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1982 ANNUAL REPORT

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(Contract OAU/CSTR - Joint Project 31)

FARMING SYSTEMS RESEARCH UNIT IN UPPER VOLTA

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I. INTRODUCTION

A. Program Goals

The goals of the Farming System Unit (FSU) are:

1. To identify the principal constraints to increased food production;
2. To develop and implement a multi-disciplinary research method which can guide production technology and production research to directly address these production constraints;
3. To identify the elements of that method which can be implemented in a national farming systems research program, and,
4. To train Voltaic personnel to assume increasing responsibility in the continuation of this work.

B. Project Objectives of 1982.

To achieve these goals, FSU pursued the following working objectives during 1982:

1. To understand how farmers make key resource allocation decisions;
2. To assemble data with which to model farmers' resource use decisions, thereby facilitating the identification of production constraints and the evaluation of alternative production technologies;
3. To conduct on-farm agronomic trials which directly investigate most apparent obstacles to increasing cereals' production;
4. To use socio-economic and agronomic findings to evaluate the results of on-farm trials; and,
5. To use socio-economic and agronomic data to guide the selection and design of future trials.

C. Research Activities of 1982.

To achieve these objectives, the following activities were conducted during 1982:

1. Village selection: Project resources permitted the FSU team to conduct work in three villages using sample sizes adequate to derive statistically useful research findings. The criteria for selecting the villages were that they represent:
   a. distinct agroclimatic zones; and
   b. represent a complete range of tillage practices.

Using these criteria, FSU selected the villages of Bangasse, Diapangou, and Nedogo. Bangasse is 110 km northeast of Ouaga and Nedogo is 30 km northwest of Ouagadougou. Both are on the densely populated Central Plateau. Average annual rainfall ranges from 400 to 500 mm in Bangasse and from 700 to 800 mm in Nedogo. Bangasse has very little animal traction whereas about half of the farmers in Nedogo use donkey traction. Diapangou, 210 km east of Ouaga, typically receives the same rainfall as does Nedogo. Land is relatively abundant and shifting cultivation is practiced. Diapangou has a complete range of tillage practices. Both donkey and oxen traction are common and traditional. Nonetheless, hand tillage remains.

2. Sample selection: In each village, control and laboratory samples were drawn.

A census of each village was taken. The census data included ethnic background, family size, number of active workers and years of experience with animal traction. Random samples of 30 laboratory households in each village and of 30 control households in Bangasse and Nedogo were drawn. Sixty households were drawn for the control group in Diapangou. This was done to insure at least 20 sample households with donkey traction and 20 with oxen traction. Both control and laboratory samples were stratified by donkey traction and traditional tillage in Nedogo.

A survey of each household in the sample was taken. This provided a detailed household resource base including household size, age and sex of members, animal traction equipment, the number of active workers, and other variables.

3. Collection of agricultural input data: For 30 households in Bangasse, 60 in Diapangou, and 60 in Nedogo, interviewers collected data on the number of hours worked, by person, by crop, by field, and by agricultural activity. Labor hours for animals, fertilizer application, seed usage and other input data were also taken. From field preparation until harvest, these interviews were conducted twice weekly using "Fiche 11." (Appendix A)

This data was taken for all cereal fields and for at least one field of every other crop in all control households. The same data were taken for the farmer-managed field trials in the laboratory households. This data was aggregated in the village by FSU controllers, whose duty it was to sum input data for each week for the interviewers' coded forms and to enter it on "Fiche 12." (Appendix B). Data on these forms were recorded on discs for processing by microcomputer.

4. Agronomic trials: Two types of agronomic trials were conducted. The first type, farmer-managed trials, conducted by the farmer at the direction of the FSU agronomic assistants, were placed in the major millet field of each laboratory household. The other type, researcher-managed trials, were conducted on much smaller plots by the agronomic assistants. These trials are explained in greater detail in the analysis of agronomic trials.

5. Interviews on farmers' decision-making: In each village, at least 30 farmers were interviewed (Appendix C) to determine goals and objectives from the farmer's perspective, and to identify factors he considers in making his key resource-use decisions and to identify his production constraints.

6. Collection of acreage and yield data: Near the end of the cropping season, the surface area of all fields in the control sample households were measured and, at harvest, yields were weighed for each. Threshing percentages for grain were based on ten kilogram samples from each field. These percentages were applied to the gross yield from each field. These data were recorded on "Fiche 04." (Appendix D)

II. THE FARMING SYSTEMS

The ultimate goal of this project is to implement a national FSR program which can guide or shape production technology and component research. Achievement of this goal presumes an understanding of the existing farming systems for which such a research program would be implemented. The activities listed in the introduction were designed to achieve this understanding. Two kinds of information were used in this effort. First, questions were asked of farmers to determine their goals, those factors affecting their resource allocation decisions, and their perceptions of production constraints. Often the farmers' assertions require empirical testing of measurement. Thus, objective measurement of how farmers use their resources is also used extensively to complete the description of the farming systems in the FSU villages.

A. Farmers' Goals and Objectives.

One aim of the on-farm decision-making questionnaire was to determine whether farmers could identify long-term goals for their farms and/or specific, instrumental objectives they wished to achieve during a given crop year. It was assumed, for example, that the farmer might be able to identify investments he wished to make or consumption goods he wished to acquire assuming a specific level of grain production, adequate stocks for consumption, and a margin of risk.

In fact, the farmers of Bangasse and Nedogo indicated uniformly that their only concern was "subsistence." In general terms, this means harvesting enough sorghum and millet in November to feed their families until corn can be harvested in late August and consumed during the "hungry season" prior to the current year's grain harvest.

Repeatedly pushed to specify other goals or objectives, the farmers would reiterate their concern with "survival." They would then say that they must pay the head tax and, if resources remain, meet "urgent (mainly medical) needs," reward their families with clothes for their work during the cropping season, "greet" their in-laws, or arrange marriages for themselves or their sons.

In Diapangou, half of the farmers echoed the subsistence orientation of the farmers of Bangasse and Nedogo, but others related notably different aspirations. "We were once concerned only with 'survival'", they said, "now we think of accumulating wealth." Asked, "what is wealth?", they replied, "cattle."

The farmer's account of his marketing pattern is consistent with his orientation to subsistence. As Table 1 shows, by total weight, less than 10% of available sorghum and millet were sold by farmers during the 1981-82 season. Peanuts, planted mainly to pay taxes, were almost all sold.

Table 1: Crops Sold by Household Heads, 1981-82, Percent of Available Supply.[a]

	DIAPANGOU	BANGASSE	NEDOGO
White Sorghum	8.9	3.5	13.4
Millet	4.0	1.0	7.7
Peanuts	69.7	72.5	58.4
Red Sorghum	—	—	27.4
Rice	—	33.3	—
SAMPLE SIZE	32	34	28

[a]Crops harvested plus storage at harvest

Table 2 reflects a disproportionate share of sales in the two month period immediately following harvest. In percentage terms, peanuts are the principal crop sold during this period. The farmer strongly resists selling sorghum and millet unless there is an urgent need which can be met in no other way. By volume, however, millet or sorghum are the major sources of crop revenue in Nedogo and Diapangou.

Once post-harvest expenses are paid, only emergency sales are made until the next grain harvest approaches. If the farmer sees that his stock is adequate and that his harvest will meet next year's consumption requirements, he may buy livestock (goats, sheep, or preferably, cattle). The typical farmer acquires livestock not to

accumulate a herd, but to spread interseasonal risk, using animals as a store of value received from years with yields above subsistence levels towards years of production shortfall.

Table 2: Crops Sold During the First Two Months after Harvest, Mean Percent of All Crops Sold by Household Heads, 1981-82.

	DIAPANGOU	BANGASSE	NEDOGO
White Sorghum	33.3	25.5	32.0
Millet	57.7	46.7	22.2
Peanuts	79.8	60.0	45.2
Red Sorghum	——	——	50.0
Rice	——	53.1	——
SAMPLE SIZE	32	34	28

Table 3 reflects heavy reliance on livestock as a source of livelihood during bad years. During the 1972-81 period, livestock sales were easily the principal source of revenue for grain purchases in all three villages.

Table 3: Sources of Revenue Used by Household Heads to Buy Grain, 1972-81.

	DIAPANDOU		BANGASSE		NEDOGO	
	number	percent	number	percent	number	percent
Livestock Sales	14	60.9	21	72.4	16	80.0
Trades, crafts	3	13.0	3	10.3	—	——
Other	6	26.1	5	17.3	4	20.0
Total Buyers	23	100.0	29	100.0	20	100.0
SAMPLE SIZE	32		34		28	

The use of livestock as a risk-spreading mechanism reinforces the subsistence position of the farmer. When sold to buy livestock, the price of grain is approaching the seasonal low. Since many farmers purchase livestock at that time, livestock prices are relatively high. In a bad year for grain yield, much livestock is sold, therefore, the price goes down. These relatively low returns are used to buy grain which at that point has again become relatively expensive.

A successful farmer can store enough grain to avoid selling animals when he experiences a bad year. The animals multiply and he maintains a store of wealth. Such farmers exist in Bangasse and Nedogo, but are much more common in Diapangou. As livestock is accumulated, it becomes a source of capital to support the farmer in small business, grain trading, skilled trades, or other activities demanding capital investments.

Also characteristic of the subsistence farmer is his claim that, at least for family fields, he does not consider current market price in making cropping or marketing decisions. Only one farmer in Nedogo and five in Bangasse said that price was a consideration in planting or time of sale. Farmers often found the question funny and laughed out loud. "I sell only when I have an urgent need for cash," they said. Asked if it made sense to sell when the price was high in anticipation of cash needs, they said, "No, money doesn't store well." Importantly, the farmers' attitudes toward price is not based on ignorance of price movements. Asked what they would do with 10,000 CFA, 13 of 60 farmers in Bangasse and Nedogo said they would buy grain when the price was down and sell it later when price was high.

While the farmers of Bangasse and Nedogo tended to say that price did not affect their production or marketing behavior, 15 of 32 farmers in Diapangou (those who said they were no longer subsistence farmers) said that price was definitely a consideration with respect to peanut plantings. They indicated that if they had planted enough grain to meet consumption needs, a "good" price for peanuts would definitely encourage them to plant more.

B. Factors Affecting the Cropping Decision.

Asked whether price affects his decision regarding what to plant, the farmers' most common response was "the land tells me what to plant." During the personal interviews, farmers repeatedly made it clear that land quality is the dominant factor in their cropping decisions. While factors such as risk or labor availability determine the extent of plantings, land quality is always the basic consideration.

Corn and rice plantings are fixed by the farmer's land resource. Corn is planted only in the compound field where night-soil and animal manure are deposited. Rice is planted only in bottom land. Cowpeas are subject to serious insect infestation if planted in close proximity or if planted repeatedly on the same field. They are rarely planted as a sole-stand crop. They are almost always planted in relatively fixed association with millet or sorghum.

For all but the market-oriented farmers of Diapangou, and for all but a few in Bangasse and Nedogo, peanuts and other cash crops are planted only to meet specific post-harvest cash requirements. Farmers say that they don't plant more peanuts because, "Peanuts are not for food. If I produce more they would have to be sold to buy millet" or "Peanuts must be planted when I'm weeding my millet and the millet is more important."

The farmer's major cropping decision is that of how much white sorghum and how much millet to plant. Farmers offer a clear and consistent account of the actors considered in this decision. In fact, farmers' responses to open-ended questions about why they did not plant more of each crop were so consistent that they were readily coded. Their responses are summarized in Table 4.

Table 4: Farmers' Reasons for Not Planting More of Their Principal Cereal and Cash Crops (% of Responses), 1982.

	BANGASSE			DIAPANGOU			NEDOGO			TOTAL		
	MILLET	SORGHUM	PEANUTS	MILLET	SORGHUM	PEANUTS	MILLET	SORGHUM	PEANUTS	MILLET	SORGHUM	PEANUTS
Land is Not Appropriate		70		26	74			56		9	67	
Crop is Too Risky (Rainfall, Disease)		30			23			33			29	
Labor is Not Sufficient	91		33	61		10	52		15	69		20
Crop Competes with Cereals			48			61			41			51
Other of No Response	9		19	13	3	29	48	11	44	22	4	29
SAMPLE SIZE		33			31			27			91	

White sorghum and millet are the dominant cereals for all three zones. Farmers consistently say that white sorghum is highly valued because it can be stored twice as long (3-4 years) as millet (1-2 years). Under desirable soil and rain conditions, it yields more grain and flour than millet. But white sorghum requires better land and more consistent rainfall than does millet. Further, white sorghum is more vulnerable to parasites (striga) and other diseases than is millet. Thus, white sorghum is viewed as a highly desirable grain but a very risky crop.

In comparison to white sorghum, millet is drought and diesease resistant. If rains do not come early enough to plant sorghum, millet may be planted instead. In the worst of years, farmers say that some millet can always be harvested. Millet can be planted later and on less fertile land; therefore, on the Central Plateau, it is planted

more than is sorghum. Because soil quality continues to deteriorate, millet accounts for an increasing share of cereal acreage.

Given the choice of short-time security offered by millet (stable storage) and the long-term security offered by sorghum (durability in storage), the farmer balances his preference for short- and long-term risk. Because he has limited "sorghum land," he plants more millet relative to sorghum than he actually desires. He plants as much sorghum as he can given his labor force and remaining land.

The use of land by crop is strikingly similar in the three villages. As Table 5 shows, the area is devoted to cereal crops ranges from 91.8 percent in Diapangou to 94.19 percent in Nedogo. In Diapangou, where farmers are more market-oriented, slightly more land is devoted to cash crops, but land use or cash crops may be understated in Nedogo since red sorghum, 27.4 percent of which was sold between harvest, 1981, and harvest, 1982, is used in part as a cash crop.

Table 5: Allocation of Land by Primary Crop, 1982-83.

