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Prepared by: The Coordination Office  
OAU/STRC - SAFGRAD  
B.P. 1783 - OUAGADOUGOU  
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Burkina Faso  
Tél. 30 - 80 - 71 31 - 15 - 88  
01 89. 1783 Ouagadougou 01  
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# ACRONYMS AND ABBREVIATIONS

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ADF	Acid Detergent Fibre
ARC	Agricultural Research Council (UK)
CARDER	National Extension Service - Benin
CIMMYT	Centro Internacional de Mejoramiento de Maiz y Trigo
CP	Crude Protein
DM	Dry Matter
DMD	Dry Matter Digestibility
DOMD	Digestible Organic Matter in the Dry Matter
FAC	Fonds d'Aide de Cooperation
FSR	Farming Systems Research
FSU	Farming Systems Unit
h	Hour
IARC	International Agricultural Research Centers
ICRAF	International Centre for Research into Agro-Forestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IITA	International Institute for Tropical Agriculture
ILCA	International Livestock Centre for Africa
INERA	Institut d'Etudes et de Recherche Agricoles (Burkina Faso)
IRAT	Institut de Recherche Agronomique Tropicale
LSD	Least Significant Difference
MAFF	Ministry of Agriculture, Food and Fisheries (UK)
ME	Metabolizable Energy
N	Nitrogen
NARS	National Agricultural Research System
NDF	Neutral Detergent Fibre



OAU	Organization of African Unity
OM	Organic Matter
ORD	Organisation Régionale de Développement
P	Phosphorous
PMC	Project Management Committee
ppm	Parts Per Million
RDN	Rumen Degradable Nitrogen
R.Y.T.	Relative Yield Totals
SAFGRAD	Semi-Arid Food Grain Research and Development
STRC	Scientific, Technical and Research Commission
TN	Tissue Nitrogen
UDN	Undergraded Dietary Nitrogen

## INTRODUCTION

The purpose of the IFAD Farming Systems Research (FSR) support programme is to enable national research programmes to face the challenge of food production by developing suitable technologies for the efficient management of farm resources. The main focus of the programme is, therefore, to improve indigenous research capabilities in order to understand the total farm environment and systems of production, thereby facilitating a transfer of innovations through identification and alleviation of production constraints through uninterrupted research and technology evaluation.

In order to evolve a holistic approach to farming practices encompassing various food production systems, the scientists who have been placed at the disposal of national research programmes (Benin, Burkina Faso and Cameroon) have provided the technical support to develop a national FSR programme based on research priorities and agricultural development policies of the respective countries.

The IFAD-funded FSR activities started in Burkina Faso in 1985, following a series of discussions with host government officials and national scientists. Three scientists were recruited to provide technical support to Burkina Faso. Two of them, a soil scientist and an animal production specialist, joined the national FSR department in March 1985; the third scientist, an agricultural economist, joined the department in September 1985.

The FSR activities in Northern Benin were initiated late in the 1985 season. In order to take advantage of the season, on-farm and on-station research-managed trials were initiated, even though such studies should ideally have been conducted after data from the socio-economic studies had been collected, analysed and interpreted. It was, however, considered appropriate and useful to initiate some agronomic on-farm trials after certain information had been gathered during the preliminary exploratory surveys. Concurrently, preliminary socio-economic surveys were conducted in Borgou and Atacora provinces in Northern Benin. Two scientists were recruited and based at Ina to provide both technical and administrative support to the Benin FSR programme. The agronomist started in March 1985 and the agricultural economist who had been recruited for the Cameroon FSR programme, was temporarily assigned to INA to undertake the socio-economic base-line surveys. Initially, six villages were identified as sites for FSR activities, representing the three ecological zones: the sudan, sahel and northern guinea savanna.



The protocol of agreement was signed between OAU/STRC and the Government of Cameroon in November 1985. The programme is well-integrated with existing research activities. Research scientists at both Maroua and Garoua stations participate in the FSR programme, which will include cropping systems, soil fertility and socio-economic studies.

This report covers results of Farming Systems Research activities supported by IFAD in Benin and Burkina Faso. In addition to helping develop appropriate farming systems in the three countries, IFAD participation has also resulted in substantial progress being made in the improvement of research coordination among the national research programmes and International Agricultural Research Centres (IITA and ICRISAT) within the SAFGRAD project. Progress made along such lines, with regard to the overall SAFGRAD project, is reported elsewhere.

The OAU/STRC SAFGRAD Coordination Office has provided administrative and technical backstop support to each SAFGRAD-supported FSR programme. The approach that was adopted was to integrate both the technical and administrative aspects of the FSR programmes with the National Agricultural Research Systems (NARSs). Following lengthy discussions with officials and scientist of host countries, it was agreed that the FSR Coordinator or National Director of Research (or his designee) and the SAFGRAD team leader would administer the FSR programme at the national level.

Funding support by IFAD has facilitated the realization of the national FSR programmes in Benin, Burkina Faso and, most recently, Cameroon. The Cameroon FSR programme, also started in February 1986.

In order to facilitate the disbursement of grant funds at the country level, special bank accounts were opened, both in Burkina Faso and Benin. The national FSR Coordinator or the designee of the National Director of Research, together with the SAFGRAD team leader, were the co-signatories for joint management and disbursement of funds in each of the respective countries.



## S U M M A R Y

In Benin, preliminary surveys were successfully carried out in various villages of Borgou and Atacora provinces. The inventory of farm activities covered types of crops grown, cropping calendar, rainfall amount and distribution, source of farm power etc. This survey was followed by socio-economic studies in six villages.

The traditional farming system is largely characterized by shifting cultivation where farmers' exhausted land lie fallow for three to four years. A diversified cropping system is greatly dominated by crop associations. Most farmers grow cotton in pure stand and use fertilizer and insecticide to improve its yield. The most important crop enterprises in the sahelian zone are millet and cotton and each being grown by 76% of the farmers; sorghum and groundnuts are grown by 69% of the farmers. In the sudan savanna zone, cotton is the most important cash crop. Cassava, groundnuts, millet, maize/sorghum and beans are grown by 85, 64, 57 and 35 per cent of the farmers, respectively.

Cotton is a crop that has strong backing of extension service including credit facilities for ox plough, fertilizers, seeds and insecticides. Most farmers have adopted the practices in case of cotton. Farmers, although interested in obtaining improved varieties of maize, sorghum and other food crops, rarely use fertilizers and other recommended agronomic practices. The common agronomic practices are slash and burn, plough or dig the land, planting on flats or ridges, mounds for yams and cassava. In the sahelian zone, land preparation is mostly done by oxen for growing millet, cotton, groundnuts and sorghum, whereas less than 50% of the farmers in the sudanian zone use animal traction for the cultivation of cotton, maize/sorghum, and millet. In the northern guinea savanna zone less than 20% of the farmers use animal traction and instead, hoe and similar tools are used to make ridges, holes and mounds for groundnut, cotton, yams and cassava cultivation.

Livestock plays an important role in the production systems in northern Benin. In the sahelian, sudan and guinea savanna zones, 54, 50 and 60 per cent of the farmers keep a stock of cattle, goats and sheep. The interaction between crop and livestock production is becoming increasingly significant due to the use of animal traction. In the sahelian savanna zones, practically every farmer has oxen



for draught power, while 78 and 12 per cent of the farmers in the sudan and guinea savanna respectively have animal traction giving an average of 39% of the farmers who use cattle in the sahelian and sudan savanna zones, most of the cattle belong to nomads who do little or no farming and have probably moved there in search of suitable grazing pastures.

Researcher-managed trials have been established at Ina, Sokka, Bensekou and Birni Lafia in Borgou Province. These experiments covered maize, sorghum, cowpea, groundnuts, millet and cotton. Yams and cassava, though important, have been left out because the planting season was missed. The performance of local and improved varieties were evaluated either on the flat or ridges. The use of cotton fertilizers which is widely accepted by the farmers for cotton, but not for food crops, was investigated. The contribution of green manure to maize yield was evaluated. At the three sites (Ina, Sokka and Bensekou), highest yield was obtained with local sorghum. Overall application of fertilizer increased total yield by 50%.

Intercropping maize and cotton always reduced the yield of individual crops and the combined yield was not in any case higher than monoculture maize. Sorghum grown on the flat yielded more than sorghum grown on ridge. Similarly, higher values were obtained with fertilization. Overall, low income was realized when sorghum was grown in pure stand and highest income was attained when cowpeas were grown in monoculture. When crops were grown in association the cash income was higher than sorghum alone.

Forest clearing, decrease in fallow period and exhaustive soil management practices have led to low soil fertility of the area. Success in agricultural development is thus linked to the improvement of the soil resource base. It was recommended that special emphasis should be placed on the improvement of soil fertility. Furthermore, work on legume crops adopted to drought, such as pigeon pea and bambara nut, were initiated.

*Burkina Faso - FSR*

The major FSR activities that were conducted in Burkina Faso are summarize below:

Preliminary research activities were conducted in 1985 in three villages of Burkina Faso where adequate socio-economic data existed. Concurrently, long-term sites for the National Farming Systems Research Programme were identified between late 1985 and early 1986. The three villages were Nedego, 30 km northwest;



Diapangou, 210 km east and Poedogo, 310 km south-east of Ouagadougou. Diapangou contains areas with sizeable fallow land where mixed crop and animal farming are practiced. The vegetation still has notable tree covers. Varying intensities of land use, ranging from bush land to fields cultivated for decades, are observed within short distances. The stage of mechanization ranges from use of simple hand tools to animal drawn implements and even rented tractors. In Nedogo, agricultural practice is predominantly settled and crop-dominated. There is limited fallow area in Nedogo. Poedogo has agricultural characteristics intermediate between the two, i.e, more mixed farming; more fallow land and tree cover than in Nedogo. Soil erosion marks were noted in the three villages with the problem most pronounced in Poedogo.

The major food grains are sorghum, millet and maize, and some legumes. Maize is drought-sensitive and requires more fertile soils. It is cultivated on small intensively managed plots (0.1 - 0.2 ha) near the compounds where manure and other forms of organic matter are applied. Yields on the small plots range from 0.6 to 1.4 t/ha. Sorghum is planted near lowlands where there is some water collection while millet is grown on relatively poorer soils. Yields are less than 1 ton/ha. Similarly, legume yields (cowpea, peanuts, bambara nut, etc) rarely exceed 700 kg/ha at the farm level.

↓ It was noted that maize has more potential than sorghum under improved management. With improved soil-water management and soil fertility maize could be grown on fields previously cultivated with sorghum which could in turn be grown on former millet fields. In contrast to sorghum and maize, millet and legume crop yield improvement have not been consistent. Similarly, effects of Burkina phosphate and manure application on crop yields were variable. It is understood that due to the long period required for restoring soil fertility, improved yield increments over a large area, would take time.

↓ Previous technological interventions at the farm level, considered soil-water management, application of minimal amounts of fertilizer (100 kg/ha NPK, 50 kg/ha urea), testing of improved cereal crop varieties, legume cereal crop associations, evaluation of Burkina phosphate as a source of phosphorus fertilizer, and application of manure. Tied-ridging was the soil-water management technology introduced. This is the construction of small depression between crop rows, either by hand tillage or with a combination of animal traction and hand tying of ridges. Tied ridges prevent



runoff, thereby increasing soil moisture storage. The practice of tied ridging by hand has limited prospects of expansion due to its high labour requirement. A mechanical ridge tier pulled by animals (ox or donkey) has been developed to reduce the labour requirement. Trials conducted on farmers' fields indicated that significant improvement of yield increments were obtained when fertilizer was applied in combination with tied-ridging.

The soil fertility investigation included, the evaluation of fallow fields that had very low levels of organic matter, available phosphorus and exchangeable bases. Samples from compound fields, adjacent to Nere and Acacia albida trees, and those from termite mounds had higher values of exchangeable bases (K, Ca and Mg). In addition, compound fields and samples from nearby Nere trees had higher values of organic matter and available phosphorus. Application of Burkina phosphate up to 200 kg/ha for four years, did not influence available phosphorus noticeably. Localised fertilizer application, leading to heterogeneity, may prevent detection by soil sample analysis of any changes.

Millet fertilization with manure was also conducted at Diapangou in 1985. Manure application up to 3.1 t/ha each year for two years, did not influence millet yields significantly. Similarly, there was no significant effect on yield of Burkina phosphate applied during the first year. There was a significant response of millet grain and stalk yield to the application of 110 kg/ha NPK. The results were consistent with those obtained in 1984 for the same site. The mean grain yield was 611 kg/ha without fertilizer and 784 kg/ha with 100 kg/ha of NPK. Corresponding stalk yields were 5130 and 8110 kg/ha on air dried weight basis. Framida managed trials were carried out in Poedogo with Framida (on improved variety) and local red sorghum. Framida outperformed the local variety with and without inputs. Grains, as well as stalk higher yield were recorded for Framida with inputs. Stalk yields were 3450 kg/ha for local variety and 4060 kg/ha for Framida. Net revenue gain of as much as 10,000 CFA/ha could be obtained if Framida were grown in place of the local variety. This involves no additional labour or fertilizer use. Return on additional labour under an improved management level was more than twice as much as the labour opportunity cost, of 50 CFA/hour for Framida. With the local variety, returns to additional labour were less than the labour opportunity cost.

The livestock component experiments comprised evaluation of forage legumes, assessment of the establishment on abandoned land and conservation of forages for dry season feeding. The work has emphasized the use of abandoned fallow land to grow forage legumes for animal feed and partial regeneration of soil fertility. It was hypothesized that such work could demonstrate, over time, the benefits of regenerating the soil to lead to higher crop productivity and stable agriculture in the area.



## BURKINA FASO FSR

### BACKGROUND

Food production by small farmers is partially impeded by the socio-economic constraints that influence the conditions and rate of adoption of technology. The main objective of FSR has been to develop appropriate agricultural technologies that can globally fit the physical and socio-economic conditions of small farms.

Farming Systems Research (FSR) commenced in Burkina Faso during the last decade and has been carried out mainly by FSU, ICRISAT and IRAT.

Previous FSR programmes have carried out mostly cropping systems research.

The programmes have concentrated for the most part on improvement of crop productivity and have given relatively little attention to the improvement of the farm resource base which is being severely degraded as a result of increasing demographic and livestock pressures.

An OAU/STRC/IFAD consultative mission to Burkina Faso, Mali and Senegal recommended that SAFGRAD strengthen the FSR programme in Burkina Faso with a new FSR team composed of an agricultural economist, a soil scientist and an animal production specialist. The mission recommended a much more active programme of resource management systems studies which involve trees, livestock, crops and other inputs (Couprie et al, 1984). The mission proposed that the new FSR programme in Burkina Faso pursue the following objectives :

1. To evolve sustained systems of production in the semi-arid zone for small or poor farmers whose systems have major cereal (maize, sorghum, millet) and/or grain legume (cowpea) components.
2. To develop an effective communication system between farmers, extension workers, research scientists and others, and to ensure that agricultural research is relevant to the short and long term needs of poor farmers.

In early 1985 a reorganization of the research structures of INERA (Institut d'Etudes et de Recherches Agricoles), the Burkina Faso National Agricultural Research Institute, led to the creation of eight national agricultural research departments including the Farming Systems Research Department within the Institute.



The farming systems department is viewed within INERA as an important department of the Institute. It is described as a "horizontal" department which is expected to link all the other departments of the institute to one another, to extension agencies, and to farmers, so as to increase their efficiency in solving the agricultural development problems of the country.

A National Farming System<sup>s</sup> Research Programme was then elaborated by INERA and has been approved by a national seminar (Seminaire national sur la Recherche Agronomique au Service des Agriculteurs) held in Ouagadougou from February 11 to February 15 of 1985. Prior to the elaboration of the national FSR programme, a protocol of agreement was signed in October 1984 between OAU/STRC and the Burkina Faso Government to strengthen the national farming systems research through IFAD technical and financial assistance. The National Farming Systems Research is based at the Kamboinsé Research Station.

#### OBJECTIVES

The global objective of the National FSR programme is to advance the development of technologies and rural development policy actions that are adapted to the actual conditions of farmers so as to increase food production and a greater food security. The specific objectives of the programme may be summarised as follows :

1. To study current farming systems in Burkina Faso with multidisciplinary teams of scientists so as to acquire more knowledge on the farming systems conditions, in order to identify small farmers' problems and particularly, the technical and socio-economic constraints on adoption of new technology.
2. To develop a system of communication and dialogue between farmers, thematic researchers, and developers so as to influence the objectives and the methodology of the thematic research and rural development programmes in a way that would enable such programmes to address the actual problems and needs of small farmers.
3. To develop, in full collaboration with farmers, thematic <sup>re</sup>searchers and extension agencies, farming technologies that could fit into farmers' conditions, and help alleviate the major production constraints.



4. To train national scientists and technicians to assume full responsibility in the implementation of the national programme.

The expected output of the Programme include :

1. An increase in the general state of knowledge of the technical and socio-economic constraints on farming systems in Burkina Faso.
2. A system of communication and dialogue between farmers, researchers and developers (including extension agents) to discuss farmers' problems and to search for solutions to such problems.
3. An increase in the relevancy of thematic agricultural research programmes and rural development programmes thereby increasing efficiency in tackling farmers' problems.
- X 4. The generation, modification and <sup>adaptation</sup> adaption of a certain number of technologies to fit farmers' needs and conditions, so as to provide the farming systems with a greater stability and a greater food security.
5. The training of national scientists and technicians to assume full responsibility in the implementation of the national programme all over the country.

#### Implementation strategy

X The implementation strategy of the programme consists <sup>in</sup> of extending the programme activities over the whole country in two phases. During the first phase, two FSR teams are to be activated : one based at the Kamboinsé station, near Ouagadougou, to cover the Mossi Plateau; the other based at Farako-Ba, near Bobo-Dioulasso, to cover a large part of the western region of the country. The programme activities are expected to be extended to the northern and eastern parts of the country during the second phase.

#### Collaborative linkages

Besides the farmers with whom the regional teams are expected to work, each regional team has established close working relationship with two other types



of partners. These are the researchers and the development agencies working in the region.

The research partners of the regional team include the thematic researchers of INERA, the Faculty of Agriculture of the University of Ouagadougou and members of the local branches of the international agricultural research centres. The development partners include the regional rural development agencies (or ORDs) and the agricultural development policy markers. The collaborative links with the regional development agencies are mostly established through the Research-Development units of the ORDs where they exist, such as in the ORD of Yatenga, and through the extension services of the ORDs.

The role of FSR is to strengthen direct links between thematic researchers, extension-development workers and farmers.

The implementation of the programme will be carried out through the execution of ten activities. These activities are listed in Table 1 along with their optimal execution periods.

#### Advantages over previous FSR programmes

The Farming System Research Programme is an integral unit of the national research system. It has therefore direct administrative and technical links with all the national thematic or commodity research programmes of INERA and also with the international agricultural research programmes in Burkina Faso. As a national programme, it has a broader capacity to facilitate agricultural research and development in the country than any previous FSR programme and thus to increase their relevancy vis-a-vis farmers' needs. The IRAT Recherche-Développement Programme has been integrated within the National FSR programme. The programme also has access to a wider range of new technologies than previous ones. It can use any technologies developed in Burkina Faso or elsewhere in the design, testing, and evaluation of technological packages.

Furthermore, unlike most previous FSR programmes, the national FSR programme takes into account the animal production and agro-forestry components of the farming systems in Burkina Faso and places more emphasis on the development of technologies to stabilize and improve the farming systems resource base (particularly soil fertility, water, livestock and forest resources) than on the development of technologies to increase only crop productivity.



### Rainfall pattern 1985 season

The total rainfall for 1985 was 608.6 mm in Nedogo and 597.9 mm in Diapangou. The long term average values for adjacent stations (Pabre, near Nedogo and Fada N'Gourma, near Diapangou) are 809 and 865 mm respectively. The rainfall amounts for 1984 in Nedogo and Poedogo were 452 and 458 mm respectively.

