much of the agronomist's effort was dedicated to developing and perfecting this concept through exchange of ideas with USAID officials, members of the TSC, and research colleagues.

Recommendations for Research on Fertilizer Response

It has been suggested that the best approach to the problem of efficient fertilizer recommendations would be to conduct N-P-K response surface trials for coffee and food crops in the southern seven provinces of Cameroon. This approach implies a large and expensive on-farm testing program supported by soil fertility experts as well as a large staff of trained field agents, and a fully equipped and functioning soils laboratory. Precise recommendation domains required for improving fertilizer efficiency by a substantial margin would require a large number of trials. It seems questionable that the expected increase in fertilizer efficiency would justify the expense of a large number of N-P-K response trials.

Even if perfect recommendations could be established for the multitude of cropping systems and soils in southern Cameroon, there is no guarantee that the recommendations would be adopted by farmers. Trained personnel in research and extension to conduct, interpret, and report the results of a large number of on-farm N-P-K response surface trials simply do not exist and those that are available have many competing responsibilities.

It is generally recognized that one of the shortcomings of previous soil fertility research is that it was conducted on research stations and not under farmers' conditions -- for which the fertilizer recommendations were to be made. By common agreement, any new N-P-K response surface trials would have to be conducted in farmers' fields. However, the minimum number of plots for a complete N-P-K response surface trial, even without replication, is 27 plots (3N x 3P x 3K). This number of plots is far too many to be conducted by farmers and extension agents, thus they would have to be conducted by trained research technicians. One technician could not conduct more than two or three trials per year.

Even if such personnel were available, the effort and expense required to conduct, interpret, and report complete N-P-K response surface trials would consume the resources of the information gathering and monitoring network proposed for the FSSRP and cause this activity to exceed the boundaries of a supporting, complementary activity to the major project.

The proposals advanced as recommendations in this report are intended to circumvent the heavy expense, demanding requirements, and small improvements in efficiency that could be expected from complete N-P-K response surface trials. Simple nitrogen response trials are recommended within limited geographical areas for major cropping systems and where trained personnel already exist. Demonstrations are recommended to introduce farmers to forms of fertilizer known to be more efficient without experimentation. Areas of fertilizer research that would be mutually beneficial to IRA and FSSRP are outlined. An appropriate role for government agencies in this liberalized fertilizer distribution system is that of monitoring of the potentially deleterious effects of fertilizer on the chemical and physical properties of Cameroonian soils.

PART ONE: FERTILIZER UTILIZATION PRACTICES

1.0 INTRODUCTION

This section of the report provides a brief overview of the patterns of fertilizer use in the seven southern provinces of Cameroon. It is intended to provide background information for the implementation of the Fertilizer Sub-Sector Reform Program (FSSRP). The three northern provinces are not covered by the review because the FSSRP does not operate in that region.

Although by no means complete, the information available on fertilizer consumption in Cameroon is relatively abundant. Two major studies have looked at the fertilizer situation in the country: a report for the World Bank (Elliot Berg Assoc., 1983a and 1983b) and the International Fertilizer Development Center (IFDC) report for USAID (IFDC, 1986). In addition, the Agricultural Survey carried out by the Ministry of Agriculture on an annual basis since 1984 provides national and provincial estimates of fertilizer use. And finally, a number of farm-level surveys and studies have been carried out recently which shed light on patterns of fertilizer use in specific areas of the country. The results of these studies will be summarized below.

2.0 HISTORICAL TRENDS IN FERTILIZER USE

2.1 Aggregate Fertilizer Use

Estimates of annual fertilizer consumption are available from various sources: the U.S. Department of Agriculture, the Food and Agriculture Organization (FAO), FONADER, and the Ministry of Plan and Regional Development (MINPAT). Unfortunately, there is little agreement among these sources. For example, Berg notes that FAO figures for the late 1970s apparently exclude 30,000 mt of unsubsidized imports (Elliot Berg Assoc., 1983a). The table on the following page is compiled from MINPAT and the International Fertilizer Development Center (IFDC). The IFDC figures are based on a survey of fertilizer-using organizations, such as cooperatives, plantations, and agricultural projects.

From 1966 to 1971, a FED-financed program subsidized fertilizer and other inputs for small coffee and cotton farmers. At the same time, an FAO program supported a series of fertilizer trials and demonstrations. In 1972, the subsidies were suddenly eliminated, causing fertilizer consumption to drop from around 50,000 mt to close to 30,000 mt. In 1973, the Cameroon government reinstated the subsidies on fertilizer for small farmers, principally coffee growers. In the following decade, fertilizer consumption rose three-fold to over 100,000 mt. Much of this growth was due to the rapid expansion of subsidized fertilizer imports from 14,800 mt in 1974-75 to 65,300 mt ten years later. Subsidized fertilizer imports came to account for over 60% of the total (Elliot Berg Assoc., 1983a: 2; IFDC, 1986: 116).

TABLE 1: FERTILIZER CONSUMPTION IN CAMEROON, 1969-1984

Year	Quantity (mt)
1969-70	58,000
1970-71	53,190
1971-72	47,833
1972-73	30,796
1973-74	38,015
1974-75	50,176
1975-76	30,664
1976-77	55,405
1977-78	64,219
1978-79	68,671
1979-80	103,268
1980-81	85,692
1981-82	90,576
1982-83	116,423
1983-84	124,066
1984-85	105,056

Source: 1969-1979 MINPAT cited in E. Berg Assoc., 1983a.
1980-1985 IFDC, 1986: 120.

Note: MINPAT figures show 73,000 and 63,000 mt for 1980-81 and 1981-82, although estimates by both Elliot Berg Assoc. (1983a) and IFDC (1986) are higher.

Indeed, it was this very growth in demand for subsidized fertilizer, combined with the fiscal constraints of recent years, which made it impossible to sustain the fertilizer subsidies. As the amount of fertilizer which could be subsidized stagnated, the other distortions caused by the subsidies and public-sector control became more obvious. First, the fertilizer often arrived six to ten months late as a result of fiscal and administrative constraints. Second, the subsidies introduced a strong bias toward the five types of fertilizer included in the program, though they were not necessarily the lowest cost sources of nutrients. Third, cost control procedures for fertilizer importation were not very tight so that, for example, orders were placed for relatively small shipments which raised unit costs. And fourth, fertilizer was allocated administratively to selected cooperatives and projects involved in cash crop production, rather than allowing all farmers to decide whether its use would be profitable in their particular circumstances.

2.2 Types of Fertilizer Used

Five types of fertilizer are allowed under the subsidy program: NPK 20-10-10, NPK 12-06-20, NPK 10-30-10, ammonium sulfate, and urea. The relative importance of each type has varied over the life of the program. In the late

1970s, ammonium sulfate accounted for 50-70% of the total and compound (NPK) fertilizers the rest. However, the importance of ammonium sulfate has declined, reaching 27% in 1984 and 20% in 1988. At the same time, the use of urea has increased rapidly from zero before 1983 to 20% in 1988. The proportion of compound fertilizers has increased to around 60% (IFDC, 1986: 116 and Abt Assoc., 1989: 10).

The composition of unsubsidized fertilizer imports is quite different from that of subsidized fertilizer imports. Although recent figures are not available, the IFDC survey provides figures for the period 1980-84. Over those years, ammonium sulfate accounted for 3-8% of unsubsidized fertilizer consumption, while compound fertilizers generally represented 10-25%. The most common types of fertilizer were urea and potassium chloride, followed by di-ammonium phosphate (DAP) and rock phosphate (calculated from IFDC, 1986: 116, 120). All but DAP are single-nutrient fertilizers. In addition, all but rock phosphate are high-analysis fertilizers. Many observers believe that these concentrated fertilizers, generally less expensive per unit of nutrient, will become more widely used as the subsidies are removed from the five types mentioned above. This issue is discussed more fully in Section 5 of this report.

2.3 Fertilizer Use by Province

The IFDC survey provides some information on the distribution of fertilizer deliveries among the provinces. The proportions going to each province appear relatively stable, with the Littoral, the West, and the nothern provinces being the most important consumers. The most noticeable anomoly is that in 1984 the proportion going to the Littoral and to the northern provinces rose, while that to the West fell. The authors of the IFDC report compare their results (based on sales) and those of the Agricultural Survey (based on consumption) and note that there appear to be some sales in the Littoral which are resold and used in the West Province. They estimate the amount to be on the order of 6,000 to 12,000 mt (IFDC, 1986: 122).

TABLE 2: FERTILIZER SALES BY PROVINCE BY YEAR

	1980	1981	1982	1983	1984
West	27.2%	33.4%	23.3%	28.5%	19.9%
Littoral	27.1%	24.2%	33.2%	27.2%	34.7%
North West	6.5%	5.2%	8.9%	8.8%	4.5%
South West	7.8%	9.0%	7.2%	7.0%	7.9%
Center and South	0.8%	0.7%	0.9%	1.4%	0.9%
East	9.9%	8.4%	7.0%	7.1%	6.2%
North	20.7%	19.1%	19.5%	20.0%	25.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Calculated from IFDC, 1986: 123.

With regard to the provincial distribution of subsidized fertilizer, we can compare the 1984-85 IFDC figures with those of the first year of the Fertilizer Sub-Sector Reform Program (FSSRP), 1988-89. The most striking difference is that the subsidized fertilizer was more widely distributed among the provinces in 1984-85 than in 1988-89. This is probably due to the change in procedures under FSSRP which were not always understood by the cooperatives. Indeed, the second FSSRP campaign is an improvement in this regard; the number of participating provinces is increasing from three to five.

TABLE 3: SUBSIDIZED FERTILIZER SALES BY PROVINCE

	1979-80	1984-85	1988-89
West	36.9%	32.5%	55.6%
Littoral	40.6%	42.4%	33.3%
North West	14.6%	7.3%	11.1%
South West	2.9%	6.0%	0.0%
Center and South	1.0%	1.5%	0.0%
East	3.0%	2.2%	0.0%
North	0.0%	8.0%	-
Total	100.0%	100.0%	100.0%

Source: 1979-80 FONADER cited in Elliot Berg Assoc., 1983a: 9; 1984-85 IFDC, 1986: 123; 1988-89 Abt Assoc., 1989
Notes: The FSSRP does not cover the three northern provinces. For 1979-80, FONADER reports 1% for "Other."

3.0 CURRENT FERTILIZER USE PRACTICES

3.1 Fertilizer use by crop

The 1984 Agricultural Survey recorded the estimates of the number of farmers growing each crop and the number fertilizing a few specific crops: cotton, coffee, cocoa, and food crops. The results are summarized in the table below. These results indicate that among the major crops, cotton is the most frequently fertilized. Fully 90% of the cotton farmers, located exclusively in the northern provinces, use fertilizer (including manure).

In the southern seven provinces, coffee is the most frequently fertilized crop, this practice being followed by 53% of the growers. One might expect arabica coffee to be more often fertilized than robusta, since the former has a higher value and is grown in more densely populated areas. However, a comparison of provincial data reveals that this is not the case; fertilization rates for arabica are high in the West Province and relatively

low in the North West, while robusta fertilization rates are high in the Littoral but low in the East. These patterns are discussed more fully in section 3.2 below.

TABLE 4: PERCENTAGE OF FARMS GROWING DIFFERENT CROPS WHICH FERTILIZE THOSE CROPS

Crop	% of growers fertilizing
Cotton	90 %
Coffee	53 %
Cocoa	5 %
Food crops	23 %

Source: Ministere de l'Agriculture, 1987a: 37, 60.
Note: Includes both chemical and organic fertilizer.

In any case, coffee must represent the bulk of the demand for fertilizer in the southern seven provinces. In these provinces, the 1984 Agricultural Survey estimates that there are 255,000 farms using fertilizer (including manure) and that 201,000 of them use fertilizer on coffee.

At the same time, it is important to recognize that farmers have been losing interest in coffee production due to declining real farmgate prices and recent problems with coffee payments in some regions. Although this is difficult to document, it is a widely shared perception, and several studies of the costs of production have confirmed the declining profitability of coffee production relative to food production, particularly in the case of arabica coffee (Agland, 1988; Elliot Berg Assoc., 1983a; MIDENO, 1989b).

Cocoa, on the other hand, is very rarely fertilized in Cameroon. The data from the 1984 Agricultural Survey indicate that only 5% of the growers use fertilizer on cocoa in a given year. The dominant view among researchers seems to be that management and pest control are more important than fertilization. Indeed, a World Bank review of agricultural research in West Africa concluded that "trials indicate that substantial yield increases are obtained from fertilizer use, but this is partially offset by increases in black pod [disease] losses" (World Bank, 1987: 154).

With regard to food crops, the 1984 Agricultural Survey indicates that 23% of all farms use fertilizer on food crops. However, over half of the farms that fertilize food crops are found in the northern three provinces. If we exclude this region (not covered by FSSRP), the proportion of farmers that fertilize food crops drops to around 14%.

These averages should be interpreted with caution, however, since the percentage is likely to vary considerably from one food crop to the next. In particular, maize, Irish potatoes, vegetables, and, to a lesser degree,

bananas and plantains are more likely to be fertilized than sorghum, millet, and root crops other than potatoes. For example, the percentage of farms using fertilizer on food crops is higher in the West (34%) and North West (19%) where maize, potatoes, and vegetables are more important than in the Center Province (less than 2%) where cassava is a staple.

3.2 Fertilizer Use by Province

3.2.1 West Province

The West Province is without a doubt the premier fertilizer consuming province in Cameroon. This is true both in absolute terms, with the West representing almost 38% of the national demand, and in relative terms, with fully three-quarters of the farmers using chemical fertilizer. This is partly because the West is an important producer of coffee, maize, and potatoes, which respond well to fertilizer. Menoua and Bamboutos Divisions are the two most important arabica producing divisions in the country, accounting for 42% of Cameroon production. Likewise, Haut Nkam Division is the third largest robusta producer. Noun and Mifi are major maize producing divisions, while Menoua, Bamboutos, and Noun are all among the top five potato producing divisions (Ministere de l'Agriculture, 1987a: 84, 90, 112).

In addition to being a major producer of crops which are often fertilized, fertilizer use is greater in the West even for a given crop. As noted above, the Agricultural Survey figures show that almost 80% of the coffee growers in the West Province fertilize their crop, compared to 53% of coffee producers nation-wide. (Crop-specific fertilization percentages from the Agricultural Survey always refer to both chemical and organic fertilizer.) Similarly, 25% of the cocoa producers in the West Province fertilize their crop, yet the corresponding figure at the national level is only 5%. Around a third of the farms in the West fertilize their food crops, compared to 14% nation-wide, although this could be attributed to the importance of maize, potatoes, and vegetables in the West (Ministere de l'Agriculture, 1987a: 36, 60).

A number of studies carried out by the University Centre at Dschang shed light on the patterns of fertilizer use in the West Province. Dr. Nkwain Sama Joseph prepared a report on arabica coffee production in the Menoua Division (Sama, undated). Using the results of a survey of 165 arabica producers in twelve villages, Dr. Sama used multiple regression to estimate the coffee yields as a function of fertilizer use, the average age of the trees, and type of intercropping practiced.

Tree age and level of fertilization were found to have a significant relationship to yield. Each additional year of tree age was associated with a 0.1 sack per hectare reduction in yield. On the other hand, each additional sack of fertilizer applied was associated with an additional sack per hectare of harvested coffee (no distinction was made among types of fertilizer).

Given the fact that the value of a kilogram of coffee is still several

times greater than even the unsubsidized price of fertilizer, this would imply the continued profitability of fertilizer application. However, these results should be interpreted carefully since other variables were not controlled. For example, it seems probable that farmers using more fertilizer also followed more intensive practices (higher plant density, more weeding, etc.). Thus, the measured "effect" of fertilization may include the influence of these other unmeasured variables.

The same survey asked coffee growers why yields were so low. Fully 42% of the respondents blamed "inadequate fertilizer supply." Other reasons given were disease and pests (27%), the age of the trees (19%), and improper care (4%). Another study prepared at the university was that of Gockowski, Tchoumobe, and Ayissi (1988) based on the thesis of Tchoumobe. This report analyzed arabica coffee production in Mifi Division, relying on a survey of 80 growers carried out in early 1988. Almost all (96%) of the growers intercropped coffee with food crops, most often plantains, maize, and beans. In fact, 62% had at least four crops growing in association with the coffee trees.

With regard to fertilization, all but one (99%) in the sample used fertilizer. One third of the growers applied it once a year, while the other two thirds applied it twice a year. Three quarters of the quantity of fertilizer applied was NPK 20-10-10, but 80% also used organic fertilizer on their coffee stands. Based on the survey results, the authors estimate that fertilizer purchases represents the bulk of variable monetary costs, but only about 10% of the total costs of production. Fertilizer application represents 5% of the labor requirements or less than 3% of the total cost of production.

(Multiple regression analysis was used to estimate coffee production as a function of a number of variables, similar to the analysis in the previous study. Here, the number of days of labor input was highly significant. Levels of nitrogen and phosphorus, entered as separate variables, were not found to help explain the variation in coffee production. This result is probably due to the fact that the two variables are highly correlated with each other. This problem (multicollinearity) reduces the apparent significance of each variable. A solution would have been to exclude the phosphorus variable or combine the two into one "total nutrient" variable.)

A growing source of demand for fertilizer in the West Province is commercial vegetable production. The Noun Division and, to a lesser extent, Menoua Division seem to be the centers of vegetable production. Although the 1984 Agricultural Survey does not break down vegetable production by division, it does indicate that food crop sales represent 65% of agricultural sales, while the corresponding figures for the other divisions range from 8 to 48% (Ministere de l'Agriculture, 1987b: 46). In addition, Noun and Menoua are the principal commercial producers of Irish potatoes (Ministere de l'Agriculture, 1987b: 76).

In 1987-88, a survey of over 300 vegetable producers in the West Province was carried out by the Projet de Developpement Rural - Plateau Ouest (PDRPO) and the University Centre at Dschang (PDRPO, 1988). Although the

sample was not selected randomly, consisting of the home villages of participating university students, the results are nonetheless indicative. Irish potatoes and cabbage were the most commonly grown vegetables, followed by tomatoes, carrots, leeks, and lettuce. Almost three quarters of the sampled cabbage fields were fertilized, while two thirds of the potato fields and over half the tomato fields were fertilized. More impressive is the massive doses applied to these fields, as shown in the table below.

TABLE 5: FERTILIZER USE ON VEGETABLES IN WEST PROVINCE

Crop	Average nutrient application			% fields fertilized
	kg. N/ha	kg. P/ha.	kg. K/ha.	
Cabbage	530	242	249	74 %
Potatoes	367	162	166	67 %
Tomatoes	133	60	81	55 %

Source: PDRPO, 1988.

In interpreting these figures, it is important to keep in mind three points. First, these averages include the zero values of non-users, so that the averages among users would be higher. Second, they represent the quantities of nutrients applied, not fertilizer. For example, in order to reach 530 kilograms of nitrogen per hectare, a grower would have to apply 2,650 kilograms (53 bags) of NPK 20-10-10 per hectare. And third, although the figures are expressed on a per-hectare basis, actual vegetable plots tend to be much smaller than a hectare. Thus, it is more accurate to think of two bags being applied to a 20 by 20 meter plot than 53 bags being applied to a hectare.

It is interesting to note that these high fertilization rates are determined by the farmers themselves in light of their own experience, rather than being based on extension recommendations. Researchers at the Institut de Recherche Agricole at Foumbot say that they do not have any fertilizer recommendations for vegetable growers because so little research has been done in this area.

Another source of information on fertilizer use in the West Province is the village studies carried out as part of a 1983 fertilizer study done for the World Bank. Twelve students were sent to their own villages to describe fertilizer practices and the distribution system. Although no formal survey were undertaken, the impressionistic information collected is sometimes revealing. One student described his village in the Noun Division of the West Province. He reported that farmers had very high opinions of the value of fertilizer, and that it was used principally on coffee, maize, and groundnuts. He estimated that, although all farmers would like to use it, only about 40% were able to due to various problems. First, the cooperative had eliminated credit sales in 1981. In addition, the fertilizer often

arrived late or not at all (Elliot Berg Assoc., 1983b, Report 4).