CROPS:	BANGASSE Has.	BANGASSE Percent	DIAPANGOU Has.	DIAPANGOU Percent	NEDOGO Has.	NEDOGO Percent
Red Sorghum	—	—	—	—	39.67	9.98
White Sorghum	51.46	26.17	26.51	6.6	70.65	17.77
Millet	108.76	55.31	62.50	15.5	253.17	63.68
Associations[a]	15.77	8.02	264.03	65.3	0.31	0.07
Corn	3.36	1.71	12.77	3.2	9.37	2.36
Rice	2.91	1.48	4.73	1.2	1.31	0.33
TOTAL CEREAL	182.26	92.69	370.54	91.8	374.48	94.19
Peanuts	10.94	5.56	18.58	4.6	19.49	4.90
Bambara Nuts	2.34	1.19	2.33	0.6	2.66	0.67
Cotton	0.22	0.11	0.04	0.0	0.10	0.02
Soybeans	—	—	6.49	1.6	000	000
Cowpeas	—	—	5.27	1.3	0.10	0.02
TOTAL CASH	13.50	6.86	32.71	8.1	19.59	4.92
TOTAL OTHER	0.88	0.45	0.96	0.2	0.71	0.15
TOTAL HECTARES	196.64	100.00	404.21	100.1	397.54	99.95

[a]75-90% millet, remainder sorghum

The data permit us to conduct empirical tests of the farmers' stated cropping decision rules. Below, simple linear regression analysis is used to determine the relationship between hectares planted and key explanatory variables.

Regression analyses reported on Table 6A indicate that in all three villages, more than 41 percent of the variation in millet area planted is explained by variation in the households' supplies of active labor. All coefficients are statistically significant from zero at the .01 level. These findings fit perfectly with the farmers'

explanation of why they don't plant more millet. According to these data, each additional active worker permits the farmer to add from 0.6 to 0.7 hectares of millet production.

Table 6A: MILLET Hectares Regressed on Total Active Workers, by Household, 1982-83.

	CONSTANT	COEFFICIENT	r^2	n
BANGASSE	-0.18	.601 (4.161)	.412	29
DIAPANGOU	0.758	.762 (6.338)	.428	59
NEDOGO	0.608	.615 (6.683)	.444	60

Farmers said that their sorghum planting was strictly limited by the quality of their land. Because our data on soil quality do not permit, we cannot provide a direct test of the relationship between soil quality and sorghum plantings. But the analysis presented in Table 6B, where sorghum plantings are regressed on active labor, provides a striking contrast to the same analysis when applied to millet. These data show that the amount of variation in sorghum plantings explained by available labor is very low. While the coefficients are significant, these are about one-fourth the magnitude of the same coefficients for millet.

Table 6B: SORGHUM Hectares Regressed on Total Active Workers, by Household, 1982-83.

	CONSTANT	COEFFICIENT	r^2	n
BANGASSE	1.147	0.085 (1.190)	.083	29
DIAPANGOU	0.787	0.029 (0.349)	.042	27
NEDOGO	0.457	0.164 (2.782)	.141	

While not a direct test of factors explaining sorghum plantings, this analysis points to soil quality and rainfall, the only other inputs as factors determining sorghum acreage. As such, this finding too is consistent with the farmers' accounts of their land use decisions.

Corn area, as well, is largely explained by family size, the varisble which most directly affects soil fertility around the compound. Table 6C shows that in Bangasse and Nedogo, where corn is virtually always planted around the compound, 48 and 40 percent, respectively, of the variation in corn plantings is attributable to family size. The coefficients are both significant at the .01 level. In Diapangou, where the explanatory power of family size is lower, several Fulani farmers plant corn on land away from the compound where their cattle are pastured. Nevertheless, family size still explains 18 percent of the variation in area planted, and its coefficient is significant at the .01 level of confidence.

Table 6C: CORN Hectares Regressed on Total Family Size by Household, 1982-83.

	CONSTANT	COEFFICIENT	r^2	n
BANGASSE	0.004	0.008 (4.901)	.489	29
DIAPANGOU	0.076	0.012 (3.352)	.182	58
NEDOGO	-0.005	0.017 (6.098)	.405	59

Non-cereal crop plantings, meaning peanuts in Bangasse and Nedogo, and including soybeans and cowpeas at Diapangou, are not readily explained by our analysis. The analyses presented in Table 6D were conducted to test the hypothesis that cash crop plantings per worker are determined by the total of staple crop hectares per worker. While in every case, the coefficients are significant at the .05 level of confidence, the explanatory power of each regression varies greatly

(from 7 percent in Diapangou to 46 percent in Bangasse). This may be because for some, cereals are cash crops. Considerably more analysis is required to explain cash cropping patterns. This is a key element in the 1983 research program.

Table 6D: NON-CEREAL CROP Hectares Per Active Worker Regressed on Cereal Crop Hectares per Active Worker, by Household, 1982-83.

	CONSTANT	COEFFICIENT	r^2	n
BANGASSE	-0.062	0.191 (4.625)	.461	29
DIAPANGOU	0.066	0.034 (1.785)	.07	58
NEDOGO	0.020	0.055 (3.605)	.197	60

Farmers' preference for sorghum is due, in part, to their claim that sorghum stores longer than millet. Farmers' storage practices are consistent with this claim. The disposition of grain during 1981-82 were developed for each farmer participating in the decision-making interviews. These data made it possible to compare sorghum and millet in storage as a percent of the volume available at the prior harvest. In Table 7 are the results of paired t-tests comparing the percentage of originally available sorghum in storage, as harvest approached, to the percentage of originally available millet in storage at the same time. These tests yielded highly significant results in Bangasse and Nedogo, but the values were nearly identical (and non-significant) in Diapangou. They document the tendency to keep sorghum longer and to consume millet first.

Table 7: Preharvest 1982 Storage of Millet and Sorghum as a Share of Millet and Sorghum Available by Household at Harvest, 1981.

	MILLET	SORGHUM	RESULTS OF PAIRED T-TEST[a]	n
BANGASSE	.02	.11	.002	21
DIAPANGOU	.18	.16	.115	24
NEDOGO	.08	.19	.01	19

[a]Probability that samples come from the same population.

Farmers consistently point to production risk as a reason for not planting more sorghum. Farmers also said that they did not plant peanuts because this required that labor be taken from millet which was more important. Our yield data from 1982 indicate that the mean yields of sorghum and peanuts would provide farmers with more revenue per hectare than millet and, in planting those crops, the farmer would (if he achieved expected yields) be able to sell those crops and buy more millet than he could produce himself. But yield variance comparisons for both of these crops indicate that a significantly greater risk is associated with the production of sorghum and peanuts than that associated with millet.

Table 8 presents the ratios[1] of sorghum and peanut yield variance to millet yield variance. These ratios have an F-distribution and constitute F statistics. As the table indicates, with one exception, F-tests applied to the yield data show significantly greater variance at the .05 level for sorghum and peanuts than for millet. The farmers' reticence to plant these otherwise higher yielding crops suggests that the risk is too great to compensate for the higher expected revenues associated with these

[1]Ratio of one variance to another has F-Distribution. Taro Yamene, Statistics: An Introductory Analysis, Harper and Row Publ., 2nd Edition: New York, 1969.

crops. It also argues for more intensive study of the risk preferences of subsistence farmers. Risk considerations are a key factor in the farmer's decision to adopt, or even to try, alternative technologies which may be suggested by researchers.

Table 8: Yield Variability: F-Tests Comparing Yield Variations for Millet, Sorghum and Millet, and Peanuts, 1982-83.

	BANGASSE	DIAPANGOU	NEDOGO
SORGHUM/MILLET	2.007[a]	2.234[a]	5.279[b]
PEANUTS/MILLET	1.499	2.388[b]	6.756[b]
SORGHUM/ASSOCIATION[c]	—	3.447[b]	—
PEANUTS/ASSOCIATION	—	3.684[b]	—

[a]F-test for difference in variance is statistically significant at the .05 level of confidence.

[b]F-test significant at the .01 level.

[c]Millet/Sorghum Association with 70-90% millet.

C. Production Constraints.

The availability and use of land, labor, and capital were measured in all three villages throughout the season. During the decision-making interviews, farmers were also asked to identify their production constraints. Both the farmers' perceptions and empirical analysis support the following conclusions. In terms of surface area, land is not a binding production constraint, but the land quality, mainly in Bangasse and Nedogo is limiting. This leads farmers to say that labor is their binding constraint. This is true in the sense that farmers must farm relatively poor land extensively in these zones if they are to produce adequate grain for consumption. The most promising form of capital investment, animal traction, is (in Bangasse and Nedogo) a direct substitute for labor. In Diapangou, it

facilitates intensification of production. Whether the capital required to acquire animal traction is binding cannot be concluded on the basis of this year's research. Thus, access to credit is a logical theme for research during 1983.

1. The land resource: In Diapangou, farmers have relatively easy access to new land. Sorghum is generally planted for the first two years after a new field is opened. This is typically followed by millet or a millet/sorghum association for three to four years, after which the land is fallowed and new land is opened.

In Bangasse and Nedogo, there is limited access to new land, but farmers rarely say that the lack of land limits production. They repeatedly say that soil fertility limits production. This is readily understood. Virtually all land in these villages has been cultivated continuously for at least ten years. Many fields have been planted without fallowing for as long as the farmer can remember. Soil quality is clearly deteriorating and substantial investment in fertilizer would be required to reverse this trend.

Fallowing, an alternative to costly expenditures for fertilizer, is practiced on a very limited scale. Farmers are concerned that they will lose their land to others in need if nothing is planted and, for those farmers operating on the edge of subsistence, short-term losses of production through fallowing is a more imposing consideration than the appeal of long-term gains in soil fertility.

Land and labor to resident ratios are presented in Table 9. These data, particularly when one compares Diapangou to Nedogo, are consistent with farmers' claims that quality, not quantity of land, is the limiting resource. In Nedogo, there are more hectares per worker and per resident than in Diapangou, where land is relatively accessible. In Bangasse, there is less land per worker and per resident than in Diapangou or Nedogo. But farmers in Bangasse also said that labor was their limiting resource. Animal traction is far less common in Bangasse (7 of 30 households) than in Nedogo (36 of 60 households). Thus, the farmers of Bangasse are limited in their capacities to expand area cultivated.

Table 9: Area Cultivated Per Active Worker, Per Resident, 1982.

	Hectares CULTIVATED	Hectares/ RESIDENT	Hectares/ ACTIVE WORKER
BANGASSE	196.64	.463	.855
DIAPANGOU	404.21	.595	1.039
NEDOGO	397.54	.706	1.133

The relationship of area cultivated and active workers is developed further in Table 10. Regressions of total area cultivated on active workers indicate that from 30 to 70 percent of variation in cultivated area is explained by variation in the number of farmers' active workers.

Table 10: Total Hectares Cultivated Regressed on Labor, Traditional and Animal Traction Households, 1982-83.

	CONSTANT	MALE WORKERS	FEMALE WORKERS	CHILD WORKERS	R^2	n
TRADITIONAL						
Bangasse	2.230	0.249 (0.571)	0.856 (2.708)[a]	0.137 (0.253)	.404	20
Diapangou	0.888	-1.681 (0.497)	1.397 (0.792)	2.845 (1.670)	.349	11
Nedogo	0.645	0.423 (1.176)	1.062 (3.027)[b]	1.145 (2.201)[b]	.612	24
DONKEY TRACTION						
Bangasse	4.975	-0.991 (1.406)	1.838 (3.550)[b]	-1.092 (1.392)	.705	9
Diapangou	-0.371	0.824 (0.983)	1.618 (3.985)[b]	1.012 (1.757)[a]	.582	21
Nedogo	3.691	0.134 (0.272)	1.238 (3.490)[b]	0.289 (0.705)	.296	36
OXEN TRACTION						
Diapangou	0.405	1.005	1.325	0.513	.616	27

[a]Statistically significant difference from 0 at the .05 level.

[b]Statistically significant difference from 0 at the .01 level.

Female labor is only variable for which the coefficient always has the appropriate sign. Also, it is significantly different from zero in all but one case. Male labor has a significant coefficient only in Diapangou. In general, this variable probably explains very little variation because the number of active males per household is fairly constant across households. And, since the number of men is always at least one, some of it's explanatory power remains in the intercept term.

2. The labor constraint: Farmers were asked whether labor was a binding production constraint; and, if so, during which period. The farmer was also asked whether he had hired labor and during what period. As Table 11 indicates, from 73 percent of the farmers in Bangasse to 100 precent in Diapangou said that labor was a binding production constraint. Of these, 67 percent said that first weeding was the most critical period. Second weeding (15.2 percent) and planting (6.3 percent) were mentioned as well. Some farmers (no clear response) could not say whether planting or weeding was the most critical period.

Of 79 farmers saying that labor was a binding constraint, 33 (41.8 percent) said they had hired labor. Of these 23 (70 percent) were in Diapangou. Even though first weeding was said to be the most critical period, 18 of 33 farmers who hired had done so at the second weeding. Asked "why not at the first weeding?", the farmers invariably said "because there's no one to hire then -- everyone is busy with their own weeding."

Table 11: Farmers' Accounts of Labor Supply as an Obstacle to Increased Production. (Parenthesis indicates number having hired labor at least once.)

	BANGASSE		DIAPANGOU		NEDOGO		TOTAL	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
LABOR IS A BINDING CONSTRAINT	24 (6)	100.0	31 (23)	100.0	24 (4)	100.0	79 (33)	100.0
PERIOD: During:								
Land Preparation	0 (1)	0.0	1 (1)	3.2	1	4.2	2 (2)	2.5
Planting	2	8.3	0 (1)	0.0	3	12.5	5 (1)	6.3
First Weeding	21 (2)	87.5	20 (5)	64.5	12 (1)	50.0	53 (8)	67.1
Second Weeding	0 (3)	0.0	8 (12)	25.8	4 (3)	16.7	12 (18)	15.2
Third Weeding/ Harvest	0	0.0	1 (4)	3.2	0		1 (4)	1.3
NO RESPONSE/ OTHER	1	4.2	1	3.2	4	16.7	6	7.6
LAND IS THE BINDING CONSTRAINT	9	100.0	0	99.9	3	100.1	12	100.0

Empirical observations of mean labor times per hectare by agricultural activity (see Table 12) shows data consistent with the farmers' claims. For millet and white sorghum, first weeding is always the most time-consuming activity. It is generally followed by second weeding and then, very closely, by planting. A more detailed evaluation of labor utilization shows that both the first and second weeding peaks for sorghum precede those of millet by one or two weeks. This is because sorghum is planted in better soil, because weeds grow better there and because sorghum is less drought-resistent than is millet and competes less successfully with weeds.

