A CASE STUDY OF ON-FARM ADAPTIVE RESEARCH AT BIDA AGRICULTURAL DEVELOPMENT PROJECT, NIGERIA

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INTRODUCTION

The Bida Agricultural Development Project (BADP) operates from 1980 until 1985. It is jointly funded by the Federal Government of Nigeria (25%), Niger State Government (39%) and a World Bank Loan (36%). The objectives during the Project life, are to raise agricultural production by 25% and to increase farm income by providing farm inputs such as fertilizers, credit, tractor hiring service, extension information, developing low cost irrigation schemes, and by constructing feeder roads for the evacuation of surplus farm products.

In late 1981 Bida Agricultural Development Project in collaboration with the International Institute of Tropical Agriculture (IITA), initiated an agronomic research program designed to identify major production constraints in the local farming systems. The aim was to identify intervention points and develop technologies and recommendations adapted to the needs of the local farmers, for use by the Project's extension staff. This case study is a preliminary description of the resulting On-farm Adaptive Research (OFAR) program.

DESCRIPTION OF THE PROJECT AREA

The Project area covers some 17,000 km^2 of land in the southern part of Niger State and lies in the Southern Guinea Savannah zone. The topography is characterized by gently undulating country, underlain by sandstone. One of the major determinants of the cropping system is the network of rivers, especially the Niger River and its tributary and the Kaduna River. These rivers are characterized by their large, swampy flood-plains, which flood during the rainy season and then gradually dry out during the dry season. The flood-plains and the complex of smaller river valleys and inland swamps (fadamas) are usually referred to as lowlands and are used to grow rice. The major part of the project area, which does not flood, is referred to as, upland and is used for rain fed farming. Soils in the uplands are generally sandy and acidic with low levels of organic matter and low cation exchange capacity. They are also highly permeable and liable to erosion, especially on steeper slopes. Soils in the lowlands are loamy and of higher quality, allowing longer periods of cropping without need of a fallow period. Temperatures rarely fall below 20°C, except during the dry season and are not a major constraint to crop growth in the area. Rainfall is the major constraint and is characterized by its seasonal nature, monomodal distribution and variability from year to year. Seed-bed preparation, germination and the early stages of crop growth are entirely dependent on the amount and frequency of precipitation, since the soil profile and particularly the soil surface carry a large soil moisture deficit at the beginning of the rainy season. Reference to Figure 1 shows the high variability in the amount of rainfall during this period. Mean rainfall (1182mm/annum, 23 years data, Bida Airport) is in excess of evapotranspiration from 11th May until 10th October (152 days). However, rainfall can only be relied on to exceed evapotranspiration from 1st July until 30th September (91 days). The period between early May and early July presents considerable risk to farmers. The amount of moisture available may not be sufficient for sustained crop growth.

An estimated 9% of the total Project area is under cultivation (BADP, 1982), with concentrations of farm land around the lowlands and Bida, the major urban center. Cultivation in the lowlands is semi-permanent to permanent in nature (following Ruthenberg's classification, 1980). Upland farming is practiced under bush fallow or shifting cultivation. Little of the lowland area is cultivated in the dry season except for plantings of cassava, grown as a gap filling crop for consumption during the 'hungry period' prior to the main harvest, sugar-cane (for chewing) and vegetables. Nomadic Fulani herdsmen migrate into the area during the dry season with their cattle (estimated 400,000 head/year) to find dry season grazing and drinking water.

The Project area contained an estimated 65,000 farming families with an average size of 6.5 persons. Population is denser to the east of Kaduna, especially around Bida, the main urban center. Farming is the main occupation of the rural population and is the primary source of income. Supplemental income activities are fuel wood, fishing, trading and employment in government.

Rice, sorghum,[1] and dried fish are the major surplus commodities in the area and a local marketing system has arisen for these items. Most villages hold a market every 5 days for sale of goods for local consumption. Project area level surpluses are sold through two marketing systems; through the major markets which are usually found on the main roads and to traders who visit the villages during the harvest period to buy directly. Bida market is the dominant market and is held daily. Bida and other large markets serve as the wholesale markets for sorghum and rice. Traders from urban centers outside the project area also come to villages each year to buy par-boiled rice. It is estimated (BADP, 1982) that 16,000 tons of rice and 15,000 tons of sorghum leave the project area every year. The on-farm storage and marketing of surplus farm products is not considered to be a major constraint at the present time.

ORGANIZATION OF THE OFAR PROGRAM

The function of the OFAR program was to provide recommendations for use by the Extension Service which would be adapted to the farmers within the project area and would utilize the potential benefits of inputs and services provided by the project. The OFAR program of BADP can be split into 5 activities:

a) Exploratory and diagnostic phase to make a preliminary

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[1] Sorghum is the common vernacular name for guinea corn.

definition of target areas and identify opportunities for experimentation within these areas;

b) Screening trials of on-station technology for use in the on-farm trials;

c) On-farm testing and evaluation of selected technology;

d) Verification of target domains and use of knowledge gained from farmer interviews and reactions to trials for design of the subsequent years' program;

e) Recommendations to the Project extension service.

<u>The Exploratory and Diagnostic Phase</u>

The wide range of agroeconomic circumstances faced by farmers within the Project area made it impossible to run a series of on-farm trials relevant to all farmers within the area. Therefore it was necessary to first group farmers with similar agroeconomic circumstances and then design a program to produce recommendations relevant to the separate groups (target domains).

The Project was visited by an IITA agricultural economist and an agronomist shortly before the start of the planting season in 1981. After an aerial reconnaisance to familiarize themselves with the general features of the area, the team collected secondary data concerning population, general agronomic practices and farm labor use pattern.

The obvious difference between farmers whose cropping system was based around the lowland cultivation of rice and farmers whose cropping system was based on upland crops led to an initial hypothesis of two target domains i.e. farmers with a lowland based cropping system (Domain 1) and those with an upland based cropping system (Domain 2).

The short period of time available before establishment of the first year trials did not allow time for extensive verification of the target domains. Verification and refinement of the target domains was carried out concurrently with the first year trials. Analysis of a yearly agronomic survey, referred to as FRADYS (Field Records for Agronomic Details, Yields and Stands) and a series of informal interviews, formed the basis for verification. Data from the 1982/83 survey of 225 farmers in 15 villages was used. Farmers were grouped by land area allocated to specific crops/crop mixtures, on the assumption that aggregate area reflects the interaction between the bio-physical and socio-economic circumstances of the farmers and their priorities.

Analysis revealed 4 cropping systems based target domains, 1 in the lowlands and 3 in the uplands:

(i) Lowland rice based;
(ii) Upland yam based;
(iii) Upland cassava based;
(iv) Upland cereals based.

The major determinants of the four cropping systems were soil types (including the varying level of soil fertility) and the availability of moisture during the wet and dry seasons. In the lowland, surface soils are deep and loamy. They are subjected to flooding caused by surface runoffs and there is seepage water supply during the dry season. The upland soils can be divided into three types. The first type contains the lower edges of the sloping fields having deep rich surface soil, heavier soil texture and experience little erosion. Farmers use these soils for growing yams and maize. The availability of such soils is limited in the project area. The second type has slightly loose soil texture, lower fertility and lies on the mid slopes. These fields are planted to cassava. The third type refers to the top section of the catena; they are either sandy or gravelly, highly eroded, leached and very low in fertility. Majority of the project land falls in this category. These fields are planted to sorghum, millets, egusi melon, bambaranut, groundnut, etc; the crops best adapted to low fertility soils.

