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SEMI-ARID FOOD GRAIN RESEARCH AND DEVELOPMENT PROGRAM

FARMING SYSTEMS RESEARCH UNIT

(Contract AFR-C-1472)

1985 ANNUAL REPORT

SEMI-ARID FOOD GRAIN RESEARCH AND DEVELOPMENT PROGRAM

(Contract OAU/STRC - Joint Project 31)

FARMING SYSTEMS RESEARCH UNIT IN BURKINA FASO

1985 ANNUAL REPORT

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between
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and
Purdue University

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Prepared by:
Joseph G. Nagy
Herbert W. Ohm

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I. INTRODUCTION

The Purdue University farming systems unit (FSU), a component of the Semi-Arid Food Grain Research and Development Program (SAFGRAD), funded by the United States Agency for International Development (USAID) - Contract AID/AFR-C-1472 completed its seventh and final year of its contract on March 31, 1986. The mandate for the final period April 1, 1985 to March 31, 1986 differed from the previous major program goals of 1) identifying the constraints to increased food production and 2) identifying technologies appropriate for farmers in semi-arid West Africa which can alleviate the constraints (Ohm et al., 1985). The specific description of services to be performed in the final year was as follows:

1. Complete the transfer of the FSR methodology and techniques gained under this contract to national research organizations in the SAFGRAD countries.
2. Finalize analyses of empirical research results and publish these in French and English for use in interested countries.
3. Finalize and publish guidelines for the methodological, analytical, or organizational and operational conduct of Farming Systems Research in the SAFGRAD region and in similar developing countries.
4. In conjunction with the SAFGRAD Coordination Office, complete the groundwork for a West African regional FSR network.

In addition to the above, an End of Project Report was submitted to USAID. This final annual report discusses the FSU accomplishments for the period of April 1, 1985 to March 31, 1986 of items 1, 2 and 4 of the description of services above. Item 3 is presented in a separate document.

II. TRANSFER OF THE FARMING SYSTEMS PROGRAM

The national research organizations in the countries of Burkina Faso, Benin, and Cameroon were designated by SAFGRAD for a transfer of FSU's program and methodology. The contract between SAFGRAD and Cameroon was negotiated just prior to FSU's departure, leaving only Burkina and Benin to interact with.

A. Program Transfer in Burkina Faso

The FSU program and part of its staff were transferred to the National Farming Systems Program (NFSP) of the Institut Burkinabe de Recherches Agronomiques et Zootechniques (IBRAZ). 1986 was the first year of operation for the NFSP. The NFSP coordinator is Mr. Sibiri Sawadogo, a former employee of FSU for five years. Mr. Sawadogo had worked with all three FSU professional teams and thus was a very good choice by IBRAZ for program continuity. Continuity with the FSU program was further established by transferring to NFSP three of the best FSU field staff, two highly competent office staff and the typist along with two chauffeurs.

Negotiations for the transfer began in the fall of 1985 but were slow to develop. Many meetings were held involving the Director of IBRAZ, the Minister of Research and Higher Education, the Committee for the Defense of the Revolution (CDR) and the Office of Labor. Many administrative and procedural problems had to be worked out. Because of the low education levels of the staff that were transferred to the NFSP, special negotiations with the government were required before they could be hired. This also delayed the transfer. The transfer was made at the end of May 1986--very late for the 1985 field research program.

Extensive meetings were held in the April-June period with the NFSP Coordinator and the two new SAFGRAD Farming Systems team (SFS) members who were to work as a unit within the NFSP. The SFS members included a Soil Scientist and a Livestock Specialist who arrived in mid-March 1985 and were joined by an economist in September 1985. The purpose of the meetings was to acquaint the new SFS staff with FSU research and experiences and lay out the 1985 field research protocols. NFSP and SFS decided to continue work in three of the five established FSU villages (Nedogo, Poedogo and Diapangou) and continued most of the FSU field program.

Because of extensive delays in the hiring of field staff, FSU agreed to provide leadership and advisory input for conducting the new on-farm farmer-managed trial of the IITA/SAFGRAD mechanical ridge tier that was conducted by the NFSP. All field workers and inputs were supplied by NFSP. FSU, through Mr. Lee Schaber, a Peace Corps Volunteer (PCV), provided advisory support in the field. The FSU report on the mechanical ridge tier has been

published (Nagy et al., 1986a) and is reproduced in this report in the Appendix.

B. Program Establishment in Benin

Two new SFS personnel, an agronomist and an economist, were assigned to work with the national research program at Ina research station at Parakou. While in Ouagadougou for their briefing with SAFGRAD, several meetings were held with FSU to outline previous FSU experience and to work on the 1985 protocol for the field trials. The Benin SFS personnel were late in arriving and the planning for the 1985 field and socio-economic campaign was very rushed.

At the request of the Director of Research, OAU/SAFGRAD, a field trip was made to Ina research station by Dr. J. G. Nagy 20-24 November 1985 (Trip Report on file with IPIA, SAFGRAD and USAID). The purpose of the trip was to provide advisory assistance for the program establishment in Benin and report problems and accomplishments to the Director of Research, SAFGRAD Coordination Office.

III. PROJECT ACTIVITIES AND PUBLICATIONS

A. Workshop and Proceedings Publication

A significant portion of FSU and IPIA resources and staff time were spent in the organization of the workshop and the publishing of the proceedings from the workshop.

After nearly two decades of intensive agricultural research, at experiment stations and more recently on-farm, the question needs to be asked: What technologies have been developed which appear to be appropriate to the WASAT, and what are the promising research directions?

To answer these questions, FSU, with encouragement from the national and international research community at Ouagadougou, provided leadership to organize a workshop. The workshop, Appropriate Technologies for Farmers in Semi-Arid West Africa, took place at Ouagadougou from 2 to 5 April, 1985.

The primary objective of the workshop was to assess agricultural technologies currently available in the region and focus on technology needs and new avenues of research.

Twenty-two papers were presented in four sessions. Session I included two general papers on soil and water management and soil fertility outlining research experiences to date. Each general paper was followed by case study papers. Two general papers were presented in Session II on plant improvement and crop associations and were followed by case studies in each area. Papers on livestock were presented in Session III. Session IV focused on technology needs and promising avenues of research, technology evaluation, and the broader aspect of the interface between production and future consumption patterns and the implications for new technology design. Each session was followed by in-depth group discussions. The discussions of the first three sessions focused mainly on the micro issues involved in technology design and dissemination while the discussion in Session IV focused on macro policy issues.

Workshops and workshop proceedings provide an important vehicle for researcher interaction and they provide an outlet for publication and dissemination of research findings. This is particularly true of regions such as the WASAT where there are limited opportunities for publication of research results. This workshop was an opportunity for more than 60 scientists and agricultural administrators from national and international research institutions who are engaged in research in the WASAT to participate in an exchange of research information and extensive discussions of ideas. We believe that the topics covered and the papers that were presented add significantly to the information base in the WASAT. In particular, the general papers along with several of the case study papers can serve as a basis for future research directions in resolving some of the complex problems of the WASAT.

The Proceedings were published in both English and French and is entitled "Appropriate Technologies for Farmers in Semi-Arid West Africa," 1985, H. W. Ohm and J. G. Nagy (eds.), International Programs in Agriculture, Purdue University, West Lafayette, Indiana. The proceedings include two papers from FSU (Ohm et al., 1985c; Sawadogo et al., 1985) and

three papers from Purdue University (Sanders and Roth, 1985; Jaeger and Sanders, 1985; and Sawadogo, 1985) which are based on FSU data and collaboration with FSU.

B. Farming Systems Unit Case Study

A case study of the Purdue University farming systems unit in Burkina Faso was prepared for the Population Council/Farming Systems Support Project Case Studies Project on Intra-Household Dynamics and Farming Systems Research and Extension. The project was funded by the Ford Foundation and the United States Agency for International Development. The FSU case is part of a series of eight cases that will be used for training purposes.

The eight case studies selected were chosen from over 90 submissions. The principal case study writers (Dr. J. G. Nagy for FSU) attended a meeting in Boston, Massachusetts in June 1985 to acquaint themselves with case writing methods and style. A manuscript has been submitted to the Case Study project managing editor and is available in published form (Nagy et al., 1986c) from IPIA.[1/]

The case study is designed to permit students, working as an interdisciplinary team, to follow through the stages of the FSR/E approach. Descriptive information and data sets are given at each stage for the student to analyze and critique.

The first section of the case study presents the country and project background. The country's physical features, climate, demography, economy, food security position, and government agricultural policy are outlined. The importance of agriculture and the food security problem are highlighted. The evolution of Burkina's agricultural research institutions are briefly outlined as background to the institutional setting within which the farming

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[1/] Further information about the case study Nagy et al., 1986b and other case studies can be obtained from Ms. Hilary S. Feldstein, Managing Editor, Intra-Household Case Studies Project, RFD 1, Box 821, Hancock, NH 03449 or Dr. Susan Poats, FSSP, 3028 McCarty Hall, University of Florida, Gainesville, FL 32611. The case studies project is considering translating the FSU case into French.

systems unit was placed. Diagnostic information on the farming systems (including intra-household and inter-household relationships), farmer goals and objectives, factors affecting cropping and marketing decisions, farmers' production constraints and available research station technologies are presented. Sufficient information is given for students to determine production constraints, priority problems, and recommendation domains using an FSR/E framework. From this information, students can design on-farm agronomic field trials and plan further socio-economic surveys.