Rainfall was recorded in three locations, not more than 10 km apart, in Poedogo. Levels for the three stations were 784.7, 805 and 735.5 mm. The difference of 70 mm between nearby locations gives an indication of the spatial variability even over short distances. The long term average for Manga, near Poedogo, is 865 mm. The value for 1984 was 633 mm in Poedogo. Rainfall in 1985 was higher than in 1984 but still lower than the long term average.

Early rains started in mid-April, early May and mid-May in Poedogo, Diapangou and Nedogo respectively. The early showers stopped around late May. June rainfall was irregular in Nedogo; as a result, two to three plantings were required. Reliable rainfall from July to August favoured good crop development. In Diapangou, however, grain filling was affected by serious drought at the end of the season. Only early maturing crops gave satisfactory grain yield.

Rainfall distribution was uneven. A high proportion of the seasonal rainfall occurs in a few showers around August, while a large number of heavy showers contribute an ineffective quantity of rainfall early in the season. As much as 14.5% of the total rainfall in Nedogo is accounted for 56 mm (9.3%) of total rainfall and two storms (3.8%) in Poedogo contributed to 84 mm (10.4% of total). Such rainfall distribution results in severe crop moisture stress at critical stages of growth while a few heavy showers contribute to serious runoff and soil erosion. The problem is further aggravated by the low moisture intake and moisture holding capacity of the soils in the area. As an illustration, it was observed that on August 2 a storm covering areas around Diapangou, Poedogo and Ouagadougou caused heavy runoff. Such incidents create havoc for agricultural production. On the other hand, there is the possibility that substantial runoff can be collected to be used subsequently to alleviate stress during critical crop growth stages.

Long term analysis of rainfall and its implications for agricultural productivity have<sup>s</sup> been carried out. One such study (Alberget and Grouzis, 1985) indicates that, among other things, years of deficit rainfall tend to be clustered, i.e, periods of deficit rainfall were persistent. Further, crop deficit years were closely related to rainfall deficit or maldistribution.



Results of Nedogo trials

All three treatments which used tied ridging resulted in significant yield increases over the control. However, due to the timing of the rains, yield increases were only 18-29% in 1985 compared to 60% in 1983 and 18% in 1984. Yields are higher when ridges were tied normally. There was no difference in sorghum yields between mechanically tying the ridges, with ox-traction or donkey traction (Table 13). Economic analysis indicated that net revenue kg/ha of all three tied ridging treatments were above that of the control. The net revenue gain per hectare of tying by hand was higher than that of using the MRT. Some problems encountered by farmers with the machine were noted. The main problem was that the machine was too heavy and hard on the animals pulling it. Farmers indicated prospective use of the machine on sorghum and millet fields. It is concluded that more work is required to :

- . Reduce the weight of the machine
- . Establish geographical areas and soil conditions suited to tied ridging
- . Increase adaptability of the machine across a wide range of equipment.

As the conclusions are based on 14 farmers in one village, wider testing and improvement of the machine is needed before it can be used on a larger scale. More detailed discussion of the experiment is presented by Nagy et al, 1986.

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## 1.0 AGRONOMIC TRIALS AND TECHNOLOGY EVALUATION

### 1.1 Millet/cowpea association on fallow-land

As land use becomes more intensive there is a need to maintain soil productivity. One way of achieving this objective is by growing a cereal crop in association with legumes. The latter would contribute to soil fertility improvement through nitrogen fixation. The incorporation of crop residues would gradually improve the soil productivity.

Farmers use little purchased input on the marginal land. Thus, the experiment was conducted with no purchased inputs on land abandoned two years ago at Diapangou. (FSU report 1983/84)

The treatments were :

- . Local millet at a density of 30,000 pockets per hectare;
- . Local millet and cowpeas (TNA 8863) at 30,000 pockets/ha each;
- . Local millet and cowpeas as in (2). Cowpeas to determine forage dry matter;
- . Local millet at 30,000 pockets/ha and cowpeas at 60,000 pockets/ha.

The treatments were assigned to a random complete block design with four replications. Millet was planted at a spacing of 80 cm between rows and 40 cm between plants for the lower density, and 20 cm between plants for the higher density (60,000 plants/ha). Due to delays in land preparation planting was delayed to mid-July.

### Results

Millet establishment was slow. Cowpeas germinated well and covered the ground within one month. However, insects destroyed the cowpea crop later in the season. The most prevalent insects identified were :

Pod feeders ..... Corcidae and Pentatomidae  
Flower and pod feeders ..... Meloidae

Insect infestation was noted to be higher than in nearby farmers' fields. This is attributed to the fact that the plots were isolated, i.e, surrounded by grass vegetation.

The grain and stalk yields of millet are summarized in Table 1. Grain yields were low due to late planting and striga infestation. Analysis of soil samples also indicated very low levels of available phosphorus and organic matter. Stalk yields decreased with the density of intercropped cowpeas, presumably due to competition by cowpeas early in the season.



OBJECTIVES

The objectives of the trial were :

- . To obtain and compare the yield of mechanical ridge tier (MRT) to flat cultivation and ridging by hand;
- . To evaluate the economic profitability and labor demands of the MRT, and
- . To obtain technical data on MRT and information on operation by farmers.

The trial was conducted in :

- Nedego : seven farmers with donkey-traction and seven farmers with ox-traction
- Poedogo : fifteen farmers with ox-traction
- Diapangou : fifteen farmers with donkey-traction and fifteen farmers with ox-traction.

The treatments were :

- . Traditional animal traction tillage (control). Weeding one and two months after planting with a cultivator.
- . Tying ridges made by animal traction every 1 to 1.5 m and by hand at the second weeding
- . Tying the ridges mechanically with MRT at the second weeding;
- . Tying the ridges mechanically with MRT at the first and second weedings.

The last treatment was included to evaluate feasibility and profitability of tying ridges twice compared to once in treatment 3.

Farmers managed and carried out the experiments. Fertilizer was supplied by the IFAD-supported National Farming Systems Research Programme. All treatments received 100 kg/ha NPK (14-23-15) two to three weeks after planting plus 50 kg/ha of urea about two months after planting.

Trials in Diapangou were conducted too late and the experiment was abandoned. There was insufficient data on Poedogo trials. Only data from Nedogo were presented.

Crop residue could not be incorporated into the soil at the end of the season; the surface became too hard after harvest. Tillage at the end of the season was not feasible due to the high draught power requirement.

Studies on intercropping cowpeas with cereals under traditional management need to consider varieties that are more tolerant to insect attack or alternative legume crops.

## 1.2 Millet fertilization with manure

The experiment was conducted to evaluate the cumulative effect of manure applied in 1984 and 1985 and the residual effect of manure or Burkina phosphate from the first year. The trial was conducted in Diapangou on the same location as in 1984 (Ohm, H. Nagy, J. and Pardy, C. 1985). The treatments were:

*details of experimental treatments are reported elsewhere (1985 Burkina Faso report)*

### Control with no fertilizer

- . Fertilizer (14-23-15) at 100 kg/ha applied on a band 10-15 cm wide from seed pockets two weeks after planting.

The fertilizer trial comprised main plot treatments in a split-plot design with two observations of each of the two whole-plots. The subplot treatments were

- . No application of manure, control;
- . Manure, 3.1 t/ha, applied in 1984 and 1985;
- . Manure applied, 3.1 t/ha, in 1984;
- . Manure, 3.1 t/ha, and Burkina phosphate (1000 kg/ha) applied in 1984.

Cattle manure was sun-dried, mixed and applied 10-15 cm from seed pockets. Tied ridges were constructed before planting, 80 cm apart and tied at one meter intervals. Local millet was planted on July 9 at a spacing of 80 cm between rows and 40 cm between pockets resulting in an approximate density of 30,000 pockets/ha.

## Results

Millet growth was satisfactory. Downy mildew attack was slightly lower this year than that observed in the 1984 treatment; effects were similar. Manure (table 2) application did not influence yields significantly either year. There was a significant response of yields to fertilizer application. Soil analysis results did not indicate any significant effect of Burkina phosphate on available phosphorus. Similarly there was



Table 1. Grain and stalk yield of local millet grown in association with cowpea, Diapangou 1985.

Treatment	Millet grain yield, Kg/ha	
	Grain	Stover
Pure millet	287 a	918 a
Millet + Cowpea (30,000 plants/ha each)	318 a	709 b
Millet (30,000 plants/ha) + Cowpea (60,000 plants/ha)	156 a	495 c
LSD	167	141

- Cowpea TNA 8863

- Means having common letters are not significantly different from each other at 5% level by Duncan's Multiple Range Test.

Table 2. Millet yield response to manure, fertilizer and Burkina phosphate.

Treatment	Millet grain yield, kg/ha	
	Grain	Stover
Fertilizer		
Without	611 b	5130 b
100 kg/ha NPK	784 a	8110 a
Manure (M)		
Without M	690 a	6450 a
With M, 1984 + 1985	728 a	7720 a
With M, 1984	645 a	6250 a
With M and ABP, 1984	728 a	6060 a

- Means with common letter within a column are not significantly different from each other at 5% level (Duncan's Multiple Test).

- M manure 3.1 t/ha; - ABP, acidulated Burkina phosphate  
- 100 kg/ha.

- L.S.D - Grain = 125

Stover = 242



no significant difference in organic matter content between plots receiving manure and the control. It is inferred that 3.1 t/ha of manure for two years was not enough to influence millet yield. (Table 3)

### 1.3 Response of sorghum to fertilizer application

The objective was to determine response of sorghum, ICSV 1002, to NPK fertilizer application. This was a follow up of a more detailed experiment conducted in 1984 (Ohm H., Nagy J., and Pardy G., 1985) in five villages. The present experiment was carried out with reduced number of treatments in one site, Nedogo.

The treatments were :

- . Neither tied ridging, nor fertilizer. Control;
- . Tied ridging before planting. No fertilizer;
- . Tied ridging with cotton fertilizer, 100 kg/ha NPK;  
(14: 23: 15) at planting;
- . Tied ridging with 200 kg/ha NPK;
- . Tied ridging with 200 kg/ha NPK. Micronutrients to be sprayed one month after planting (not conducted due to delays of procuring micro-nutrients)

The design was randomised complete block. Sorghum was planted on July 12. Seedling establishment was poor due to attack by shoot fly and furadan had to be applied for control. Two transplantings were required (July 20 and 29) before satisfactory seedling establishment could be obtained. Sorghum was harvested 107 days after planting.

### Results

Favorable rainfall distribution during late July and August resulted in good sorghum development. There was complete head formation (100%).

Plants with fertilizer and tied ridging were taller compared to the control starting two weeks after planting. Similarly flowering was earlier with tied ridging and fertilizer application. Grain and stalk yield values were significantly higher with higher management (tied ridging and fertilizer use). Sorghum response with 200 kg/ha NPK was, however, comparable to that with 100 kg/ha NPK implying (Table 4) that other nutrient<sup>s</sup> may be limiting yield at the high input level. Thus, investigations on micronutrient availability may be worthwhile.

Sorghum grain yield in 1985 was slightly higher than for 1984. This is attributed to the more favorable rainfall distribution in 1985.



Table 3. % organic matter and available phosphorus in soil samples of millet field (Diapangou)

treatment	% O.M		Available P, ppm	
	Without fertilizer	With fertilizer	Without fertilizer	With fertilizer
No manure	0.78	0.82	4.03	1.14
Manure, 3.1 t/ha 1984 + 1985	0.86	0.81	1.85	Trace
Manure, 3.1 t/ha 1984	1.66	0.56	2.37	Trace
Manure + ABP, 1984	1.14	0.62	2.05	Trace

Table 4. Sorghum (ICSV 1002) response to tied ridging and fertilizer application, Nedego

Treatment	Mean Yield	
	Grain	Stover
Control	352 b	2773 b
Tied ridging, No fertilizer	459 b	3037 b
Tied ridging, + 100 kg/ha NPK (14-23-15)	1143 a	5010 a
Tied ridging + 200 kg/ha NPK	1348 a	5020 a
L.S.D	432	468

- Means followed by a common letter within a column are not significantly different at the 5% level by Duncan's Multiple Range Test.
- Cotton fertilizer (NPK 14-23-15) applied in a band 10-15 cm from seed pockets.
- Tied ridges constructed prior to planting
- Control had neither tied ridging nor fertilizer.

#### 1.4 Evaluation of early sorghum varieties at two levels of management

The objective was to compare performance of four sorghum varieties at two levels of fertilizer and soil-water management combinations.

The varieties were IRAT 204, ICSV 1002/Kanfiagui and local sorghum. The management levels were as follows :

- . Neither tied ridging nor fertilization;
- . Tied ridging and fertilizer

All varieties were assigned by management level combinations to a randomized block design with four replications. The experiment was conducted in Nedego.

Sorghum was planted on July 13, 80 cm between rows and 40 cm between pockets with 2 plants per pocket. Fertilizer NPK (14-23-15), applied at 200 kg/ha, was side dressed 10-15 cm from seed rows two weeks after planting and urea, at rate of 50 kg/ha, was applied one month after planting. Ridges, 80 cm apart and tied at one meter intervals were constructed one month after planting.

Sorghum establishment was poor early in the season due to an attack by shoot flies. Later in the season plant development was good.

#### Results

Sorghum development was rapid after establishment. All varieties were taller with tied ridging and fertilizer application. Kanfiagui and the local sorghum varieties were tallest at harvest. The difference was more marked with fertilizer use and tied ridging. (Tables 4 & 5)

IRAT 204, Kanfiagui and the local sorghum variety at the improved management level flowered in 55, 67 and 69 days respectively. The corresponding values at low management levels were 81, 76 and 77 days in that order. ICSV 1002 flowering did not differ with management level. It flowered 86 days after planting. All four varieties had completed head formation (100%) (Table 7).

Stalk yield was highest for ICSV 1002. The remaining three varieties had comparable stalk yield. The mean stalk yield values were much higher with fertilizer use and tied ridging. For all four varieties stalk yield was trebled at the higher management level compared to the control. This would suggest that availability of crop residue could be significantly increased by improved crop management



Table 5. Sorghum (ICSV 1002) development with tied ridging and fertilizer application.

	Plant height - cm			Days to 50% flowering
	Two weeks after planting	One month after planting	at harvest	
Control	17 c	62 c	110 c	87 a
Tied ridging no fertilizer	20 b	76 b	127 b	87 a
Tied ridging + 100 kg/ha 14-23-15	24 a	118 a	154 a	80 b
Tied ridging + 200 kg/ha 14-23-15	24 a	123 a	160 a	81 b
L.S.D	1.5	9	8.6	2

- Means followed by a common letter within a column are not significantly different from each other at the 5% level by Duncan's Multiple Range Test.

Table 6. Sorghum varieties yield at two levels of management.

Treatment	Yield in kg/ha	
	Grain	Stalk
Traditional management		
IRAT 204	400 cd	810 d
ICSV 1002	264 d	1910 c
Local variety	382 d	980 d
Kanfiagui	528 cd	900 d
Improved management		
IRAT 204	1924 a	2850 bc
ICSV 1002	733 c	5130 a
Local variety	1485 b	3000 b
Kanfiagui	1885 a	2720 bc
L.S.D	322	900

- Means followed by a common letter in the same column are not significantly different at the 5% level by Duncan's Multiple Range Test.

Traditional management - Neither fertilizer nor tied ridging were used  
Improved management - Tied ridging one month after planting. Fertilizer applied at 200 kg/ha, NPK (14-23-15) two weeks after planting and urea at 50 kg/ha was applied one month after planting.

and variety selection. As the biomass production increases more plant material can be obtained for mulching, animal feed supplement and other uses. Grain yield was significantly influenced by the management level. Increases in grain yields were on the order of 177% for ICSV 1002, 257% for Kanfiangui, 290% for the local variety and 380% for IRAT.

Under improved management IRAT 204 was ready for harvest 93 days after planting, Kanfiangui in 101 days followed by the local variety in 105 days and 107 days for ICSV 1002. Under traditional management IRAT 204 matured latest : 107 days after planting. The harvest date of the other three varieties was the same under the two management levels.

## 2.0 FARMER MANAGED TRIALS

### 2.1 Effect of tied ridging and Burkina phosphate on millet yield

The objective was to test the effects of Burkina phosphate applied over four consecutive years and tied ridging on millet yield. The treatments were :

- . No tied ridging, no fertilizer.(Control)
- . Tied ridging at second weeding without fertilizer;
- . Burkina phosphate, 100 kg/ha, applied in seed pockets and urea, 50 kg/ha at first weeding (1982-1985)
- . Burkina phosphate, 200 kg/ha, and urea 50 kg/ha (1982-1985);
- . Burkina phosphate, 100 kg/ha, and urea 50/kg/ha (1982-1985). No tied ridging.

Treatments were assigned in randomized block design with one replication per farmer. There were ten farmers with donkey traction in Nedego who participated in the experiment, on the same locations as in the previous three years.

### Results

Millet grain yields were twice as much in 1985 as those for 1984 (Ohm et al) 1985). However, unlike the results of 1984, the effect of treatment, on grain yields in 1985 were not significantly different. However, there was an increase in grain yields with tied ridging and fertilizer compared to the control. It is inferred that, due to higher rainfall amount in 1985, the effect of tied ridging was not as marked as in 1984. With more favourable rainfall distribution higher levels of soluble forms of P may have been required to increase yield. (Table 8)



Table 7. Sorghum varieties development at two levels of management.

- 22.

Treatment	Plant height cm			Days to 50% Flowering	
	Two weeks after planting	One month after planting	At harvest		
Traditional management					
IRAT 204	18 a	40 c	105 d	81	ab
ICSV 1002	21 a	50 c	113 d	86	a
Local	18 a	36 c	198 b	77	b
Kanfiagni	19 a	41 c	177 bc	76	b
Improved management					
IRAT 204	22 a	90 ab	118 d	55	d
ICSV 1002	22 a	81 ab	152 c	86	a
Local	20 a	79 b	289 a	69	c
Kanfiagui	20 a	100 a	287 a	67	c
L.S.D	41	18	29		7

- Means followed by a common letter within a column are not significantly different from each other by DMR test.

- Traditional management - Neither fertilizer nor tied ridging was used
- Improved management - Tied ridging one month after planting : with 200 kg/ha PK (14-23-15) applied two weeks after planting and urea at 50 kg/ha, applied one month after planting.

Table 8. Farmer managed millet grain yields, kg/ha, at different levels in Nedego

Treatment	Grain Yield kg/ha
Control	548 a
Tied ridging	645 a
Tied ridging + BP, 100 kg/ha, + urea	734 a
BP, 200 kg/ha, + urea	691 a
BP, 100 kg/ha + urea	639 a
CV %	27.8
N	10
L.S.D	163

- Means followed by a common letter are not significantly different Duncan's Multiple Range Test.

- Tied ridging at second weeding
- BP, Burkina phosphate applied in seed pockets at planting (1982-1985)
- Urea, at 50 kg/ha, 1982-1985, applied at first weeding.
- N= number of replications or number of farmers conducting trial.

A partial budget analysis showed that tied ridging alone gave a return on the additional labor of 91 CFA/hour as compared to that of tied ridging with fertilizer application which gave a return of 69 CFA/hour. (Tab.9)

Using a high dose of fertilizer without tied ridging returned 46 CFA/hour. There was no economic benefit in using low doses of Burkina phosphate. As much as 40-60% of the farmers would have lost cash with the application of fertilizer.

## 2.2 Red sorghum yield evaluation at two levels of management

The objective was to evaluate the performance of a local red sorghum variety and Framida at two level, of fertilizer and soil-water management levels. This experiment was similar to one conducted in 1984 by FSU (Ohm, et al 1985).

The treatments were

- . Local variety, at the traditional management level : no fertilizer and no tied ridging.
- . Local variety, using fertilizer NPK (14-23-15) at 100 kg/ha, applied at first weeding and urea, applied at 50 kg/ha at second weeding. Tied ridging was done at the second weeding.
- . Framida, at traditional management level;
- . Framida with fertilizer and tied ridging as in (2).