Although Nupe population settlement is related to the location of inland valleys and access to the drinking water supply during the dry season, they farm all types of land. Some farmers have access to both lowlands and one or the other type of upland, while many farmers have access to only different types of upland. Thus, those farmers having both lowland and upland, are referred to as practicing the rice based cropping system. Those having upland, some of which is suitable for yam cultivation, are referred to as practicing a yam based system. Similarly, those farmers who grow both cassava and upland cereals are referred to as practicing a cassava based system. Lastly, those farmers who have access to only poor quality land which is planted to rough cereals and legumes are referred to as practicing a cereals based cropping system.

The definition of target domains in this paper is therefore very much related to the bio-physical factors which, in our view, have major influence over farmer's cropping plans and management decisions.

DESCRIPTION OF TARGET DOMAINS

The dominant crop by area in all four target domains was sorghum (Appendix 1) but within their respective domains rice, yam, and cassava were the major cash crops. These crops also produced higher yields (Appendix 2) and failed least often (Appendix 3) in their respective domains. Crop failure rates were highest in the upland cereals based system. As mentioned above, this system is confined to the less fertile soils in the uplands, with soils which are both highly erodable and shallow and which quickly show the effects of drought.

Rice Based System

Twenty seven percent of the sampled farmers fall into this system i.e. growing both lowland and upland crops. In late April or May, upland fields are planted with sorghum (Figure 2), usually in a mixture with millet, maize or egusi melon. Sorghum is the major food grown for home consumption and so priority is attached to ensuring good establishment of this crop. Although, once established, the crop can compete well with weeds, it is important that fields be kept clean during the early stages of growth. Therefore, land preparation for the rice crop in the lowlands occurs only after the first weeding of the upland crops, in late July and

August. Since the majority of the rice area is classified as rainfed lowlands with little water control, the crop is exposed to the risk of moisture stress at the end of the rainy season. Delay in planting of rice is exacerbated by the high labor input necessary to ridge the land.

Within the project, rice is grown mainly in two ecological environments: on the flood plains; and in inland valleys where seepage water from the surrounding uplands accounts for much of the water. In both environments ridging is the major method of seedbed preparation and is a function of water status and position in the topographic sequence. Close to the bottom of the sequence, where the water level is deep, rice is seeded directly onto the ridges; while in the upper part of the toposequence, ridges are made to conserve water and facilitate weeding.

Land preparation for rice usually occurs 3 months after the start of the rainy season and so farmers are faced with substantial weed growth. Simply turning over the soil will not prevent quick re-growth unless water is present in sufficient quantity to suppress them. Therefore, farmers use ridging as a weed control measure at the establishment stage and also during the first weeding, when weeds are pulled into the furrow with the hoe and then buried. Herbicides are only rarely used and are unknown to most farmers.

Harvesting of short-season upland crops such as millet and egusi melon and weeding of the rice crop are the major activities until the dry season in November and December, when the sorghum and rice are harvested.

The dry season is a period of slack labor demand for most farmers in the rice based system, since only a small part of the lowlands are utilized for production of dry season crops on residual moisture and few opportunities exist for off-farm employment.

Upland Based Systems

Within the survey sample, 27% of farmers fall into the yam based system, 7% into the cassava based and 39% into the upland cereals based system. Farm size was largest for farmers in the yam based system, smallest for those in the upland cereals based. For the yam and cassava based systems, farm labor input was high at 365 and 239 man-days respectively, with peak labor demand at the start of the rains during the planting of sorghum and after the rains when harvesting occurs. Potential conflicts in the allocation of scarce labor for establishment of yam and sorghum are avoided by planting most the yam area during the dry season (Figure 3), thus spreading out the demand for labor over time. Within the cassava based system, the planting of cassava occurs after the establishment of the sorghum crop. Since cassava is a relatively drought resistant crop with a growth cycle of over 12 months, timeliness of planting is not as important as it is for the rice crop allowing establishment over several months (Figure 4).

The upland cereals based system was the poorest domain; crop yields were lower than in the other domains and farm size was smaller. The first half of the rainy season is usually busy in the activities of planting and weeding, (Figure 5) during the second half many of these farmers sell their labor to richer farmers who practice rice and yam based systems. Families in this domain hunt, fish or sell their surplus labor to supplement farm incomes.

Farm Productivity

Farm productivity measured in terms of farm income and returns to farm inputs varies considerably among the four target domain cropping systems. The root crops based systems of yam and cassava yield greater quantities of food, when converted to value terms these systems produce higher farm incomes. The rice based system which has access to good land and water resources is comparatively less productive, mainly due to lower cropping intensity practiced in the lowland fields. Farmers' capital costs are mostly in the form of seed, small quantities of fertilizer and primitive hand tools. Farmers do not have access to animal and mechanical farm power. Thus, the return to capital is negligible. Nearly 85% of the farm costs are labor inputs (mostly family sources) and returns to labor input is close to the rural wage rate. After accounting for costs of labor and capital, the return to land is negative for the rice and cereals based systems and positive for the yam and cassava based systems (Appendix 4).

SYSTEM CONSTRAINTS AND EXPERIMENTAL OPPORTUNITIES

Rice Based System

Planting of rice is usually delayed by the farmers' practice of weeding their upland crops before commencing land preparation for rice and by the large labor input necessary for ridging by hand. Easing this labor constraint in July and August would allow for an increase in the area of rice planted, increase yields by more timely planting and lessen the risk of crop failure due to moisture stress later in the season. Changing from ridged to flat seedbeds would save labor and also fit in with the newly expanded tractor hire services and chemical weed control methods provided by the Project. The change would also tie in with the Project work on informal irrigation schemes in the lowlands and their advocacy of contour bunding.

Other factors limiting rice yields in the area were the low stand density and iron toxicity. Stand density is closely related to the ridging of seedbeds; wider spacing between ridges results in lower stand densities. Stand density could be increased either by reducing the gap between ridges or by planting on the flat.

Iron toxicity is a more complex problem. Improved varieties tolerant to this problem is one possible solution which the farmers might easily adopt. Other expensive solutions are use of lime (1-2 tons/ha), drainage of seepage water and planting on raised beds. Other problems, such as irregular water supply and bird damage were noted, but as these problems were outside the control of the farmer, they were not included in the short term research program.

The presence of seepage water from the surrounding uplands in the fadamas during the dry season offered the possibility of increasing system productivity by growing a 'catch crop' using this residual moisture. Since labor was not a constraint within this system during the dry season, this opportunity offered chances of introducing change into the system without major problems of resource allocation.

The Upland Based Systems

For the three systems, improvement possibilities lie in the mid-season, between July and November, when surplus labor is available. Project records and informal interviews have shown that the area planted to cowpea had declined rapidly within the last few years due to insect problems principally at flowering. Cowpeas are still a major component of the diet and are imported from Northern Nigeria. Local cowpea varieties are indeterminate, making the use of insecticides inefficient, since the crop flowers over several weeks. The surplus labor in mid-season and new determinate varieties requiring a minimum spray regime for insect control, offer the opportunity to re-establish the crop(Fig.6).

The local cassava varieties were observed to be heavily infested with green spider mite and cassava mosaic virus, both depressing their yields. As solution to this problem, improved varieties could be screened for tolerance to these problems.

Although the Project area is well suited to maize production, maize was a relatively minor crop grown mainly for home-consumption. The Project extension unit was attempting to increase maize production, but a major constraint observed was the parasitic weed, *Striga homotheca*. As an initial step, screening of improved varieties with some resistance to striga and finding cultural control are necessary.

