Sustainable Production Systems

Economic and Sustainability Evaluation of New Technologies in Sorghum and Millet Production in INTSORMIL Priority Countries

Project PRF 205
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Summary

Synthesis of the lessons from the four Sahelian country, Marketing-Processing project: In the good rainfall year of 2003-04 the gains from selling later in the post harvest period with inventory credit programs are considerably lower than in the bad rainfall year (2002-03). However, there are much larger payoffs to the new technologies in these good rainfall years so that the total gains to farmers' incomes are much higher than in the bad rainfall years. The myth that farmers will not use higher input levels (inorganic fertilizers and other chemicals) on their millet was once again refuted. The big payoff initial marketing strategy innovation is the inventory credit. However, with the contracting process the project is also developing the food and feed processing sector and facilitating the availability of greater quantities of a high quality cereals.

In two zones of Ethiopia the *Striga* resistant cultivars were being introduced. Their introduction was constrained by being shorter season than most local cultivars but the *Striga* resistant cultivars were appreciated in low rainfall years. A variety of water retention techniques were being adopted in both regions. Little inorganic fertilizer was being used on these short season cultivars. There is a general agreement among farmers and extension agents of the payoff to moderate and longer season length sorghums with *Striga* resistance.

We extended our research on the link between new technology introduction and marketing strategy improvement from the Sahel to central Mozambique. Without price increase from new marketing strategies no new technologies evaluated would be introduced. With inventory credit and/or the other marketing strategies evaluated new technologies are introduced and farmers' income increased by 58 to 81%.

Objectives, Production and Utilization Constraints

In the last two years we became involved in a development program in the Sahel to operationalize many of the concepts, which we have been researching. This development project is operating in five countries (four in the Sahel and it will include Nigeria). This project facilitates the introduction of both marketing strategies and new technologies in millet and sorghum production.

We continue to evaluate the introduction of *Striga*-resistant cultivars and associated technologies in Ethiopia. Field work for the second major region of Ethiopia-the Amhara zone focusing on the north Kobo valley- was begun and a journal article written on the introduction of these technologies in the Tigray region on the border with Eritrea (Sheraro). In other work an evaluation of the combined introduction of farm level technologies and marketing innovations for maize and sorghum in Mozambique was almost finished. We are taking the same concepts we are using in the Marketing-Processing project and evaluating their potential impact in Mozambique. Finally we have begun a program to resurvey the introduction of inorganic fertilizer in western Niger. We are examining the dynamics of this introduction as well as looking at the performance of inventory credit there.

Research Approach and Project Output

Marketing-Processing Development Project in the Sahel and northern Nigeria

The six weeks of field interviewing of farmers and processors in four Sahelian countries in the spring-summer of 2004 indicated the importance of combining inorganic fertilizer with the new cultivars. It also demonstrated again the returns to inventory credit so that farmers can avoid selling their cereals during the post harvest price collapse. Figure 1 indicates the differences in prices between harvest time and six months later for both a poor rainfall year (2002-03) and a good rainfall year (2003-04).

In a good year, there will be a much larger yield effect from the use of the improved cultivar, seed treatment, and inorganic fertilizers. There have been two important myths in the Sahel. First, that there is not a response to fertilizing millet. Secondly, that, farmers would not use inorganic fertilizer on millet because they only use it on cash crops, such as cotton or maize, and not on subsistence crops, such as millet and sorghum. In this good rainfall year (2003) the substantial yield gains to inorganic fertilizer were consistently observed. In the poor rainfall year of 2002 there were also yield gains from higher input use but smaller ones.

As soils continue to be depleted and organic fertilizers are increasingly used by farmers to increase the availability of water and nutrients in the sandy soils,[1] farmers focus on the importance of getting adequate inorganic fertilizers on a timely basis. For the increased use of inputs to be profitable, farmers need to sell part of their crops after the price recovery in the post harvest period. This is especially important in good rainfall years when there is not only the annual harvest price collapse but also the between year price collapse resulting from good weather.

Of the marketing strategies the most potential is for the farmer to obtain more of the gains from seasonal price variation rather than the merchant or the processor capturing all these gains. In the long run the returns from a quality premium and the expansion of the food and feed sectors are expected to have substantial impacts on farmers' incomes. In the short run the farmers need to benefit from the seasonal price variation and some type of inventory credit program enables them to do that. In a bad rainfall year, such as 2002-03, millet prices in the four Sahelian countries doubled during the off-season.