As part of the same study, another student described the situation in his village in Nde Division. Similar problems existed in this division: the cooperative had recently abandonned credit sales due to unpaid debts and the fertilizer often arrived too late to be of use. Here, however, the student estimated that 80 to 90% of the farmers in the village used fertilizer (Elliot Berg Assoc., 1983b, Report 5).

3.2.2 Littoral Province

The Littoral is the second largest fertilizer consumer among the provinces of Cameroon, representing 19% of the national demand according to the 1984 Agricultural Survey. In addition, the percentage of Littoral farmers using chemical fertilizer (37%) is the second highest among the seven southern provinces. Unfortunately, fertilizer use in the Littoral is less well documented than in the West, North West, and even South West Provinces. This is related to the fact that the Littoral does not have an agricultural university (as the West does), nor an active regional development authority (as the North West does), nor a Testing and Liaison Unit of the Institut de Recherche Agricole (as the North West and South West do).

Thus, we are forced to glean information from the 1984 Agricultural Survey and one village study done as part of the 1983 World Bank fertilizer study. The Littoral Province stands out in the Agricultural Survey as a major producer of robusta coffee. Fully 55% of the farmers in the Littoral grow robusta coffee, and 38% of the cultivated land is devoted to this crop. Moungo Division is the largest robusta producing division in the country, accounting for 28% of the national production and almost all of the production in the Littoral (Ministere de l'Agriculture, 1987a: 60, 61, 90).

About 68% of the coffee growers in the Littoral use fertilizer (both chemical and organic), while the corresponding figure is 23% for cocoa and 8% for food crops. The coffee and cocoa figures are significantly higher than the national percentages for these crops. On the other hand, the food crop percentage is lower than the national average, probably due to the importance in the Littoral of root crops, which are generally not fertilized (Ministere de l'Agriculture, 1987a: 37, 60).

One unusual aspect of the Littoral is that among fertilizer users, the quantity consumed per farm is quite large. On average, fertilizer users in the Littoral apply 822 kilograms per farm, compared to the national average of 292 kilogram per farm. This is not the result of farm size, since farms in the Littoral tend to be somewhat smaller than average (Ministere de l'Agriculture, 1987a: 39).

Useful as the data from the 1984 Agricultural Survey is, it is important to keep in mind that it refers only to the "traditional sector," thus excluding plantation production. In many provinces, this exception is not worth noting, but in the Littoral rubber, oil palm, and banana plantations are an important part of the agricultural economy.

Since fertilizer purchased by the plantations are generally not subsidized, we can use unsubsidized fertilizer imports to estimate the demand by the plantation sector. The International Fertilizer Development Center estimates that, during the 1984-85 agricultural season, around 9,200 mt of unsubsidized fertilizer was used in the Littoral. This represented almost a quarter of the fertilizer consumption in the province and close to half of the unsubsidized fertilizer used in the southern seven provinces (IFDC, 1986: 123).

Of course, the correspondence between unsubsidized fertilizer distribution and the plantation sector is not perfect. Some farmers reportedly bought unsubsidized fertilizer in Douala in order to avoid the delays and quantity limitations that characterized the subsidized fertilizer system. Since Douala is in the Littoral, one would expect that the use of unsubsidized fertilizer by individual farmers would be greater in this province than elsewhere.

Indeed, this is confirmed, albeit anecdotically, by a village study done by one of the students involved in the 1983 World Bank fertilizer study. His village was located in Moungo Division, about 36 kilometers from Douala. The sources of fertilizer in this village were varied: SOCAPALM, FONADER, other farmers, or from people in Mbanga or Douala. He reports that "a fairly large proportion" of the farmers used fertilizer, mainly on oil palm, plantains, and, to a lesser degree, on coffee. On the other hand, fertilizers were "unknown" among the women who produce the food crops: cassava, taro root, and yams. Nonetheless, they did use green manure and legumes to maintain soil fertility (Elliot Berg Assoc., 1983b, Report 10).

3.2.3 North West Province

Fertilizer Use Levels

Among the seven southern provinces, the North West is the third most important fertilizer consumer. Around 37% of the farmers in the North West use chemical fertilizer, and the province constitutes 12% of the national demand. This is, in part, due to the importance of arabica coffee, maize, potato, and vegetable production in the North West. Around two thirds of the farms in the North West grow arabica coffee, accounting for about 45% of the national production. Virtually all farms in the province (99%) grow maize, representing 41% of the total output in Cameroon. Over 40% of the provinces farms produce potatoes, adding up to over 60% of the national potato harvest.

According to the 1984 Agricultural Survey, 48% of the coffee growers in the North West fertilize their crop, while 19% of the farmers fertilize one or more food crops (crop-specific figures from the Agricultural Survey refer to both chemical and organic fertilizer). Both of these percentages are close to the national averages (Ministere de l'Agriculture, 1987c). Surveys carried out by the Testing and Liaison Unit (TLU) at the Institut de Recherche Agricole (IRA) at Bambui and by the Mission de Developpement du Nord-Ouest (MIDENO) have produced similar results. The results of these

surveys will be discussed in order of crop, starting with coffee and proceding to maize and other food crops.

With regard to coffee fertilization, MIDENO carried out a survey of 110 members of the North West Cooperative Association (NWCA) in 1983. Over 60% of the coffee growers in the sample used chemical fertilizer and 10% reported the use of dung or coffee hullings as fertilizer. MIDENO compares this to 1972 Census figures in which only 14% of the North West coffee growers used chemical fertilizer, but 40% used dung or coffee hullings. At the same time, it should be noted that, because the 1983 survey included only cooperative members, it is not necessarily representative of the province as a whole (MIDENO, 1983).

According to the sampled coffee farmers, the average fertilizer application on coffee was 173 kg/ha of NPK 20-10-10 and 81 kg/ha of ammonium sulfate (including farms not using fertilizer). However, based on province-wide sales by NWCA, the authors of the report believe these figures are overstated. Their "adjusted estimates" are 92 kg/ha of NPK 20-10-10 and 75 kg/ha of ammonium sulfate. They note that these rates are considerably below the recommended rates of 300 kg/ha of NPK 20-10-10 for the first application and an equal dose for the second application.

Effect on Yields

Correlation analysis of the survey data revealed that 1) smaller farms have higher yields, 2) yields are significantly related to NPK 20-10-10 fertilizer use (although the relationship is not specified), and 3) fertilizer use is not related to farm size. Interestingly, yields were not related to ammonium sulfate use.

Intercropping

The MIDENO report also highlights the prevalence of intercropping coffee and food crops. Fully 99% of the coffee farmers in the sample intercropped coffee with banana/plantains, 54% with maize, 35% with beans, and 35% with kola, to mention only the four most common associated crops. In addition, several farms in the sample had both arabica and robusta trees (MIDENO, 1983).

Fertilizer Use Patterns on Coffee

The Testing and Liaison Unit of the Institut de Recherche Agricole at Bambui carried out a rapid rural appraisal survey of the Bui highlands. Although the emphasis was on maize cropping systems, the patterns of coffee fertilization were briefly described. The report states that men apply fertilizer in a ring around the stem of the tree, generally in September-October. The rates of application were generally low: less than 100 kg of NPK 20-10-10 per hectare (IRA, 1988-89: 23).

In 1989, MIDENO published the results of a coffee production survey carried out in 1987-88 (MIDENO, 1989b). There are several main points stressed in this report:

- Farmers are losing interest in coffee production as a result of lower producer prices, late payments, and the collapse of several production programs such as the young farmer program and the coffee regeneration program.

- This is reflected in the abandonment of coffee parcels, declining care for the coffee trees (mulching, weeding, etc.), and increased marketing of fertilizer outside NWCA (as high as 20%).

- At the same time, coffee farmers have greater access to inputs such as fertilizer and sprayers and are using them more frequently than in the past. This is attributed to MIDENO efforts to improve credit and access to inputs.

The study also provided some details on fertilizer use among coffee growers. A breakdown by type of fertilizer is given as follows:

TABLE 6: TYPE OF FERTILIZER USED BY NORTH WEST COFFEE GROWERS USING FERTILIZER

Type of fertilizer	Percentage of coffee growers
Compound (NPK) only	66 %
Ammonium sulfate only	9 %
Compound and ammonium sulfate	19 %
Other fertilizers	8 %

Source: MIDENO, 1989b: 9.

The average application rate was 204 kg/ha of NPK 20-10-10 and 27 kg/ha of ammonium sulfate (apparently, these averages include non-users). The report notes that this represents an increase in NPK 20-10-10 and a decrease in ammonium sulfate (SA) compared to the 1983 MIDENO survey (cited earlier). According to the authors, "the discrepancy in the rates for NPK and SA is better explained by the limited availability (supply) of SA during the 1987-88 crop season than by farmer preference" (MIDENO, 1989b: 9).

The distribution of NPK 20-10-10 fertilization rates among those using it are given as follows:

TABLE 7: DISTRIBUTION OF NPK 20-10-10 APPLICATION RATES AMONG NORTH WEST COFFEE GROWERS USING IT

NPK 20-10-10 application rate	% of fertilizer-using coffee growers
1 to 100 kg/ha	34 %
100 to 200 kg/ha	29 %
200 to 300 kg/ha	17 %
More than 300 kg/ha	20 %

Source: MIDENO, 1989b: 9.

In one table, the percentage of coffee farmers using fertilizer is given as 72% (MIDENO, 1989b: Annex I). Contradicting this is another table which indicates that 79% use NPK fertilizer and 25% use ammonium sulfate (MIDENO, 1989b: Annex II). However, if either of these percentages is representative of the North West Province as a whole, it would imply a significant increase in the frequency of fertilizer use among coffee growers. By comparison, the 1984 Agricultural Survey estimated that less than half of the North West coffee growers used fertilizers.

Fertilizer Use Patterns on Maize

The estimates of the proportion of maize farmers using fertilizer range between 12% and 29%. In 1982, the TLU carried out a pilot survey of 40 farmers and found that 22% of the maize farmers used fertilizer (IRA, 1983). Later that year, this figure was confirmed by the main survey of 330 farmers, of which 23% used fertilizer (IRA, 1984).

The 1983 MIDENO report refered to above also describes the results of a survey of 161 maize growers in the North West. Of this sample, only 12% used fertilizer on their maize fields. Yields among fertilizer users averaged 2.7 tons per hectare, compared to 1.8 tons per hectare among non-users (MIDENO, 1983).

During the 1987 agricultural season, the Testing and Liaison Unit (TLU) at IRA/Bambui carried out an intensive farm management study of maize-based cropping systems in the Ndop Plain of the Mezam Division, North West Province (IRA, 1988b). Twenty-four farmers, selected randomly from six of the thirteen villages on the Plain, were followed throughout the year and labor utilization monitored. The report notes that fertilizer use is limited by several factors: the fertilizer is often delivered late, farmers do not have access to fertilizer if they do not produce coffee or rice, farmers lack cash, and in many cases they are not familiar with the use of fertilizer on maize.

Nonetheless, 29% of the monitored maize fields received fertilizer.

Both NPK 20-10-10 and ammonium sulfate were used, with the average dose being 56 kg/ha of nitrogen, 23 kg/ha of phosphorus, and 23 kg/ha of potassium. The fertilizer was applied in a ring around each maize plant, normally in April (three to six weeks after planting). The labor input averaged 24 person-hours per hectare, of which 46% was done by the wife and 54% by the children. The other crops in the same field (groundnuts, beans, and cocoyams) were not fertilized (IRA, 1989b).

During the following year, the TLU at Bambui carried out a study of the maize-based cropping systems of the highlands of the Bui Division (IRA, 1988-89 and IRA, 1989). This study was based on 20 farms in five villages. In this area, maize is planted in March and harvested in September or October, later at higher altitudes. Both men and women apply NPK 20-10-10 fertilizer directly around the base of each maize plant during the second weeding in May. The authors note that previous surveys had indicated that 20-25% of maize farmers use fertilizer, but go on to report:

> However, the impression we got during the RRA [Rapid Rural Appraisal] was that a much greater proportion are now using fertilizer on maize. This is probably due to the increased emphasis placed on food-crops by the extension service of the PDA [Provincial Delegate of Agriculture] (IRA, 1988-89: 18).

On the other hand, they also report that:

> Fertilizer was generally unavailable to farmers in Bui in 1988 or only available from traders at exhorbitant prices (4000 FCFA/bag)... The rate of application varies directly with its availability and the farmer's means. Average rates, however, are very low, ranging from 50 to 100 kg per hectare (IRA, 1988-89: 18).

In 1989, MIDENO prepared an evaluation of the new extension system being developed in the North West Province, based on a survey of farmers in the affected region (MIDENO, 1989a). The maize extension message includes the application of at least 100 kg/ha of NPK 20-10-10. "Full adopters" were defined as farmers who adopted 75% of the message including the fertilizer recommendations. The survey results indicated that 23% of the farmers in the region surveyed were "full adopters."

Fertilizer Use Patterns on Other Crops

Less information is available about fertilization of other food crops in the North West Province. The 1983 MIDENO report included the results of a survey of 118 farmers growing beans. Of the sample, 12% used fertilizer, although the authors point out that a wording error in the questionnaire makes this figure somewhat suspect. Oddly, fertilizer use was associated with lower bean yields (MIDENO, 1983).

And finally, the TLU at IRA/Bambui carried out a survey in the rice development zone covering part of the North West Province and part of the West Province. The Upper Noun Valley Development Authority (UNVDA) is

promoting rice production among some 6500 farmers in the area. The survey of 150 rice producers revealed that almost all the growers use fertilizer on their rice fields. The average application levels were 206 kg/ha of NPK 20-10-10 and 225 kg/ha of ammonium sulfate. The fertilizer is sold to the farmers by the UNVDA (IRA, 1986).

3.2.4 South West Province

According to the 1984 Agricultural Survey, only 10.3% of the farms in the South West Province use chemical fertilizer. Furthermore, fertilizer use in this province accounts for less than 4% of the demand for fertilizer in Cameroon. Part of this is due to the fact that the dominant crops in the South West are generally not fertilized. The crops grown on over half of the farms in the South West include cocoyams/taro, maize, plantain/bananas, yams, cassava, cocoa, and robusta coffee. Even this list is misleading since maize represents only 3% of the cultivated area (Ministere de l'Agriculture, 1987a: 38, 60).

In looking at rates of fertilizer use (both chemical and organic) by crop, 9% of the cocoa farms are fertilized, somewhat higher than the national average of 5%. Only 21% of the coffee growing farms use fertilizer on that crop, and 12% of farms fertilize one or more food crops, the latter two figures being below the respective national averages. One explanation of this may be the low population density in the South West; the area planted per farm in this province is considerable greater than in any other province. Thus, increasing production may be more easily accomplished by expanding area than by applying fertilizer (Ministere de l'Agriculture, 1987a: 37, 58, 60).

The survey of fertilizer-using organizations carried out by the International Fertilizer Development Center (IFDC) in 1985 indicated that over half of the fertilizer used in the South West Province were not subsidized. Plantations no doubt represent a good portion of this, although there may also be individual buyers who are not members of a coffee cooperative (IFDC, 1986: 123).

The Testing and Liaison Unit (TLU) of the Institut de Recherche Agricole (IRA) in Ekona has carried out a series of farming systems surveys, one in each of the four divisions of the South West Province. These surveys confirm the low level of demand in the province. "Fertilizer supplies in local cooperatives are limited, but seldom exhausted due to extremely low demand" (IRA, 1989: 200). The TLU estimates, based on these surveys, that 9% of the farms have used fertilizer on a food crop and 12% have used manure. Maize and plantains are said to be the primary recipients of fertilizer. The following table summarizes fertilizer application rates by agro-climatic zone and by type of crop.

TABLE 8: FREQUENCY OF FERTILIZER USE IN THE SOUTH WEST BY AGRO-CLIMATIC ZONE AND CROP TYPE

Agro-climatic zone	Division(s)	Type of crop	% using fertilizer
Kumba Corridor	Meme, Ndian	Food crops	9 %
Lower Volcanic	Fako	Food crops	13 %
Mamfe	Manyu	Food crops	0 %
Sands	Fako, Meme	Food crops	1 %
Sands	Fako, Meme	Tree crops	4 %
Manyu highlands	Manyu	Food crops	32 %
Manyu highlands	Manyu	Tree crops	24 %
Volcanic mt. forest	Fako, Meme	Food crops	11 %
Granitic mt. forest	Ndian	Food crops	0 %

Source: IRA, 1989: 220-221.

The Manyu highland zone, bordering the North West Province and Nigeria, is the only one with more than 20% of the farmers using fertilizer. The food crops most often fertilized in the highlands were maize and potatoes, followed by cocoyams, carrots, garlic, and leeks. Except for the fertilization of cocoyams, this follows the patterns found elsewhere in Cameroon. The most common fertilizer was NPK 20-10-10, although there were some fertilizers and "anonymous powders" brought in from Nigeria. In the same Division but outside the highlands, fertilizers are rarely used. On the other hand, two thirds of the sample claimed they would buy fertilizer if it were available (IRA, forth-coming).

The survey in the Ndian Division involved 54 farmers. In this Division, perhaps the most remote and most sparsely populated in the province, "cash inputs to agriculture other than paid labor were almost non-existent". Some farmers complained about the lack of availability. Traders would occasionally bring small amounts of fertilizer or other chemicals to the area to sell at high prices. One farmer reportedly paid 1200 FCFA/kg for NPK 20-10-10 (IRA, forthcoming).

The report on the Meme Division was based on a sample of 120 farmers. Even in this centrally located division, only six farmers in the sample had used fertilizer on food crops, and two of them felt it had increased vegetative growth but reduced yield (the soil in this region was already high in nitrogen).

> There is much more present concern with crop protection against destruction than with initial yield improvement. Farmers are willing to pay for the former, but not the latter (IRA, 1987: 22).

The village study done as part of the World Bank fertilizer report

presents an even more extreme picture. In this village (the division is not identified), little effort is put into agriculture because of opportunities for hunting and fishing in the area. The cooperative structure is weak in this village because much of the coffee harvest is sold to "smugglers from Nigeria." Not only is fertilizer use non-existent, but there is very little knowledge about them.

> The majority of the farmers think that fertilizers and pesticides have the same usage; some believe they are the same product. None of these farmers has ever seen, much less had reason to use, fertilizers (Elliot Berg Assoc., 1983b, Report 7, p. 8).

3.2.5 Center, South, and East Provinces

The Center, South, and Eastern Provinces have the weakest demand for fertilizer among the seven southern provinces. These three provinces together account for one quarter of the farms and one quarter of the cultivated area, but less than 3% of the fertilizer use. Interestingly, the quantities applied per farm using fertilizer are similar to the national average. The difference is that so few farmers use fertilizer in the first place. The proportion of farmers in the East who use chemical fertilizer, 12%, is similar to that in the South West, but the Center and South Provinces have virtually no fertilizer users (less than 2% of all farmers in both cases).

The infrequency of fertilizer use appears to be a combination of 1) the predominance in these provinces of crops which are generally not fertilized, principally cocoa and root crops, and 2) the relatively low rates of fertilizer use for a given crop compared to the national averages. Table 9 illustrates the latter point. Only cocoa growers in the East Province use fertilizer more often than their counterparts elsewhere in Cameroon, and even here the difference is not large.

In the East Province, fertilizer seems to be almost exclusively used on robusta coffee production. Over half the growers in this province produce robusta; indeed, the Haut Nyong Division is the second largest robusta producer in the country. And among the coffee producers in the East, 37% use either chemical or organic fertilizer (Ministere de l'Agriculture, 1987a).

As part of the 1983 World Bank fertilizer study, a village study was done by a student in the Haut Nyong Division of the East Province. The student estimated that 95% of the robusta coffee farmers in the village used fertilizer. Compound fertilizers and ammonium sulfate were obtained through the ZAPI/Est project, in spite of some mistrust of the project officials by local farmers. The principal problems with the fertilizer distribution system were, once again, those of late delivery and insufficient supply. In addition, the student noted that little information was available about correct usage. Non-users believed that once the soil became "used to" fertilizer, it would no longer yield well without fertilizer (Elliot Berg Assoc., 1983b: Report 6).

