ORGANIZATION OF AFRICAN UNITY

SCIENTIFIC, TECHNICAL AND RESEARCH COMMISSION

(OAU/STRC)

ON-FARM ADAPTIVE RESEARCH AND TECHNOLOGY DEVELOPMENT IN NORTHERN BENIN

OAU/STRC-SAFGRAD FARMING SYSTEMS RESEARCH PROGRAMME
END OF PROJECT REPORT
IFAD TECHNICAL ASSISTANCE GRANT N° 110

SAFGRAD

SEMI-ARID FOOD GRAIN RESEARCH AND DEVELOPMENT

JANUARY 1989

F A R M I N G S Y S T E M S R E S E A R C H

I N N O R T H E R N B E N I N

END OF PROJECT REPORT

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ACKNOWLEDGMENT

The Semi-Arid Food Grain Research and Development Agency (SAFGRAD) has enjoined the partnership of the Directorate of Agricultural Research of the Ministry of Rural Development in the total efforts made to develop appropriate farming systems in Northern Benin. The genuine participation and support of various scientists and institutions in Northern Benin was instrumental in facilitating the implementation of the FSR project. OAU/STRC SAFGRAD would like to specially record its appreciation to both Professor F.D Adjahossou and Mr B. Soude, respectively, former and current Directors of Agricultural Research (DRA). The FSR team that was based in Northern Benin and the SAFGRAD Coordination Office also are grateful to Mr M. Adomou, the Director of INA Research Station for his continuous encouragement and day to day administrative support.

The support and mutual interactions at the field level of "Le Centre d'Action Regional pour le Developpement Rural" of Borgou and Atacora Province are highly appreciated. OAU/STRC SAFGRAD wishes to express its thanks to the International Fund for Agricultural Development (IFAD) for the financial assistance in supporting SAFGRAD/Benin FSR activities from March 1985 to 30 June 1988.

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ACRONYMS

AVA	Agent de Vulgarisation Agricole
ATDR	Agent Technique du Developpement Rural
CARDER	Centre d'Action Regionale pour le Developpement Rural
CENAP	Centre d'Etudes en Agropedologie
DRA	Direction de la Recherche Agronomique
FSR	Farming Systems Research
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture
ILCA	International Livestock Center for Africa
ICRISAT	International Crops Research Institute for Semi Arid Tropics
ICRAF	International Council for Research in Agroforestry
IRAT	Institut de Recherches en Agronomie Tropicale
MDRAC	Ministere du Developpement Rural et Action Cooperative
OAU/STRC	Organization of African Unity/Scientific, Technical and Research Commission
RAMR	Recherche Appliquee en Milieu Reel
R-D	Recherche Developpement
SAFGRAD	Semi Arid Food Grain Research and Development
UNSO	United Nation Sahelian Orgnization
URP	Unite de Recherche et de Production
WASAT	West African Semi Arid Tropcs

PREFACE

This report highlights major research undertakings of the SAFGRAD/FSR in Northern Benin. The reader is kindly referred to to the project's annual reports for 1985, 1986 and 1987 for details.

The FSR project was started in mid 1985. Initially two senior researchers--an agronomist and an economist-- were based in Northern Benin where available national researchers were invited to collaborate in FSR activities. The economist was transferred to Cameroon in February 1986 and was replaced in July of the same year. The agronomist and team leader of the programme left in September 1986. The new agronomist and the agroforester joined in January and March 1987, respectively. This rather rapid turnover of the project senior staff seriously disrupted the running of the programme.

The FSR programme was reviewed by the IFAD Evaluation Mission in November/December 1987. The Mission also realized that the project had operated under serious constraints including limited financial resources and the lack of appropriate research facilities in Northern Benin. The Mission noted however that the FSR team acquired a good knowledge of farming sytems in the region and succeeded to sensitize the national programme on the essence of FSR.

We hope that this report will be fully exploited by the relevant groups for the continuity of FSR activities in Northern Benin.

E X E C U T I V E S U M M A R Y

1. The SAFGRAD/FSR project was started in Northern Benin and was based at the Ina Agricultural Research Station in Borgou province with research activities extending to the Atacora province as well.

2. Exploratory surveys conducted in 1985 revealed the following major constraints: (a) drought in recent years; (b) low soil fertility and soil degradation in certain parts of Atacora; (c) lack of animal feeds during the long dry seasons and (d) generally a paucity of research recommendations tailored to the socio-economic conditions of farmers.

3. Moving across ecological zones of Northern Benin, existing farming systems can be characterized by cropping systems consisting mostly of intercropping cereals, shifting cultivation of 3-5 years fallow and a high interaction between crop and livestock production systems.
Farm sizes range between 2-5 ha and are much larger in the Sudan and Sahelian zones where animal traction is widely used. Cotton is the main cash crop (1/3 of average farm holding) and 75% of cotton farmers use animal traction. Net incomes from cropping enterprises range from 22,000 CFA/ha in the extreme north to over 87,000 CFA/ha in the Guinea Savanna zone where a wide range of crops including yams are cultivated.

4. During the first two years of the project, FSR activities were concentrated on improving cropping systems with emphasis on developing crop association techniques for Northern Benin . Recognizing the role of livestock and agroforestry , preliminary surveys and experiments were carried out. The ultimate objective of the programme was hence to develop sustainable food production systems that integrate crops, trees, animals as well as techniques to improve soil fertility and water use efficiency.

5. Technology evaluation to improve existing farming systems was undertaken between 1985-1987. The summary is as follows:
--In all crop association trials, yields of individual crops across sites and seasons are reduced as compared to yields in pure stand. For cereal/legume associations, yield reductions of up to 50% were recorded. Land equivalent ratios (LER) however are higher in the associations with values sometimes exceeding 1.50 . Coefficients of variation (CV) across sites and seasons were lower under associations, thus showing increased stability of intercropping over monocultures.
-- Improved white grain maize (TZB) fits well in the sorghum/maize intercrop when associated with local sorghum. This is due to their different growth patterns which minimize competition. Ridging and fertilizer application increased the grain yield of sorghum/cowpea association by 32% .
-- Crotalaria spp (sunhemp) planted as green manure improved the yield of maize by 45% when incorporated into the soil at the

second weeding (45 days after sowing of maize). This practice has been recommended for pre-extension tests as it involves minimal additional labour.

-- Improved maize responds to fertilizer. It was found that in Northerhn Guinea and Sudan Savanna, maize should be planted on flat and then rigded after the last weeding to incoporate fertilizer (or manure) and guard against lodging.

-- On-farm trials indicated the following : (a) the benefit-cost ratio for fertilizer application on maize was higher in the Sudan Savanna than in the Northern Guinea zone; (b) on poor and degraded soils of Ouake district (Atacora) with relatively higher rainfall, the appication to maize of 1/4 of the recommended dose (60 kg/ha N.) resulted in the highest marginal rate of return ; (c) application of 10 t/ha of animal manure increased yield of sorghum by more than 100% .

-- The comparison of two land preparation techniques for yams i.e. ridges vs mounds revealed no significant differences in yields over two years. High returns to family labour,however, can only be obtained if animal traction is used for making ridges.

-- Mixed intercropping of leguminous trees -- Acacia albida and Leucaena leucocephala with sorghum and cowpeas for soil fertility improvement, fodder and firewood showed great promise. Grain yield increases of more than 40% were recorded for sorghum and cowpea in association with albida. Preliminary results of alley cropping with Leucaena and Cajanus cajan indicte that initial establishment does not seriously interfere with or reduce yields of associated crops. The experiment at Alafiarou near Parakou stimulated interest among visiting farmers.

-- Evaluation of adaptable forage species for introduction in traditional farming systems showed the following species as promising for Northern Benin conditions: Stylosanthes hamata,Centrosema pubescens, Leucaena,Pennisetum purpereum and Panicum maximum.

6. Efforts to institutionalize FSR were hampered by many constraints. Financial resources were limited to achieve all programme objectives given the very large mandate area and the lack of research facilities at Ina.

Short and long term training could not be achieved as planned for lack of funds. Building local FSR capacity was seriously constrained by the lack of counterparts while the high turnover of the project senior staff disrupted the continuity of research activities. The short duration of the project prevented the programme to acquire enough results to formulate far reaching recommendations.

1.BACKGROUND INFORMATION

1.1. Objectives

In March 1985 an agreement was signed between OAU/STRC/SAFGRAD and the People's Republic of Benin for the implementation of the Farming Systems Research project with financial assistance from IFAD. The general objective of the project has been to improve Benin FSR capacity and assist the national FSR programme in establishing functional linkages between research, development and farmers. While enhancing agricultural development in rural areas, the project had to influence research priorities, approach and strategies so that emphasis would be on farmers' needs. The short term (specific) objectives of the FSR programme in Northern Benin included (a) conducting baseline surveys to generate information on the existing crop, livestock and agroforestry production systems ; (b) identification of location specific physical, biological and socio-economic constraints ; (c) conducting on-farm adaptive trials and (d) development of production methods that integrate trees, crops and animals as well as techniques to conserve soil moisture and other resources.

To facilitate the linkages between farmers, extension workers, researchers and other institutions involved in management of natural resources ,the conceptual framework depicted in Figure 1 was adopted.

1.2.The Project Area

The People's Republic of Benin has an area of 112,600 km2 with a population of 3.6 million (Adam and Boko, 1983). It is situated

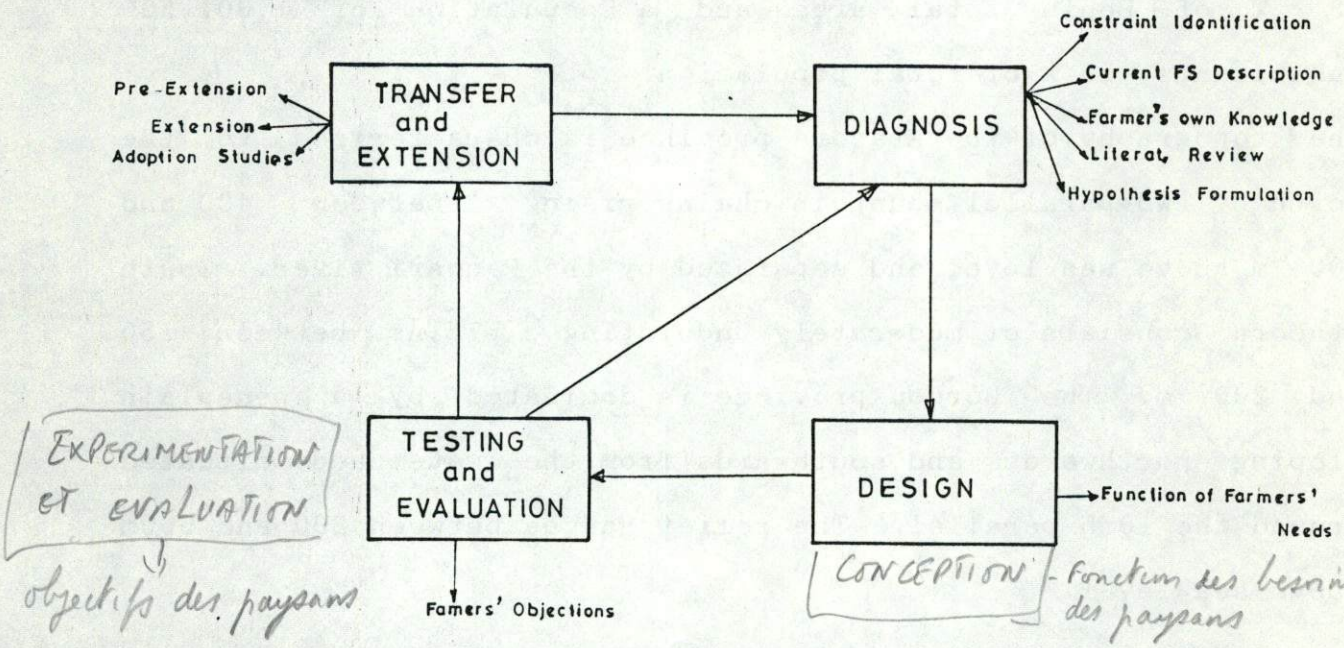


Fig. 1 Activities/Stages in the Implementation of FSR

Fig 1 : Activités / étapes de mise en oeuvre de la RSP

between latitudes 6.30 degrees and 12.30' degrees north stretching across five agro-ecological zones (fig. 2) : the Coastal Forest zone, Southern Guinea Savanna, Northern Guinea Savanna , Sudan Savanna and Sudano-Sahelian Savanna in the extreme north.

The project activities were conducted in the two northern provinces of Borgou and Atacora with a total area of 82,200 km2, 73 % of Benin total area and a population of 1,001,500 inhabitants, 28 % of total population.

The topography of the Atacora province is characterized to the north by two parallel mountain chains rising between 400 and 600 m above sea level and separated by the Panjari river. South Atacora consists of moderately undulating plains between 150 and 200 m. The Borgou province is dominated by a peneplain sloping northwards and southwards from the watershed situated around the 10th parallel. The relief ranges between 200 and 500m above sea level.

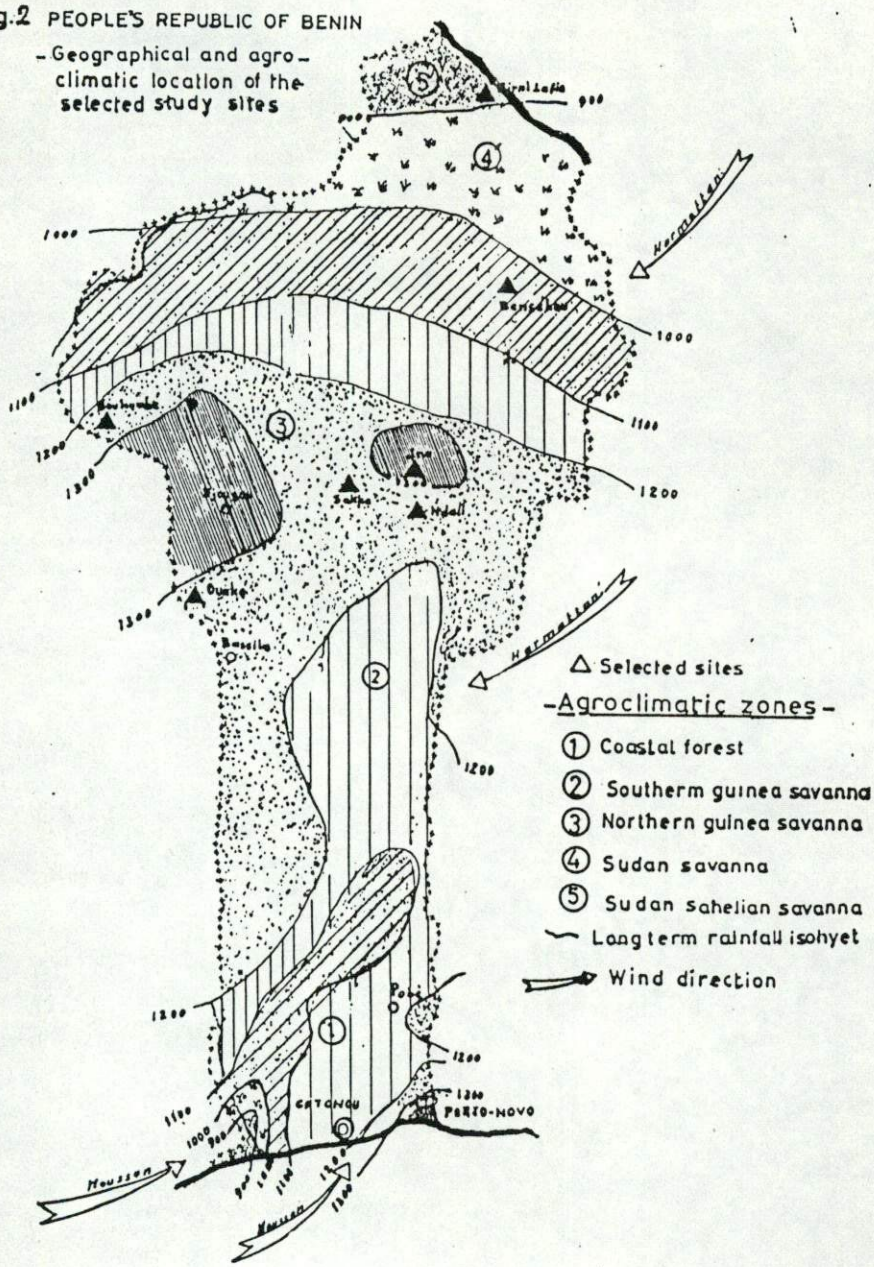
The climate of the country is influenced by the movement of two winds : The Oceanic humid monsoon winds which blow from the Atlantic Ocean arriving in Northern Benin towards May and staying until October, and thus responsible for the rainy season ; and the Harmattan, the continental dry winds which blow from the continent (northeast) from November to April thus responsible for the dry season. Generally, the rainfall declines and becomes more irregular as one moves north.