However, as many farmers store and sell in later periods the seasonal price swings will smooth out. Hence, we need to be developing several marketing strategies to increase farm incomes over time and to moderate the price declines of good rainfall years. The Marketing-Processing Project works with food and feed processors: (1) to supply a higher quality product, (2) to make contracts with farmers for purchasing later in the season (after the post harvest price recovery) and for processors to pay a price premium for a higher quality product to farmers.

Striga resistant cultivars and associated technology introduction in two major zones of Ethiopian sorghum production

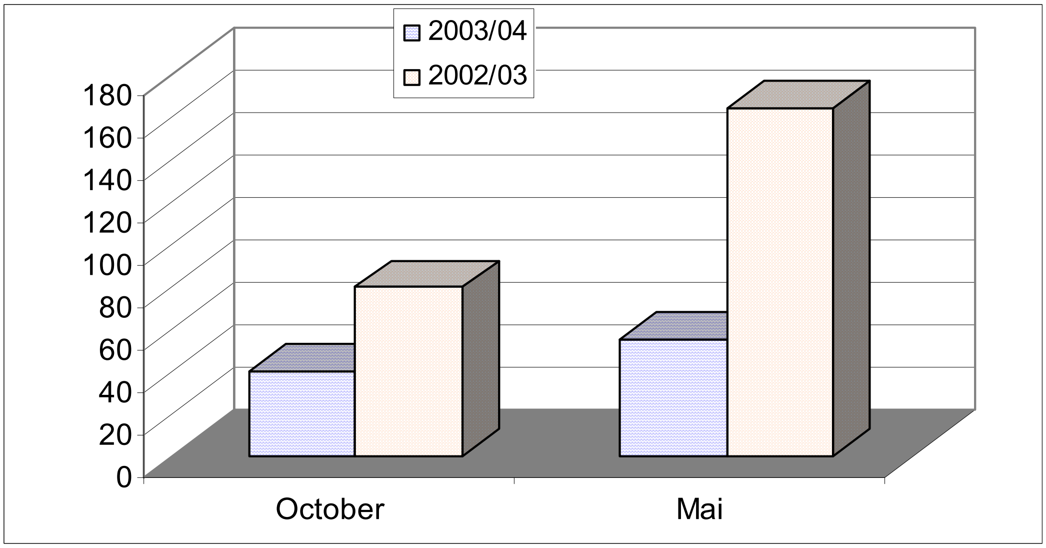
In earlier (INTSORMIL Annual Report, 2002) work we reported the results for the diffusion of new *Striga* resistant sorghum cultivars and associated technologies in northern Tigray. There a series of water retention techniques had been introduced with government organized farmer collaboration to dig trenches and do ridges with dirt, stones and plants. The introduction of the tied ridger was included in this *Striga* technology diffusion program but the ridger was not used on the hillsides (due to stones or incline according to farmers). Moreover, there were only a limited number of ridgers made available in the region. Nevertheless, use of some water retention technique was pervasive. Ninety percent of the farmers used one or more water retention techniques with the most popular being soil or stone ridges (65%).

The diffusion of inorganic fertilizer was still limited. Twenty percent of the farmers utilized inorganic fertilizers but none on the short season, *Striga* resistant cultivars. For the fertilization it will be important to make sure that farmers can get a higher return as they use higher input levels. One technique for achieving this objective is by selling later in the season and the potential returns from this activity and whether it leads to increased sorghum technology diffusion are presently being examined with Nega Wubenah re-interviewing the Tigray survey participants in 2003.

In Tigray only 8% of the farmers were using the *Striga* resistant cultivars in 2001. The diffusion process was still very early as the official release of the new cultivars had only been in 1999 and 2000. Unofficially these cultivars began to be available from the regional trials after 1996. Nevertheless, the majority of the farmers sampled had not even heard about the *Striga* resistant cultivars in the 2001 interviews. Note that a significant statistical factor in the diffusion of the new cultivars was

[1] In the sandy soils of semiarid regions millet is the predominant cereal with sorghum replacing it in the heavier or better soils with more clay as in the river valleys, the water recession areas, under the legume tree and around the household compound.