TABLE 9: FREQUENCY OF FERTILIZER USE BY CROP IN THE EAST, CENTER, AND SOUTH PROVINCES

Crop	Province	% using fertilizers
Coffee	East	37 %
	Center	3 %
	Cameroon average	53 %
Cocoa	East	8 %
	Center	1 %
	South	* %
	Cameroon average	5 %
Food crops	East	8 %
	Center	2 %
	South	* %
	Cameroon average	14 %

* Less than 0.5 %
Source: Ministere de l'Agriculture, 1987a: 37, 60.

In the Center Province, coffee and maize represent less than 10% of the cultivated crop area. In addition, fertilization rates for specific crops are far below the national average. It is not clear why coffee and cocoa fertilization rates should be lower in the Center than in the East. If anything, one would expect the reverse given the greater distances from Douala to the East and given the lower population density in the East.

In 1987, the Testing and Liaison Unit at the Institut de Recherche Agricole (IRA) in Nkolbisson carried out a farming systems survey of 200 farmers in three areas of the Center Province: a savanah-forest transition zone, a forest zone off the main roads, and a forest zone on a main road. In the transition zone and the on-road forest zone, 8% of the sample used fertilizer. By contrast, only 2% of the off-road forest zone used fertilizer. This difference could be explained either by differential access to the main road or by local cropping intensity. The latter hypothesis is supported by the fact that, unlike the other two zones, none of the sampled farms in the off-road forest zone used less than two years of fallow between plantings (IRA, 1989: 262).

Two village studies were conducted in what is now the Center Province. One was done in the Mbam Division near Bafia. The student could not find "any trace" of current fertilizer use in the village. He attributes this to a lack of resources on the part of farmers and to their absence from local markets (Elliot Berg Assoc., 1983b, Report 9).

The second village study took place in the Lekie Division, just 30

kilometers from Yaounde. The student here reports highly positive attitudes regarding the value of fertilizer, but practically no use. At first, he attributes this to lack of supply, but he later observes that farmers do not try very hard to find fertilizer. A nearby village had SEPCAE fertilizer for food crops, but sales were very weak. He speculates that fertilizer is not attractive to farmers because long fallow periods are still possible in this area (Elliot Berg Assoc., 1983b: Report 2).

4.0 FURTHER RESEARCH

The data from the Agricultural Survey provide important information on the incidence of fertilizer use in different regions of the country, while the farms surveys carried out by the Testing and Liaison Units and various projects describe the role of fertilizer in the cropping system of specific regions. However, these sources do not provide information on four topics of importance to the operation and evaluation of the Fertilizer Sub-Sector Reform Program. These topics, discussed below, formed the basis for the design of a survey questionnaire (Appendix A) and research protocols (Appendix B).

Fertilization of food crops: Although information on fertilization of coffee is relatively abundant, less is known about the fertilization of food crops. It is generally accepted that maize represents a large share of fertilizer for food crops, but no province-wide figures are available. How many farmers fertilize maize? How important is vegetable and potato fertilization? How do food crop fertilization rates vary among the provinces? Such questions are important in determining the appropriate direction of fertilizer research and extension efforts.

Factors affecting the demand for fertilizer: In this review, the variation in fertilizer use among regions was explained primarily in terms of crop mix. However, it was noted that the effectiveness of local cooperatives, the distance to major roads, population density, and purchasing power need also to be considered. Little is known about the relative importance of each of these factors, yet the answer is important in determining the best way to improve the distribution system. Such information may also help identify pockets of unmet demand for fertilizer. (Appendix C describes the statistical procedures which could be used to estimate the relative importance of each factor using survey data.)

Identification of problems with fertilizer supply: Although impressionistic evidence is available, none of the available sources of information tell us how the fertilizer distribution is working at the farm level. Is the fertilizer arriving on time? Is it available in sufficient quantities? Are the right types of fertilizer available? And is credit a limiting factor? Such information would be very useful in fine-tuning the FSSRP and facilitating complementary efforts by related programs and projects.

Level of knowledge about fertilizers: It is important to know how much farmers know about fertilizer in order to tailor extension and promotion messages. In addition, there is disagreement on whether farmers have definite preferences among types of fertilizer or whether they simply buy what is available. This affects the cooperative purchasing policy, particularly with regard to the feasibility of influencing the composition of demand.

These topics, therefore, represent priority areas for investigation for survey data collection efforts organized by the FSSRP.

PART TWO: FERTILIZER CROP RESPONSE RESEARCH

5.0 REVIEW OF FERTILIZER RESEARCH IN CAMEROON

5.1 Introduction

The majority of fertilizer imported in the first year of the project was distributed by coffee cooperatives in the West, Northwest, and Littoral Provinces for use on coffee and associated food crops, especially maize. Second year fertilizer importations will include the Center and Southwest Provinces. Commercial plantation production of rubber, palm oil, and bananas are not affected by the FSSRP project and cocoa is generally not fertilized. Fertilizer importation in the three northern provinces (by cotton company) is not expected to be affected by the project in the near future. Consequently, this review of fertilizer research results will focus on coffee and food crops in the southern seven provinces of Cameroon.

USAID sponsored a study of the fertilizer sector in Cameroon that was completed by IFDC in 1986. The agronomic portion of the IFDC report included a set of fertilizer response surfaces for different crops in different parts of the country.

The response surfaces permitted fertilizer sector planners to estimate approximate national fertilizer needs under the hypothesis of eventual removal of fertilizer subsidies. The response surface approach to fertilizer study is attractive because, in theory, once the N-P-K response functions have been accurately derived it should not be necessary to conduct more trials until the overall soil characteristics have changed to such a degree that the response function specifying the relationships among crop responses to N, P, and K also changes. When the response functions for fertilization of the same crop in two different environments are significantly different, then agronomists can assert the existence of two different fertilizer recommendation domains. Economists can fit the most economical sources of N, P, and K fertilizer into the response function elements at prevailing prices for crop yield and tell planners the optimum rates of fertilization application and sources of fertilizer within each recommendation domain.

IFDC demonstrated this approach in francophone Africa in the late 1970's by conducting and analyzing on-farm N-P-K response surface trials in the millet-groundnut basin of Senegal. Fertilizer efficiency is maximized because farmers are only applying the type and quantity of fertilizer to the crop for which there is an economic benefit.

In reality, the application of this approach is more complicated. In the northern provinces of Cameroon the optimum rate of fertilization depends upon the year, thus rendering the predictability of a response function highly questionable unless it is derived from crop response data over many years. In southern Cameroon the optimum fertilization rate depends upon location (with the possible exception of nitrogen), meaning that two locations, possibly in close proximity to one another, can have very different response

functions. This makes it necessary to study the soil, climatic, and crop variables that determine the magnitude of the interaction in order to make recommendation domains that are agronomically and economically viable. IFDC attempted, in the Fertilizer Sector Report (10), to use secondary data (from previous trials) to generate response functions for the principal crops of Cameroon.

5.2 Coffee Fertilizer Research

The soils of western Cameroon (West, Northwest, Littoral, and Southwest provinces) are generally low in available phosphorus and exchangeable bases. They are generally high in exchangeable aluminum, and often underlaid with parent material that is even more acidic than the surface horizon which is moderately to highly acidic (2). Soil phosphorus is characteristically available for plant uptake within a relatively well-defined range of soil pH values (11). Coffee is generally tolerant to acidity and aluminum toxicity but is known to be susceptible to manganese toxicity (11).

Arabica coffee, grown on 121,000 ha in 1984 and often intercropped with food crops, has been shown to respond to nitrogen fertilizer in such a way that fertilization can be expected to be economically feasible even at unsubsidized fertilizer prices (10). Arabica coffee response to potassium fertilization in the IRA trials was shown to be dependent on location (6). There is a common belief among agronomists of western Cameroon that coffee needs potassium fertilizer applications for fruit formation at 3-4 years after establishment. No response to phosphate fertilization has been shown for arabica coffee (6).

Robusta coffee, grown on approximately 150,000 ha in 1984, has been shown to respond to nitrogen fertilizer and not to potassium and phosphate fertilization (10). The IFDC regression of fertilizer effects on robusta coffee yield, based on IRA trials conducted on research stations, indicated that nitrogen fertilizer application would probably not be economically feasible under unsubsidized fertilizer costs (10).

Fertilizer response research on coffee is difficult to conduct due to the length of time necessary to draw even preliminary conclusions. The IFDC regression is based on five trials conducted by IRA for four to ten years per trial (10,6). This database is insufficient to draw conclusions about the economics of coffee fertilization on a national scale due to the strong location interactions. It is, at best, only indicative of a probable response of unknown magnitude by coffee to nitrogen fertilizer on an unknown proportion of Cameroonian coffee lands. The IRA fertilizer response trials were conducted under station conditions in pure stands and outside the complex mixed cropping systems that characterize coffee production in Cameroon (6). Arabica coffee trees in actual production are significantly older than the trees that were the objects of these experiments (10). A valid response function should be based upon trials conducted under conditions reflecting the highly variable landscape where coffee is grown in Cameroon.

Coffee cooperatives have been the largest consumers of fertilizer in Cameroon under the FSSRP (1). The majority of the fertilizer used has been a compound fertilizer containing significant proportions of potassium and phosphorus (1). In the event that there is no agronomic response to phosphate and potassium fertilization, a major opportunity to increase the efficiency of fertilizer use in Cameroon would be to eliminate generalized application of compound fertilizer and recommend applications of nitrogen fertilizer only.

Significant amounts of ammonium sulfate have been used on coffee plantations (10). It has only 1/2 the amount of nitrogen per unit fertilizer as urea. Without subsidies it will be considerably more expensive than urea for each unit of nitrogen delivered to the crop. More importantly, ammonium sulfate requires 5-6 kg of lime to neutralize one kg of nitrogen whereas only 1-2 kg of lime are required to neutralize one kg of nitrogen applied as urea (11). Acid-tolerant coffee trees may not have manifested the effects of increasing soil acidity yet. No lime has been applied to soils that have been subjected to long term ammonium sulfate application and soil pH values in these soils can be expected to be exceedingly low.

5.3 Maize and Other Food Crop Fertilizer Research

Maize is an important food crop in all the southern provinces with which the FSSRP is concerned. It is cropped in association with other crops and accounted for approximately 15% of the total fertilizer used in Cameroon in 1984 (10).

5.3.1 The FAO Fertilizer Program in Cameroon

From 1967 through 1973 the FAO and the Ministry of Agriculture collaborated to conduct over 700 fertilizer trials and 4000 fertilizer demonstrations on nine different food crops encompassing most of the country (3). Maize response trials in the southern province of Cameroon accounted for approximately one-third of the trials and demonstrations (3). In all provinces and on all soils except the recent volcanic soils of the Southwest Province, there was a strong response to nitrogen fertilizer that yielded returns on investment ranging from 330% to 1900% (3). Phosphate (and in some cases potassium) increased the rate of return to fertilizer investment for certain soils in all provinces (3).

Significant increases in yield were obtained by fertilization of cocoyams with N, P, and K in the Southwest, Center, and South Provinces (3). Fertilization of yams with nitrogen alone or N-P-K (around Mbam) was highly beneficial (3). The N-P-K formula 75-75-75 was found most economical on potatoes in the West and the Northwest Provinces (3). For bananas and plantains in the Littoral, Center, and South Provinces, 600 kg/ha of 12-6-20 was the recommended fertilizer rate after demonstrations had been conducted (3). Trials were also conducted on peanuts, cotton, rice, and sorghum (3).

The FAO trials were conducted and analyzed as comparisons of different

combinations of N-P-K and not as response surfaces. Consequently, the rates of fertilization recommended from the trials and demonstrations are probably erroneous. Without the raw data it is would be difficult to use the FAO report to compute optimal rates as a function of different economic hypotheses.

The fertilizers used from 1967 through 1972 for trials, demonstrations, and pilot fertilizer sales were ammonium sulfate, single super phosphate, and potassium chlorate (3). Compound fertilizers were imported after trial results showed economic response to more than one nutrient for many different crops (3). The price of fertilizer was very low through the early 1970's and fertilizer efficiency was not as important as the creation of a demand for fertilizers by demonstrations of the effects of N-P-K application to crops.

The effects of the FAO fertilizer program are still apparent in the western provinces of Cameroon. The demand for ammonium sulfate in coffee and vegetable cooperatives can be attributed, at least in part, to the familiarity of farmers with this fertilizer by comparison with more economical and less-acidifying urea. The compound fertilizers introduced by this program, especially 20-10-10, are still the favored fertilizer by the FSSRP clients. Many of the rates of fertilizer recommended by the FAO program are still being reiterated by the extension service though they may now be uneconomical recommendations.

5.3.2 The IFDC Report on Maize Fertilizer Response

The IFDC response function for maize fertilization in the southern provinces of Cameroon is based on six factorial experiments conducted on research stations that included different levels of N, P, and K (10). Response to nitrogen and phosphorus was indicated in all cases and a significant nitrogen/phosphorus interaction existed in one trial (10).

The number of trials used to derive the response functions is exceedingly low and research station conditions are likely to indicate optimum levels of fertilization that are much higher than optimum levels derived from experiments conducted under farmers' conditions. Indeed, the regression functions derived by IFDC for two experiments indicate that maize yield without fertilizer would exceed five tons per hectare (10)! Again, these results can only be considered indicative of a probable response of maize to nitrogen and phosphorus fertilization. The magnitude of the response implied by the response function is therefore illusory.

5.3.3 NCRE and MIDENO Fertilizer Research

The NCRE project has conducted a large number of station and on-farm trials of maize response to fertilizer since 1985 in the Northwest, West, Center, and Southwest Provinces (4,5,7,8,9). MIDENO (Mission du Developpement du Nord Ouest) has also conducted fertilizer trials on maize at seven training and demonstration centers in the Northwest Province (13). Some conclusions can be drawn from these trials despite the fact that many of

the experiments have measured maize response to a single compound fertilizer. This approach confounds the effects of the three macronutrients and does not lend itself to response surface analysis. Nitrogen and phosphorus response trials have been conducted in two divisions of the Northwest Province by the Bambui TLU. Some of the more interesting fertility trials concerning residue management, leguminous cover crop association, use of rock phosphate, response to lime and phosphate, and response to micronutrients have been conducted on research stations. It is uncertain if the results obtained from these trials would apply to the predominant soil conditions in the Northwest and West Provinces.

Some general observations drawn from NCRE fertilizer experimentation from 1984-1988 (4,5,7,8,9) are as follows:

1) The agronomic response of maize to nitrogen fertilizer is sufficiently strong and generalized that nitrogen application will probably be economically feasible even under non-subsidized prices.

2) Maize responses to phosphorus, lime, and the nitrogen x phosphorus interactions are highly dependent on location though seemingly independent of year.

3) Urea appears to be the most economical nitrogen fertilizer source but requires incorporation at the time of application to be efficient. Super granule urea is as effective as prilled urea and may be preferred by farmers due to ease of application and incorporation.

4) Triple super phosphate is the most economical phosphate fertilizer due to the high concentration of phosphorus in TSP compared to alternative sources that contain half as much phosphorus per unit weight. Soil sample data has not been used to identify areas where rock phosphate containing CaO (both a liming agent and source of calcium) would be equally effective as triple super phosphate in supplying crop phosphorus needs. Rock phosphate from Togo has been the sole source of rock phosphate tested to date and may be contaminated with aluminum. Use of rock phosphate contaminated with aluminum would exacerbate the general problem of aluminum toxicity for maize production. Other sources of rock phosphate from West Africa that have higher amounts of soluble phosphate and lower contamination with aluminum need to be tested. Soil samples have not been used to determine areas where single super phosphate containing sulfur would be more economical than triple super phosphate. Locations that can be expected to respond economically to phosphate application have not been characterized within the maize cropping system. The long term effects of TSP need to be compared to those of single super phosphate in light of the growing problem of increasing soil acidity.

5) Very few trials have demonstrated agronomic or economic response to potassium though many trials have demonstrated economic response to the compound fertilizer, 20-10-10, containing potassium. Locations responding to potassium fertilizer applications have not been characterized.

6) Like potassium, calcium and sulfur responses can be expected to be location dependent. No work has been done to characterize locations that can be expected to provide economical response to calcium and sulfur applications.

7) There is a general preoccupation among researchers in the Southwest and Northwest provinces concerning decreasing soil fertility on crop land characterized by decreasing, if not disappearing, fallow periods. The soil parameters that characterize decreasing soil fertility in these provinces have not been determined.

8) A recent survey in several divisions in the Southwest province conducted by the TLU (Testing and Liaison Unit) of the NCRE project shows that the majority of food crop production is done by women and very few women use fertilizer (personal communication, Dr. Susan Almy). Women are not an object of extension effort and if they do attend meetings, they do not participate. This issue needs to be examined in other parts of the country and, where appropriate, fertilizer demonstrations need to be conducted with female collaborators. Food crop fertilizer distribution may be improved in areas where cultivation is done by women by being aimed at markets used by women instead of traditional marketing through markets used by men. Fertilizer marketing in Nigeria apparently involves the sale of sacks of fertilizer in local markets that are labelled according to the crop for which it is intended, such as "yam fertilizer". If food production is carried out by women independently of the rest of the household, then cost-of-production studies and cash availability need to be focussed on those portions of the budget controlled by women and not on the entire household production budget.

9) The addition of economic analyses to agronomic analysis of fertilizer response would be facilitated by the generation of response surfaces instead of a factorial analysis approach. Economic analyses can be very beneficial in determining appropriate fertilizer recommendation domains.

6.0 RECOMMENDATIONS

6.1 The National Fertilizer Response Database

6.1.1 Introduction

Fertilizer is one of the most important and manageable inputs for improving crop production in Cameroon. Due to its importance and the importance of proper management for soil fertility improvement and optimum economic returns, fertilizer response and management has attracted the attention of all agronomists working on commercial and food crop improvement in Cameroon since the beginning of agronomic research. Hundreds of

fertilizer response trials have been conducted in Cameroon that have focused on the following aspects of fertilizer use:

1) Yield response to plant nutrients (N,P,K,S,Ca,B..,) and to compound fertilizers (20-10-10, 15-15-15, etc.).

2) Best source of fertilizer element (e.g. comparative response of plant to triple super phosphate, single super phosphate, or rock phosphate as sources of phosphate fertilizer).

3) Optimum rate of fertilizer application for single nutrients or compound fertilizers.

4) Optimum time and method of application for different crops.

5) Interaction of fertilizer response with other factors (e.g. variety, plant density, tillage practice).

6) Non-fertilizer alternatives to maintaining soil fertility or complementing fertilizer application (e.g. rotation with legumes or manure application).

6.1.2 The Problem

Despite the large number of trials that have been conducted it is still not possible to answer, with an acceptable degree of precision, basic extension and farmer questions concerning the optimum fertilizer recommendation for a specific crop in a specific part of the country. A partial list of the reasons why trial data have not been effectively translated into fertilizer recommendation domains follows.

1) Many trials have been conducted on research stations that are not representative of the farmers' conditions to which the results might be applied.

2) Many fertilizers studied have been compound fertilizers that confound the effects of nitrogen, phosphorus, and potassium.

3) There is a lack of uniformity in trial observations. Soil sampling depths vary for the same crop in different trials. Soil sample parameters requested in soil analyses differ across research programs. Soil testing procedures differ for different soils laboratories. Yields are calculated differently by different research programs. Additional crop observations which influence crop response to fertilizer, such as plant density, degree of pest attack, and preceding crops on test site, are made differently by different research programs. Soil and environmental variables like rainfall,temperature, soil depth, soil type, and parent material are often not recorded.