Table 12: Weighted Yields per Hectare and Weighted Laobr Hours per Hectare for Major Agricultural Activities and Key Crops, 1982.[a] (Standard deviations in parenthesis)

	MILLET			SORGHUM			PEANUTS		
	Bangasse	Diapangou	Nedogo	Bangasse	Diapangou	Nedogo	Bangasse	Diapangou	Nedogo
Yield	379.6 (167.4)	346.1 (153.4)	341.9 (124.9)	509.3 (237.2)	361.0 (229.1)	410.2 (286.5)	542.3 (204.4)	496.9 (238.7)	461.3 (324.7)
Planting	52.93 (51.86)	81.07 (111.33)	48.11 (48.13)	74.47 (66.84)	69.25 (59.10)	73.41 (87.51)	131.4 (100.79)	180.96 (212.65)	179.74 (168.00)
First Weeding	145.03 (86.15)	113.04 (121.70)	165.11 (111.24)	182.34 (122.91)	101.41 (83.25)	239.68 (108.50)	134.12 (217.45)	129.85 (122.00)	233.83 (354.99)
Second Weeding	101.72 (75.10)	79.50 (78.82)	97.25 (130.89)	123.06 (95.65)	79.71 (79.78)	158.05 (190.16)			
TOTAL HOURS	299.68	273.61	310.47	379.87	250.37	471.06	265.52	310.81	413.57
VALUE/HECTARE	18,220	17,651	22,223	24,446	18,411	25,022	25,488	27,329	24,449
Average Returns per Hour (CFA)	60.8	64.5	71.6	64.4	73.5	53.1	96.0	87.9	59.1
n	65	55	257	63	197	64	63	80	143

[a]See Appendix E.

Table 13 provides an overview of the crop year in terms of total hours worked per hectare. These data are compiled from calculations of hours per hectare by activity for each crop. These are then weighted by the relative area devoted to each crop to arrive at the total hours per hectare on a representative farm.

These data indicate that weeks eight and nine were the most demanding periods of the year. During that time, sorghum weeding was at its peak as was the planting of peanuts. More important in terms of total hours, first weeding period for millet was approaching its peak.

The second most demanding period included weeks 14 and 15 when again the second weedings for sorghum and millet were peaking as was the first weeding for peanuts. While these data support the farmer's claim that the first weeding period is most critical, they also show that at its peak, the second weeding is nearly as demanding. The difference in the two periods is that the weeks on either side of the first weeding peaks are more demanding than are those surrounding the peak second weeding period. If there is labor slack to be exploited during the second weeding, it is to be done more by lengthening the second weeding than by intensifying it. One consideration in this regard is the farmer's claim that the second weeding is hard because laborers are so tired by that time in the season.

Table 13: Total Weighted Labor Hours per Hectare with Representative Cropping Pattern, Nedogo, 1982.

WEEK	DATE	WHITE SORGHUM	RED SORGHUM	MILLET	MAIZE	RICE	GROUND NUT	TOTAL
1	5/3-9	0.9	0.4	4.6	-	-	-	5.9
2	5/10-16	1.5	1.1	6.1	-	0.1	0	8.8
3	5/17-23	2.3	0.2	4.5	-	-	-	7.0
4	5/24-30	3.7	2.8	10.1	-	-	-	16.6
5	5/31-6/6	5.8	2.8	9.9	-	1.2	1.8	21.5
6	6/7-13	2.6	3.4	5.1	-	0.8	2.0	13.9
7	6/14-20	7.9	2.6	7.8	-	0.4	2.4	21.1
8	6/21-27	5.2	3.3	8.1	6.1	-	3.3	26.0
9	6/28-7/4	8.8	1.6	12.2	1.0	0.3	6.5	30.4
10	7/5-11	0.8	1.3	15.9	0.8	0.5	-	19.3
11	7/12-18	0.6	1.3	19.4	0.2	0.4	0.6	22.5
12	7/19-25	1.4	3.6	4.0	3.0	0.1	1.4	13.5
13	7/26-8/1	5.6	2.3	6.9	0.4	0.6	1.6	17.4
14	8/2-8	12.3	2.9	7.8	0.1	0.3	0.7	24.1
15	8/14-15	8.9	1.5	11.8	-	-	5.9	27.5
16	8/16-22	2.7	2.6	6.9	0.5	0.1	1.2	14.0
17	8/23-29	2.8	1.3	4.0	0.2	-	1.0	9.3
18	8/30-9/5	2.5	0.7	9.3	-	0.1	-	12.6
19	9/6-12	1.0	1.3	2.6	-	-	-	4.9

Given the farmers' observations and the empirical data, one would expect higher marginal returns for first weeding hours than to hours expended in other agricultural activities. To test this hypothesis, yields per hectare were regressed[2] on "man-unit per hectare equivalents" for each major agricultural activity. This was done using family fields for the cereals and all fields for peanuts. The results of these regressions are presented on Table 14.[3]

[2]OLS estimates were used. Both quadratic and log linear estimates showed higher values for R^2 but signs were often wrong and the coefficients were rarely significant.

[3]At Diapangou, an association of millet (75%) and sorghum (25%) was analyzed under the table category, WHITE SORGHUM.

Table 14: Labor Coefficients Multiple Linear Regression Explaining Yield per Hectare, 1982.

	MILLET			WHITE SORGHUM			PEANUTS		
	Bangassee	Diapangou	Nedogo	Bangasse	Diapangou[a]	Nedogo	Bangasse	Diapangou	Nedogo
CONSTANT	228.4	41.1	257.6	341.6	362.59	293.6	508.6	384.5	258.8
Planting Hours per Hectare	2.087 (3.773)	1.002 (1.827)	0.717 (2.733)	0.318 (0.459)	-0.502 (1.607)	1.283 (2.021)	-0.19 (0.52)	0.09 (0.59)	1.093 (5.006)
First Weeding: Hours per Hectare	-0.295 (0.794)	2.952 (5.199)	0.238 (1.978)	0.387 (1.033)	0.030 (0.124)	-0.216 (1.208)	0.701 (4.136)	1.000 (3.564)	0.141 (1.372)
Second Weeding: Hours per Hectare	1.176 (2.799)	0.510 (0.647)	0.303 (3.152)	0.829 (1.728)	1.090 (4.352)	0.444 (1.223)	NO	SECOND	WEEDING
R^2	.258	.604	.16	.095	.109	.108	.282	.168	.233
n	65	55	257	63	197	64	63	80	143

[a]Sorghum/Millet Association.

The percent of variation in yield explained by labor times is generally between 10 and 25 percent. But seven of nine labor coefficients for millet were significant at the .05 level. Labor was a less reliable predictor of yields with sorghum. In general, the data show that labor is rewarded, but that much variation in yield remains to be explained. Soil quality and rainfall, the only other important inputs, account for 75 to 90 percent of variation in yields. In only one case for millet (Diapangou) and 2 cases for peanuts (Bangasse and Diapangou) did first weeding have the highest statistically significant coefficient. While the coefficient for second weeding was significant in four of six cases for millet and sorghum, in only two of those cases did it have the highest significant coefficient. Planting hours had the highest significant coefficient in three of six cases for grain and in one of three cases for peanuts.

Our tentative interpretation of these findings is that while farmers spend more time on first weeding than on any other activity, they do so because their experience tells them that weeding at this period is most critical to the establishment of new plants. Thus, they carry out their weeding activity counting on continued rain from which they will benefit if their work is done thoroughly.

Alternatively, second weeding hours are a function of actual crop progress in that farmers will spend more time on second weeding if their crops (and the weeds) are progressing well. Thus, the hours expended in second weeding may show high returns in regression analysis even though their number is as much the result of a strong crop as it is a contributor to it. The significant coefficients for planting may be explained by density of planting. Further analysis of labor data is required to interpret these findings.

3. The capital constraint: The preceding discussion of the labor constraint considers the labor provided by animal traction which, during weeding periods, substitutes for labor at a rate of about 3.8 man-units. Animal traction is the only major capital investment made by farmers in the villages studied. Thus, to evaluate the effects of animal traction is to address the capital constraint. For this reason, the following section of this report is devoted to our findings on these effects.

III. ANIMAL TRACTION

Animal traction is believed by some to have the most promise among available alternatives on the "technology shelf." However, adaption rates and evidence from previous studies have been inconclusive at best. Previous surveys in Upper Volta were unable to demonstrate statistically significant increases in either yield or acreage cultivated, effects that are necessary but not sufficient, to demonstrate profitability of mechanization with animal power.

The principle hypotheses with respect to the effects of animal traction are:

1. that increased labor productivity permits a household to cultivate more land and obtain higher yields when field operations are performed on a more timely basis; and,
2. that yields are increased through deeper tillage to facilitate early plant development, to improve moisture retention, and incorporation of plant and animal by-products.

As an investment activity or capital input that increases the productivity of both land and labor, animal traction must first be shown to result in increased production via yield and/or acreage effects. It must also be shown that the expected value of that increased production is sufficient to compare favorably with alternative investment opportunities.

In two of FSU's three study villages, samples of 60 households were chosen randomly but split between hand tillage and traction-equipped households in order to make cross-sectional comparisons (the principle method used for this evaluation). The

sample in Nedogo consists of 24 hand tillage households and 36 donkey traction households (five of which also have single-ox traction). In Diapangou, this sample consists of 11 households with hand tillage, 21 with donkey traction, and 27 with oxen traction (7 of which also use donkey traction).

In addition, a series of in-depth farmer interviews were conducted to elicit farmers' perceptions about the potential benefits of animal traction and its impact on resource allocation decisions. The subjective responses are compared to the input-output production data and both are used to test the principle hypotheses and to identify additional hypotheses to be tested.

A detailed list of hypotheses appears below:

1. Yield increases associated with animal traction are due mainly to preplant plowing. These effects are larger with oxen plowing than the shallower donkey plowing.
2. Potential acreage increases are due mainly to increased productivity of labor during weeding operations.
3. Problems associated with peak labor bottlenecks can be exacerbated when preplant plowing results in delay in planting and first weeding. Plowing alone may actually result in a decrease in area cultivated.
4. Animal traction allows child labor to be used more productively. Subsequently, it reduces the constraint on adult family labor during critical periods.
5. The critical timing required for animal traction activities associated with short season, rainfed agriculture restricts the potential for rental market development thereby limiting profitability.
6. There are economies of scale associated with animal traction.
7. Complementarities exist between returns to animal traction and to other soil fertility and moisture conservation technologies.
8. Actual production increases diverge from potential increases due to income effects associated with increased labor productiviy; that is, farmers may choose to work less, while at the same time maintaining, or increasing their production.

9. Increased factor productivity with animal traction results in a larger share of resources being allocated to cash crop activities.

A. Farmer Interviews

Questions asked in farmer interviews were of two types. The first set of questions attempted, by recall, to provide some "before and after" information to complement the cross-sectional "with and without" production data.

Responses about increased area cultivated over time were inconclusive even though nearly all households reported cultivating more land now than before adopting animal traction; and, nearly all househoulds increased the number of active workers. However, hand tillage households gave similar responses. There was, however, a notable increase in marketed surplus according to farmers. All animal traction households in Diapangou and 75% of those in Nedogo reported that they sell more of the production from the principal family millet field now than before using animal traction. Harvests from personal fields are more often marketed now as well: the increase is mainly in millet followed by peanuts, and in Diapangou, by soybeans.

In both villages first weeding appears to be the primary labor bottleneck, followed by planting in Nedogo, and preplant plowing in Diapangou. Animal traction appears to have shifted these constraints on household labor. Farmers were asked to indicate the activitiy for which the lack of labor restricted their ability to increase production both before and after adopting animal traction. The results are presented in Table 15. In Nedogo, preplant plowing is normally not done. Even with animal traction, line tracing or superficial scarification with the Houe Manga are the only land preparation activities. The use of the Houe Manga appears to have lessened the constraint on first weeding substantially: two-thirds of those using animal traction said that labor is no longer a constraint. In Diapangou, animal traction appears to facilitate preplant plowing and to reduce the constraint of early weeding. Planting was more frequently cited, presumably a result of increased preplant plowing that delays planting and constricts the period during which it can be done.

Table 16 summarizes farmers' perceptions about factor productivities with animal traction. Yield increases due to preplant plowing are thought to be greatest for maize and peanuts, followed by sorghum and millet. With donkey traction, farmers expect to perform weeding operations twice as fast as by hand tillage; and with oxen traction, it is believed to cut weeding time to about a third. These results conform very closely to the coefficients obtained for weighting labor productivity. Using these coefficients, a typical household with two men, two women, and three children using donkey traction for five hours per day would reduce weeding time from ten days to about six days for this hypothetical field. This assumes all members work 8 hours per day and one adult and one child work the donkey. Oxen reportedly can plow twice as much land per day as donkeys, but it appears that the shallower donkey plowing can be continued longer after a rain under dryer soil conditions. (In Nedogo, the same shallow scarification is done with both donkeys and single ox traction.)

Table 15: Most Constraining Agricultural Activity

	REPLANT PLOWING	PLANTING	FIRST WEEDING	SECOND WEEDING	LABOR NOT P CONSTRAINING
DIAPANGOU					
Before using Animal Traction	43%	11%	66%	19%	0%
With Animal Traction	6%	38%	49%	21%	9%
Hand Tillage Households	36%	36%	55%	0%	0%
NEDOGO					
Before using Animal Traction	—	36%	81%	0%	3%
With Animal Traction	—	14%	25%	0%	67%
Hand Tillage Households	—	30%	70%	0%	0%

Note: Totals exceed 100% due to multiple responses. Planting and first weeding were often cited jointly. These findings differ from those reported on Table 11. This is because different samples were used and because the data in Table 11 aggregate animal traction and traditional households whereas Table 15 separates them.