ON-FARM TRIALS AND RESULTS

The aim of on-farm trials was to maximize information about the constraints identified in the diagnostic phase and evaluate selected crop varieties and management alternatives to overcome crop specific constraints. Results were used to assess the agro-economic feasibility of the selected interventions compared to the farmers current practices and to improve the level of socio-economic information which was found lacking during the diagnostic phase. After discussions with scientists and project staff, priority was placed on research in the lowland rice based domain. The rice based cropping system was identified as having the most potential for improvement using technologies available on-station. In addition, the first year trials were used to:

a) develop the capability of Project staff to run OFAR trails and to reveal areas in which further training would be necessary;
b) assess the logistical demands of the program;
c) develop knowledge of the level of farmers willingness to participate in OFAR and their level of technical sophistication.

Rice Based System

As stated before, farmers grouped under the rice-based cropping system grow rice in the lowland and a mixture of cereal and legume crops in the uplands. The productivity of the lowlands is very low mainly because of low paddy yields caused by a late planting and less intensive use of lowland fields. Since farmers attached greater importance to the cash crop of paddy, system improvement was therefore sought through changes in the crop management practices of lowlands.

There are two feasible approaches to the moving forward of rice planting dates by; (a) changing the existing laborious ridge seedbed preparation method to the flat cultivation techniques and (b) replacing a portion of the area planted in photoperiod sensitive sorghum varieties to a short season modern variety which can be planted later in the season, thus allowing the paddy to be planted a few weeks earlier. The third alternative of saving weeding labor from the upland fields was not considered since there was no known mechanical or chemical technology for the crop mixtures practiced by the farmers.

Relating to the first approach, rice trials were conducted to evaluate the effects of flat seedbed preparation, rice hill density of 50%, and modern rice varieties, on the paddy yield and the labor use pattern. Experimentation was conducted on the second approach to identify and evaluate the short season improved sorghum varieties by planting later i.e. in the month of August.

A factorial agronomic experimental design was used for the rice trials with two treatment levels, the farmer level and the level recommended by the scientists. The variety factor included four varieties, one of which was the farmer's. The three experimental factors were: (a) seedbed preparation method; (b) stand density; and (c) variety. These were combined in an experimental design which required different levels of management. The first design consisted of representing 5 different rice fadamas under direct management of the Project research staff. The second design included two varieties rather than four and utilized farmers' participation, especially for the management of non-treatment factors. In the third design, stand density was eliminated, leaving 2 varieties and two seedbed preparation methods. These trials were fully managed by the farmer and supervised by the Project Extension Staff. These trials were conducted consecutively for two years and produced valuable feedback.

<u>Variety</u>

A total of 6 varieties were planted at different sites. Varietal selection was based on performance in a seed multiplication plot, with new varieties being recommended by the extension service. Due to the late start of the rains, rice planting by farmers in the project area was delayed by two to three weeks. The planting of on-farm trials was, therefore, also delayed at all but one site. The farmer variety was photoperiod sensitive and experienced little water stress after cessation of the rains. Among the improved varieties, only one had a comparable season length and did not experience moisture stress at panicle filling. The local short season varieties, which yield 2.25 tons per hectare were better adapted to local physical and biological conditions of little or no water control than the selected improved varieties.

At one site where water management was good and irrigation continued after the rains ceased, yields of the improved varieties were 32% - 40% higher than those of the local control.

Seedbed Preparation

The hypothesis was that yield could be maintained or even increased by planting rice on a flat seedbed rather than on ridges, thus saving labor. Results from the trials produced two opposing agronomic yield responses. Half the sites showed a positive yield response to changing from a ridged to flat seedbed, the other sites a negative yield response. Based on the preliminary observations made during the crop season and subsequent visits by a soil scientist it was concluded that the differing yield responses were due to differing levels of flooding and degree of water control. On sites where flooding through seepage water was less severe, flat planting of rice (direct seeding) produced higher yields. However, for sites where seepage water brings excessive amounts of ferrous iron, the farmers' practice of ridge planting to raise plant beds minimized toxicity problems and thus produced better results.

For sites with a positive yield response to flat seedbeds, yield gap analysis showed that the switch from ridged to flat seed beds contributed on average, an extra 514 kg/ha of paddy yield or about 23% above the farmer practice yield rate of 2.2 tons/ha. Appendix 5 shows that the management change was highly beneficial, with return to labor expressed as paddy yield and gross return per man-day being increased with little or no increase in total labor use.

Stand Density

The farmer stand density of less than 100,000 plants/ha was considered low to make full use of land and water resources. As with the tillage method, some increase in stand density from 100,000 plants/ha to 150,000 plants/ha was observed. At sites identified as not having a flooding problem, increased stand density produced an extra 300 kg/ha of paddy rice. At sites identified as having excessive seepage of water, yield increments for increased stand density were not significant. The contribution of increased stand density is, however, expected to be much greater with a modest dose of fertilizer use.

Farmer Opinion to Interventions

The informal surveys of rice growers revealed the possibility of recommending closer spacing and flat seedbed preparation to farmers in those areas with better water control. When asked about using flat seedbeds instead of ridges, farmers stated that they want to try it on their own plots and agreed that it might give as good or better yields and/or be less work than ridging. However, some farmers believed that planting rice on flat seedbeds was either not feasible due to the variation in water conditions during the season, or would take more work to achieve good weed control. Based on these reactions BADP has undertaken work to classify different types of fadamas and layout plots to demonstrate the value of planting a denser crop on flat seedbeds.

Farmers reactions to increasing stand density were mixed. This was due to fears that increased stand density would reduce tillering and make it more difficult to hoe weeds as closer spacing would not leave room for their hoe between stands and weeding would be more time consuming. Adaptation to closer spacing was observed in one village where a smaller hoe was used. A survey of farmers' hoes indicated that smaller hoes were not easily available in the project area and it required a special effort to have the blacksmiths make small hoes. Thus a wider spacing between hills was considered necessary for weeding with large hoes.

Regarding experimentation on later planting of short-season sorghum varieties, two years exploratory work has shown that under research management, International Crops Research Institute for the Semi-Arid Tropics(ICRISAT) varieties are highly suitable and have produced economic yields. This experimental work has now been shifted to the on-farm testing phase along with the study of labor use pattern and farmer assessments of the new sorghum varieties.

Exploratory Cowpea Trials

An informal survey of project farmers was conducted investigating the possibility of intensifying the use of lowland fields. It indicated that their lowland fields after paddy crop remained wet for some weeks during the dry season. Farmers have surplus family labor during the dry season and said that they would welcome any innovation which would increase their food supply by using slack period resources. Survey investigations further revealed that the average Nupe family consumed 2-3 meals each week prepared from cowpeas and spent about $250 per annum in buying them. A variety popularly known as 60-day cowpeas was considered a good "catch crop" on residual moisture during the dry season.

The exploratory trials were designed to test the viability of growing cowpeas after rice. Since farmers had the best understanding of local conditions, they were asked to bear responsibility for trial management. Trial design was kept simple with only two experimental factors, variety and insect control. Four short season varieties were selected and the plot was split into 2 sections, one section was sprayed to control insects, the other section was not.

Results from the two sites established in the first year were encouraging. At the first, site established yields were reasonable, especially for the variety IT82 E-60, which had the shortest season length. Yield rates from the second site whose establishment was delayed by two weeks were considerably depressed due to moisture stress and the reported destruction by goats. Economic returns (Appendix 7) at the first site compared favorably with cash costs, especially for a slack labor period. Total cash costs for seed and fertilizer at the local market price and for spraying were figured at $125/ha while net return to labor and land inputs was $1470/ha. The cooperating farmers also stated that demand for seed from other farmers was high. Encouraged by the results of the first year dry season cowpea trials, the subsequent dry season research program was expanded to gain information on factors affecting crop establishment, suitable methods of seedbed preparation, and the effect of planting date and location of the crop in the toposequence for the dry season crop.