The second section outlines the analysis of the diagnostic information of the FSU team and presents three years of on-farm researcher-managed and farmer-managed field trials and socio-economic surveys in chronological order. Students can then compare their field and socio-economic campaign plans. The design and results of two farmer-managed trials (focusing on water retention and soil fertility), and associated socio-economic data are presented in detail. Students can analyze the results which include ANOVA and economic budget information and make recommendations for further testing and/or dissemination.

FSU's evaluation, modifications, recommendations and plans for dissemination of the technologies are presented in Section III. Students can critique the evaluation criteria as well as the recommendations and dissemination plans.

C. International Agricultural Economics Conference Paper

The Conference (attended by J. G. Nagy) in Malaga, Spain 26 August to 2 September, 1985, gave the opportunity to present FSU's methodology and 1984 agronomic and economic data analysis in Burkina to a large international audience. The paper (J. G. Nagy and W. H. Ohm, 1985) received a good response and contacts were made with other farming systems projects.

D. Kansas Farming Systems Symposium

A paper (J. G. Nagy, L. L. Ames, and W. H. Ohm,1985) was presented at the 1985 Kansas Farming Systems Symposium 13-16 October, 1986. The paper has been published by IPIA in both English and French. The paper has also been accepted for publication in the 1985 volume; Farm Systems Research and

Extension Selected Proceedings: Management and Methodology, International Agricultural Programs, Kansas State University.

The paper starts with background on Burkina Faso. Diagnostic and farming systems information are then presented leading to the description of the on-farm farmer-managed trials and the socio-economic program and presentation of agronomic and socio-economic results. The evaluation of the technology interventions of tied ridging and fertilization are presented, followed by modifications that were made to the research program (i.e., introduction of the mechanical ridge tier). Linear programming is used to analyze the technology interventions in a whole farm context.

FSU was asked by the Farming Systems Support Project (FSSP) to assist in designing a "minimum data set" for farming systems agronomic and socio-economic papers. FSU was asked to take one of their trials and fill out the list of specific data requirements that had been decided on at the 1984 Farming Systems Symposium. The FSU 'minimum data set paper' and suggestions were part of the discussion session on minimum data sets presented by FSSP at the 1985 Symposium. Copies of the paper are on file with IPIA and FSSP.

E. WASAT Soils Fertility Literature Review

A literature review of soil fertility in the West African semi-arid tropics (Schaber, 1985) was completed by Lee Schaber (PCV). This work is part of a larger work on soils by FSU. Soil samples of farmers' fields were taken in the fall of 1985 and analyzed. Initial results are presented in Nagy et al., 1985b.

F. Gender Issues in Farming Systems Research and Extension Conference

A paper (Diallo and Nagy, 1986) was presented at the Conference on Gender Issues in Farming Systems Research and Extension, February 26-March 1, 1986 at Gainesville, Florida. Ms. Nell Diallo presented the paper and was also a member for one of the panel discussion groups. Funding was provided by FSSP.

The paper explores the intra-household issues of the access to and control of resources within the farming systems of the Mossi Plateau. After a brief background on Burkina and the farming systems of the Mossi Plateau,

a description of the traditional access to and control of resources are given along with the legal and political environment within which the farming system operates. The most recent legal and political changes which have possible implications for changes in gender access to and control of resources are then discussed.

G. OAU/SAFGRAD International Drought Symposium

A paper (Nagy et al., 1986d) was presented at the OAU/SAFGRAD International Drought Symposium, 19-24 May, 1986, Nairobi, Kenya. The paper makes use of recent research experiences of Burkina Faso as a development model that is applicable to similar agroclimatic zones and farming systems in many of the WASAT countries.

The first section of the paper describes the farming systems and major production constraints of the WASAT. The following section outlines various recommendation domains based on production constraints, household endowments and household decision-making characteristics. Technological interventions and farmer management techniques that are presently being proposed to alleviate the major constraints are then presented. The technologies are then categorized as to their potential in the short, intermediate and long run based on their agronomic and economic feasibility. This information is then used to chart out potential adoption sequences for several recommendation domains. This leads to a discussion of priorities and avenues for research and extension and the necessary conditions for the adoption of various technologies.

H. American Agricultural Economics Association Meetings Paper

The paper (Nagy and Ames, 1986) was accepted for the selected papers sessions at the American Agricultural Economics Association meetings in Reno, Nevada, July 1986. In the paper, whole farm modeling (Linear Programming) is used to model the production unit of the farming systems of the Central Plateau of Burkina Faso. The model is used to indicate the degree of technology adoption of tied ridges and fertilization, their impact on income, and the production constraints preventing further adoption of the technologies.

I. Collaboration with INTSORMIL

Ms. Linda L. Ames, Research Associate, Food Research Institute, Stanford University, on contract with INTSORMIL through Purdue University, was associated with FSU from July 1985 to March 1986. Ms. Ames contributed substantially to the whole farm modeling analysis employed by FSU. The objective of her stay in Burkina was to become familiar with the farming systems of the Mossi Plateau and collect data for the application of farm risk and behavior analysis using whole farm modeling. FSU provided advisory input, a data base, and the opportunity to survey the NFSP (previously FSU) cooperator farmers. Her report is on file with INTSORMIL at Purdue University.

J. Analysis of the IITA/SAFGRAD Mechanical Ridge Tier

FSU oversaw the mechanical ridge tier field trials and socio-economic data collection with the aid of the Burkina national farming systems field staff. The report is reproduced in the Appendix.

K. Cereal Sales Behavior Among Farm Households

An agreement was made between FSU and the Center for Research on Economic Development (CRED), Ann Arbor, Michigan to use FSU stocks and transactions and related data to supplement CRED's Burkina Faso marketing studies data. The analysis of the data was conducted at the University of Wisconsin, Office of International Agricultural Programs (USAID subcontract AFR-0243-C-00-2063-00). Chris Pardy, a former member of the FSU team, conducted the analysis at Wisconsin.

The objective of the analysis was to identify factors which influence household cereal sales. The first section of the paper provides an overview of the four villages of Nedogo, Poedogo, Dissankuy, and Diapangou where the data was collected. The second section describes the methodology of the data collection and the variables used in the analysis. The third section analyzes 1) annual cereal sales behavior and 2) intra-annual sales behavior. The fourth and final section focuses on conclusions and policy implications.

IV. TRAINING/NETWORKING

A training course for field technicians was given by the University of Ouagadougou 19 March-April 19. Eight field technicians from the NFSP in Burkina, four from the SFS unit in Benin and two from Cameroon attended the course. The funding was through SAFGRAD with coordination by FSU. The course was similar to the one given to FSU, ICRISAT, and IBRAZ field technicians in 1984. FSU worked closely with the University in course design and with SAFGRAD to coordinate the logistics of the training course. The establishment of the course outline and the experience gained by both the University and SAFGRAD will enable SAFGRAD to continue similar technician training courses for other SAFGRAD countries in the future.

The major focus of the course was to provide technicians with a systematic outline of tasks to be performed in the course of an agricultural season. In addition, technicians learned the researcher's objectives for doing trials and why the trials had to be done with particular precision. They were also made aware of how the agronomic and economic results were arrived at and how they would be made use of.

Ms. Nell Diallo, Training coordinator, in conjunction with the SAFGRAD Coordination Office, gathered information on several farming systems programs in the WASAT. Communication was established with the Farming Systems Support Project (FSSP), Gainesville, Florida for information on networking methodology and further association in establishing a West African regional FSR network. This information is presently with the SAFGRAD Coordination Office. Continuity of the FSU training/networking program has been established by Ms. Diallo taking employment at the SAFGRAD Coordination Office.

Training Course Outline

A. Introduction (Total 60 hours)

1. The role of soil in the life of the plant

2. Physiology of plants
   - development cycles
3. Plant nutrition (water and minerals)
4. The environment of the plant
   - climate
   - types of soils
   - diseases
   - insects
   - weeds
5. Basic principles of statistics
6. Basic production economic principles
7. Summary and synthesis

B. Agronomic Experimentation (Total 135 hours)

1. Introduction
   - objectives of experimentation
   - parameters of agronomic experimentation
2. Preliminary steps in conducting trials (includes 10 hrs. in the field)
   - plot selection
   - choice of experiment
   - implementation of the trial
3. Conducting the trials (includes 15 hrs. in the field)
   - soil preparation
   - planting
   - maintenance
   - fertilization
   - thinning
   - plant protection
   - irrigation
4. Observations and data collection
   - in the field (10 hrs.)
   - in the laboratory

5. Practical examples of agronomy experimentation
    - variety selection
    - fertilization
    - plant protection
    - disease resistance
    - water conservation methods (i.e., tied ridges)
6. Economic analysis and farmer surveys
    - economic budgeting analysis
    - survey questionnaires
7. Statistical analysis
    - objectives
    - analysis of results (ANOVA)
    - presentation of results

C. Final Exam and Student Evaluations

V. 1985 AND 1986 PUBLICATIONS

Ames, Linda L. 1986. A preliminary report on the evaluation of new technologies in Burkina Faso. Mimeo, Department of Agricultural Economics, Purdue University, West Lafayette, Indiana.