Northern Benin has three major agro-ecological zones (fig.3) :

(a) Northern Guinea Savanna to the south of the two provinces ;

Fig.2 PEOPLE'S REPUBLIC OF BENIN

- Geographical and agro-climatic location of the selected study sites



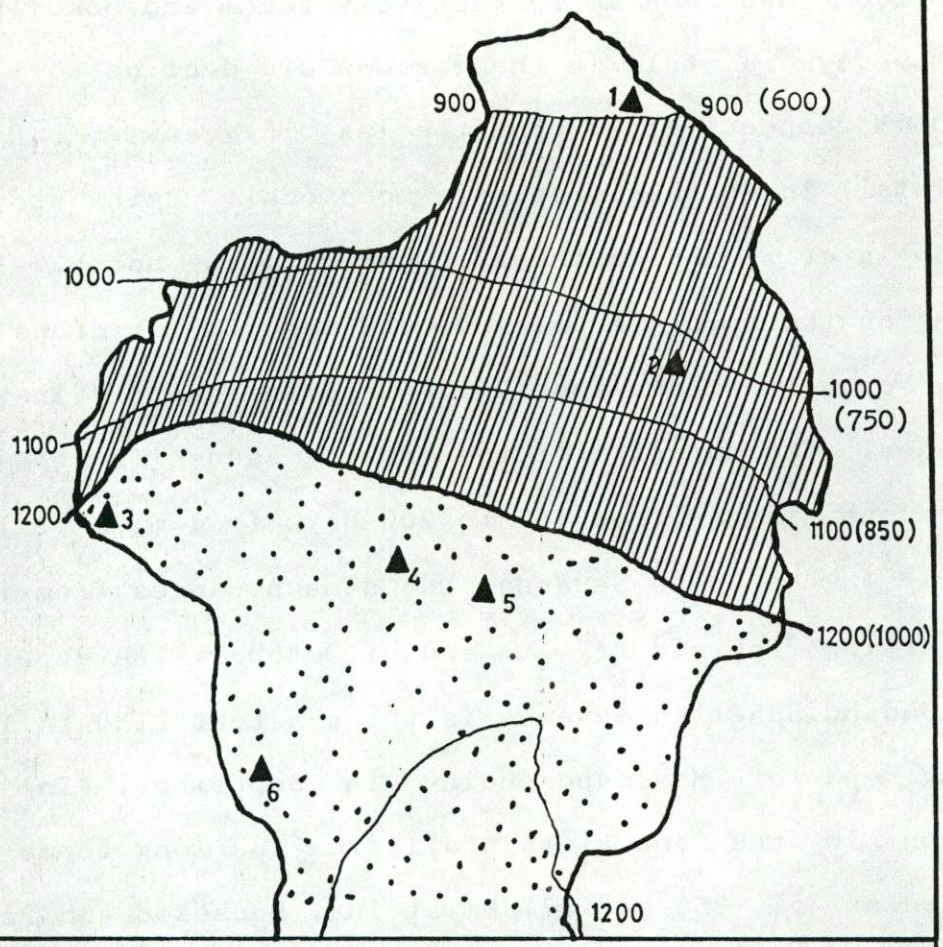


Fig.3

1. AGRO CLIMATIC ZONES : 1. ZONES AGRO CLIMATIQUES

NORTHERN GUINEA SAVANNA SAVANE NORD GUINEENNE

SUDAN SAVANNA SAVANE SOUDANIENNE

SUDANO SAHELIAN SAVANNA SAVANE SOUDANO-SAHELIENNE

2. ▲ SELECTED SITES : SITES RETENUS

1 BIRINI-LAFIA 2 BENSEKOU 3 BOUKOUMBE
4 SOKKA 5 INA 6 OUAKE

3. Figures in parentheses are recent precipitations (last 2 decades)
Les chiffres entre parentheses representent les recentes precipitations (2 dernières décennies)

(b) Sudan Savanna in the mid-belt and (c) Sudan Sahelian Savanna in the extreme north with long term annual average rainfall of 1200, 1100, and 900 mm respectively (Adam and Boko 1983). The annual average rainfall in these zones did decline to 1000, 850 and 750 mm respectively during the last 15 years.

The rainfall in Northern Benin is monomodal. Rains start earlier and stop later in the south as compared to the north. Throughout the region the rainfall peaks around August. It drops gradually in the Northern Guinea zone while tapering sharply in the other two zones. The duration of the growing season in the Northern Guinea zone ranges from 160 to 200 days from mid April to mid October. In the Sudan Savanna, the season ranges from 140 to 160 days starting from mid May to end of October. The growing season in the Sudano Sahelian Savanna is the shortest (120 to 140 days), starting end of May and ending in September. In 1987 the reduction in the annual rainfall from the long term mean was estimated at 357, 265 and 277 mm at Ina, Bensekou and Birni-Lafia respectively. In addition to its declining trend, the rainfall is very irregular and poorly distributed (fig. 4). This has resulted in frequent droughts and consequent losses in crop yields. Throughout the region the mean minimum (24-25 degrees) and mean maximum (29 - 30 degrees) monthly temperatures are recorded during the rainy season (August) and dry season (March) respectively. The high temperature, high irradiation coupled with low rainfall culminate in a water balance deficit in the region for most parts of the year (fig. 5).

The dominant soil group in Borgou province is the Ferruginous

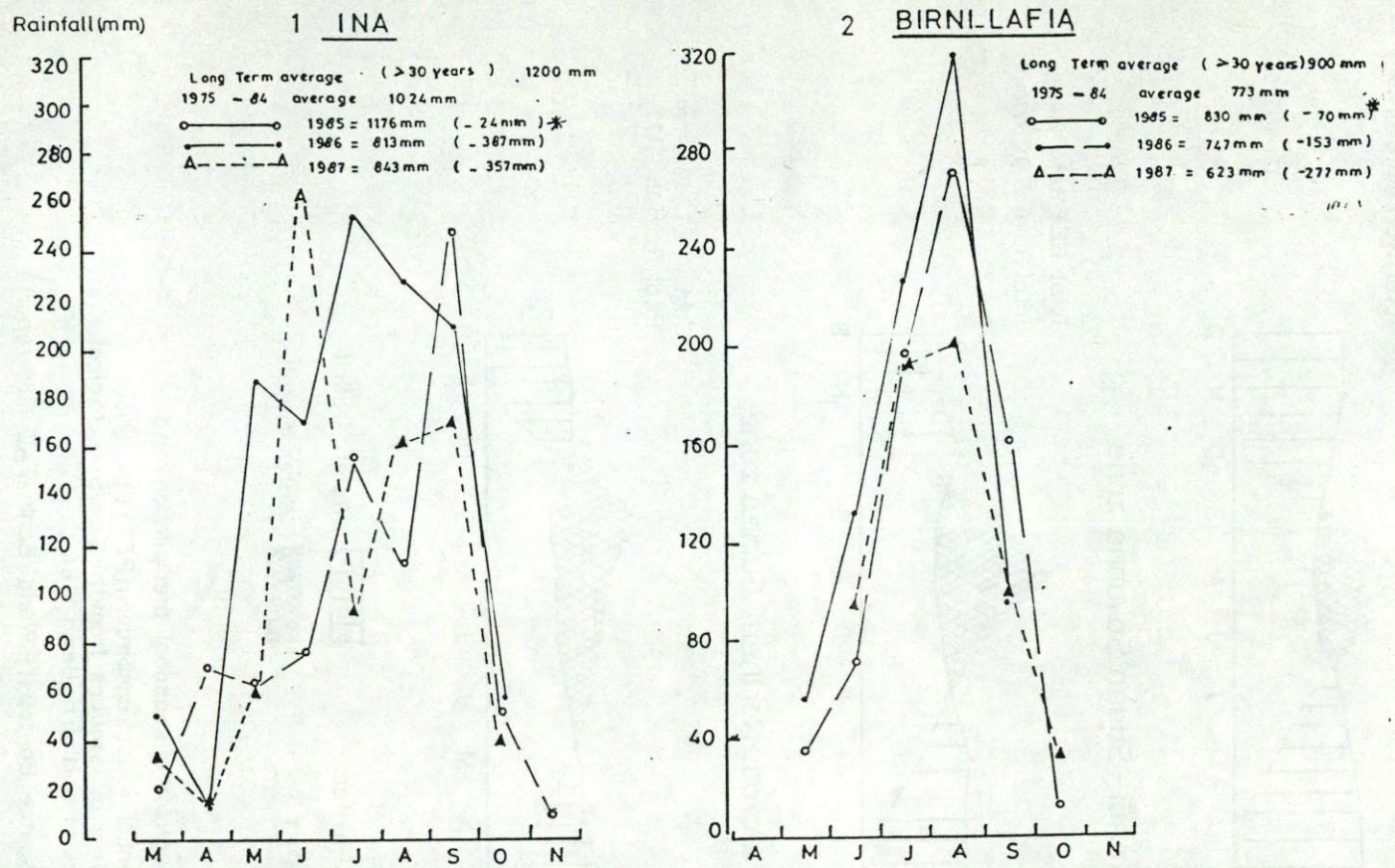


Fig 4. Average annual rain fall (long Term) (>30yrs); 1985, 86 and 87 for Ina (Northern Guinea zone) and Birni Lafia (Sudano Sahelian zone)

* Reduction from the long term annual average rainfall

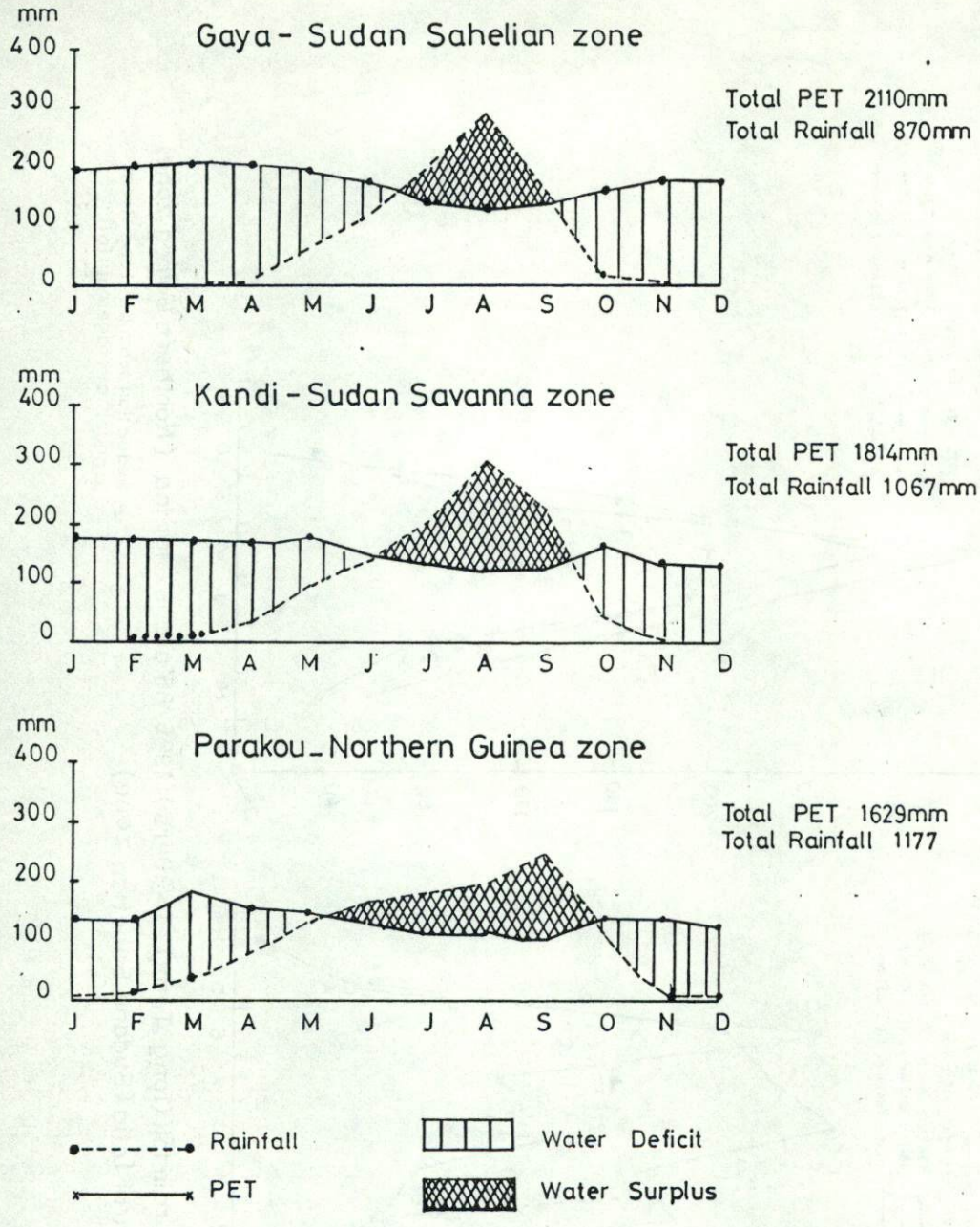


Fig 5 Comparison of seasonal precipitation and potential evapotranspiration (PET) throughout the year at 3 stations from the 3 agro-ecological zones of Northern Benin 1984

(source Borgou II - World Bank FAO 1986 report)

Tropical soil (85 %). This group is subdivided into four subgroups according to the degree of leaching and parental material. Soils in this group are slightly acid and redish in colour with medium texture (except those in Kandi-Malanville and Sota areas which are sandier and more acidic). Some subgroups have iron concretions and in the extreme case, an indurated layer which interferes with root penetration. With the exception of the subgroup with an indurated layer, Ferruginous Tropical soils are moderately productive and would support a wide range of crops (sorghum, maize, cotton, groundnut, cowpea, yams and manioc). Phosphorus levels are low thus this element needs to be supplied. The other soil groups of relatively minor occurence in Borgou province are : (i) Ferrallitic soils weakly desaturated (5 %) ; these soils are susceptible to degradation by erosion and nutrient depletion and are consequently better used for forest and perennial crops. (ii) Hydromorphic soils (less than 1 %), covering valley bottom and back swamps of streams ; they are poorly drained and are thus good only for rice during the rainy season and vegetables growing in the dry season under irrigation. (iii) Vertisols wich include fertile alluvial black, heavy soils with high clay content of the Niger Valley.

The soils of Atacora are generally similar to those of Borgou province, being dominated by the different subgroups of Ferruginous Tropical soils. The subgroup with an indurated horizon covers a significant part of the Kouande district. In certain districts of Atacora, namely Boukoumbe and Ouake, the high population density has led to increased deforestation and subsequent deterioration of physical and chemical soil

properties.

The natural vegetation of the two provinces is generally the same. It is largely wooded savanna (parkland) with Pterocarpus enrinaceus, Afzelia africana, Bombax buenopose, Butyrospermum parkii, Khaya senegalensis and Parkia biglobosa as the dominant species. These are seen in the forest reserves, particulary of Wari-Mono and Oueme superieur. Other more degraded forms of savanna such as the Thorny brush savanna and herbacious grass savanna have succeeded the natural vegetation in most areas. Weeds and secondary shrubs following shifting cultivation are the most common forms of vegetation .

1.3.Institutional Setting

Agricultural research, development and extension services in Benin are under the auspices of the Ministry of Rural Development and Cooperatives (MDRAC). A Directorate of Agronomic Research (DRA) supervises 13 research and production units (URP), of which 8 have a commodity mandate (fig.6).

Extension activities are implememted by the Centre d'Action Regionale pour le Developpement Rural (CARDER) with financial support from the World Bank, IFAD and other agencies. The extension service is recognized as strong and well decentralized; nearly all vilages in Benin are tended by an extension agent (AVA).

The SAFGRAD/FSR programme was based at URP/Ina. The station is 70km north of Parakou, the capital of Borgou province. Ina was started in 1930 as an exprimental farm working on animal traction and seed multiplication. It became a fully fledged research

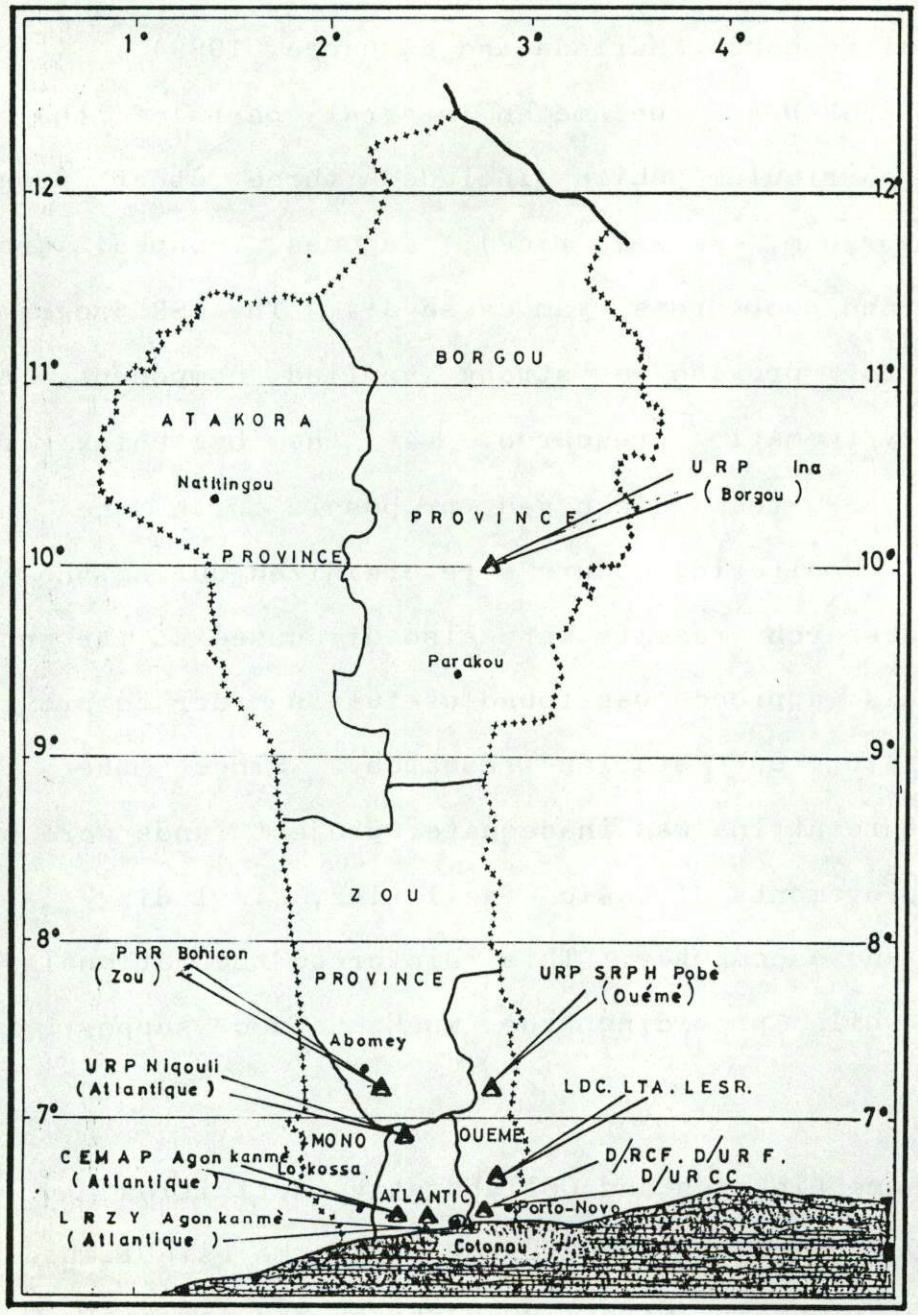


Fig 6 PEOPLE'S REPUBLIC OF BENIN: Location of agricultural research centres

▲ Research centers (Acronyms are spelled out in Appendix 1)

station in the 1960's under the patronage of the French "Institut de Recherches Agronomiques Tropicales(IRAT) until late 1970's when the government of Benin took over the responsibilty of all agricultural research (Murinda and Kamuanga, 1988) .