The three methods of tillage: zero, strip, and conventional hand hoe were all successful for seed germination and crop establishment in the paddy fields, thus offering the possibility of reducing labor input and expanding the area under cowpeas through timely planting. Crop performance along the slope/gradient was affected by the availability of moisture. On the top sections of fadamas with 5% or steeper slopes, moisture depletion was fast and therefore, yield level was uneconomic. Crops on the middle and bottom sections of the fadamas matured successfully by giving economic yields both on experimental and extension verification plots (Appendix 6). The dry season cowpea yields of 600-700 kg/ha with two sprayings have been quite attractive to farmers who have become so enthused with this new crop enterprise that they refused to sell their produce to the Project and have begun to invest in the spraying equipment.

Farmers' experience with the dry season cowpeas revealed a number of adaptive innovations. Once told about the moisture requirement of the crop, they were fairly accurate in locating fields on the toposequence and using the appropriate method of seed-bed preparation.

In the wetter fields they preferred planting on raised beds and in drier fields on flat beds. To protect their cowpea fields against rodents and monkeys, farmers used five alternative devices: (a) fencing with tree branches; (b) fencing with fish nets; (c) tieing a dog inside the plot; (d) erecting scare-crows; and, lastly, (e) by having their young children watch the crop at the podding stage. Similarly, to protect the crop from the Fulani cattle, village chiefs were influencial in alerting the herdsmen. Farmers erected small signboards in their cowpea fields that the herdsmen were eager to avoid (signboards are traditionally used to label government property).

We had previously estimated an increase in paddy yield of 800 kg/ha, with changes in hill density and tillage method while requiring little extra labor input. Similarly, dry season cowpea crop (E-60) produced 777 kg/ha yield with 60 days labor and about $125 capital cost/ha in insecticide spraying. Using these extra costs and returns we have measured their consequences on overall farm productivity (Appendix 8). Column one represents the benchmark situation while columns 2, 3 and 4 show the level of costs and returns with an incremental change of rice management practices, dry season cowpea and when respectively both of these improvements are incorporated into the system. With the selected crop component improvements there has been substantial improvement in net farm returns to labor and capital inputs. Farm returns of all costs have become positive from its benchmark state of negative income. Because of the low costs and high financial gains associated with these innovations many of the farmers have started increasing the plant density of their paddy crop and growing dry season cowpeas.

Rice Sickle

During the course of second year OFAR trials it was observed that farmers preferred to harvest paddies when the crop was over ripened and fully lodged which not only caused loss of paddy through shattering, but also delayed the planting of dry season cowpeas. Farmers alleged that lodged paddy was easier to harvest and it saves their labor time. A paddy reaping experiment conducted with the farmers' unserrated sickle and the improved serrated sickle confirmed the farmers' opinion (Appendix 9). This experiment also revealed that before modern rice varieties (comparatively short and unlodging) are accepted for mass adoption, farmer sickles must also be improved. Although farmers preferred the serrated sickle (and a few rich farmers have acquired them from abroad), the village and town blacksmith lacked equipment to put on the serration.

Upland Based Systems

Only limited on-farm research was carried out in the upland based systems. It was conducted to generate more information on improved crop varieties for their ability to withstand attack by common insect pests and diseases and to test the suitability of introducing short season cowpea crop towards the end of the rainy season.

With the success of dry season cowpea, farmers' interest for main season cowpeas on upland fields has considerably been increased for a number of reasons. These were related to cost economies in the fixed operational cost of spraying equipment; reductions in the on-farm storage period and consequently less losses; and to improvement in the farmer cash flows. As stated before, the months of August/September for the upland based cropping systems were a period requiring relatively less labor input. Any crop enterprise which will successfully mature within the last two months of the rainy season was of interest to the farmers, particularly to those who practiced a cereals based system. Land is not a limiting factor of production. Short season cowpea varieties were tested under farmer conditions for the upland systems and found to produce a yield level between 700 - 1000kg/ha with a minimum spraying regime. Thus, for the main season, the cowpea enterprise has a benefit: cost ratio of at least 8:1 for the pest management coverage.

The failure of the maize trials emphasized the need for a striga resistant variety and/or effective cultural practices. Although the cassava trial was not harvested until the second year, observations suggested that several of the improved varieties were tolerant to cassava mosaic virus and cassava mealy bug. Since these improved varieties had been successful elsewhere in Nigeria, it was decided to set up cassava extension trials to assess the agronomic performance of the new variety under the care of the extension staff.

The success of the improved varieties of cowpea when sprayed in the on-farm trials proved that the crop was agronomically viable. Further work is needed to investigate the economic returns to this crop, especially considering the necessity for the farmer to buy an insecticide sprayer to control pests. In addition, cowpeas are traditionally grown in mixture with other crops, such as sorghum, whereas the cowpea screening trials were carried out with a sole crop. Therefore, further trials are planned to assess the agro-economic performance of cowpeas when intercropped with sorghum.

CONCLUSION

The experience of 2 years OFAR trials at BADP has shown that it is possible to quickly identify areas of improvement in the local farming systems and to successfully exploit them. The intervention of short season cowpeas as a dry season crop has proven so successful that demand for seed by farmers was far in excess of the Project's ability to supply it. In addition, many farmers now wish to re-introduce the crop into the main season as an upland crop. Farmers in the upland based systems are also showing interest in the crop, even though the 2 years of main season trials created little interest. This lack of interest was due to the unavailability of good quality seed and cost economies of spraying equipment over two crops a year.

Unless they stand to gain something, farmers are reluctant to offer their fields for trials that require significant changes in crop management. Their reluctance stems from the high cost of land and seedbed preparation and from the risk involved in making changes. However, farmer participation proved to be essential to the establishment and maintenance of research plots and for assessment of farmers' reactions to the proposed changes in crop management.

The OFAR program at BADP has shown the potential benefits of the farm level agro-economic data collected by the Project's Monitoring and Evaluation Unit. Without any extra efforts, the data was sufficient for delineating the important cropping systems and farmers' production practices. The data facilitated the diagnostic part of the OFAR program and provided insights for identifying opportunities for the agronomic experimentation. The Project's interest in OFAR approach enabled the research institutes to test their component technologies and helped the BADP by identifying those components which are suitable for farmer adoption. For example, the Project was able to offer the potential for improving the local farming systems through the introduction of short season cowpeas and serrated sickle. It was also able to exhibit to farmers located in good fadamas the value of increasing rice hill density. The Project identified the need for undertaking land development engineering work for the control of surface runoff and seepage water to enable a better utilization of stream flow on valley land.

The on-farm adaptive research program has been instrumental to the development of close contact and cooperation between the BADP's commercial, extension and research divisions. The contact point was the farmer, whose progress is the best measure of success for all these divisions.

The major impediment to success in the OFAR program has been staffing. Despite a training program run by the Project for its field staff, the level of technical knowledge and ability of staff remained low. Since many of the junior staff were from an urban back-ground, there was little understanding or appreciation of the traditional farming systems or why farmers carried out certain operations. An OFAR program such as that run at BADP is dependent on field research staff carrying out their work accurately and conscientiously. For the West African region as a whole, the lack of trained research staff capable of carrying out diagnostic farm survey and agronomic experimental work will be the major impediment to the expansion of an OFAR program.

REFERENCES

Kowal, J. M. and Knabe, D. T. 1972. An agroclimatological Atlas of the Northern Status of Nigeria with explanatory notes. Zaria, ABU.

BADP. 1983. Bida Agricultural Development Project Mid-term Implementation Report.

BADP. 1983. Field Records for Agronomic Details, Yields and Stands, Preliminary Report.