Figure 1: Millet prices (CFA/kg) in good (2002/03) and bad (2003/04) cropping years, Cinzana, Mali.



1US $=500 CFA
Source: Field interviews

participation in the local governmental administration. This awareness of the new cultivars was a type of insider information.

Besides *Striga* resistance the cultivars are much earlier than the local cultivars. So farmers prefer them when the rains start late, approximately 37% of the time. With normal or early rainfall (two thirds of the time) the longer season, local cultivars respond better to being in the field longer. Note that some farmers were using inorganic fertilizers on the local sorghums but none on the new shorter season cultivars. When the rains are early or normal, farmers do not plant the shorter season *Striga* resistant cultivars. Moderate and longer season *Striga* resistant cultivars will be very important in the next stage of introduction of new technologies. This over-emphasis on drought avoidance via shorter season material is a pervasive behavior in semi-arid regions. However, as improved water retention and soil fertility improving technologies are being introduced, breeders can return to a focus on biotic resistances and higher yield characteristics.

Table 1. Use of the *Striga* resistant sorghums in the North Kobo sample (2001-2003).

Local name of Striga resistant cultivar	Crop Year 2001	2002	2003	Total
Gobiye	3	6	17	26
Abshir	0	0	10	10
Birhan	0	1	2	3
Total	3	7	29	39*

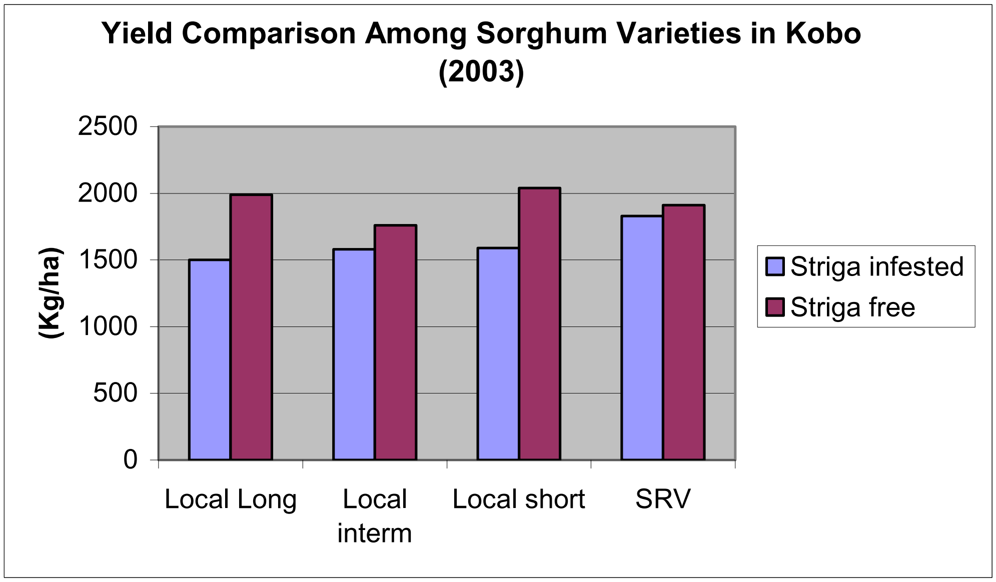
*/There were 101 farmers in the survey and one of the farmers planted Gobiye in the last two years so only 38 innovators. The seed distribution scheme needs to be improved as farmers expected to be given the seed each year.
Source: Yigezu, 2004 (unpublished survey data)

In 2003 surveying began in the older settled, north Kobo valley in Amhara state. A similar diffusion program of *Striga* resistant cultivars and associated technologies has also been implemented there in the last three years and in the two other major zones of Ethiopia.

Diffusion of water retention techniques was a national priority of the extension services after the drought of 2002. So a series of measures especially the Chinese lined pit technique were promoted in this crop year. These valley soils are regularly flooded with the erosion of the highlands. Many farmers also do some supplemental irrigation of higher value crops. So in these naturally fertilized fields with generally abundant water, yields are high even without inorganic fertilizers. The diffusion of the new *Striga* resistant cultivars is rapidly reaching 38% in the third year of the program to extend these technologies (Table 1). As in Tigray farmers did complain about the earliness of the *Striga* resistant cultivars but they also expressed substantial interest in continuing to grow them. With some support to continuing quality seed systems this diffusion is expected to accelerate over time.