Diallo, Nell N. and Joseph G. Nagy. 1986. Burkina Faso: Access and control of resources in the farming systems: Recent legal, political and socio-economic changes. Paper presented at the Conference on Gender Issues in Farming Systems Research and Extension, February 26-March 1, 1986, Gainesville, Florida.

Jaeger, William and John H. Sanders. 1985. Profitability of animal traction: Field study in Burkina Faso. In: Appropriate technologies for farmers in semi-arid West Africa. H. W. Ohm and J. G. Nagy (eds.) International Programs in Agriculture, Purdue University, West Lafayette, Indiana (English and French).

Nagy, Joseph G., Herbert W. Ohm, Linda L. Ames and Lee D. Schaber, 1986a. Analysis of the IITA/SAFGRAD mechanical ridge tier. International Programs in Agriculture, Purdue University, West Lafayette, Indiana, (English and French).

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Ohm, Herbert W., Joseph G. Nagy, and Sibiri Sawadogo. 1985c. Complimentary effects of tied ridging and fertilization with cultivation by manual and donkey and ox traction. In: Appropriate technologies for farmers in semi-arid West Africa. H. W. Ohm and J. G. Nagy (eds.) International Programs in Agriculture, Purdue University, West Lafayette, Indiana (English and French).

Pardy, Christopher R. 1985. Cereal sales behavior among farm households in four villages of Burkina Faso. Joint Publication between International Agricultural Programs, University of Wisconsin, Madison, Wisconsin and International Programs in Agriculture, Purdue University, West Lafayette, Indiana.

Sanders, John H. and Michael Roth. 1985. The development and evaluation of new systems of agricultural production: Some field and model results from Burkina Faso for tied ridges and fertilization. In: Appropriate technologies for farmers in semi-arid West Africa. H. W. Ohm and J. G. Nagy (eds.) International Programs in Agriculture, Purdue University, West Lafayette, Indiana (English and French).

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APPENDIX

ANALYSIS OF THE IITA/SAFGRAD MECHANICAL RIDGE TIER[1]

Joseph G. NAGY, Herbert W. OHM, Linda L. AMES, and Lee D. SCHABER[2]

INTRODUCTION

With FSU and IITA/SAFGRAD collaboration, a prototype mechanical ridge tier was tested in the field as part of Burkina's (IBRAZ) 1985 national farming systems field trial program. FSU oversaw the field trials and socio-economic data collection with the aid of the national farming systems field staff. The objective of this paper is to report the findings from the field trials and socio-economic campaign.

BACKGROUND INFORMATION

In Burkina Faso and in the sahel and sudanian regions of Africa in general, low soil fertility, lack of soil water retention and availability, and labor shortages are major constraints to increased yield and production. FSU has focused a major part of its efforts on these problems and in particular have worked with soil fertility increasing methods (fertilizers, manures, and mulch) and with the water retention technique of tied ridging.

Tied ridges are small depressions made between the crop rows either by hand tillage or with a combination of animal traction and hand tillage. If done by hand, depressions 32 cm long x 24 cm wide x 16 cm deep are made between the rows spaced 1 1/2 meters apart. If done with animal traction, the cultivator (Houe Manga) is equipped with a middle sweep to create a furrow which is then followed by hand tillage to make a 16 cm high ridge perpendicular to the furrow every one to two meters. The depressions catch and hold water after a rain and increase soil water infiltration and retention. Both methods are very labor intensive.

Tied ridging is not a new technique and previous research has been undertaken on the subject (Dagg and Macartney, 1968). More recently, there has been work on tied ridging in Burkina Faso indicating that tied ridging can result in significant yield increases (ICRISAT; IITA/SAFGRAD; Rodriguez, 1982; IRAT; Dugue, 1985; Nicou and Charteau, 1985). FSU on-farm trials (both researcher-managed and farmer-managed) indicate that either the use of commercial fertilizers or the water retention technique of tied ridging can increase yields of maize, sorghum and millet but have their greatest effect on yields when used in combination (Lang et al, 1984, and Ohm et al., 1985a and 1985b).

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[1]The Purdue University Farming Systems Unit (FSU) is part of the Semi-Arid Food Grain Research and Development project (SAFGRAD) and collaborates with the national farming systems program within the Institut Burkinabe de Recherches Agronomiques et Zootechniques (IBRAZ).

[2]Economist, FSU/SAFGRAD, Burkina Faso; Agronomist, FSU/SAFGRAD and Professor, Agronomy Department, Purdue University and Associate, Food Research Institute, Stanford University and presently with FSU/SAFGRAD; and Peace Corps Volunteer with FSU/SAFGRAD. The authors would like to thank Mr. Sibiri Sawadogo, IBRAZ Farming Systems Coordinator, Mr. Jeff Wright (PCV) and Dr. Mario Rodriguez IITA/SAFGRAD for their assistance.

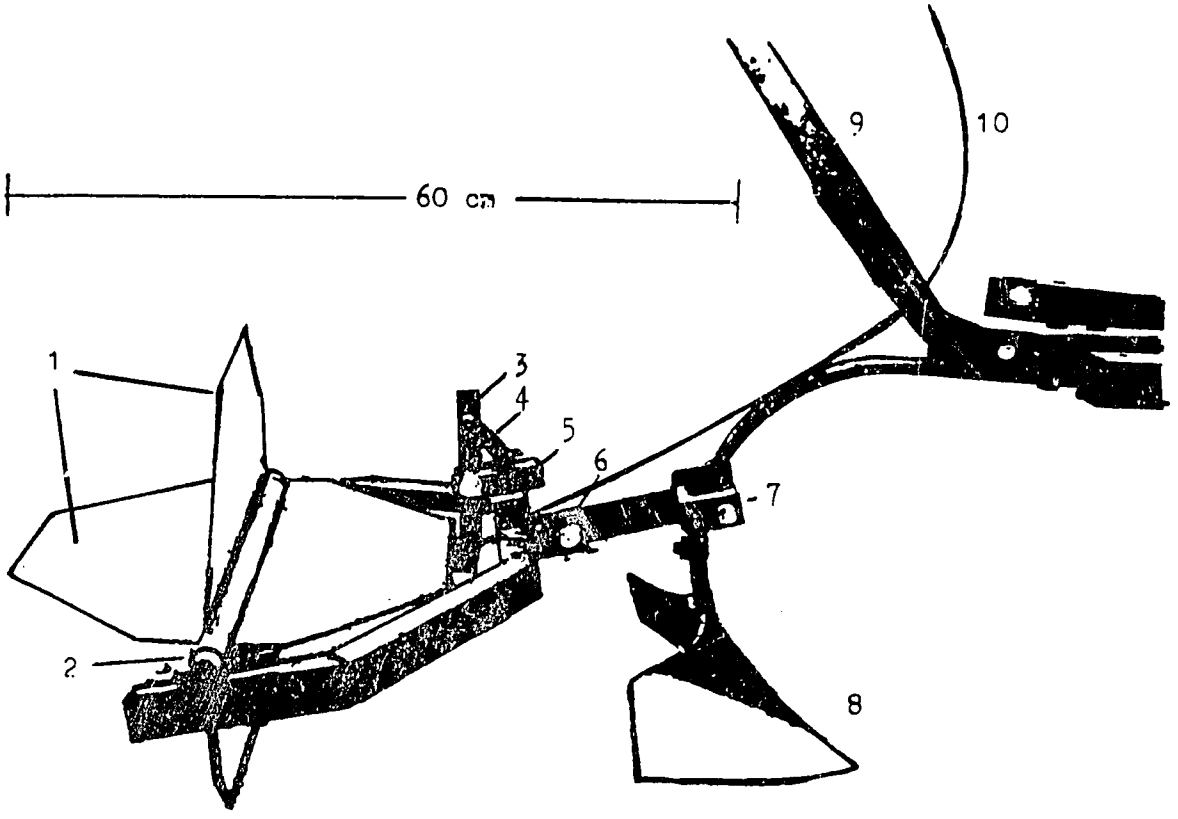
FSU socio-economic data indicated that the use of tied ridging and fertilization together was profitable and gave a higher economic return than when the technologies were used separately. Although tied ridges can be profitable alone, fertilizer application alone is very risky and the incidence of farmers losing their cash outlay is very high (Lang et al., 1984 and Ohm et al., 1985a and 1985b). Socio-economic data also pointed out that there is a labor constraint during the planting to second weeding period within the agricultural season - particularly at the planting and first weeding stages of the major subsistence crops. To be most beneficial, the labor intensive tied ridges need to be constructed within the period from planting to second weeding - the period of high labor demand. Farmer interviews indicated that farmers see the benefits from tied ridging but say they do not have the labor to construct them on other than small areas of their land. A survey of the adoption of technology by farmers in FSU villages in the fall of 1984 indicated that the number of farmers constructing tied ridges and the hectarage of tied ridging construction outside of trial plots was small (Ohm et al., 1985a and 1985b).