Treatments were assigned in random<sup>ized</sup> blocks with one replication per farmer. The experiment was conducted in Poedogo. Twelve farmers with ox-traction participated in the trial.

## Results

Seven farmers carried out the experiment as specified while five farmers modified the design. In the latter cases the fields were subjected to waterlogging.

Grain yield, of red sorghum for the seven farmers was analysed separately. (Tab.10 -11) The results indicate that Framida outperformed the local variety under both low and high management levels, but the differences were not statistically significant. In contrast to the 1984 experiment, Framida did not suffer from insect attack in 1985. In stalk yield Framida significantly outperformed the local variety under both management levels. Stalk yield was also higher with improved management.



Table 9. Economic analysis of farmer managed trials of millet with Burkina phosphate and tied ridges, Nedogo

	Control	TR	TR+P	2P	P
Grain yield, kg/ha	548	645	734	691	639
Yield above control	-	97	186	143	91
Gross gain CFA/ha	-	6,790	13,020	10,010	6,370
Net gain CFA/ha	-	6,790	6,520	910	-130
Return/hr. of additional					
Labor		91	69	46	-
% Farmers who would have					
lost cash	-	%	60%	60%	40%

Control = Neither tied ridges, nor fertilizer used

TR = Tied ridging one month after sowing.

P = 100 kg/ha Burkina phosphate applied in seed pockets at sowing and 50 kg/ha urea applied in pockets 10-15 from seed pockets two weeks after sowing.

2P = 200 kg/ha Burkina phosphate applied at planting and urea at 50 kg/ha at first weeding.

Net revenue gain: Yield gain x grain price (70 CFA/kg) minus fertilizer cost (Burkina phosphate 26 CFA/kg urea 78 CFA/kg)

Net revenue/additional labor of tied ridging and/or fertilizer application requires 20 additional hrs/ha

Opportunity cost of labor = 50 CFA/hour.

Table 10. Red sorghum yield at two levels of management in Poedogo

Treatment	Mean Yield, kg/ha	
	Grain	Stover
Traditional management		
Local red sorghum	1310 a	2510 c
Pramida	1480 a	3810 c
Improved management		
Local red sorghum	1560 a	3450 b
Pramida	1710 a	4060 a
N	7	7
CV %	26	30
L.S.D	450	540

Means followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

- traditional mangement, neither fertilizer, nor tied ridging used.

Table 11. Grain yield of red sorghum and millet where millet was intercropped with sorghum.

Treatment	Mean Yield kg/ha		
	Red Sorghum	Millet	Total
Local variety			
Traditional management	780	194	974
Improved management	939	170	1109
Framida			
Traditional management	482	318	800
Improved management	707	302	1002
N	5	5	5

Table 12 . Economic analysis of farmer managed trials of red sorghum in Poedogo

	MO		M1	
	Local	Framida	Local	Framida
Grain yield kg/ha	1310	1480	1560	1710
Yield above control	-	170	250	400
Gross gain CFA/ha	-	10,200	15,000	24,000
Net gain CFA/ha	-	10,200	12,100	11,100
Return/hr. of additional labor	-	-	22	117
% farmers who would have lost cash	-	0	43%	57%

- MO : Traditional management

M1 Improved management, Tied ridging at second weeding by oxen traction, 100 kg/ha NPK applied at first weeding, 50 kg/ha urea applied at time of tied ridging.

Local: Local red sorghum

Net revenue gain : Yield gain x grain price (60 CFA/kg) minus fertilizer

Cost (90 CFA/kg NPK and 78 CFA/kg urea)

Net revenue/additional labor for tied ridging and fertilizer application.

Tied ridging requires 75 hrs/ha of additional labor. Fertilizer application requires 20 additional hours/ha.

A sub sample of 7 Poedogo farmers who followed procedures.



For the five farmers who interplanted millet with red sorghum grain yields are summarized separately. The total grain yields for sorghum and millet range from 800-1109 kg/ha. These values are slightly less than for the red sorghum monocrops. However, since waterlogging was a problem the adjustment mechanism of the farmers seems a rational step.

Economic analysis using the data of the seven farmers indicated that replacing the local sorghum variety with Framida could give a net revenue gain of 10,000 CFA/ha with no fertilizer or additional labor use. With improved management, returns on additional labor would amount <sup>nt</sup> to 117 CFA/hour for Framida compared to 22 CFA/hour for local sorghum. The labor opportunity cost is estimated to be 50CFA/hour. Application of fertilizer could involve a cash loss for 43-57% of farmers. (Tab.12)

### 2.3 Evaluation of mechanical tied ridger

Tied ridging is traditionally practiced in the sahel - sudanian regions of Africa to hold water and increase soil-water retention. Research on the practice indicated that tied ridging can result in significant yield increases, especially when combined with fertilizer application (Rodriguez 1982, Nicou and Charreau 1985). Tied ridging is labor intensive, and to be effective, need to be conducted within the period from planting to the second weeding- ↗

-the period of high labor demand. A mechanical device attached to an animal drawn cultivator was developed to alleviate the labor constraint (Wright and Rodriguez, 1985). Two sizes were developed, one for donkey traction and a second for ox traction.

The mechanical ridge tier was tested as part of the 1985 National Farming Systems Research trial programme with FSU and IITA/SAFGRAD collaboration. FSU staff supervised the field trials and collected socio-economic data with the aid of the National Farming Systems field staff. The results of the findings have been reported separately (Nagy et al, 1986).

X X OBJECTIVES

X X X Results of Nedogo trials

Table 13. Sorghum grain yield for three methods of tied ridging at Nedogo

Treatment	Mean grain/yield <sup>1</sup> Kg/ha
Traction - MRT2	
Donkey	920.5
Oxen	882.6
SE	71.6
Tied Ridging Methods	
Control	740.0
TR-Manual	954.4
MRT-1	875.6
MRT-2	927.5
SE	62.8
CV %	19
N	14

SE = Standard Error of the difference between two treatment means.

Notes on Table

1. Local varieties of sorghum were used
2. Comparing mechanical tying of ridges by donkey traction with the mechanical tying by oxen traction.
3. Fertilizer NPK, 100 kg/ha, in a band 10-15 cm from rows of sorghum one month after planting and urea, 50 kg/ha, two months after planting.
4. No tied ridging
5. Manually tying ridges two months after planting
6. Mechanically tying ridges two months after planting
7. Mechanically tying ridges one month and again two months after planting.
8. Number of farmers' fields (replications)
  - 7 farmers with donkey traction and
  - 7 farmers with ox traction..



### 3.0 TOWARDS INTEGRATING LIVESTOCK AND FORAGE RESOURCES INTO EXISTING CROPPING SYSTEM

#### 3.1 Background

Natural pastures and crop residues constitute the basic diet for animal production. Creating improved conditions of these natural resources is of prime importance in the attempt to integrate animals in the crop production system.

Forage legumes appear to have the potential to enhance the favourable conditions in order to maximize animal production on limited land in the Mossi Plateau, the heavily cropped region in Burkina Faso. Forage legumes production on fallow (or arable) land could enable farmers to conserve more animal feed. The integrated system of production that is being evolved will lead :

- . To the efficient utilization of crop residues and natural pastures;
- . To the establishment of a feeding system that will fit into the requirements of the animals according to their physiological state throughout the year, overcoming the long dry season of feed deficit;
- . To an increase in the efficiency of draught power at anytime of the year;
- . To the reduction of movement of animals and allow the practise of feeding in enclosures, which in turn could lead to better production and management of manure for incorporation into soil or development of biogas; thus strengthening the integration between crops and animals through resource recycling (adhering to recent policy of the government).
- . To the long-term genetic improvement of animals for milk and meat production that could increase family income quantitatively and qualitatively.

Although not yet fully quantified under on-farm research conditions, the introduction of forage legumes is expected to lead to the partial restoration of the fertility of the soil through nitrogen fixation, and green manuring of the regrowth of annual legumes after cutting for conservation for feed. In the long-run the farmer could therefore depend for sources of nitrogen (the most important input which has been beyond his economic reach to purchase), on an appropriate integrated farming system based on managing of resources. Furthermore, fallow land could be improved through the progressive incorporation of organic carbon and nitrogen of the soil for subsequent cereal cropping.



In general, the systematic production of forage legumes and raising of livestock could facilitate the effective integration of crops and animal production in the Mossi plateau.

In the sudanian zone of Burkina Faso food crops receive greater attention than livestock despite the equally important role the latter could play in the economic life of the people. The larger ruminants are usually entrusted to herders, while small ruminants are kept on the property throughout the year, probably due to the low demand for feed and the minimum management required to rear goats and sheep.

The benefits that could be realized by keeping large ruminants are greater than those offered by small ruminants. Large ruminants can provide draught power to expand and intensify the crop production system, generate income through sales of milk and calves for reinvestment into the system and produce larger quantities of manure for partial fertilization of soil in addition to providing meat. Despite their knowledge of these benefits, farmers are discouraged from integrating large ruminants into the production system mainly due to the constraints of feed and water.

As a heavily cropped region the sudanian zone produces large quantities of crop residues which are highly valued as feed resources for use during periods of inadequate feed supplies. Natural pasture, usually seen standing mature and dry in the bush and fallow lands form the basic diet for animals. At times of feed deficit farmers are known to use up to 50 kg of cereals to supplement the diets of their draught animals (Jaeger, 1984). They also devote some labour time to the collection of wild plants for feed during the dry season.

Under such systems of production the animals are usually exposed to varying quantities and qualities of feed and rarely do these conditions allow the full expression of the animals' productive potential. Loss of liveweight and poor reproductive performance are common phenomena. This indicates that alleviating the constraints of feed and water is by far the most important task for the effective integration of livestock into the existing production systems.

Cellulosic energy is abundant in the region. However, its utilization is limited mainly by the lignification and <sup>low</sup> Nitrogen (N) content of the roughages. The utilization of such material is known to be responsive to dietary supplementation with N sources.



So far farmers have not placed due importance on the incorporation of forage crops in the production system. The economic benefits to be realized may need to be made obvious and the required inputs placed within their reach before they venture into the production of forages.

One of the major objectives of the animal production component within the FSR programme is to identify and help create the conditions that will allow the effective integration of animals into the production system through recycling of resources. Forage legumes possess an enormous potential as sources of N and could serve as the key link in the integration of crop and animal production systems.

Emphasis was, therefore, given to assess :

- . The performance of leguminous forages in biomass yield and nutritive quality;
- . The rate of change in the nutritive quality of natural pasture with time to enable identify the right stage of harvest;
- . The technical possibility of conserving forage legumes and natural pasture in the form of hay.

The species and cultivars kept by the national and international institutions in Burkina Faso were used for study at the Kamboinsé Research Station and three village sites : Diapangou, Nedogo and Poedogo. These studies were planned to be followed by feeding trials and management of manure for subsequent seasons' agronomic trials. However, due to the abandonment of village sites and lack of animal research facilities at Kamboinsé Station the intended feeding trials were not conducted. The report, therefore, discusses some aspects of the research on feed resources only.

### 3.2 Preliminary investigation on the establishment of forage legumes on fallow land and assessment of their nutritive values at different stages of growth.

As a result of the increase in organic carbon and nitrogen, legume crops in fallow soil have been observed to increase the yields of subsequent cereal crops (ILCA, 1983). They can also provide fodder of high nutritive value that could serve as a major thrust to increased animal productivity. In areas where prolonged fallowing is practised, the incorporation of legume might be a reliable source of nitrogen (N) which the farmer can harvest from his own property, for use by animals and for gradual restoration of soil fertility.



Before the introduction of new legume species into the farms, where the practice of forage production is non existent, preliminary experimentation was necessary to test the materials under the prevailing conditions.

The purpose of this study was :

- . To assess the establishment and agronomic characteristics of seven tropical legumes grown on fallow land without any input except ploughing.
- . To evaluate the chemical constituents and their biodegradability in the rumen of animals at different stages of growth to facilitate identification of the right stage of harvest to preserve nutrients for periods of deficiency.
- . To screen those legumes, the N of which could be compatible with the rate of digestion of crop residues.

#### Agronomic observations

All except S. humilis established, and viability of the seeds was suspected for the very poor germination. P. aureus and V. unguiculata c.v. KN-1 germinated and grew faster, flowering earlier than the rest (table 14), and the latter stayed green for longer time after podding. Besides the vigorous growth and biomass yield, on visual assessment, D. lablab showed few flowers sometime in October, after the rains had stopped, but failed to set seeds.

Germination of C. retusa was delayed but <sup>it</sup> established well. It tended to be stemmy for most of its growth period. When the rest of the legumes were eaten by animals after termination of the trial, the stems of C. retusa were untouched and stood green, but without leaves, for about five months after the rains. S. hamata and M. atropurpureum manifested delayed germination, but once the stands were established they appeared to spread fairly well and both, but particularly M. atropurpureum, gave good soil cover.

It appeared that the pods of P. aureus and KN-1 were attacked by insects more easily than the rest. Of the legumes tested only KN-1 was infested by striga, the emergence of which was detected at about podding time.

#### Nutritive value

##### Chemical composition

The major chemical entities that are believed to influence the nutritive value of the legumes at various stages of growth are given in Tables 15 & 16.



Table 14 :                      Age of legumes at 1st flowering

Species	Age (days)
<u>D. lablab</u> (cv. Highworth	92
<u>V. unguiculata</u> (cv. KN-1)	38
<u>P. aureus</u>	38
<u>C. retusa</u>	66
<u>S. humilis</u>	-
<u>S. hamata</u>	68
<u>M. atropurpureum</u>	56

Table 15.

Nitrogen (N) and Phosphorus (P) contents of legume<sup>s</sup> grown on fallow  
land and cut at different stages of growth,  
Diapangou

Species	Nitrogen (% dry matter, DM)					Phosphorus (% DM)				
	Age of cutting (days)					Age of cutting (days)				
	35	49	77	84	mean	35	49	77	84	mean
D. lablab (cv. highworth)	3.6	3.6	3.4	3.5	3.6	0.19	0.21	0.18	0.18	0.19
V. unguiculata (cv. KN-1)	3.9	3.7	3.3	3.4	3.6	0.18	0.18	0.17	0.17	0.18
P. aureus	3.3	3.1	2.6	2.1	2.8	0.15	0.14	0.13	0.10	0.13
C. retusa	4.0	4.1	3.5	2.8	3.6	0.15	0.15	0.12	0.10	0.12
S. hamata	3.9	3.8	3.6	3.1	3.5	0.18	0.18	0.16	0.14	0.16
M. atropurpureum	3.5	2.9	3.1	3.0	3.2	0.18	0.15	0.14	0.11	0.15
Mean	3.6	3.5	3.3	3.0		0.18	0.17	0.15	0.13	

Species L.S.D (P = 0.05)  
0.43  
Age of cutting 0.35

L.S.D (P = 0.05)  
0.017  
0.015



Table 16 : Neutral detergent fibre (NDF) and lignin contents of legumes grown on fallow land and cut at different stages of growth, Diapangou

Species	NDF (% DM)					Lignin (% DM)				
	Age of cutting (days)					Age of cutting (days)				
	35	49	77	84	Mean	35	49	77	84	Mean
D. lablab (cv. Highworth)	27.8	27.1	42.0	47.9	36.2	3.1	3.7	6.5	5.7	4.8
V. unguiculata (cv. KN-1)	32.5	29.1	38.6	39.1	34.8	3.6	5.1	7.4	6.1	5.6
P. aureus	40.0	41.0	46.4	44.0	43.0	2.5	2.7	4.6	3.4	3.3
C. retusa	40.0	40.8	35.7	40.2	39.2	6.4	8.4	11.0	8.6	8.6
S. hamata	31.1	31.1	38.7	41.6	35.6	3.7	3.9	4.7	4.4	4.3
M. atropurpureum	34.1	38.2	43.1	42.0	39.4	4.6	6.4	6.5	6.5	6.0
Mean	34.3	34.6	40.8	42.5		4.0	5.0	6.8	5.9	

L.S.D (P = 0.05)

Species 7.8

Age of cutting 6.4

L.S.D (P = 0.05)

1.5

1.2

A difference in the N content was observed ( $P < 0.01$ ) between species. Within the experimental period, relative constancy in N content was observed for D. lablab followed by KN-1 relative to stage of maturity (Table 17). The rate of decline tended to be relatively higher for C. retusa followed by S. hamata and P. aureus.

The P. level was low and varied between species ( $P < 0.001$ ) due to stages of growth ( $P < 0.01$ ). A general decline was observed in P as the plants aged.

The proportion of lignin increased as the plants matured ( $P < 0.01$ ) and the differences between species were significant ( $P < 0.01$ ). C. retusa had the highest lignin content throughout the experimental period.

The cell wall component represented by the NDF showed no significant difference between species ( $P > 0.05$ ) and the difference due to stage of growth just failed to reach significance at  $P = 0.05$ .

#### Digestibility

Significant differences in in vitro DM digestibility ( $P < 0.05$ ) between species have been found (Table 18). The increase in age had no significant effect ( $P > 0.05$ ) on digestibility. P. aureus and KN-1 remained more digestible at advanced stages of growth than the other legumes. D. lablab had higher digestibility values at younger age but declined by 9 percentage units from 49 to 77 days of age. M. atropurpureum had the least DM digestibility and declined at a faster rate than the rest.

#### Disappearance of DM in the rumen

There were differences in DM disappearance between species and stages of growth ( $P < 0.01$  and  $P < 0.05$  respectively) at 0 and 48 h of incubation in the rumen (Table 19). The disappearance at 0 hour, reflecting the water soluble and rapidly degraded component, was highest for D. lablab with a solubility of up to 56% at 49 days of age, declining to 40% at the age of 84 days. Least solubility was recorded for S. hamata and M. atropurpureum with DM solubility of only 36%, declining to 32% at the age of 84 days.

The remaining insoluble DM disappeared at different rates and by 48 hours of incubation about 90% of the DM of D. lablab and 65% of that of M. atropurpureum



Table 17. : Relationship between N concentration and stage of growth<sup>a</sup> of forage legumes grown on fallow land, Diapangou

Species	Regression relationship	R <sup>2</sup>
D. lablab (cv. Highworth)	$Y^b = 3.21 - 0.009X^c$	0.01
V. unguiculata (cv. KN-1)	$Y = 3.13 - 0.049X$	0.11
P. aureus	$Y = 3.06 - 0.101X$	0.41
C. retusa	$Y = 3.97 - 0.154X$	0.60
S. hamata	$Y = 3.79 - 0.139X$	0.33
M. atropurpureum	$Y = 3.15 - 0.09 X$	0.23

<sup>a</sup>- data of 12 stages of cutting are used for the regression analysis

<sup>b</sup> Y = N concentration

<sup>c</sup> X = Age of cutting

Table 18. : In vitro DM digestibility (DMD) of forage legumes grown on fallow land and cut at different <sup>stages</sup> of growth, Diapangou

Species	In vitro DMD (%)				
	Age of cutting (days)				
	35	49	77	84	Mean
D. lablab (cv. Highworth)	74.9	74.3	66.3	68.8	71.1
V. unguiculata (cv. KN-1)	71.0	74.1	69.3	70.7	71.3
P. aureus	64.3	73.5	75.8	76.3	72.5
C. retusa	66.5	66.5	66.9	68.3	67.1
S. hamata	73.1	74.8	69.5	68.3	71.4
M. atropurpureum	68.5	68.5	58.9	60.0	64.0
Mean	69.7	72.0	67.8	68.7	

L.S.D (P = 0.05)

Species 5.7

Age of cutting NS

X had disappeared when the stage of growth was 49 days. At the age of 84 days, all the legumes, had 75% of their DM disappear<sup>ed</sup> by 48 hours<sup>of incubation</sup>, except for M. atropurpureum with only 59% disappearance at the same incubation interval.

## Discussion

It is apparent from this study that the variations that exist between the legumes in agronomic characteristics and nutritive value might allow identification of those legumes that might fit into the objective conditions of crop and animal production systems.