4) There is a lack of rigor in data analysis, interpretation, and reporting. Field agronomists provide annual accounts of research

activities that usually do not include a complete analysis of yield data with soil sample results. Many agronomists know how to conduct factorial fertilizer trials but few know how, or have the time and computing capacity, to use the results to develop fertilizer recommendation domains. National, regional, and international documentation is rarely reviewed before design and implementation of fertilizer response trials. Since complete analyses of trial data and soil sample data are rare, trial designs and observations are incompatible with the objective of fertilizer recommendation domains. Trial results are not compared to similar results obtained elsewhere in the country or in similar environments in Africa. Trial results are not interpreted in relation to soil classification units derived from soil mapping studies that have been conducted throughout large parts of Cameroon (Annex II).

5) High turnover of expatriates of differing competence, nationality, and approach to soil fertility who have sponsored and conducted fertilizer response trials in Cameroon. Until recently, few trained Cameroonian counterparts were available to participate in data analysis and interpretation.

6.1.3 Objectives

It is proposed that the FSSRP collect, copy, analyse, and interpret all existing fertilizer response data in Cameroon. The objectives would be to:

1) Make available to multiple users (research, agriculture extension, education, donors, and private investors), through the Technical Supervisory Committee of FSSRP, a database of all fertilizer response trials and descriptions of the conditions under which the trials were conducted.

2) Provide copies of the database to the research centers where the data was collected at the time of data entry. Provide copies of the database to a supervising committee within IRA and to the TSC of the FSSRP before data analysis and interpretation.

3) Collate and classify response data by geographical region and cropping system for analysis and interpretation in such a form that raw data as well as the interpretation would be available to users.

4) Establish minimum requirements for present and future fertilizer response trials for soil sampling techniques, analysis procedures, environmental variable measurements, and forms of reporting that would permit future response trials to be easily incorporated into the national fertilizer response database.

5) Demonstrate how fertilizer response surface analyses including soil sampling, soil mapping, and enviromental measurements can be used to make fertilizer recommendation domains that are useful to researchers, extension agencies, and national planners.

6) Create the capacity for on-going data entry, analysis, and interpretation of the national fertilizer response database within the National Soils Center of IRA.

Details on sources of response data, proposed organization of the NFRD, and soils maps are included in Appendix D.

6.2 On-Farm Fertilizer Response Trials

The objective of the proposed trials is to improve fertilizer use efficiency in two provinces of western Cameroon that presently account for the majority of imported fertilizer. This is to be done by development of fertilizer recommendations for different cropping systems and different soil and climatic zones that are most likely to provide the highest return on fertilizer investment to the farmer -- in an economic environment characterized by increasing fertilizer costs, decreasing commodity prices, and increasing pressure on agricultural lands.

In addition, this activity and others under the FSSRP are designed to aid the Government of Cameroon to redefine the appropriate role of government in a privatized fertilizer sub-sector. The on-farm testing activity is designed to aid the adaptive research unit in the Northwest to build the institutional capacity to conduct and interpret on-farm tests that serve dual purposes as research and demonstration plots. It is hoped that collaboration with the University Center at Dschang will provide the opportunity for students within the Department of Agriculture to develop appropriate skills in the realm of soil science, natural resource management, and applied agronomy. Finally, the methodology developed for on-farm testing of fertilizers in two provinces can be adapted for use in other provinces, under different cropping systems and for solution of different soil fertility problems.

Details regarding first year activities, test conditions, observations and data collection, and data analysis appear in Appendix E.

6.3 Farmer Demonstrations

6.3.1 Need for Demonstrations

With the removal of fertilizer subsidies, it appears likely that urea and triple super phosphate (TSP) will become the most economical forms of nitrogen and phosphorus fertilization. Both fertilizers are less well-known to farmers of the southern provinces of Cameroon than ammonium sulfate and 20-10-10. It is uncertain whether farmers are using ammonium sulfate and and 20-10-10 in preference to urea because it is their preference or because these are the fertilizers ordered by the cooperatives. It may be that the FAO fertilizer program demonstrations conducted from 1966-1973 influenced farmers and cooperative leaders and induced the demand for ammonium sulfate

and the compound fertilizer, 20-10-10. In any case, it is recommended that demonstrations be conducted to familiarize farmers with the use of urea and TSP on food crops, especially maize.

6.3.2 Recommended Procedures

It is expected that the demonstrations would be conducted by the provincial delegations of agriculture in the seven southern provinces of Cameroon. M. Felix Nkonabang, member of the TSC and director of extension within the national agriculture extension agency, will coordinate the demonstrations. The required amounts of urea and TSP will be purchased by the project.

The demonstrations would comprise three treatments:

1) No fertilizer

2) Nitrogen as urea at 60 kg N/ha

3) Nitrogen as urea at 60 kg N/ha and phosphate as TSP at 30 kg P205/ha

The demonstration would be superimposed on farmers' fields of maize in the first year and the fertilizer would be applied to 20m by 10m plots at 20-30 days after planting. Urea (and phosphate) would be incorporated in a circle band around each plant in the respective plot. Extension agents would be trained to compute the amount of fertilizer required per plant to maintain the above fertilizer treatment rates across fields of different plant densities. Commonly found containers like matchbox units could be graduated to guarantee application of approximately correct rates for varying plant densities. For example, if 375 to 425 maize plants were found in a 20m x 10m plot, then seven grams of urea or one common unit would be applied to each plant in the plot receiving urea only. The plot requiring TSP would receive one-half of a common unit per plant. No attempt would be made to measure yields but relative yields would be estimated by the extension agent. More weight would be placed on the observations made by the person cultivating the maize to decide if additional yield was obtained by urea or by urea and phosphate together. Constraints to the use of urea and TSP would be identified and the demonstration treatments in the second year could be adjusted as a function of the feedback from the first year.

It should be explained to farmers that the rates of fertilizer use employed in the demonstrations are not those expected to be optimal for all farmers. After the results of the on-farm tests, fertilizers and rates will be adjusted to reflect recommendations based on the analyses of response data.

It is expected that three hundred demonstrations could be conducted in the first year and over 1000 in the second year. The fertilizer required in the first year would be:

Urea -- 300 demonstration x 2 plots x 0.02 ha x 133 kg urea/ha
= 1600 kg or about two tons of urea
TSP -- 500 kg

6.3.3 Planning Requirements

The fertilizer should be delivered to the Department of Agriculture as soon as possible after the first of the year and professional trainers with the Ministry need to begin elaboration of instructions for agents and training well before the beginning of the growing season.

M. Nkonabong, or his designee, will submit a report of first year demonstration activities in October 1990 accompanied by a proposal for second year demonstrations. Use of different rates based on on-farm test results where tests have been conducted or other fertilizers or use of fertilizer on other crops would be considered in the second year. The organization and implementation of a large number of demonstrations is an onerous task requiring at least one year of experience to iron out the difficulties.

Despite the expected low cost of this activity, the effects of a large number of well-conducted demonstrations could have a significant effect on the demand for fertilizer.

6.4 Fertilizer Research Interface with IRA/NCRE

The results of the NCRE project evaluation clearly indicate soil fertility research as a problem area needing improvement within IRA and the NCRE project. The future direction of soil fertility research under NCRE is uncertain and the issues under consideration are larger than those with which the FSSRP is concerned. After discussion with researchers, project officers, and project administrators, several opportunities for collaboration and complementarity of effort seem obvious.

6.4.1 NCRE Participation in the NFRD

Cooperation, participation, even contribution to the data collection, analysis, and interpretation of the NFRD would benefit both the NCRE and the NFRD effort.

NCRE and IITA could take advantage of the data collection effort at each NCRE agronomy and TLU post to assist researchers to review soil fertility research results and make summaries of research on specific fertility themes that concern NCRE directly and only concern the NFRD indirectly. To this end, Dr. Mario Rodriguez, maize agronomist and soil fertility expert from IITA headquarters might want to accompany/follow the IFDC team throughout the country to work with individual research programs.

6.4.2 TLU involvement in FSSRP activities.

Each of the TLUs contacted -- Ekona, Bambui, and Nkolbisson -- has different approaches to the problem of soil fertility and the relative importance of fertilizer research in their larger mandate for applied food crop systems research and extension. Consequently, the on-farm trial suggested in this report may or may not comply with their needs and means. The older TLU at Bambui has undertaken nitrogen x phosphorus response trials in two divisions and is constantly consulted by the adaptive research unit of MIDENO. Given the capacity of MIDENO to conduct on-farm research, it seems feasible for the Agronomy and TLU sections of NCRE at Bambui to undertake research on more fundamental problems of soil fertility in the maize-based farming systems. Description of the sources of variability of soil acidity (soil surface, profile, and time) and aluminum levels would be a contribution to station work being conducted on liming while preparing the ground for future on-farm testing themes concerning liming and/or response to sulfur, calcium, and magnesium fertilization. The economic feasibility of super granule urea determined by on-farm trials would also be a contribution to promising fertilizer technology research.

The agronomist at the TLU in Ekona was interested in the FSSRP design for response to nitrogen and phosphate. If the TLU undertook these trials then the soil sample analysis could be financed by FSSRP and similar analysis could be undertaken. The TLU agronomists could also improve/refine the analyses suggested by FSSRP and should review results from MIDENO and Dschang.

The TLU in Nkolbisson has undertaken some work on farmer involvement in research design and execution. If fertilizer research were to become a priority for the TLU or for other TLUs competent to work directly with farmers, their collaboration would be invaluable. The questions that farmers might have about fertilizer use in complex cropping systems may be different than those assumed by researchers. Farmers normally have considerable traditional knowledge of land use groups that could be the most practical way to form useful recommendation domains. Farmer involvement in fertilizer research may be a means of tapping this traditional knowledge of soil-plant interactions.

All of the TLUs should be encouraged by the FSSRP to observe and comment on fertilizer demonstrations of urea and triple super phosphate to be conducted under FSSRP. The TLUs should be informed of FSSRP activities throughout the year and FSSRP representatives should attend the annual research meetings to understand on-going research and assess the potential for collaboration.

6.4.3 Soil Laboratory Support

One recommendation of the NCRE evaluation is to update and support the soils laboratory at Nkolbisson. It is expected that many more soil analyses will be done in Cameroon in the future and that the soil laboratory capacity will be insufficient to meet that demand. Soil sample analysis is an

integral part of the FSSRP on-farm fertilizer testing program. Due to the proximity of NCRE and the Nkolbisson soils laboratory, it would seem logical that NCRE support this laboratory. Some work is necessary to obtain correct analytical procedures for soil fertility research.

The NCRE agronomists could work with the TLUs and the adaptive research units to calibrate commercially available soil test kit results to response data and soil analyses in the soils laboratory. If soil test kits could be calibrated to indicate recommendation domains for fertilizer use then their use could be demonstrated to extension agents and used widely throughout the West and Northwest Provinces.

6.4.4 Training in Soil Fertility

Soil fertility is a discipline that has been neglected to date. With so much attention now being focussed on fertilizer response and soil fertility, it is evident that there is little local expertise on this subject. Crop agronomists and soil chemists have been trained, but there is a need for training of soil fertility experts in combining crop response, soil map information, and soil analysis results to make statistically sound fertilizer (or soil fertility) recommendation domains. The future of the NFRD will depend upon local expertise to update and maintain the database for multiple users. Long-term graduate training is necessary to provide for this need. As pointed out by one of the NCRE researchers, "We don't need a soil fertility expert in a laboratory or in an office in Yaounde. We need him/her out here with us in the field."

6.5 Soil Ecology

6.5.1 The Problem

Researchers in the Southwest, Northwest, and West Provinces of Cameroon are concerned about the larger question of sustainable soil fertility. Fallow periods in cropping rotations are disappearing as the population increases and increasing production pressure is applied to lands of increasing fragility. Land use patterns in the Northwest and West have changed significantly in the last 23 years since the FAO published "The Soils and Ecology of Western Cameroon". These changes indicate that farming is moving out of the relative stable valley soils onto the hillsides and hilltops of the Northwest and West Provinces with greater potentials for soil acidification and soil erosion.

The traditional grazing lands of this mountainous terrain have been replaced by complex cropping systems of maize, coffee, raffia, bananas and plantains, and vegetables. Tree species have given way to tin roofs that dot the horizon as far as the eye can see in much of the West Province and part of the Northwest Province. Many of the new agricultural lands are underlain by parent material that is about one pH level more acidic than the surface horizon (2). The subsoils are being exposed at a rapid rate by erosion due

to cultivation of hillsides. The NCRE maize breeder for this region, concerned about the large amount of variability within his breeding plots, found that aluminum saturation was over 50% at two of his testing sites. As he states, "It is a wonder there is any growth at all!"

It is no coincidence that these two provinces are the largest consumers of fertilizer in Cameroon. Large amounts of ammonium sulfate have been used in the past to maintain crop yields on coffee-maize farms. Increasing soil acidification and aluminum saturation may be the reason that the economic return on investment of one kg of nitrogen fertilizer has fallen from over 1000% (3) to less than 250% in the last 20 years (10). Replacing ammonium sulfate with urea may decrease the speed at which soil acidification occurs but will not diminish the inevitability of acidification. This is especially true for those fragile sloping soils where fertilizer is used to maintain nitrogen fertility but are subjected to high rates of soil erosion, leaching, and loss of organic matter. Traditional fallow periods and grazing systems no longer exist to buffer soil deterioration.

The agricultural research system is under economic and social pressure to produce results that can be implemented as quickly as possible to increase agricultural production. They cannot be expected to devote portions of scarce financial and human resources to the study of long term soil ecology problems. They can, and have already begun to, investigate organic alternatives to chemical fertilization to maintain soil fertility and crop yields. Alley cropping, legume intercropping, legume fallow, and response to lime are being studied. Acid-tolerant maize breeding is being undertaken and maize responses to micronutrient applications are being charted. The efforts to find economically viable short-to-medium term solutions to crop production in this environment should be congratulated and encouraged.

The enormity and dynamics of the problem of soil destruction are such that it is unlikely that they can be dealt with by the existing agronomy research stucture. These people are struggling to maintain production-oriented research needed to meet the immediate needs of a rapidly growing population in an economic environment that is pushing Cameroon faster toward the group of low-income countries.

6.5.2 Suggested Approach

What can be done? What should be done? No one seems to have even a suggestion. Much debate has been centered around the responsibility of USAID to address this problem through the FSSRP. One of the purposes of providing project funds in the FSSRP was to help the Cameroonian government define the appropriate role for government in a privatized fertilizer system. Given the fact that the U.S. fertilizer industry is itself coming under greater and greater environmental scrutiny, it seems appropriate to propose some alternatives to environmental damage by fertilizers under this USAID-sponsored program in Cameroon.

It is proposed for consideration and discussion that project and FSSRP program funds be used to endow a chair for soil ecology within the soils

department of the University Center at Dschang. Modest, but sufficient funds need to be provided to staff the position, equip a laboratory, provide local and international travel, and provide research funds for long term research in Cameroonian soil ecology. It is expected that the professor of soil ecology would teach, supervise graduate students, and conduct research on soil ecology. It may be staffed by an expatriate until suitable Cameroonian candidates could be trained and hired.

The research program would quantify and document the evolution and dynamics of changes in soil chemical and physical properties within Cameroonian agricultural lands. Methods for monitoring changes in soil ecology would be established and implemented. The long term objective of the research program would be to design and test syctems of improving soil fertility by biological, physical, and chemical means that are compatible with Cameroonian needs for sustainable agricultural production.

APPENDICES

APPENDIX A

SURVEY ON FERTILIZER USE

General characteristics of the household

1) How many people live in your household? | | persons

2) How much area does your farm cover? | | hectares

3) How much of that area is currently cultivated? | | %

What crops did you harvest last year?
Was it for home consumption, for sale, or for both?
(circle appropriate number)

	Don't produce	Do produce the crop for: Home cons.	Sale	Both
4) Coffee	0		2	
5) Cocoa	0		2	
6) Oil palm	0	1	2	3
7) Cassava	0	1	2	3
8) Plantain/banana	0	1	2	3
9) Irish potatoes	0	1	2	3
10) Yams/cocoyams/taro	0	1	2	3
11) Maize	0	1	2	3
12) Sorghum/millet	0	1	2	3
13) Beans	0	1	2	3
14) Groundnuts	0	1	2	3
Others (specify)	0	1	2	3
15) _____ 16)	0	1	2	3
17) _____ 18)	0	1	2	3

Do you keep any of the following animals?

19) Cattle	0-No	1-Yes
20) Goats	0-No	1-Yes
21) Pigs	0-No	1-Yes
22) Fowl	0-No	1-Yes

Does your household work in any of the following professions?

23) Trading (buying and reselling)	0-No	1-Yes
24) Artisanry (tailoring, repair, etc.)	0-No	1-Yes
25) Agricultural wage-labor	0-No	1-Yes
26) Other wage-labor	0-No	1-Yes

27) Other (specify) _____

Do you own any of the following items?

28) Radio	0-No	1-Yes
29) Bicycle	0-No	1-Yes
30) Motorcycle	0-No	1-Yes

How many years of schooling do you have?

31) Husband [ ] years 32) Wife [ ] years

32a) Are you a member of a coffee cooperative? 0-No 1-Yes

Coffee production

33) Did you harvest coffee last year? 0-No 1-Yes
(If no, skip to Maize Production; if yes, continue)

34) What kind of coffee trees do you have?
1-Robusta
2-Arabica
3-Both

35) How many trees do you have? [ ] trees

36) What is the distance between trees? [ ] meters

37) What is the distance between rows? [ ] meters

38) Did you intercrop another crop with the coffee?
0-No 1-Yes

39) How many sacks did you harvest last year? [ ] sacks

40) Who did you sell the coffee to?
1-Cooperative
2-Coffee processor
3-Merchant
4-Other (specify) _____

41) What month did you deliver the coffee harvest? [ ]

42) When did you receive the first payment for the coffee?
1-Immediately
2-Within a week of delivery
3-Between one and four weeks
4-Between one and three months
5-Longer than three months
6-Not yet

43) When did you receive the final payment for the coffee?
1-Within a week of delivery
2-Between one and four weeks
3-Between one and three months
4-Longer than three months
5-Not yet

Maize production

44) Did you produce maize last year? 0-No 1-Yes
(If no, skip to Fertilizer Use; if yes, continue)

45) What kind of maize seed did you use?
1-Improved
2-Traditional
3-Both

46) Where did you obtain the maize seed?
1-Cooperative
2-Credit Program
3-Ministry of Agriculture
4-Merchant
5-Another farmer
6-Saved from own harvest

47) Did you intercrop maize with other crops?
0-No 1-Yes

48) How much maize did you harvest? | | | |
quantity unit

49) Did you sell any of the maize? 0-No 1-Yes
(If no, skip to Fertilizer Use; if yes, continue)

50) What proportion of the harvest was sold?
1-Only a little
2-About half
3-Over half

51) How was the maize sold?
1-Through a cooperative
2-At a market place
3-To a merchant
4-To another farmer
5-Other (specify) _____

52) What price did you receive for the maize sold?
| | | |
value unit

Fertilizer use

53) Have you used fertilizer in the past five years?
0-No 1-Yes

(If no, skip to Non-user of Fertilizer; if yes, continue)

54) How often do you use fertilizer?
1-Rarely
2-About every two years
3-Every year

55) How far do you have to go to buy fertilizer? [ ] kilometers

56) Did you use fertilizer last year?
0-No 1-Yes
(If no, skip to Recent Fertilizer User; if yes, continue)

Current Fertilizer User

57) What is the best type of fertilizer for your farm?
1-Ammonium sulfate
2-Urea
3-NPK 20-10-10
4-NPK 12-06-20
5-NPK 10-30-10
6-Other (specify) _____
7-No preference

58) What is the second best type of fertilizer for your farm?
1-Ammonium sulfate
2-Urea
3-NPK 20-10-10
4-NPK 12-06-20
5-NPK 10-30-10
6-Other (specify) _____
7-No preference

For each type of fertilizer, answer the following questions:

	Ammonium sulfate	Urea	20-10-10	12-06-20	10-30-10	59)_____
How many bags of fertilizer did you use?	60	61	62	63	64	65
What was the price per bag?	66	67	68	69	70	71
What month did you buy it?	72	73	74	75	76	77
What month did you put it on the fields?	78	79	80	81	82	83

On which crop(s) did you use fertilizer? (mark with X)

	Ammonium sulfate	Urea	20-10-10	12-06-20	10-30-10	59)_____
Arabica	84	85	86	87	88	89
Robusta	90	91	92	93	94	95
Maize	96	97	98	99	100	101
Potatoes	102	103	104	105	106	107
108) Other _____	109	110	111	112	113	114

How did you put on the fields?
(check those that apply)?