The information on the labor shortage was communicated to other researchers within SAFGRAD, and in the Fall of 1983 a Peace Corps Volunteer with the IITA/SAFGRAD maize agronomy program (Jeff Wright) started work on a prototype mechanical device (Fig. 1.) to tie the ridges (Wright and Rodriguez, 1985). The mechanical device is attached to an animal drawn cultivator with one large middle sweep. The ridging and tying of the ridge can be done simultaneously in one pass through each crop row or the operation can be done in two passes. With two passes the rows are first ridged by the cultivator in the normal way and then in a second pass the ridges are tied by the mechanical ridge tier (MRT) which is attached to the cultivator. In the second pass the cultivator is equipped with a smaller middle sweep. The device is essentially a paddle wheel (45 cm in diameter) with four paddles, one scraping the ground, building up earth until it is tripped by the operator every 1 1/2 to 2 meters to create the tie in the ridge. Two sizes of the MRT were made; one for donkey traction as presented in Fig 1 and one for ox traction which is a similar model but slightly larger.

OBJECTIVES AND METHODOLOGY

The objectives of the mechanical ridge tier field campaign were threefold; 1) to obtain and compare yield and other agronomic data of the MRT to flat cultivation and to animal traction ridges tied by hand, 2) to assess the economic profitability and labor demands of the MRT and 3) to obtain technical data about the MRT and question farmers about the operation of the MRT.

Three village sites were selected for the field trials and socio-economic data collection (Fig. 2) and are as follows: Nedogo, 30 km north-west of Ouagadougou; Poedogo, 130 km south of Ouagadougou; and Diapangou, 15 km west of Fada. Eight farmers with donkey and 7 farmers with ox traction were selected in Nedogo, 15 farmers with donkey traction were selected in Poedogo and 15 farmers with donkey and 15 farmers with ox traction were selected in Diapangou. Most of the farmers selected would be classified as good to very good and experienced with animal traction.



1. Shovels
2. Axel Bearing (Pipe)
3. Latch Lever
4. Rubber Band (Inner Tube Strip)
5. Latch Adjuster (for correct angle and to compensate for wear in bearings, shovels and latch).
6. Shovel angle Adjusting Bolt
7. Coupler
8. 30 cm Ridger that allows soil to flow over the top.
9. Handles of "houe Manga" (FAO donkey weeder)
10. Bicycle cable to Brake Lever

Fig 1. The IITA/SAFGRAD mechanical ridge tier (donkey version).

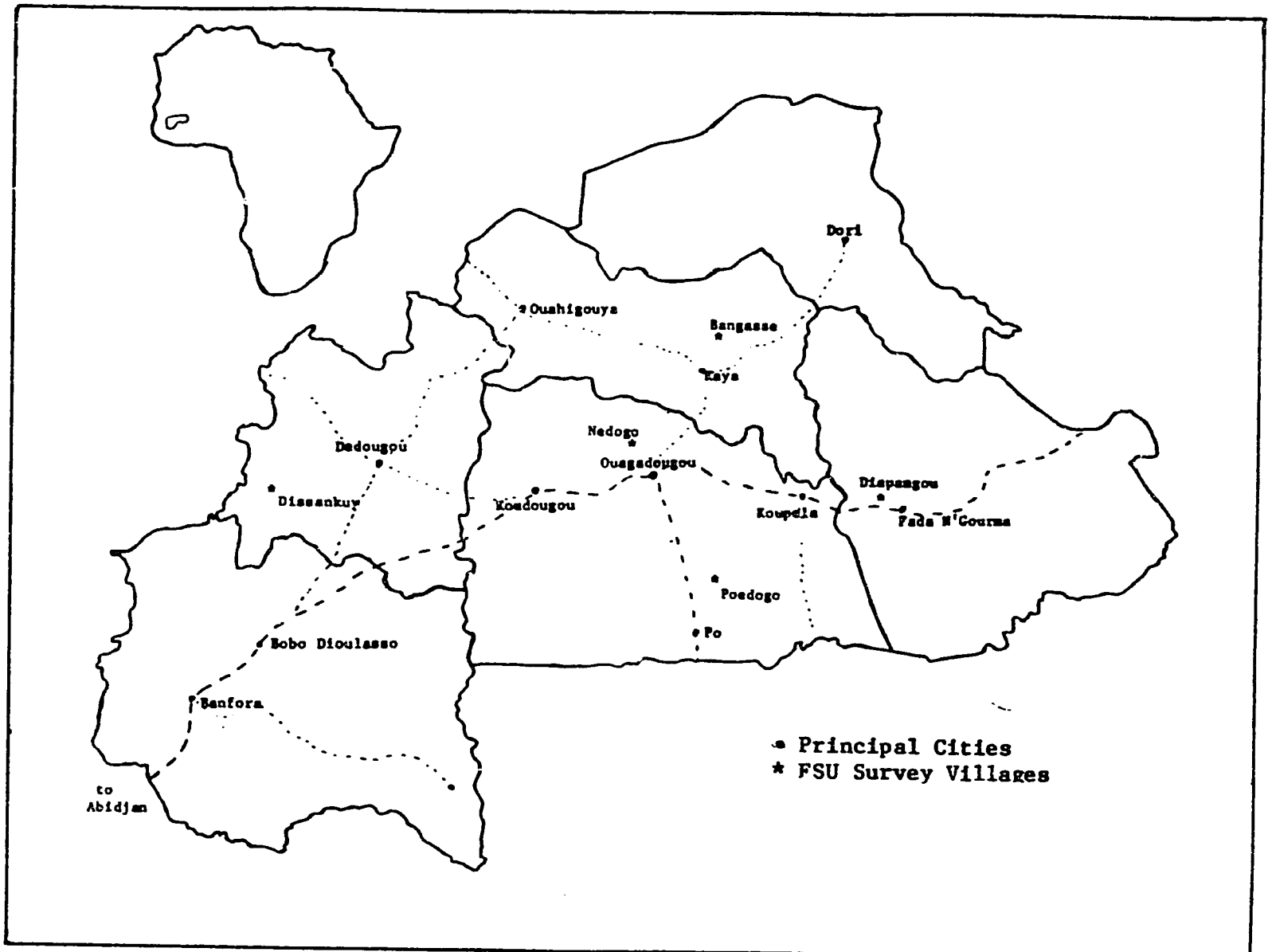


Figure 2: Map of Burkina Faso

The field trials conducted were on-farm farmer-managed trials. Previous research (Lang et al., 1984, and Ohm et al., 1985a and 1985b) indicated that both agronomic and economic results were the most favorable when the two technologies of tied ridging and fertilizer were used in combination. Thus all treatments received 100 kg/ha 14-23-15 fertilizer applied in a band 10-15 cm from the crop rows 2 to 3 weeks after planting plus 50 kg/ha of urea applied in a band 10-15 cm from the crop rows 6 to 8 weeks after planting. The treatments were as follows:

1) traditional animal traction tillage practices (control),[3]
2) tying the animal traction-made ridges every 1 to 1.5 m by hand at second weeding (6 to 8 weeks after planting),
3) tying the ridges mechanically with the MRT at second weeding and,
4) tying the ridges mechanically with the MRT at first weeding (3 to 4 weeks after planting) and again at second weeding.

The purpose of doing Treatment 4 was twofold. First, constructing tied ridges closer to planting should be more beneficial however, the plants are not very large at the first weeding period and this treatment enabled the assessment of any damage done to the young plants. Secondly, if tied ridges are to be made in the first weeding period, the ties will have to be broken at the second weeding/ridging period and therefore the ties will have to be made over again. Therefore, Treatment 4 allows an assessment of the profitability of tying the ridges twice as compared to once in Treatment 3 and also assesses whether the farmers had problems in constructing ties in the second weeding period because of the presence of the first weeding ties.

Farmers managed and carried out the experiments and were responsible for all labor inputs. Fertilizer was supplied to the farmers. Local sorghum varieties were used. Prior to seeding, the field staff delineated each parcel with colored stakes and measured the area of all parcels. Parcel size ranged from 0.05 to 0.12 ha depending on the size of the farmers' field. Prior to harvest, all parcels were evaluated for general conditions of the crop. Farmers harvested all parcels and the field staff weighed the harvest.

Field plots were chosen using the following criteria: at least a 1% slope, no previous mineral fertilization and homogeneity in soil structure, texture and type for all treatments within a block (soils are predominantly sandy-clay).

Labor inputs associated with the MRT were obtained by the field staff on a farmer recall basis (within one week after use of the MRT). A farmer questionnaire was conducted just prior to harvest to obtain the farmers' opinions, problems and suggestions.

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[3]Traditional animal traction tillage practices generally include weeding with a cultivator (Houe Manga) at the first weeding period (3 to 4 weeks after planting) and at the second weeding/ridging period (6 to 8 weeks after planting). At second weeding, the cultivator is equipped with a wide middle sweep that places soil at the base of the plants to keep them from lodging.

Objectives 1 and 2 were unable to be met at Diapangou or Poedogo because of field staff shortages.[4] The farmers that did the trials in Diapangou did most operations later than the protocol called for and the trials were abandoned. The trials in Poedogo were not abandoned but there was insufficient data on all treatments to conduct a statistical analysis. However, the findings and the problems experienced in Poedogo are discussed in the text. Thus only agronomic data and an economic analysis from the trials at Nedogo are presented. The farmer questionnaire was conducted in all three villages.