Table 16: Animal Traction and Resource Productivity; Farmers' Subjective Responses

	NEDOGO	DIAPANGOU
Yield Increases Expected with Preplant Plowing:		
Millet?	20% - 50%	20% - 50%
Sorghum?	10% - 60%	30% - 60%
Maize?	50% - 150%	20% - 50%
Peanuts?	20% - 100%	50% - 100%
A field requiring ten days to weed by hand, requires how many days with:		
donkey traction?	5 days	4 - 6 days
oxen traction?	3 days (single ox)	2 - 4 days
A field requring five days to plow with oxen, requires how many days with a donkey?	7 - 8 days (compared to a single ox)	8 - 12 days
Maximum hours per day the animals can plow:		
donkey?	4 - 6 hours (Scarification)	3 - 4 hours
oxen?	7 - 8 hours (Scarification)	4 - 5 hours
Number of days after a good rain that preplant plowing is possible with:		
donkey traction?	3 - 5 days (Scarification)	4 days
oxen traction?	4 - 6 days (Scarification)	3 days
Hours per day animals can weed:		
donkey?	5 - 7 hours	4 hours
oxen?	6 - 8 hours	5 hours

B. Comparison of Animal Traction and Hand Tillage

The cross-sectional data from FSU's 1982 farm surveys is examined in four separate, but related, ways for evidence of the benefits from animal traction. First, acreage cultivated by crop is compared (both total area and as a share of total croped area). Second, yields are compared between groups. Third, total production by crop is compared and should incorporate net effects of yield and acreage differences. Lastly, total production is valued at harvest period market prices to compare the direct effects of animal traction on farm income.

1. Acreage effects: Tables 17 and 18 compare arithmetic means of area cultivated by crop. Minor crops occupying less than one percent of land area are excluded. Fields that were intercropped are classified according to the dominant crop.

In Nedogo, where the Houe Manga is used primarily in weeding operations, donkey traction households cultivate an average of 1.29 hectares per worker compared to 0.97 hectares per worker for hand tillage households. This increase of 32.9% is significant at the 0.1 level and is the result of increases in area planted for millet, white sorghum, maize, and groundnuts. The cropping patterns of the two groups are nearly identical except for a small shift from red sorghum to white sorghum by animal traction households.

Table 17: Land Use and Cropping Patterns, NEDOGO.

	HAND TILLAGE		DONKEY TILLAGE			
	Area (Ha)	Percent of Total	Area (Ha)	Percent of Total	Increase over Hand Tillage (Ha)	
MILLET	2.74	62.0	5.2	63.0	2.46	***
WHITE SORGHUM	0.68	15.4	1.51	18.5	.83	***
RED SORGHUM	0.56	12.7	0.71	8.6	.15	NS
MAIZE	0.09	2.0	0.2	2.4	.11	***
GROUNDNUT	0.24	5.4	0.45	5.5	.21	***
BAMBARA NUTS	0.08	1.8	0.1	1.2	.03	NS
RICE	0.02	0.5	0.01	0.1	.01	NS
TOTAL	4.41	100.0	8.18	100.0	3.77	***
Active Workers per Household	4.71		6.64			
Mean Area Cultivated per Worker	0.97		1.29	0.319** (Increase of 32.9%)		

Significance levels are indicated by:
*for significance at the 0.1 level
**for significance at the 0.05 level
***for significance at the 0.01 level
NSindicates not significant.

Table 18: Land Use and Cropping Patterns, Diapangou.

	HAND TILLAGE		DONKEY TRACTION				OXEN TRACTION			
	Area (HA)	Increase Percent of Total	Area (Ha)	Percent of Total	Increase Over Hand Tillage (Ha)		Area (Ha)	Percent Of Total	Increase Hand Tillage (Ha)	
MILLET/SORGHUM	4.48	89.1	5.59	75.0	1.1	NS	6.27	81.2	1.79	
WHITE SORGHUM	0.14	2.8	0.87	11.7	0.73	*	0.25	3.2	0.11	
MAIZE	0.14	2.8	0.17	2.3	0.03	NS	0.28	3.6	0.14	**
GROUNDNUT	0.18	3.5	0.45	6.0	0.27	NS	0.58	7.5	0.4	*
BAMBARA NUT	0.03	0.6	0.04	0.5	0.01	NS	0.06	0.8	0.03	
RICE	0.01	0.2	0.13	1.8	0.12	NS	0.07	0.9	0.06	
SOYBEAN	0.05	1.0	0.2	2.7	0.15	NS	0.22	2.9	0.17	
TOTAL	5.03	100.0	7.45	100.0	2.42		7.73	100.0	2.7	
Active Workers per Household	4.36		6.38				7.63			
Mean Area Cultivated per Worker	1.15		1.17		0.02	NS	1.01		-0.14	NS

In Diapangou, where more preplant plowing is done and only 60% of the animal traction farmers have weeding equipment, there is no increase in area cultivated per worker. Increases in area per household occur for millet/sorghum, maize, and peanuts but these are attributable to the larger number of workers in animal traction households. Millet's share of the total cropped area is less among animal traction farmers with an increase in the shares of white sorghum, peanuts, rice, and soybeans: an indication that land is shifted away from subsistance productions towards cash crops.

2. Yield effects: Tables 19 and 20 compare yields for the two villages.[4]

The results from Nedogo show a significant decrease in white sorghum yields and a similar (but not statistically significant) increase in red sorghum yields.

The yield effects in Diapangou are more pronounced. Statistically significant yield increases are obtained for wihte sorghum, millet/sorghum, maize, and peanuts. A large decrease in soybean yields was observed among donkey traction households (although the comparison is questionable since the hand tillage sample contains only six observations for a total area of 0.55 Ha; similarly, for white sorghum and peanuts, the number of hand tillage households is small).

Table 19: Yields by Tillage Technology (KG/HA), NEDOGO.

	HAND TILLAGE	DONKEY TRACTION	INCREASE OVER HAND TILLAGE	PERCENT INCREASE
MILLET	350 (n=24)	336 (n=36)	- 14	- 4.0
WHITE SORGHUM	515 (n=19)	343 (n=30)	- 172 **	- 33.4
RED SORGHUM	421 (n=20)	578 (n=32)	157	37.3
MAIZE	1140 (n=24)	971 (n=35)	- 169	- 14.8
PEANUT	502 (n=24)	435 (n=36)	- 67	- 13.4

[4]Mean yields were weighted within households by field area, but grouped means are arithmetic between households. Minor intercrops and border crops were ignored. Harvests were summed when cereals were intercropped.

Table 20: Yields by Tillage Technology (Kg/Ha), Diapangou.

	HAND TILLAGE	DONKEY TRACTION	INCREASE OVER HAND TILLAGE	PERCENT INCREASE	OXEN TRACTION	INCREASE OVER HAND TILLAGE	PERCENT INCREASE
MILLET/SORGHUM (Sole Millet Included)	329 (n=11)	403 (n=21)	74 *	22.5	391 (n=26)	62 *	18.8
WHITE SORGHUM	171 (n=5)	428 (n=13)	256 **	150.0	368 (n=9)	197 *	115.0
MAIZE	1429 (n=11)	1636 (n=21)	208	14.6	1879 (n=26)	451 **	31.6
PEANUTS	256 (n=6)	519 (n=19)	263 ***	102.0	548 (n=20)	292 **	114.0
SOYBEANS	762 (n=6)	297 (n=18)	-465 ***	-61.0	764 (n=19)	2	0.3

3. Total crop production: Differences in weight harvested between farm classes should be close to the product of the acreage and yield effects presented above. The actual differences presented in Tables 21 and 22 diverge from these products for two reasons. First, intercrops will be represented here separately when they were harvested and weighed apart. Second, the product of mean yield and mean acreage will differ from the mean of the products of yield and acreage if yield and acreage are correlated. Using Equation 13:

$$\left(\frac{1}{n}\sum_{i=1}^{n} A_1\right)\left(\frac{1}{n}\sum_{i=1}^{n} Y_1\right) \neq \frac{1}{n}\sum_{i=1}^{n} A_1 Y_1$$

if A_1 and Y_1 are correlated:

A_i = acreage of the ith crop

Y_i = yield of the ith crop

The measure used here is the most straight forward one; summing harvested weight by crop and by household, is most straight forward.

In spite of differences between the two villages in yield and acreage effects, the overall effects on production per worker are surprisingly similar: both show significant increases in millet, millet/sorghum, maize, and peanuts. In both villages, there is evidence of a decrease in bambara nut producton (although not statistically significant) and no change in cowpeas harvested per worker. In Nedogo, although millet production per worker increased 37.7%, red and white sorghum production declined (not statistically significiant) resulting in a net increase of 15.7% for millet and sorghum.

4. Total crop value: In order to synthesize the yield and acreage effects associated with animal traction, we have valued all crop production at harvest period prices in the respective villages and compared these figures as value of farm production per worker between farm classes. The differences are significant in all classes of animal traction farms. Somewhat surprisingly the largest increse is in donkey traction in Diapangou, although this figure is not significantly different from the increases associated with oxen traction.

Assuming then that the increases associated with animal traction are attributable to animal traction, we multiply the differences per worker by the mean number of workers per household to estimate the production benefits of animal traction by farm class. Here oxen traction in Diapangou comes out slightly ahead of donkey traction: the results suggest an increase of 67,530 Francs CFA in farm income with a pair of oxen, and 66,856 Francs CFA with a single donkey. Farm classes were grouped independent of the number of years of experience with animal traction. This will tend to bias downwards the potential benefits after several years experience with animal traction. The linear regressions in Table 25 show relationships between years of experience with animal traction and crop value per worker. The term for experience with oxen traction is not significant largely because of the ambiguity when oxen experience coincides or follows years of experience with donkey traction.

Table 21: Production per Worker, Nedogo.

	HAND TILLAGE (n=24)	DONKEY TRACTION (n=36)		
	KG/WORKER	KG/ WORKER	INCREASES OVER HAND TILLAGE	PERCENT INCREASE
MILLET	190.8	262.6	71.9***	37.7
WHITE SORGHUM	83.2	71.6	-11.6	-13.9
RED SORGHUM	57.6	49.5	-8.1	-14.1
MAIZE	15.4	24.1	8.7**	56.5
GROUNDNUT	17.0	23.6	6.6*	38.8
BAMBARA NUT	8.5	2.2	-6.3	-74.0
COWPEA	7.5	7.7	0.2	2.6

Table 22: Production per Worker, Diapangou.

	HAND TILLAGE (n = 11)	DONKEY TRACTION (n = 21)			OXEN TRACTION (n = 27)		
	KG/WORKER	KG/ WORKER	INCREASE OVER HAND TILLAGE	PERCENT INCREASE	KG/ WORKER	INCREASE OVER HAND TILLAGE	PERCENT INCREASE
MILLET/SORGHUM	294.3	454.7	160.4 **	54.0	416.2	121.9 *	41.0
MAIZE	42.2	46.5	4.3	10.2	74.1	31.9 **	75.6
GROUNDNUT	6.7	27.0	20.3 ***	303.0	27.5	20.8 **	310.0
BAMBARA NUT	6.8	5.6	-1.15	-16.9	3.35	-3.4	-50.0
COWPEA	44.6	51.5	6.9	15.5	44.7	0.1	0.2
SOYBEAN	6.5	7.2	0.7	10.7	7.21	0.71	10.9

Table 23: Value of Production per Worker (CFA)

	HAND TILLAGE	DONKEY TRACTION	OXEN TRACTION	DONKEY AND OXEN TRACTION
NEDOGO	(n=24)	(n=31)		(n=5)
(A) Revenue per Worker	24,422	28,418 *	—	31,862 *
(B) Increase Over Hand Tillage	—	4,473 *	—	7,439 *
(C) Percent Increase	—	18.3	—	30.4
(D) Workers/ Household	4.71	6.45	—	7.8
(E) Increased Revenue per Worker x No. of Workers (D x B = E)	—	28,850	—	58,024
DIAPANGOU	(n=11)	(n=21)	(n=20)	(n=7)
(A) Revenue per Worker	22,191	32,670	31,196	29,556
(B) Increase Over Hand Tillage	—	10,479 **	9,004 **	7,358 *
(C) Percent Increase	—	47	40	33
(D) Workers/ Household	4.36	6.38	7.5	8.0
(E) Increased Revenue per Worker x No. of Workers (D x B = E)	—	66,856	67,530	58,864

Table 24: Farm Income per Worker Regressed on Years of Experience with Animal Traction.

	COEFFICIENT	t - VALUE
DIAPANGOU		
CONSTANT	24,945	
Years experience with donkey traction	1,027	1.79 *
Years experience with oxen traction	256	0.67
	R^2 = .06 n = 58 F-Ratio = 1.75	
NEDOGO		
CONSTANT	23,525	—
Years experience with donkey traction	834	2.87 **
Years experience with oxen traction	-1,008	-0.73
	R^2 = .127 n = 60 F-Ratio = 4.138	

The existence of a "learning curve" associated with animal traction is most clearly demonstrated in Nedogo by a log linear regression of years of experience on area cultivated. The regression is presented in Table 25 and the resulting estimated learning curve is depicted in Figure 1. It suggests that with five years experience a donkey traction farmer expands the area cultivated by more than one hectare.