In 1985 SAFGRAD/FSR became an integral part of the URP/Ina research curriculum which included three other programmes: Cereals (sorghum, maize, rice); Legumes (cowpea, groundnut, soybeans) and Root Crops (yam,cassava). The FSR programme was intended to provide a strong applied component to the disciplinary/thematic research. At the beginning of each season,the FSR team discussed proposals with the national scientists. Monitoring tours were organized during the growing seasons. Research results were also discussed at the end of the season. This approach was found useful in order to provide the feed-back to on -station research. Since the research infrastructure at Ina was inadequate, project funds were used for modest improvements of basic facilities, including laboratory equipments and a computer. This reinforced the national research capacity while providing the much needed support to FSR activities.

1.4. Programme Linkages and Collaborative Activities

From the beginning the SAFGRAD/FSR programme established a good working relationship with CARDER/Borgou and Atacora. The main areas of collaboration with CARDER included the selection of FSR sites,planning and implementation of research activities as well as sharing socio-economic data. The team maintained contacts with the DRA's Center for Economics and Sociology Studies of

Porto-Novo and with two FSR projects in Zou (Recherche Developpement -Zou-RD) and Mono province (Recherche Appliquee en Milieu Reel -RAMR). FSR/Benin also collaborated with the United Nation Sahelian Organization (UNSO) and FAO's Livestock projects at Parakou through joint experimentation.

At the regional level the programme intended to utilize technologies developed by IITA, ICRISAT and ILCA for the West African Semi-Arid Tropics (WASAT). This was partly realized through the testing of new varieties of maize, cowpea, and groundnut and to a limited extent sorghum. Improved practices such alley cropping and tied ridges developed by IITA were also tested for adaptation to Northern Benin conditions.

2. FARMING PRACTICES IN NORTHERN BENIN

Production systems in Northern Benin are predominantly subsistence oriented. They are characterised by rudimentary division of labour and complex and integrated forms of agricultural systems (cropping, livestock etc.). Areas with very low population densities still practice shifting cultivation. Large sections of farmers practice fallow systems and the duration of fallow (3-5 years) depends on available land . Permanent land cultivation systems have evolved in some districts of Atacora province due to high demographic pressures. Specialised traditional crop rotation systems exist in all cropping systems. Food crops are grown in associations while cash crops (cotton and groundnuts) are mostly grown in pure stands. Livestock plays an important role in traditional systems. A large number of crop farmers also keep animals. Crop/livestock integration is mainly through the use of animal traction, manure and the grazing of crop residues. A detailed description of each component of the production systems is given below.

2.1. Cropping Systems

The prevalent cropping systems consist largely of intercropping food crops under shifting cultivation or under fallow systems to restore soil fertility (SAFGRAD/FSR,1985). In the Borgou province, yams is often the first crop to be planted after the forest is cleared ; it is followed typically in successive seasons by cotton or groundnuts (one or two crops) ; maize or sorghum in pure culture or in association and lastly manioc

before the fallow lasting 3 years or more depending on available land (CARDER/Borgou , 1986). In the Northern Guinea Savanna, a maize-sorghum intercrop is the major association grown by 75 % of the farmers. This is followed by cotton (46 %), yams (44 %), pure sorghum (40 %) ; groundnuts, cassava and cowpeas are grown by 35, 33 and 31 % respectively. Millet and yams intercropped with beans are also found in this zone.

Cotton is by far the dominant crop in the Sudan Savanna. It is followed by sorghum intercropped with maize or in pure stand. Other crops are groundnuts, millet, and beans, respectively grown by 64, 57 and 35 % of the farmers. In the Sudano-Sahelian zone, the most important crops are millet, sometimes associated with beans. This is followed by sorghum and groundnuts grown by 69 % of the farmers. Although the area planted to cotton is small, in this zone, still 76 % of the farmers grow it. Other frequently associated crops are maize, sorghum, millet, and beans. In the Atacora province major crops respond to a certain pattern of geographical distribution (CARDER/Atacora, 1985). Sorghum is the principal crop on all farms, followed by yams and cassava. In the southern area, maize and cowpea play a significant role ; in the east cotton and maize are found ; in the west cowpea and voandzou (Bambara beans) enter the rotation ; and in the center emphasis is on groundnuts.

In the Sahelian zone land clearing is light whereas in the other two zones, with much vegetation, slash and burn are common practices. Land preparation in the Sahelian zone is mainly by oxen (SAFGRAD/Benin 1985). The percentage of farmers using ox-ploughs reduces as one moves south. In the Northern Guinea zone

the most common method of land preparation is hoe ploughing, ridging for cotton and groundnuts and mounds for yams and cassava. In both Sudan and Northern Guinea savanna land clearing for yams is done in September and mounds made in November/December to take advantage of the post harvest residual moisture. The mounds are mulched throughout the dry season to maintain low soil temperatures. Unfinished mounds are completed at the begining of the rains in April/May. Land prepparation for the other crops is done in April/may in the Sahelian and Sudan Savanna and in March/April in the Northern Guinea zone .

Planting in lines on flat is used in both the Sahelian and Northern Guinea savanna zones while planting on ridges is more popular in the Sudan and Northern Guinea zones. In Northern Guinea and Sudan savanna zones, yams are planted in February/March on mounds made in November/December of the previous year and the second planting is done in April/May on mounds made at the begining of the rains. In these two zones cotton is sown in early June and in late June for the Sudan Sahel. The sowing period is usually short (two weeks) as a result of the close supervision provided by CARDER agents.

Sowing of food crops is done in April/May/June in the Northern Guinea zone (depending on the onset of the rains), in May in the Sudan savanna and in June/July in the Sudan-Sahel zone. The long sowing period for food crops is attributed to staggered planting (SAFGRAD/FSR, 1986) with the intention to minimise crop failure arising from drought spells which can occur any time during the season.

Cotton is planted at a recommended density of around 62,500

plants/ha (80 cm x 40 with two plants per hill). Plant densities for food crops vary from farmer to farmer and location to location, depending on soil water, fertility and type of crop associations (SAFGRAD/FSR,1986). Generally, plant densities are lower in the north which is relatively drier than the south. Plant densities for cereals range from 12,000 plants/ha at Ouake (relatively poor soils) to 100,000 plants/ha at Ina. Plant densities for legumes range from 1000 plants/ha in the associations, when legumes are considered as secondary crops to around 100,000 plants/ha in pure stands (groundnut is the only legume grown in pure stand).

All cotton farmers apply fertilizer at the recommended rate (150 kg/ha NPK + 50 kg/ha urea) by CARDER, which supplies it on credit. Fertililizer is rarely used on food crops for financial reasons ; occasionally cotton fertilizer is applied to maize at low doses. To overcome this constraint, farmers tend to grow the high fertility demanding crops such as yams and maize on the more fertile soils (i.e. they come first in the rotation); in addition the maize crop following cotton seem to benefit from cotton fertilizer. Farmers also believe that cereal/legume associations degrade soils less than monocultures.

CARDER also supplies high quality seeds of improved cotton varieties (299-10-75 for Northern Guinea zone, MK 73 for Sudan Savanna and Sudan Sahelian zones) to farmers free of charge. Yields of such varieties of up to 2.0 tons/ha have been recorded on some farmers' fields (SAFGRAD/FSR, 1986). In the Northern Guinea and Sudan Savanna zone, new varieties of maize have been successfully adopted by farmers. The current popular variety TZB

yields on average 1.5 tons/ha as compared to 0.86 tons/ha for local maize in Northern Guinea zone (CARDER Borgou 1985). Farmers have also picked up some improved varieties of groundnuts (69.101) and cowpeas (TN.61). On the other hand they still use local varieties of sorghum and yams as there are no improved varieties of these crops which can out yield the local ones in the region.

No herbicide is used on any crop in the region. First weeding is generally done by hand. On the other hand the second weeding is done either by hand or animal traction, the latter is especially so for cotton, sorghum and maize. All root crops are always weeded by land. Food crops in associations are generally weeded before the pure stands (SAFGRAD/FSR,1986). The frequency of weeding ranges from one to three depending mostly on the duration of the season and the availability of labour. There is no chemical pest or disease control on food crops. However, farmers in the region claim that association of crops minimizes diseases and pests.

All harvesting is done manually ; hence high labour demand at this period results in labour bottleneck. Cotton harvesting is staggered from the Sudan-Sahelian zone to the Northern Guinea Savanna as a result of different planting dates. Except for millet in the Northern Guinea Savanna, where it is not a major crop, other cereals are harvested earlier in the north than in the south of the two provinces. In most cases cereals grown in association are harvested before those in monoculture. Generally, harvesting starts in September with early maize and continues up

to late December with late varieties of sorghum.

2.2. Livestock System

Livestock is an important component of the production system in Northern Benin. The two Northern provinces provide over 88 percent of the national herd, 66.3 % from e Borgou and 22.1 % from Atacora provinces ,respectively (Louis Berger Inc. 1987). Small ruminants (sheep and goats), pigs and poultry make up 94.9, 7.4 and 72.1 percent of the national stocks respectively.

The most important cattle breeds found in Northern Benin include the Taurin Borgou, Taurin Somba, Zebu and crosses between the three breeds. Most of the cattle are managed by nomad herdsmen (Fulani and Gando) who do little farming and move extensively in search for feed and water. Small holder producers own and manage small numbers of cattle and small ruminants for draught power, manure, milk, farm transport, meat and cash. Livestock ownership and distribution among smallholders varies significantly among the three agro-ecological zones. It is further influenced by livestock keeping traditions and needs. Surveys data (SAFGRAD/FSR, 1986) showed that 100, 78 and 12 % of farm families in the Sahel, Sudan and Guinea Savanna zones respectively, own and manage livestock for animal traction. Small ruminants are more prominent in the Guinea Savanna zone where livestock keeping traditions and the need for animal traction are minimized.

Basically two systems of herd management coexist : sedentary and extensive. The intensive management is practiced by small stock owners, usually of less than 10 animals.

During the rainy season, animals are herded by small children

and grazed on fallows and rangelands around the compounds. Small ruminants are often tethered on short ropes during the day. Supplementary feed, in the form of browse and fresh herbs is usually given to small ruminants during this period. In the dry season, after crop harvest, animals are left to graze freely on crop residues and natural rangelands. Some amount of supplementary feeding in the form of stored crop residues and browse is practised at the later part of the dry season.

The extensive management is practised by the Fulani herdsmen. A regular transhumance pattern is observed where animals migrate to river basins southwards after crop residue grazing and return with the onset of the rains. Animals subside basically on natural rangelands with little or no supplementation.

Traditional production systems at the small farmer level have been based on long fallow periods and use of farm yard and animal manure for soil regeneration. Due to increasing population and cultivation pressures, fallow periods have considerably decreased and given way to almost continuous cultivation, particularly in the Ouake and Boukoumbe districts of Atacora. The use of manure has also declined considerably with the introduction of chemical fertilizers for cotton. Crop/livesock integration in this system is through crop residues, fallow grazing,animal manure,animal traction and transportation. The degree of integration depends on the type of farm entreprise, agro-ecological zone and ownership of livestock. More efficient integration for self sustainance of the system is required through forage legume introduction.

The use of animal traction is relatively new in Northern Benin.

It was introduced between 1960 and 1970 to the Borgou and Atacora provinces (CARDER 1985). It is gaining ground rapidly and is being supported by CARDER through training of both farmers and work animals as well as supply of equipment. It is estimated that between 40 and 60 % of all farmers in Borgou use animal traction (Louis Berger Inc, 1987 ; CARDER Borgou, 1987). The recent increase in the use of animal traction in the Sudan and Northern Guinean zones can be attributed to increases in cash crop production (cotton and groundnuts) in these zones. Factors that limit the wide use of animal traction include : (a) lack of feed at the later part of the dry season and at the begining of the wet season when animals are needed most for land preparation. This results in poor condition of animals and reduced work output; (b) diseases at the beginning of the rains and (c) lack of appropriate equipment and insufficient farmer training.

2.3.Agroforestry Systems

The traditional land use system in Northern Benin is characterised by (a) the presence of economic trees, which are deliberately left on crop fields, home gardens and fallow lands ; (b) shifting cultivation and specialised crop rotation systems. Tree species often encountered on fields include : Butyrospernum parkii (karite),Parkia biglobosa (nere), Adansonia petandra (kapokier), Khaya senegalensis (khaycidra) and to a small extent, Acacia albida at the extreme north.

These trees are usually associated with crops and constitute an important economic and natural resource. The nut of karite is an important source of fat and cash for most peasant families, the

wood for carpentry and the bark for medicinal purposes. The nere follows the karite in economic importance ; its fruits and seeds, rich in sugars and vitamic c, are used in fresh local drinks and as food condiment.

Acacia albida and Khaya senegalensis are often retained for browse during the dry season and for pharmacological uses.

Economic trees are usually associated with the major food crops in each zone. Special tree crop associations are prefered by the farmers; these differ from zone to zone depending on the crop preferences and climatic conditions. In the Northern Guinea zone, yam/karite and karite/sorghum associations are prefered. Although nere is associated with most crops it is believed to slightly reduce yields of associated crops. Less frequent tree/crop associations such as pigeonpea with maize and sorghum are found in all zones. Pigeonpea is usually planted on farm boundaries for food grain and fodder.

The tree component is dominated by the nere and karite which form the upper story with heights ranging from 2 - 5 meters.

Trees are randomly distributed and in no organised arrangement. Densities are variable, ranging from 50 - 100 trees per hectare in the Guinea savanna zone to less than 20/ha in the extreme north. Acacia albida, naturally encountered in the Sudano-Sahelian zone (extreme north), has been reduced considerably through severe grazing pressures and frequent bush fires.

Sustained food production from associated crop is attained through systematic rotation of crops and fallows, usually 3 - 5 years, to ensure soil regeneration. The major interaction between

the tree and crop components is through litter and nutrient recycling. The trees are mainly managed by cutting or pruning to allow enough light for crops and to induce fruit production. Normal crop husbandry practices such as weeding and ridging seem to benefit the trees as well. Farmers interviewed (SAFGRAD surveys 1987) clearly indicated that trees regularly associated with crops yield much higher than trees in the wild. Other than the economic value of associated trees in the cropping system, farmers do not realise any other benefits. However, this benefit alone is enough to maintain these trees on the fields.

2.4 Farm Economics

This section draws mainly on data collected at CARDER (Borgou and Atacora) on a sample of about 600 farms. Other data were collected by SAFGRAD/FSR through exploratory and baseline surveys in 1985 and 1987. A comprehensive resource allocation study conducted for one year (March 1987 to March 1988) on the project sample of 90 farmers in 6 villages is discussed in detail in the 1987 annual report, with particular emphasis labour use.

Farm holdings vary from one agro-climatic zone to another. As shown in table 1, in the Sudan Savanna and Sudano Sahelian zones where animal traction is widely used farm sizes above 5 hectares are very common. The farm family sizes range from 2 to 19 with an average of 10 persons of whom nearly half are children below 15 years of age. There are two criteria generally used to stratify farmers in Northern Benin : the cultivation of cotton and the use of animal traction. Data from CARDER Borgou indicate that an average Borgou farmer allocates 1/3 of his holding to cotton

TABLE 1 : FARM CHARACTERISTICS IN NORTHERN BENIN

Zone	Farm sizes (ha)		Family size		Number of active working men	
	CARDER Sample	SAFGRAD Villages	CARDER Sample	SAFGRAD Villages	CARDER Sample	SAFGRAD Villages
Northern Guinea	4.4	4.6	10.6	10.0	4.9	6.0
Sudan Savanna	5.3	7.6	11.2	10.0	5.6	5.0
Sudan Sahel	5.0	5.4	11.5	7.0	5.2	3.0
Average	4.8	6.4	10.9	9.0	5.2	4.7

Source : CARDER/BORGOU, 1987 ; SAFGRAD/BENIN, 1986

with the highest average percentage (44 %) realized by farmers in the Sudan savanna. A look at table 2 reveals that 58 % of farmers in Borgou grow cotton, with the highest percentage (87 %) being encountered in the Sudan-Savanna zone. There are only 25 % of farmers in the extreme north who cultivate cotton.

On the average 75 % of cotton farmers use animal traction to plow their fields ; the highest proportion (100 %) is found in the extreme north. Of the total number of farmers across the province who do not plant cotton, only 23 % use animal traction. Hence the use of animal traction is highly correlated to the cultivation of cotton. Indeed cotton farmers have the largest holdings and allocate as much land (sometimes more) to foodcrops than non-cotton farmers. This implies that those who own animal traction equipment also use it to increase the amount of land under foodcrops. In the Atacora province farm sizes and family labour availability are smaller than in Borgou. Larger farms average 3.3 ha in size ; the majority have less than 3 ha (2.7 ha average). Large farm families have an average of 4.8 active workers, small famillies comprise 3 active workers.

Available data (SAFGRAD/FSR,1985) indicate that : in the Sudan Sahelian zone, an average farm family has over 6 domestic animals of which 2 are typically oxen for drought power, 2 cattle and 2 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 ; 2 cattle and 3 small ruminants. The Northern Guinea average farm keep 11 animals of which 6 cattle and 4 goats or sheep, possibly one or two oxen.

Table 2.