Farmer recall data generally are not very accurate as these Ethiopian farmers (and most small farmers in developing countries) do not know their exact areas and the principal crop use is for subsistence so they are not very accurate about quantities. More accurate estimation of yields would need to employ crop cutting and surveying. Nevertheless, we obtained farmers' estimates of their yields with different varieties and fertili-

Figure 2. Yield Comparisons between the New *Striga* Resistant and other sorghum varieties in Kobo valley



zation techniques. Sorghum yields are fairly high in this fertile valley. Figure 2 indicates that farmers generally perceive that the new cultivars are out yielding the local cultivars and that there are returns even in this fertile valley to the recommended *Striga* resistant cultivars and inorganic fertilizer.

Marketing Strategies and Introduction of New Technologies in central Mozambique

From the involvement in the Marketing-Processing development project (see Figure 1 above in this section) has come the recognition that the intensification of sorghum and millet production depends upon farmers receiving higher prices. Low farmer prices are due to selling at the post harvest price collapse period, the price inelastic demand for most staples in developing countries resulting in price collapses in good rainfall years, and the downward price pressures from food aid in bad rainfall years.

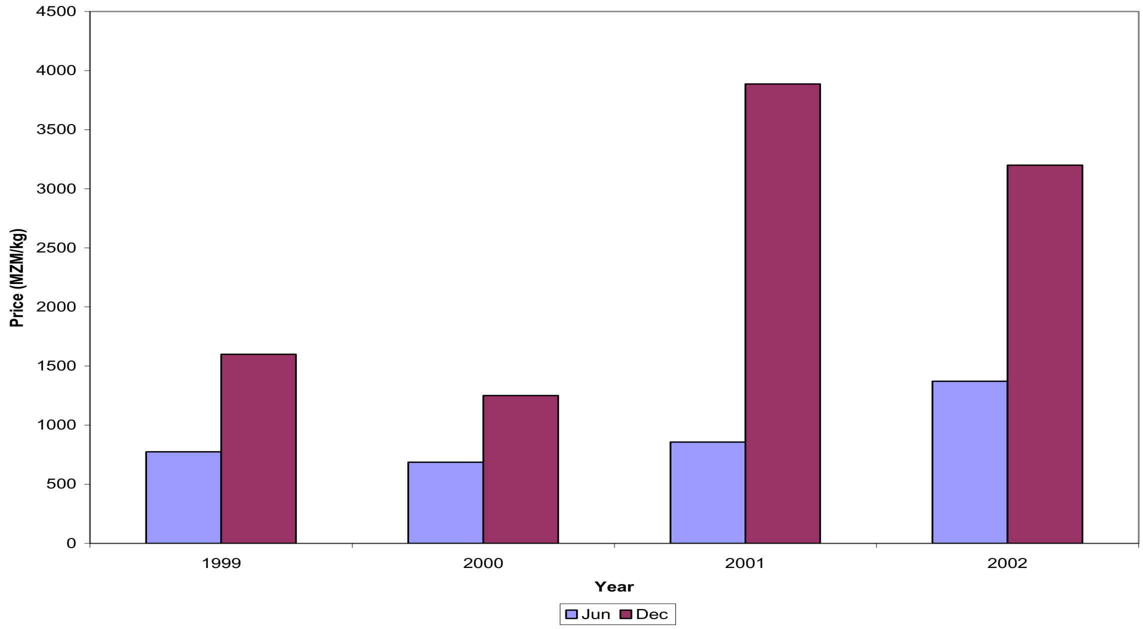
The fieldwork of Rafael Uaiene was in the main maize zone in Central Mozambique, Manica. Sorghum is also an important crop here but rainfall averages 1100 mm/year, soils are fertile and infrastructure is good. In spite of numerous activities of the public sector and various NGOs new cereal technology introduction has been minimal and, where successful, has been associated with subsidized inputs as for fertilizer and/or credit.