Ruthenburg, H. 1980. Farming Systems in the Tropics, 3rd ed Clarendon Press.

BADP, 1984 Mid-term Review BADP, September 1983.

Ashraf, M. 1983. A Background Paper on the Farming System On-Farm Adaptive Research at BADP.

Ashraf, M. and A. Jibrin, On-farm Rice Experimentation at Bida - Results for 1982.

IITA. 1983. Introducing a new component in a local farming system, Research Highlights.

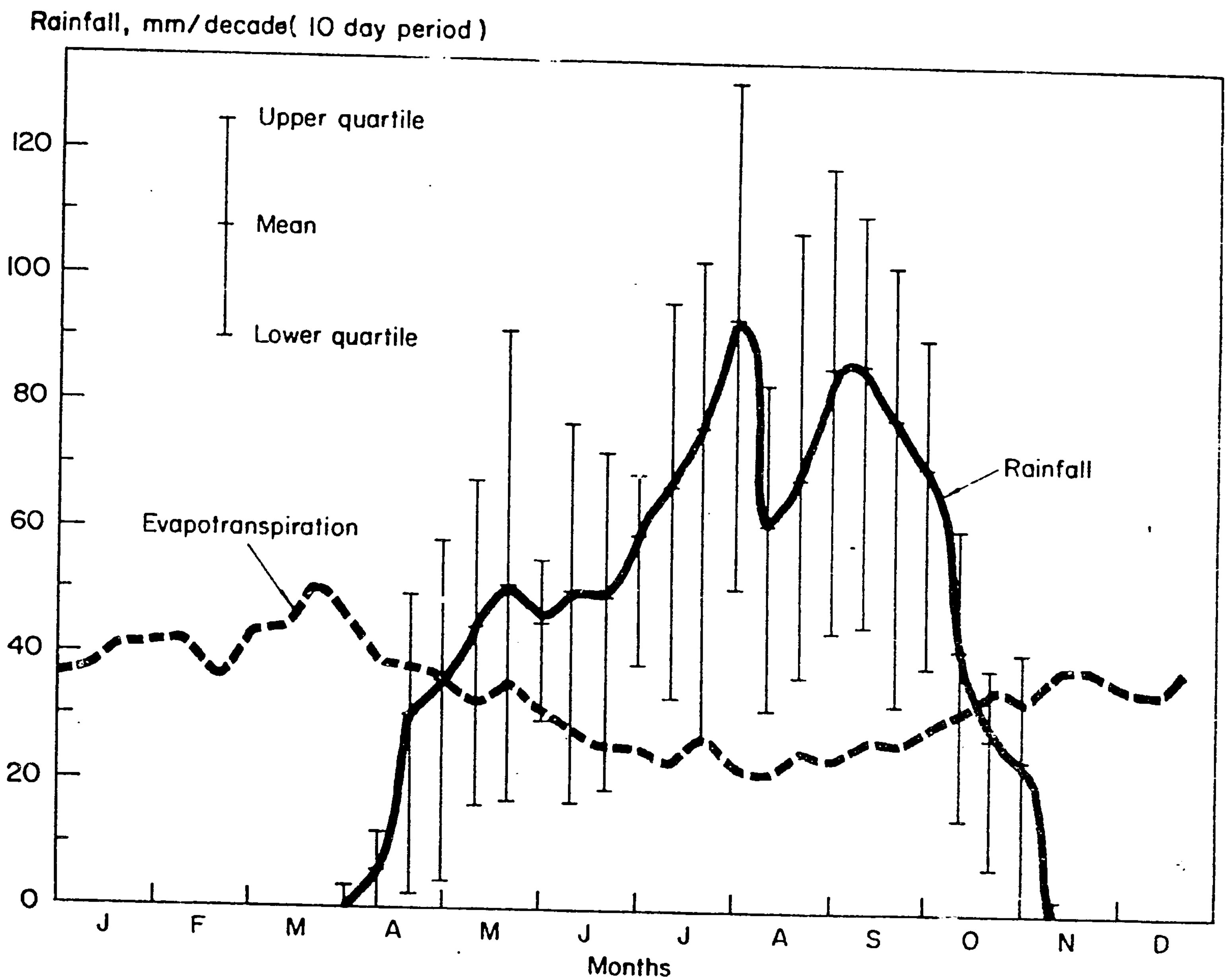

Fig. 1 Rainfall for 10-day periods (decade) at Bida, Nigeria (1961-83).

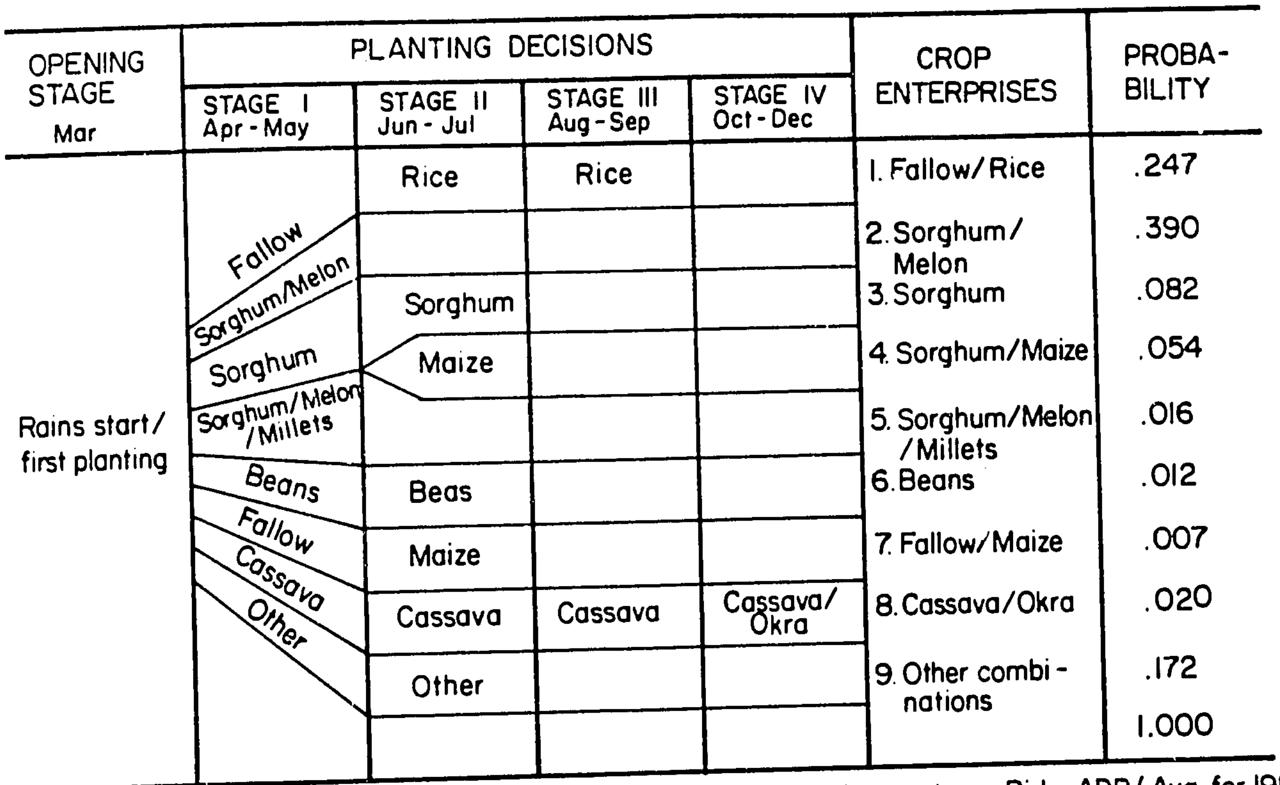

Fig. 2. Crop enterprise decision tree for the rice-based cropping system, Bida ADP (Avg. for 1982-83).