PROPORTION OF ANIMAL TRACTION (AT) AND HOE FARMERS IN NORTHERN BENIN

Agro climat. Zone	Cotton Farmers					Non Cotton Farmers					Grand Tot. %	
	total Nb.	AT Farm.	%	Hoe Farm.	%	total Nb.	AT Farm.	%	Hoe Farm.	%	AT	Hoe
North. Guinea	12734	6997	55	5737	45	14264	620	4	13642	96	28	72
Sudan Savan.	13378	12241	91	1157	9	1988	723	36	1265	64	84	16
Sudan Sahel	1274	1274	100	--	--	3905	3280	84	625	16	88	12
Borgou	27386	20492	75	6894	25	20157	4623	23	15534	77	59	47

Source: CARDER/Borgou 1987.

Farm Incomes.

There are to-date few studies in Northern Benin on the composition of farmers' income. The following are estimates based on previous CARDER studies and preliminary analysis of the data collected by SAFGRAD/FSR in the 6 villages where farm monitoring was done.

The income derived from cropping enterprises is estimated in table 3. Only major crop in each agro-climatic region are considered for an average farm. The average farm shown here does not indicate in any way the range and multiplicity of crop combinations that exist among farmers in Northern Benin. Because fixed costs are small and land is virtually priceless, gross margins can stand as proxy for net returns in table 3. The results show that the average farmer in the extreme north (Borgou) realizes the smallest net income (21,838 F/ha) from crop enterprises, the highest is in Northern Guinea, followed by the farmer in Sudan Savanna zone. The most profitable enterprises are yams (142,932 CFA/ha) in Northern Guinea zone, cotton (102,035 CFA/ha) in Sudan Savanna and groundnut (35203 CFA/ha) in the Sudan Sahel zone. The average net farm income across Borgou is 56,634 CFA/ha.

No income data from livestock enterprises are available in Northern Benin. This is partly due to the difficulty in evaluating cash incomes from animal entrusted to Fulani herders, and also because farmers keep cattle for social prestige and as a store of wealth. Results from similar environments point out magnitudes of 22,000 CFA in net cash income per farm per year in

Table 3

ESTIMATES OF FARM INCOMES FROM MAJOR CROPPING ENTERPRISES IN NORTHERN BENIN (IN CFA)

		Cotton	Ground. nuts	Maize	Sorgh	Yams	Cassava	Millet	Beans Cowpeas	Total	Income/ha
Northern Guinea	Aver. Crop area (ha)	1.12	0.07	1.44 [1]	0.13	1.01	0.12		0.05		4.13 [3]
	Value of prod.	159390	4824	58300	28312	163782	19440	-	5460	439508	
	Variable costs	29370	2056	25820	1700	19420	2540	-	390	81296	
	Gross margin	130020	2768	32480	26612	144362	16900	-	5070	358212	86734
Sudan Savanna	Aver. Crop area (ha)	2.32	0.38	0.93	0.86	0.13	-	0.06	-		5.28 [3]
	Value of prod.	297550	27360	27900	44854	27720	-	1316	-	425384	
	Variable costs	60830	11160	15440	11215	2603	-	315	-	101563	
	Gross margin	236720	16200	12460	33639	25117	-	1001	-	323821	61330
Sudan-Sahel	Aver. Crop area (ha)	0.34	1.29	0.34 [2]	1.56	-	-	1.26			4.99 [3]
	Value of prod.	32120	83592	10200	32280	-	-	25830	5814	189836	
	Variable costs	8915	38180	8100	20340	-	-	4100	1230	80865	
	Gross margin	23205	45412	2100	11940	-	-	21730	4584	108971	21838

Source : SAFGRAD/BENIN 1987 ; CARDER BORGOU, 1987

Notes 1) maize-sorghum association
2) maize in pure stand
3) total cropped area includes the land planted to other minor crops.

the Segou area of Mali (Kamuanga, 1985), 44000 CFA per farm in Tenkodogou, Burkina Faso (Delgado, 1979) and 66700 CFA per farm in Northern Nigeria from Abet farmers (Ingawa, 1984). Results from the 1987 monitoring study in the 6 SAFGRAD villages were not available at the time this document was in press; they will be presented in a separate paper.

3.TECHNOLOGY TESTING AND EVALUATION

3.1.Research Methodology and Approach

Programme activities started in mid 1985 with the conduct of exploratory surveys, followed by a baseline survey from June to November 1985. This was carried out along with researcher managed trials in the five sites chosen to represent the agro-ecological zones of Northern Benin. In 1986 additional data were collected at the plot level to improve the understanding of farmers'practices and production strategies.

The agronomy programme concentrated on the evaluation of improved technologies and their adaptation to Northern Benin conditions. In order to establish relationships among factors of production, parameters and variables have to be carefully managed. Hence the reason why in FSR, researcher managed trials are conducted in early stages. Cropping systems trials in 1985 and 1986 were researcher managed at primary sites. In 1987 a number of on-farm, farmer managed trials were conducted and involved some of the technologies evaluated in the previous two years at Sokka, Birni-Lafia and Ouake. Many of the experiments were redesigned in order to account for the results of the 1986 field survey on agricultural practices. This was particularly so for crop association trials.

The inclusion of agroforestry in the FSR programme follows the recognition by many governments in the WASAT of the threat of encroaching desertification and its associated consequences. The strategy pursued consisted of identifying, developing and testing agroforestry technologies based on both multipurpose trees and

introduction trees into cropping systems. The livestock component of this programme emphasized the theme of livestock/crop integration such as the use of cattle manure to improve soil fertility and the use of crop residues, natural pastures, leguminous forages and trees as animal feeds. Because the agroforestry programme did not start until 1987, all experiments were researcher managed during the first year.

Concurrently with on-farm researcher managed and farmer managed trials, a comprehensive resource allocation study was carried out in five villages in 1987-88 . Its purpose was to generate parameters that will characterize existing cropping, livestock and agroforestry systems and to determine their biological and economic productivity under improved technologies.

3.2 Testing Improved Technologies

Major constraints to increasing agricultural production in Northern Benin along with relevant research needs were discussed and documented earlier (Benin/FSR annual reports 1985,1986). To address these constraints, experiments were initiated in 1985 and continued as expertise became available over the course of the project. Results of technology evaluation towards developing sustainable systems of food production are discussed below.

3.2.1. Improving Traditional Cropping Systems

Crop Associations

This is an old cultural practice in the region. Nearly all food crops are grown in association in Northern Benin. The practice has both economic and agronomic advantages (Norman, 1974). The

economic advantages result from minimizing food risks and increasing labour productivity ; the agronomic advantages include increased total production per unit area, soil fertility restoration and the minimization of pests and diseases. On the other hand, the yields of individual crops in the association are lower in comparison with those under monocropping. When the SAFGRAD/Benin FSR project started in Northern Benin, there was no research data on the performance of crops in associations. Consequently a number of trials were initiated at various sites to evaluate the performance of major crop associations practiced in the region. These included : a) cereal/cereal associations : sorghum/maize and sorghum/millet ; b) cereal/legume associations: sorghum/cowpea and maize/groundnut. The objectives of the trials were as follows :

- evaluation of the performance of crops in association in comparison with those in pure stands;
- evaluation of the performance of new varieties in crop associations;
- evaluation of economic advantages of crop associations.

The trials involved growing crops in pure stand and in association in order to compare the performance of individual crops and the total production of the two systems. Sorghum/maize association trials were conducted in the Northern Guinea and Sudan Savanna zones with millet replacing maize in the Sudano Sahelian zone. This was in accordance with traditional practices of cereal/cereal associations in the region. Sorghum/cowpea association trial was conducted at various sites because this is

how cowpea is grown in the whole region. The maize/groundnuts trial was dropped because with the gradual use of improved varieties, the general tendency is to grow groundnuts in pure stand as a cash crop. To improve the sorghum/maize association, the trial was grown on ridges receiving fertilizer as opposed to flat cultivation with no fertilizer. To improve the performance of cowpea in association with sorghum, cowpea was grown in alternate rows to those of sorghum as opposed to growing the two crops in the same row which is the farmers' practice in the region.

The following general trends and results were observed :

- Yields of individual crops in association were reduced as compared to yields in pure stand ; this was especially so in legumes associated with cereals where reductions of up to 50 % were not uncommon.

- Land Equivalent ratio (LER) was very high in the associations. Values exceeding 1.50 were recorded. This is an economic advantage of crop associations over monocropping considering that a subsistence farmer has labour constraints which limit the amount of land he can cultivate (Tables 4 and 5).

- The C.V. across seasons and sites was lower in the association as compared to monocropping, thus implying a higher yield stability from crop association over monocropping. This is another economic advantage of crop association in subsistence farming where yield stability is one of the criteria that measure food risk avoidance.

In sorghum/maize association, ridging + fertilizer application, (the higher management) under all conditions, increased total

grain production in pure stands and in association, as compared to flat cultivation without fertilizer ; the % increases ranged from 22.8 to 102.6 (Table 4). The higher management also reduced the C.V. This implies that high management increased both total grain production and grain yield stability. On the other hand, LER was consistently higher in the associations under low management level thus implying that association under low management has higher percentage increase in total grain production as compared to high management. This point is very important if one considers that most farmers in the region operate under low management.

Partial budget analysis of each treatment reveals that local sorghum does not respond to higher management (fertilizer and ploughing on ridge) as shown by the negative change in gross margin (-10,4 %). The highest returns under high management in pure stand came from TZB maize (135,100 CFA/ha). In crop association, the results revealed that TZB was compatible with the local sorghum both in terms of yield increases and returns per hectare. This is attributed to the fact that TZB has half the vegetative growth cycle (around 55 days) of local sorghum (110 days). The improved sorghum (Ghana 1) was not compatible with local maize because their vegetative growth cycles are similar. In terms of returns, however, farmers who have adopted improved varieties (Ghana 1 and TZB) will benefit most by applying fertilizer (57.2 % increase under high management).

Results of sorghum/cowpea association revealed a consistent high reduction in grain yield of cowpea in association with sorghum (Table 5). The yield reduction ranged from 27 to 60 %. On the

Table 4.

EFFECTS OF CROP ASSOCIATION ON TOTAL GRAIN (KG/HA)
IMPROVED VARIETIES OF MAIZE AND SORGHUM
UNDER DIFFERENT LEVELS OF MANAGEMENT IN NORTHERN BENIN
1985 - 1987 (MEANS ACROSS 3 SEASONS, 3 SITES :
INA, BENSEKOU, SOKKA)

LEVEL OF MANAGEMENT	PARAMETERS	PURE STANDS				CROP ASSOCIATIONS				
		Local Sorghum pure S1	Ghana 1 pure S2	Local maize pure M1	TZB pure M2	S1 M1	S1 M2	S2 M1	S2 M2	Mean
1. Low management (no fertilizer, on-flat)	1. yield kg/ha -	659	503	1082	1461	1175	1680	1230	1343	
	2. C.V. %	17.4	30.4	20.7	31.1	22.4	25.4	18.6	22.5	23.6
	3. LER	1.00	1.00	1.00	1.00	1.50	1.67	1.38	1.32	1.47
	4. Value of prod.(1000 CFA)[1]	57.3	43.8	64.9	87.7	80.3	109.9	82.1	86.7	
	5. variable costs [2]	5.8	6.0	5.0	5.9	5.7	5.9	5.9	6.1	
	6. Gross margin	51.5	37.8	59.9	81.8	74.6	104.0	76.2	80.6	
2. High management (with fertilizer on-ridges)	1. Yield kg/ha	809	1250	2192	2625	2042	2492	1921	2402	
	2. C.V. %	14.7	34.5	15.0	16.1	13.1	17.4	16.4	19.5	18.4
	3. LER	1.0	1.0	1.0	1.0	1.39	1.42	1.14	1.16	1.28
	4. Value of prod[1](1000CFA)	70.4	108.8	131.5	157.5	139.6	162.9	128.7	155.8	
	5. Variable costs [2]	24.3	26.5	30.0	28.9	28.5	27.4	30.4	29.1	
	6. Gross margin	46.1	82.3	101.5	135.1	111.1	135.5	98.3	126.7	
% - increase under high manag.	1) yield	22.8	48.5	102.6	79.7	73.8	48.3	56.2	78.9	
	2) returns	-10.4	117	69	65.1	48.9	30.2	29.0	57.2	

Note 1) estimates are based on 1987 market prices of sorghum (87 F/kg) and maize (60 F/kg)
2) include cost of seeds fertilizer and opportunity cost of additional labour for making ridges, fertilizer application and harvesting

Table 5 GRAIN PRODUCTION (KG/HA) AND LAND EQUIVALENT RATIOS (LER) OF COWPEA AND SORGHUM GROWN IN PURE STAND AND IN ASSOCIATION IN NORTHERN BENIN, 1985-87

PARAMETERS	1985			1986		1987				Gross Returns (1000 CFA/ha)
	Ina	Bensekou	Karimama	Ina	Karimama	Ina	Sokka	Mean	C.V. %	
Pure Cowpea	1080	913	209	1370	523	905	685	812	16.4	172.8
Cowpea in association	787	399	135	696	337	363	368	441	17.8	
% reduction due to assoc.	27.1	56.3	35.4	49.2	35.6	59.9	46.3	44.3		
Pure Sorghum	922	337	529	761	1210	998	753	787	13.0	45.9
Sorghum in association	589	331	450	910	992	760	823	694	12.3	
% reduction	36.1	1.8	14.9	+19.6	18.0	23.8	+ 9.3	9.4		
Sorghum/Cowpea association	1376	730	585	1606	1329	1123	1191	1134	11.2	135.5
L E R of association	1.37	1.42	1.50	1.70	1.46	1.16	1.63	1.46		

other hand, grain yield of sorghum was reduced only slightly by 9.4 % on the average. One of the objectives of growing cowpea in association with sorghum, according to the farmers in the region, is that it provides a secondary crop without (a) significantly reducing the yield of the main crop (sometime it increases it), and (b) without requiring additional labour for land preparation and weeding. Using prevailing on-farm market prices of sorghum (87 F/kg) and cowpea (227 F/kg), at harvest time gross returns shown in table 5 were compared on the assumption that labour costs per hectare remain the same. Because sorghum has the largest share in the association and its price is lower, returns for the sorghum/ cowpea association are lower than under pure cowpea.

The socio-economics of crop associations, however, goes beyond the calculation of returns based on market prices. In this particular case, sorghum/cowpea association is seen by farmers primarily in terms of more quantity of foodgrain for subsistence than would be obtained by planting sorghum in pure stand. If the increased output as shown by the value of LER can be secured at low cost, so much the better.

Introduction of New Sorghum and Millet Varieties in the Dry Region of Extreme North Borgou

Sorghum and millet are the dominant food crops in the north of Borgou province. Declining and poor distribution of rainfall experienced in the past decades has resulted in frequent droughts which in turn has led to declining yields of local sorghum and millet varieties. To sustain food production, drought tolerant and/or early maturing varieties are needed for this region.

Consequently, a trial was initiated by the FSR programme in 1987 at Birni-Lafia with the objective to test different new varieties for adaptability and yield performance.

The rainfall was extremely low in 1987 and most of it fell in July, August and September (Table 6). This was therefore a good year for testing for drought tolerance or avoidance. The results of the trial are illustrated in Figures 7 and 8. Some of the new varieties performed better than the local ones because the former matured early thus escaping the late drought which started in October while the local varieties were still in their reproductive growth phase.

IRAT-Togo (fig. 7) produced a reasonable grain yield (2033 kg/ha), despite the very dry conditions experienced during the season ; It significantly outyielded the local sorghum (Blanc de Karimama) by 970 kg/ha. The new millet varieties introduced from Niger, ITMV 8001, ITVM 8304 and CIVT outyielded the local variety (Somnon) by 740, 440 and 396 kg/ha respectively. Somnon produced only 484 kg/ha.

In future these varieties should be evaluated in the farmers' fields under farmer-management to find out ,in addition to yields, their profitability and acceptability. To maximize the water use efficiency of the system the new varieties and tied ridging techniques should be combined.