Available new sorghum technologies were not an improvement over traditional cultivars as most new sorghum cultivars were early and therefore subject to bird attack, increased head bug and mold complexes, and lack of farmer interest during normal and good rainfall years. Local cultivars were also predominantly Guineas as opposed to the new Caudatum cultivars, which are much more subject to birds and the head bug-mold complex. In higher rainfall, prime zones, such as Manica, sorghum is there principally to take advantage of the lower fertility soils and to diversify the production of the basic food staple for the bad rainfall years. So unless a longer season, higher yielding sorghum is produced not only is new sorghum technology not going to be introduced but also we would expect sorghum to disappear from the crop combination as improved maize technologies are introduced. Nevertheless, the results for maize here would be expected to be relevant for sorghum in other regions where rainfall is lower and sorghum is the principal cereal.

The potential gains to two types of marketing intervention are illustrated in Figure 3. By selling six months after the post harvest price collapses there are substantial differences in prices. These price differences indicate the potential benefits to an inventory credit program. The costs are the direct storage costs, grain losses over the six-month period of storage, and the costs of borrowing the money to store (opportunity cost of capital). When simple economic analysis was undertaken (partial budgeting), inventory credit was a profitable activity for both of the traditional cereal production techniques (sorghum and millet) and for the new maize technologies.

Using farm-programming models no new technology would not be introduced for maize production in the absence of at least one of the new marketing strategies (Table 2). If inventory credit were available, 1.5 ha of new maize technology would be adopted and farm income increased by 58%. The farm needs to moderately expand liquidity but this can be done by selling small animals. There is still a very high return to further capital invested, with a shadow price of capital of 82%. So we would expect a further dynamic effect of farmers' reinvesting their

Figure 3. Maize price variation between June and December in Manica, Mozambique (1998-2002)



1 US$=MZM 23,854
Source: SIMA (various years)

increased profits. Over time the income effect would be even larger as farmers respond to the high potential returns of further investments in inputs.

There are two other marketing strategies evaluated. The expansion of the processing demand for food and feed would moderate the price collapse in good rainfall years (see C and E above in Table 2). A modification by the public sector of polices to drive down the prices of agricultural products in bad rainfall years would also help increase the expected prices for farmers and thereby encourage more investments in purchased inputs (see D and E). The combination of all three marketing strategies would further increase the crop area in new technologies to 1.8 ha and increase farmers' incomes from present levels by 81%. A further dynamic effect of continuing adoption is expected from the high return on capital once the adoption process is begun.

Table 2. Technology introduction and the income effects of the different marketing strategies in Manica, Mozambique

	Model				
Technology	A	B	C	D	E
Traditional maize technology	3.2	2.5	2.5	2.5	2.3
Improved Maize+NPK	0	1.5	1.5	1.5	1.8
Traditional sorghum tech.	0.5	0	0	0	0
Beans	0.4	0.4	0.4	0.4	0.4
Cowpeas	0.50	0.5	0.5	0.5	0.5
Cotton	0.9	0.6	0.6	0.6	0.5
Expected income	$357	$565	$610	$598	$645
Income increase (%)	-	58	71	68	81
Shadow price of capital (%)		82	82	82	82

A. Base Model; B. Inventory Credit; C. Inventory credit and moderation of price collapse in good and very good states of nature; D. Inventory credit and moderate public intervention in bad years and E. Combination of scenarios B+C+D

1 USD $ =MZM 23,854 (IMF, 2004) Source: Model results

Networking Activity

Dr. Rooney, Felix Baquedano and Dr. Sanders spent approximately two weeks in El Salvador and Nicaragua in the summer of 2003. The objective of the trip was to explore extending the Marketing-Food Technology project into Central America. Felix Baquedano submitted a research proposal to a local funder and that was useful for his present field research even though not successful in obtaining funding. A new potential graduate student was identified from El Salvador and future funding promised by the INTSORMIL Central American program. An extensive trip report reporting on marketing and food/feed processing was also produced.

Dr. Sanders participated in the Eritrean workshop in September 2003 in Asmara, Eritrea to introduce *Striga* resistant sorghums and associated technologies in the highlands. Sorghum is the principal cereal in Eritrea. He presented a paper there and interacted with participants.

Botorou Ouendeba spent two months in the fall of 2003 with Drs. Sanders and Tahirou Abdoulaye at Purdue developing a five-year research program for funding from the USAID regional office in Bamako, Mali. One objective of this work was the revision of the two concept papers on Marketing and Food Technology respectively and a third paper on the first year results from the Marketing-Processing development work. The three papers were combined and printed in a bulletin and widely distributed.