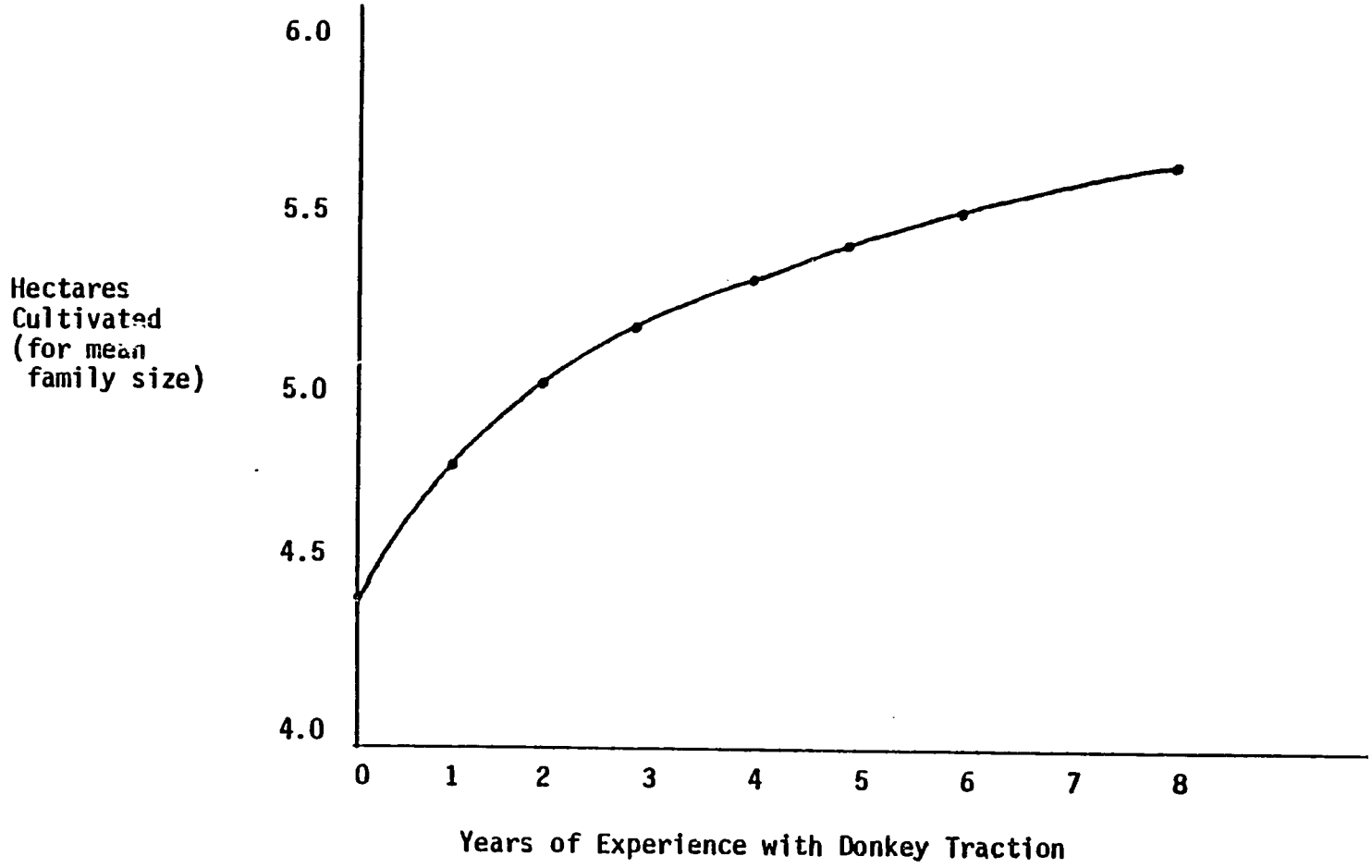
Table 25: Total Area Cultivated Regressed on Workers and Years of Experience with Animal Traction.

VARIABLE	COEFFICIENT	t - VALUE
CONSTANT	1.231	
Male Workers	0.306	1.124
Female Workers	1.011	4.174 ***
Children Workers	0.499	1.641
Log (Years of donkey experience + 1)	1.258	4.303 ***
Log (Years of oxen experience + 1)	1.113	1.530
	R^2 = 0.671 n = 60 F-Ration = 22.06	

C. Returns to Investment in Animal Traction.

An investment in animal traction must be evaluated in terms of the opportunity cost of that investment. The results from the previous section, including evidence of a learning curve are incorporated into the partial budgets presented here. These projections assure no increase in production the first year; but a linear "learning curve" occurs during the four following years so that, in year five, the adaptor obtains the mean benefits in crop production income found in Table 23. Animal prices and all variable costs are means derived from actual observations in the two villages. The expected cost, or risk of financial loss, when an animal dies is calculated directly from complete histories of animal traction use by all households in the sample. Equipment prices are current prices from APICOMA, one of the two major farm equipment suppliers in the country. Values used are chosen to give conservative results of the profitability of animal traction. For example, most donkeys sold

Figure 1: Illustration of Learning Curve, Hectares Cultivated Versus Years of Experience with Animal Traction, Nedogo, Upper Volta.



Source: Based upon regression of Table 25.

maintained their value or appreciated slightly. We assume here a 40% depreciation over four years. On an average, oxen appreciated 15,000 Francs CFA per year; we use here 12,500 Francs CFA. These budgets indicate an internal rate of return of 9.8% for donkey traction in Nedogo and 31.2% in Diapangou. For oxen traction in Diapangou, the value is 20.7%.

Table 26: Partial Budget for Donkey Traction, Nedogo.

	YEARS 1	2	3	4	5	6	7	8
REVENUES								
Incremental Value of Crop Production	0	7,000	14,000	21,000	28,000	28,000	28,000	28,000
Animal Sales	—	—	—	—	15,000	—	—	15,000
Equipment Sales	—	—	—	—	—	—	—	2,000
VARIABLE COSTS								
Equipment Purchase	29,490	—	—	—	—	—	—	—
Animal Purchase	25,000	—	—	—	25,000	—	—	—
Equipment Repair	—	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Feed Grain, Salt	4,310	4,310	4,310	4,310	4,310	4,310	4,310	4,310
Expected Loss Due to Animals Death (5% per year)	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250
EXPECTED NET BENEFITS	-60,050	-560	6,440	13,440	10,440	20,440	20,440	37,440

INTERNAL RATE OF RETURN = 9.84%

Table 27: Partial Budget for Donkey Traction, Diapangou.

	YEARS 1	2	3	4	5	6	7	8
REVENUES								
Value of Increased Crop Production	0	16,500	33,000	49,500	66,000	66,000	66,000	66,000
Animal Sales	—	—	—	—	15,000	—	—	15,000
Equipment Sales	—	—	—	—	—	—	—	2,000
VARIABLE COSTS								
Equipment Purchase	39,060	—	—	—	—	—	—	—
Animal Purchase	25,000	—	—	—	25,000	—	—	—
Equipment Repair	—	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Feed Grain, Salt	4,310	4,310	4,310	4,310	4,310	4,310	4,310	4,310
Expected Average Loss Due to Animal Death (5% per year)	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000
EXPECTED NET BENEFIT	-70,370	8,190	24,690	41,190	47,690	57,690	57,690	74,690

INTERNAL RATE OF RETURN = 31.2%

Table 28: Partial Budget for Oxen Traction, Diapangou.

	YEARS 1	2	3	4	5	6	7	8
REVENUES								
Value of Increased Crop Production	0	16,750	33,500	50,250	67,000	67.000	67,000	67,000
Animal Sales	—	—	—	—	200,000	—	—	175,000
Equipment Sales	—	—	—	—	—	—	—	4,000
VARIABLE COSTS								
Equipment Purchase	48,710	—	—	—	—	—	—	—
Animal Purchase	100,000	—	—	—	100,000	—	—	—
Equipment Repair	—	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Animal Feed, Salt	8,275	8,275	8,275	8,275	8,275	8,275	8,275	8,275
Expected Average Loss Due to Animal Death (6% per year)	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
EXPECTED NET BENEFITS	-162,985	-525	16,225	32,975	149,725	49,725	49,725	228,725

INTERNAL RATE OF RETURN = 20.7%

Conclusions

The preceding analysis suggests the following about animal traction in these villages:

1. In both villages, animal traction can be used profitably within the traditional farming systems.
2. Donkey traction using the Houe Manga increases labor productivity during critical weeding activities and allows farmers to increase the area they cultivate.
3. With agro-climatic conditions similar to those in Diapangou, both donkey and oxen traction can result in significant yield increases in years when early rains provide sufficient opportunities to plow.

These results should be interpreted with caution since several factors affecting costs and benefits of each technology have not been considered. These factors are:

* We have thus far ignored the increased labor costs of caring for draft animals as well as the possibility of increased labor inputs being responsible for the higher production levels. We have implicitly assumed that workers in both groups work similar numbers of hours;

* Correlation of animal traction with higher levels of production does not prove causality. It is probably true in some cases that access to better, or more, land or higher levels of managerial skill were in part responsible for the adaption of animal traction and higher levels of production. In these cases one may mistakenly attribute the higher production entirely to the use of animal traction;

* In Nedogo, where animal traction results in increased acreage cultivated, we are assuming that land for expansion is available. It is not entirely clear that in this relatively land scarce part of Upper Volta, all farmers have access to more land; and,

* These results rely on one year's production data. A different rainfall pattern, especially differences during the onset of early rains, may have resulted in very different data, and hence, different conclusions.

A glance at the hypotheses at the beginning of this section reveals that many questions have not been addressed in detail. Due to the limited capacity for data processing in the field, the following topics remain to be thoroughly treated:

1. Shifts in labor allocation with animal traction by activity, labor type, and time period.
2. Whole farm production function analysis.
3. Detailed assessment of potential and realized productivity increases of labor.
4. Evidence of factor biases with animal traction.
5. Separate evaluation of the impact of plowing versus weeding technologies.
6. Assessment of the constraints on the amount of preplant plowing possible using historical rainfall data.
7. Evaluation of yield effect at the field level using linear regression.

IV. TECHNOLOGY EVALUATION

The technologies evaluated by FSU in 1982 were agronomic and emphasized water conservation and soil fertility. There were two basic types of on-farm trials in the 1982 agronomy program. "Researcher-managed" trials use standard experimental designs (i.e., split-plot, randomized complete block). The primary objective of this type of trial is to evaluate the yield gap between experiment station conditions and on-farm conditions. The "farmer-managed" trials use simpler designs with a larger plot size and more replications than researcher-managed trials. Farmer-managed trials are designed to permit economic analysis required to evaluate the potential for farmer implementation of these technologies.

A. Researcher-Managed Trials

1. Intercropping trial: This trial was designed to evaluate the performance of millet and several legumes in associated cropping. The experimental design was a randomized complete block performed in three

villages (Diapangou, Bangasse, and Nedogo) using two locations per village with four replications per location. The treatments included: (1) mungbean -- millet intercrop; (2) local cowpea -- millet intercrop; (3) Suvita 2 (new variety of cowpea) -- millet intercrop; (4) TVX 3236 (new variety of cowpea) -- millet intercrop; and (5) millet monocrop. The plot sizes were 3.6 m x 8 m (6 rows x 8 m) using row spacings of 60 cm x 60 cm for millet (66,700 plants/Ha) and 120 cm x 120 cm for legumes (16,675 plants/Ha). The four innermost rows were harvested to measure yield.

The results are shown in Table 29. Poor stand establishment caused by an early season drought at Diapangou resulted in the loss of both locations. Adequate stands were obtained at Nedogo but heavy infestations of thrips and severe drought in late August and early September reduced the yield of the legumes to zero. One location at Bangasse was lost because of poor millet stands; thus at harvest, only one location of the original six remained. The results at this location indicate that a density of 16,675 plants/Ha of the legumes did not affect the yield of millet. Also, the yield of the local cowpea variety was superior to the other entries; however, additional years and location data are needed to corroborate these results.

Table 29: Intercropping Trial at Bangasse; Analysis of Variance for Millet Yield (Kg/Ha).

SOURCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARE	F-TEST
Blocks	3	413,664	137,888	
Treatments	4	23,934	5,984	NS
Error	12	306,947	25,579	
		CV = 17.9		
Analysis of Variance for Legume Yield (Kg/Ha)				
Blocks	3	2,739	913	
Treatments	3	26,806	8,935	10.8 **
Error	9	7,439	827	
		CV = 11.8		

Summary of Means

SOURCE	MILLET (KG/HA)	LEGUME (KG/HA)
TREATMENTS:		
Millet + Mungbean	859.4	40.6
Millet + Local Niebe	885.4	133.9
Millet + TVX 3236	859.4	28.5
Millet + SAFITA 2	953.9	76.5
Millet only	885.4	—

2. Legumes variety trial: This trial was designed to evaluate the performance of several cowpea varieties in monocrop with insecticide treatment and to observe the performance of three other legumes grown in monocrop. The experimental design was a randomized complete block performed in three villages using two locations per village with four replications per location. The treatments (varieties) included a local cowpea, Cowpea KN-1, Cowpea Suvita.2, Cowpea TVX 3236, Cowpea TVX 1999, Cowpea Mougne, bambara nuts, soybeans, and a local peanut. The plot sizes were 4.8 m x 10 m (6 rows x 10 m) using row spacings of 80 cm x 40 cm (33,350 plants/Ha) for improved varieties. The inner four rows were harvested for yield.

Rock Phosphate (250 Kg/Ha) was broadcast and incorporated on all plots before planting. All plots were sprayed with 12-20 A.I/Ha for Decis three times: the first at budding; the second, 7-9 days after the first spraying; and, the third was 7-9 days after the second spraying.

The results are given in Table 30. These results are the summary of four locations since the variety and location term was nonsignificant. Good stands were obtained at all locations and excellent insect control was obtained. Good results were obtained at Nedogo and Bangasse for all varieties except soybeans which were not harvested because of poor stand establishment. Significant differences were observed among some of the cowpea varieties. The local cowpeas varieties performed equally well at all locations with the improved varieties. In 1983, the cost of an ultra low volume (ULV) sprayer in Ouagadougou was 7500 FCFA. The cost of insecticide applied at the recommended rates was 43.650 FCFA per hectare. The local variety yielded an average of 614 kg/ha which, valued at a market price at harvest of 60 FCFA/kg, results in a production value of 36.840 FCFA. Thus, the yield level of sole stand cowpeas in this trial does not demonstrate this to be a promising technology, especially when considering all other costs of production such as labor, equipment and the risk involved.

Table 30: Legume Variety Trial; Summary Analysis; Bangasse and Nedogo; Analysis of Variance for Yield (Kg/Ha).

SOURCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F TEST
Locations	3	6,007,420	2,002,470	13.5 **
Blocks	3	220,724	73,575	
Error (a)	9	667,572	74,175	
Varieties	8	1,268,450	158,557	8.67 **
Varieties x Locations	24	960,248	40,010	2.19 NS
Error (b)	96	1,755,152	18,282	

CV = 26.7

Summary of Means

FACTOR	KG/HA	lsd (.05)
LOCATIONS		
Bangasse 1	703.9	
Bangasse 2	670.7	
Nedogo 1	359.4	
Nedogo 2	273.3	
VARIETIES		
Local Niebe	613.5	
KN-1	447.3	
SUVITA.2	618.1	
TVX 3236	574.3	
TVX 1999	543.0	146.8
Mougne	576.6	
Bambara Nut	365.0	
Peanuts	376.8	
Mungbean	441.7	
Soybean	0.0	

3. Maize Tied-Ridges Trial on Compound Plots: These evaluated the effect of tied-ridges on maize production. The experimental design was a randomized block performed in three villages using two locations per village with three replications per location. The treatments included traditional cultivation, tied-ridges made before planting (at Diapangou and Nedogo, every other ridge was tied, while at Bangasse, every ridge was tied), and tied-ridges made 30 to 35 days after planting (at Diapangou and Nedogo, every other ridge was tied, while at Bangasse, every ridge was tied). The plot sizes were 3.2 m x 8 m (4 rows x 8 m) with a plant population of 60,000 plants/Ha. The local variety used by the farmers in each village was planted.

The results included in Table 31 are the summary over locations since the interaction term (treatments x locations) was nonsignificant. The summary analysis of five locations shows a significant difference among treatments with the two tied-ridge treatments being superior to traditional planting by approximately 25% increase in yield.

Table 31: Maize Tied-Ridge Trial on Compound Plots; Summary Analysis of Nedogo, Bangasse and Diapangou; Analysis of Variance for Yield (Kg/Ha).

SOURCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F TEST
Locations	4	28,023,000	7,005,750	
Blocks	2	945,824	472,912	
Error (a)	8	7,936,260	992,032	
Treatments	2	3,924,320	1,962,160	17.25 **
Location x Treatment	8	271,808	33,976	
Error (b)	20	2,274,978	113,749	

CV = 12.8

Summary of Means

FACTOR	KG/HA	lsd (.05)
LOCATIONS		
Nedogo 1	2060	
Nedogo 2	2027	
Bangasse 1	1994	
Diapangou 1	3070	
Diapangou 2	3982	
TREATMENTS		
Traditional	2220	
Tied-ridges before Planting	2911	262.3
Tied-ridges 35 days after planting	2749	

4. Maize Tied-Ridges Trial on Village Fields: This trial evaluated the effect of tied-ridges and applications of fertilizer on non-compound fields where maize normally would not be grown. The objective was to determine the potential for growing maize on soil that would normally be planted to sorghum or millet. The experimental design was a split plot where the main plots were fertilizer applications and the subplots were tied-ridges. These were performed in two villages, Diapangou and Nedogo, with two locations per village using four replications per location. The treatments included two levels of fertilizer applications: level 1 used 0 fertilizer and level 2 used 100 kg/ha cotton fertilizer (14-25-15 NPK) plus 50 Kg/Ha urea. Water conservation treatments included traditional cultivation, tied-ridges prepared before planting, and tied-ridges prepared 30-35 days after planting. The plot sizes were 4.8 m x 8 m (6 rows x 8 m) with a plant population of 60,000 plants/Ha. The local variety utilized by the farmers in each village was planted.

The results are shown in Table 32. The summary table indicates that response to tied-ridges was non-significant but the response to an additional 100 Kg/Ha cotton fertilizer and 50 kg/ha of urea was significant, but location specific. The low mean of location at Nedogo reflects both an early and late season drought where the addition of fertilizer did not increase yields enough to pay for its cost. At location two in Diapangou, even though the farmer said it was a sorghum field, the soil was deep and friable with a high percentage of organic matter and was very typical of land normally planted to maize. At this location, the additional fertilizer demonstrated a very small response. Location 1 at Diapangou, was a typical sorghum/millet field and yielded a 600 Kg/Ha increase for the additional 100 Kg/Ha of cotton fertilizer. Because of location, specific response, and the high risk of cash loss associated with fertilizer usage, this approach of moving maize onto land normally planted to sorghum and millet needs additional research at the researcher-managed level.

Table 32: Maize Tied-Ridge Trial on Village Fields; Summary Analyses, Nedogo and Diapangou; Analysis of Variance for Yield (Kg/Ha).

SOURCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F TEST
Locations	2	76,137,786	36,068,893	
Blocks	3	1,176,100	392,032	
Error (a)	6	3,116,450	519,408	
Fertility	1	3,163,440	3,163,440	8.0 *
Location x Fertility	2	4,363,660	2,181,830	5.52 *
Error (b)	9	3,558,590	395,399	
Water Conservation Treatments	2	604,432	302,216	NS
Location x Water Conservation Treatments	4	408,720	102,180	NS
Fertility x Water Conservation Treatments	2	489,776	244,888	NS
Location x Fertility x Water Conservation Treatments	4	835,440	208,860	
Error (c)	36	6,276,606	174,350	

CV = 22.1

Location Means

LOCATION	KG/HA
NEDOGO	624.5
DIAPANGOU 1	1890.6
DIAPANGOU 2	3143.4

Treatment Means (Kg/Ha)

	WATER CONSERVATION TREATMENTS			
FERTILITY TREATMENTS	Traditional	Tied-Ridges Before Planting	Tied-Ridges 35 days After Planting	$\bar{X}$
Without Fertilizer	1505.6	1608.6	1915.4	1676.5
With Fertilizer	2090.5	2087.2	2109.5	2095.8
$\bar{X}$	1798.0	1847.9	2012.5	

5. Sorghum tied-ridges trial: These trials evaluated the effect of tied-ridges on sorghum with and without fertilizer applications. The experimental design was a split plot and with the main plots receiving a fertility treatment with the subplots as the water conservation treatment. These were performed in four villages with two locations per village using four replications per location. The treatment included two levels of fertilizer applications: level one was 0, and level two was 100 Kg/Ha cotton fertilizer (14-25-15 NPK) plus 50 Kg/Ha urea. Water conservation treatments included traditional cultivation, tied-ridges prepared before planting, and tied-ridges prepared 30 - 35 days after planting. The plot sizes were 4.8 m x 8 m (6 rows x 8 m) with plant populations of 66,700 plants/Ha. The local variety utilized by the farmers in each village was planted.

The results are given in Table 33. The summary table shows a highly significant difference for both fertilizer treatment and water conservation techniques. Both fertility and water conservation techniques had an interaction with locations. In all cases, the response to tied-ridges and fertilizer were positive and the magnitude of the response was associated with quantity and frequency of rainfall. We did not expect the results from tied-ridges after planting indicating that this is a better method than tied-ridges before planting. One possible explanation was the deterioration of the ridges made before planting; and thus, they did not entrap the water as effectively during the drier periods at the end of the season. Also, there could have been a cultivation effect associated with the tied-ridges made after planting. Nevertheless, the results are impressive and warrant trying this experiment at the farmer-managed level. The use of tied-ridges and fertilizer increased the yield over traditional methods by 744 kg/ha. With sorghum prices at 50 FCFA/kg and cotton fertilizer and urea at 65 FCFA/kg, this combination of treatment appears profitable for the farmer if labor is available for preparing the tied-ridges.

Table 33: Sorghum Tied-Ridge Trial, Summary Analysis; Nedogo, Bangasse, Diapangou, and Yako; Analysis of Variance of Yield (Kg/Ha).

SOURCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F TEST	
Locations	5	11,701,214	2,340,243		
Blocks	3	34,280	11,247		
Error (a)	15	793,568	52,905		
Fertility	1	6,837,130	6,837,130	153.7	**
Location x Fertility	5	3,837,390	767,478	17.2	**
Error (b)	18	804,928	44,718		
Water Conservation Treatment	2	1,889,930	944,964	25.1	**
Location x Water Conservation Treatments	10	1,441,340	144,134	3.8	**
Fertility x Water Conservation Treatment	2	308,976	154,488	4.1	*
Location x Fertility x Water Conservation Treatment	10	612,552	61,255		
Error (c)	72	2,712,792	37,678		

CV = 26.6

Location Means

LOCATION	KG/HA
Nedogo	917.6
Bangasse	1095.4
Diapangou 1	506.6
Diapangou 2	680.9
Yako 1	951.3
Yako 2	274.5

Treatment Means (Kg/Ha)

	WATER CONSERVATION TREATMENTS			
FERTILITY TREATMENTS	Traditional	Tied-Ridges Before Planting	Tied-Ridges 30 days After Planting	$\bar{X}$
Without Fertilizer	385.2	579.9	561.4	508.8
With Fertilizer	759.2	948.8	1129.6	945.8
$\bar{X}$	572.2	764.4	845.5	

lsd = 79.2

6. Volta rock phosphate trials: This trial evaluates the methods and rates of application of rock phosphate on the production of sorghum and millet. The experimental design was a randomized complete block performed in four villages using two locations per village with one location of sorghum and one location of millet. The treatments included 0 of Rock Phosphate (VP), 50 kg/ha VP placed in the seed pocket, 100 kg/ha VP placed in the seed pocket, 200 kg/ha placed in the seed pocket, 50 kg/ha VP side band application, 100 kg/ha VP side band application, 200 kg/ha VP side band application, 200 kg/ha VP broadcasted, and 400 kg/ha VP broadcasted. (NOTE: 50 kg/ha urea was applied as a side dress during first weeding to all plots.) The plot sizes were 4.8 m x 8 m (6 rows x 8 m) with a plant population of approximately 66,700 plants/ha. The local variety utilized by the farmers in each village was planted.

The results are shown in Tables 34 and 35. The analysis of yield for sorghum does not show a significant difference for treatments. The analysis for millet shows significant difference for treatments even though only one of the four individual location analyses was significant. Observations throughout the growing season were the same for all locations of sorghum and millet and there were no obvious differences between methods or rates of application.

Table 34: Volta Rock Phosphate Trial on Sorghum; Summary of Analysis: Bangasse, Diapangou, Yako; Analysis of Variance for Yield (Kg/Ha).

SOURCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F TEST
Locations	2	1,645,730	822,864	
Blocks	3	121,200	40,400	
Error (a)	6	1,128,080	188,014	
Treatments	8	433,756	54,220	NS
Location x Treatments	16	460,672	28,792	NS
Error (b)	72	2,663,936	36,999	

CV = 27.9

Summary of Means

FACTOR	KG/HA
LOCATIONS	
Bangasse	842.0
Diapangou	539.7
Yako	680.1
TREATMENTS	
0 Volta Phosphate (V)	639.9
50 Kg/Ha VP in Seed Pocket	661.5
100 Kg/Ha VP in Seed Pocket	708.4
200 KG/HA VP in Seed Pocket	656.7
50 Kg/Ha VP in Side Band	607.2
100 Kg/Ha VP in Side Band	701.8
200 Kg/Ha VP in Side Band	704.0
200 Kg/Hs VP Broadcast	845.1
400 Kg/Ha VP Broadcast	678.8

Table 35: Volta Rock Phosphate Trial on Millet; Summary of Analysis: Nedogo, Bangasse, Diapangou, Yako; Analysis of Variance for Yield (Kg/Ha).

SOURCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F TEST
Locations	3	5,373,140	1,791,050	
Blocks	3	280,916	93,639	
Error (a)	9	673,040	74,782	
Treatments	8	734,976	91,872	2.79 *
Location x Treatments	24	949,832	39,576	NS
Error (b)	96	3,163,164	32,950	

CV = 28

Summary of Means

FACTOR	KG/HA	lsd (.05)
LOCATIONS		
Nedogo	811.0	
Bangasse	862.1	
Diapangou	406.4	
Yako	512.1	
TREATMENTS		
0 Volta Phosphate (V)	599.2	
50 Kg/Ha VP in Seed Pocket	636.8	
100 Kg/Ha VP in Seed Pocket	647.9	
200 KG/HA VP in Seed Pocket	596.7	
		128.4
50 Kg/Ha VP is Side Band	704.8	
100 Kg/Ha VP in Side Band	574.0	
200 Kg/Ha VP is Side Band	567.8	
200 Kg/Hs VP Broadcast	797.1	
400 Kg/Ha VP Broadcast	706.6	

7. Maize variety trials on compound plots: These trials evaluated improved maize varieties with and without applications of fertilizer. The experimental design was a split plot with the main plots receiving treatments of fertilizer and the subplots were varieties. These were performed in three villages using two locations per village with four replications per location. The treatments included two levels of fertilizer applications at all locations: level one was 0 and level two was 100 Kg/Ha cotton fertilizer (14-25-15 NPK) plus 50 Kg/Ha urea side dress. The varieties planted at Nedogo were Pool 16, UST 42, and the local variety while the varieties planted at Diapangou and Bangasse were SAFITA 104, SAFITA 2, and the local variety. The plot sizes were 4.8 m x 7 m (6 rows x 7 m) and plant populations of approximately 66,000 plants/Ha.

The results are shown in Tables 36 and 37. The summary analysis of two locations at Nedogo revealed no significant differences due to fertilizers with variety UST 42 performing significantly worse than Pool 16 and the local. The results of one location at Bangasse and two locations at Diapangou show no significant differences between fertilizer treatments or varieties.

Table 36: Maize Variety Trial; Summary of Two Locations, Nedogo; Analysis of Variance for Yield (Kg/Ha).

SOURCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F TEST
Locations	1	1,070	1,070	
Blocks	3	839,240	279,747	
Error (a)	3	834,208	278,069	
Fertilizer Treatment	1	10,959	10,959	NS
Location x Fertilizer Treatment	1	105,928	105,928	NS
Error (b)	6	1,543,560	257,260	
Varieties	2	2,584,780	1,292,390	8.30 **
Location x Varieties	2	121,016	60,508	NS
Varieties x Fertilizer	2	706,372	353,186	NS
Location x Varieties x Fertilizer	2	182,508	91,254	NS
Error (c)	24	3,737,062	155,710	

CV = 45.7

Location Means

LOCATION	KG/HA
NEDOGO 1	868.7
NEDOGO 2	859.6

Treatment Means (Kg/Ha)

FERTILIZER	VARIETIES			$\bar{X}$
	POOL 16	UST 42	LOCAL	
Without Fertilizer	926.0	545.1	1076.0	879.3
With Fertilizer	1265.7	549.0	823.1	849.0
$\bar{X}$	1095.9	547.1	949.6	

1SD (.05) = 238.7

Table 37: Maize Variety Trial; Summary of Bangasse and Diapangou; Analysis of Variance for Yield (Kg/Ha).

SOURCE	DEGREES OF FREEDOM	SUM OF SQUARES	MEAN SQUARES	F TEST
Locations	2	9,069,156	4,534,578	
Blocks	3	490,176	163,392	
Error (a)	6	4,366,300	727,717	
Fertilizer Treatment	1	529,952	529,952	NS
Location x Fertilizer Treatment	2	910,176	455,088	NS
Error (b)	9	6,397,440	710,826	
Varieties	2	652,320	326,160	NS
Location x Varieties	4	910,176	455,088	NS
Varieties x Fertilizer Treatment	2	1,268,290	634,144	NS
Location x Fertilizer x Varieties	4	2,373,820	593,456	NS
Error (c)	36	10,331,550	286,988	

CV = 22.0

Location Means

LOCATIONS	KG/HA
Bangasse	1859.1
Diapangou 1	2617.1
Diapangou 2	2608.8

Treatment Means

	VARIETIES			
FERTILITY	SAFITA 104	SAFITA 2	LOCAL	$\bar{X}$
Without Fertilizer	2485.5	2459.3	2395.7	2446.8
With Fertilizer	2017.2	2236.8	2571.5	2275.1
$\bar{X}$	2251.3	2348.1	2483.6	

B. Farmer-Managed Trial

The 1982 trial evaluated two methods of fertilizer application in association with one method of water conservation designated "modified" tied-ridges. Of equal importance was the evaluation of an approach for conducting large scale on-farm farmer-managed trials.

1. Approach: Thirty households were selected in Bangasse, Nedogo, and Diapangou. Four treatments plus the traditional methodology were used on the largest family cereal (millet - sorghum) field. Before planting, a portion of the field was measured and subdivided into five equal plots. The farmer was asked to consider these as five separate fields. During the season, agronomic and socio-economic data were taken on these five fields.

2. Treatment: These included five designations: treatment 80 used traditional manageme . techniques; treatment 81 used traditional management plus the technique of modified tied-ridges[5] placed during the second weeding; treatment 82 used 100 kg/ha Volta Phosphate (VP) applied in the seed pocket and 50 kg/ha urea applied as a side dressing at the first weeding with the modified tied-ridges being placed after the second weeding; treatment 83 used 200 kg/ha VP and 50 kg/ha urea applied as side dressings during the first weeding; treatment 84 used 100 kg/ha VP applied in the seed pocket and 50 kg/ha urea applied as a side dressing at the first weeding.

3. Field design and methodology: The following is an example of a typical field. The treatments were randomly assigned to the plots in each field.

84 81 80 82 83

The size of the plots varied from field to field but the average size of each plot was approximately .15 hectares and all plots in the same field were of equal size. Color coded stakes were used to identify the treatments and all questions asked of the farmer were with respect to the black, red, green, yellow, or blue field. The

[5]The technique of modified tied-ridges consists of creating a small depression between the seed rows either by hand tillage or animal traction. If done by hand tillage, depressions (32 cm long x 24 cm wide x 16 cm deep) are made between rows and spaced 1-1/2 meters apart. If done by animal traction, the cultivator must be equipped with a middle sweep to create a furrow, then followed by hand tillage to make a 16 cm high ridge perpendicular to the furrow every meter.

plots in each field were measured and the exact area determined. At harvest, the off-take from each plot was weighed and a sample was taken for determination of threshing percentage.

The results are shown in Table 38. The farmers in Bangasse and Nedogo followed the protocol for all treatments; whereas, the farmers in Diapangou planted the trial plots much later than their traditional fields. Also at Diapangou, the fertilizer to be applied at the first weeding was added too late and the tied-ridges, when constructed, were very poorly done. The major reason for the departure from protocol in Diapanogu was in communicating the need for timely application of the treatments. For these reasons no economic data will be presented for Diapangou.

Table 38: Results of 1982 FSU Farmer-Managed Trials

	81 vs 80	82 vs 80	83 vs 80	84 vs 80
MEAN YIELD/TRMT 80 EQUALS 435 kg/ha		BANGASSE		
Mean Difference Kg/Ha Between 2 Treatments	24(36)	53(38)	71(24) **	0(29)
Mean Difference Hr/Ha for Planting	0(4)	29(7) ***	5(7)	31(8) ***
Mean Difference Hr/Ha for 2nd Weeding	102(16) ***	98(26) ***	13(7) *	9(9)
MEAN YIELD/TRMT 80 EQUALS 345 KG/HA		NEDOGO		
Mean Difference Kg/Ha Between 2 Treatments	11(16)	118(28) ***	43(32)	75(28) **
Mean Difference Hr/Ha for Planting	1(1)	19(3) ***	1(1)	16(3) ***
Mean Difference Hr/Ha for 2nd Weeding	31(14) **	54(13) ***	22(10) **	22(14)
MEAN YIELD/TRMT 80 EQUALS 484 KG/HA		DIAPANGOU		
Mean Difference Kg/Ha Between 2 Treatments	12(37)	30(28)	7(29)	10(36)
Mean Difference Hr/Ha for Plantings	3(4)	39(7) ***	0(5)	33(8) ***
Mean Difference Hr/Ha for 2nd Weeding	96(48)	136(64) *	16(16)	41(24)

Designation	Treatment
80	Traditional
81	Modified Tied-Ridges
82	100 Kg/Ha VP in the seed pocket + 50 Kg/Ha urea side dress + Modified tied-ridges.
83	200 Kg/Ha VP and 50 Kg/Ha urea side dress
84	100 Kg/Ha VP in the seed pocket + 50 Kg/Ha urea side dress.

Numbers in parenthesis are:
* significant t test 90% probability
** significant t test 95% probability
*** significant t test 99% probability

In general, the results were as expected. Large increases in yield due to small applications of Volta Phosphate and urea were not observed the first year. It was hoped that yield increase would be sufficient to pay for the cost of the fertilizer and labor inputs and that, if the same treatments were applied for several years, the farmer would achieve a net gain in production adequate to partially restore soil fertility and to reduce soil erosion. When compared with the traditional treatment (80), treatments 82 and 83 were significantly different from 80 at Bangasse. Economic analysis of these differences follows in the next section.

One major question at the beginning of 1982 was what was the optimal experimental design and sample size which would detect small increases in yields on farmer-managed trials. This year's results indicate that the design and sample size chosen for 1982 gave significant yield differences among treatments for as low as 70 kg/ha.

C. Cost Considerations and Economic Analysis of the 1982 Farmer-Managed Trials.

Three kinds of costs were considered in evaluating these agronomic treatments. Cash cost is easily calculted. Evaluating labor inputs should ideally be expressed in terms of their opportunity cost or highest alternative use. Since these values were not yet available, the average return (or loss) to labor is calculated as an indication of the return a farmer would have to secure in other uses of labor to make it more attractive than that used in the technology being evaluated. The risk associated with each treatment must also be considered. Even though an average farmer may gain from the use of a technology, if he knows that there is a risk that he may lose money, he might discount the value of his expected gains.

1. The Results of the Trial at Nedogo: These are shown in Table 39 for tied-ridges alone (Treatment 81) when millet is valued at 65 FCFA per kilogram. The treatment demonstrates a cash gain of 715 FCFA per hectare. This constitutes a return of 23 FCFA per hour of labor required to add tied-ridges and there is no risk of cash loss. This is not a promising treatment statistically because the yield increment is not significant and the treatment does nothing to restore the fertility of the soil.

With Treatment 82, which combines phosphate in the seed pocket, urea, and tied-ridges, the mean increment in yields covered cash costs and returned 1887 FCFA per hectare. Incremental labor estimated to be 71 hours per hectare receives a residual of 27 FCFA per hour. With the exception of a very high (.50) risk of cash loss, this is a promising trial. With experience, farmers may reduce labor times required to construct tied-ridges and to apply fertilizer. Further residual effects of phosphate may add to yields in succeeding years. This was the most promising treatment at Nedogo.

Treatment 83, which used 200 kg/ha of broadcast phosphate and 50 kg/ha of urea, was the least promising treatment. The residual effects of phosphate would have to raise yields by about 85 kilograms per hectare in order to cover cash costs. This is considered to be highly unlikely.

Treatment 84, using urea and 100 kg/ha of phosphate in the seed pocket, showed that this treatment would have to have significant yield gains from the residual effects of phosphate to cover cash cost and labor returns.

Table 39: Economic Analysis of Farmer-Managed Trials; Nedogo, 1982.

	TRIALS			
	81 vs 80	82 vs 80	83 vs 80	84 vs 80
Yield, Mean Difference (Kg/Ha)	11	117.5	42.9	75
Cash Gain 65 FCFA/KG	715	7637	2789	4875
Cash costs of Trial:				
Urea	0	3250	3250	3250
Phosphate	0	2500	5000	2500
Net Revenue of Trial: (Cash Gain minus Cash Costs)	715	1887	-5463	-875
Labor Increase of Trial Over Traditional Methods (Hr/Ha):				
Planting		18		18
Fertilizing		14	14	14
Tied-Ridges	36	36		
Total Labor Increase	36	68	14	32
Returns to Increased Labor (CFA/Hr)	20	28	—	—
PROBABILITY OF CASH LOSS	0	50%	78%	61%
PROMISE	UNCERTAIN	PROMISING	DOUBTFUL	UNCERTAIN

2. Results of Trials at Bangasse: These are shown in Table 40. In Treatment 81, tying the ridges at second weeding resulted in a net revenue increase of 1,755 CFA/Ha. This constituted a gain of 19 Francs CFA per hour spent tying the ridges, slightly lower than average returns to labor for traditional methods.

Although Treatments 82 and 83 resulted in substantial yield increases, in neither case was the value of the increased production sufficient to cover the costs of the application of fertilizers. The additional effect of using tied-ridges in trial 82 was not obvious.

In Treatment 84, no significant yield increase was detected.

Table 40: Economic Analysis of Farmer-Managed Trials; Bangasse, 1982.

	TRIALS			
	81 vs 80	82 vs 80	83 vs 80	84 vs 80
Yield, Mean Difference (Kg/Ha)	27	53	71	0
Cash Gain 65 FCFA/KG	1755	3445	4615	0
Cash costs of Trial:				
Urea 65 cfa/kg	0	3250	3250	3250
Phosphate 25 cfa/kg	0	2500	5000	2500
Net Revenue of Trial: (Cash Gain minus Cash Costs)	1755	-2305	-3635	-5750
Labor Increase of Trial Over Traditional Methods (Hr/Ha):				
Planting		30		30
Fertilizing		11	11	11
Tied-Ridges	94	94		
Total Labor Increase	94	135	11	41
Returns to Increased Labor (CFA/Hr)	19	--	--	--
PROBABILITY OF CASH LOSS	0	100%	100%	100%
PROMISE	UNCERTAIN	DOUBTFUL	DOUBTFUL	DOUBTFUL

D. Implications for Future Trials.

The results of the researcher-managed trials identified two very promising technologies which should be elevated to the level of farmer-managed trials in 1983. Tied-ridges made 30 to 35 days after planting on maize grown on compound plots resulted in a 23 percent yield increase over traditional methods. Tied-ridges made 30 to 35 days after planting on sorghum plus the use of 100 Kg/Ha cotton fertilizer (engrais coton) and 50 Kg/Ha urea resulted in a 193 percent yield increase over traditional methods. Information is now needed on the yield increase under farmer-managed conditions and the labor required to make the tied-ridges. To obtain this information, these two trials will be conducted in 1983 using the same design as was used with our Volta Phosphate trials on millet fields in 1982.

The economic analysis of the Volta Phosphate farmer-managed trials did not indicate any of the four treatments to be highly promising. However, this trial will be continued in 1983 in the same fields and the same parcels to determine the benefit of the residual phosphate and the water conservation of the modified tied-ridges constructed in 1982.

V. CONCLUSIONS AND IMPLICATIONS OF THE 1982 PROGRAM

During 1982, socio-economic research by FSU focused on the farmer's goals and objectives, factors affecting the farmer's resource use decisions and the production constraints within which he operates. Agronomic research focused on soil fertility and water conservation themes for millet. This research has identified key features of the farming systems within three villages which should guide future agronomic and socio-economic research.

1. The farmers of the Central Plateau and many on its perimeter are subsistence farmers. Their working objective is not to acquire cash for consumption or investment. It is rather to avert risk -- to minimize the likelihood that their food consumption needs in current and in future years will not be met.

2. These farmers base their resource use decisions on soil quality, timeliness of rains, and their available labor supply. They plant less sorghum than they wish because soil quality (fertility and moisture retention) is low and because rainfall is unreliable. They plant as much millet as their labor supply permits. They plant peanuts mainly to pay taxes and very little more because the planting of peanuts competes with their millet crop which is considered more important than cash.
3. Land is rarely fallowed and, in the absence of added fertilizer or natural organic matter, subject to continuing deterioration. Increasingly acreage is shifted from sorghum to millet, already the dominant crop.
4. Risk is a major factor in the cropping decision. Expected yields (and expected revenues) of sorghum and peanuts are superior to those for millet. But, millet is planted more extensively because its yield is less variable than that of sorghum or peanuts. While the farmer expects lower yields when planting millet, he is also less concerned that his yield will be catastrophically low as can be the case with sorghum or peanuts.
5. After soil quality and timeliness of rain, the binding production constraint is reached during the first weeding period. While demanding, the second weeding period and the interim which follows offers a relatively slack labor period.
6. On the central plateau, donkey traction offers favorable returns to extensification on marginal land where such land is accessible. In the land abundant zone around Diapangou, both donkey and ox traction offer favorable returns to intensification.