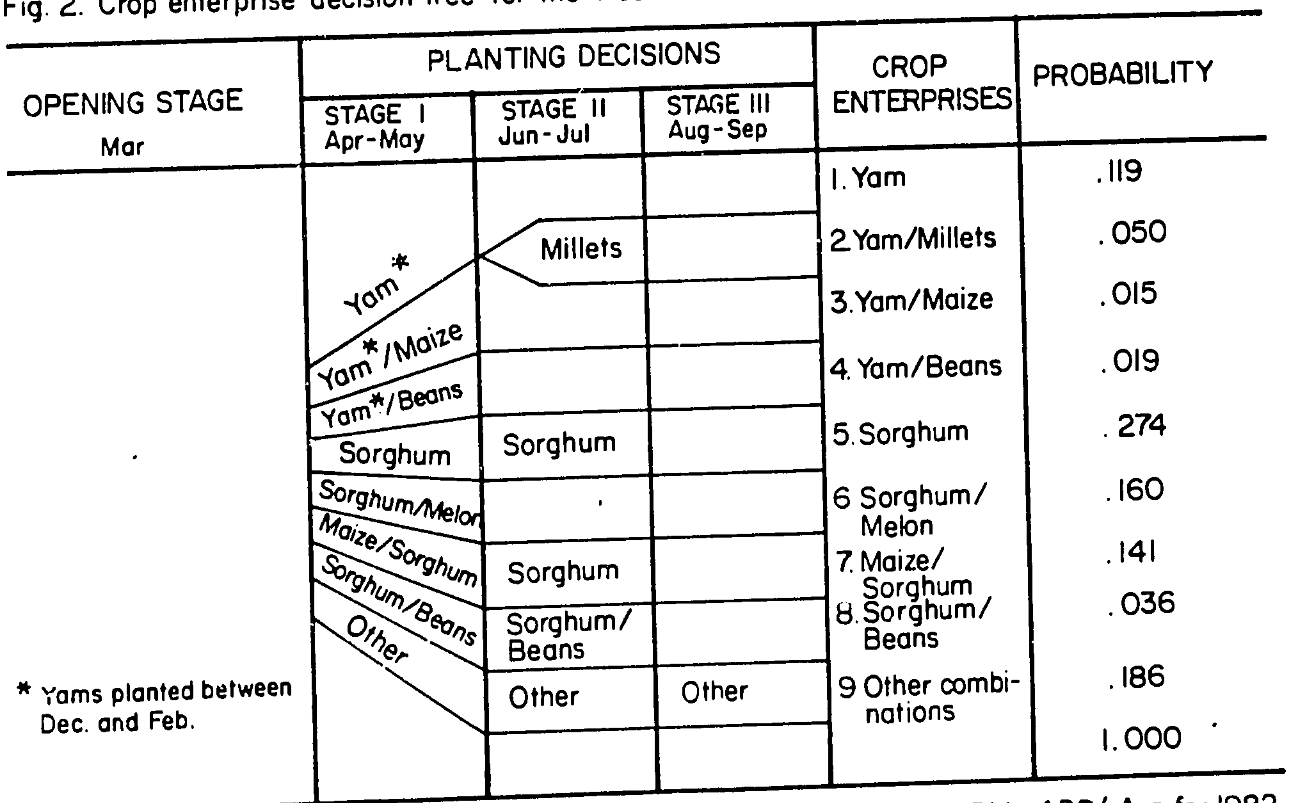

Fig. 3. Crop enterprise decision tree for the yam-based cropping system, Bida ADP (Avg. for 1982-83).

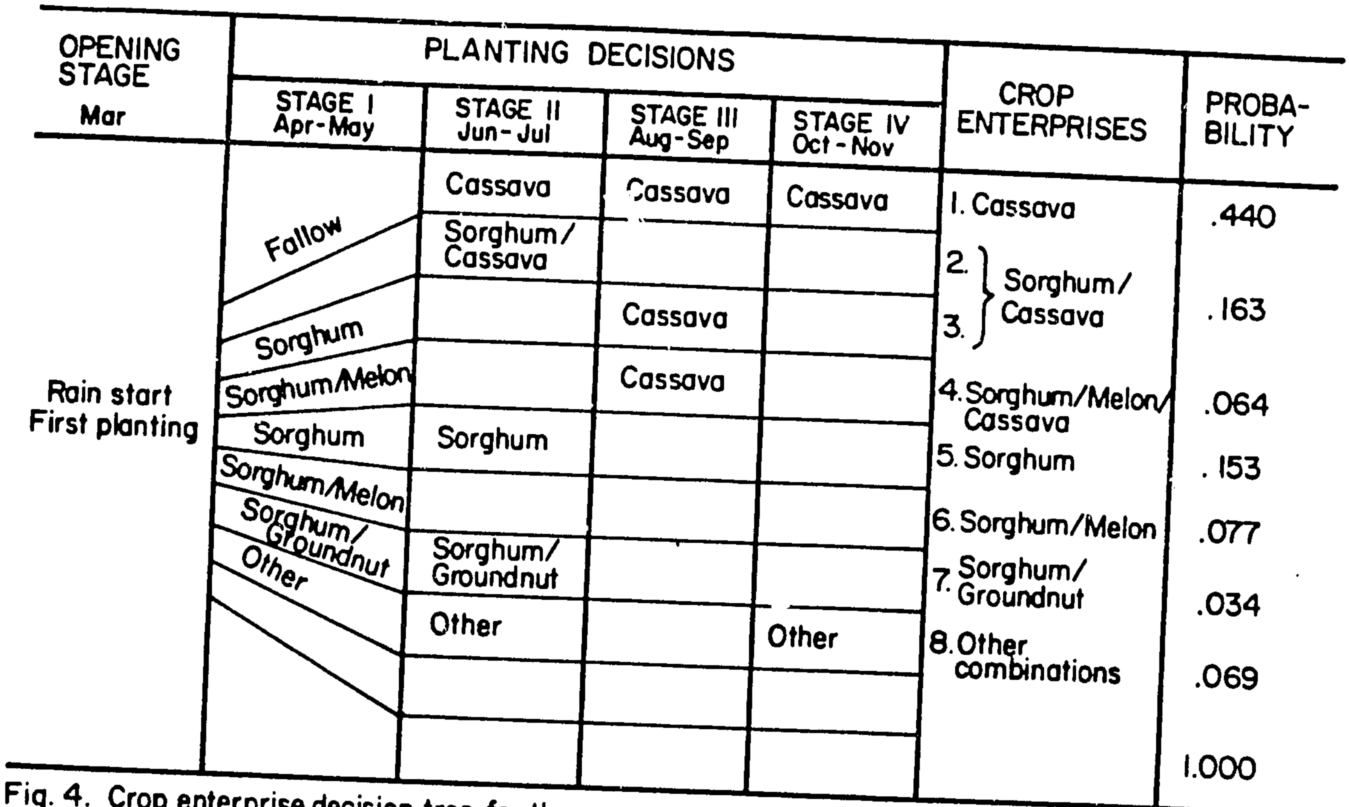

Fig. 4. Crop enterprise decision tree for the cassava-based cropping system, Bida ADP (Avg. for 1982-83).