Ouendeba Botorou and Dr. Sanders spent two weeks in Nigeria in March 2004. This trip was in response to the request from Dr. A. Levine of USAID, Nigeria to evaluate the possible extension of our Sahelian Marketing-Processing program into northern Nigeria. Collaborating with on-going programs of IITA, Global 2000, IFDC and the Nigerian government we visited farm trials and processors and made a report to Dr. Levine and others on our observations and suggestion for future activities.

In May-June 2004 Ouendeba Botrou, Tahirou Abdoulaye and Dr. Sanders spent six weeks reviewing the progress of the Marketing-Processing project visiting farmers' groups, food and feed processors in four Sahelian countries. A summary trip report is now available and Tahirou Abdoulaye is making the calculations to estimate the income gains from the new technologies and from the marketing strategies. These estimates will be incorporated into another paper and compared with the results for 2002-03.

Publications and Presentations

Journal Articles

Abdoulaye, Tahirou and J.H.Sanders, in press. Stages and determinants of fertilizer use in semiarid African agriculture. Agricultural Economics, 39 pages.

Sanders, J. H. and B. I. Shapiro, 2003. Crop technology introduction in semiarid West Africa: Performance and future strategy. Journal of Crop Production, 9, 2 and 3, 559-592.

Vitale, Jeffrey D. and J. H. Sanders, in press. New markets and technological change for the traditional cereals in semiarid Sub-Saharan Africa: The Malian case. Agricultural Economics, 55 pages.

Book Chapter

Sanders, J.H. and B. Shapiro**,** in press. Policies and market development to accelerate technological change in the semiarid zones: A focus on Sub-Saharan Africa. Dryland Agriculture, American Society of Agronomy, 40 pages.

Conference Proceedings

Sanders, J.H. and B. Shapiro**, (**in press) Policies and market development to accelerate technological change in the semiarid zones: A focus on Sub-Saharan Africa. Proceedings from the international INTSORMIL conference held in Ethiopia in November 2002, 26 pages.

Bulletin

Ouendeba, B. 2003. Market improvements and new food crop technologies in the Sahel. INTSORMIL, University of Nebraska, Lincoln, Nebraska.

Conference Presentations

Sanders, J.H. 2003. Public policies, markets and new sorghum technologies. Workshop on the Introduction of *Striga* Resistant Sorghums, Asmara, Eritrea.

Cropping Systems to Optimize Yield, Water and Nutrient Use Efficiency of Pearl Millet and Grain Sorghum

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Summary

Principal investigators in INTSORMIL Project UNL-213 continue with international research efforts related to nutrient management and use efficiency in West Africa and Central America. Microdose fertilizer application increased pearl millet grain yield across three years and three West African countries by 249 kg ha^{-1} (49%), but results were variable as indicated by interaction effects. Microdose application resulted in similar net nutrient removal as the zero fertilizer control. Over 30 kg ha^{-1} N and approximately 10 kg ha^{-1} P were required to eliminate mining of nutrients from the soil. The highest grain and stover yields required 20 kg ha^{-1} P and 30 kg ha^{-1} N. Rotation of rows between pearl millet and cowpea in a row-intercropping system increased pearl millet grain yields by 114 kg ha^{-1} (9%) over monoculture pearl millet, thus increasing the land efficiency ratio by 42%. Zaï plus 300 g manure per hill increased grain sorghum grain yields greatly due to water conservation and nutrient application. Study was initiated to determine best management practices for production of grain sorghum for dolo (traditional beer) in Burkina Faso.

In Nicaragua, nitrogen application increased sorghum grain yields quadratically for both photoperiod insensitive varieties with the highest yields of 3.9 Mg ha^{-1} being produced at the highest N rate of 194 kg ha^{-1}, but economic analysis indicated 129 kg ha^{-1} to be the optimal rate. Little difference in nitrogen use efficiency was found among the photoperiod insensitive varieties tested, indicating that broader screening of germplasm in Central America sorghum breeding programs will be needed to identify and develop high nitrogen use efficient photoinsensitive sorghum varieties. In El Salvador, the photoperiod sensitive varieties 85SCP805 with 47 kg ha^{-1} N application increased grain yield by approximately 800 kg ha^{-1} (26%) over the local check without N application

Research in the United States determined that 90 kg ha^{-1} N produced optimum pearl millet grain yields in Eastern Nebraska, but N application often resulted no economic yield increase in the drier western Nebraska production environment. Yield component studies indicated that newer released grain sorghum had more interaction among yield components, although yield was only slight higher.