115) Scattered	0-No	1-Yes
116) Along line	0-No	1-Yes
117) Around each plant	0-No	1-Yes
118) Between plants	0-No	1-Yes

119) Was the fertilizer mixed into the soil? 0-No 1-Yes

120) Where did you buy your fertilizer?
1-Through a cooperative
2-From a merchant
3-From a project
4-From another farmer
5-Other _____
6-More than one source

121) How did you buy the fertilizer?
1-In cash
2-On credit
3-Part cash, part credit

122) Were you allowed to buy as much fertilizer as you wanted at the going price?
0-No 1-Yes
(If yes, skip next question)

123) If not, why not:
1-Limitation on the quantity of fertilizer available
2-Limitation based on amount of coffee sold
3-Limitation of the amount of credit available

124) Was the fertilizer available on time?
0-No 1-Yes

(If yes, skip next question)

125) If not, what month would you like it to be available? | |

126) Were the types of fertilizer you wanted to buy available?
0-No 1-Yes
(If yes, skip next question)

127) If not, what types of fertilizer did you want that were not available?
1-NPK 20-10-10
2-NPK 10-30-10
3-Urea
4-Ammonium sulfate
5-Other (specify) _____
6-Other (specify) _____

128) Was the quality of the fertilizer good?
0-No 1-Yes
(If yes, skip next question)

129) If not, what was the problem:
1-Bags were ripped
2-Fertilizer was clumped together
3-Other (specify) _____

(continue to Recent Fertilizer User)

Recent fertilizer user

130) Do you use more or less fertilizer than you used to before 1988?
1-More than before
2-Less than before
3-About same amount as before

131) What do you think of fertilizer distribution now compared to before 1988?
1-Much better now
2-Somewhat better now
3-About the same as before
4-Somewhat better before
5-Much better before

In what way has fertilizer distribution gotten better (check those that apply)?

132) You are allowed to buy more fertilizer now 0-No 1-Yes
133) The fertilizer arrives more on time now 0-No 1-Yes
134) More types of fertilizer are available now 0-No 1-Yes
135) The fertilizer is less expensive now 0-No 1-Yes
136) The quality of the fertilizer is better now 0-No 1-Yes
137) Credit for fertilizer is more available now 0-No 1-Yes
138) Fertilizer is now sold closer to your farm 0-No 1-Yes
139) Other _____
140) It hasn't gotten better in any way 0-No 1-Yes

In what way has fertilizer distribution gotten worse (check those that apply)?

141) You aren't allowed to buy as much as before 0-No 1-Yes
142) The fertilizer arrives later than it used to 0-No 1-Yes
143) Fewer types of fertilizer are available now 0-No 1-Yes
144) The fertilizer is more expensive now 0-No 1-Yes
145) Credit for fertilizer has become less available 0-No 1-Yes
146) The quality of the fertilizer has gotten worse 0-No 1-Yes
147) It is necessary to go further to buy fertilizer 0-No 1-Yes
148) Other _____
149) It hasn't gotten worse in any way 0-No 1-Yes

Non-user of Fertilizer

150) Do you believe fertilizer will increase yields on your farm?
0-No 1-Yes
(If yes, skip next question)

151) If it doesn't increase yields, why not?
1-Fertilizer has little effect due to poor soils
2-Fertilizer has little effect due to good soils
3-Crops grown do not respond to fertilizer
4-Other _____
(Skip to Q # 155)

152) Do you believe fertilizer is worth the cost and risk?
0-No 1-Yes
(If yes, skip next question)

153) If it isn't worth it, why not?
1-Crop prices are too low
2-Payment for crop is not certain
3-Fertilizer price is too high
4-Risk of crop failure is too high
5-Other _____
(Skip to Q # 155)

154) If fertilizer increases yield and is worth the cost, then why don't you buy fertilizer?
1-Can't buy on credit
2-Can buy on credit, but don't want to borrow
3-Fertilizer arrives too late to use
4-Fertilizer is not sold near by
5-Can't buy the right type of fertilizer
(If answer is "lack of resources", give choice of first two)

155) Do you know where you can buy fertilizer?
0-No 1-Yes
(If no, skip to Fertilizer Knowledge)

156) If so, how far away is it? | | kilometers

Fertilizer Knowledge

157) What is your most important source of information on correct use of fertilizer?
1-Cooperative
2-Extension agent
3-Other farmers
4-Merchant
5-Radio
6-Own experience with fertilizer
7-Other _____
8-No source of information on fertilizer use

158) Have you been visited by an extension agent in the last 12 months?
0-No 1-Yes
(If no, skip next question)

159) If so, how many times? | | times in 12 months

160) Which fertilizer has the most nitrogen?
1-NPK 20-10-10
2-NPK 10-30-10
3-Urea
4-Ammonium sulfate
5-Don't know

161) Which fertilizer works better if it is covered by soil?
1-NPK 20-10-10
2-NPK 10-30-10
3-Urea
4-Ammonium sulfate
5-Don't know

162) Which fertilizer can make the soil more acidic?
1-NPK 20-10-10
2-NPK 10-30-10
3-Urea
4-Ammonium sulfate
5-Don't know

163) Do you use any agricultural chemicals to kill weeds, insects, or diseases?
0-No 1-Yes
(If no, skip to Pesticide/herbicide Non-user; if yes, continue)

Pesticides/herbicide user

What kinds of chemicals do you use?
164) Chemicals to kill insects and other pests 0-No 1-Yes
165) Chemicals to kill weeds and diseases 0-No 1-Yes

166) Do you know the names of the chemicals?
0-No 1-Yes
(If no, skip next question)

What are the name(s) of the chemicals?
167) _____
168) _____

Are there any problems in getting these chemicals?
(choose those that apply)
169) Not enough is available for sale 0-No 1-Yes
170) The chemical arrives late 0-No 1-Yes
171) Sometimes it isn't available 0-No 1-Yes
172) You want a chemical that isn't now available 0-No 1-Yes
173) There isn't any credit available 0-No 1-Yes
174) They are sold too far away 0-No 1-Yes
175) Other (specify) _____

Pesticide/herbicide non-user

Why don't you use these products?
(choose those that apply)
176) The crops you grow don't need them 0-No 1-Yes
177) They aren't worth the cost 0-No 1-Yes
178) They arrive too late to use 0-No 1-Yes
179) They are rarely or never available 0-No 1-Yes
180) There is no credit available for them 0-No 1-Yes
181) They are sold too far away 0-No 1-Yes
182) Other (specify) _____

APPENDIX B

RESEARCH PROTOCOLS

B.1 RESEARCH PROTOCOL FOR NORTH WEST PROVINCE FERTILIZER SURVEY

Summary information

Name of the survey:	North West Province Fertilizer Survey
Contracting institution:	Fertilizer Sub-Sector Reform Program
Contracted institution:	Mission de Developpement au Nord-Ouest (MIDENO)
Province:	North West
Principal investigator:	NIBA Fidelis
Title/position:	Director of Project Evaluation and Monitoring (PEM) at MIDENO
Other investigators:	James Muwang, PEM Officer Mike Sabum, PEM Officer

Calender of events

	From	To
Training enumerators	Oct. 16	Oct. 17
Pilot survey and revisions	Oct. 18	Oct. 20
Survey data collection	Oct. 23	Nov. 3
Data entry and cleaning	Nov. 6	Nov. 16
Analysis and report prepration	Nov. 16	Nov. 30
Preliminary report	Nov. 30	
Final report	Dec. 20	

Questionnaire

The questionnaire will be provided by USAID. The phrasing of questions and answers can be modified according to the experience gained in the pilot survey. The final version of the questionnaire should be authorized by USAID before the main survey is begun.

Pilot survey

A pilot survey will be undertaken to train the enumerators, establish procedures, and identify problems. Problem questions or answers can be rephrased if need be. The sample size of the pilot survey should be at least 15% of the sample size of the main survey.

Data collection methodology

Universe: The universe will be the agricultural population of the North West Province.

Sample size: The sample size will be 100 households.

Sampling: The primary sampling unit will be the "Segment", a group of households selected for the Agricultural Survey. In the North West Province, there are 67 segments of 5 to 7 households each. Of these, 25 segments will be chosen at random. Within each segment, four households will be chosen at random. The remaining 1 to 3 households in the segment will serve at backup households, in the event that one of the four is absent or declines to participate.

Enumerators: There will be approximately ten enumerators.

Collection: Each enumerator will do three interviews per day. With 100 households and 10 enumerators, this makes less than four days of interviews. However, 10 work days are planned for data collection, allowing time to find the segments and to re-interview in the event of errors or omissions in filling out the questionnaire. The three researchers will devote full-time to supervision of the data collection, each one using a driver and vehicle.

Data entry, cleaning, and analysis:

Data entry: Data entry will be carried out by a data entry clerk who used to work for MIDENO. He will be hired for two weeks. The original data entry should take around 10 days, but corrections will probably need to be made afterwards.

Tabulation: A data analyst will be hired to do the tabulation of the data. The tables to be produced are described in Annex B.

Computer: One of two available computers will used for the data entry and tabulation: either an IBM XT with two disk drives, a 30 Mb hard drive, and 640 K or an IBM PS/30 with two disk drives, a 20-Mb hard drive, and 640 K. The software to be used is USP, User-friendly Statistical Package, one which they have used often.

Reporting requirements to USAID

A brief (2-3 page) progress report will be provided to the FSSRP one month from the beginning of the survey. This will probably correspond to the end of the data entry. The report will describe the progress and problems with the survey.

Final products of the survey

A document will be delivered to the Comite Technique de Supervision of the FSSRP in French or English including 1) an executive summary at the beginning, 2) a table of contents with headings and sub-headings, 3) the body which contains tables and their interpretation, and 4) an annex briefly describing the methodology. Other annexes may be added if needed. In order to standardize among surveys, a specified format will be followed (see Annex C).
In addition, a brief report (4-8 pages single-spaced) will be provided which explains any problems with the questionnaire (problems questions etc.), the sample, the methodology, or the analysis. This report can be a revised and expanded version of the one-month progress report.

And finally, copies of the complete data files are to be made available to USAID. The files should be in ASCII or Lotus 123 format.

Budget and allowable expenses

USAID will pay the entire amount of the grant whether or not expenses were as much as budgeted. The contractor will perform the all specified work, whether or not the expenses exceed budget. Half of the grant will be paid at the beginning of the survey and the other half upon completion of the final report. In addition, USAID will pay a 10% bonus if the preliminary report is completed by December 5.

Allowable budget items include the costs of per diem, fuel, minor repairs, office supplies, reproduction of documents, and other minor supplies. It will not cover the costs of equipment (vehicles, motorcycles, computers, etc.), nor the salaries of people who are already under salary. Enumerators and/or data entry people may be hired.

BUDGET FOR NORTH WEST FERTILIZER SURVEY

ITEM	Number	Units	Price	Total
Per diem				
Researchers				
3 x 17 nights	51	nights	15,000	765,000
Drivers				
3 x 17 nights	51	nights	5,000	255,000
Enumerators				
10 x 1 month	10	months	10,000	100,000
Fuel				
50 l/day x 3 veh. x 15 days	2250	liters	282	634,500
Maintenance	3	vehicles	75,000	225,000
Data entry clerk	15	days		35,000
Data analyst				50,000
Office supplies				200,000
Photocopying	800	pages	100	80,000
Unexpected (10%)				234,450
SUBTOTAL				2,578,950
Bonus if work completed on time and meets requirements (10 %)				257,895
TOTAL				2,836,845

BASIC TABLES TO BE PRODUCED FROM FERTILIZER SURVEY

1. Single-variable tables

The mean of each continuous variable in the questionnaire should be reported, as well as the frequency distribution of each discrete variable collected. For the core survey, this makes around 33 frequency distributions, 20 percentages, and 15 means. Other tables such as frequency distributions for continuous variables may be added as seems appropriate. More detail on single-variable tables is provided on page 65.

2. Two-variable tables

The two-variable tables should be selected for having interesting or surprising results. The tables should also be designed with the number of observations in mind. A given percentage or average should not be based on fewer than 15 households, preferable more. The following themes should be covered:

Type of fertilizer	BY fertilizer practices and sources
Type of fertilizer	BY crop fertilized
Use/non-use of fertilizer	BY household characteristics
Use/non-use of fertilizer	BY agricultural characteristics
Use/non-use of fertilizer	BY yield of fertilized crops
Use/non-use of fertilizer	BY length of delay in coffee payments
Knowledge of fertilizer	BY household characteristics
Knowledge of fertilizer	BY agricultural characteristics
Knowledge of fertilizer	BY extension visits
Evaluation of system	BY household characteristics
Evaluation of system	BY agricultural characteristics
Agricul. characteristics	BY region
Household characteristics	BY region
Fertilizer practices	BY region

FORMAT OF FINAL REPORT

In order to standardize the format, the following system of headings will be used:

	1. SECTION HEADING
1.1	Major heading
1.1.1	Heading
	Minor heading

The margins will be approximately one inch on all sides. The text will be single-spaced with paragraphs separated by a blank line. Indentation will be used only for the major heading, heading, and minor heading. For ease of reading, the paragraphs to be at least 5-6 lines long, but not more than 20 lines long. The text should give highlights and explanation of tables, at least mentioning each one, but not listing large numbers of figures already available in the table.

B.2 RESEARCH PROTOCOL FOR WESTERN PROVINCE FERTILIZER SURVEY DATA COLLECTION

Summary information

Name of the survey:	West Province Fertilizer Survey - Data collection phase
Contracting institution:	Fertilizer Sub-Sector Reform Program
Contracted institution:	Projet de Developpement Rural - Plateau Ouest (PDRPO)
Province:	West
Principal investigator:	SOFFO Gilbert
Title/position:	Ing. Agronome, Cellule de Suivi, PDRPO/UCCAO

Calender of events

	From	To
Training enumerators	Oct. 16	Oct. 18
Pilot survey and revisions	Oct. 19	Oct. 20
Survey data collection	Oct. 23	Nov. 13

Questionnaire

The questionnaire will be provided by USAID. The phrasing of questions and answers can be modified according to the experience gained in the pilot survey. The final version of the questionnaire should be authorized by USAID before the main survey is begun.

Pilot survey

A pilot survey will be undertaken to train the enumerators, establish procedures, and identify problems. Problem questions or answers can be rephrased if need be. The sample size of the pilot survey should be at least 15% of the sample size of the main survey. Researchers from the university may participate in this phase of the survey, although the PDRPO is alone responsable for supervision of the data collection.

Data collection methodology

Universe: The universe will be the agricultural population of the Western Province.

Sample size: The sample size will be 100 households.

Sampling: The primary sampling unit will be the "Segment", a group households selected for the Agricultural Survey. In the Western Province, there are xx segments of 5 to 7 households each. Of these, 25 segments will be chosen at random. Within each segment, four households will be chosen at random. The remaining 1 to 3 households in the segment will serve at

backup households, in the event that one of the four is absent or declines to participate.

Enumerators: There will be approximately four enumerators.

Collection: Each enumerator will do three interviews per day. With 100 households and 4 enumerators, this makes around eight days of interviews. However, 16 work days are planned for data collection, allowing time to find the segments and to re-interview in the event of errors or omissions in filling out the questionnaire. The researcher will devote full-time to supervision of the data collection.

Data entry, cleaning, and analysis:

Data entry, analysis, and preparation of the report will be carried out by the Department of Agricultural Economics and Rural Education of the University Centre at Dschang. PDRPO is only responsable for providing the questionnaires to the researchers at the university.

Budget and allowable expenses

The FSSRP will pay the entire amount of the grant whether or not expenses were as much as budgeted. The contractor will perform the all specified work, whether or not the expenses exceed budget. Half of the grant will be paid at the beginning of the survey and the other half upon completion of the data collection. In addition, USAID will pay a 10% bonus if the data collection is completed by November 16.

Allowable budget items include the costs of per diem, fuel, minor repairs, office supplies, reproduction of documents, and other minor supplies. It will not cover the costs of equipment (vehicles, motorcycles, computers, etc.), nor the salaries of people who are already under salary. Enumerators and/or data entry people may be hired.

BUDGET FOR WEST PROVINCE FERTILIZER SURVEY DATA COLLECTION

ITEM	Number	Units	Price	Total
Per diem				
Researchers				
1 x 4 nights	4	nights	9,000	36,000
Drivers				
1 x 4 nights	4	nights	500	2,000
Enumerators				
4 x 8 nights	32	nights	500	16,000
Enumerator salaries				
4 x 21 days x 8 hours	672	hours	232	155,904
Fuel				
12 l/day x 4 moto x 16 days	768	liters	282	216,576
30 l/day x 1 veh. x 16 days	480	liters	282	135,360
Office supplies				19,050
Unexpected (10%)				58,089
SUBTOTAL				638,979
Bonus if work completed on time and meets requirements (10 %)				63,898
TOTAL				702,877

BASIC TABLES TO BE PRODUCED FROM FERTILIZER SURVEY

1. Single-variable tables

The mean of each continuous variable in the questionnaire should be reported, as well as the frequency distribution of each discrete variable collected. For the core survey, this makes around 33 frequency distributions, 20 percentages, and 15 means. Other tables such as frequency distributions for continuous variables may be added as seems appropriate. More detail on single-variable tables is provided on page 65.

2. Two-variable tables

The two-variable tables should be selected for having interesting or surprising results. The tables should also be designed with the number of observations in mind. A given percentage or average should not be based on fewer than 15 households, preferable more. The following themes should be covered:

Type of fertilizer	BY fertilizer practices and sources
Type of fertilizer	BY crop fertilized
Use/non-use of fertilizer	BY household characteristics
Use/non-use of fertilizer	BY agricultural characteristics
Use/non-use of fertilizer	BY yield of fertilized crops
Use/non-use of fertilizer	BY length of delay in coffee payments
Knowledge of fertilizer	BY household characteristics
Knowledge of fertilizer	BY agricultural characteristics
Knowledge of fertilizer	BY extension visits
Evaluation of system	BY household characteristics
Evaluation of system	BY agricultural characteristics
Agricul. characteristics	BY region
Household characteristics	BY region
Fertilizer practices	BY region

FORMAT OF FINAL REPORT

In order to standardize the format, the following system of headings will be used:

	1. SECTION HEADING
1.1	Major heading
1.1.1	Heading
	Minor heading

The margins will be approximately one inch on all sides. The text will be single-spaced with paragraphs separated by a blank line. Indentation will be used only for the major heading, heading, and minor heading. For ease of reading, the paragraphs to be at least 5-6 lines long, but not more than 20 lines long. The text should give highlights and explanation of tables, at least mentioning each one, but not listing large numbers of figures already available in the table.

B.3 RESEARCH PROTOCOL FOR WESTERN PROVINCE FERTILIZER SURVEY DATA ANALYSIS

Summary information

Name of the survey:	Western Province Fertilizer Survey - Data analysis phase
Contracting institution:	Fertilizer Sub-Sector Reform Program
Contracted institution:	Department of Agricultural Economics and Rural Education, University Centre at Dschang
Province:	Western Province
Principal investigator:	KAMAJOU Francois
Title/position:	Professor of Agricultural Economics, University Centre at Dschang
Other investigators:	NYEMBA John, Professor NKWAIN SAMA Joseph, Professor AYISSI MBALA J. P., Professor

Calender of events

	From	To
Data entry and cleaning	Nov. 16	Nov. 30
Analysis and report prepration	Dec. 1	Jan. 1
Preliminary report	Jan. 1	
Final report	Jan. 25	

Questionnaire and data collection

The questionnaire will be provided by the FSSRP. The data collection is to be carried out by the Projet Developpement Rural - Plateau Ouest (PDRPO). University researchers are expected to participate in the training of enumerators and revision of the questionnaire following the pilot survey, but supervision of this phase of the survey is the responsability of the PDRPO. By November 16, the PDRPO is to provide the questionnaires to the university researchers.