THE NEDOGO TRIALS

General Crop and Field Conditions. At Nedogo, the total rainfall received in 1985 of 572 mm was below the long term average of 809 mm (Fig. 3) and below the 670 mm received in 1983 but higher than the 452 mm received in 1984. Seeding of millet and sorghum crops began in mid-June. Crop establishment was excellent and little replanting was necessary. A 17-day dry spell in August at the time of peak flowering severely reduced maize yield. Millet and sorghum crops showed only minor drought stress symptoms and were not adversely affected. In mid-September, sorghum reached 50% flower under ideal field conditions. Millet began flowering in late September. The last good rain fell on 1 October allowing both sorghum and millet to complete grain fill before soil moisture reserves were exhausted. Maize, sorghum and millet yields were estimated by the field staff to be 60%, 100% and 100% of normal respectively.

Description. The experimental design was a split-plot with whole-plots (types of traction) arranged in a completely randomized design and treatments were subplots. The four treatments were presented in the Introduction. Seven farmers with mono-donkey traction and seven farmers with mono-ox traction did all the treatments according to the protocol. The smaller donkey MRT was used by both donkey and ox traction farmers. Both ridging and tying were done simultaneously in one pass in Nedogo. On average, the ties made with the MRT were about 13 cm high whereas the ties made manually were about 15 cm in height and had a broader base. There was little difference in the height of the MRT ties between donkey or ox traction. An oversized triangular weeding sweep 15 cm in width was used on the cultivator in place of the normal 30 cm wide sweep because the large sweep cleaned out the furrow too well and did not leave enough soil for the MRT to scrape up and form ties.

Results and Discussion. All three treatments consisting of tied ridging resulted in significant yield increases over the control (Table 1). Increases in yield from the tied ridging treatments over that of the control ranged from 18% to 29%. Given the distribution and timeliness of the rains, the yields of the tied ridging treatments were not dramatically higher than the yield of the control. This is in contrast to the Nedogo donkey traction sorghum trials in 1983 and 1984 (Ohm et al., 1985b). Treatments where ridges were tied by hand out-yielded the fertilized only treatments by 60% in 1983 and 118% in 1984. In 1984 less rainfall was received than in 1985 and although the 1983 rainfall was higher than in 1985, the distribution and timeliness was not as good for crop growing conditions.

[4]This was the first operational year for the newly formed national farming systems program in Burkina. In 1985, FSU took on an advisory role and transferred its staff to IBRAZ and relied on the IBRAZ staff for all the field work. The demands put on the limited number of IBRAZ field staff in this first year of operation were substantial.

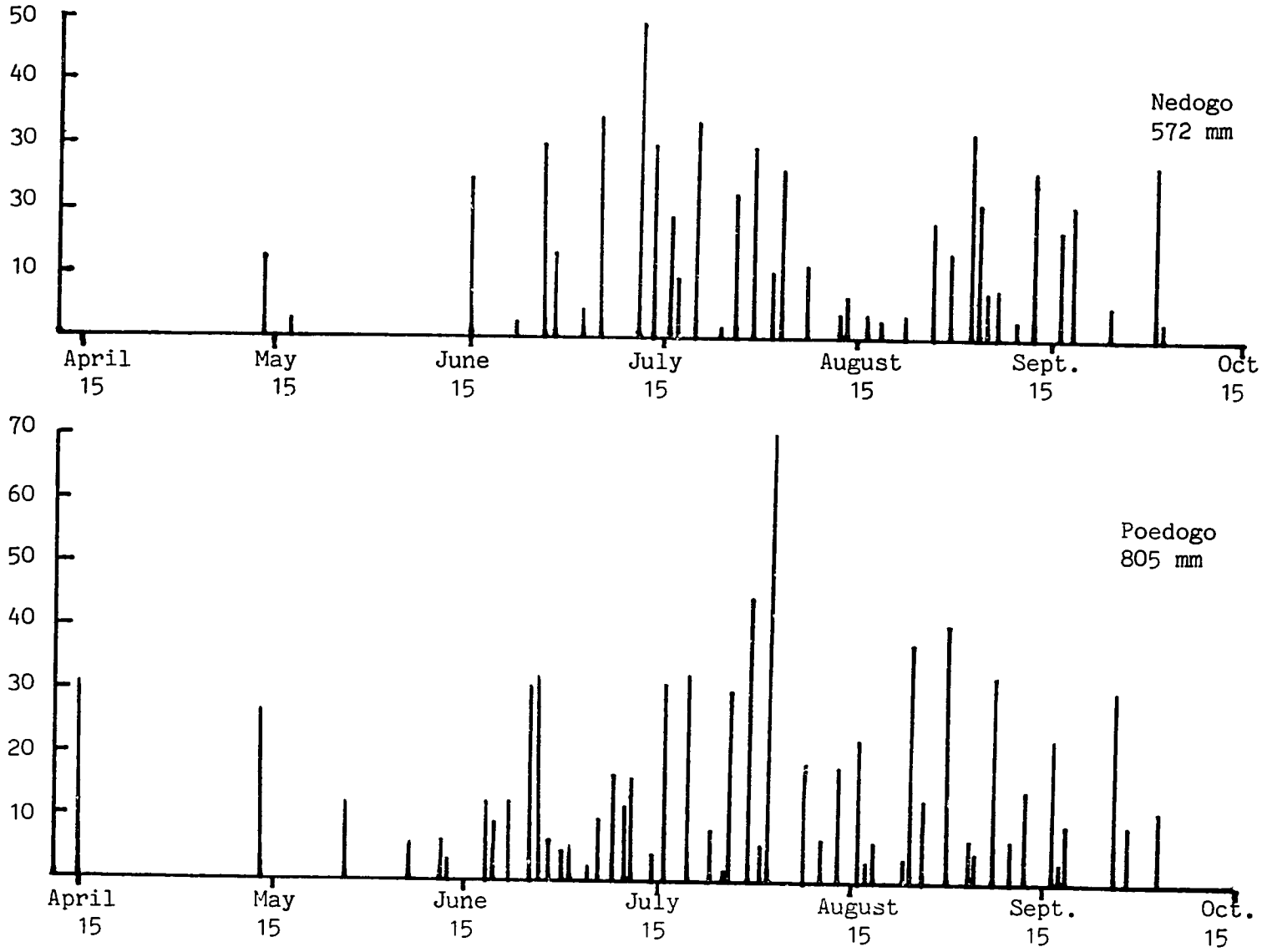

Fig. 3. Daily rainfall for the two village sites of Nedogo and Poedogo in Burkina Faso, 1985. Long term average annual rainfall at data collection sites near Nedogo (Pabre) is 809 mm (1952 to 1975) and at Poedogo (Manga) is 905 mm (1947 to 1975) (ICRISAT, In Press).

Table 1. Means for effects of animal traction and for three methods of tied ridging at Nedogo, 1985.

Treatments[1]	Mean Grain Yield
	kg/ha
Traction - MRT[2]	
Donkey	920.5
Ox	882.6
SE[3]	71.6
Tied Ridging Methods[4]	
Control[5]	740.0
TR-Manual[6]	954.4
MRT-1[7]	875.6
MRT-2[8]	927.5
SE[3]	62.8
CV%	19.0
N[9]	14

[1]Local varieties of sorghum were used.

[2]Comparing the mechanical tying of ridges by donkey traction with the mechanical tying of ridges with ox traction.

[3]Standard Error of the difference between two treatment means.

[4]Fertilizer application of 100 kg/ha 14-23-15 in a band 10 to 15 cm from the rows of sorghum 3 to 4 weeks after planting and 50 kg/ha urea applied in a band 10 to 15 cm from the rows of sorghum 6 to 8 weeks after planting was applied to all treatments.

[5]Flat cultivation without tied ridges.

[6]Manually tying the ridges made by animal traction 6 to 8 weeks after planting.

[7]Mechanically tying the ridges 6 to 8 weeks after planting.

[8]Mechanically tying the ridges 3 to 4 weeks after planting and again at 6 to 8 weeks after planting.

[9]The number of farmers' fields (replications) on which the experiment was grown - 7 farmers with donkey and 7 farmers with ox traction.

The three ridging treatments did not significantly differ. The yield however tended to be higher when the ridges were tied manually (TR-Manual) as compared to those tied with the MRT. The lower yields observed in the two treatments using the MRT may be the result of root pruning or the damage caused to the plants by the MRT. To overcome this problem, the width of the MRT should be made shorter or the rows wider by about 5 cm keeping in mind that the operation must deposit enough soil at the base of the plants at second weeding to keep them from lodging. Also, the higher ties of the manually constructed tied ridges may have allowed more water to accumulate during a rain thus creating a larger moisture reserve. Yields in Treatment MRT-2 where the MRT was used at both first and second weeding was not significantly different from yields obtained in Treatment MRT-1 where the MRT was used at second weeding only. The timely and adequate rains (228.3 mm in July alone) made the yield difference minimal between the two treatments.

No difference in sorghum yields between mechanically tying the ridges with ox traction and mechanically tying the ridges with donkey traction were observed (Table 1). This is in concurrence with the field staff observations that there was little difference between the height of the MRT (donkey version) ties when using donkey or ox traction.