X One of the most important agronomic selection criteria for forages is <sup>the</sup> selection of those characteristics associated with a long vegetation period and the delayed onset of flowering (Whiteman, 1980). Such characteristics reflect slow rates of physiological change in the plant probably through slow rates of change in the proportions of nutrient composition. Amongst the legumes used in this trial D. lablab with good drought tolerance, vigorous<sup>ova</sup> vegetative growth, delayed onset of flowering and constancy in its N content as it matures, could have been the legume of choice. However, its failure to set seeds, due probably to its photoperiod sensitivity, is a disadvantage. That is, under the prevailing conditions the self-reliance of the farmer in the source of seeds for subsequent planting is of paramount importance to ensure the continuity of production of cultivated forages. Further investigations on dates of planting or other day length insensitive cultivars may need to be made.

X V. unguiculata cv. KN-1 is recommended for its good grain and vegetative yields and the characteristic of regeneration of leaves after harvest if moisture is available (Muleba, personal communication). That is, after removal of pods for human consumption, KN-1 might still provide DM with adequate levels of nutrients. However, its sensitivity to insect and striga attack demands additional management and labor costs. The sensitivity to striga has a negative implication to the preparation of fallow soil for subsequent cereal cropping. Since cowpeas are one of the best adapted and widely grown legumes in the region, further investigation on the available local and improved varieties in relation to forage yield, insect and striga resistance is necessary.

X Amongst the test materials C. retusa was the most drought-resistant. The rejection by animals was probably due to its high lignin content or some other toxic compounds like many of the Crotolaria species. M. atropurpureum with its



TABLE 19. Disappearance of DM (%) of forage legumes, grown on fallow land,  
from nylon <sup>bag</sup> suspended in the rumen of cattle for incubation periods of 0 and 48 hours  
Diapangou

Species	Age of cutting (day)									
	35		49		77		84		Mean	
	Incubation (h)		Incubation (h)		Incubation (h)		Incubation (h)		Incubation (h)	
	0	48	0	48	0	48	0	48	0	48
<i>D. lablab</i> (cv. Highworth)	52.9	84.9	55.9	89.6	40.3	80.1	40.0	83.0	47.3	84.4
<i>V. unguiculata</i> (cv. KN-1)	46.5	88.8	41.6	79.9	43.1	80.8	41.1	85.7	43.1	83.8
<i>P. aureus</i>	45.1	82.9	46.2	86.3	40.1	86.0	42.5	85.9	43.5	85.3
<i>C. retusa</i>	—	—	40.1	77.0	40.0	73.0	39.2	75.3	39.6	75.0
<i>S. hamata</i>	—	—	36.4	81.1	34.8	75.9	32.5	75.4	34.6	77.5
<i>M. atropurpureum</i>	37.3	72.3	36.4	64.5	34.2	62.2	32.3	58.8	35.1	64.5
Mean	45.5	82.2	42.8	79.7	38.8	76.3	37.9	77.4	41.3	78.9

L.S.D ( P = 0.05)	Species		Age of cutting	
	0 h	48 h	0 h	48 h
	4.7	4.6	3.9	3.8

good drought tolerance, trailing or creeping characteristics and pod shattering behaviour for self seeding, might be suitable for growing in mixture with natural pasture. S. hamata too appears to be useful if grown in mixture with natural pasture.

The decline in the concentration of Nitrogen with maturity was accompanied by an increase in the proportion of the cell wall component as expected. This did not appear to cause significant reduction in DM digestibility. However, the existence of variation in digestibility between the legumes even at similar stages of growth, indicates the possible differences in the supply of energy to the animals.

The differences in solubility and disappearance of the soluble fraction in 48 hours of incubation in the rumen indicate the possibility of categorizing the legumes according to their biodegradability. This could facilitate manipulation of the feeding system according to the locally available feedstuffs.

Phosphorus concentration in the legumes is well below the desired minimum level of 0,25% required by animals (Osbourne, 1980). There is low level of phosphorus in the soil. This indicates that P fertilizers need to be applied to soil, for the legumes or the animals have to be offered supplementary P in their diet.

The results of the trend of change in nutritive value with advances in stages of growth indicate the possibility of :

1. Identifying the stage of growth that will allow harvesting the forages at the optimum concentration of nutrients.
  2. Adjusting the timing of planting to enable harvesting for conservation at the time when the demand for labour for other farm activities is at its lowest level.
- 3.3 Assessment of the nutritive value of natural pastures on fallow land at different stages of growth

Substantial amount of pasture on fallow land is left unutilized by the animals during the dry season, the period with severe feed deficit. Farmers are aware that the same pasture grasses are consumed better by the animals at younger stages of growth.

A cutting trial was conducted in order to assess the pattern of change in the ratio of the chemical components and biodegradability in the rumen. This was



expected to help determine the optimum stage of growth for the preservation of nutrients in conserved hay for use as a basal diet during the long dry season.

The pasture was predominantly composed of species<sup>1</sup> such as Borreria chaetocephala, Schizachyrium exile and Schoenefelidia gracilis. The constituents of nutritive value are given in Table 20.

During the early part of the rainy season the regrowth of the pasture as young herbage contained as much as 2.8% N (17.5% CP). As the plant matured, however, the N content declined rapidly from the above level on July 31 to 0.9% N on August 28. This decline in the proportion of N was accompanied by an increase in the cellwall content (from 52% to 75% NDF) and a decrease in DM digestibility (from 63% to 54% DMD) as shown in Table 21. The soluble fraction of the DM was low with only 27% at a younger age in August. It declined by about 42% by the time the pasture was dry in November. The value of disappearance of the soluble fraction also declined by about 19% between August 21 and November 14.

#### Discussion

The low level of N in the natural pasture might indicate that the fallow soil was an inadequate source of N for the plants. With the N content, the pasture cannot be expected to support even the N requirement of the microbes in the rumen for most of the year. The critical level of N below which voluntary intake of DM is depressed is 1.12% (Whiteman, 1980). When the level of N was above the critical level required by the microbes in the rumen, the pasture was about 26 cm tall. This was only 28% of its mature height, indicating the low biomass yield for conservation at that stage of regrowth.

The decline in digestibility was probably associated with the decrease in N and increase in the cell wall content. This might serve as a possible explanation of why the mature-dry natural pasture is unutilized even at times of severe feed deficit. Since it is a large mass of DM that could provide cellulosic energy to ruminants, attempts should be made to create the necessary conditions to increase its rate of digestion by the microbes in the rumen.

The low ingestibility at maturity does not make the pasture useless. Since the stage of maturity appeared to influence its quality, a particular stage with acceptable level of biomass yield and nutritive quality could be identified for conservation as hay. Considering the DM digestibility value and conditions of labor demand for other farm activities, conservation of this and similar pastures in the locality can be made

<sup>1</sup> species were identified by Zoundi Sibiri, FSR programme

TABLE 20

Chemical constituents of fallow natural pasture cut at different stages of growth, Diapangou

Date of Cutting	Height (cm)	N <sup>1</sup>	P <sup>2</sup>	NDF <sup>2</sup>	ADF <sup>2</sup>	Lignin <sup>2</sup>
31.7.85	9.0	2.8				
14.8.85	13.0	1.9				
21.8.85	26.0	1.4	0.12	52.4	38.1	7.5
28.8.85	27.0	0.9				
4.9.85	37.0	0.7				
11.9.85	59.0	0.8	0.10	58.0	38.1	7.7
18.9.85	66.0	0.7				
25.9.85	91.0					
2.10.85	91.0	0.8	0.09	64.8	45.1	6.3
9.10.85	92.0	0.7				
16.10.85	81.0	0.6				
23.10.85	84.0	0.7	0.06	68.7	46.3	7.0
30.10.85	80.0	0.5				
14.11.85	79.0	0.5	0.06	74.6	47.3	6.5
LSD (P = 0.05)		0.14	0.03	5.5	3.1	0.4

$$^1N = 4$$

$$^2N = 2$$

ADF = Acid detergent fibre



TABLE 21

In Vitro DM digestibility and in sacco disappearance of DM of fallow natural pasture cut at different stages of growth, Diapangou, 1985.

Date of Cutting	In vitro DMD %	Disappearance of DM in the rumen	
		Incubation (h)	
		0	48
21.8.85	63.4	26.7	71.4
11.9.85	61.4	22.7	65.5
2.10.85	59.1	19.6	55.6
23.10.85	57.1	15.7	58.7
14.11.85	54.1	13.7	57.9
L.S.D	2.3	3.3	4.1

TABLE 22

DM yield and chemical constituents of forage legume and natural pasture hay. made at Kamboinsé and Diapangou, 1985.

Species	Site	MD yield (kg/ha)	N	P	NDF	ADF	Lignin
V. unguiculata (cv. KN-1)	Kamboinsé	2700	3.6	0.20	34.5	24.4	3.8
P. aureus	Kamboinsé	2700	2.7	0.13	34.9	22.8	6.0
S. hamata	Diapangou	880	3.0	0.14	34.9	29.9	3.8
C. retusa	Diapangou	430	3.3	0.14	32.7	22.0	6.0
Natural pasture	Kamboinsé	---	1.9	0.15	57.4	34.5	6.9
Natural pasture	Diapangou	4460	0.7	0.13	77.6	49.4	10.4



sometime from mid to late September, provided the rains start at about the same time. Due to the possible wide variations in the composition of species from one fallow pasture to the other, the above suggestion may not hold true under all conditions. However, it might indicate the technical possibility for improving the contribution of fallow pasture through conservation as hay for dry season feeding.

### 3.4 Observations on the conservation of forage legumes and natural pasture as hay

Forage production for conservation is seldom a priority in Burkina Faso despite the large concentration of livestock. Increasing the resources of forage in quantity and quality for use during inadequate feed supply is of paramount importance.

The purpose of this investigation was :

1. To assess the influence of conservation of forage legumes and natural pasture on the feed budget that may be available throughout the cycle of the season ;
2. To make a preliminary assessment of the possible effects of partial use of legume incorporation into the soil to increase the Organic Matter (OM) level
3. To assess the possible influence of such conservation techniques on the effectiveness of the integration of animal production into existing cropping systems.

Hay made from natural pastures at Diapangou was predominantly composed of B. chaetocephala, S. exile and S. gracilis species. At Kamboinsé P. pedicellatum was the dominant species. The species composition at Poedogo was not identified.

The DM yield, the chemical constituents and biodegradability of the DM of some of the hay are given in Tables 22 and 23 respectively.

Owing to their poor stand S. hamata and C. retusa were not conserved as hay at Poedogo. C. retusa collapsed and changed its colour from green to grey immediately after cutting. The reason for this is not known to the researcher. The stems and pods containing beans of both P. aureus, and KN-1 took longer time to dry compared to leaves. By the time baling was done some hrowing and loss of dry leaves, particularly those of P. aureus, were observed.

The DM yields of S. hamata and C. retusa at Diapangou, where they performed better, were very low when compared to P. aureus and KN-1. Although the DM yield of the natural pasture from the fallow land at Diapangou was high its nutritive value was low. In contrast, the natural pasture hay at Kamboinsé showed an N content well above the critical level of 1.12% and digestibility was fairly high. As expected



all the legumes had higher nutritive value than the natural pasture hay. More than 84% of the insoluble <sup>DM</sup> of the <sup>legumes</sup> and the natural hay from Kamboinsé disappeared within 48 hours of <sup>incubation</sup> in the <sup>rumen</sup>, but only 50% disappeared from the natural hay harvested from Diapangou.

After harvest all the legumes produced regrowth that appeared to be substantial, based on visual assessment, for incorporation into the soil. The regrowth of C. retusa was more vigorous than the rest.

The observations indicated the technical possibility of conserving forages in the form of hay. Conservation in all sites was carried out between September 10 and September 30. The weather conditions did not pose serious problems for hay making except the one time heavy rainfall that occurred in Kamboinsé immediately after harvesting P. aureus. The drying potential of the air between the rains appeared to be adequate to dry the materials; no moulding, due to moist patches, was observed in the stacks at all sites.

The results indicated that fallow pasture can be replaced advantageously by legumes. Except for KN-1 the other legumes have suppressed the growth of striga, and this reduction in weeds could be a benefit for subsequent cereal crops through regeneration of fertility of soil. Since no follow-up measurements were made on the effects of the incorporation of the regrowth of the legumes on soil DM, due to abandonment of the sites, such parameters need to be considered in future studies.

In general annual legumes such as V. unguiculata and P. aureus, with the exception of C. retusa, are promising species for conservation as hay. Since the DM yield of S. hamata was low it might be more beneficial if it were over or under sown in the natural pasture. However, in the savana zone of Nigeria hay yields of 4.1 t/ha have been observed for S. hamata (Shehu, et al., quoted by Lazler, 1984) indicating the possibility of increasing its yield from the present level of 0.8 t/ha.

#### General discussion

From the results, although the trials need to be repeated, it is apparent that the introduction of forage legumes might minimize or at least alleviate the problem of the deficiencies of N and energy available to the animals. The differences in nutritive parameters between the legumes and natural pasture at different stages of growth are illustrated in Fig.1.

Table 23 : Chemical constituents, in vitro DM digestibility and in sacco disappearance of DM of crop residues incubated in the rumen (samples obtained from farmers fields at Diapangou)

Crop residue	Composition of DM (%)					In vitro DMO %	Disappearance of DM in the rumen
	N	P	NDF	ADF	Lignin		
Sorghum stover	0.98	0.08	68.1	40.9	7.2	61.8	21.6
Millet Stover	1.18	0.03	80.0	49.0	8.3	44.0	15.7
Maize stover	0.94	0.11	74.6	40.6	5.0	60.2	16.1
Cowpea residue	2.00	0.09	51.6	45.0	8.5	58.1	33.8
Groundnut residue	2.07	0.20	43.1	39.9	7.0	65.9	36.4
							80.3
							72.5
							61.2
							49.1
							59.5
							48
							0
							Incubation (h)



Legumes are known to be less dependant on soil N for they obtain their N through biological fixation. The N content of the legumes in this trial has been above the critical level at all stages of growth in contrast to that of the natural pasture (Fig.1). The use of legumes as supplement might, therefore, permit maintenance of N above the critical level for increased intake of the associated low N cellulosic roughages, including cereal crop residues. There is ample evidence that protein supplements can stimulate intake of low N - cellulosic roughages by meeting the requirements 1) for degradable N for the microbes in the rumen (Sriskandarajah et al, 1982; Mehrez & Orskov, 1978; Kempton & Leng 1979) and 2) for amino acids absorbed from the small intestine (Egan, 1965; Kempton & Leng, 1979). However, the synchronization of N degradation and energy release in the rumen is of paramount importance for the efficient capture of N by the microbes (Meggison et al, 1979) as shown in Fig.2.

In section 3.2 it was noted that the major portion of the DM (56%) of D. lablab and a minor portion (36%) of that of S. hamata or M. atropurpureum are in soluble form at the same stage of growth. These variations in the proportion of the components that are rapidly available for rumen fermentation could be used to identify the legumes that might be suitable for supplementation of cellulosic materials. For example, if the soluble portion of D. lablab and S. hamata was predominantly N, then the supplementation of D. lablab to a cereal crop residue (Table 15) might manifest a mismatching in the release of N and energy. However, the combination of S. hamata with the same roughage might result in a relatively better matching. If the rapidly degraded N from D. lablab is not captured by a readily available carbohydrate energy, the excess N could be lost in the urine, thus reducing the protein value of the material. Such information is of paramount importance if the efficient utilization of the N source, the availability of which is very limited, is desired. Investigations on these aspects are expected to be conducted with animals in 1986.

The information on digestibility will be used to estimate the metabolizable energy (ME) of the feedstuffs as the basis for initiating the adoption of new energy and protein feeding systems. The equation to be used to estimate the ME value from digestible organic matter (DOM) was developed for temperate forages. Since the mean energy value of the DOM of tropical forages is similar to that found in temperate forages (Minson, 1980), equation 1 (MAFF, 1975) can be adopted to estimate ME to serve as a guideline in the formulation of diets for 1986 feeding trials.



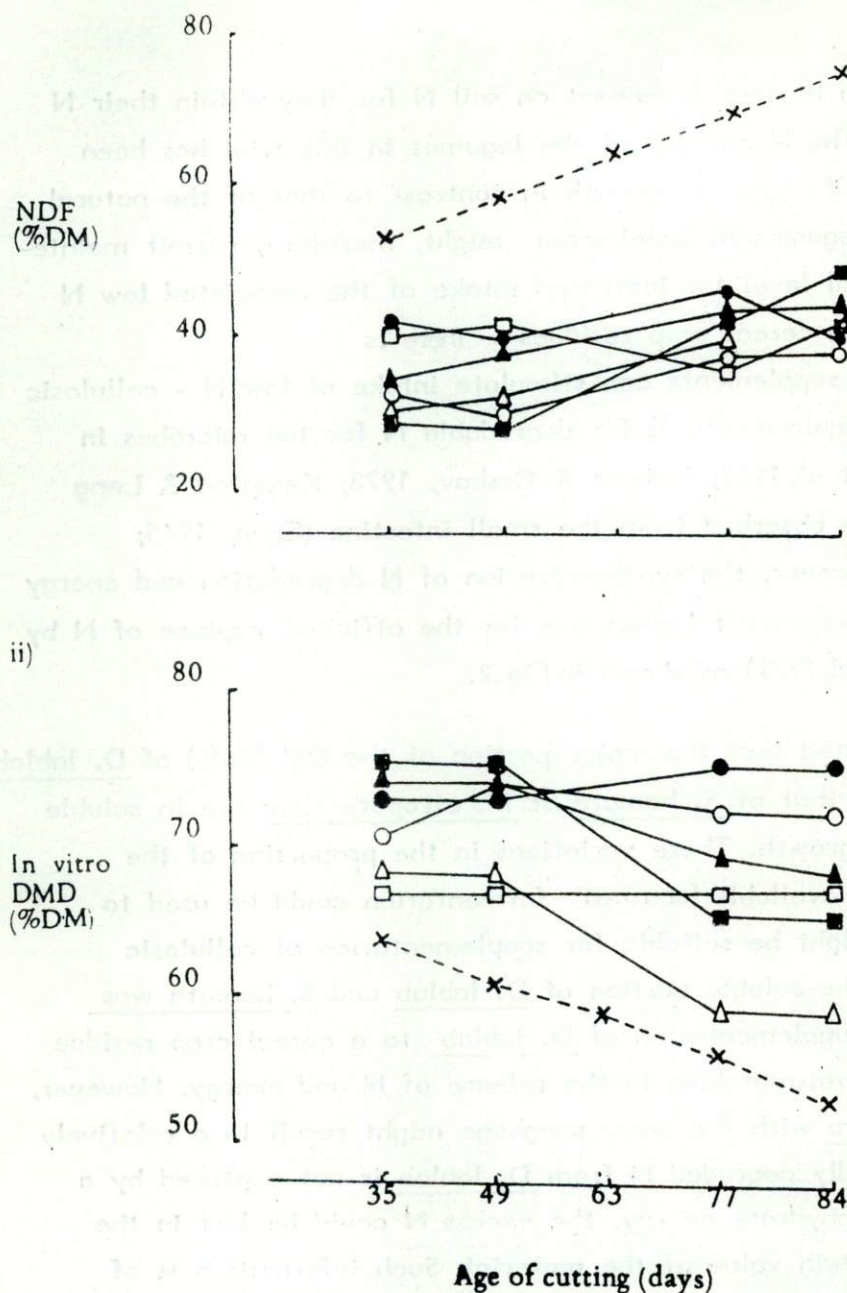


Fig. 1a: Patterns of change in DMD and NDF content of forage legumes compared to fallow natural pasture as growth advances.

■ = *D. lablab*, ○ = KN-1, ● = *P. aureus*, □ = *C. retusa*,  
 ▲ = *S. hamata*, △ = *M. atropurpureum* (Exp. 3.2); and  
 x = natural pasture (Exp. 3.3.)