The following conclusions are drawn from these findings:

1. With current technology, subsistence (non-commercial) farmers cannot be expected to apply many, if any, purchased inputs (fertilizer) to their fields.

2. As a result, the reduction in soil fertility and yields will continue. This will provide a growing incentive to extensive farming, partially aided by animal traction, and focusing on millet.
3. The inevitable result of this trend is the emergence of serious land access and land tenure issues. It is assumed here that intensification of farming is a preferable alternative.
4. Intensification through the application of purchased inputs is not, for most farmers, a viable alternative. Even if expected returns to the use of fertilizer are adequate to cover cash costs, such technologies introduce cash risks to farmers who are often not part of a cash economy. They cannot be expected to assume more than minimal cash risks.
5. In developing new technologies, the use of non-cash inputs must be exploited as much as possible to minimize associated production and cash risk to new or potential adopters.

These conclusions should be considered in the choice of future agronomic trials, in future socio-economic research and in the continuing analysis of data assembled during 1982.

Implications for Agronomic Trials

1. Given the continuing deterioration of soil fertility and the limited supply of local organic matter, it is essential that some purchased fertilizers be incorporated in future agronomic trials. However, the lowest cost applications of fertilizer, those which can generate joint products with non-purchased inputs, stand the best chance of adoption by the farmers on the central plateau.
2. The second weeding is less intensive relative to the first weeding period. The period surrounding second weeding is slack for agricultural purposes until harvest. Labor demands drop slightly as planting activity winds down and first weeding is beginning. Any new technology which draws upon labor would have to use labor during these periods unless accompanied by some labor-saving effect.

3. Increasingly, trials should focus on crops for which farmers indicate a preference. They wish, for expamle, to produce more sorghum relative to millet. They do not because they don't have enough "sorghum land." The same may be true of corn; and, where labor is not scarce, of peanuts. Farmers are more likely to invest both time and cash in a technology that would reduce the risk of catastrophic shortfalls in sorghum production than to increase yields of millet which they find to be relatively risk free.
4. Only these trials for which break-even increases are adequate to reduce risk of catastrophic shortfalls should be attempted.
5. The development of new technology should focus first on the reduction of risk to the farmer. It is the risk of catastrophic shortfall that currently prevents the farmer from planting more sorghum. The aim of the agronomic trials program should be to bring farmers to a commercial level of production with a minimum of purchased inputs.

Implications for socio-economic research: The major findings of 1982 point to several specific research themes related to risk, factors explaining the adoption of fertilizer and movement into commercial production. Specifically, the following objectives should be pursued:

1. To measure the level of risk assumed by farmers under different grain security positions, different cropping patterns, and using different technologies.
2. To estimate the levels of risk at which farmers will shift production from one crop to another. (For example, what is the relationship between grain in storage and sorghum or peanut hectares planted?)
3. For those farmers who use fertilizer, to determine what factors explain their decision to do so.
4. To determine what factors explain the share of production which is marketed. (At what level of grain security does the farmer become price-responsive?)

5. To determine the rate of marketings from family fields and personal fields and the factors explaining the allocation of land to personal fields.
6. To determine farmers' access to credit and factors affecting their decisions to use it.
7. To learn more about the role of livestock in risk management. (As an aid in assessing the level of risk assumed by farmers.)
8. To estimate the off-farm opportunity cost of labor as an aid in evaluating returns to labor used in new technologies.
9. To understand the land tenure process and the degree of access to land on the central plateau.

The 1983 FSU research program directly addresses these issues and others. The program is organized to process data throughout the year and, while covering a wider range of subject matter, carries a lower data processing burden than did the 1982 research program. It focuses directly on the major constraints and technology adoption issues identified during 1982 and should provide more detailed guidance to the design of future trials.

APPENDICES

Appendix A. Fiche 11

Appendix B. Fiche 12

Appendix C. Decision Making Interview

Appendix D. Fiche 04

Appendix E. Derivation of Productivity Fomula for Labor Types

FICHE 11

TEMPS DE TRAVAIL, INTRANTS ET RENDEMENTS

Village	Ménage	Champ	Unité de mesure

Propriétaire du champ	Identification du champ

JOUR	Parcelle	Culture	Activité Agricole	TEMPS DE TRAVAIL Catégor.	HEURES HOMMES	HEURES FEMMES	HEURES ENFANT	TRACTION ANIMALE ANIM Nbre	ANIM Type	Equipem.	Location	HEURES TOTALE	INTANT, DEPENSES, RENDEMENT Catégor.	Type d'intrant	Unité de Mesure	NOMBRE D'UNITE	Forme	Kilogram.

I HE 12

AGGREGATION HEBDOMADAIRE
(Temps Travail,
Intrants ec Rendement)

Village	Ménage	Champ	Type de champ

Propriétaire du champ	Identification du champ

					TEMPS DE TRAVAIL			TRACTION ANIMALE					INTRANTS, DEPENSES, RENDEMENT				
								ANIM									
Semaine	Parcelle	Culture	Activité Agricole	Catégor.	HEURES HOMMES	HEURES FEMMES	HEURES ENFANTS	Nbre	Type	Equipem.	Location	HEURES TOTALES	Catégor.	Type d'Intrant	Kilogram.	Forme	FRANC CFA

ENQUETE SUR LA GESTION ET L'EXPLOITATION

1) Quels sont les buts que vous poursuivez en exploitant votre terre ?
Y-a-t-il des objectifs qu'il faut atteindre chaque année ?
Si oui, quels sont ces objectifs ?

2) Pendant les dix dernières années, quelles sont celles au cours desquelles vous avez acheté des grains ? (Encerclez les années concernées)
1982, 1981, 1980, 1979, 1978, 1977, 1976, 1975, 1974, 1973.

3) A quelle fin avez-vous acheté ces grains ? (Insuffisance de nourriture, mariage, baptême, funéraille, commerce, autre, spécifiez)

4) De quelle source provenait le bien qui a servi à payer les grains ? (Vente d'aniamux, produits d'artisanat, commerce, dons etc...)

5) Pendant les dix dernières années, quelles sont celles au cours desquelles vous avez vendu des grains? (Encerclez les années concernées)
1982, 1981, 1980, 1979, 1978, 1977, 1976, 1975, 1974, 1973

6) Pour quels motifs avez-vous fait ces ventes ?
(Payer les impôts, acheter un bien d'équipement agricole, habitat, scolarité, déplacement, élévage, autre ... spécifiez).

7) Des dix dernières années, quelle a été la plus mauvaise en terme de production agricole ? (Encerclez l'année)
1982, 1981, 1980, 1979, 1978, 1977, 1976, 1975, 1974, 1973.
Pourquoi ?

8) En rapport avec la réponse de la question 7, avez-vous changer ou modifié quelque chose dans la gestion de votre système d'exploitation depuis l'année indiquée ci-dessus ?
(Système de labour, équipement, achat d'animaux, changement de variétés ou de culture, activités non agricoles, etc... spécifiez)

9) La non-régularité des pluies provoque de grandes variations dans les productions agricoles annuelles. On a ainsi des bonnes années et de mauvaises années. Cependant bon an, mal an, vous devez nourrir votre famille. Quelle stratégie principale utilisez-vous pour résoudre ce problème ? (Stock de sécurité d'une année à l'autre, achat dès les récoltes, investir dans les animaux le bonnes années et revendre aux mauvaises années, autre ... spécifiez)

10) Donnez, par ordre décroissant, vos quatre plus grandes cultures en terme de superficie couverte.
Listez (1. _____ 2. _____ 3. _____ 4._____)
Pour chaque culture, pourquoi ne semez-vous pas plus de celle-ci ?
1.

2.

3.

4.

11) Pour chacune des cultures citées, pourquoi n'en semez-vous pas moins ?
1.

2.

3.

4.

12) Si vous pouviez varier l'importance relative des superficies de vos cultures, laquelle augmenteriez-vous au détriment de laquelle ?
Pourquoi ?

13) Pour chacune des quatre principales cultures, à quelle période de l'année les vendez-vous ? Pourquoi à cette période ? A quelle fin ? (Périodes possibles : entre les récoltes et la fin de l'année, de Janvier à Avril, Mai à Juillet, Août à Octobre)

Culture 1.

Culture 2.

Culture 3.

Culture 4.

14) Dans une année normale, quelle produit agricole vous rapporte le plus de revenu monétaire ? Avez-vous une autre source plus importante de revenu monétaire ? (Commerce, élévage, artisanat, cadeaux, autre...)
Si oui, laquelle ?

15) Les prix des produits agricoles sur le marché détermient-ils votre décision quant aux cultures à semer ? La date de la vente ? Pour quelles cultures ?

16) Avez-vous suffisamment de terres pour vos besoins en culture ?

17) Cultivez-vous principalement sur vos terres personnelles ou en empruntez-vous ?

../..

18) L'accès à la terre est-il une grande difficulté ? Pourquoi ?

19) Donnez votre jugement personnel de la qualité des terres que vous exploitez. (En terme de fertilité)

20) Selon vous, entre les difficultés d'accès de la terre et leur qualité, lequel est le plus contraignant pour l'augmentation de votre production ?

21) De tous les intrants agricoles modernes (semences, pesticides, fertilisants, etc...) lequel est le plus profitable pour vous et pourquoi ?

- Lequel est le moins profitables pour vous et pourquoi ?

22) Au cours des cinq dernières années, la superficies totale de vos champs a-t-elle augmentée ? Pour quelle culture ?

- Cette augmentation a-t-elle affecté l'utilisation de la main d'oeuvre dans les autres champs ? Et comment ?

23) Le manque de main-doeuvre est-il une contrainte pour vous pour l'augmentation de votre production agricole ? Si oui, pour quelle activité agricole en particulier ?

24) Vous est-il déjà arrivé d'engager de la main d'oeuvre pour vos travaux agricoles ?
Pour quelle activité agricole en particulier ?

- Si vous deviez engager de la main d'oeuvre, pour quelle activité agricole le feriez-vous ? Pourquoi ?

25) Classez par ordre de priorité décroissante, les problèmes liés aux préoccupations suivantes :
Rareté de la terre

Pauvreté de la terre

Manque de main-d'oeuvre

Mauvaises pluviométries.

FICHE 4 CARACTERISTIQUES DU CHAMP

Enquêteur_____ Date de mesurage_____

Culture sur le champ Distance de la concession_____

	Code	Disposition
1		
2		
3		
4		

VILLAGE	MENAGE	CHAMP	ANNEE

Propriétaire du champ

Identification du champ

Côté	Longueur (mètres)	Angle (degré)	Côté	Longueur (mètres)	Angle (degré)
1			22		
2			23		
3			24		
4			25		
5			26		
6			27		
7			28		
8			29		
9			30		
10			31		
11			32		
12			33		
13			34		
14			35		
15			36		
16			37		
17			38		
18			39		
19			40		
20			41		
21			42		

CROQUIS DU CHAMP

NORD

Superficie_____hectares

Erreur de Distance_____%

CARACTERISTIQUES DU CHAMP

Histoire du champ						
Année	Cultures (1)	(2)	(3)	Engrais Type	Dose	Fumier Dose
81						
80						
79						

Le champ a été cultivé continuellement depuis combien d'an [ ]

Est-ce que le champ est emprunté [ ]

Situation sur la toposéquence [ ]

1. Plateau
2. Supérieure
3. Intermédiaire
4. Inférieure
5. Bas-fond

Type de sols..... A [ ] B [ ] C [ ]

1. Gravillon
2. Sable
3. Limon
4. Argile

Erosion ..... [ ]

1. Faible
2. Moyenne
3. Greve

Date	Observations (insectes, maladies, etc.)

RECOLTE

Culture						
Tas ou classe des tiges						
Date						
Poids total non battu						
Poids du sac Echantillon sec et battu						
Poids du sac Echantillon sec et battu						
Pourcentage du battage (C/B)						
Poids total battu (D X A)						

Culture	Rendement Total battu

A	
B	
C	
D	
E	
F	
G	
H	
I	
J	

Appendix E. Derivation of Productivity Formula for Labor Types

The relative productivity of different labor types (men, women, children, donkeys, oxen) can be estimated econometrically given obervations across field and different combinations of labor types.

The hours per hectare required to accomplish a given task (such as weeding) varies across fields for several reasons. The relative proportion of man-hours, child-hours, etc., will explain a portion of that variation. Therefore, by deriving coefficients for each labor type that will minimize the variance of hours spent per hectare across fields, we can (1) show the amount of variation explained by differences in labor productivity (only that which is attributable to differences between groups) and (2) estimate the relative productivities of each labor type directly from the coefficients.

We have: $Y = Xb + c$

where Y = vector of expected hours for each field (area times mean hours per hectare)

X = matrix of hours spent by labor type across fields

b = vector of relative productivities

c = constant

Regression analysis using this formula was unsatisfactory for two reasons. First, the distribution of field sizes, and therefore, of total expected hours is highly skewed. Second, often a relatively large constant term was responsible for biased coefficients. To solve these problems independent and dependent variables were normalized (divided by the field sizes) and then "re-weighed" (multiplied by a set of random numbers with mean = 0). This replaced the actual field area weights with a set of weights that are normally distributed. This resolves both the problem of non-normality and it will result in a constant term approaching zero. Otherwise the transaction should have no effect on the relationships estimated.

For the set of observations:

h_i =

x_i = labor hours by labor type i

y_i = area of field i

with the vector of random numbers r

we can specify for the regression:

$$Hr = (r \quad x_i/y_i) \; b + c$$

so, we estimate the equation:

$$Hr_i = a + bm_ir_i + cw_ir_i + dc_ir_i + fA_ir_i + gO_ir_i$$

where m_i = men A_i = donkey

w_i = women O_i = oxen

c_i = children

and drew upon the estimated coefficients to weight labor hours by type and to convert these to "man-units" of labor which could then be aggregated.