THE POEDOGO TRIALS

General Crop and Field Conditions. At Poedogo, the total rainfall received in 1985 of 805 mm was below the long term average of 905 mm (Fig 3) but higher than the 1984 average of 633 mm. Seeding of millet and sorghum began in mid-May with some farmers seeding "dry" in the hopes of a good early rainfall. Plant establishment was poor and required at least one reseeding and in some cases two reseedings. The months of July and August were very wet (222.5 mm and 242.0 mm respectively) and farmers had difficulty getting into the fields. Soil moisture was not limiting during the agricultural season other than during the seeding period. Sorghum began to flower in early September under ideal field conditions. Maize, sorghum and millet yields were estimated by the field staff to be 120, 120 and 80% of normal, respectively.

Description. The protocol called for the same treatments as outlined in the Introduction. Initially, 15 farmers with donkey traction were to conduct the trials with the donkey version of the MRT. When constructing the ties with the MRT at first weeding, the 15 cm sweep was used on the cultivator and weeding and tying were done simultaneously in one pass. When constructing the ties with the MRT at second weeding, farmers did not like the smaller than normal ridges that the 15 cm sweep made. Farmers at Poedogo normally use a 30 cm sweep (a different type from that used in Nedogo) which makes very large ridges that support the plants from late season storms and subsequent lodging. The use of the large ridger combined with the MRT increased the draft to the point where it was too heavy for the donkeys do pull. Thus farmers did the operation in two passes by ridging with the large sweep in the first pass and then tying the ridge with the MRT attached to the cultivator with the 15 cm sweep for the second pass. The ties made by the MRT in the two pass method were on average 17 cm high compared to 13 cm for the one pass method and 15 cm when constructed manually.

Results and Discussion. Data was limited as few farmers completed all the treatments. Due to favorable weather conditions after planting and the very wet months of July and August, farmers had difficulty getting into

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the field and about half the farmers decided not to construct tied ridges because sufficient moisture existed. The shortage of field staff precluded any effort to get the farmers to do the trials. Given the adequate moisture in 1985, farmers would logically not construct tied ridges however an opportunity was lost to assess if in times of good rainfall, tied ridges could have an adverse effect on yields in the Poedogo area because of water logging and/or denitrification (adverse yield effects have been observed in some instances by IITA on some soil types). Field staff did observe however that the three tied ridging treatments tended to have the same relationship to each other as was observed in Nedogo.

ECONOMIC AND LABOR DATA ANALYSIS

A survey was conducted to obtain the labor demands required by the use of the MRT relative to that of tying the ridges by hand. Since farmers traditionally ridge, the variable of interest is the additional time required to construct the ties over and above that of ridging. The average amount of labor required for tying the ridges by hand after the ridges had been constructed for Treatment TR-Manual was 38.56 manhours/ha (N = 14) in Nedogo and 45.62 manhours/ha (N = 7) in Poedogo.[5] In Nedogo, when ridging and constructing tied ridges simultaneously with the MRT in one pass, farmers with donkey traction took on average 1.02 actual hours/ha (N = 6) more time than when the traditional ridging operation was performed alone. This is to be expected since the addition of the ridger increases the draft that the donkey must pull. Thus if two men performed the one pass MRT operation in Nedogo with donkey traction, it would require 2.04 manhours to construct tied ridges on one hectare in contrast to taking 38.56 manhours to tie the ridges by hand on one hectare; a saving of 36.51 manhours/ha. For ox traction farmers in Nedogo, an extra 0.43 actual hours/ha were required when the MRT was used in one pass.

In Poedogo, the survey results indicated that on average, farmers required an additional 3.34 (N = 6) actual hours to construct tied ridges in one pass with the MRT above that of traditionally constructing ridges alone. When the two pass method was used - ridging first, then tying the ridges with the MRT attached to the cultivator - the second pass to tie the ridges with the MRT required on average 13.74 actual hours/ha which still represents a substantial labor saving over that of tying the ridges by hand (discussions with the field staff indicated the 13.74 hrs/ha to be on the high side).

The gross revenue and net revenue figures on a CFA/ha basis are presented in the partial budget analysis in Table 2. The net revenue figures account for the cost/ha of fertilizer (13,868 CFA/ha) for all four Treatments and the annual cost/ha of the MRT (1,467 CFA/ha) for Treatments MRT-1 and MRT-2.[6] The net revenue/ha figures of all three tied ridging Treatments are all above the net revenue/ha figure of the Control and the

[5] A composite labor hour figure in terms of manhours/ha is calculated using the following weights: one male hour ($\geq$ 15 yrs) = 1, one female hour ($\geq$ 15 yrs) = .75 and one child hour ($<$ 15 yrs) = .5.

[6] The 1,467 CFA/ha cost of the MRT is calculated as 15,000 CFA total cost annualized over 5 years at 15% interest rate assuming the MRT is used on 3.0 ha/year.

difference is expressed in Table 2 as the net revenue gain/ha.[7] The net revenue gain/ha of the three tied ridging Treatments represent the net revenue gained solely because of the increased yield from the use of tied ridging. The net revenue gain/ha of using the MRT (Treatments MRT-1 and MRT-2) are below the net revenue gain/ha of tying the ridges by hand Treatment TR-Manual). The cost of the MRT and the lower yields observed in Treatments MRT-1 and MRT-2 contributed to the lower net revenue gain/ha relative to the TR-Manual Treatment.

The important fact however is that there is a labor constraint which precludes the tying of ridges manually on a significantly large hectarage per household.[8] Results from a linear programming model (LP) of a Nedogo representative farm indicated that family labor availability constrained the manual tying of tidges to 0.9 ha whereas, when given the option to use the MRT, family labor and donkey traction resources existed to profitably tie ridges on about 3.0 hectares (Nagy et al., 1985). Thus when the net revenue gain above the control is calculated using 0.9 ha as the maximum hectarage that can be tied under TR-Manual (0.9 x 10,700 CFA/ha) and 3.0 ha as the maximum hectarage that can be tied under MRT-1 (3.0 x 5,283 CFA/ha) and MRT-2 (3.0 x 7.883 CFA/ha), the MRT Treatments show net revenue gains to tied ridging that are larger than that of the net revenue gain under TR-Manual (Table 2). The use of the MRT therefore increases the number of hectares that can be profitably tied ridged given the labor resources of the farm and substantially increases the net revenue of the farm.[9] In the future, it may be expected that the yields obtained from the MRT Treatments will be similar to that obtained in Treatment TR-Manual once the equipment is improved and the farmers adapt the MRT technology

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[7]Most of the agricultural labor is provided by the family members throughout the agricultural season. Although some farmers are able to hire labor in peak periods because of economic or social status, little labor is available for hire at these critical times because a labor pool does not exist and farmers cannot be hired away from their own farm work at the average going wage of between 40 to 50 CFA/hr. Imperfections in the labor market account for the fact that the marginal product of labor is four to seven times the average wage rate in critical labor shortage periods (Roth et al., 1984). Thus the cost to hire sufficient labor for tying the ridges by hand for treatment TR-Manual would be between 160 to 350 CFA/hr. At a cost of 275 CFA/hr for labor, the net revenue gain/ha of treatment TR-Manual in Table 2 would be near zero.

[8]The FSU 1984 adoption of technology survey indicated that the average hectares of manual tied ridging construction was 0.32 at Nedogo (Ohm et al., 1985b). One farmer with a large household who embraced the idea of tied ridging was able to do one hectare. Farmers indicated that they would have liked to do more but could not because of the labor constraint.

[9]The 3.0 ha figure is for tied ridging with donkey traction and is reflected in the budget analysis of Table 2. Thus the net revenue figures would be larger in Table 2 if the Table was based on the number of hectares an ox could tied ridge with the MRT which would be larger because oxen can work longer hours and move faster.

Table 2. Economic analysis of the mechanical ridge tier (MRT), 1985

	Treatments[1]			
	C	TR-Manual	MRT-1	MRT-2
Grain Yield, kg/ha	740	954	875	927
Yield Gain Above Control, kg/ha	-	214	135	187
Gross Revenue, CFA/ha[2]	37,000	47,700	43,750	46,350
Net Revenue, CFA/ha[3]	23,132	33,832	28,415	31,015
Net Revenue Gain Above Control, CFA/ha	-	10,700	5,283	7,883
Net Revenue Gain Above Control, CFA/ Area Tied Ridged[4]	-	9,630	15,849	23,649

[1]C= Control (traditional flat animal traction cultivation); TR-Manual = tying of animal traction made ridges manually at second weeding; MRT-1 = tying the ridges with the MRT at second weeding; MRT-2 = tying the ridges with the MRT at both first and second weeding. All treatments received 100 kg/ha of 14-23-15 applied at first weeding in a band 10-15 cm from crop rows and 50 kg/ha urea applied similarly at second weeding.

[2]Post harvest sorghum farm price of 50 CFA/kg x yield.

[3]Gross revenue minus fertilizer cost (90 CFA/kg for 14-23-15 and 78 CFA/kg for urea including 6 months interest charge of 15%) and minus yearly MRT cost 1,467 CFA/ha for treatments MRT-1 and MRT-2 (15,000 CFA total cost annualized over 5 years at 15% interest rate assuming the MRT is used on 3 ha/year).