Data entry, cleaning, and analysis:

Data entry: Data entry will be carried out by a data entry clerk hired by the university. He or she will be hired for two weeks. The original data entry should take around 10 days, but corrections will probably need to be made afterwards.

Tabulation: The tabulation will be carried out by the researchers. The tables to be produced are described below.

Computer: The university has a number of computers with hard drives available for the data entry and tabulation. The one chosen should be an IBM-compatible. The software to be used is either SPSS/PC or Statpak, both of which are available at the university. Professor NYEMBA John has experience with SPSS.

Reporting requirements to USAID

A brief (2-3 page) progress report will be provided to the FSSRP one month from the beginning of the survey. This will probably correspond to the end of the data entry. The report will describe the progress and problems with the survey.

Final products of the survey

A document will be delivered to the Comite Technique de Supervision of the FSSRP in French or English including 1) an executive summary at the beginning, 2) a table of contents with headings and sub-headings, 3) the body which contains tables and their interpretation, and 4) an annex briefly describing the methodology. Other annexes may be added if needed. In order to standardize among surveys, a specified format will be followed (see Annex C).

In addition, a brief report (4-8 pages single-spaced) will be provided which explains any problems with the questionnaire (problems questions etc.), the sample, the methodology, or the analysis. This report can be a revised and expanded version of the one-month progress report.

And finally, copies of the complete data files are to be made available to USAID. The files should be in ASCII or Lotus 123 format.

Budget and allowable expenses

USAID will pay the entire amount of the grant whether or not expenses were as much as budgeted. The contractor will perform the all specified work, whether or not the expenses exceed budget. Half of the grant will be paid at the beginning of the survey and the other half upon completion of the final report. In addition, USAID will pay a 10% bonus if the preliminary report is completed by December 5.

Allowable budget items include the costs of per diem, fuel, minor repairs, office supplies, reproduction of documents, and other minor supplies. It will not cover the costs of equipment (vehicles, motorcycles, computers, etc.), nor the salaries of people who are already under salary. Enumerators and/or data entry people may be hired.

BASIC TABLES TO BE PRODUCED FROM FERTILIZER SURVEY

1. Single-variable tables

The mean of each continuous variable in the questionnaire should be reported, as well as the frequency distribution of each discrete variable collected. For the core survey, this makes around 33 frequency distributions, 20 percentages, and 15 means. Other tables such as frequency distributions for continuous variables may be added as seems appropriate. More detail on single-variable tables is provided on page 65.

2. Two-variable tables

The two-variable tables should be selected for having interesting or surprising results. The tables should also be designed with the number of observations in mind. A given percentage or average should not be based on fewer than 15 households, preferable more. The following themes should be covered:

Type of fertilizer	BY	fertilizer practices and sources
Type of fertilizer	BY	crop fertilized
Use/non-use of fertilizer	BY	household characteristics
Use/non-use of fertilizer	BY	agricultural characteristics
Use/non-use of fertilizer	BY	yield of fertilized crops
Use/non-use of fertilizer	BY	length of delay in coffee payments
Knowledge of fertilizer	BY	household characteristics
Knowledge of fertilizer	BY	agricultural characteristics
Knowledge of fertilizer	BY	extension visits
Evaluation of system	BY	household characteristics
Evaluation of system	BY	agricultural characteristics
Agricul. characteristics	BY	region
Household characteristics	BY	region
Fertilizer practices	BY	region

FORMAT OF FINAL REPORT

In order to standardize the format, the following system of headings will be used:

		1. SECTION HEADING
1.1	Major heading	
1.1.1		Heading
		Minor heading

The margins will be approximately one inch on all sides. The text will be single-spaced with paragraphs separated by a blank line. Indentation will be used only for the major heading, heading, and minor heading. For ease of reading, the paragraphs to be at least 5-6 lines long, but not more than 20 lines long. The text should give highlights and explanation of tables, at least mentioning each one, but not listing large numbers of figures already available in the table.

B.4 RESEARCH PROTOCOL FOR SEVEN-PROVINCE FERTILIZER SURVEY

Summary information

Name of the survey:	Seven-province fertilizer survey
Contracted institution:	Directorate of Statistics, Minagri
Principal investigator:	M. Mbappou
Title/position:	Director of Statistics, Minagri
Data collection:	Ayissi Timothe Pouansi Paul Pierre Tchomte Vincent Monte Wallace
Data analysis:	Agoum Anabel Takou Pierre Jim Otto

Calender of events

	From	To
Training for pilot survey	26 Sept	28 Sept
Pilot survey and revisions	1 Oct	21 Oct
Training for main survey	10 Dec	15 Dec
Survey data collection	7 Jan	28 Feb
Data entry and cleaning	1 March	30 April
Analysis and report prepration	1 May	30 June
Preliminary report	1 July	
Final report	1 August	

Questionnaire

The basic questionnaire will be provided by FSSRP. The phrasing of questions and answers can be modified according to the experience gained in the pilot survey. In addition, questions may be eliminated if the information is available from the Agricultural Survey. In this case, the variables must be transfered from the Agricultural Survey files and used in the tabulation of the fertilizer survey. In any case, the final version of the questionnaire should be authorized by FSSRP.

Pilot survey

A pilot survey will be undertaken to train the enumerators, establish procedures, and identify problems. Problem questions or answers can be rephrased if need be. The sample size of the pilot survey should be around 10% of the sample size of the main survey. It need not cover all seven provinces, however it should include at least two provinces. One possibility would be to include one Francophone major fertilizer consumer (e.g. Littoral) and one anglophone minor consumer (e.g. South West).

Data collection methodology

Universe: Agricultural population in seven southern provinces

Sample size: 420

Sampling methodology: The survey will use a sub-sample of the households in the Agricultural Survey sample. This sample is based on "segments" of 5-7 households, of which there are around 700 in the country and around 540 in the seven southern provinces. The households will be selected in such a way so that there are 55 to 65 households in each of the seven provinces and 10-15 households in each of the 34 departments in those provinces. Ideally, only one household per segment will be selected to avoid clusters of interviewed households. Care will be taken not to choose the same segments used in the North West and West Province surveys.

Number of enumerators (approx): There are generally four Agricultural Survey enumerators per department, thus around 136 in the seven southern provinces. However, the number of enumerators involved in the fertilizer surveyed should be minimized to reduce training costs and maintain consistency among interviews. No more than 40 or 50 enumerators should be involved. The distribution of bonuses among enumerators to ensure fairness is at the discretion of the Directorate of Statistics.

Organization of enumerators: In each department, there are generally one section chief and two assistants who are responsible for organizing the enumerators and checking for errors. At the provincial level, there is a provincial section chief and two assistants. They coordinate the departmental units and liase with the Directorate of Statistics in Yaounde.

Data entry, cleaning, and analysis:

Organization of data entry: A data entry program with error checking will be prepared before the end of the data collection. Agoum Anabel, Takou Pierre, and Jim Otto will be responsible for the data entry phase.

Description of computer equipment to be used: The Directorate of Statistics has a number of IBM-compatible computers with hard disks, of which two or three would be available for the data entry of the fertilizer data. The software to use has not yet been determined but the Directorate has various ones which would be appropriate including FOCUS, Ariel, and dBase.

Description of data analysis: The same people and software used for the data entry would be involved in the tabulation.

Reporting requirements to USAID

Brief monthly progress reports will be provided to the FSSRP until the final document is delivered. They will include a description of progress and problems with the survey, as well as an update on expenses by budget categorie. The reports should be brief (2-4 pages single-spaced) and concise. They should each have the same format.

Final products of the survey

When the first raw averages and frequency counts are available, copies will be submitted to FSSRP for preliminary review.

The final report will be delivered to the FSSRP in French or English including 1) an executive summary at the beginning, 2) a table of contents with headings and sub-headings, 3) the body which contains tables and their interpretation, and 4) an annex briefly describing the methodology. Other annexes may be added if needed. In order to standardize among surveys, a specified format will be followed (see Annex).

In addition, a brief report (4-8 pages single-spaced) will be provided which explains any problems with the questionnaire (problems questions etc.), the sample, the methodology, or the analysis. This provides lessons for future surveys. And finally, copies of the complete data files are to be made available to FSSRP. The files should be in ASCII or Lotus 123 format.

Budget and allowable expenses

FSSRP will pay the entire amount of the grant whether or not expenses were as much as budgeted. The contractor will perform the all specified work, whether or not the expenses exceed budget. In addition, FSSRP will pay a 10% bonus if the final document is produced within 10% of the planned time (at least three weeks must be allowed for FSSRP review of the preliminary report). Allowable budget items include the costs of per diem, fuel, minor repairs, office supplies, reproduction of documents, and other minor supplies. It will not cover the costs of equipment (vehicles, motorcycles, computers, etc.), nor the salaries of people who are already under salary. Enumerators and/or data entry people may be hired.

BASIC TABLES TO BE PRODUCED FROM FERTILIZER SURVEY

1. Single-variable tables

The mean of each continuous variable in the questionnaire should be reported, as well as the frequency distribution of each discrete variable collected. For the core survey, this makes around 65 means and tables. Other tables such as frequency distributions for continuous variables may be added as seems appropriate. More detail on single-variable tables is provided on page 65.

2. Two-variable tables

The two-variable tables should be selected for having interesting or surprising results. The tables should also be designed with the number of observations in mind. A given percentage or average should not be based on fewer than 15 households, preferable more. The following themes should be covered:

Type of fertilizer	BY fertilizer practices and sources
Type of fertilizer	BY crop fertilized
Use/non-use of fertilizer	BY household characteristics
Use/non-use of fertilizer	BY agricultural characteristics
Use/non-use of fertilizer	BY yield of fertilized crops
Use/non-use of fertilizer	BY length of delay in coffee payments
Knowledge of fertilizer	BY household characteristics
Knowledge of fertilizer	BY agricultural characteristics
Knowledge of fertilizer	BY extension visits
Evaluation of system	BY household characteristics
Evaluation of system	BY agricultural characteristics
Agricul. characteristics	BY region
Household characteristics	BY region
Fertilizer practices	BY region

FORMAT OF FINAL REPORT

In order to standardize the format, the following system of headings will be used:

	1. SECTION HEADING
1.1	Major heading
1.1.1	heading
	Minor heading

The margins will be approximately one inch on all sides. The text will be single-spaced with paragraphs separated by a blank line. Indentation will be used only for the major heading, heading, and minor heading. For ease of reading, the paragraphs to be at least 5-6 lines long, but not more than 20 lines long. The text should give highlights and explanation of tables, at least mentioning each one, but not listing large numbers of figures already available in the table.

SINGLE-VARIABLE TABLES TO BE PRODUCED FROM FERTILIZER SURVEY

Average household size
Average farm size
Average cultivated area
Percentage growing each crop
Percentage owning each of 3 animals
Percentage working in each non-agricultural activity
Percentage owning each of 3 durable goods

Percentage growing coffee
Percentage growing arabica
Percentage growing robusta
Average number of trees
Average spacing of trees
Average number of sacks harvested
Percentage harvesting each month
Percentage by time of first payment (5 categories)
Percentage by time of final payment (5 categories)

Percentage producing maize
Percentage using each of 2 types of seed
Percentage buying seed from each of 4 sources
Percentage intercropping
Percentage intercropping each of 5 crops
Average quantity of maize harvest
Percentage by proportion of harvest sold (3 categories)
Percentage selling at each of three places
Average sale price of maize

Percentage buying fertilizer in past five years
Percentage buying fertilizer last year
Percentage by frequency of fertilizer purchase
Percentage by type of fertilizer purchased
Average distance to buy fertilizer
Percentage by mode of purchase
Percentage able to buy as much as wanted
Percentage by reason for why not able
Percentage for whom fertilizer arrived on time
Percentage by month they would like it available
Percentage for whom desired type of fertilizer was available
Percentage by type of fertilizer wanted but not available
Percentage for whom fertilizer quality was good
Percentage by reason fertilizer was not good
Percentage paid on time for coffee harvest
Percentage increasing purchases if it were more available
Average increase in purchases if it were more available

Percentage who have increased or decreased purchases
Percentage by reason for buying less fertilizer
Percentage by reason for buying more fertilizer
Percentage by evaluation of distribution system
Percentage by reason for thinking distribution better
Percentage by reason for thinking distribution worse

Percentage of non-users who believe fertilizer increases yield
Percentage by reason for thinking it won't
Percentage believing fertilizer is worth cost
Percentage by reason for thinking it isn't worth cost
Percentage by reasons for not buying fertilizer
Percentage knowing where to buy fertilizer
Average distance to point of sale

Percentage by source of information about fertilizer
Percentage visited by extension agent in last 12 months
Average number of times visited
Percentage knowing which fertilizer has most nitrogen
Percentage knowing which fertilizer

APPENDIX C

PROPOSAL FOR FERTILIZER DEMAND ANALYSIS

With the data being collected as part of the monitoring and data collection system of the Fertilizer Sub-Sector Reform Program, it will be possible to develop one or more models of fertilizer demand. Such models would be helpful in understanding current patterns and predicting future trends in fertilizer consumption.

There are three types of demand models that might be developed. First, fertilizer demand as a function of prices and production variables could be estimated econometrically using time-series data. Second, fertilizer demand could be estimated econometrically using cross-sectional data. And third, fertilizer demand could be derived from agronomic data on crop-response to fertilizer combined with some adjustment for the risk-aversion element of farm-level decision making. Each of these will be discussed in turn.

Estimating demand from time-series data

A standard way of estimating demand is to work with time-series data on price, quantity, income, and other variables. This analysis is easiest when either 1) the quantity supplied is determined exogenously (it is not affected by the current price) or 2) the price is set exogenously (it is not affected by the quantity demanded). An example of the first is agricultural supply which is more determined by weather and previous-year prices (i.e. the so-called cob-web model). Here the supply curve is vertical and variation in supply traces out the shape of the demand curve. An example of the second case is an imported good where the consuming country is too small to affect world prices or a good where the price is set administratively. In this case, the supply curve is horizontal and its movement again traces out the shape of the demand curve.

Unfortunately, time-series estimation of demand requires at least 20 or 30 periods of relatively accurate price and quantity data. This is difficult to find in many less developed countries and certainly would be a problem in estimating fertilizer demand in Cameroon. In addition, it would be difficult to incorporate the effect of factors such as the timeliness of supply, quantitative restrictions, and administrative allocation which have played an important role in fertilizer demand in Cameroon. In sum, this option does not look promising for the estimation of fertilizer demand in Cameroon.

Estimating demand from cross-section data

Cross-sectional data, particularly survey data, are often used to estimate demand. Using the household or the farm as the unit of observation, variation in prices are compared statistically to variation in quantity demanded. In this procedure, it is easier to accept the assumption that the price is not influenced by the individual decision to purchase fertilizer.

The dependent variable can be expressed in two ways: 1) the quantity of fertilizer used, and 2) a dichotomous (or dummy) variable indicating whether or not the farm used fertilizer. Strictly speaking, the clumping of zero values violates one of the assumption underlying ordinary-least-squares regression analysis (homoskedasticity) and thus introducing bias. In the first case, some researchers exclude the zero values (the non-users of fertilizer), but this merely substitutes one type of bias for another. More complex non-linear methods have been developed, but for our purposes ordinary-least-squares is probably sufficient. In case of the dummy dependent variable, a logit or probit regression model is designed to deal with this problem. With these models, the estimated variable is the probability that a household with given characteristics and facing given prices will decide to use fertilizer.

Among the independent variables, fertilizer price is the most obvious, although other types of explanatory variables include 1) non-price costs involved in fertilizer use, 2) producer prices for fertilized crops, 3) indicators of income or wealth, 4) indicators of how informed the farmer is, and 5) indicators of access to fertilizer supplies.

In estimating the demand for consumer goods, efforts are made to capture (if only approximately) differences in tastes by using regional dummy variables. In the case of intermediate goods such as fertilizer, it is not consumer tastes but the profitability of the input which may vary across regions. Specifically, fertilizer is more profitable for some crops and on some soils than others, and hence more profitable in some regions than others. This variation in profitability can be controled by including areas planted to selected crops as independent variables. Crop area is prefered to crop production as an explanatory variable. This is because production is likely to be influenced by fertilizer use itself, thus introducing simultaneity bias (mutual causation).

The fertilizer price coefficient will probably not be statitistically significant for two reasons. First, the regional variation is still not very great. Second, fertilizer purchases are probably more dependent on a household's crop mix and the availability of fertilizer than on prices per se. Nonetheless, a demand equation based on crop areas, distance from outlets, lateness of coffee payments, a proxy for income, and land pressure would be quite informative.

There are several possible data sources for such an analysis. The Agricultural Survey has a sample of over 3000 farming households, but the data set does not contain many non-agricultural household characteristics nor many fertilizer-specific variables. The seven-province survey and the provincial level surveys will yield data bases with fewer observations and less detailed agricultural data, but more household characteristics and fertilizer-specific variables. For example, the fertilizer surveys ask which crops were grown on a farm, but not the area and production of each.

The following table summarizes the dependent and independent variables which should be considered in the demand model, as well as which surveys provide each variable.

TABLE C-1: POSSIBLE INDEPENDENT VARIABLES FOR ANALYSIS OF FERTILIZER DEMAND

Independent variables	Available in agricultural Survey	Available in fertilizer surveys
Fertilizer price	No	Yes
Distance to fert. outlet	No	Yes
Arabica coffee	Area	Whether or not
Robusta coffee	Area	Whether or not
Maize	Area	Whether or not
Irish potato	Area	Whether or not
Rice	Area	Whether or not
Cotton	Area	Whether or not
Ownership of durables	Yes	Yes
Ownership of animals	Yes	Yes
Non-farm income	No	Yes
Size of holding	Yes	Yes
Prompt coffee payments	No	Yes
Cooperative membership	No	Yes
Recent extension visits	No	Yes
Level of schooling	Yes	Yes
Availability of credit	No	Yes
Maize price	Yes	Yes
Use improved maize seed	No	Yes
Proportion of maize sold	Yes	Yes
Land per family member	Yes	Yes

TABLE C-2: POSSIBLE DEPENDENT VARIABLES FOR ANALYSIS OF FERTILIZER DEMAND

Dependent variables	Available in agricultural Survey	Available in fertilizer surveys
Quantity used (with zeroes)	Yes	Yes
Quantity used (without zeroes)	Yes	Yes
Whether or not used fertilizer	Yes	Yes

Estimating demand from agronomic data

This procedure is less empirical and requires more assumptions, but can yield some interesting, if tentative, results. In order to develop a model of a given crop, we need 1) the agronomic relationship between fertilizer use and yield, 2) the prices of fertilizer and the crop, and 3) certain assumptions about how farmers decide on fertilizer application levels. From this, we can estimate the effect that changes in fertilizer and crop prices have on fertilizer demand and crop supply.

The agronomic relationship needed is an equation expressing yield as a function of the amount of different types of fertilizer applied. This is obtained through multiple regression analysis of the results of on-farm agronomic trials involving different combinations of nutrients. For example, the equation might take the following general form:

$$Y = f(N,H,K)$$

where Y = crop yield
N = nitrogen level
H = phosphorus level
K = potassium level
f is function with a declining slope

The "profit" (return to other factors of production) could be expressed:

$$\text{Profit} = P_Y Y - (P_N N + P_H H + P_K K)$$

where P_X = price of X

The prices should be those faced by the farmer. In other words, crop prices are farm-gate prices (not town prices) and fertilizer prices include the cost of transportation to the farm. By substituting the production function into the profit function, profit can be expressed solely in terms of prices and fertilizer application levels:

$$\text{Profit} = P_Y f(N,H,K) - (P_N N + P_H H + P_K K)$$

By taking the first derivatives in terms of N, H, and K and setting them equal to zero, we get the first-order conditions for profit maximization. By then solving for N, H, and K, we get the derived demand function (given profit maximizing behavior) for each in terms of nutrient prices and the crop price.