3.2.2 Improving Soil Fertility and Soil Water Conservation

Farming systems in the WASAT have been traditionally based on shifting cultivation (Richards, 1985). Virgin lands are by nature fertile ; so with shifting cultivation, soil fertility was not a

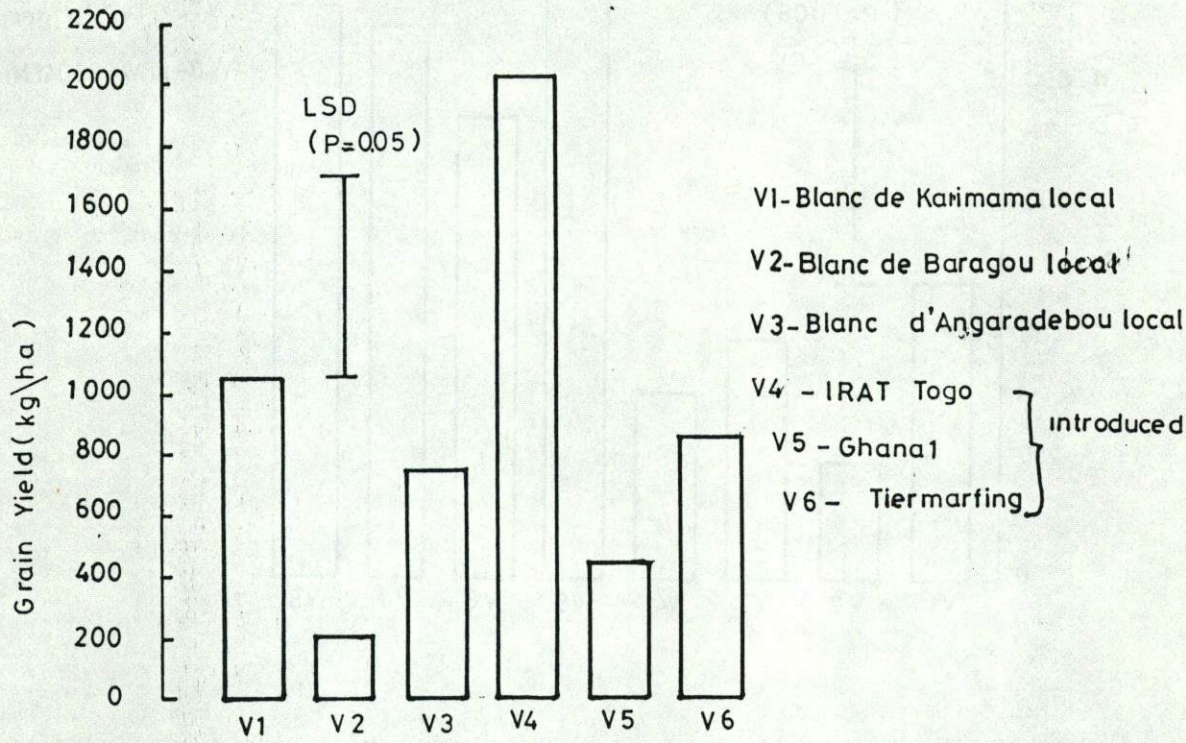


Fig 7 Yield (kg/ha) of local and introduced sorghum varieties at Birni lafia (Karimama district) Northern Benin 1987

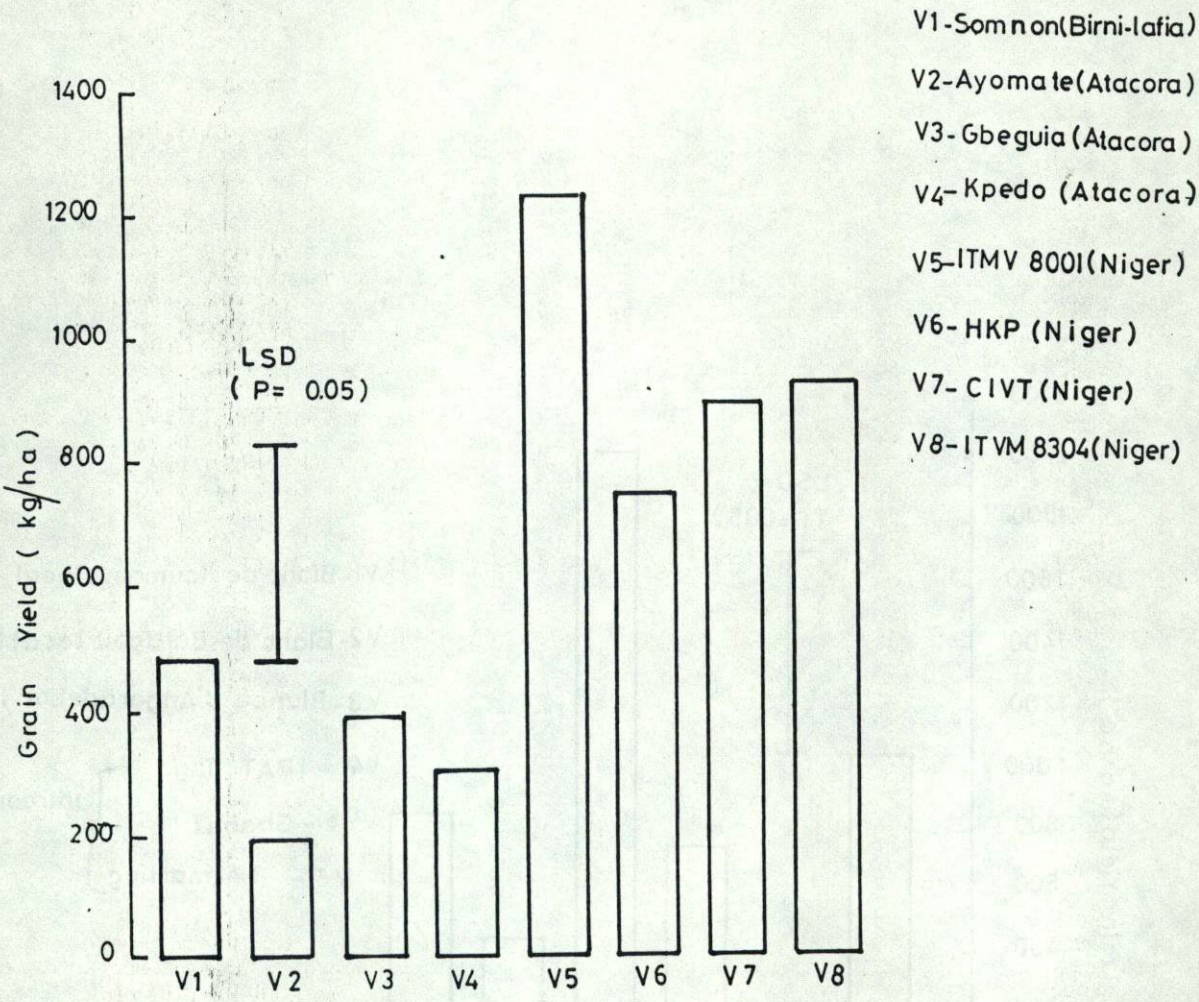


Fig 8 Yield (kg/ha) of local and introduced millet varieties at Birni Lafia (Karimama district) 1987

Table 6. MONTHLY RAINFALL AND NUMBER OF DAYS OF RAIN AT BIRNI-LAFIA (SUDAN-SAHEL ZONE)

	1985		1986		1987	
Month	Total rainfall (mm)	Nb. of rainy days	Total rainfall (mm)	Nb. of rainy days	Total rainfall (mm)	Nb. of rainy days
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	56.0	3	36.5	3	0	0
June	133.0	5	72.2	4	95	7
July	226.0	9	194.0	9	193	13
August	319.0	11	270.0	10	202.5	11
Sept.	96.0	9	161.5	10	99.0	8
October	0	0	13.0	1	33.0	3
November	0	0	0	0	0	0
TOTAL	830.0	37	747.0	37	622.5	42

Source: SAFGRAD/Benin; CARDER/Borgou.

constraint. With increased demographic presure, shifting cultivation becomes impracticable. In the absence of chemical fertilizers in the subsistence farming, for economic reasons, continuous cultivation of WASAT soil leads to soil degradation and hence a reduction in yields. There is therefore need to formulate techniques to conserve soil fertility, in order to sustain agricultural production of small holders. Such techniques could include proper crop rotation, organic fertilizer, efficient use of chemical fertilizer and the introduction of tree/crop associations.

In addition to the decling annual average rainfall in the region, soils of WASAT have low water retention capacity and when rains fall in torrents (which happens frequently) most of it is lost through run-off. Techniques to improve soil water use efficiency in the region could improve overall productivity. Such techniques could include : tied-ridging, mulching, minimum tillage etc.

In the above context a number of trials were conducted with the following objectives :

-evaluation of suitable crop rotations in Boukoumbe district where land scarcity is highest thus leading to continuous cropping on the same land;

-evaluation of the animal and green manure as alternative to chemical fertilizer;

-evaluation of effects of cotton fertilizer on maize growing in association with cotton to maximize fertilizer use efficiency.

-evaluation of the interactions : land preparation x fertilizer x variety;

-evaluation of tied-ridging to increase water use efficiency in

the extreme north Borgou.

-evaluation of new technologies: on farm trials to involve farmers in technology evaluation and generation feed back;

-mixed intercropping of leguminous trees (leucaena et acacia) with sorghum, maize and cowpea for soil fertility improvement, fodder and firewood;

-alley farming with leucaena and pigeonpea, and multi-porpose tree evaluation for soil fertility maintenance, fodder, fuelwood and soil conservation.

Crop Rotation

The rotation trial was initiated at Boukoumbe in 1987. It was conducted on land which had been on a natural fallow for two consecutive years (1985, 1986). In 1987 the first year of the trial, the major food crops grown in Boukoumbe namely sorghum, millet, cowpea, groundnut and fonio were grown in pure stand and in association as practiced in the district.

In addition, a natural fallow and an improved fallow involving the use of forage legume (Stylosanthes hamata) were included in the trial. The treatments were randomized in three large blocks ; each treatment was allocated 12 m x 20 m plot size. In the subsequent years starting from 1988, the plots receiving various crops would be divided into two parts. The first part would continue to grow the same crop while the second part would receive a uniform crop of sorghum with 3 levels of N (0, 30 and 60 kg/ha). From the soil sample analysis taken at the beginning and end of each season, and from the yields of sorghum following the various crops, an assessment of the best cropping rotation

would be evaluated. The effects of the preceding crops is realized approximately after three or more seasons. Due to the long term nature of this trial, the national soil science research authority (CENAP) has been consulted for close collaboration.

The yield of sorghum in 1987 was 647 kg/ha without fertilizer ; and 1190 kg/ha with 60 kg/ha N. The low yield of sorghum not receiving fertilizer already indicates the low fertility level of the land despite the fact that it had been under natural fallow for two consecutive years. Thus implying that natural fallows in this region take too long to rejuvenate the soils.

Animal and Green Manure

The trial initiated in 1987 at Ouake and Boukoumbe to evaluate the effects of alternative sources of fertilizer, included the following treatments : chemical fertilizer, animal manure, green manure and crop residue. These were applied singly or in various combinations. The most important finding was that at both sites, the application of animal manure at the rate of 10 tons/ha increased grain yield of sorghum by more than 100 %. Because of limited supply of animal manure farmers in the region use it to a very limited extent to fertilize sorghum, the major food crop. An integrated forage/livestock/animal manure/soil fertility management study could address this shortage and thus provide an alternative to chemical fertilizer.

For three consecutive years a trial was conducted at Ina station to evaluate species of crotalaria as green manure for maize. When well nodulated species of crotalaria were grown in the same rows with maize and incorporated into the soil at the second weeding

operation (45 days after sowing) increases of maize yield of up to 40 % were recorded. This practice could fit into the traditional crop associations as it requires no extra labour for land preparation and weeding. It has been recommended for pre-extension testing.

Cotton Fertilizer for Maize

For two consecutive years 1985/86, trials were conducted at Ina to determine whether maize growing in association with cotton would benefit from the cotton fertilizer. Evaluations were based on comparison of maize yields in pure stands receiving no fertilizer and those of maize growing in association with a fertilized cotton crop. In both years, maize never benefited from the cotton fertilizer. On the other hand, a trial conducted on farmers' fields (URP/Ina, 1985) pointed out that maize benefited from fertilizer which had been applied to a preceding cotton crop. Thus implying that cotton/maize rotation is a more efficient fertilizer use system than cotton/maize association in the same season. This finding was to be later incorporated into the crop rotation trials.

Land Preparation and Fertilizer Use

A trial was conducted at Ina, Sokka, and Bensekou in 1985 and 1987 to evaluate effects of land preparation and fertilizer application on local maize and TZB. As shown in table 7, ridging had little significant effect on yield of maize. On the other hand, fertilizer application significantly increased yield of maize in 9 out of 12 cases and in 3 out of 12 cases for TZB and local maize respectively. The results point out a clearly consistent response to fertilizer application by TZB ; it

Table 7 EFFECT OF FERTILIZER APPLICATION X LAND PREPARATION ON YIELD (KG/HA) OF LOCAL MAIZE AND TZB IN NORTHERN BENIN, 1985 AND 1987

Season	Site	Land preparation	Local Maize		TZB		C.V. %
			Without Fertilizer	With Fertilizer	Without Fertilizer	With Fertilizer	
1985	Ina	flat	1278 b *	2142 ab	1353 b	2829 a	16.5
		ridge	1676 b	1934 ab	1277 b	2938 a	
	Sokka	flat	910 b	898 b	769 b	1873 a	12.7
		ridge	855 b	1005 b	879 b	1531 ab	
	Bensekou	flat	306 d	557 bc	475 c	759 a	16.4
		ridge	465 c	647 ab	439 c	636 ab	
1987	Ina	flat	1290 bc	1618 bc	2375 ab	3463 a	28.4
		ridge	740 c	2318 ab	2015 bc	2418 ab	
	Sokka	flat	1593 c	2090 c	2740 c	3940 b	11.1
		ridge	1835 c	1838 c	2093 c	3013 b	
	Bensekou	flat	695 b	940 b	893 b	1710 a	25.5
		ridge	680 b	983 b	1008 b	1700 a	

* means at same site in same season joined by same letter are not statistically significant -P = 0.05)

approached 4 tons/ha at Sokka under researcher management. From the above results of trials conducted at different sites in two seasons the following conclusions can be made :

(a) In the Northern Guinea and Sudan Savanna zones there is no advantage of growing maize on ridges ; on the other hand ridges should be made after the last weeding to incorporate fertilizer manure and guard against lodging. (b) Since TZB has become a popular variety, farmers should be encouraged to apply fertilizer in order to realize the full potential of TZB even under association with sorghum.

Tied-ridging in Sudano-Sahelian Zone

A trial was initiated in 1987 at Birni-Lafia, in the Sudano-Sahelian zone with soils of low water retention capacity, in order to increase water use efficiency in a sorghum crop by using tied ridges. Tied ridges made before planting were destroyed by the first torrential rains. Those made two months after planting (second week of September) produced more vigorous plants than plants growing on flat but had no significant effect on grain yield. After mid September, the site received little rainfall (around 60 mm of rains out of the total 623 mm). This could have contributed to the non-significant effect on grain yield by tied ridges made in mid-September. Tied-ridging in a similar agro-ecological zone of WASAT increased sorghum grain yields (IITA/SAFGRAD 1986). The trial should therefore continue on-farm for a number of seasons using more appropriate tied ridges and timing of the operations.

Fertilizer Trials

Two types of on-farm trials were conducted in 1987 : (a) A researcher/farmer managed trial involved testing different levels of N. on maize crop in different agro-ecological zone of the studied area. (b) A farmer-managed trial involved testing fertilizer use on local and new varieties of maize and groundnuts. Observations can be summarized as follows:

(a) Farmers were enthusiastic to do the trials probably because fertilizer and new varieties were given free of charge.

(b) Farmers had problems in looking after trials mainly due to shortage of labour at planting and weeding periods ; consequently trials were planted and weeded late (mainly because cotton is given priority over other crops). Technologies to speed up land preparation and weeding would definitely increase overall productivity of the system.

(c) Maize responded positively to N. in the farmer-managed trial but for reasons given above, overall yields were low. TZB receiving 60 kg N. yielded less than 2 tons/ha on farm trials (fig.9). This was quite low as compared with 4 tons/ha obtained at the Ina station. The interest of this trial lies in the fact that it was possible to compare the profitability of fertilizer in the Northern Guinea and Sudan Savanna zones. Using simple benefit cost ratios (Table 8), fertilizer is shown to be more profitable in the Sudan Savanna than in the south of the province. This could be attributed to low management and the fact that leachable soils loose nitrogen to under groundwaters.

(d) The farmer managed trial (systematic design) was implemented in order to determine the most economical dose of

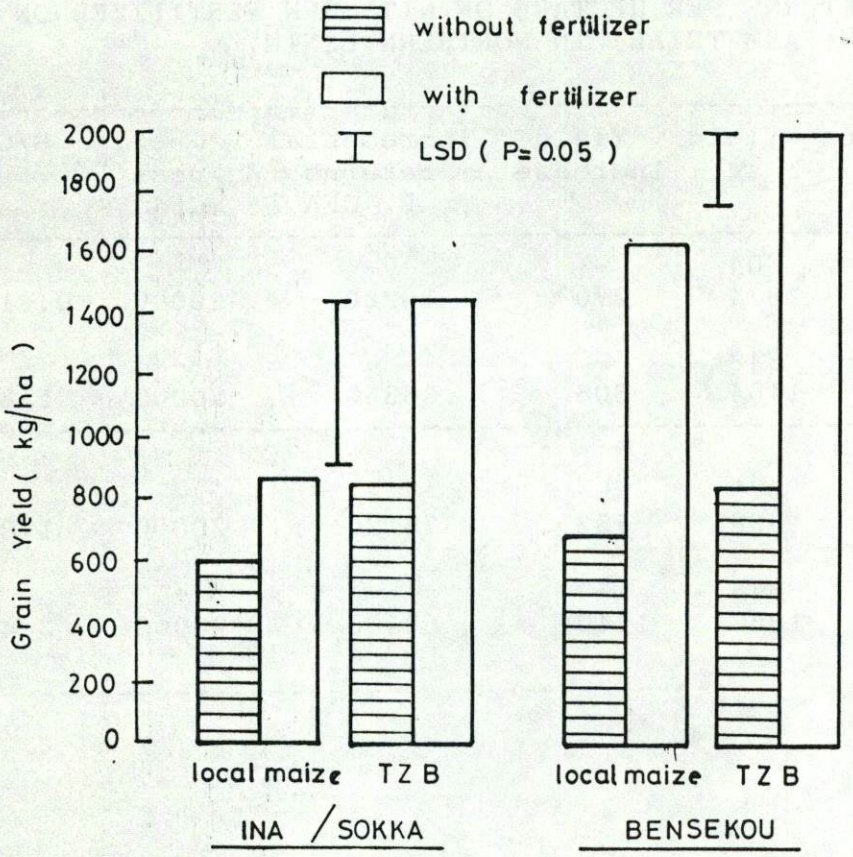


Fig 9. Yield (kg/ha) of local and TZB maize varieties with and without fertilizer at different locations in Northern Benin: on-farm trial 1987

fertilizer which can be recommended to farmers in the region. As shown in Figure 10 this trial revealed that under relatively poor soils and higher rainfall as in Ouake, very low doses of N gave high yield increases in maize (e.g.15 kg/ha of N increased

Table 8. COST AND RETURNS PER HECTARE OF NITROGEN FERTILIZER ON MAIZE (ON-FARM TRIAL) IN NORTHERN BENIN.