INTSORMIL Project UNL-213 emphasizes capacity development through graduate education, short-term training, and coordination of the Central America Regional Program. Graduate students from Chad and the U.S. are working on M.S. degrees.

Objectives, Production and Utilization Constraints

Objectives

Conduct multi-year research on microdose, N and P fertilizer application on pearl millet grain yield, nutrient removal, and changes in soil nutrient levels in Burkina Faso, Mali and Niger.

Conduct research on mechanized (i.e. animal traction) Zaï production system for pearl millet in Burkina Faso, production practices for traditional beer production in Burkina Faso, weed control interactions with fertilizer rates in Mali, fertilizer rate by plant population for hybrid grain sorghum seed production in Niger, and use of poultry manure as nutrient and soil improvement for pearl millet production in Niger.

Evaluate grain sorghum and maize hybrid from the 1950s, 1970s and 1990s under low and high water holding capacity soils, wide and narrow rows, and dryland and irrigated environments to better understand the shift of dryland sorghum area to maize in the western corn belt.

Determine recommended production practices for pearl millet production in Nebraska.

Conduct N rate and N use efficiency studies for grain sorghum production in El Salvador and Nicaragua to identify N use efficient varieties and determine N rate recommendations.

Increase research human capital in West African and Central American countries where pearl millet is an important crop through graduate education, short-term training and through mentoring former students upon return to their home country.

Collaborate with national extension services and NGO/PVOs in transferring improved pearl millet and grain sorghum agronomy practices.

Constraints

This project has focused primarily on crop production systems which increase the probability of obtaining higher pearl millet and sorghum grain and stover yields. This involves systems which increase nutrient and water availability to growing crops, and produces desired uniform stands. Present efforts emphasize inorganic and organic fertilizer management, developing varieties and cropping systems to improve nitrogen use efficiency of sorghum, water management of traditional and improved cultivars, and weed control strategies. Cropping system research efforts require long-term investments of well-trained, interested scientists and stable funding. Education of additional scientists in crop management and continued support of their work after return to their home countries is needed to improve productivity of cropping systems and to maintain the soil/land resource.

Research Approach and Project Output

Pearl millet and grain sorghum are usually grown in stressful environments with high temperatures, lack of predictable water supply, fragile soils with low nutrient status, and limited growing season length. Lack of water is usually considered to be the most critical environmental factor controlling growth and limiting yield in Africa, but a source of nitrogen and/or phosphorus often is more critical. This is especially true for intensive cropping systems using improved cultivars on degraded land. Nutrient use and water use efficiencies are closely interwoven with higher yields possible with improved cropping systems utilizing improved cultivars. Since human capital for research and extension activities are very limited for pearl millet producing areas in West Africa, project activities are generally conducted as either as graduate education programs for scientists from this region and as mentored collaborative activities upon return of former graduate students. Studies have been initiated with collaborators in Central America on nitrogen fertilizer management and identification of nitrogen use efficient genotypes for grain sorghum production which is also a critical issue in the region. In the U.S. Great Plains, production practice recommendations for planting date, nitrogen rate and water supply for high yielding, dwarf pearl millet hybrids are being determined to help adoption as an alternate grain crop. Due to pearl millet having relatively higher grain yields than other crops with late planting, double cropping research with winter wheat will be conducted. This complex interaction of water, nitrogen, phosphorus, cultivars and yield enhancing production practices is the focus of Project UNL-213's research efforts.

Domestic (Nebraska)

Nitrogen Rate Recommendations for Pearl Millet Production in Nebraska (Nouri Maman, Ph.D. Thesis)

Research Methods

Field experiments were conducted in five different environments in eastern and western Nebraska. The pearl millet hybrids '68 x 086R' and '293A x 086R' were grown at N rates of 0, 45, 90 and 135 kg N ha^{-1}. Grain and stover yield, and yield components were determined, nitrogen use efficiencies calculated, and marginal product economic analysis was conducted.