Unfortunately, farmer behavior is more complicated than simple profit maximization; they must make trade-offs between profit and risk on the basis on incomplete information, ending up with lower fertilizer application levels than those predicted by perfect-information profit maximization. Therefore, we need a rule of thumb to estimate actual fertilizer application levels from profit-maximizing application levels. This step involves a leap of faith. The simplest rule would be to assume farmers apply a certain percentage of

the profit-maximizing level of fertilizer, that percentage determined by the observed relationship between actual applications levels and predicted application levels.

The final result would be equations in which the demand for different types of fertilizer are expressed in terms of the prices of the crop and the fertilizer prices. Elasticities of fertilizer demand for that crop could be directly calculated from these equations. Furthermore, by plugging the predicted fertilizer application levels into the production function, the relationship between prices (both fertilizer and crop) and crop production could be obtained.

Such equations could be derived for any crop for which on-farm fertilizer response surfaces have been estimated. In addition, such equations could be developed for different regions using local trial results and local prices. Aggregate crop production would be estimated by combining different regional models. Aggregate fertilizer demand would be estimated by combining demand estimates for each crop and each region.

Nonetheless, two points should be emphasized. First, it is an assumption of the FSSRP, and one borne out by experience thus far, that prices are not the most important factor determining demand. Such a model should not divert attention from this fact. Second, this model involves a number of judgement calls: choosing "representative" agronomic trial results, selecting a method for predicting actual behavior from profit-maximizing behavior, etc. Thus, the results of this exercise must be considered no more than a rough indication of actual demand patterns.

APPENDIX D

PROPOSED NATIONAL FERTILIZER RESPONSE DATABASE

1.0 The Proposed Organization of the NFRD

After agreement among cooperating national and international agencies, IRA would establish a supervisory committee headed by the director of IRA and consisting of the head of the soil research center, the researcher in charge of soil science databases, the representative of GERDAT (soil scientist) within IRA, a member of IRA's biometrics section, the chief soil chemist at Nkolbisson's soil analyses laboratory, a senior agronomist from NCRE, and the computer specialist at NCRE. The committee would organize participation of all researchers in the data collection operation and guide the NFRD team to all sources of existing data. It is proposed that IFDC be contracted to collaborate with the National Soils Center (NSC) in forming the NFRD team.

It would be advisable to begin activities with an advance visit to Cameroon by one bilingual member from IFDC. The objectives of the advance visit would be to visit all IRA research centers and explain the objectives of the NFRD to researchers and research administrators and to furnish a specific timetable for the impending team visit. The amount of data and its exact nature could be more accurately assessed at the time of this visit. The supervisory committee would form and coordinate the activities of the first visit.

The IFDC team member(s) must be bilingual and have expertise in soil fertility research. It is expected that IFDC will provide the statistical support and computer expertise necessary to carry out the work.

The NFRD team would travel around the country to collect data from researchers presently in the field. Even though there has been a high turnover of expatriate researchers, much of the raw data is available within the research units where the response trials were conducted. Soil descriptions and soil sample analysis data has often not been reported but is available within the respective research units. It is imperative that the IFDC team assist researchers in collecting the maximum amount of existing data in the location where the research unit exists. Several visits to research units may be necessary to obtain and enter all available data. The team must be prepared to leave a copy of all data collected within a research unit at the research center before moving on to a new research center. It is expected that the soil fertility expert will provide some training to field researchers in response surface analysis while collecting available data.

The NFRD team would include a soil scientist from the NSC who would participate in data collection and subsequently travel with the IFDC members of the team to Lome to analyse and interpret the database. It is expected that this person, suggested to be M. Martin Tchienkoua (M.S. in soils), would become the Cameroonian expert on the National Fertilizer

Response Database. He would continue to update the database in the future as more response data becomes available. The National Soils Center has been promised a microcomputer by ACCT (Agence de Cooperation Culturelle et Technique) that could be used for the permanent home of the NFRD.

The data collection and entry process is expected to take a minimum of three months and a maximum of five months and should be conducted from January to April in the northern provinces and from September to February in the rest of the country while researchers are tradionally occupied with trial analysis and reporting. The amount of time necessary to collect the data will depend upon the findings of the preliminary field visit.

After providing hard copies of the data collected to the supervisory committee with IRA and the TSC, the NFRD team could go to Lome to process, classify, analyse, and interpret the database. A final report would include progress toward the objectives listed in the text.

There should be no equivocation about the ownership of the data contained in the NFRD. Any publication of studies using the database would require authorization from the appropriate Cameroonian government authorities.

2.0 Sources of Information for the NFRD

It is understood that one of the important assumptions on which the concept of the NFRD is based is that significant amounts of response data exist within the IRA centers and sections that have not been compiled and analyzed. It is believed that this assumption is valid. However, in order to verify the existence and usefulness of existing data, a preliminary visit to IRA structures by one member of the IFDC team is encouraged. The following partial list of known sources of information is given to guide IFDC researchers in the preliminary effort to uncover as much useful data as possible. It is believed, however, that much more data exist than what is indicated below. The director of IRA, M. Kaiser, and the IRA program heads could be instrumental in completing this partial list.

I. Institute of Agronomic Research

A. IRCC reports and Coffee and Cacao program results:
See M. Bouamo, Nkolbisson, for coffee research results and M. Bakala, Nkolbisson, for cocoa research results.

B. Soil center or soil laboratory results: Consult with M. Bindzi-Tsala, head of National Soils Center, Nkolbisson, or with Department of Soils, Dschang University Center.

C. IRCT reports and cotton and textile program results: Cotton, rotation, foodcrop response trials have been conducted from the early 1970's until the present. Much response data is available with soil sample and some tissue analysis. M. Kaiser, now Gerdat representative in Nkolbisson was the agronomist/soil scientist on

the IRCT team in Maroua and has indicated support for the concept of the NFRD.

D. IRAT reports and data. IRAT has been conducting agronomy research in the northern provinces of Cameroon since at least the mid-1960's. Some of those reports are available in Maroua but they should be searched in Nkolbisson as well. See M. Kaiser for location of as much of the raw data as possible though recovery of all the data is unlikely. IRAT provided expatriate researchers for rice research conducted by SEMRY in the Extreme North and for upland rice research and farming systems research in the North Province. Raw data for years 1982-1987 should be with the Cameroonian counterparts in Maroua and Garoua as well as data for trials that have been conducted by the counterparts since their departure.

E. NCRE reports

1. Bambui
   a. Cereal agronomy -- five years of fertilizer response data on maize and intercrops conducted by Dr. Kikafunda who is still working in Bambui. He should have soil sample data as well as yield data. He serves as cooperator in regional IFDC trials.
   b. TLU -- six years of on-farm fertilizer response data on maize-based farming systems conducted by Dermot McHugh and counterparts in the Northwest Province. Dr. McHugh is still working in Bambui and has performed some economic analysis on response data.
2. Dschang
   a. Rice agronomy and fertilizer response on food crops-- annual reports indicate rice and food crop response trials jave been conducted. Dr. Roy, agronomist, is still working in Dschang and would have access to raw data collected on fertilizer research since the beginning of the NCRE project.
3. Nkolbisson
   a. Cereal Agronomy and TLU Sections -- several researchers have worked on fertilizer responses in maize. See Annual Reports for the NCRE project for outline of trials conducted since the beginning of the project. Dr. Poku now doing the on-farm agronomy research and would know where the raw data for past trials would be found.
4. Ekona
   a. TLU -- agronomic responses and Division surveys. Dr. Almy collected soil samples and had them analysed at Ekona for fields that were being intensively surveyed. She is still working in Ekona. The TLU agronomist has been conducting on-farm and station response trials for two years and should have soil sample as well as yield response data. Mr. Besong, economist with the TLU, did his M.S. research on response of cassava to three

different fertilizer treatments at 20 locations and has soil sample data for those trials. The soils laboratory at Ekona should be an invaluable source of information concerning research and extension programs that have conducted fertilizer trials and demonstrations because it is the oldest soils laboratory in the country and must have some institutional memory of soil analyses clientele.

5. Maroua
   a. Cereal agronomy -- data from 1986 to present from station trials of rainy season and mouskwari sorghum response to fertilizers. It is assumed that most response trials have soil sample data. Dr. Singh began in 1988 but should have data left by Dr. Rao, his predecessor, or with his Cameroonian counterpart.
   b. SAFGRAD/TLU -- fertilizer research since the early 1970's. Raw data exists for peanut response to TSP in 1984 at 20 locations without soil sampling. Data exists for fertilizer response of sorghum at 23 locations, together with soil sample data in 1985 and cowpea response to single fertilizer rate of TSP in 1985. Peanut response to single super phosphate in 1988 with soil sample analyses (except texture)also exist. See John Russell, extension agronomist since 1988 who also has raw data for trials conducted between 1984 and 1988.
   c. Peanut research section -- Dr. Tim Shilling conducted research on peanut response to phosphate, sulfur, and different strains of rhizobia. Raw data should be with Mr. Thomas Mecountchou, present head of peanut research in Maroua.
   d. Cowpea research section -- Dr. Moffi Ta'ama conducted trials on cowpea response to fertilizer. Exact amount and nature of the data that is available is unknown but he is still working in Maroua.
   e. Antennae research stations -- From 1983 until 1987, the World Bank financed the operation of nine research antennaes in the Extreme North and North Provinces. M. Jacques Gouthiere organized the research at all of the antennaes and conducted research on soil fertility and crop rotations with soil sampling. It is uncertain who has this data now. Ask M. Kaiser in Nkolbisson and M. Boli, head of Maroua station.

6. Garoua cereals agronomy section -- Dr. Henri Talleyrand has been one of the most active advocates of fertilizer research in northern Cameroon. He is still working in the North and Adamoua provinces. He is also most familiar with the fertilizer trials that have been conducted in the Adamoua by other organizations including the IRDC-financed root and tuber research, large private maize production farm, SODEBLE, etc. He has regularly sent soil samples to IITA/Ibadan for analyses. Other researchers have been

conducting fertilizer trials in Garoua but the new IRAT team just arrived in 1988.

F. Food crop research at Bertoua -- see director of IRA and past research results for extent and nature of fertilizer trials conducted in the East Province. Food crop researchers have made presentations at annual IRA meetings since at least 1985.

G. Root and Tuber research at Ekona -- see USAID evaluation report of the root and tuber research project completed in August 1989. At least one field agronomist conducting limited number of trials on root and tuber response to fertilizer.

II. Benchmark Soils Project Results and Report

A copy of the project report is in the USAID library in Yaounde. Cameroon was one of nine locations worldwide for studying the transferability of maize response to N-P-K in tropical soil families. Raw data should be available in the country. See the IRA Director for information or write to project leaders.

III. Industrial Plantations

The National Soils Center has done numerous soil maps at different scales for the Cameroon Development Corporation. It is assumed that much fertilizer response data is available for rubber, palm oil, and banana production. See IRACHO reports. See director of IRA. Visit CDC headquarters.

IV. Educational Institutions

An understanding of the organization of education and research functions within the educational structure of Cameroon -- before and after the creation of the university structure -- is necessary for anyone working on the NFRD.

Examples of the types of information available through these institutions are as follows:

- Memoires fin d'etudes
- M.S. and PhD theses
- Faculty publications

Sources of information are:

- University Center at Dschang
- Nkolbisson
- University of Yaounde
- Ngaoundere

V. List of Cameroon Soil Maps

1) ORSTOM. Segalin and Martin. Scale 1/1000000 of all Cameroon except Southwest and Northwest Provinces.

2) ORSTOM. Valerie. Scale 1/1000000 of Southwest and Northwest Provinces.

3) FAO. 1965. P. Hawkins and M. Brunt. Broad reconnaissance survey of West Cameroon (most of Southwest, West, and Northwest Provences), and detailed study of Bamenda area. Two volume publication entitled The Soils and Ecology of West Cameroun with soil, land use, and climatogical maps available in USAID Yaounde library.

4) ORSTOM. 1985. P. Brabaut. Soils and Land Resources of North Cameroon. Scale 1/500000. Most recent classification publication. Available at ORSTOM Yaounde.

5) USDA/ORSTOM. 1978. Soil classification map of North Cameroon in three different classification systems. Scale 1/500000.

6) FAO project support to soils laboratory at Ekona has completed more detailed maps of specific areas of Southwest Province.

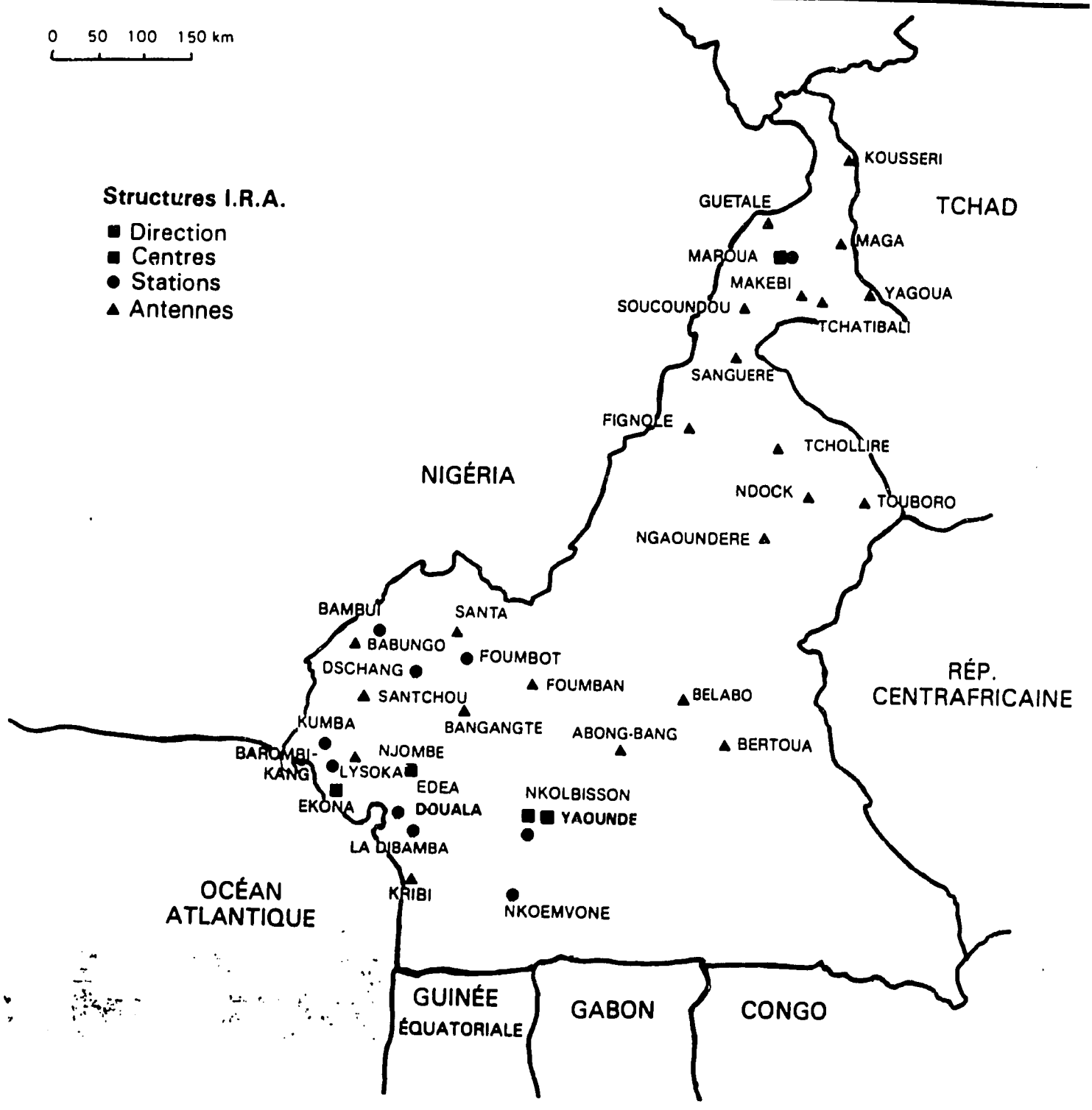
7) National Soils Center and FAO. Fort. Soils map of the MIDENO project area in the Northwest Province. Scale 1/200000.

8) ORSTOM. Detailed map of Bafoussam area in West Province. Scale 1/50000.

We have included on the following page (Figure D-1) a map showing locations of all IRA installations.

FIGURE D-1

CARTE DE SITUATION DES STRUCTURES



APPENDIX E

PROPOSAL FOR PROGRAM OF ON-FARM FERTILIZER RESPONSE TRIALS

Sponsor: Fertilizer Sub-Sector Reform Project
Collaborators: Adaptive Research Unit/MIDENO/Bamenda
Principal investigator: George Yebit,
Dept. of Agriculture/University Centre Dschang
Principal investigators: Drs. Lyonga/Nkodo/Bikomo
Duration of trials: February 1990 - January 1991

1.0 Objectives

The objective of the proposed trials is to improve fertilizer use efficiency in the two provinces of western Cameroon that presently account for the majority of imported fertilizer. This is to be done by development of fertilizer recommendations for different cropping systems and different soil and climatic zones that are most likely to provide the highest return on fertilizer investment to the farmer -- in an economic environment characterized by increasing fertilizer costs, decreasing commodity prices, and increasing pressure on agricultural lands. In addition, this activity and others under the FSSRP are designed to aid the Government of Cameroon to redefine the appropriate role of government in a privatized fertilizer sub-sector.

The on-farm testing activity is designed to aid the adaptive research unit in the Northwest to build the institutional capacity to conduct and interpret on-farm tests that serve dual purposes as research and demonstration plots. It is hoped that collaboration with the University Center at Dschang will provide the opportunity for students within the Dept. of Agriculture to develop appropriate skills in the realm of soil science, natural resource management, and applied agronomy. Finally, the methodology developed for on-farm testing of fertilizers in two provinces can be adapted for use in other provinces, under different cropping systems and for solution of different soil fertility problems.

2.0 Activities of the First Year

Cropping systems: Bamenda trials will test fertilizer response on four different cropping systems that dominate high, mid, and low altitude farming systems in the Northwest. Dschang trials will be conducted on the maize-based farming system prevalent in the Midewa department of the West Province. Details are indicated below.

Original recommendation domain	Cropping System	Number of Locations
Northwest Province:		
High altitude	maize/beans or maize/beans/potatoes	35
Mid altitude	maize/beans/groundnuts	50
Low altitude	maize/beans/cocoyams	20
High altitude	arabica coffee	15
West Province:		
Mid altitude (Menoua Div.)	maize/grain legume	20

Field Layout: Six treatments randomized independently at each location with one replication per location. Plot size will be 10m by 20m giving total area per farm of approximately 1/8th hectare.

Treatment	Nitrogen in kg N/ha as urea	Phosphate in kg P2O5/ha as triple super phosphate
1	0	0
2	30	0
3	60	0
4	90	0
5	0	50
6	90	50

3.0 Test Conditions

Site selection: Test fields will be chosen that best represent the population of fields to which the fertilizer recommendations will be made within each of the cropping systems. No research stations, substations, training centers, school farms or controlled situations will serve as test sites. All tests will be conducted on farmers' fields.

Varieties: As recommended by IRA for the recommendation domains.

Plant density: Must reflect densities used by farmers for the cropping system under investigation. Experience in the Northwest indicates that maize density should be around 20,000 plants per hectare.

Date of planting: Coincide with mean date of seeding of different species within the test area.

Soil samples: One composite soil sample (ten subsamples) will be taken from each plot at 0-30cm depth before planting. This implies that six soil samples per location will be analysed. Soil samples from Bamenda will be analysed at the Ekona soil antenna and Dschang samples will be

analysed at the soils laboratory at the University Center in Dschang.