[4]Based on the assumption that labor availability constrains manual tied ridging construction (TR-Manual) to 0.9 ha whereas labor and animal traction resources exist to construct 3.0 ha of tied ridging with the MRT in Treatments MRT-1 and MRT-2. Hectarage estimates are derived from a linear programming model (Table 6, Nagy et al., 1985).

thus making the difference in the net revenue and net revenue gains of the MRT larger.[10]

The 1985 data presented in Table 2 represent yields obtained under good weather conditions of an adequate and good distribution of rainfall throughout the cropping season. A good year such as 1985 however is not the norm. A survey of twenty Nedogo farmers indicated that a good distribution and rainfall year equal to or better than 1985 occurs about three years out of ten and that a poor year similar to the distribution and rainfall levels of 1984 also occurs three years out of ten. Thus the economic analysis presented in Table 2 is a good weather year scenario. In contrast, two poor weather year economic analysis scenarios are presented in Tables 3 and 4 using actual 1984 data for the Control and TR-Manual Treatments from the 1984 Nedogo donkey traction sorghum trials (Ohm et al., 1985b). Yields for the MRT-1 and MRT-2 Treatments in Tables 3 and 4 are hypothetical since the MRT was not used in 1984 however the yields bear a similar relationship to the yield of Treatment TR-Manual as was observed in the 1985 MRT trials. The partial budget analysis in Table 3 uses the same sorghum prices and fertilizer prices as those in Table 2 and reflects a poor weather year in which drought was a local phenomenon (hence the same sorghum price). Although the overall revenues in Table 3 are lower than those of Table 2, the difference in the net revenue gain in CFA/Area Tied Ridged for the MRT Treatments are much larger relative to that of the TR-Manual Treatment than for the corresponding figures in Table 2. The partial budget analysis in Table 4 reflects a poor weather year that is regional (as in 1984) and uses the 1984 sorghum price of 90 CFA/kg (prices were forced up because of the general drought). Both overall revenues and net revenue gains in this scenario are substantially larger than those of Table 2 as is the difference in the net revenue gains in CFA/Area Tied ridged between TR-Manual and the MRT Treatments.

Several conclusions can be drawn from the economic and labor data analysis. When using the one pass method with donkey traction, tying ridges with the MRT only requires 1 to 3.5 hours/ha of additional labor and substantially reduces the amount of labor required to construct tied ridges relative to that of tying the ridges by hand. Ox traction takes less time. Given the labor and time constraints, the MRT can be used to construct over three times as much tied ridging as can be tied by hand. The economic budget analysis indicates that the use of the MRT is very profitable for the farmer. The MRT was also found to be profitable under a range of both good and poor weather year scenarios.

SUMMARY OF RIDGE TYING MACHINE SURVEY

In October and November of 1985, farmers involved in the trials with the MRT were surveyed regarding their use of the machine as well as the problems they experienced. The survey was conducted in all three villages with MRT trials (Nedogo, Poedogo and Diapangou), after farmers had completed using the MRT at second weeding. A total of 43 households participated in the survey. The fifteen households in Nedogo included eight

[10] In the Nedogo MRT trial and in the two scenarios in Tables 3 and 4, the Control was fertilized. Had the Control not been fertilized, all the revenue figures above that of the Control would have been much larger in Tables 2 to 4.

Table 3. Scenario I, poor local weather year economic analysis of the mechanical ridge tier.

	Treatments[1]			
	C	TR-Manual	MRT-1	MRT-2
Grain Yield, kg/ha	355	773	750	750
Yield Gain Above Control, kg/ha	-	418	395	395
Gross Revenue, CFA/ha[2]	17,750	38,650	37,500	37,500
Net Revenue, CFA/ha[3]	3,882	24,782	22,165	22,165
Net Revenue Gain Above Control, CFA/ha	-	20,900	18,283	18,283
Net Revenue Gain Above Control, CFA/ Area Tied Ridged[4]	-	18,810	54,849	54,849

[1]Treatments correspond to those in Table 2, footnote 1. Yields for the control C and for manually tying the ridges (TR-Manual) are actual yields from the 1984 Nedogo donkey traction trials (Ohm et al., 1985b). Yields for MRT-1 and MRT-2 are hypothetical since the MRT was not used in the 1984 trials. The yields however bear a similar relationship to the yield of Treatment TR-Manual as was observed in the 1985 MRT trials.

[2]Post harvest sorghum farm price of 50 CFA/kg x yield.

[3]Gross revenue minus fertilizer cost (90 CFA/kg for 14-23-15 and 78 CFA/kg for urea including 6 months interest charge of 15%) and minus yearly MRT cost of 1,467 CFA/ha for treatments MRT-1 and MRT-2 (15,000 CFA total cost annualized over 5 years at 15% interest rate assuming the MRT is used on 3 ha/year).

[4]Based on the assumption that labor availability constrains manual tied ridging construction (TR-Manual) to 0.9 ha whereas labor and animal traction resources exist to construct 3.0 ha of tied ridging with the MRT in Treatments MRT-1 and MRT-2. Hectarage estimates are derived from a linear programming model (Table 6, Nagy et al., 1985).

Table 4. Scenario II, poor regional weather year economic analysis of the mechanical ridge tier.

	Treatments[1]			
	C	TR-Manual	MRT-1	MRT-2
Grain Yield, kg/ha	355	773	750	750
Yield Gain Above Control, kg/ha	-	418	395	395
Gross Revenue, CFA/ha[2]	31,950	69,570	67,500	67,500
Net Revenue, CFA/ha[3]	18,082	55,702	52,165	52,165
Net Revenue Gain Above Control, CFA/ha	-	37,620	34,083	34,083
Net Revenue Gain Above Control, CFA/ Area Tied Ridged[4]	-	33,858	102,249	102,249

[1]Treatments correspond to those in Table 2, footnote 1. Yields for the control C and for manually tying the ridges (TR-Manual) are actual yields from the 1984 Nedogo donkey traction trials (Ohm et al., 1985b). Yields for for MRT-1 and MRT-2 are hypothetical since the MRT was not used in the 1984 trials. The yields however bear a similar relationship to the yield of Treatment TR-Manual as was observed in the 1985 MRT trials.

[2]Post harvest sorghum farm price of 90 CFA/kg x yield.

[3]Gross revenue minus fertilizer cost (90 CFA/kg for 14-23-15 and 78 CFA/kg for urea including 6 months interest charge of 15%) and minus yearly MRT cost of 1,467 CFA/ha for treatments MRT-1 and MRT-2 (15,000 CFA total cost annualized over 5 years at 15% interest rate assuming the MRT is used on 3 ha/year).

[4]Based on the assumption that labor availability constrains manual tied ridging construction (TR-Manual) to 0.9 ha whereas labor and animal traction resources exist to construct 3.0 ha of tied ridging with the MRT in Treatments MRT-1 and MRT-2. Hectarage estimates are derived from a linear programming model (Table 6, Nagy et al., 1985).

with donkey traction and seven with oxen traction. In Poedogo, seven donkey traction and two horse traction households were surveyed, and the 19 households in Diapangou included eleven with donkey traction and eight with oxen traction. It should be noted that none of the farmers in Diapangou completed the trials correctly, so their responses may reflect lack of experience. This will be evident in the discussion of farmers' problems with the machine. The regular donkey version of the MRT was used with donkey and mono-bovine traction in Nedogo, donkey and horse traction in Poedogo and donkey traction in Diapangou. A heavier version of the machine was used for bi-bovine traction in Diapangou.

The farmers were questioned about a number of possible problems with the machine. These included problems with the MRT itself, agronomic problems, and evaluation of the quality of tied made. One of the problems was the weight of the machine. Many farmers thought the machine was too heavy, and consequently too hard on the animal pulling it. This varied by type of animal traction and by village. In Nedogo most donkey users (80%) thought the machine was too heavy, but none of the farmers thought the machine was too heavy for oxen. In Poedogo, 63% of donkey users thought the machine was too heavy but horses did not have a problem. Most donkey users in Diapangou found the machine too heavy (82%), and unlike the other villages, oxen users also thought the machine was too heavy (88%). This is because oxen teams are used in Diapangou, and the machine that was adapted to this traction is substantially heavier than the regular donkey version.

Closely related to the problem of weight is the technique used in various villages. In Nedogo, one pass through the field was used at both first and second weeding, with the ridging and tying of ridges done simultaneously. The load on the animals could be lessened by doing ridging and tying in two separate passes. Forty percent of donkey users in Nedogo thought two passes would be better, especially at second weeding. Farmers with oxen, however, preferred one pass. Diapangou farmers used one pass through the field at both first and second weeding. About half the farmers using both types of traction thought that the two pass method was better because it was less tiring for the animal. However, a number of farmers expressed concern over the amount of time needed to do two passes, especially during first weeding when time is an important constraint. Regardless of their yes-no response to the question, most farmers expressed this animal fatigue-time constraint trade-off. The practices in Poedogo are somewhat different. The ridger (middle sweep) used at second weeding in Poedogo is subtantially bigger than elsewhere and the making of the large ridges increases the draft the animals must pull. In addition the soils are slightly heavier than in the other two villages. While the one pass method was used at first weeding in Poedogo, the draft of the MRT in addition to that of the ridger with the large middle sweep at second weeding was considered too heavy for one animal and all trials were done using two passes at second weeding. Most farmers surveyed (89%) thought the two pass method would be better to use at first weeding, and all farmers preferred two passes at second weeding.