Age of cutting refers to the legumes only. Height of regrowth of natural pasture at first cut only 9.0cm. Cutting of the latter was made to coincide with dates of cutting of the former.



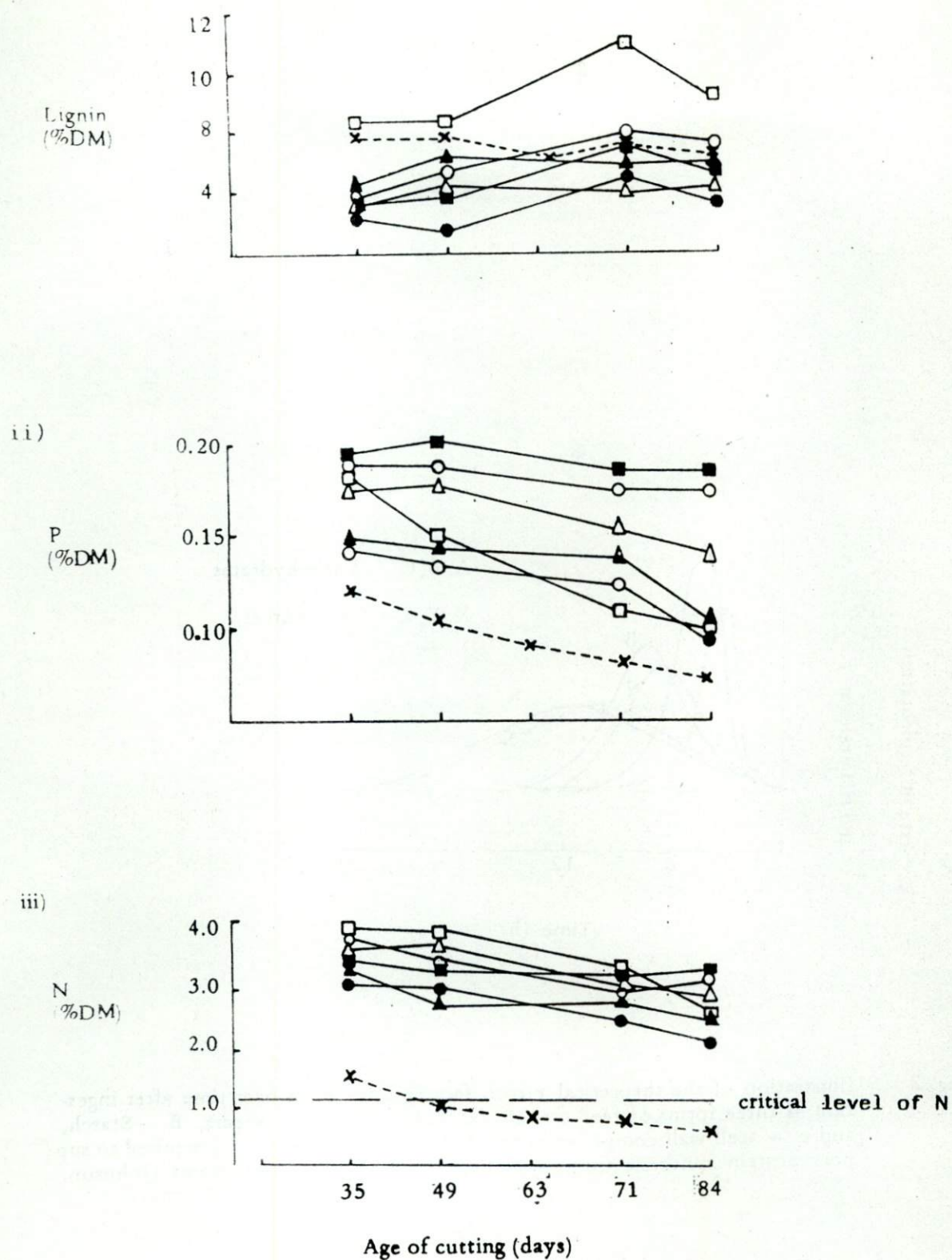


Fig. 1 b : Patterns of change in the contents of N, P and lignin of forage legumes compared to fallow natural pasture as growth advances.

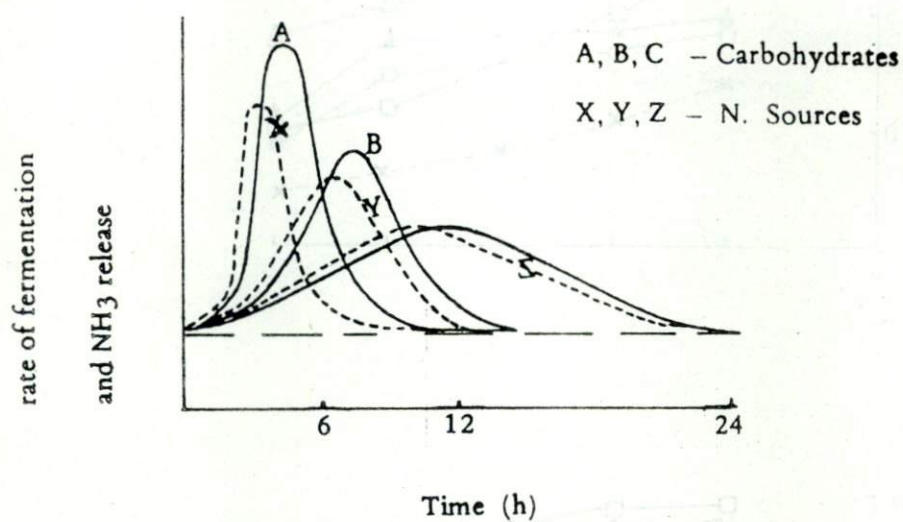


Fig. 2 : Illustration of the theoretical rumen fermentation rates over time after ingestion of three forms of feed carbohydrates (A - soluble sugars, B - Starch, and C - cell wall components) and rumen  $\text{NH}_3$  curves (....) required to support protein synthesis from fermentation of these carbohydrates (Johnson, 1976).



$$ME = 0.15 \text{ DOMD \% } \dots\dots (1)$$

Where, ME = Metabolizable energy

DOMD = digestible organic mater in the dry matter

Using the ME and degradability values of forage protein and other feedstuffs being determined at ILCA the amount of N needed for microbial synthesis in the rumen and the host animals' tissue needs will be estimated. That is, once the ME required by the animal is known then equations (2) and (3) (ARC, 1980) can be used to estimate the N required and formulate rations using the available feed ingredients.

$$RDN = 1.25 \text{ ME } \dots\dots\dots(2)$$

$$UDN = 1.91 \text{ TN} - 1.00\text{ME } \dots\dots\dots(3)$$

Where, RDN is rumen degradable nitrogen,

UDN is integrated dietary nitrogen, and

TN is tissue nitrogen.

These equations will be adopted because the division of inputs into RDN and UDN in the formulation of diets is a simple, logical and useful approach to supply N to the ruminant animal.

Until the feeding trials to be conducted provide adequate information, the metabolizable energy, requirements of the indigenous animals at various physiological states such as growth, <sup>pregnancy</sup> pregnancy and lactation will be approximated by extrapolation from data on other animals in other countries. This information will, in turn, be used to estimate the area required for forage production and the number of animals that need to be carried by the farm with acceptable levels of productivity. These estimations are expected to change as more accurate data become available.

One of the major reasons for introducing forage legumes in the crop production system is their N fixing capability and contribution to soil fertility. In order to exploit this potential of legumes in N fixation the guarantee of P appears to be a necessity (Haque & Jutzi, 1985). Although the deficiency of soil N can at least be partially corrected by the legumes, the deficiency of soil P requires the application of fertilizer. Besides, the repeated harvesting of legumes for conservation will undoubtedly deplete the available P in the soil. The cheapest source of P in Burkina Faso is the local rock phosphate. Responses of millet grown on alfisols deficient in P (1.9 ppm) and with a pH of 6.7 to Burkina Rock phosphate were not significant due to poor solubility. On a vertisol, deficient in P (1 ppm)



and with a pH of 6.0, rock phosphate application as low as 15 kg/ha has resulted in significant increases in the DM of forage legumes (Haque & Jutzi, 1985).

It has been noted earlier that the P level in the forages tested was not adequate to satisfy the requirements of animals, thus the need to supplement with a source of P. No known information is available to the researcher on the direct supplementation of Burkina rock phosphate to the diets of ruminant animals. Investigation on this aspect will be considered in the 1986 feeding trials.

With a diet of forage only and forage mixed with cereals the rumen pH could range from 6.3 to 7.0 and 5.1 to 6.6 respectively (Thomas & Rook, 1982). A certain level of solubility may be expected as the phosphate is exposed to the rumen fermentation and gastric environment of high acidity (pH 1.0, Lewis & Hill, 1983) coupled with a higher pH buffering in the small intestine. The P that escapes digestion or absorption might also contribute to the level of soluble P in the manure. Such aspects will be considered in the management of manure and compost during the feeding trials for use in soil fertilization.

With the intended use of grasses such as A. gayanus, B. ruziziensis and P. pedicellatum for ensilage in 1986, Burkina phosphate will be considered as an additive to raise the level of P. When making silage, the pH of fresh forage, usually about 7.0, is expected to fall to about pH 4.0. This acidic environment might solubilize the P and improve its availability to the animal. An increase in the level of soluble P may also be expected in the silage effluent which could be conserved to mix with manure or compost. If the passage of rock phosphate through the alimentary tract and fermentation in the compost and silage is able to transform the availability of P to animals and plants then the implication is important to the utilization of local resources. These points might indicate the influence of one component in enhancing the efficiency of the other for the efficient recycling of resources.

In general the production of forage legumes accompanied with conservation will undoubtedly increase the feed budget both quantitatively and qualitatively to fit into the demands of nutrients for various physiological states of animals. As shown in Figs 3 and 4 the demand for amino acids for tissue synthesis and energy requirements are high during the physiological state of growth, pregnancy and lactation. As in most West African semi-arid regions the prevailing feeding system does not appear to match the physiological state of the animal. From the few surveys made, it is observed, for example, that the main calving, lambing and kidding seasons in the soudanian zone of Burkina Faso are just before or during the rains (May/June) that is, after the long period of dry months (8-9 months)



which are notorious for their feed deficit. The high demand for nutrients during pregnancy (particularly during the last 8 weeks for cattle and 6 weeks for sheep and goats) cannot be satisfied by feeding crop residues and natural pasture only. Thus, the need to produce and conserve forages.

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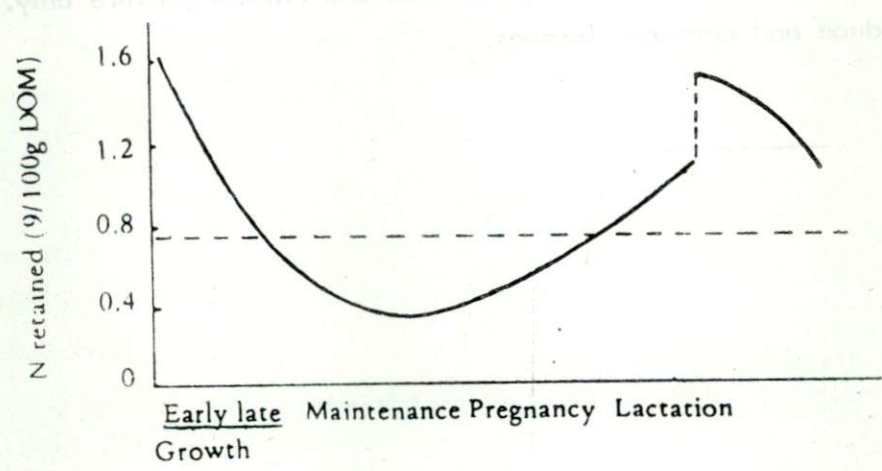


Fig. 3 : Effect of Physiological state on potential retention of N in relation to digestible organic matter (DOM) intake (Orskov, quoted by Leng 1982)

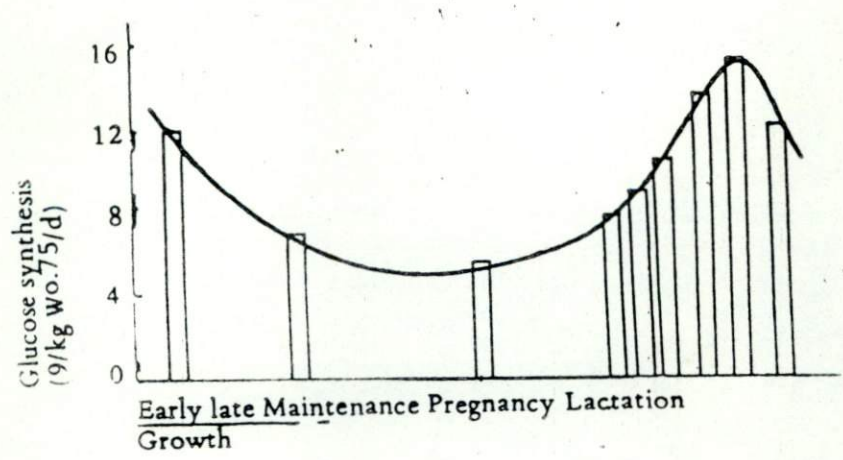


Fig. 4 : Glucose synthesis rates in sheep in various physiological states (kempton et al, quoted by Leng, 1982)



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## II IFAD SUPPORTED FSR ACTIVITIES IN BENIN

### 1.0 INTRODUCTION

Agricultural production plays a very important role in Benin as a source of food supply, means of livelihood economic activity and more importantly as a foreign exchange earner. Over 60% of population living in rural areas produce over 77% of total exports as a source of raw materials for agro-industries. In 1977/78 the production levels of major food and cash crops in Benin were : (in thousand ton.) maize 308, sorghum 80, millet 2, rice 22, fonio 537, cassava 700, yams 650, beans 39, groundnuts 6 and cotton 10 (Adam and Boko 1983, MDRAC 1977-78). Cotton earned about 40% of the country's foreign exchange, followed by palm oil, groundnut, maize, coffee and cocoa. Benin's agricultural development is unique in that the country has a strong decentralized agricultural extension system organised at provincial level which focuses on cotton, the principal foreign exchange earner.

Although there are 13 agricultural research establishments in Benin, three stations, Niaouli, Ina and Houeda, focus on food crops and the country has a weak research capacity. Others focus on palm oil, livestock, processing, phytosanitary services, rural economic studies, forestry, coffee, cocoa and coconut (Ndunguru & Ngambeki, 1985).

### OBJECTIVES

Following the signing of an agreement between the People's Republic of Benin and OAU/STRC in March 1985, a SAFGRAD/Benin FSR development programme was initiated with the following main objectives :

- . To strengthen the National Farming Systems Research Programme so as to develop a method of production to integrate crop and animal production as well as a technique to conserve soil moisture and other resources.
- . To assist the National Farming System in establishing a functional link between research, development and farmers.
- . To conduct baseline socio-economic surveys in selected villages.



## 2.0 Socio-Economic Studies

With the help of extension personnel and village leaders, a sample of 14 farmers from each of the selected villages and 2 to 6 farmers from adjacent villages were randomly selected (a total of 80 farmers) for the socio-economic survey. A questionnaire was designed (in French) to cover the farmers' social and climatic environments, production systems, consumption patterns, infrastructural facilities, their priorities and goals plus physical and socio-economic constraints to production. Information on these aspects was obtained from repeated visits to farmers (including visits to their farms) in August through November during various agricultural peak periods of the season. Frequent monitoring tours were made to each village and periodically questionnaire forms were withdrawn from the field to the office to check on the accuracy of the information being collected. At the end of November, all questionnaire forms were withdrawn, the data compiled, and various types of analysis performed.

### 2.1 Delineation of Agroclimatic Zones

The SAFGRAD/Benin FSR Project covers two northern provinces, Borgou and Atacora, spreading over three agroclimatic zones. The delineation of these zones, based on vegetation and rainfall, give:

- a. Transition from sudan to sahel to savanna (400-600) in the extreme north,
- b. Sudan savanna (600-800) in the mid belt, and
- c. Northern Guinea savanna (800 mm and above) in the southern part. Table 24.

Analysis of rainfall from 1975 to 1982 as compared with long term average rainfall, indicates that in recent years, annual rainfall has decreased by as much as 400 mm in the extreme north and by about 200-300 mm in the southern part of two provinces. In the 1960s these zones had a mean rainfall of 900 mm, 1000 mm and 1000-1200 mm, respectively (Adam and Boko, 1983). But the rainfall figures from 1975-1982 give a mean rainfall of 412 mm for the sudan-sahel, 760 mm for the sudan savanna and for the northern Guinea savanna, 1014. 25 mm. (Fig. 1)



The rainfall distribution in the sahelian savanna starts at the end of March/beginning of April, but does not stabilize till mid-May. From May, the rainfall increase gradually with a peak of about 108 mm in August, then drops sharply, cutting off at the end of October/beginning of November. As for the rainfall distribution in the sudan savanna, it tends to begin late in April, with a peak of about 196 mm in August, then cuts off quickly by the end of October (Fig. 2). The rainfall distribution in northern guinea starts by the end of March, stabilizing in May, increasing gradually to a peak of about 211 mm in August and then drops sharply, cutting off at the beginning of November. The sudan sahelian zone now has a vegetation of grass savanna with acacia trees, clay-sandy and clay soils. The sudan savanna has woody grassland savanna with loamy-sandy soils. The northern guinea zone has a woody grassland moving into forest savanna with loamy-sandy soil.

## 2.2 Demographic characteristics of farmers

Borgou province has an area of 51,000 km<sup>2</sup> (54% R.P. Benin) with a population of 530,000 inhabitants (1985), giving a population density of 15.4 persons per km<sup>2</sup>. Table 24 shows the demographic characteristics of the farmers in the different agroclimatic zones of the provinces. Active farmers in Borgou and Atacora provinces are relatively young with an average age of 43.2 years old; their ages range from 16 to 72. 90% of these farmers are between 16 and 32 years, 41% between 32 and 40 years. 40% are between 40 and 56 years, while 10% are between 56 and 72. However, the farmers in the sahelian zone have an average age of 37.7 years, those in the sudan savanna zone an average of 44 years and those in northern guinea savanna an average of 44.4 years.

Farm family sizes range from 2 to 19 with an average of 10 persons, of whom 51.3% are children between 0 and 15 years old. The farm families in the sahelian zone have an average of 7 persons of whom over 60% are children. Those in the sudan savanna have an average family size of 10 persons, of whom 50% are children. Families in the northern guinea savanna have an average of 10 persons of whom 40% are children. The availability of family labour is on the average 2.69 man-units per farm family in the sahelian zone, 5.12 man units per family in the sudan savanna and 5.23 man-units per family in the northern guinea. This gives an average of 4.94 man-units per farm family in the whole region. Again on the regional basis 52.0% are males whereas 47.2% are females. The age distribution of persons in each family is such that 19.9% aged 6 to 10, 11.9% ages 11 to 15, 28.4% ages 16 to 20, 3% ages 31 to 72.