		Fertilizer kg/N	Yield kg	Yield increase	Incremental returns F. CFA	Incr. cost CFA	B/C
1. Northern Guinea	LM	0	604	-	-	-	-
		60	874	270	16200	20000	0.81
	TZB	0	848	-	-	-	-
		60	1454	606	36360	20000	1.82
2. Sudan Savanna	LM	0	676	-	-	-	-
		60	1628	752	75120	20000	1.86
	TZB	0	848	-	-	-	-
		60	1988	1140	68400	20000	3.42

LM : local maize.

yields from 500 to 1000 kg/ha). The fertilizer response curves for TZB maize in Ouake and to local maize in Bensekou follow the normal pattern of diminishing returns, with the bliss point somewhere after 60 kg N. In Bensekou, the response curve is linear over the whole range of doses applied to TZB maize ; which is an indication of good soil properties. The very marked difference in productivity between TZB and local maize in Bensekou implies that improved maize should be used by farmers if fertilizer is available. TZB maize could not be used in the trial at Birni-Lafia because its cycle is not short enough for the

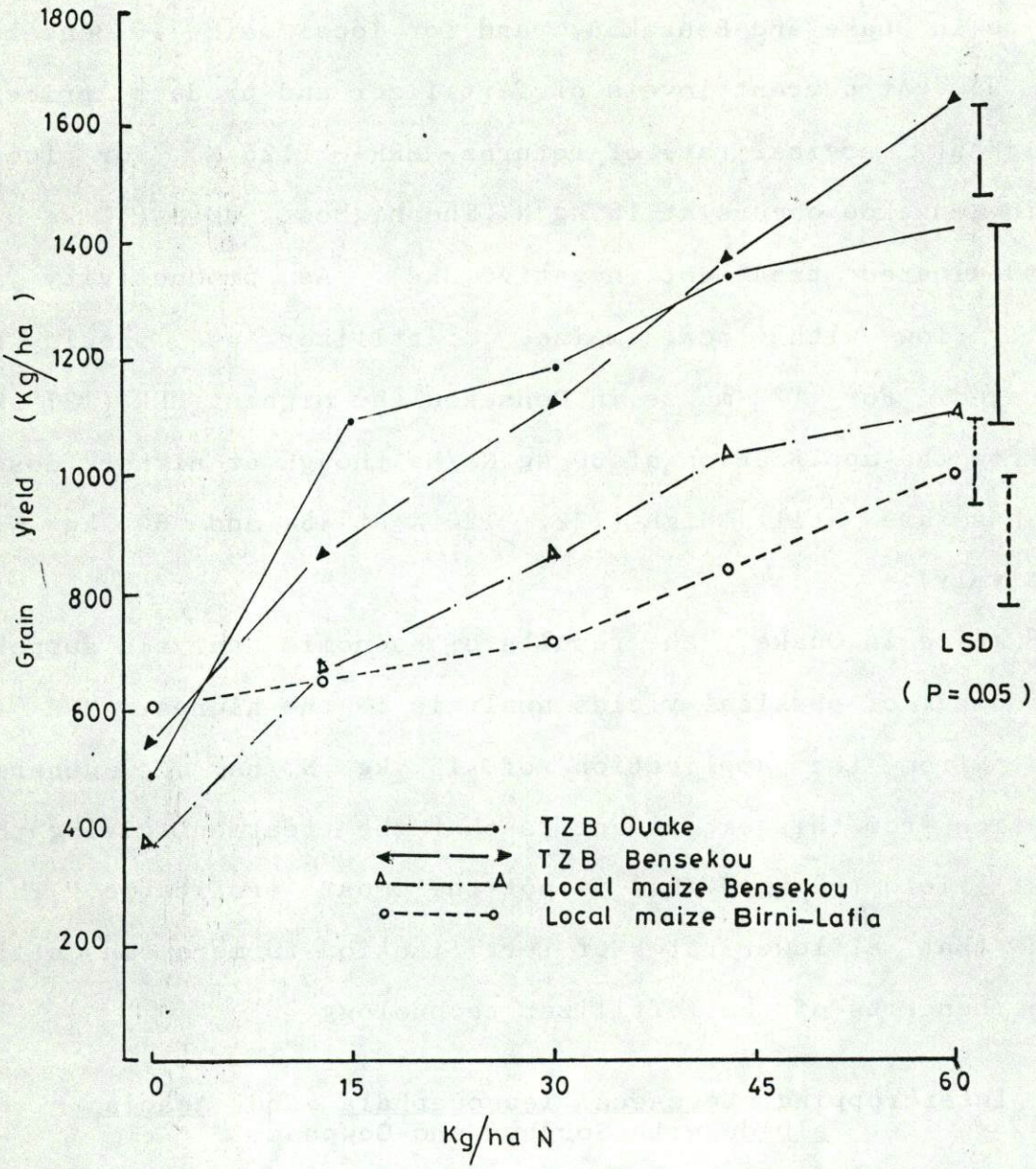


Fig. 10 Yield (kg/ha) of maize at varying levels of N. fertilizer at different locations in Northern Benin (on-farm trial) 1987

shorter growing season of the Sudano-Sahelian zone. Farmers in that zone will therefore benefit from fertilizer on local maize only if applied at higher rates (45 to 60 kg N/ha).

A partial budget analysis was conducted on this experiment for TZB maize in Ouake and Bensekou, and for local maize in Bensekou (table 9). At current levels of fertilizer and product prices, the highest marginal rate of returns--MRR-- (125 %) for local maize in Bensekou occurs at 15 kg N. The highest dose (60 kg N.) is a dominated treatment (negative MRR). As productivity is generally low with local maize, fertilizer use should be discouraged. For TZB maize in Bensekou the highest MRR (127 %) comes from the application of 30 kg N./ha though at higher doses the MRR's are still high (122, 120 % at 45 and 60 kg N., respectively).

For TZB maize in Ouake, the results of economic analysis support the finding of physical yields analysis : the highest MRR is derived from the application of 15 kg N./ha. A general observation from this experiment is that the treatment giving the greatest yield (60 kg N./ha) is not the most profitable. This implies that at lower rates of fertilization farmers can still reap the benefits of the fertilizer technology.

Mixed Intercropping Leucaena leucocephala and Acacia albida with Sorghum and Cowpeas

A trial was established at Ina, in the Northern Guinean zone, Boukoumbe in the Atacora province, and Birni Lafia in the Sudan-Sahelian zone, mainly to evaluate the establishment of leucaena and albida and their effects on the yields of the associated

Table 9. PARTIAL BUDGET (in 100 CFA) OF FERTILIZER APPLICATION TO TZB MAIZE: ON-FARM EXPERIMENT OUAKE AND BENSEKOU 1987.

Fertilization rates in kg N./ha

Item	BENSEKOU: Local Maize					BENSEKOU: TZB Maize					OUAKE: TZB Maize				
	To	T1	T2	T3	T4	To	T1	T2	T3	T4	To	T1	T2	T3	T4
	0	15	30	45	60	0	15	30	45	60	0	15	30	45	60
Yield (kg/ha)	370	670	860	1040	1110	550	870	1130	1380	1640	495	1097	1190	1350	1433
Gross reven.	222	402	516	624	666	330	522	678	828	984	297	658	714	810	860
Fertl. cost	0	50	100	150	200	0	50	100	150	200	0	50	100	150	200
Extra labour (m-days) applic	0	.5	1	1.5	2	0	.5	1	1.5	2	0	.5	1	1.5	2
Value	-	30	42	51	63	0	39	58	75	96	0	45	58	75	87
Total variab. cost	0	80	142	201	263	0	89	158	225	296	0	95	158	225	287
Net Benef.	222	322	374	423	403	330	433	520	603	688	297	563	556	585	573
Incremental cost	_	80	62	59	62	_	89	69	67	71	_	95	63	67	62
Incremental benef.	_	100	52	49	-20	_	103	87	83	85	_	266	-7	29	-12
Marg. rate of ret.	_	125	84	83	d	_	116	127	122	120	_	280	d	42	d

d=dominated treatment.

crops and to monitor soil nutrient changes with time. It essentially involved intercropping leucaena and albida on 10 x 10m plots at a spacing of 2.5 m between trees, with sorghum and cowpeas. All trees were established from nursery grown plants. The crops were planted in-between the trees on traditionally made ridges. Leaves from cut leucaena plants were used as green manure during the second year. Grain and residue yields were measured by harvesting whole plots at the end of the season.

Results :

Plant Vigor : Tree growth in all association was less vigorous than in the pure stands during the year of establishment. Cowpea seemed to reduce the development of both leucaena and albida in association. Both trees regenerated vigourously during the second year. Albida plants shed about 75 % of their leaves during the second growing season.

Grain yields of sorghum and cowpeas in leucaena and albida associations were much lower than those in the pure controls at Ina during the first year. The differences were, however, not significant. Trials at Boukoumbe and Birni-Lafia were seriously attacked by striga, consequently, the grain yield evaluation was ignored for this period.

Sorghum grain yields in the various associations and sites during the second year are shown in Figure 11. Sorghum yields in Acacia albida association were higher than in leucaena by 46.5 %, 44.6 % at and 1.3 % at Ina, Birni-Lafia and Boukoumbe respectively. Yields in both associations were slightly higher than the pure controls. There were, however, no significant differences between treatments. This observation might be due to the high

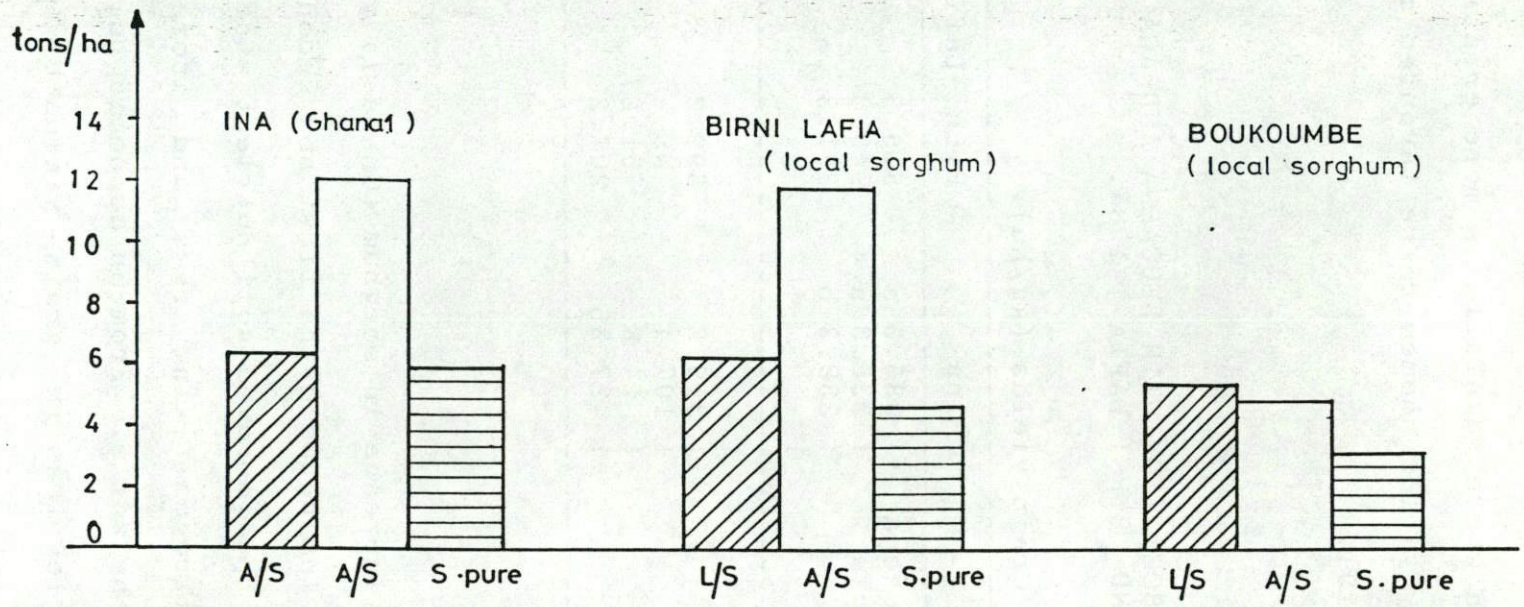


Fig. 11 Yield of sorghum (Ghana1) in association with leucaena and albida at Ina, Birni Lafia and Boukoumbe 1987

variabilities in grain fill as a result of periodic droughts. Cowpea yielded higher in leucaena association than with albiba at Ina . At Birni-Lafia where rainfall is more erratic and poorly distributed, cowpea yields seemed to be favoured in the albida association (Table 10).

Table 10.

COWPEA YIELDS IN ASSOCIATION WITH LEUCAENA AND ACACIA ALBIDA AT INA AND BIRNI-LAFIA , 1987.

	Grain yields (kg/ha).	
Association	Ina	Birni-Lafia
Cowpea - Leucaena	383.3 a	515.3
Cowpea - Acacia	336.3 a	943.0
Pure cowpea	238.3 b	361.3
Grand mean	319.2	699.8
LSD.	107.4	NS
C.V.	14.8	51.27
SEM.	27.36	207.2

There was a marked increase in sorghum (Ghana I) yields in all tree associations at Ina between the first and second years. This can be attributed to the improved soil nutrient status caused by the presence of nitrogen fixing trees and increased organic matter content of the soils. From an economic point of view, since there is little loss in grain yields by incorporating trees into the cereals (due to a reduction in plant densities) the additional benefit from the trees such as fodder supply, fuelwood and inherent soil fertility improvement are real

benefits to the farmer. However, labour input for tree establishment as well as maintenance and acceptability of the technology need to be evaluated in future designs involving farmers' participation.

Evaluation of Alley Cropping with Leucaena leucocephala and Cajanus cajan for Northern Benin Conditions.

Alley cropping is one of the most studied systems of integrating trees into cropping systems for soil fertility improvement, fodder and fuelwood. The use of fast growing leguminous trees and shrubs is already advanced in the humid tropics of West Africa. There are speculations that the system, with adequate modifications could be adapted for sub-humid and semi-arid regions. This study was therefore set up to evaluate the feasibility of alley cropping for soil fertility improvement, and provision of fodder using two adapted tree legumes ; Leucaena leucocephala and Cajanus cajan .Preliminary surveys indicated that the two species grow quite well in the Northern Guinea and Sudan zones of Northern Benin.

Cajanus cajan is an adapted multipurpose grain legume, often encountered in association with local sorghum and millet in home gardens and on field boundaries. It is normally grown as grain legume. Alley spacings of 4 m, 6 m and 8 m with 0.5 m ; 1.0 m and 2.0 m intra-row spacings were tested on fertilized and unfertilised plots. The trial was spread out in all agro-ecological zones including sites such as Ina, Alafiarou (CARDER Farm), Malanville (extreme north), Ouake and Boukoumbe (UNSO sites in Atacora). The major cereal crop in each zone was used. Tree and crop development as well as grain and residues yields

were determined.

Results :

In general, during the establishment year, grain yields of the various crops at all the sites were not significantly different from the pure controls and yields obtained from farmers' fields. The trees associated with crops did not seem to have much effect on the growth and production of the cereals in association. Results from Ina and Alafiarou where sorghum and maize were evaluated in association with leucaena and cajanus are presented in detail.

Tree growth. Visual observations on the development of trees throughout the growing season indicated no adverse effect of crops on tree growth. Relative heights and number of branches in the various associations are shown in table 11. There was no significant difference in tree height and branching habits among the various spacing treatments in both maize and sorghum associations. However, both trees produced more branches, 24 and 55,6 % respectively, for Cajanus and leucaena in association with maize over sorghum. This may be due to the tall and shadding effects of sorghum on the trees.

Maize grain yields were not significantly different between the spacing treatments at all sites except Alafiarou during the first year. High inter-row densities (0.5 m) gave significantly higher grain yields which were comparable to the fertilized plots. Maize responded remarkably to fertilizer application, yields increased from 1.3 tons/ha to 3.0 tons/ha in leucaena and 0.94 to 2.4 tons/ha in cajanus associations with fertilization at Ina. Maize

Table 11 .

HEIGHT AND BRANCHING HABITS OF LEUCAENA AND PIGEONPEA IN ASSOCIATION WITH SORGHUM AND MAIZE AFTER 7 MONTHS OF GROWTH (JANUARY 1988, ALAFIAROU)

	ASSOCIATION			
	Sorghum/Cajanus		Maize/Cajanus	
Spacing	Height	Nb. of branches	Height	Nb. of branches
4 X 0.5 m	248.4	49	221.2	48
4 X 1.0	229.4	36	235.2	53
4 X 2.0	225.0	40	240.2	58
6 X 0.5	234.7	38	229.4	44
6 X I.0	208.9	29	231.2	47
6 X 2.0	235.5	39	230.3	54
Mean	231.8	38.5	231.2	50.7
C V. %	12.5	35.0	11.8	19.6
LSD(0.05)	N S	N S	N S	16.2
	Sorghum/Leucaena		Maize/Leucaena	
4 X .05	190.1	8.0	195.9	15.0
4 X 1.0	189.4	8.0	189.0	15.0
4 X 2.0	181.2	8.0	218.4	20.0
6 X 0.5	199.7	7.0	236.3	19.0
6 X 1.0	220.8	10.0	220.9	20.0
6 X 2.0	184.3	8.0	230.6	17.0
Mean	195.4	8.0	215.1	18
C V. %	29.2	57.3	22.8	21.5
LSD(0.05)	N S	N S	N S	N S

grain yields were much higher at Alafiarou due to differences in soils and management.

Fertilization seemed to improve tree crop interaction in the maize association. Fertilized associations gave consistently higher grain yields for both leucaena and cajanus (fig.12) compared to the non-fertilized controls at Alafiarou.

Sorghum grain yields were not significantly different among the various spacing arrangements, for both leucaena and cajanus. Fertilization did not seem to influence sorghum yields either ; however, tree crop associations gave higher yields (fig. 13) compared to the controls except where animal manure and urea were applied. Local sorghum responded to fertilization by producing more vegetative growth over grain. This was evident in the height and vigor of sorghum plants.

Cajanus grain yields during the year of establishment, were not different among the various densities in the association with sorhgum. In the maize association the 4 m x 2.0 m spacing gave the highest yields (49.8 g/plant at Alafirou). At Ina, average yield in maize was 66.5 g/plant. In general, Cajanus yields were higher by 37.7 % in the maize association than in Sorghum. Farmers' experience with pigeonpea in the region indicates that its yields are usually low during the establishment year but improve considerably during the second year and decrease during the third and last productive year. This characteristic coupled with good germination and establishment properties allows the plant to be used in short rotations. The influence of cutting frequency on productivity and life span of the plant are being investigated.