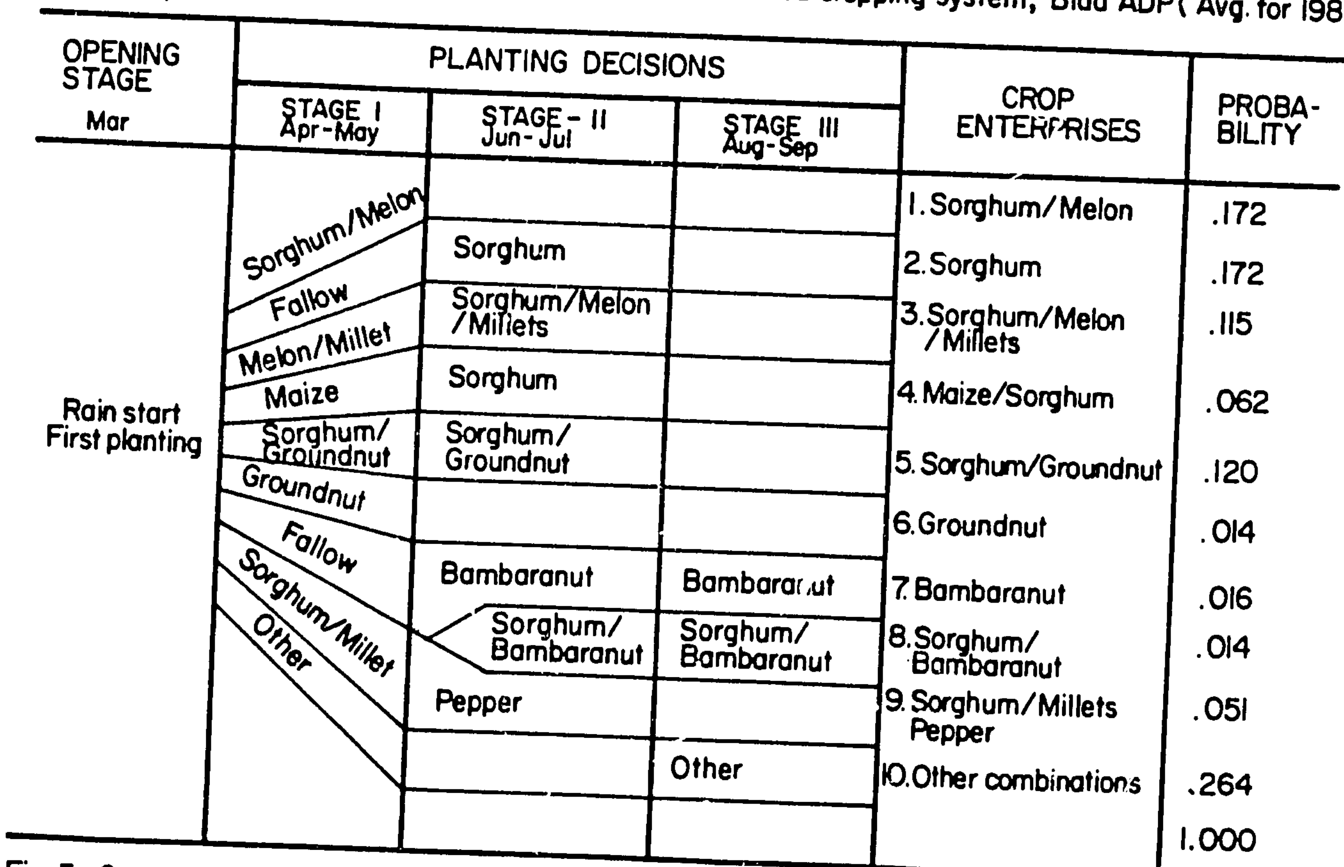

Fig. 5. Crop enterprise decision tree for the cereals-based cropping system, Bida ADP (Avg. for 1982-83.

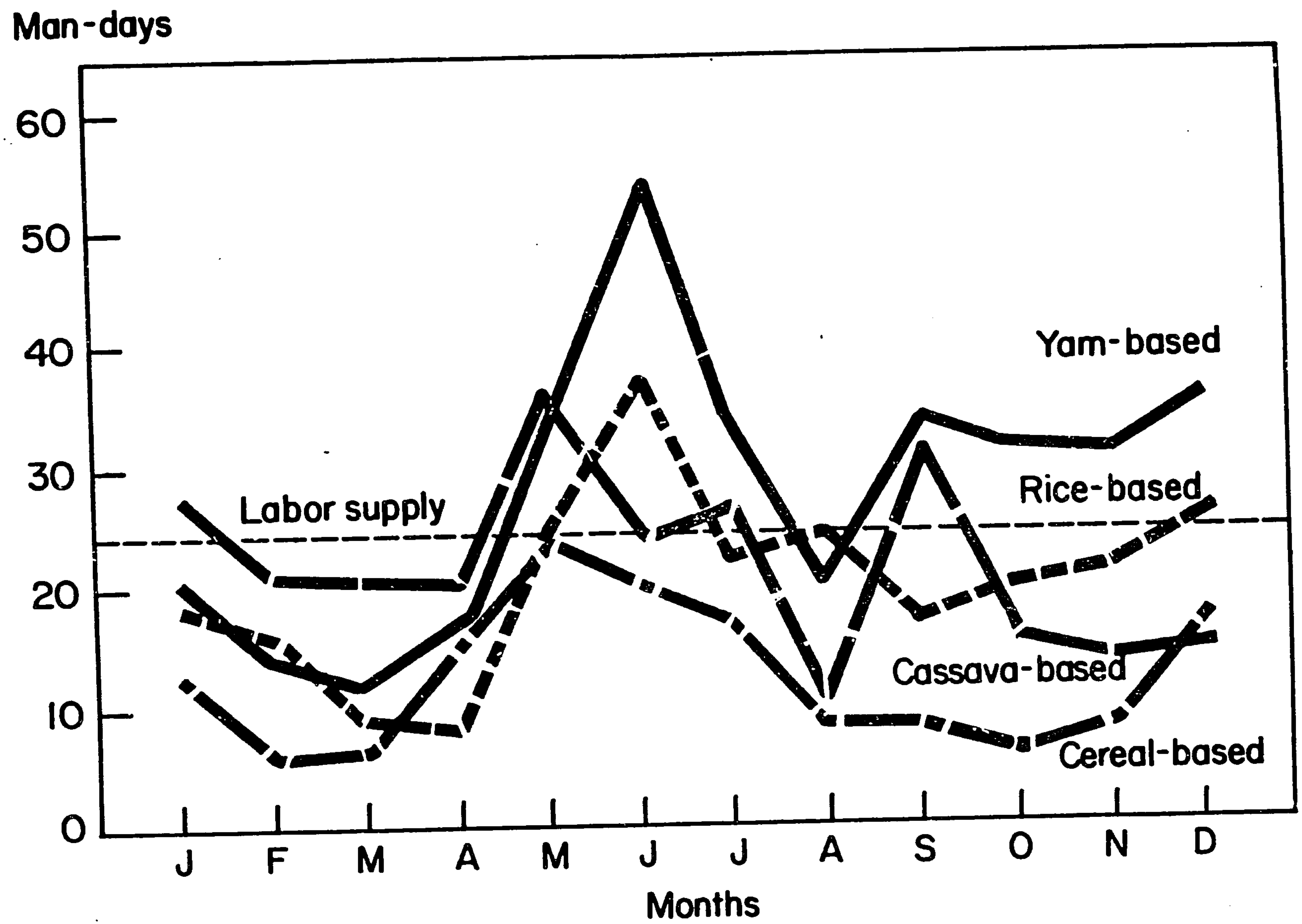

Fig. 6. Average household labor input (man-days) for agricultural activities in various cropping systems, Bida ADP, Nigeria 1983.