20.3%



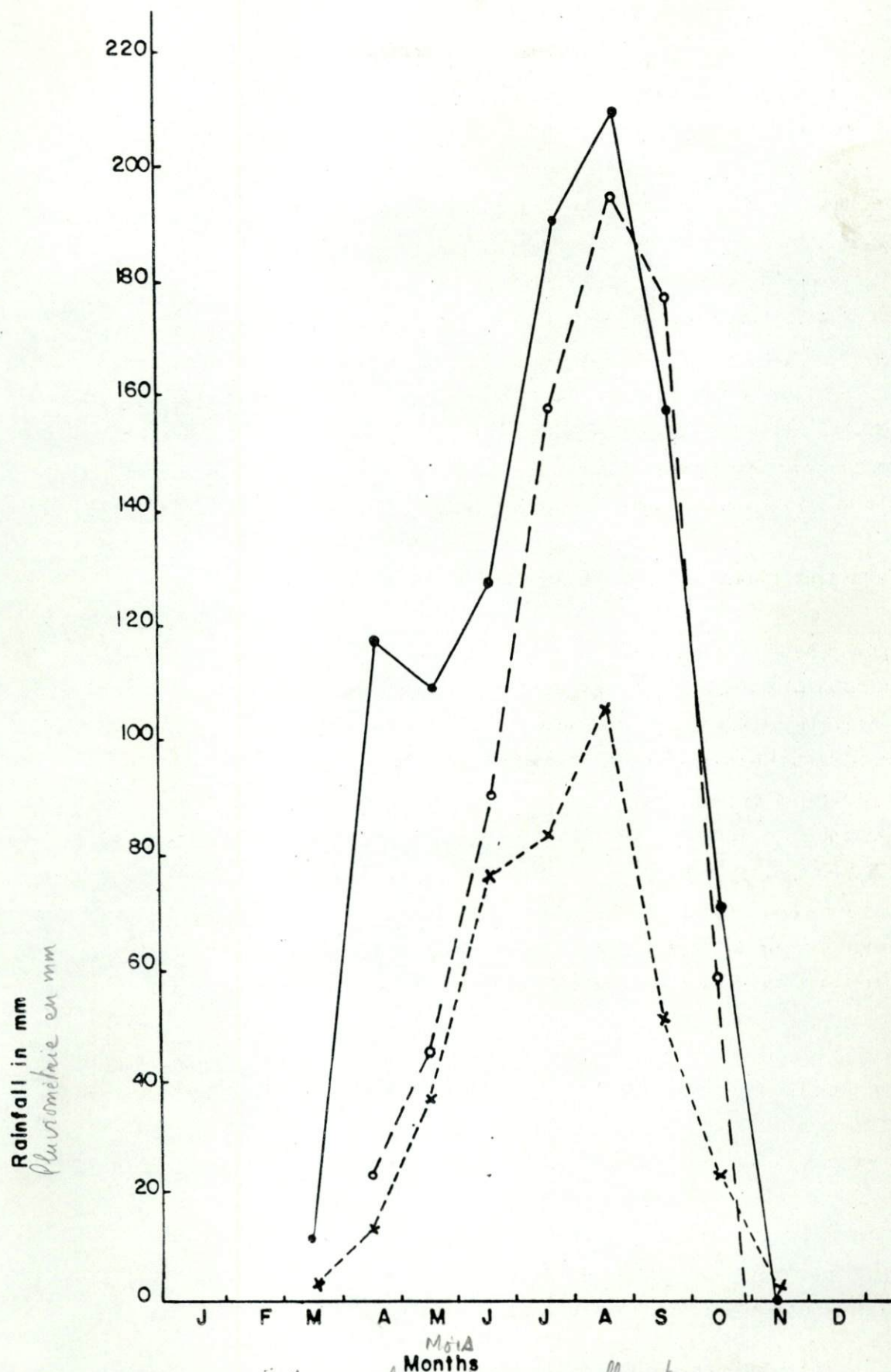


Fig. 5 Mean Annual Rainfall between 1975-1982

- x---x---x Sahelian savanna (S.H) *Savane Sahélienne*
- o---o---o Sudan savanna (S.S) *Savane Soudanaise*
- Northern guinea savanna (N.G.S) *Savane Nord guinéenne*

## 2.3 Land utilisation

The average farm size in the region is 7.45 ha per farm family, with 6.5 ha being cultivated and 0.9 ha under fallow. Table 25 shows the portion and percentage of the farm size planted to different crop enterprises in each agroclimatic zone.

In the sahelian zone, an average farm family plants 1.36 ha (22% of the farm size) in sorghum, 1.06 ha (17% of farm size) in millet, 0.7 (12% of farm size) in cotton and 0.5, (8% of farm size) in groundnuts. The family also plants about 13% of the land with other crops, leaving 1.76 ha (28% of the farm size) under fallow.

A farm family in the sudan savanna plants 3.84 ha (49% of the farm size) in cotton, 0.64 ha (8% of the farm) in maize/sorghum, 0.39 ha (5% of the farm) in cassava and 0.37 (5% of the farm) in groundnuts. However, in the northern guinea savanna, an average family uses 1.66 ha (17% of the farm) for maize/yam/beans, 0.77 ha (8% of the farm) for yams and 0.4 ha (4% of the farm) for maize. In this zone, there is a diversity of crop enterprises such that different families plant about 38% of their farms with various crops, leaving 0.68 ha (2% of the farm) under fallow.

## 2.4 Existing farming systems

The farmers' system is characterized by :

- a. Shifting cultivation where farmers leave exhausted land to lie fallow for 3 to 4 years and use fallowed lands or shift altogether to newly cleared sites.
- b. A diversified cropping system greatly dominated by crop associations and a significant component of livestock.

The most important crops in the sahelian zone are millet and cotton (grown by 76% of the farmers), sorghum and groundnuts (grown by 69%) maize and cassava (each 23%) and maize/sorghum (8%). Less cultivated crops are beans, sorghum/beans, millet/beans; millet/sorghum and maize/sorghum/cowpeas each grown by 7% of the farmers. As for the sudan savanna, cotton is the most dominant crop followed by cassava, groundnuts, millet, maize/sorghum and beans grown by 85, 64, 57, 35 per cent of the farmers. In the northern guinea savanna, maize/sorghum is the most popular crop being grown by 75% of the farmers. Other important



TABLEAU 24  
TABLE 24

CARACTERISTIQUES DEMOGRAPHIQUES DE CERTAINS PAYSANS  
DEMOGRAPHIC CHARACTERISTICS OF SELECTED FARMERS

ZONE	AVERAGE MOYENNE					MOYENNE DU NOMBRE DE PERSONNES PAR GROUPE D'AGE AVERAGE NUMBER OF PERSONS BY AGE GROUPS					
	Farmer's age âge du paysan	Family size Taille de la famille	Units available for farm man-days	N° of males Nb° du Sexe masculin	N° of females Nb° du Sexe féminin	0-5	6-10	11-15	16-30	31-46	46-60
Sudan-Sahel Savane sahéloenne	37.7	7	2.69	3	4	2	2	1	1	1	+
Sudan- Savane Savanna soudanienne	44	10	5.12	5	5	2	2	1	3	1	1
Northern Savane Guinea Nord Savanna guinéenne	44.4	10	5.23	6	4	2	1	2	3	1	1
MOYENNE GENERALE Grand average	43.2	10	4.94	5	5	2	2	1	3	1	1
Percentage of Total Pourcentage du Total				52.8	47.2	19.9	9.5	11.9	28.4	12.6	6.8



Tableau 25 Superficie (en hectares) utilisée par famille paysanne.  
(les chiffres entre parenthèses indiquent le pourcentage des terres  
consacrées aux différentes cultures.)

TABLE 25 LAND AREA (IN HECTARES) USED PER FARM FAMILY  
(FIGURES IN PARENTHESES SHOWS PER CENTAGE OF  
FARM SIZE UNDER DIFFERENT CROP ENTREPRISES)

- 61 -

CROP ENTREPRISE CULTURES	SUDAN SAHEL ZONE SAHEL	SUDAN SAVANNA SAVANE SUDAN	NORTHERN GUINEA SAVANNA SAVANE NORD GUIN.	REGIONAL AVERAGE MOYENNE REGIONALE
Cotton Coton	0.71 (12%)	3.84 (49%)	1.58 (16%)	1.69 (22%)
Maize Maïs	0.19 (3%)	0.14 (2%)	0.4 (4%)	0.4 (4%)
Sorghum Sorgho	1.36 (22%)		0.37 (3.8%)	0.43 (6%)
Millet Mil	1.06 (17%)	0.07	0.12 (1%)	0.13 (4%)
Groundnuts Arachide	0.5 (8%)	0.37 (5%)	0.3 (3%)	0.41 (5%)
Yams Igname		0.03	0.77 (8%)	0.48 (6.4%)
Cassava Manioc		0.39 (5%)		0.21 (3%)
Cowpeas Niche		0.05	0.01	0.02
Beans haricot		0.09	0.03	0.05
Rice Riz	0.02		0.03	0.03
Maize/Sorghum Maïs/Sorgho	0.15 (2.5%)	0.64 (8%)	1.66 (17%)	1.19 (16%)
Maize/Yam/Benas Maïs/Igname/haricot			0.9 (9.4%)	0.35
Yam/Beans Igname/haricot			0.35	0.13
Cassava/Maize Manioc/Maïs			0.05	0.01
Millet/Beans Mil/haricot	0.19 (3%)			0.03
Maize/sorghum Beans Maïs/Sorgho/haricot	0.08		0.09*	0.05
Yam/Cowpeas Igname/niche		0.21	0.05*	0.06
Sorghum/Cowpeas Sorgho/niche		0.25		0.05
Maize/Millet Maïs/Mil		0.41	0.02*	0.11



suite du Tableau 25  
Table 25 continued

Yam/Millet <i>igname / mil</i>			0.16*	0.03
Sorghum/Millet <i>sorgho / mil</i>		0.25*	0.05*	0.05
Sorghum/Beans <i>sorgho / haricot</i>			0.34*	0.07
Yam/Millet/Beans <i>igname / mil / haricot</i>			0.36*	0.08
Maize/Cowpeas <i>Maïs / Niche</i>		0.41		0.07
Others <i>Autres</i>			0.86	0.34
Cultivated land ha <i>superficie cultivée ha</i>	0.4.32	6.9	8.89	6.55
Fallow ha <i>jachère, ha</i>	1.76	0.87	0.68	0.9

\* Crop enterprises practised in Atacora Province.

*Cultures exploitées dans la Province de l'Atacora*



crops in this zone are cotton grown by 49%, yams 44%, sorghum 40%, groundnuts 35%, cassava 33% and cowpeas 31%. Millet, yams/beans and beans are grown by 22, 18 and 15 per cent of the farmers. Sorghum/beans and yam/millet beans are grown particularly by farmers in Atacora province.

The farmers recognised advantage and disadvantages of intercropping. They commonly plant cereal crops like maize/sorghum and millet/sorghum, among other crop associations. About 38% of the farmers pointed out that intercropping bean with either sorghum, millet or sorghum/millet appears to give good yields and benefits soils. In the sudan savanna, intercropping maximises calorie production, saves labour during weeding and also minimizes the risks of crop failures. The disadvantages observed by farmers include depletion of soil fertility, delays in maturity of some of the associated crops, and reductions in yields of the individual crops. Farmers in the sudan savanna zone usually plant as many as three cereals such as maize, sorghum and millet, in the same associations.

There are some agronomic practices and small farm equipment recommended by extension agents for cotton, maize and groundnuts. Cotton has the strong backing of extension services CARDER which provides economic incentives including credit facilities for ox-ploughs, fertilizers, insecticides, farm purchases and handling of cotton at harvest. They also provide free seeds. Most farmers have adopted recommended cotton seed varieties 299-10-75 for the northern guinea savanna zone and MK 73 for the sudan and sahelian savanna zone. Farmers also apply NPK and urea fertilizers to cotton, spray insecticides five to six times and weed up to two times in sudan and sahelien zones or up to three times in the northern guinea savanna.

But in cases of maize and groundnuts, farmers are mainly picking up the improved varieties TZB and Novara for maize and RMP.12 and Moto for groundnuts. They tend to ignore the use of fertilizers on food crops and other recommendations. In the northern guinea, 55% of the farmers described the advantages of intercropping as saving labour for timely planting and weeding as well as maximizing the use of land. 47% of the farmers believe that intercropping ensures the production of calorie requirements for the family and minimizes risks. Other advantages of intercropping described by farmers are maximizing cash income, increasing the quantity of crop residues and maintaining ecological balance of the soil micro-nutrients. But about 47% of the farmers observed that some of their crop associations, particularly millet/sorghum, yam/millet and yam/millet/beans accelerate the depletion of the soil fertility, generally tend to give lower yields of crops in



association and often make physical movement in the field difficult.

The most common agronomic techniques used for food crop production are clearing by slash-and-burn, preparation by ploughing or digging the land, hand planting on flat land or in ridges and mounds for yams and cassava, then hand weeding with a hoe. Table 26 shows the percentage of farmers using the various agronomic practices in each zone. The types of land used for food crops are compound farm, plateau, valley or bottom land. In the sahelian zone sorghum is often planted in the fields nearest to the compound which have a higher fertility level, then millet, maize, and the rest of the sorghum are planted in valleys or bottom lands. In both the sudan and northern guinea savanna zone most food crops are planted on plateaus. Most of the farmers in the sahelian zone use light clearing which implies that there is not much vegetation to slash and burn.

Soil preparation in the sahelian zone is done mostly with oxen; 84% the farmers use the ox-plough for millet, 61% use it for cotton, groundnuts and sorghum. In the sudan savanna, 42% of the farmers use the ox-plough for groundnuts, 36% for cotton and 14% use for maize/sorghum and millet. In the northern guinea savanna, the ox-plough is rarely used, while only 10% use it for maize/sorghum and groundnuts. The most common methods of land preparation in the northern guinea savanna, are digging ridges with a hoe, especially for cotton and groundnuts or making mounds for yams and cassava. Planting in rows on flat ground is mostly used in both the sahelian and northern guinea savanna, and rarely used in the sudan savanna. Whereas planting in ridges is more popular in the sudan and northern guinea savanna, farmers in the sahelian zone frequently hand plant, whereas farmers in the other two zones plant in pocket holes with a hoe, a stick on a rolling castor (wheel). Very few farmers apply fertilizers; in this study only 6% of the farmers were observed applying fertilizers on maize in the northern guinea savanna; 2% on maize/sorghum and 7% on yam/beans in the sudan savanna.

#### Cropping Calendar

Land clearing for yams in both the sudan and the northern guinea savanna is done in September; soil preparation is done at the beginning of November before the soils become hardened during the dry season. The tops of the yam mounds are mulched throughout the dry season to maintain low soil temperature. The yams are planted in February-March just before the rains.



TABLE 26 PERCENTAGE OF FARMERS USING VARIOUS AGRONOMIC  
PRACTICES IN EACH ZONE

(a = Sahel, b = Sudan and c = Northern Guinea)

a = sahélienne b = soudanaise c = Nord guinéenne

Pratique Agronomique Practice et zone and Zone	Cotton Coton	Maize + sorghum Maïs + sorgho	Groundnuts Arachide	Millet mil	Sorghum sorgho	Cassava Manioc	Yams Igname	Cowpeas Vetch	Beans Haricot	Maize Maïs	Yams/beans igname/haricot	Yams/beans millet
Type de Terre Type of Land	a) 76	-	-	-	-	-	-	-	-	-	-	-
-Plateau	b) 42	28	28	21	-	28	-	28	-	-	-	-
	c) 55	38	28	14	14	42	45	-	6	14	-	-
-Valley/ bottom land	a) -	-	-	15	69	15	-	-	-	38	-	-
	b) -	-	-	-	-	-	-	-	-	-	-	-
	c) -	-	-	-	-	-	-	-	-	-	-	-
Defrichage Land Clearing	a) 61	-	38	7	7	-	-	-	-	-	-	-
-slash or cut and burn	b) 28	-	28	14	-	14	-	-	-	-	-	-
	c) 51	37	12	12	6	41	38	10	-	14	2	-
- Light clearing	a) 23	-	31	76	69	-	-	-	-	38	-	-
Defrichage léger	b) 7	7	7	7	-	7	-	7	-	-	-	-
	c) 8	18	20	20	-	-	8	-	-	12	-	-
Soil Preparation Préparation du sol	a) 61	15	61	84	61	7	-	7	-	-	-	-
- use of ox-plough	b) 36	14	42	14	-	-	-	28	-	-	-	-
	c) 16	10	10	6	8	-	-	-	-	8	-	-
- dig with hoe	a) 7	-	15	7	7	-	-	-	-	-	-	-
binage à la houe	b) -	-	-	-	-	-	-	-	-	-	-	-
	c) 20	24	-	10	6	-	-	14	-	2	-	-
-make ridges construction de billons	a) 15	-	-	-	-	-	-	-	-	-	-	-
	b) -	-	-	-	-	-	-	-	-	-	-	-
	c) 16	6	14	4	4	-	-	-	-	12	-	-
Planting Semis	a) 28	15	23	46	46	7	-	-	-	15	-	-
- on flat in lines	b) 7	7	7	7	-	-	-	42	-	-	-	-
sur lit plat	c) 22	22	16	8	6	-	-	10	-	-	-	-



Suite Tableau 26  
Table 26 continued

- on ridges <i>sur billons</i>	a) 15	-	-	-	-	-	-	-	-	-	-	-	-
	b) 36	21	36	21	-	-	-	-	-	-	-	-	-
	c) 33	16	18	4	6	-	-	-	-	-	-	-	-
- on mounds <i>sur buttes</i>	a) -	-	-	-	-	15	-	-	-	-	-	-	-
	b) -	-	-	-	-	28	7	-	-	-	-	-	-
	c) -	-	-	-	-	28	51	-	-	-	-	-	-
-with fingers <i>avec les doigts</i>	a) 46	-	46	46	46	-	-	-	-	-	-	-	-
	b) -	-	-	-	-	-	-	-	-	-	-	-	-
	c) 2	4	2	-	4	2	-	2	-	-	-	-	-
Fertilizer application <i>d'engrais</i>	a) yes	-	-	-	-	-	-	-	-	-	-	-	-
	b) "	-	-	-	-	-	-	-	-	-	7	-	-
	c) "	2	-	-	-	-	-	-	-	6	e	-	-



In the sahel zone, soil preparation is done in April and <sup>f</sup> good crops are planted before the end of May, whereas cotton is planted in early June. In the sudan savanna, planting is also done in early or late May, depending on the onset of rains. In the northern guinea savanna, soil is prepared in March and planted in April/May again depending on the stability of the rains. The optimal date for planting in the northern guinea savanna is before first week of June, weeding in june and harvesting in October for millets and sorghum; maize is harvested in November and December. 2

## 2.5 Livestock and sources of feed

Both in the sahelian and in the sudan savanna zones, livestock plays a very important role in the production system. Table <sup>4</sup> 27 shows the number of livestock per farm family and sources of livestock feed in the rainy and dry seasons in each zone. In the sahelian zone, an average farm family has over 6 domestic animals of which 2 are typically oxen for draught power, 2 cattle and 2 are goats or sheep. Although some camels can be seen in the area, they normally belong to the nomadic herders who may travel across the borders. In the sudan savanna, an average farm family has 8 domestic animals, typically 3 oxen for draught power 2 cattle and 3 goats and sheep. In the northern guinea savanna, an average farm family has 11 domestic animals typically about 6 cattle and 4 goats and sheep, possibly two oxen for draught power. In terms of distribution, it should be noted that in the sahelian zone practically every farmer has oxen for draught power whereas in the sudan savanna, 78% of the farmers have animal traction while only 12% of the farmers in the northern guinea savanna have animal traction, making an average of 39% of the farmers in the entire region with animal traction. It should also be noted that there are more cattle in the sahelian and sudan savanna zones, most of the cattle belong to nomads who do little or no farming and mainly move in search of grazing grounds.

Livestock usually feed by grazing during the rainy season. But during the season when most vegetation gets dried-up and often burnt down by bush fires, livestock are moved further south in search of grazing grounds or else left to eat on tree leaves and crop residues. In the sudan savanna, in 57% of the cases, livestock is grazed in wet bottom lands. In over 20% of cases, the livestock is moved further south. In the northern guinea savanna about 20% of farmers feed their livestock in wet bottom lands, 10% move their livestock southwards and 32% use tree leaves to feed the livestock. Parts of food crops like peels unfit for human consumption, are commonly used to feed goats and sheep in this zone.