Fertilizer application: Both fertilizers will be applied 20 to 30 days after seeding in a band around individual plants (traditional method) and covered immediately. All fertilizer application and incorporation will be supervised by agents designated by the collaborating institutions.

Weeding: Collaborating farmers should be encouraged to maintain test plots free of weed competition especially in the early stages of crop development.

Harvest: Harvest of each species in the cropping system will be supervised by agents from collaborating institutions. Weighing and counting will be done at the location and all harvest will remain with the collaborating farmer except small samples that may be needed for estimation of percent moisture.

4.0 Observations and Data Collection

4.1 Location Specific Observations

1. Dates of cropping operations:
   Date of seeding
   Date of fertilizer application
   Dates of weeding
   Dates of harvest

2. Daily observations (closest approximation if not at location)
   Rainfall in mm
   Maximum and minimum temperature for computation of growing-degree-days at each location.

3. Soil characterization/description from a soil pit (1.5m deep) and soil maps done by previous studies. Two pits per location may be necessary if significant topographical variation exists within the location, e.g. more than 5% slope. For previous studies characterizing soils of western Cameroon see references. Soils will also be characterized by any indigenous soils or land use classification system that may be applied to locations within a cropping system.

4. Altitude, latitude, and longitude of test site to the nearest approximation.

5. Cropping history of test site by recall of farmer. Length of time since last fallow, duration of last fallow period, and estimation of yields (approximate scale used across all locations) for previous year.

6. Characterization of collaborating farm family, history of fertilizer use, farmer strategies for maintaining soil fertility,

local erosion control measures, and description of constraints to fertilizer use as perceived by the farmer.

7. Researcher observations concerning the growth and development of crops within the test, anomilies in test implementation, abnormal climatic conditions that help explain response of crops to fertilizer, and some indication of the relative fidelity of the observations made during the cropping season.

4.2 Plot Level Observations

1. Plant density (000/ha) at time of fertilizer application and at harvest.

2. Date of 50% flowering or closest approximation.

3. Number of ears by market class of fresh maize. For example, 3 large ears = 10 small ears = 100 cfa.

5.0 Approaches and Objectives of the Analyses

The following analyses are suggested as expected results. Statistically non-significant as well as significant results should be reported. Investigators may wish to modify specific suggested analyses or add analyses that may be equally informative. In the interest of obtaining the maximum amount of information from these trials and in the educational interest of these trials to future agronomists, complete analysis, interpretation, and reporting of trials will be required. Continued collaboration will be dependent upon the quality and completeness, not the quantity, of research activities undertaken under this program.

The trial design is intended to answer three questions within the five original recommendation domains, and within any recommendation domains suggested by the response data, soil classification groups, or groups of locations with similar soil sample parameter values:

1) How much nitrogen, in the form of urea, should be applied to maize-based cropping systems for optimal agronomic and economic returns without phosphate application?

2) Is there a response to phosphate application without nitrogen application? In light of previous research which shows phosphate response to be dependent upon location, the intent of the phosphate response treatments are only to identify groups of locations where significant responses to phosphate application occur.

3) Is there a response to phosphate application if nitrogen is not a limiting factor? Is there a significant phosphate x nitrogen interaction?

It is understood that the trial is not a complete nitrogen x phosphate response surface design. Due to the imperative of conducting research on farmers' fields under farmers' management, the number of possible treatments do not permit a complete N*P response surface design in the first year of on-farm testing. Consequently, it is hoped that for those groups of locations demonstrating a strong response to phosphate application, or nitrogen x phosphate interaction, there will be complete nitrogen x phosphate response surface trials in the second year. Previous research has shown that there is a strong location x phosphate interaction and a weak year x fertilizer treatment interaction, meaning that results can be accumulated from year to year within groups of locations with little risk of misinterpretation. This stepwise approach to testing nitrogen and phosphate response seems preferable to commencing complete nitrogen x phosphate response surface studies on all locations, because phosphate application is not expected to be advisable on the entire set of locations. A stepwise approach will permit collaborating institutions to gradually develop their competence in on-farm testing and interpretation.

It is further understood that the statistical analyses suggested below are intended to develop new hypotheses concerning the most appropriate recommendation domains for different fertilizer recommendations as well as to explain the results that have been obtained. The suggested response variables are as follows:

1. Grain yield in kg/ha at standard percent moisture.

2. Estimated value using maize ear market classes and market prices at the time of harvest for other crops in the system.

3. Yield components for maize -- number of ears and weight per ear.

4. Maize or intercrop density (at the discretion of the investigator).

6.0 Analyses

6.1 Response Functions.

A. Nitrogen response function without phosphate.

B. Linear response to phosphate without nitrogen.

C. Interaction of phosphate and nitrogen.

Regression analysis will be used to test the statistical significance of both linear and quadratic portions of nitrogen effects on maize (and intercrop) grain yields. Linear regression will be used to test the significance of response to a single application of phosphate. (Is the slope greater than 0?) The nitrogen by phosphate interaction can be tested by traditional analysis of variance or with regression by comparison of the slopes of the two linear responses to phosphate, with and without nitrogen. The probability of type I error for each test will be reported

along with some indication of test power. It is understood that a separate regression will be done within each of the original recommendation domains and for any recommendation domains that are suggested by different responses to nitrogen and phosphate fertilizer. Coefficients of variation will be reported for each analysis of variants.

Examples of possible response functions are shown in Figure E-1 below.

6.2 Multiple Regression with Soil Analysis Parameters

Soil sample analyses will include approximately 10 parameters that may individually, or in interaction, significantly affect the responses to nitrogen and phosphate outlined above. Obviously, not all possible combinations of soil parameters and their interactions can be tested within each of the recommendation domains for their effects on responses. However, stepwise regression will be used to test the individual soil parameters and reasonable first order interactions of soil parameters on the responses. Two examples:

Yield = a + bN + cN2 + initial level of soil phosphorus.

Yield = a + bN + cN2 + (soil P) x (pH).

6.3 Use of Soil Analysis Parameters to Group Locations

Each of the ten different soil sample parameters will be broken into two or three ranges for grouping locations. Each group response to nitrogen and phosphate will then studied. For example, for locations with initial soil pH less than 5.0, how does the optimal rate of nitrogen compare to the optimal rate in locations with soil pH greater than 5.0?

6.4 Analysis of Variance of Soil Parameters

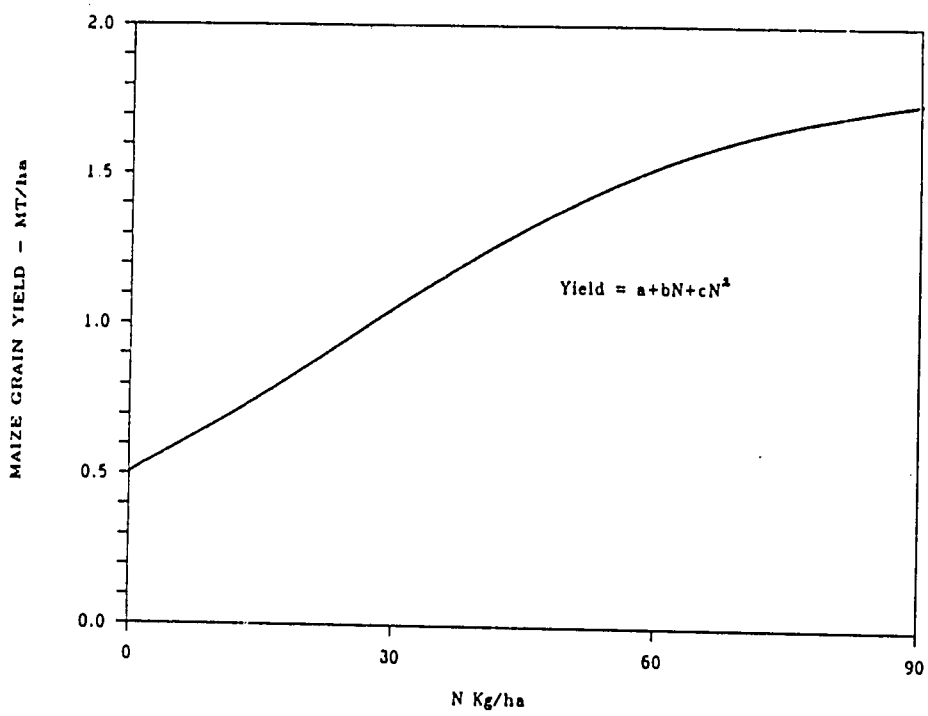
For each of the soil parameters, an analysis of variance will break down the relative amount of variability into variability within locations and variability among locations. Given the complex nature of the farming systems under consideration and the general lack of knowledge of the variability of important soil parameters, it is important to characterize the variability of each of the parameters in space and time. The number of soil samples in future years can be limited to those parameters of most interest. For example, if it is shown that percent sand is an important criteria for grouping soils with regard to potential response to phosphate, and soil texture does not vary significantly within a location, then one sample per location for soil texture would be sufficient in future years.

6.5 Analysis of Covariation

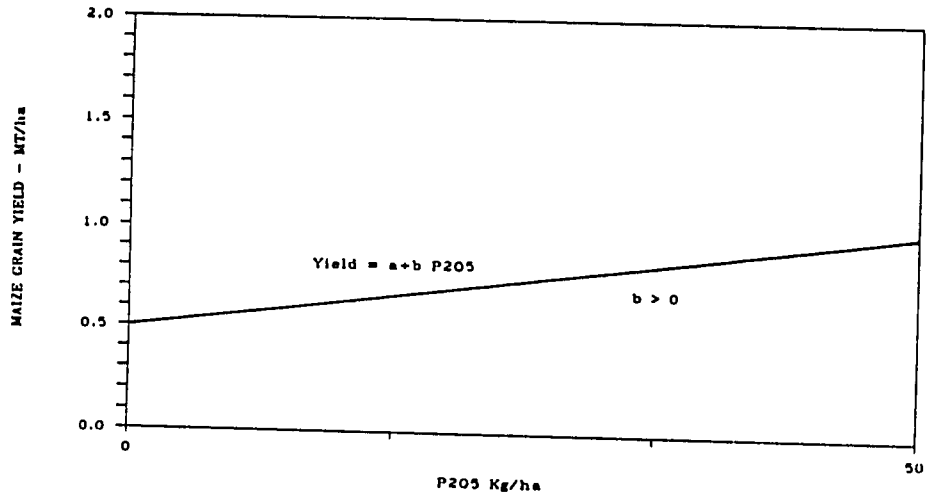
At his discretion, the researcher will investigate soil sample parameters as covariates in the analysis of covariance.

FIGURE E-1: EXAMPLES OF RESPONSE CURVES

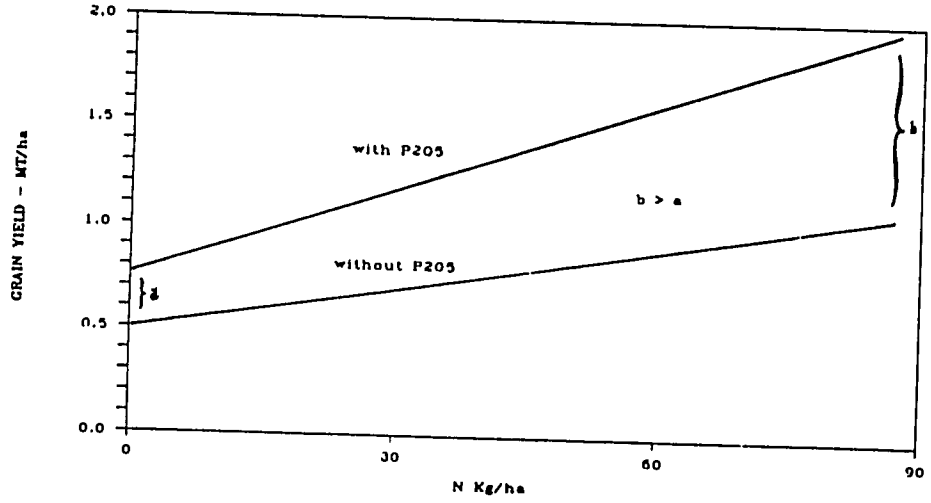
N RESPONSE CURVE



P RESPONSE LINE



INTERACTION N*P



6.6 Use of Environmental Parameters to Group Locations

In a similar way to the use of soil parameters to group locations according to responses to nitrogen and phosphate, additional environmental criteria will be used, such as:

-groups of locations within ranges of altitude
-groups of locations within ranges of growing-degree-days
-groups of locations within ranges of seasonal rainfall

6.7 Economic Analyses

Nitrogen and phosphate recommendations within recommendation domains will be analysed under the hypothetical non-subsidized price structures.

6.8 Interpretation

Using the above analyses, describe domains that merit independent nitrogen fertilizer rate recommendations and domains where significant response can be expected to phosphate application. Describe domains that require complete nitrogen x phosphorus response surface testing and how the testing can and should be accomplished.

Describe proposed changes in on-farm testing for a second year including:

-Different or more optimal levels for N and P for a similar test as conducted in the first year.
-Different cropping systems that should be tested or different species combinations in the same cropping systems.
-Different, interacting, or higher priority fertilizer elements to test within the recommendation domains. For example: potassium, sulfur, calcium, magnesium, lime, rock phosphate, organic amendments -- alone or in combination with treatments used in the first year.
-Geographic areas of highest priority for extension of the on-farm fertilizer testing program.
-Suggestions for improving on-farm testing methodology, including choice of site, identification of more or less data and observations that should or shouldn't be collected, more economical means of testing to obtain equally useful and reliable results, improved demonstration effects from the tests, practical use of results by extension, suggestions for improved test methodology for improving the linkages among research, extension, education, and farmers.
-Describe the success and failure of the dual objectives of on-farm fertilizer testing (research vs demonstrations). How many tests were visited by how many farmers? How good were the visual effects of different fertilizer rates on maize growth? What constraints to improved and increased fertilizer use were cited by farmers and how should these constraints be addressed?

7.0 Example Budgets

Based on per-test estimations made by J.Johnson and G.Yebit:

	FCFA
1. Raingauge	3500
2. Maximum-minimum thermometer	10000
3. Seed	5000
4. Fertilizer	2000
5. Fuel for vehicles to supervise test implementation	12500
6. Soil sample analyses (6 samples x 11500)	69000
7. Miscellaneous (seed strings, plot labels, bags)	8000
Estimated total per site	110000

Notes:

1) It is expected that a motorcycle would be procured for the Department of Agriculture, University Center Dschang, to permit students and technicians to supervise on-farm tests and collect necessary data. Fuel would be provided for UCD vehicles for site visits by staff members.

2) The cost of soil sample analyses should be considerably less than present price cited above by the head of Ekona soil center because an alternative (faster and cheaper) method of texture analysis, the Bouyoucos method, would provide sufficient precision. Suggested price for negotiation with Dschang and Ekona would be 5000-6000 FCFA per sample for a large number of soil samples. Figure E-2 (IRA's "Fiche Analytique") indicates the soil sample parameters to be tested.

3) The purpose of these on-farm tests have been explained to members of the Ekona and Nkolbisson TLUs within NCRE/IRA. NCRE workplans for the coming year have not yet been finalized but in the event that they wanted to conduct similar on-farm tests, it would be desirable to adopt similar approaches to the analysis and interpretation of results. Technical review of results obtained by the on-farm testing activity after the first year should be sought regardless of their direct participation.

4) The vegetable research unit within IRA at Foumbot is preparing a proposal for fertilizer tests on vegetable crops in farmers fields surrounding Foumbot. They should be furnished with a copy of this report and their participation should be encouraged if modest amounts of input would lead to reliable fertilizer response data for vegetable crops.

8.0 Timetable of Operations

Agreement between contracting parties	1989
Advance of agreed upon percentage of estimated costs	1989
Procurement of materials and motorcycle	1989
Soil sample collection and delivery to laboratories	Feb. 90
Planting	March 90
Soil sample results obtained from Ekona and UCD	Aug. 90
Harvest	Aug. 90
Data entry, analyses, and interpretation	Sept.- Oct. 90
Report due for first year of activities	Nov. 90
Second year activity planned, contracted, and schedule	Dec. 90

FIGURE E-2

INSTITUT de la RECHERCHE AGRONOMIQUE

FICHE ANALYTIQUE

TYPE DE SOL	

N° PROFIL :

N° Echantillon								
Profondeur cm.								
Refus 2 mm %								
CO_3 Ca %								
Humidité %								
ANALYSE MECANIQUE								
Argile %								
Limon fin %								
Limon grossier %								
Sable fin %								
Sable grossier %								
MATIERE ORGANIQUE								
Mat. org. totale %								
Carbone ‰								
Azote ‰								
C/N								
ACIDE PHOSPHORIQUE								
P_2O_5 total ‰								
FER								
Fe_2O_3 libre %								
Fe_2O_3 total %								
Fer libre/Fer total								
Bases totales ME pour 100 g de sol								
Calcium								
Magnésium								
Potassium								
Sodium								
Bases échangeables ME pour 100 g de sol								
Calcium								
Magnésium								
Potassium								
Sodium								
S								
T								
S/T = V %								
ACIDITE ALCALINITE								
pH eau								
pH KCL								
CARACTERISTIQUES PHYSIQUES								
Poids spéc. réel								
Poids spéc. appar								
Porosité %								
pF 4 2								
pF 3								
pF 2,5								
Eau utile %								
Instabilité structurale Is								
Perméabilité Kcm/h								

Analyses terminées le : au laboratoire de :

APPENDIX F

SCOPE OF WORK

SUPPORT TO ONGOING INFORMATION GENERATION AND MONITORING

This scope of work describes three phases of activities in support of the FSSRP's ongoing information generation and monitoring network. The qualification of the three consultants required to perform these activities are also specified.

Activities to be Performed

Phase 1: Fertilizer Research Synthesis

In the period June - August 1989, the Agricultural Economist and the Research Agronomist will come to Cameroon for approximately two weeks to synthesize existing agronomic research and survey results so as to understand the current status of knowledge about fertilizer use in Cameroon. To this end, the consultants will:

-Review published and unpublished reports, studies, results, and data sets, particularly those from the Institute for Agricultural Research (IRA), the Department of Statistics of the Ministry of Agriculture, and the MIDENO, PDRO, and Bafou Projects.

-Prepare a draft report in English before departing the country that summarizes what is and is not known about fertilizer and its use in Cameroon and the current state and direction of research. The report should also identify the key gaps in understanding and which of those are appropriate for the FSSRP to address.

-Submit a final report in French and English within four weeks of departing the country.

Phase 2: Research Design

Immediately upon completion of Phase 1, the two consultants will spend an additional three weeks in Cameroon working with identified collaborating projects or organizations on developing and finalizing the research designs for the surveys and agronomic trials listed below. In each case the final product will be a written research protocol that specifies the research methodology, sampling techniques (as appropriate), implementation procedures, report formats, principal researchers,the timetable, and a detailed budget and is acceptable to both the FSSRP and the collaborating project or orqanization. These research protocols should be developed so as to be consistent with and to support the FSSRP monitoring system design and the results of the synthesis completed in Phase 1.

Research protocols will be prepared for:

-The addition of questions on fertilizer pricing to the annual national agricultural survey in collaboration with the Cameroon Agriculture Policy and Planning (CAPP) project.

-The seven-province socio-economic survey of patterns of fertilizer use and constraints. This survey will be conducted by the Department of Statistics, Ministry of Agriculture under the direction of CAPP. In this case, the consultants will work with MINAGRI and CAPP staff to develop the actual questions.

-A more detailed survey of fertilizer use and on-farm results from fertilizer application to be conducted in a pilot zone in both the West and the North West provinces. In the West Province the survey will be conducted by faculty of the University Center of Dschang through the USAID-funded Agricultural Education project. In the North West Province, the survey will be conducted collaboratively by the Planning, Evaluation, and Monitoring Division of MIDENO and Testing and Liaison Unit of IRA/Bambui through the USAID-funded NCRE project.

Phase 3: Second-Year Annual Assessment

(To be conducted in January/February 1990.)

APPENDIX G

LIST OF PEOPLE CONTACTED

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APPENDIX H

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