Appendix 1

PERCENT AREA GROWN TO DIFFERENT CROPS AND MIXTURES BY TARGET DOMAIN IN BIDA ADP, NIGERIA, 1982

Crop Enterprise	Cropping System Domain				
	Rice based	Yam based	Cassava based	Cereals based	Overall
Rice	25	*	-	3	7
Yam	9	12	-	4	8
Yam + Millets	-	5	-	-	2
Cassava	1	1	44	2	4
Sorghum	8	27	15	18	19
Egusi Melon	3	1	-	3	2
Sorghum + Melon	40	16	8	17	22
Sorghum + Maize	5	14	3	6	9
Sorghum + Millet	*	3	-	4	2
Sorghum + Cowpea	*	4	-	-	2
Sorghum + Groundnut	1	1	3	12	4
Sorghum + Millet + Melon	2	1	-	12	4
Cereals ± Others	1	8	-	3	5
Tubers ± Others	1	3	24	5	4
Others	4	4	3	11	6
Percent	100	100	100	100	100

* Denotes value less than 0.5 percent

Appendix 2

CROP YIELD RATES(Ton/Ha) BY TARGET DOMAIN IN BIDA ADP, NIGERIA 1982*

Crop	Rice based	Yam based	Cassava based	Cereals based	Overall
	Target Domain				
Rice	2.2	1.2	-	1.3	2.1
Yam	5.5	9.1	2.7	6.9	7.9
Cassava	2.2	3.9	6.6	1.6	5.4
Sorghum	1.3	1.2	1.1	0.9	1.1
Millets	0.5	0.8	-	0.9	0.8
Maize	1.4	1.1	1.2	0.5	1.0
Cowpeas	0.3	0.5	-	**	0.5
Groundnut	0.3	1.0	1.3	0.8	0.8
Bambaranut	-	0.6	-	0.5	0.5
Melon Seed	0.1	0.3	**	0.2	0.2

* Yield rates are average under various inter or mix cropping situation.

** Denotes value less than 0.1 ton/ha.

Appendix 3

PERCENT CROPPED AREA FAILED IN BIDA ADP, 1982

Crop	Target Domain				
	Rice based	Yam based	Cassava based	Cereals based	Overall
Yam	0	3	0	2	2
Cassava	43	0	2	15	8
Sorghum	4	1	3	5	3
Millets	0	*	-	2	2
Maize	0	6	0	20	10
Cowpeas	0	0	-	19	2
Groundnut	0	0	0	1	1
Egusi melon	6	3	0	2	4
Total	4	2	2	6	4

* Denotes value less than 0.5 percent.

Appendix 4

AVERAGE FARM COST AND INCOME BUDGETS FOR TARGET DOMAINS
IN BIDA ADP, NIGERIA, 1982

Item	Target Domains: Rice based	Yam based	Cassava based	Cereals based	Overall
1. Average Farm size (ha)	2.02	3.21	2.1	1.32	2.07
2. Total Labor input:					
Mandays	248	365	239	147	250
Cost 1/	1674	2464	1613	992	1686
3. Seed Cost ($)	153	285	66	86	147
4. Fertilizer input cost ($)2/	16	3	18	9	12
5. Farm tools annual cost ($)3/	92	79	79	77	82
6. Land rent ($)4/	27	43	28	18	29
7. Total farm cost ($)	1962	2874	1804	1182	1956
8. Total Farm Income ($)	1802	3842	2427	1053	2281
9. Net Farm Income ($)	-160	968	623	-129	326
MEASURES OF EFFICIENCY					
Return to Land ($/ha)	-66	315	310	-84	171
Return to Capital ($)	0.4	3.6	4.8	0.3	2.3
Return to Labor and Management $/man-day	'6.1	9.4	9.4	5.9	8.0

1/ Labor valued at the current wage rate of ₦5 (or $6.75)/man-day.

2/ Fertilizer cost is calculated at the subsidized price of ₦2 (or $2.70)/50kg bag of fertilizer.

3/ Cost based on a hand tool set of 2 large and 3 small hoes, 2 cutlasses, one axe, 3 sickles (rice system only), 3 baskets and 2-5 sacks. Annual cost of cash capital is charged at 25% interest rate.

4/ Land rent is assumed at ₦10 or $13.5)/ha.

Appendix 5

EFFECT OF CHANGING TILLAGE METHOD AND INCREASING RICE HILL DENSITY ON LABOR PRODUCTIVITY ON LOWLAND RICE PRODUCTION BIDA ADP, NIGERIA, 1982

Management Practices	Average yield kg/ha	Total Labor input man-day/ha	Total Revenue $/ha	Labor productivity kg/man day	Labor productivity $/man day
1. Farmer	2203	118	1190	19	10
2. High hill density (HD)	2552	129	1378	20	11
3. Flat cultivation (FC)	2683	112	1449	24	13
4. HD + FC	3003	122	1622	25	13

Appendix 6

AVERAGE YIELD/HA OF E-60 AND TVX3236 COWPEAS BY LOWLAND TYPE/TOPOGRAPHIC POSITION WITH 2 INSECTICIDE SPRAYINGS, BIDA, 1983/84

Lowland Type	E-60			TVX3236		
	Middle	Bottom	Average	Middle	Bottom	Average
a) Fadamas	571	620	578	707	536	669
b) River overflow	750	672	711	750	-	750
c) Floodplain	-	-	-	-	830	830
Overall	597	646	608	712	634	691

Appendix 7

ECONOMIC RETURNS FROM EXPLORATORY SHORT SEASON COWPEA TRIALS, BIDA

Cowpea Variety	Yield (kg/ha)	kg/ manday*	Total Crop Value ($/ha**)	Net benefits ($/ha+)	Benefit/cost Ratio
A. 1982/83					
E-60	945	14.5	1595	1470	12.8
E-77	545	8.4	920	795	7.4
B. 1983/84					
E-60	608	9.4	1026	901	8.2
TVX3236	691	10.6	1166	1041	9.3

* Based on 65 man-days/ha
** Based on net field price of N1.25/kg (N1.00 = US $1.35)
\+ Assuming total cash costs of $125/ha, cost of family labor not included.

Appendix 8

ESTIMATED GAINS OF FARM PRODUCTIVITY FOR THE RICE BASED CROPPING SYSTEM*

Item	Benchmark (1)	Traditional with: Improved rice management (2)	Dry Season Cowpeas** (3)	Both (4)
A. FARM COSTS - ($/HA)				
1. Labor	1674	1701	1775	1802
2. Capital	261	261	314	314
3. Land Rent	27	27	27	27
4. Total	1962	1989	2116	2143
B. FARM RETURNS - ($/ha)				
1. Gross	1802	2018	2263	2479
2. Net after land & capital	1514	1730	1775	2138
3. Net after labor & land rent	101	290	461	650
4. Net after labor & capital costs	-133	56	174	363
5. Net of all costs	-160	29	147	336
C. RETURNS PER UNIT OF:				
1. Land ($/ha)	-66	28	86	180
2. Capital ($)	0.4	1.1	1.5	2.1
3. Labor & Mgt. ($/man-day)	6.1	6.9	6.9	7.6

* Measured for an average farm size of 2.02 ha cropped land.

** Dry season labor cost for the slack farm period valued at 50% of the normal wage rate (6.75/man-day).

Appendix 9

RELATIVE EFFICIENCY OF DIFFERENT SICKLES MEASURED BY AREA REAPED IN 20 MINUTES

Condition of Paddy	Local sickle	Improved sickle	% Efficiency increament
A. Field Condition			
Wet	53.4	65.3	22
Dry	83.1	92.4	11
B. Lodging Rate			
Fully Lodged	74.1	76.5	3
Semi-Lodged	67.5	78.2	16
Erect	57.7	80.8	40
C. Overall	67.5	78.2	16

* Tests carried out with 30 farmers on their fields.