Tableau 27 Nombre d'animaux par famille agricole et source d'alimentation pour bétail en saison pluvieuse et sèche dans chaque zone

TABLE 27

NUMBER OF LIVESTOCK PER FARM FAMILY AND SOURCE OF LIVESTOCK FEED IN RAINY AND DRY SEASONS IN EACH ZONE

Z O N E	Number of livestock (Figures in parentheses show percentage of farmers) <i>indiquent le pourcentage de paysans</i>				Source of livestock feed (Figures show percentage of farmers) <i>entre parenthèses indiquent le pourcentage de paysans</i>						
	Oxen for draught power <i>Bœufs de trait</i>	Cattle <i>gros animaux</i>	Goats + sheep <i>chèvres + moutons</i>	Total livestock <i>Total des animaux</i>	Rainy Season <i>Saison pluvieuse</i>			Dry Season <i>Saison sèche</i>			
					grazing <i>Pâturage</i>	grazing in wet bottom land <i>Pâturage dans les bas fonds humides</i>	transhumance	use tree leaves <i>feuilles d'arbres</i>	crop residues <i>résidus de récolte</i>	peels of food <i>écorces de nourriture</i>	(goats + sheep) <i>(chèvres + moutons)</i>
Sahel Savanna <i>Savane Sahélienne</i>	2.4 (100%)	2 (54%)	2 (54%)	6.4	92			80			
Sudan Savanna <i>Savane soudanienne</i>	3 (78%)	2 (43%)	3 (57%)	8	85	57	21				
Northern Guinea Savanna <i>Savane Nord Guinéenne</i>	0.4 (12%)	6 (45%)	4 (77%)	11	53	20	10	32		47	
Regional Average <i>Moyenne Régionale</i>	1.2	4.5	3.5	9.2	65	24	16	55	2.6	0	

\*In the sahelian zone, there are two types of dwellers. Those who keep cattle and keep moving in search of grazing grounds, then those who practice farming. The purely cattle keepers were not included in this study.

\* Dans la zone sahélienne, il existe deux types de résidents : ceux qui élèvent les animaux et se déplacent sans cesse en quête de pâturages et ceux qui pratiquent l'agriculture. Les simples éleveurs ne sont pas inclus dans cette étude.



## 2.6 ECONOMICS OF EXISTING FARMERS' PRACTICES

### Farmers' farm resource use

Besides land, the important farm resources are family labour, animal traction, and ox-ploughs, cash income for purchased input like fertilizers, small farm tools and seeds also play a very important role. Table 29 shows a farmer's farm resource base in each agroclimatic zone.

The farmer in the sudan savanna spends 806.95 man-days for all his farming activities as compared to his counterpart in the northern guinea savanna who spends 917.8 man-days.

The most labour-demanding farming operation in each of the agroclimatic zones is harvesting, followed by weeding, soil preparation and planting. The labour requirements for soil preparation, ridging, mounding and planting are 104 man-days in the sahelian zone, 256.95 man-days in the sudan savanna and 226 man-days in the northern guinea savanna. Considering the family supply in man-units of 2.69, 5.23 and 4.94 for sahelian, sudan and northern guinea savanna respectively, along with a 6 day working week, the implication is that the family in the sahelian savanna needs 7 weeks to complete the farming activities up to planting, while the family in the sudan savanna needs over 8 weeks. Their counterparts in the northern guinea savanna also require 8 weeks. The implication of this analysis is that if the last planting date is the first week of June, then soil preparation and planting activities must be started in March.

Table 28<sup>6</sup> Total labour requirements for some selected crops

Crops	Labour man/days/ha	Crops	Labour man/day/ha
Cotton	170	Cassava	152
Maize	103	Yams	269
Sorghum	115	Maize/sorghum	141
Millet	125	Yam/beans	280
Groundnuts	126		

This also implies that if the onset of rains is late or if there is a prolonged dry spell, then farmers in each of the zones face a high risk of late planting.



## 2.7 Farmers' priorities and goals

Each farmer was asked to rank in order of importance the objectives that he is trying to achieve by pursuing farming as an occupation. To produce adequate food for the family throughout the year was the number one priority for most of the farmers in each agroclimatic zone. The number two priority mentioned by the farmers was to earn sufficient money for the family's vital basic needs. The third and fourth priorities declared by farmers were to earn enough money for their children's education and to save enough to improve their standard of living.

Farmers were asked to rank major food crops according to their order of preference. In the sahelian savanna zone, the major food crops preferred are sorghum, millets and maize. The sudan savanna farmers' major food crops preferred are yams, sorghum and maize; whereas farmers in the northern guinea savanna ranked yams as the most food crop preferred, followed by sorghum, maize and millet.

Considering the food crop<sup>p</sup> references on a regional basis sorghum, maize, millets and beans are the most important, in that order. This implies that in all three agroclimatic zones, sorghum, maize and millet are the most important sources of calories, while yams serve as a major supply of calories in both the sudan and northern guinea savanna zones.

### Available Infrastructural and communal facilities

Input delivery systems, infrastructural and communal facilities play an important role in facilitating rural agricultural production systems. The infrastructural and social facilities existing in the region include agricultural village cooperatives, two sources of agricultural credit namely CARDER and CLCAM (Caisse Locale de Crédit Agricole Mutuelle), local markets, communal storage facilities and wells as a source of drinking water. In the sahelian savanna, 69% of the farmers belong to village cooperatives, 38% have communal storage facilities and 95% have access to a source of drinking water; practically all the farmers have access to markets. In the sudan savanna 92% belong to an agricultural village cooperative, 57% have communal storage facilities and 92% have access to some type of agricultural credit and about 85% of the farmers have access to markets. <sup>see</sup> Table 29. In the northern guinea savanna, relatively fewer farmers have access to any of the facilities.



Table 29. <sup>1</sup> Percentage of farmers with access to infrastructural and communal facilities

Type of facility	Sahelian savanna	Sudan savanna	Northern Guinea Savanna
Agricultural cooperatives	69	92	69
Communal storage	38	57	39
Source of drinking water/well	95	92	69
Agricultural credit	-	100	61
Markets	100	85	81

## FARMERS' PRODUCTION CONSTRAINTS

One of the objectives of the socio-economic study is to examine the constraints on farmers' production. This investigation was carried out on three levels. The first was interaction with the farmers throughout the agricultural season, asking them to point out the problems they observe in their fields. The second was examination of the yields obtained, if these were dramatically reduced, an attempt was made to determine the factors that might be responsible for such losses. ~~Thirdly constraints are delivered from different analyses.~~

Farmers in the sahelian savanna zone observed two major production constraints: late and torrential rainfall causing water logging affected more than half of the farms. In the sudan savanna, striga weeds and poor soils affected respectively 57 and 28 per cent of the farms. In the northern guinea savanna late rains were cited by 41% while lack of alternative cropping techniques was cited by 70% of the farmers.

Late rains and poor soils were cited as major constraints, followed by moisture stress. Late rains affected maize, millet, sorghum, yams and cotton in various degrees in each agroclimatic zone. Poor soils affected mostly sorghum and yams in the sudan savanna and in the northern guinea savanna. Moisture stress affected mostly millet, sorghum and cotton in guinea savanna.



Results from the various analyses performed suggest that labour for critical farming operations like timely planting constitute one of the major constraints on production. The use of ox-ploughs seems to facilitate soil preparation and thus allows the farmer to plant by the optimal dates.

The most labour-demanding crops are yam/beans, yams and cotton taking respectively 280, 269 and 170 man-days/ha from land clearing to harvesting. Maize/sorghum; millet and sorghum in pure stand, take respectively 141, 125 and 115 man-days/ha. Maize appears to require relatively less labour, taking about 103 man-days/ha. (Table 28)

#### Efficient utilization of farm resources

In order to determine the efficiency levels of the available farm resources in the existing production systems, different analytical techniques were carried out.

It was hypothesized that total cultivated land,; an indicator of total farm production, is a function of the farmer's family size, his age, total labour input, use of ox-plough, small farm tools, and animal traction. Regression analysis of the socio-economic data are presented in Annex 1.

### 3.0. CROP PRODUCTION TECHNOLOGY EVALUATION

X Ideally, the agronomic studies should have been initiated after the socio-economic data <sup>were</sup> analysed and interpreted, since the detailed information on crops and their relevant agronomic practices would have been defined. It was, however, decided to initiate some agronomic trials after certain information had been gathered during the preliminary survey. The rationale behind the choice of the type of crops and issues to be investigated was:

- X
- . Scarcity of information on the performance of local varieties <sup>in comparison</sup> with available improved varieties. ?
  - . The lack of information on the performance of these varieties under the local farming practices such as intercropping and monoculture.
  - . The recognition of the importance of cotton as a major cash crop.
  - . Comparison of the performance of these crops with inorganic fertilizer to their performance without any fertilizer as is commonly practised.
  - . Studying the effects of ridging and flat cultivation both common practices, and assessing the merits of each.
  - . Assessment of the potential of green manure in the cropping pattern.

It was clear that time and effort had to be devoted to shoring-up the on-station research in addition to the proposed Farming Systems Research. A set of researcher-managed experiments were designed and carried out at four sites in the agro-ecological zones defined earlier.

#### 3.1 Evaluation of the performance of local and improved maize and sorghum varieties in pure stand and in association.

A field trial of maize and sorghum grown on flat ground either in monoculture or in association was conducted at Ina, Sokka and Bensekou during the 1985 season. Two maize cultivars (a local and TZB) and two sorghum cultivars (Toko - Bensekou (local) and improved Ghana 1) were used. The treatments were M1 = local maize M2 = improved maize, S1 = local sorghum, S2 = improved sorghum, M1S1 = local maize/local sorghum, M1S2 = local maize/improved sorghum, M2S1 = improved maize, however, was recorded when TZB maize was grown in monoculture. There was no significant difference between treatments M1, M1S1, M1S2, and M2S1, but these treatments yielded less than TZB maize. There was a significant variety x fertilizer interaction (Table 30).



local sorghum and M2S2 = improved maize/improved sorghum. Half the number of plots were fertilized with cotton fertilizer at the rate of 150 kg/ha of NPK at emergence and a top dressing of 50 kg/ha of urea. The remaining half received no fertilizer (F0 and F1, respectively). The experiment was a factorial design replicated four times.

Seeds were spaced on <sup>flat</sup> ground, 80 cm between rows and 40 cm within the row, leaving two plants per hill. Crops were grown in alternate rows. Maize was sown two weeks before sorghum. Thus, the sowing dates were July 12 and 29 in Ina, July 15 and 29 in Sokka and July 18 and August 4, 1985, in Besekou. The plots were weeded three times during the season and at harvest the four central rows were taken leaving 50 cm at the end of each row.

Plants emerged after 3 to 4 days at all three sites with the exception of sorghum at Ina which emerged after 11 days. On the average maize tasselled before 60 days after sowing and sorghum flowered 98 days after sowing. There were no great differences between the local and improved varieties.

The data were analysed by splitting the trial first to establish the bench marks of maize and sorghum. Then a factorial analysis was done to evaluate mixed cropping. This was done using two methods. The first was to consider that one kilogramme of maize was equal to one kilogramme of sorghum with analysis done on the totals. The second was to transform the data into relative yield totals (R.Y.T) which were obtained by taking the sum of each component species in the mixture.

$$\begin{array}{rcccl}
 & \text{maize yield} & & \text{sorghum} & \\
 & \text{intercropped} & & \text{intercropped} & \\
 \text{R.Y.T} & \frac{\quad}{\quad} & + & \frac{\quad}{\quad} & \\
 & \text{maize yield in} & & \text{sorghum yield in} & \\
 & \text{monoculture} & & \text{monoculture} & 
 \end{array}$$

➤ The results from these analyses for Ina are presented in table 30<sup>9</sup>

Results are stated as being significant at  $P = 0.05$ . The application of the cotton fertilizer increased the total yield by 50% (1042 and 1565 kg respectively, for the unfertilized and fertilized treatments). The lowest yields were obtained with sorghum varieties (S1, S2). The next highest yields were achieved when improved maize TZB and improved sorghum Ghana I were grown in association. The highest yield,

TABLE 30

Tableau 30 Effet de traitements sur le rendement en grain (kg/ha) et Relatif Rendement Total (RYT) des cultures semées sur lit plat à INA.

Effect of treatments on grain yield ( kg/ha ) and the relative yield total (RYT) values of crops grown on the flat ground at INA.

Combinations de Traitements Combinations	Rendement Yield		Rendement Total Total Yield		RYT
	Maïs Maize	Sorgho Sorghum			
S2Fo	-	210	210	a	
S2F1	-	225	225	a	
S1F1	-	403	403	a	
S1Fo	-	461	461	a	
M1S1Fo	539	380	919	b	1.26 abc
M2S2Fo	941	167	1108	bc	1.31 abc
M1Fo	1278	-	1278	bcd	-
M1S2Fo	1117	199	1316	bcd	1.68 bc
M2Fo	1353	-	1353	bcd	-
M2S2F1	1162	229	1391	bcd	1.08 ab
M2S1F1	1362	159	1521	cde	0.90 a
M2F1Fo	1312	385	1697	de	1.81 c
M1S2F1	1528	344	1872	ef	1.28 abc
M1S1F1	1775	361	2136	f	1.75 c
M1F1	2142	-	2142	f	-
M2F1	2829	-	2829	g	-
<del>S E</del> E, S			225.52		0.29
C V			17.3 %		20.7 %

Means followed by different letters within each column are not the same ( P = 0.05 ). F<sub>0</sub> and F<sub>1</sub> denote unfertilized and fertilized respectively.

Les moyennes suivies de lettres différentes dans chaque colonne ne sont pas similaires (P = 0,05) F<sub>0</sub> et F<sub>1</sub> indiquent respectivement les traitements fertilisés et non fertilisés.



Examination of the relative yield totals (RYT) revealed that the highest values were obtained where crops were not fertilized whereas the lowest values were associated with fertilization, although there were exceptions to this generalization. Mixing crops in low level fertility may allow a better utilization of scarce resources. These RYT values should however be interpreted with caution because the higher ones are mainly due to the sorghum yields and not necessarily to the beneficial effects of intercropping.

Fertilization increased overall yields by 55% at Sokka (866 and 1341 kg for unfertilized and fertilized, respectively). The best yields at Sokka were obtained when TZB maize was fertilized and grown either in monoculture or in association with local sorghum, table 31. With the exception of the association of TZB maize and improved sorghum, the RYT values are higher than 1, indicating that mixing crops had certain advantages.

The findings for Bensekou are presented in Table 32. The yields were generally lower than those from Ina and Sokka mainly because striga attacked the crops at Bensekou. Although the actual damage was not recorded both crops seem to have suffered equally from the striga attack. As was the case at Ina and Sokka, fertilizing the plots significantly increased the yield, although by only 36%, i.e. 407 and 558 kg for unfertilized and fertilized, respectively.

TZB maize variety gave the best yield whether grown in monoculture or in association with local sorghum. There was no significant difference between the two sorghum varieties which yielded less than maize. Combinations of local maize and local sorghum or local maize and improved sorghum gave the same total yield. Fertilization decreased the RYT.

Table 33 shows the overall trend in maize yield at the three sites. The highest yield was obtained when improved variety TZB was fertilized. Next highest yield was fertilized. When both varieties were not fertilized they gave the lowest yield with no significant difference between them. Similar data for sorghum was not available at the time of writing.

*Tableau 31 Effet de Traitements sur le rendement (kg/ha) du maïs et du sorgho, et Relatif Rendement Total (RYT) des cultures semées sur lit plat à Sokka* 77 -

TABLE 31

Effect of treatments on yield (kg/ha) of maize and sorghum and the relative yield totals (RYT) of the crops grown on flat ground at Sokka.

<i>Combinaisons</i> Treatment de Traitements Combinations	<i>Maïs</i> Maize	<i>Sorgho</i> Sorghum	<i>Yield Rendement</i> Yield	<i>Total Rendement</i> Total	RYT
S2Fo	-	634	634 a		
M2Fo	769	-	769 ab		
S1Fo	-	807	807 ab		
M2S2Fo	655	182	837 ab		1.13
M1F1	898	-	898 abc		
M1S2Fo	666	236	902 abc		1.10
M1Fo	910	-	910 abc		
M1S1Fo	523	402	925 abc		1.06
S2F1	-	1047	1047 bc		
S1F1	-	1078	1078 bc		
M2S1Fo	750	399	1149 c		1.46
M1S2F1	649	533	1182 c		1.22
M1S1F1	688	767	1455 d		1.47
M2S2F1	1189	313	1502 d		0.92
M2S1F1	1123	575	1698 e		1.12
M2F1	1873	-	1873 e		
<del>S-E</del> E.S.			135.23		0.14
C V			12.2%		11.5

Means followed by different letters within each column are significantly different ( $P = 0.05$ ) from each other.

*Les moyennes suivies de lettres différentes dans chaque colonne sont significativement différentes ( $P = 0,05$ ) les unes des autres.*

.../...



TABLE 32

Tableau 32 - Effet de traitements sur le rendement (kg/ha) et Relatifs Rendement Total des cultures semées sur lit plat à Bensekoui

Effect of treatments on yield (kg/ha) and the relative yield totals (RYT) of the crops grown on flat ground at Bensekoui.

Treatment Combinations <i>Combinaisons de Traitements</i>	Maize Yield <i>Maïs Rendement</i>	Sorghum Yield <i>Sorgho Rendement</i>	Total Yield <i>Rendement Total</i>	RYT
S2Fo	-	259	259 a	
M1Fo	306	-	306 b	
S1Fo	-	313	313 b	
M1S2Fo	105	253	358 c	1.30
S1F1	-		417 d	
M1S1Fo	154	263	417 d	1.34
S2F1	-	443	443 de	
M2Fo	475	-	475 e	
M2S2F1	306	219	525 f	0.89
M1S1F1	262	266	529 f	1.24
M2S2Fo	277	268	545 fg	1.61
M1F1	557	-	557 fg	
M2S1Fo	269	322	591 g	1.58
M1S2F1	332	260	592 g	1.17
M2S1F1	384	259	643 h	1.25
M2F1	759	-	759 i	
S.E. E.S.			26.9	
C.V.			12%	

Means followed by different letters within a column are significantly different (  $P = 0.05$  ) from each other.

Les moyennes suivies de lettres différentes dans une même colonne sont significativement différentes ( $P = 0,05$ ) les unes des autres  
.../...

Tableau 33 Rendements groupés du maïs à Ina, Sokka et Bensekou (D) (Les données pour les traitements fertilisés et non fertilisés combinés (A, B, C) dans les trois sites sont présentées pour référence)

TABLE 33. Grouped yields of maize from Ina, Sokka and Bensekou (D) (Data for the combined fertilized and unfertilized treatments (A, B, C) at the three sites are presented for case of reference).

(A) I N A		(B) SOKKA		(C) BENSEKOU		(D) GROUPED YIELDS FOR MAIZE (INA, SOKKA, BENSEKOU)	
Traitement Treatment	Rendement Yield	Traitement Treatment	Rendement Yield	Traitement Treatment	Rendement Yield	Traitement Treatment	Rendement Yield
S2	217 a	S2	841 a	S2	351 a	M1Fo	831 a
S1	432 a	M1	904 ab	S1	365 a	M2Fo	865 a
M2S2	1250 b	S1	943 ab	M1	431 b	M1F1	1199 b
M1S1	1527 c	M1S2	1042 bc	M1S1	473 c	M2F1	1778 c
M1S2	1594 c	M2S2	1169 cd	M1S2	475 c		
M2S1	1609 c	M1S1	1190 cd	M2S2	535 d		
M1	1710 c	M2	1321 de	M1S1	617 e		
M2	2091 d	M2S1	1424 e	M2	617 e		



### 3.2 Evaluation of the performance of maize and sorghum grown either in monoculture or in association in ridges.

The varieties, treatments and agronomic details were exactly as described in the previous experiment with the exception that in this trial the crops were grown in ridges.

X The time it took for the plants to emerge and flower was similar to the time taken by crops grown on <sup>flat</sup> ~~that~~ ground. The effects of treatments on the yield for Ina are presented in table <sup>13</sup> ~~34~~. Results are reported as significant at  $P = 0.05$ . Fertilizer application increased overall yield by 65%. The lowest yields were obtained when both sorghum varieties were grown in monoculture and the highest when TZB maize was grown either in monoculture or in association with the local sorghum variety. Local maize in pure stand gave the same yield as TZB grown in association with improved sorghum. Similarly, associating local maize either with local or improved sorghum gave the same yields. The RYT values were all above one, but again this was not necessarily due to the beneficial effects of intercropping.