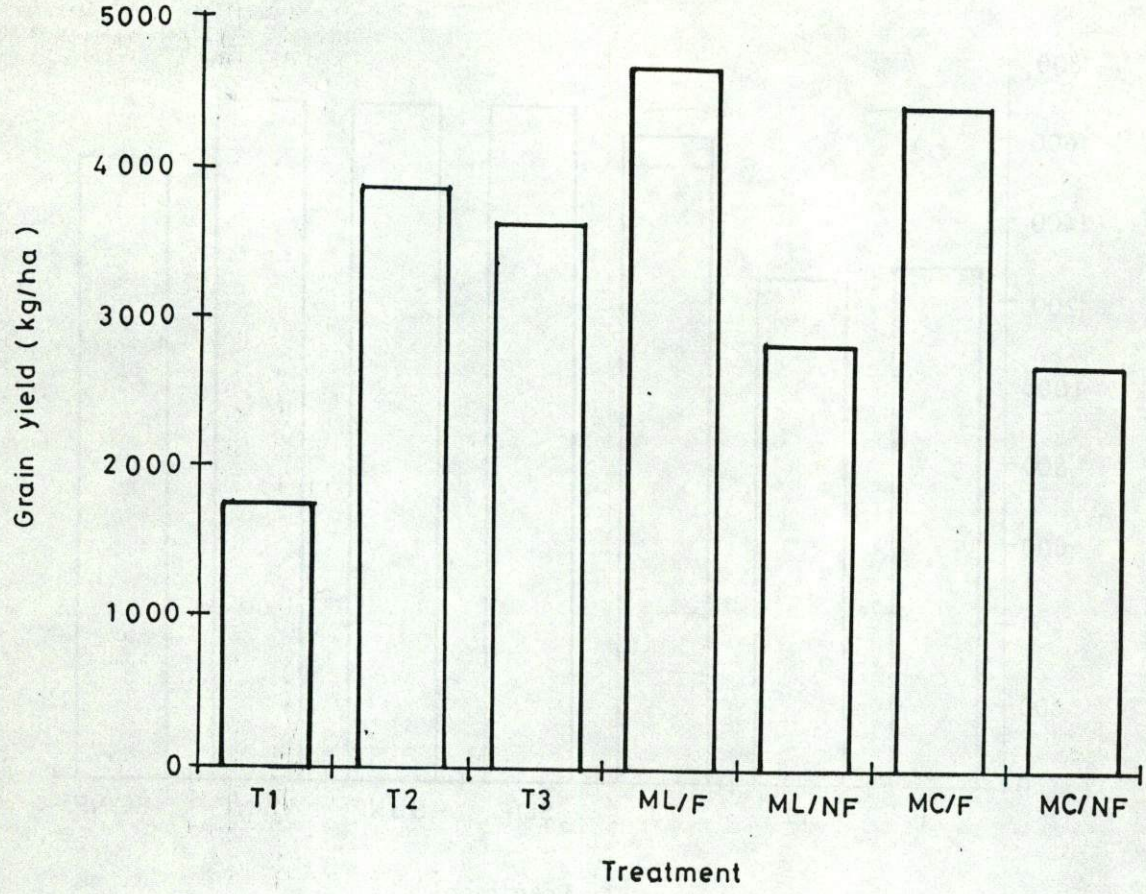


Fig 12 Grain yields of maize (TZB) alley cropped with leucaena and pigeonpea compared to various controls at Alafiarou

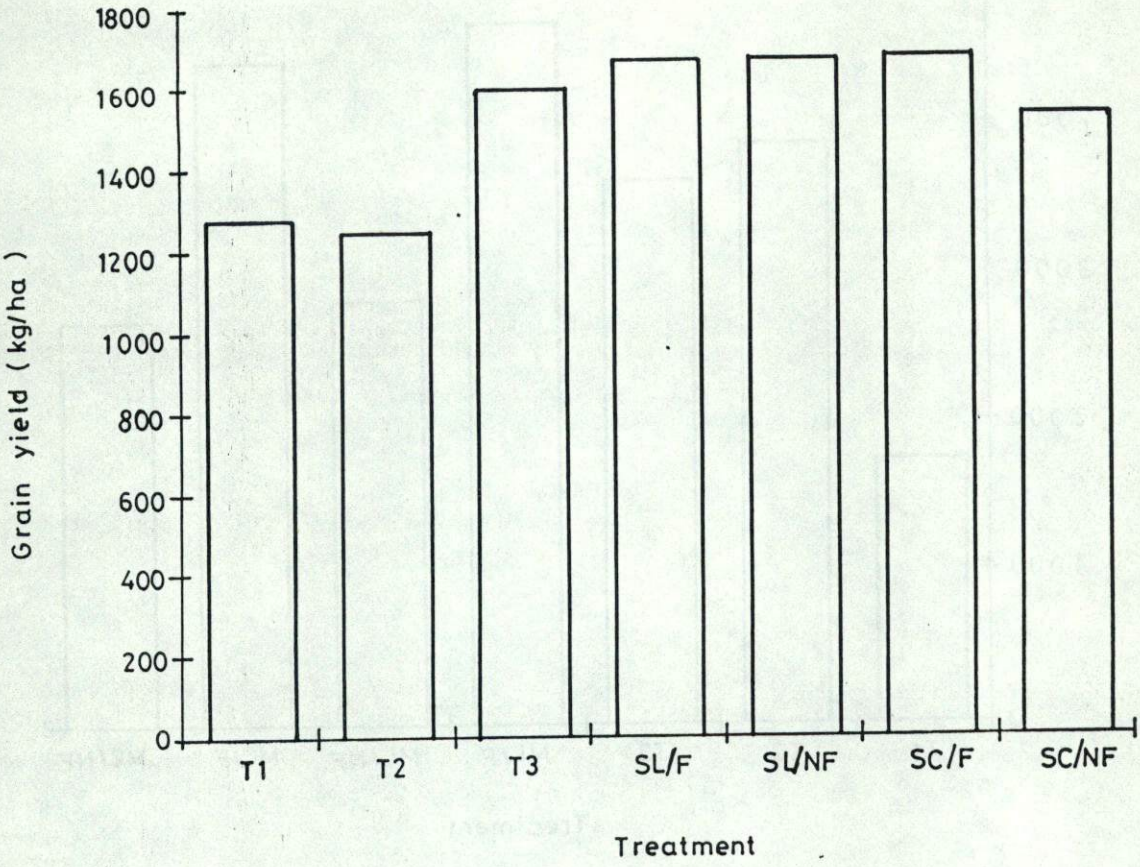


Fig 13 Sorghum grain yields in an alley cropping arrangement with leucaena and pigeonpea compared to fertilised and non fertilised controls at Alafiarou

Crop residues: maize and sorghum residues yields increased with fertilization. There were no significant differences among the spacing treatments (Table 13). Maize residues yields were higher in association with leucaena than with pigeonpea. This may be due to the higher competition with cajanus during the year of initial establishment.

Table 12

MAIZE RESIDUE YIELDS IN LEUCAENA AND CAJANUS CAJAN ASSOCIATIONS

	Crop Residue Yields (kg/ha)			
	Leucaena		Cajanus	
Treatment	non fertilized	fertilized	non fertilized	fertilized
4 x 0.5	1375.0	3434.2	1222.3	2485.8
4 x 1.0	3260.5	3184.0	1562.6	2361.0
4 x 2.0	2472.2	3107.0	1271.0	2124.0
6 x 0.5	1777.8	3159.8	1291.7	2125.0
6 x 1.0	1899.3	3277.8	1249.8	2090.2
6 x 2.0	2472.3	2847.3	1569.7	2250.0
Mean	2209.5	3168.5	1361.2	2239.5
CV %	30.2	6.2	11.8	7.1
LSD (0.05)	NS	NS	NS	NS

These preliminary results on the evaluation of alley cropping in the region clearly indicate that initial establishment does not seriously interfere with or reduce yields of the associated crops. The growth of the trees was fast enough to ensure good

root establishment during the short growing period.

Economic evaluation

Based on this one year experience with alley cropping we can conveniently say that it could be a feasible method for introducing trees into the cropping systems. Further experimentation with farmers in their fields would determine their acceptance of the system and indicate necessary modifications to suit traditional practices. Farmers' impressions from field visits to the trial at Alafiarou were very positive. Nevertheless it is possible to provide an account of possible benefits from alley cropping under farmer management and a rough estimate of returns as shown in table 13.

The additional labour input from the planting and maintenance of the trees is compensated for through the small increases in grain yields, and the additional fodder supplied by the trees and crop residues. The returns per man day is estimated at 850 CFA/ha,much higher than returns from many cereal crops in the region .

It is also claimed that such a land use system can support continuous cropping at intermediate yield levels, possibly indefinitely (Upton, 1984). In comparision with traditional cropping systems, alley cropping offers increased crop yields and avoids the need for periodic bush clearing. However, after installment costs have been paid for (purchase of plants, and transplanting cost) one should also consider the reduction in the arable cropped area or crop plant density as a reduced benefit in alley cropping. Similar estimates can be worked out for maize/pigeonpea, sorghum/leucaena or sorghum/pigeonpea. Due to possible disease and insect damages on leucaena, the project has

Table 13 COMPARATIVE RETURNS FOR MAIZE UNDER ALTERNATIVE CROPPING SYSTEMS

Item	Traditional Maize cultiv. under low management (no fertilizer)	Improved Maize cultiv. (fertilizer)	Maize/Leucaena in Alley Cropping (adjusted for farm level conditions)
Average yield (kg/ha)	800	1500	2200 1/
Value of prod. (CFA/ha)2/	48000	90000	132000
Value of fodder (3 t/ha at 3000 CFA/t)	-	-	9000
Non labour cost (fertil.,seeds, plants)	1500	28000 3/	22000 4/
Total labour (man-days)	103	117	140 5/
Returns/man-day (CFA)	451	530	850

1/adjusted down (by 25%) from maize yield in alley cropping with Leucaena at Alafiarou, to reflect farmers'conditions.
2/valued at 60 CFA/kg
3/assumes no use of animal traction
4/includes cost of buying leucaena plants at 25 CFA/plant (750 plants/ha)
5/additional labour includes trees establishment,pruning,and harvesting the extra output

also initiated evaluations of other multipurpose trees such as Gliricia sepium and various pigeonpea lines as possible altenatives to leucaena.

3.2.3.. Input Use Efficiency in Yam Production

Labour is one of the major constraints in yam production in the region. Making of mounds for yams is time consuming and there exists no mechanical equipment to facilitate the task. On the other hand, ridges are made easily by hand and even much faster using animal traction. If yams could be grown on ridges made with animal traction this would free substantial labour which could be used in other operations and thus increases the productivity of the whole system.

In this respect, a trial was initiated in 1986 at Ina and Sosso to compare yields of yams grown on ridges with those on mounds.

The quantity of yams used as seed for planting under traditional practices is quite large. Under certain conditions it is estimated at 50 % of the whole harvest. Trials were therefore initiated in 1986 at Ina and Sosso to test the techniques developed at IITA which reduce the quantity of yams by using smaller cutings.

Land preparation : the effect of land preparation on yam production under researcher managed trial at the station revealed no yield differences between the two practices. Yields were estimated at around 7.5 and 11 tons/ha at Sosso and Ina respectively. When the trial was tested on farmers' fields under farmer management, it failed at Ina due to late planting but succeeded at Sosso where the following results were recorded :

Labour requirement for the production of yams was similar under both manual practices. It was estimated at 787.5 and 785.5 man hours/ha for mounds and ridges, respectively (Table 14). This included mounds or ridge making, planting, weeding and harvesting.

On the other hand, yields of yams on mounds and ridges were estimated at 8.6 and 3.9 tons/ha respectively (Table 15). Although no far reaching conclusions can be made from one season results, the following remarks are worth making as they might guide the design of future trials. (a) Farmers were convinced beyond doubt that mounding was a better cultural practice than ridging ; this influenced their bias in the conduct of the trial : yams on ridges were planted and weeded 2 to 3 weeks later than yams on mounds ; this considerably reduced the yield of yams under ridging. (b) Since the final objective of the trial is to save labour by making ridges with animal traction instead of manual labour, the evaluation of labour saved should be undertaken right from early stages of the on-farm trials by including animal traction treatment in the trial. The lack of significant differences in total labour requirement between the two land preparation techniques show that if both techniques were executed without bias, the yields would have been more or less the same. It implies that comparison of economic returns from both techniques will reveal no differences as long as they are executed manually. Higher returns to labour are expected only if animal traction is used for making rigdes. Yams are sold at an average price of 20 F/kg which results in gross revenue of 160000 to 200000 F/ha.

Yam seed : researcher managed trials conducted for two consecutive years 1986 and 1987 at three different sites (Sosso, Ina, Alafiarou) releaved no significant differences in yields of yams from different tuber sizes (75, 100, 125, and 150 g/tuber). The trial should be repeated under farmer management.

Table 14. LABOUR REQUIREMENT (MAN-HOURS/HA) FOR YAM PRODUCTION ON MOUNDS AND RIDGES, SOSSO 1987.

Operations	man hours/ha			
	Mounds	Ridges	S.E.	CV. %
1. Land preparation	186.0	180.0	23.1	20.0
2. planting	117.5	107.5	9.0	12.7
3. weeding	363.0	379.0	38.9	16.6
4. harvesting	121.0	119.0	6.4	8.3
5. Total	787.5	785.5	54.6	11.0

Table 15 COMPARISON BETWEEN THE EFFECTS OF MOUNDS AND RIDGES ON YIELDS (KG/HA) AND YIELD COMPONENTS (No OF TUBERS/M2) AND TUBER SIZE (G/TUBER) OF YAM AT SOSSO 1987.

	1. kg/ha	2. tubers/m2	3.g/tuber
Mounds	8562	25.3	347.3
Ridges	3940	27.3	141.4
SE	1054	3.1	45.5
C.V.%	26.7	18.4	29.5

3.2.4. Fodder Resources Evaluation

Forage availability and quality during the dry season have been identified as a major constraint limiting livestock production

in Northern Benin. During this stress period, animals are usually fed on crop residues, browse as well as low quality natural vegetation. Although these are relatively high in quality, they are often in short supply. The need to establish pastures as a possible solution to the feed problem has been recognised and recommended by various consultants and projects operating in the region. The establishment of pastures, however, is further limited by factors such as ; (a) lack of improved forage species adapted to the region ; (b) Lack of low input and low cost establishment technologies ; (c) and lack of knowledge on pasture establishment and management by local farmers.

In view of these constraints, the SAFGRAD FSR programme initiated the introduction and evaluation of improved fodder grasses and legumes (both herbacious and ligneous) aimed at introducing forages into the existing farming systems. Low cost establishment and management techniques, developed by ILCA and other international organisations would be evaluated under farmer conditions.

The forage evaluation programme was initiated in 1986 and involved germplasm introduction, multilocational evaluation of promising species and on-farm testing (management technology development).

Forage evaluation were carried out at the Ina station. Preliminary results showed the following species as promising in terms of drought tolerance and dry matter yields: Brachiaria ruziziensis, Pennisetum purpureum, Andropogon gayanus, Panicum maximum and Stylosanthes gracilis.

Productivity (biomass) of these species under various cutting

regimes during the 1986 and 1987 seasons is shown in table 16. The rationale behind the two cutting regimes was to determine biomass available at the beginning of the rainy season and to access available biomass for hay making and storage at the begining of the dry season. Among the grasses, only Pennisetum and Panicum were cut twice in 1986. These produced a total of 12.2 and 9.8 tons/ha air dry fodder for the two cuts respectively. Brachiaria ruziziensis produced 11.0 tons/ha air dry weight at the begining of the dry season. In 1987 all species were cut at the same time. The frequent cutting seemed to adversely affect Brachiaria and Panicum as compared to the other grasses. Yields of Andropogon and Pennisetum increased with cutting. The legumes were not affected by cutting.

In 1987, additional germsplasm from ILCA/Kaduna and FAO/Rome through the Projet Elevage Integre Borgou were introduced. In collaboration with the project nine grasses and five legumes were evaluated for productivity, resistance to drought and diseases (antrachnose).

All grass species established well from seed and cuttings. No particular disease incidences were observed. Grasses were cut in December, after seed set. Another cut was done in March (middle of the dry season) to determine potential for standing hay. Relative air dry and fresh weights of grass fodder are presented in table 17. Brachiaria ruziziensis (FAO), Setaria sphacelata (Narock), Brachiaria humidicola, Pannicum maximum and Cenchrus ciliaris were most productive while Brachiaria decumbens was a total failure. The same trend was observed in March although there was regrowth on most grasses.

Table 16 BIOMASS PRODUCTION (TONS/HA) AS EFFECTED BY CUTTING PERIODICALLY OVER 2 YEARS AT INA

Species	Oct 86		Nov 86		July 87		Oct 87	
	Fresh	Air dry	Fresh	Air dry	Fresh	Air dry	Fresh	Air dry
Brachiaria ruziziensis	41.4	11.0	_	_	18.5	8.2	17.8	7.7
Pennisetum purpureum	19.7	2.6	49.6	9.6	59.5	20.9	53.6	24.3
Andropogon gayanus	21.7	4.8	_	_	28.2	10.7	31.9	19.1
Panicum maximum	23.6	3.9	18.8	6.0	27.5	10.2	12.7	6.3
Leucaena leucocephala	4.1	1.4	_	_	22.1	6.6	22.3	7.5
Stylosanthes gracilis	5.7	2.2	_	_	12.3	3.6	7.8	3.6

Table 17 PRODUCTIVITY (BIOMASS) OF GRASSES SAMPLED AT TWO PERIODS DURING THE DRY SEASON AT INA (TONS/HA)

Species	1st Cut (December 87)			2nd Cut (March 88)		
	Fresh	% DM	Air Dry	Fresh	% DM	Air Dry
Cenchrus ciliaris var gayandah	19.0	46.8	10.4	16.2	81.3	12.7
C. ciliaris (FAO 65.251)	21.4	40.2	8.80	10.5	74.1	7.4
Brachiaria decumabens	9.4	17.7	2.60	4.7	79.8	3.5
B. humidicola	31.0	44.7	13.90	14.6	65.8	9.6
B. mutica	19.7	41.1	8.80	14.8	64.1	9.7
Setaria sphacelata V. Kazurgula	29.5	37.7	11.10	23.0	63.2	13.7
S. sphacelata V. Narock	33.1	49.6	16.44	20.8	63.9	13.3
Panicum maximum	39.8	41.9	13.10	32.8	55.0	23.5
Brachiaria ruziziensis (FAO 61585)	61.5	48.1	26.92	33.7	85.7	28.8

Among the five legumes Stylosanthes guinensis (Cook) significantly outyielded (13.8 t /ha) all other species. There was no difference between the productivities of S. hamata (verano) (10.4/ha) and S. graham (9.6 t/ha). Macroptillium artropuperium (siratro) and Stylosanthes gracilis yields were very low, 3.6 and 4.6 tons/ha, respectively (Table 18). All legumes flowered and produced a good seed crop.