When farmers were asked how many hours per day their animals could work with the ridge tier (using one pass in Nedogo and Diapangou, and two passes in Poedogo), they responded as follows:

	Donkey	Oxen	Horse
Nedogo	2.3	4.7	
Diapangou	2.0	2.3	
Poedogo	3.4		4.8

As can be seen, oxen or horses have a substantial advantage over donkeys when the lighter version of the machine is used, although using two passes increases the amount of time that donkeys can work at tying.

In general, farmers did not have problems with the machine breaking down. Only 16% of the farmers reported minor problems with the brake cable or cable cover, and with the rubber "spring" on the paddle release.

Farmers stated that the machine was easy to learn to use, most farmers taking less than 15 minutes to become familiar with the machine. Only three farmers expressed problems learning to use the machine, and these problems were related to their animals rather than the machine itself. One farmer was not familiar with animal traction and one farmer had a poorly trained animal.

One agronomic problem discussed involved the size of plants at first weeding and tying. Two-thirds of the farmers in Nedogo thought the plants were too small to do weeding and tying at first weeding. However, none of the farmers in the other two villages agreed with that. It is unclear what the problem might be in Nedogo, since only a small triangular piece and not a full-sized ridger is used with the tier at first weeding. In Diapangou several farmers said that the plants were too big at second weeding, and that the plants broke in turning the machine. However, second weeding of all trials was done late in Diapangou, if at all, hence the plants were bigger than they should have been. This emphasizes the importance of timing in the ridge tying process.

Finally, farmers were asked about the quality of the ties made by machine. Only one-third of the farmers thought ties made by hand were better than those made with the machine. Again, most of those farmers qualified their response with a concern over the amount of time required to make ties by hand, concluding that the quality loss was more than offset by the gain in time. A few farmers in Poedogo and Diapangou stated that the ties erode after consecutive rains, and machine tied ridges were slightly worse than hand tied ridges. This problem was most serious in Poedogo, the village with the highest rainfall, where three out of the six farmers who responded found that machine-made ties eroded more readily in the rain. Only one farmer out of seven had the same problem with hand-made ties.

Besides problems with the machine, farmers discussed how they would use the machine. Crops on which farmers would use the tied ridging machine are as follows:

	1st Choice			2nd Choice			3rd Choice	
	Millet	Sorghum	Maize	Millet	Sorghum	Maize	Millet	Maize
Nedogo	4	11	0	9	4	2	2	12
Diapangou	9	2	7	4	5	4	0	1
Poedogo	8	1	0	1	0	0	0	0

In general, both sorghum and millet are considered good prospective crops on which to use the machine. In Nedogo and Diapangou, maize is also important. A general lack of response on 2nd and 3rd choices in Poedogo makes any conclusions there difficult. When asked on what crops they would specifically not use the machine, farmers in Diapangou and Nedogo responded overwhelmingly with peanuts. Also mentioned were cowpeas, bambara nuts, and soybeans (in Diapangou). When the response was explained, most farmers said that these crops were planted with density and spacing that was not appropriate for the machine. Many farmers in Diapangou also mentioned that they would not use the MRT on sorghum that was planted in the low-lying areas (bas-fonds) which already hold water.

The final questions on the survey asked whether the farmer would continue to use the machine next year, and whether he would buy a machine for himself if it cost 15,000 CFA. Nearly every farmer (95%) responded that he would continue to use the machine the following year. When asked if they would buy the machine, however, farmers were somewhat more cautious. In Nedogo, where the trials were completed most successfully, all 15 farmers said they would buy the machine, although two modified the response to "if I had the money". In Poedogo, seven out of nine farmers would buy the machine. One who would not said he wanted to see the results of another year first. Six of the eleven donkey users in Diapangou would buy the machine, three if they had money and one if reasonable credit was available. Of the farmers who would not buy, three indicated they would buy the machine if it cost half as much, or 7500 CFA. the machine was least popular among oxen farmers in Diapangou. Only three out of eight people indicated they would buy, and all these farmers said only if reasonable credit was available. Four farmers indicated they would be interested if the machine cost 7500 CFA. Overall, 72% of the farmers surveyed in the three villages said they would buy the machine at 15,000 CFA, possibly only if reasonable credit was available. Several other farmers would be interested if the machine was cheaper.

FIELD STAFF OBSERVATIONS

Field staff observations were in general agreement with the results from the farmer questionnaire and many of their comments have been incorporated into the text of the study thus far. They did observe however, that older farmers found it difficult to trip the paddle and lock it back in time to make a proper tie. Also, farmers found it difficult to turn around at the end of the rows because of the awkward weight displacement of the MRT. This was particularly true for the larger ox traction version of the MRT. The farmers, however, were able to manage as they gained experience with the MRT. They observed that in general, farmers were very quick to learn how to operate the MRT. They also observed that farmers did not have any problems in ridging or tied ridging with the MRT at second weeding in Treatment MRT-2 where the tied ridges that were made at first weeding had to be broken and gone over.

A problem of the adaptability (proper attachment) of the MRT arose with ox traction farmers using the HVO2-B plow, the Hoe Fada or the Charrue Verte. Modifications of the attachment apparatus of the MRT had to be made in the field but could be improved upon. The attachment apparatus either needs to be universal or several types must be made available to fit the various cultivators and plows that the farmers use.

The field staff observed that the MRT performed well across all types of soil except those heavy in clay. The best tied ridges were made on sandy loams or loamy sands. To make better tied ridges on soil with heavy clay, adjustments can be made to increase the angle at which the MRT cuts into the ground so that sufficient soil is available for the tie. This however significantly increases the draft.

SUMMARY OF ADOPTION SURVEY FOR RIDGE TYING MACHINE

In November 1985, a survey was conducted to determine the extent to which the ridge tying machine had been adopted by FSU cooperator farmers in Nedogo on their own land. This cropping season was the first time these machines had been used in Burkina Faso, so adoptors were simultaneously using the machine for the first time on farmer-managed trials and using it on their own fields. Sixteen farmers were given machines and participated in the trials. Of these sixteen, seven farmers (43.8%) used the machine to tie ridges on their own fields. The technology was used on a total area of 2.14 hectares or an average of 0.31 hectares per farmer. Of this total, 0.84 hectares were on millet and 1.30 hectares were on white sorghum. In addition, two farmers used small amounts of urea fertilizer. Six of the adoptors used oxen traction and the remaining farmer used donkey traction to pull the MRT.

By way of comparison, a 1984 survey found that 17 (24.6%) out of 69 farmer cooperators in Nedogo were using hand-tied ridges on an average of 0.31 hectares per farmer (Ohm et al., 1985b). This was the fourth year in which tied ridging trials had been done in Nedogo. A second survey to determine extent of adoption of hand-tied ridges has not been conducted in 1985, making direct comparisons impossible. Field staff were aware of a few farmers who used hand-tied ridges in Nedogo this year, but thought many farmers who had done hand tied ridges last year has switched to the machine this year. Considering the small number of farmers involved in the MRT trials, and the fact that this was the first year for the trial gives encouraging evidence that the machine will be adopted more rapidly than the time-consuming hand tied ridges. Regarding crop mix, 1984 results indicated that approximately 85% of the tied hectarage was on millet and 15% was on white sorghum (although some households were missing crop information). This again emphasizes the fact that farmers consider this a viable technology to be useful on millet as well as on the white sorghum which was stressed in the trials.

CONCLUSIONS AND RECOMMENDATIONS

The increased yields from tied ridging as noted in the Nedogo trials support the findings from previous FSU field campaigns. The MRT is profitable for farmers to use and the increase in yield more than pays for the cost of the MRT under various scenarios of good and poor weather conditions. The labor savings from the use of the MRT over that of tying the ridges by hand are substantial even if the second pass method is used. Ridging and tying in one pass represents the best method of saving labor although a number of farmers thought the machine was too heavy to use in one pass. Because of the labor savings, the MRT enables farmers to tie ridges on a larger proportion of their land relative to that being tied by hand, substantially increasing grain production and net revenue of the farm. Most farmers expressed an interest in continuing with the machine, for use on millet as well as sorghum, at the 15,000 CFA price - given that credit was available.

The yields from the two MRT Treatments were slightly lower than the yields of the Treatment where the ridges were tied by hand. Particular attention must be given to row width so that the MRT does not prune the roots and also allows for maneuverability within the row so as not to damage the plants, keeping in mind that the purpose of ridging at second weeding is to support the plants against lodging.

Although the ties made by the donkey version of the MRT were marginally lower and had a smaller base than those tied by hand, they did stand up to erosion very well especially in a year of good rainfall. Ties made with the larger ox version of the MRT and pulled by two oxen, made ties comparable to that of the ties made by hand.

Further work is required to establish the geographical areas within Burkina (as well as within the region) that are suited to tied ridging and under what circumstances the soils are suitable so that recommendations can be made to the Extension System. The research already performed by IBRAZ, IRAT, IITA, ICRISAT and FSU with respect to soils and tied ridging provides a base to make recommendations.

Future research on mechanical ridge tiers such as the MRT needs to consider the following: 1) reducing the weight and awkardness of the machine without reducing its effectiveness while striving for a machine that ridges and simultaneously ties the ridge in one pass, 2) design studies to increase the adaptability of the machine across a wide range of cultivator/plow equipment now being used, and 3) the possibility of an automatic tripping device for machines like the MRT.

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