Results for Sokka are presented in Table <sup>14</sup> ~~35~~. The superiority of TZB maize either in monoculture or when grown in association with any sorghum was clear. Improved sorghum yielded significantly better than the local sorghum. The yield of local maize in pure stand and in association with local sorghum was the same as that of the improved sorghum alone. The RYT's were in general lower at Sokka when compared to those attained at Ina.

X The yields at Bensekou were characteristically low and less consistent. As in the other two sites the major finding here was the obvious response to fertilization. Fertilizers increased overall yield by 33%. A unique feature for the Bensekou maize results <sup>was</sup> ~~was~~ that the local maize performed slightly better than TZB maize (Tables <sup>15</sup> ~~35~~ and ~~36~~). It has yet to be determined whether or not this is due to a greater tolerance of the local maize variety to striga.

### 3.3 Evaluation of the performance of local and improved maize and groundnut varieties in both pure stand and association.

The experiment was conducted at Ina. The treatment combinations were M1= local maize, M2 = TZB maize variety, G1= local groundnuts, G2 = improved groundnuts, M1G1= local maize/local groundnuts, M1G2 = local maize/improved

Tableau 34 Effet de traitements sur le rendement (kg/ha)  
et Relatifs Rendement Total de cultures  
semées sur billons à Ina.

TABLE 34

Effect of treatments on the yield (kg/ha) and relative yield totals of crops grown on the ridge at Ina.

Treatment <i>Combinaisons de traitements</i>	Total Yield <i>Rendement Total</i>	R.Y.T.
S2F°	389 a	
S1F°	501 ab	
S1F1	747 bc	
S2F1	781 bc	
M1S1F°	1119 cd	1.16
M1S2F°	1231 cde	1.54
M2F°	1277 cde	
M1S2F°	1298 cde	1.46
M2S1F°	1572 def	1.78
MAF°	1676 defg	
M1S1F1	1792 efg	1.45
M1F1	1934 fg	
M1S2F1	2015 fg	1.56
M2S1F1	2185 g	1.22
M2S2F1	2227 g	1.22
M2F1	2938 h	
S.E. E.S.	230.30	
C.V.	15.7	

Means followed by different letters within a column differed significantly ( $P = 0.05$ ) from each other.

Les moyennes suivies de lettres différentes dans une même colonne diffèrent significativement ( $P = 0,05$ ) les unes des autres.



TABLE 35

*Tableau 35 Effet de traitements sur le rendement (kg/ha)  
et Totaux relatifs de rendement de cultures semées sur  
billons à Sokka.*

Effect of treatments on the yield (kg/ha) and relative  
yield totals of crops grown in ridges at Sokka.

Treatment <i>Combinaisons de Combinations de Traitements</i>	Total Yield <i>Rendement Total</i>	R.Y.T
S2F°	571 a	
M1S2F°	644 ab	0.96
S1F°	729 abc	
M2S2F°	731 abc	0.97
S1F1	747 abc	
M1S1F°	828 abcd	1.31
M1F°	855 abcd	
M2F°	879 bcd	
M2S1F°	957 cd	1.12
M1F1	1005 cd	
M1S1F1	1094 de	1.25
S2F1	1255 ef	
M2S1F1	1293 efg	1.08
M1S2F1	1447 fg	1.28
M2S2F1	1526 g	1.07
M2F1	1531 g	
S.E. E.S.	132.62	
C.V.	15.2%	

Means followed by different letters within a column  
differed significantly ( $P = 0.05$ ) from each other.

*Les moyennes suivies de différentes lettres dans une même colonne  
diffèrent significativement ( $P = 0,05$ ) les unes des autres*

Tableau 36 Effet de traitements sur le rendement (kg/ha)  
et Relatifs Rendement Total de cultures semées  
sur billons à Bensekou

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TABLE 36

Effect of treatments on the yield (kg/ha) and relative yield totals of crops grown in ridges at Bensekou.

Treatment Combinaison de Combination Traitements	Total Yield Rendement Total	R.Y.T
M2S1F°	374 a	0.86
M1S1F°	419 ab	0.95
S1F°	423 ab	
S2F°	431 ab	
M2S2F°	436 ab	0.99
M1S2F°	439 ab	0.98
M2F°	439 ab	
S1F1	448 b	
M1F°	464 b	
M2S1F1	525 c	0.99
M1S1F1	529 c	0.97
M2S2F1	557 c	0.92
S2F1	562 c	
M2F1	636 d	
M1F1	647 d	
M1S2F1	664 d	1.10
S.E. E.S		
C.V.	31.70	

Means followed by different letters within a column differed significantly ( $P = 0.05$ ) from each other.

Les moyennes suivies de lettres différentes dans une même colonne diffèrent significativement ( $P = 0,05$ ) les unes des autres.



groundnuts, M2G1 = TZB maize/local groundnuts, M2G2 = TZB maize/improved groundnuts. The treatments were arranged on flat ground in a factorial design with four replications. The experimental details on plot size and fertilization were exactly as in the first experiment except that both crops were sown on the same day, and groundnuts in monoculture were sown at a spacing of 40 cm between rows and 20 cm within rows. The crops were sown on July 11, 1985. Four central rows of maize were harvested from the monoculture treatment, four maize and three groundnut rows from intercropping treatments and from monoculture groundnuts, the two outer rows on either side of the plot were left out.

The trial was repeated at Ina but the crops were grown in ridges which were 80 cm apart. When intercropped, the groundnuts were grown between maize plants. A similar trial was planted on July 19, 1985 at Sokka utilizing both flat and ridge cultivation but all the plots were fertilized. Results from these three trials are grouped together and are presented in Table 37<sup>16</sup>. Both maize varieties emerged four days after planting and groundnuts emerged after six days. Local maize tasselled 5 days earlier than TZB maize (55 and 60 days, respectively). On the other hand the improved groundnuts flowered 32 days after planting and the local ones after 39 days.

Data <sup>were</sup> transformed into RYT's and also the yields were converted into their monetary values and then analysed. The current price of maize at Ina is 40 francs CFA per kilo while that of groundnuts is 170 francs CFA per kilo. Overall, application of fertilizer consistently increased the cash return when compared with the nonfertilized treatments. There existed little relationship between RYT and the monetary value of crops grown in association (table 37<sup>16</sup>). Even with an RYT of over 100% pure groundnuts brought in more cash. This appeared to be the case in all locations whether the crops were grown on flat ground or in ridges. Or whether fertilized or not. The only exception to this generalization was with treatment M2G1 at Sokka when crops were grown on flat ground. With this treatment the high RYT of the crops was reflected in the monetary value as well. The lowest return was usually realized when maize was grown in pure stand, with the lowest values being realized from local maize. The local groundnut variety was consistently superior to the improved variety. This may be associated with the longer growth period of the local variety which matured one month after the improved variety. At Sokka the crops grown on flat ground brought a higher return than those grown on the ridge.

The fact that farmers use ridges despite the low return may be due to the ease with which groundnuts can be uprooted at harvest when grown in ridges.



TABLE 37

*Tableau 37. Effets de traitements sur la valeur monétaire et les valeurs de RYT du maïs et de l'arachide*

Effect of treatments on the monetary value and RYT values of maize and groundnuts.

LOCATION Land preparation Monetary Value (CFA)	INA		SOKKA	
	Flat <i>Plat</i>	Ridge <i>Billons</i>	Flat <i>Plat</i>	Ridge <i>Billons</i>
M1F°	57,980	5,660		
M1F1	75,950	64,900	48,160	64,120
M2F°	63,260	62,980	-	-
M2F1	98,230	66,340	95,600	82,360
G1F°	127,423	190,910	-	-
G1FI	235,280	179,690	199,835	188,828
G2F°	128,945	127,330	-	-
G2F1	118,405	113,220	178,415	248,498
MIGIF°	66,635	126,253		
MIG2F°	72,985	99,153		
M1GIFI	94,730	126,770	126,550	64,855
M1G2F1	79,793	94,423	125,127	68,760
M2G1F°	77,643	123,872		
M2G2F°	68,513	89,088		
M2G1F1	98,580	119,345	183,940	107,185
M2G2F1	87,810	95,295	142,590	110,918
<i>Relatif Rendement Total</i> Relative Yield Total %				
Pure maize or ground- nuts <i>Maïs ou arachide pure</i>	100	100	100	100
MIGAF°	97%	109	-	-
MIGIFI	91%	117	142	72
M1G2F°	106	133	-	-
M1G2F°	87	122	142	77
M2G1F°	105	135	-	-
M2G1F1	88	122	148	113
M2G1F°	97	120	-	-
M2G2F1	87	124	126	112

*Localité  
Préparation du sol  
Valeur monétaire*



### 3.4 Evaluation of the performance of Sorghum and cowpea in pure stand and in association

This trial was carried out at Ina, Bensekou and Karimama. The treatments, arranged in a factorial design, were two soil preparations (ridge and flat), two levels of fertilization (none and NPK at 150 kg/ha) and three planting patterns (pure sorghum, sorghum in association with cowpeas and monoculture cowpeas). Monoculture sorghum was planted at 80 cm between rows (or ridges) and the distance between hills was 40 cm. Cowpeas were planted between sorghum plants. The sorghum planting dates were July 19, 1985 for Ina and July 23 for Bensekou and Karimama. Cowpeas were planted on July 19, August 5 and July 16 at Ina, Sekou and Karimama, respectively.

Analysis was carried out on the yields of individual crops, relative yield total and monetary values. The prevailing prices of sorghum and cowpeas at Ina are 50 and 170 CFA, respectively.

Sorghum grown on flat ground yielded more than sorghum grown in ridges. Fertilization significantly increased the yield of sorghum. Intercropped sorghum yielded less than when it was grown in monoculture. On the other hand, neither land preparation nor fertilization affected the yield of cowpeas. A relatively higher monetary return was obtained when crops were grown on the flat rather than in ridges. Similarly higher values were achieved with fertilization. Overall the lowest income producer was sorghum grown in pure stand; the highest attained when cowpea was grown in monoculture.

### CONCLUSION

An attempt has been made to assess the yields of important food crops in northern Benin with practices that showed up regularly during the exploratory surveys. The crops were grown late in the season and the yields obtained are, in general, lower than expected. Certain preliminary useful information has been obtained. With the completion of socio-economic studies the path to follow now appears clearer than was the case at the initiation of these trials.

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Regression analysis of the socio-economic data of Benin FSR.

It was further hypothesized that a farmer manipulates this function, as he tries to overcome limitations in achieving his farm production objectives. This was examined using two types of analytical procedures (a) regression analysis and (b) principal component analysis, both of which are powerful analytical tools.

In order to examine the relative importance of different variables in the hypothesized function (model) alternative models were formulated.

Before going into these let us now explain the list of variables.

#### List of variables

- HP = Hectarage under Principal crops
- G = Farmer's age
- FZ = Family size
- FU = Family labour Units - a proxy for the availability of farm family labour supply.
- TL = Total Labour input for all farming operations
- LC = Labour input for critical farming operations such as land preparation, planting and weeding.
- TP = Total cost of Purchased inputs - ox-plough, ox-cart, axe, hoe, fertilizers, weeders, maize, groundnuts and yam seeds.
- OX = Hire or cost of oxplough and ox-cart.
- AT = Animal Traction
- AN = Livestock
- OP = Cost of small farm tools like hoe, axe, cutlass, fertilizer and seeds.

#### Demand for labour for critical farm operations

Given the farmer's farm production function, namely :

$$HP = f (FZ, G, TL, OX, OP, AN).(1)$$

Alternative function (models) were formulated.

Given the fact that the semi-arid region has a short and mono model rainy season, the demand for labour for critical farming operations, (soil preparation, planting and weeding) is a very important factor that the farmer has to deal with. Thus the hypothesis that the total cultivated area (as a proxy of total farm production) is a function of the farmer's family size, the farmer's age, labour inputs for critical farm operation and total cost of all purchased inputs.

$$HP = f (FZ, G, LC, TP).(2)$$

$$HP = f (LC, OX, OP) \quad (3)$$



Another hypothesis considered is that family labour supply (FU) is very important to the farm family. Thus :

$$HP = f (FU, TL, OX, OP) \quad (4)$$

$$HP = f (FU, LC, OX) \quad (5)$$

#### Regression analysis coefficients

Table 38<sup>17</sup> presents the results from regression analysis of the above-stipulated functions. In equation 6, the total cultivated area is a function of the farmer's family size, the farmer's age, total labour inputs, cost of ox-plough, cost of small farm tools and animal traction.

The most important variables in this equation are total labour inputs (TL), cost of rental or purchase of ox-plough (ox), and cost of small farm tools including fertilizers and seeds (OP).

The regression coefficients of these variables are all significant at 1 per cent level.

The use of animal traction is also significant at the 10 per cent level. The overall fitness of the regression equation is with  $R^2$  at 63.7.

Equations 7, 8 and 9 mainly concern inputs for critical <sup>farming operations LC along with</sup> (TP), (E of 7) or together with animal traction (E of 8). The regression coefficients of LC and TP in equation 7 are both significant at the 1 per cent level, whereas the coefficients of G are only significant at the 10 per cent level.

In equation 8, which includes animal traction (AN), along with LC and other variables, the regression coefficients of LC and TP are again significant at 1 per cent level, but those of FZ and AN are significant at 10 per cent level.

X In equation 9, in which the rental or purchase ~~of an~~ cost of ox-plough (OX) is used in place of animal traction (AN), the regression coefficients of LC and OP are both significant at the 1 per cent level. But <sup>that of</sup> OX is significant at the 5 per cent level.

Equations 10 and 11 focus on the availability of farm family labour (FU), along with other variables.

In equation 10, the regression coefficients of TL, OX and OP are all significant at the 1 per cent level whereas that of FU is significant at 10 per cent. The coefficient of FU is also significant at the 1 per cent level.



In equation 11, the regression coefficients of LC and OX are both significant at the 1 per cent level. The coefficient of FU is also significant at the 1 per cent level.

The fit of equations 7 and 10 is quite robust with  $R^2$  61.9 and 61.8 respectively. But the fit of equations 8, 9 and 11 is less with values of  $R^2$  at 37.8 45.5 and 49.5 respectively.

#### Relative importance of farm inputs

In order to determine the relative importance of farm inputs in the production system, principal component analysis was carried.

In this analysis related variables are grouped together and each group forms a factor. The factors given by the analysis are factors 1, 2 and 3.

The importance of each factor is determined by whether or not its latent root, the Eigenvalue, is greater than Unity.

Table 39.a shows factors and their Eigenvalues. The most important factors are factors 1 and 2 with their respective eigenvalues 2.84 and 1.64.

Factor 1 accounts for over 47 per cent of the variance, whereas factor 2 accounts for 27 per cent of the variance giving a cumulative percentage of 74.4.

The variables to be grouped as factors are considered according to the size of their factor loading. The factor loading of any variable is between 1 and -1. If the variable has a factor loading closer to either 1 or -1, then it is considered significant. But if its factor loading is closer to zero, then the variable is considered insignificant.

Table 39.b presents factor loading for the variables under consideration.

In factor 1, total farm labour and labour inputs for critical farm operations have factor loadings of 0.560 and 0.550 respectively. In factor 2, variables with high factor loadings are the cost of rental or purchase of an ox-plough and animal traction with factor loadings 0.673 and 0.634 respectively. Factor 3, whose latent root or Eigenvalue is 0.7 less than unity, includes family labour supply with a factor loading of 0.842.

The implications of the results from this analysis are that labour inputs play a major role in the agricultural production system. The cost of rental or purchase of an ox-plough and animal traction play a supportive role in the production system.



TABLEAU 38

TABLE 38

COEFFICIENTS D'ANALYSE DE REGRESSION  
REGRESSION ANALYSIS COEFFICIENTSVariable  
Dépendante

Dependant Variable	Const.	FZ	G	TL	OX	OP	AN	R <sup>2</sup> Function <i>fonction</i>
(6) HP	-0.59 (-0.4)	0.043 (0.56)	0.049+ (0.58)	0.15(10 <sup>-3</sup> )** (7.34)	0.78(10 <sup>-4</sup> )** (3.41)	0.38(10 <sup>-4</sup> )** (4.32)	0.032+ (1.63)	63.7 Linear <i>linéaire</i>
(7) HP	Const -0.55 (0.39)	FZ 0.025 (0.33)	G 0.056+ (1.86)	LC 0.56(10 <sup>-3</sup> )** (7.23)	TP 0.52(10 <sup>-4</sup> )** (7.34)			R <sup>2</sup> 61.9 Linear <i>linéaire</i>
(8) HP	Const -1.27 (-2.35)	FZ 0.016 (1.45)	G 0.37(10 <sup>-2</sup> )** (0.78)	LC 0.09** (2.15)	TP 0.2** (4.89)	AN 0.43(10 <sup>-2</sup> )** + (1.41)		R <sup>2</sup> 37.8 Log
(9) HP	Const 0.36 (1.2)	LC 0.14** (3.86)	OX 0.025* (2.5)	OP 0.57(10 <sup>-5</sup> )** (4.5)				R <sup>2</sup> 45.5 Log
(10) HP	Const 1.19+ (1.51)	FU 0.25+ (1.52)	TL 0.14(10 <sup>-3</sup> )** (6.42)	OX 0.73(10 <sup>-4</sup> )** (3.19)	OP 0.38(10 <sup>-4</sup> )** (4.21)			R <sup>2</sup> 61.8 Linear <i>linéaire</i>
(11) HP	Const (1.38) (1.53)	FU 0.54** (3.07)	LC 0.18(10 <sup>-3</sup> )** (5.19)	OX 0.11(10 <sup>-3</sup> )** (4.39)				R <sup>2</sup> 49.6 Linear <i>linéaire</i>



TABLEAU 39 IMPORTANCE RELATIVE DES ENTRANS AGRICOLES  
ANALYSE DES PRINCIPALES COMPOSANTES

TABLE 39 RELATIVE IMPORTANCE OF FARM INPUTS

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PRINCIPAL COMPONENT ANALYSIS

39 a. FACTORS AND EIGENVALUE FACTEURS ET VALEUR EIGEN

FACTOR <i>FACTEUR</i>	1	2	3
Eigen - value <i>Valeur Eigen</i>	2.84	1.62	0.7
Per Centage of Variance <i>Pourcentage de Variance</i>	47.33	27.07	11.66
Cumulative Per Cent <i>Pourcentage cumulatif</i>	47.33	74.4	86.06

39 b. FACTOR LOADINGS CHARGES DE FACTEUR

VARIABLES	FACTOR <sup>EUR</sup> 1	FACTOR <sup>EUR</sup> 2	FACTOR <sup>EUR</sup> 3
Hectares	- 0.450	0.367	- 0.068
Family labour units <i>Unités de Travail familial</i>	- 0.401	0.003	(-0.842)
Total farm labour <i>Travail agricole Total</i>	(- 0.560)	-0.096	0.342
Labour for critical farm operations <i>Travail pour opérations agricoles critiques</i>	(- 0.550)	-0.096	0.368
Hire or cost of ox-plough <i>Location ou coût de charrue à bœufs</i>	0.002	(-0.673)	-0.055
Animal traction <i>Traction animale</i>	0.145	(-0.634)	0.176



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- Team Leader and Soil Scientist SAFGRAD FSR Support, Burkina Faso.
- Team Leader and Agricultural Economist, SAFGRAD FSR Support, Cameroon
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Mrs THIOMBIANO FLORENCE	- Office Manager	Mr DOHOUEYOU ALBERT	- Accountant
Mr GUIRA HAROUNA	- Driver	Mr ZOROME SEYDOU	- Driver

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Department of Rural Economy and Agriculture (DREA)

African Union Specialized Technical Office on Research and Development

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