The low productivities of atropuperium and graham may be attributed to the severe anthrachnose attack observed during the wet season.

Comparable development and yield of forage species such as Stylo verano, Panicum maximum and Pennisetum purpureum were observed at the station in the Atacora province. Due to lower rainfall regimes Peunisetum purpurerum established and performed poorly at Birni-Lafia (extreme north). However, Panicum, Centrosema, Stylo hamata and leucaena gave encouraging yields. Chemical analysis of the various samples is not yet completed. The three legumes, S.guinensis cook, hamata and graham hold much promise as potential pasture legumes, maybe in association with leucaena, for dry season feed supplementation in the region.

3.3 Limitations to Achieving Programme Objectives

Farming systems Research involves improving existing farming systems or designing new systems adapted to the various combinations of the socio-economic environment, production factors and technical levels under which small farmers operate. The main objective being to incorporate the results of research

Table 18.

PRODUCTIVITY OF SOME FORAGE LEGUMES EVALUATED AT INA (1987)

	Productivity (tons/ha)					
	1st cut			2nd cut		
	December 87			March 88		
Species	Fresh	% DM	Air dry	Fresh	% DM	air dry
Stylosanthes hamata	28.1	47.9	14.7	12.7	74.5	9.6
S " graham	34.5	41.0	13.4	14.7	70.0	10.4
S " guinesis cook	39.1	45.4	17.4	20.7	68.8	13.8
S " gracilis	8.0	37.9	3.0	7.0	61.3	4.6
Macroptilium atropu-pereum(Siratro)	13.3	25.5	3.5	6.3	57.1	3.6

on the individual components of production so as to achieve optimum conservation of resources, high productivity and better year round utilization of labour resulting in improved economic conditions for the majority of the rural population. There is no common approach to implement FSR. For every country or region the achievements depend on historical experience, availability of research results, human and financial resources, and the institutional environment in which FSR is being conducted. When the SAFGRAD/FSR programme was initiated at Ina, research hardly existed in Northern Benin. It is generally accepted, that research results take long to realise, this is particularly so with FSR which is complex, as described above. Evaluation of the achievements of the Benin SAFGRAD/FSR in relation to its objectives should be looked at in this context.

The various goals and objectives described earlier are discussed along with limitations which hampered their sucessful achievement.

1. The gathering of knowledge on agricultural production systems in Northern Benin was constrainted by lack of continuity in staffing of the project and lack of sufficient resources to undertake zoning of the region beyond the agro-ecological criteria on which the present zones are based.

2. The improvement of national capacity to do FSR could have been better realized if the following conditions were fulfilled : (a) training of more nationals ;and (b)availability of counterparts. This was to be achieved through on-station and external training. To date the SAFGRAD /FSR project in Benin,through the

Coordination Office in Ouagadougou ,was only able to finance a medium term training course (9 months) at ICRISAT/India for two researchers to upgrade their skills in the domaine of cropping systems in 1986. In addition four rural technicians (ATDR) completed a one month training course in Ouagadougou (March 1986) to improve their capacity to conduct surveys and agronomic trials. In 1987 the programme identified a national scientist for graduate training (PhD level) at the University of Ibadan; this failed ,however for lack of financial resources. During the life of the project counterparts in socio-economics, agronomy and agroforestry were consistently requested; only one agronomist was assigned to the team .The failure to get counterparts was attributed to lack of genuine commitment by the national authorities as candidates were obviously available.

3. The objective to identify constraints to agricultural production and to develop new technologies to address these constraints was partly achieved. The testing of appropriate technologies was not conducted to the fullest for the following reasons : (a) There was very little available technology in the region which could have been tested on-farmers fields in the first two years. This prompted the FSR team to initiate some thematic research. (b) High turn over of FSR/Staff interfered with research continuity, and (c) the research infrastructure in the region was so lacking that research progress was consequently slow.

4. The orientation of national research programme towards a hoslistic research approach was to be achieved through increased interaction with nationals at all levels, dissemination of

research results in seminars and workshops. These activities were limited mainly due to lack of financial resources, and the lack of access to computer facilities which slowed down the analysis of the socio-economic data.

5. Influencing the agricultural policies (research and production) was to be realized in the final stages of the project as this is a consequence of findings and recommendations from research results. Taking into account the evolution of SAFGRAD Benin project (large mandate area and short duration of project) we succeeded in sensitizing the nationals on the essence of FSR, however, due to the above constraints, the project did not acquire enough results to formulate far reaching recommendations.

6. The development of a network to link scientists and institutions began in the right direction. A good rapport with the nationals was definitely built. Time and validation of research results could have created a good background on which to build future FSR work in Benin.

4. SUGGESTIONS FOR FUTURE FSR ACTIVITIES IN NORTHERN BENIN

1. With the understanding that there will be a new FSR programme under Borgou II Project, research activities are thus expected to be restricted to Borgou province. In this respect, the three sites -- Sokka in Northern Guinea, Bensekou in Sudan Savanna and Birni-Lafia in the Sudan- Sahel zone -- should be retained in order to take advantage of the experience gained in working with farmers and the good rapport established with CARDER field agents (AVA). These sites could be used for off- station reseacher managed trials to evaluate technologies for the three agro-ecological zones respectively.

2. Zoning of Borgou province should be finalised. Essential documentation is available at CARDER/Borgou headquarters at Parakou. What are presently needed are short surveys and field visits to each of the 14 districts of Borgou. The objective is to delineate the province into zones with clearly identifiable farming systems using criteria beyond the usual soil and agro-climatic aspects. These should include (but need not be restricted to) land tenure, land use and agroforestry practices, sexual division of labour, use of animal traction, cropping patterns, livestock systems and major off-farm activities. A similar zoning study was done for the Zou province in 1986 by the Projet R-D Zou. The researchers involved should initiate contacts with CARDER/Zou and take advantage of available documentation both at CARDER/zou and the DRA in Cotonou.

3. After the Borgou province has been delineated, say, into 6 to 8 farming systems (FS) zones, representative villages should be

selected in collaboration with CARDER. These should be primarily used for on-farm experiments with an increasing number of collaborating farmers to test improved tecnologies. Since CARDER/Borgou has, over many years, collected farm level data on structure of farm households, income levels, adoption of recommended research themes, this data set should be exploited to the fullest after a detailed typology of farms has been established.

4. The choice of collaborating farmers should be based on their identification with the characteritics of each type of farmers. A separate computer file should be held describing the structural parameters and the dynamic features of each farm. In 1987 a detailed resource utilization study was conducted over 90 farms in the 6 villages of the SAFGRAD/FSR project, four of them in Borgou (Ina, Sokka, Bensekou and Birni-Lafia). The results of this study will be made available later in 1988. They should be used as benchmark for input/output coefficients and the labour profile when the SAFGRAD site reasonably fits in the FS zone identified early. This will minimize duplication of data collection. Resource utilization data from the collaborating farmers should be restricted to monitoring of changes induced by the testing and/or the adoption of improved technologies.

The programme as mentioned earlier must be built on the achievements of phase 1. The major constraints to increased agricultural production in Northern Benin should always be pursued and research work organized in such a way that the constraints are tackled individually or collectively. A key

factor and one upon which the success of the programme should rest is the emphasis on on-farm experiments: researcher managed trials should be drastically reduced in favour of joint researcher/farmer and farmer managed trials.

With regard to Crop Association:

Competition for space could be reduced by manipulating row width i.e. wider rows of the major crop with close spacing within row; double or triple close rows to increase light for the minor crop between the main rows of the major crop.

Staggered planting dates using short growing varieties in a relatively long growing season i.e. in south Borgou, should reduce competition at peak growth of the two crops. Thus relay cropping trials should be tested in this context. Early/late crop association also reduces competition as peak growths of the various associated crops do not coincide as illustrated by TZB/local sorghum association. This practice should be exploited further.

With regard to Varieties:

It is not only the high yielding potential which is desired but also the resistance to common pests, diseases and stress such as drought. Thematic researchers in the region should work very closely with IITA and ICRISAT to increase entries for the multilocational trials. In addition, collection of local materials especially for sorghum should be intensified.

The role of FSR in the search for improved varieties would be to test continuously on farmers'fields in collaboration with them, the new promising varieties.These are the varieties which would have proved successful in the multilocational trials on the

breeder'splots. For cost effectiveness, the on-farm trials should be run jointly with CARDER extension services. A distinction would have to be made between on-farm experimental trials and on-farm demonstrations in order to avoid undermining farmers'confidence in the extension service. Demonstration plots are meant to prove that new varieties are superior to the existing ones, while on-farm experimental trials are still in the testing stage though in collaboration with the farmer.

Soil degradation and fertility constraint will become increasingly pertinent with demographic pressures and desertification. Chemical fertilizers are expensive and only economically justifiable for cash crops. Consequently, to sustain food crop production on WASAT easily degraded soils, some feasible, profitable and acceptable technologies already attempted under phase 1 should be pursued :

a) Proper crop rotations, which include fast growing forage legumes can help restore soil fertility. It is universally accepted that a fast growing forage legume in the rotation restores soil fertility faster than a natural fallow. In addition, cash crops receiving chemical fertilizer should be followed by food crops to benefit from the residual fertilizer. Research into these practices should be vigorously undertaken.

b) Deep ploughing incorporates more organic matter into the soil than the shallow clearing of fields currently practiced in the region. Leguminous herbs could also be grown in association with cereals and incorporated into soils at the latest weeding operations. Preferably a forage legume could be relayed with a cereal crop, this forage could be used for animal feed and

restoration of soil fertility for the next crop.

c)Ridging improves water use efficiency under dry conditions with soils which have low water retention capacity such as those found in the extreme north of Borgou. In this region tied ridging should continue to be evaluated, together with a tie-ridger implement to test the profitability and acceptability of this new practice.

At present, farmers in Boukoumbe slow down the run-off on the mountain slopes using tied-ridges reinforced by stones. It would be a worthwhile study to evaluate the use of trees, shrubs, and forages to reinforce the tied-ridges and replace the stones. These new introductions could also serve other purposes such as soil fertility restoration, animal feed, firewood etc. thus increasing the total productivity of the system.

Yam production: ridging and source of seeds

Since the final goal of this technique is to save labour by growing yams on ridges made by animal traction instead of mounds made manually, the trial on farmers' field should include two treatments:(i) mounds made manually and (ii) ridges made by animal traction. Participating farmers should be convinced that it is an experiment and not a demonstration in order to avoid bias and wrong interpretation of results.

Current results on station suggest no significant differences between yields of yam from different seed sizes used at planting. The trial should be moved on farmers' fields to test the profitability and acceptability of this technique.

Herbicide Trials

Groundnut and maize are becoming increasingly important cash crops after cotton. There exist even varieties of these crops with a high seed yield potential in the region. Trials under farmers' fields using new varieties and fertilizer have shown still low yields as compared to yields at research stations. The gap has been attributed to low management on farmers' fields, mainly inadequate weed control at the early crop establishment stages. A pre-emergence herbicide which could control weeds especially in cash crops (maize and groundnut) would be desirable. This would increase total production through yield increases and increased cultivated area. Presently, farmers clear only land which they can afford to weed by hand. Labour freed from weeding the cash crops would be available to efficiently manage the food crops thus increasing the total production of the whole system.

With regard to developing sustainable food production systems, agroforestry techniques to improve land use need to be incorporated within existing farming practices. The recent awareness of the role of trees generated among farmers, through the forestry department and the UNSO project, sets a good base for efficient introduction and evaluation of trees and shrubs into the farming systems using improved agroforestry systems and practices.

Based on the preliminary results reported and the team's experience in the region, the following agroforestry practices and systems are recommended for further research and evaluation:

a) Land use evaluation to determine ways of introducting trees, appropriateness of tree location and association, also to identify present farmers' practices in relations to trees and how these could be adopted to manage introduced systems. This would identify most useful trees in relation to farmer needs and requirements.

b) Promising systems such as alley cropping and mixed intercropping with fast growing, local and introduced leguminous trees and shrubs should be further investigated. Emphasis should be placed on :

- Physical and economic evaluations of practices such as tree cutting and management in relation to labour availability to the farmers.
- Low input and cost techniques for land preparation, soil water conservation and tree management.
- Use of browse (fodder cut from trees) for both soil fertility improvement and livestock feeding.

Leguminous trees such as Leucaena leucocephala, Cajanus cajan and Acacia albida seem to hold great promise in both alley cropping and mixed intercropping situations. Appropriate management techniques, acceptable to farmers should be investigated. Other uses of trees such as fencing, terracing for erosion control, boundary planting and village woodlots for firewood and poles should be evaluated.

c) Very little research has so far been done to document traditional practices, system functioning and interactions with crops. In addition to the data already available (Otsyina et al, 1987) more information to improve the systemsa is therefore

required on :

- dominant tree/crop associations in the various agro-ecological zones, their interactions (biological) and economic importance to the total household economy.
- Optimum tree densities to minimize competition between trees and crops.
- Efficient management practices for sustained productivity.
- Improvement cottage industries for processing and utilization of tree products.

With regard to integration of livestock and crop production systems:

a) The use of animal manure is well known in the region. What limits its wide use is the limited supply of dung. Research on production and management of animal manure is worthwhile undertaking. This could be tackled through a forage crop/animal manure/soil fertility integrated study. The extreme north is an appropriate location for that experiment.

b)Dry season fodder shortage remains one of the major set backs in livestock production in Northern Benin. Small scale conservation of crop residues and browse is one of the traditional ways of maintaining livestock through the long dry seasons, especially in the drier extreme north (Karimama and Malanville districts). Forage farming appears to be a promising solution to the dry season forage problem. However, this practice is new and unknown to farmers. An efficient integration of forage legumes into the cropping systems would greatly improve the situation. Research should, therefore be directed towards :

- Introduction and evaluation of indigenous and adapted forage

species under various agro-ecological conditions.

- Low input and cost techniques for introducing forage legumes into the existing cropping systems and fodder development for large herds. (Fodder banks).

- efficient management of natural rangelands and planted pastures to maximize fodder production for dry season feeding. Fire control and management could be evaluated at district and village levels through the various village social groups.

- Uses of excess vegetative biomass for manure and compost production during the wet season.

- Improvement of efficient traditional fodder conservation techniques.

- Simple forage seed production and conservation techniques at the farmer level to maintain adequate seed supply in the system

Economic Evaluation of Improved technologies

This must be a continuous activity of the team's economist in collaboration with biological scientists. Evaluation of technology needs to be done for researcher managed trials and on-farm farmer managed trials conducted in collaboration with the panel of participating farmers in each FS zone.

Data must be collected every year on inputs and outputs associated with agronomic and agroforestry trials so that the experiments can be analyzed in terms of benefits and costs.

Partial budgeting techniques should be used where single factor trials are conducted. Cropping patterns and agroforetry trials concerning the introduction of new practices or modification of traditional ones will require complete budget or wholefarm

analysis tools, sometimes involving the use of linear programming methods.

As the need arises, specially oriented studies will have to be conducted. For example adoption studies will be required at some later time to understand the factors restricting the wide adoption of profitable improved technologies. Other investigations such as the marketing of agricultural products must also be initiated. It is expected that all such inquiries be done in collobaration with the DSEI at CARDER to take full advantage of the infrastructure deployed by CARDER and to avoid duplication of efforts and resources.

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APPENDIX 1.

AGRICULTURAL RESEARCH ESTABLISHMENTS IN BENIN (1986)

Establishments	Research Focus	Location- headquarte (province)
1.Palm Oil Station (SRPH)	breeding of palm trees; control of palm oil & kernel	POBE (Oueme)
2.Food Crops Research (URP)	Maize,cowpea,groundnuts, cassava & soybeans	NIAOULI (Atlantique)
3.Food Crops Rsearch (URP)	sorghum,maize,yam,cowpea, groundnuts,cassava,sybeans	INA (Borgou)
4.Center for Coton & Fiber Research (RCF)	cotton & fibers	COTONOU (Hq);PARAKOU
5.Soil Research Labor. (CENAP)	soil classification, study & mapping	AGONKAMEY (Atlantique
6.Crop Protection Lab. (LDC)	plant pathology,phytosanitary service,insects, diseases,birds & rodents	PORTO-NOVO (Oueme)
7.Food Technology Lab. (LTA)	food & fruit processing, conservation & analysis	PORTO-NOVO
8.Livestock & Veterin. Research Laboratory (LRZV)	cattle,small ruminants, feed & forage plants	AGONKAMEY
9.Center for Economics, Rural Sociology Res. (LERS)	socio-economic research	PORTO-NOVO
10.Project for Rice Res (PRR)	rice	HOUEDA-ABOMEY (ZOU)
11.Forestry Research Station (URF)	forestry	COTONOU
12.Coffea & Cocoa Res. Station (URCC)	coffea & cocoa	COTONOU
13. Coconut Research Stat. (SRCOCO)	coconut	SEME-KPODJI (Oueme)

1989-01

OAU/STRC SAFGRAD FARMING SYSTEMS RESEARCH PROGRAMME END OF PROJECT REPORT

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