Research Results

Grain and stover yield and protein concentration varied among environments. Low yield potential in western Nebraska due to drought limited pearl millet response to N application. Hybrids had similar yield, protein concentration and N use efficiency responses to N rate, although the hybrid '293A x 086R' produced approximately 200 kg ha^{-1} more grain. In the higher rainfall environments of eastern Nebraska, maximum grain yields were between 4040 and 4890 kg ha^{-1} with 90 to 135 kg N ha^{-1}. Protein concentration increased with N rate in all environments, and most measures of N use efficiency. Economic analysis indicated 90 kg N ha^{-1} to be the optimal rate for eastern Nebraska.

Grain Sorghum - Maize Hybrid Yield Components in Dryland and Irrigated Environments (Delon Kathol, M.S. Thesis)

Research Methods

A three-year study was initiated in 1999 to determine the importance and physiological basis for shift in dryland sorghum production to maize production in eastern Nebraska. Best hybrids were identified from the 1950s, 1970s and 1990s as the best performing hybrids in the University of Nebraska Performance Tests and they were produced in three environments each year. The environments were sandy loam and silty clay loam soil types, and irrigated and dryland water regimes on the silty clay loam soil. Yield and yield component relationships were determined by correlation and path analysis procedures.

Research Results

Correlation analysis indicated that for corn and sorghum hybrids released during the last 50 years, all yield components were very important for yield determination. No interaction among yield components was present for corn hybrids, and sorghum hybrids from the 1950's. Newer grain sorghum hybrids had more interactions than old hybrids, especially for the effects of the number of panicles m^{-2} with kernels $panicle^{-1}$ and to a lesser extent with kernel weight. In all environments panicles (or ears m^{-2}) were correlated with yield of both crops, while kernels $panicle^{-1}$ (or ear) was significant under irrigation for both crops, and on dryland silty clay loam soil for maize.

Rotation of Sorghum with Nodulating and Non-Noduating Soybean Influence on Grain Yield, N Nutrition and Grain Quality (Nanga Kaye Mady, M.S. Study)

Research Methods

A long-term crop rotation experiment with continuous sorghum, sorghum rotated with nodulating soybeans, sorghum rotated with non-nodulating soybeans, continuous nodulating soybean and continuous non-noduating soybean with different fertilizer applications (zero, 90 kg ha^{-1} N to sorghum and 45 kg ha^{-1} N to soybean, and annual feedlot manure) is being studied with the goal to separate N and non-N effects of crop rotation. Data collection started in 2003, and included grain and stover yield, soil water, soil NO_3-N, relative greenness using a SPAD chlorophyll meter, yield components and grain quality assessment. Preliminary results have been analyzed using analysis of variance.

Research Results

Cropping sequence * Fertilizer interaction effects were present for most parameters measured (Table 1). Irregardless of cropping sequence, manured plots had the highest grain and stover yield, grain N concentration and TADD recovery, which is a measure of kernel hardness. Without fertilizer application, the zero control with sorghum following non-nodulating soybean had the lowest grain and stover yields. Kernel weight, test weight (bulk density) and true density were either not influenced or influenced to a small degree by treatments in the study. These preliminary sorghum yield results suggest that approximately 80% of the yield increase from the nitrogen contribution from the previous soybean crop, while about 20% of the yield increase is due to other rotational benefits. In addition, increasing nitrogen supply, whether from fertilizer application or cropping sequence, increases the grain N (i.e., protein) concentration to a greater extent than quality measures related to kernel hardness.

International

Microdose Fertilizer Study (Taonda Jean-Baptiste - Burkina Faso, Minamba Bagayoko and Samba Traoré - Mali, and Seyni Sirifi - Niger)

Research Methods

Three-year central studies were initiated on-station in

Table 1. Influence of cropping sequence and fertilizer treatments on grain sorghum yield and grain quality in 2003, Mead, NE.

Cropping sequence	Fertilizer treatment	Grain yield	Grain nitrogen	100-kernel weight	Test weight	True density	TADD recovery
		Mg ha^{-1}	%	g	lbs. bu^{-1}	g cc^{-1}	%
Sorghum following nodulating soybeans	Zero	6.6	0.89	2.35	59.9	1.333	27.3
	Nitrogen fertilizer	7.2	1.38	2.05	60.1	1.310	30.8
	Manure	7.2	1.48	2.32	60.5	1.393	34.0
Sorghum following non-nodulating soybeans	Zero	4.9	0.88	2.45	59.7	1.463	27.6
	Nitrogen fertilizer	7.5	1.03	2.34	60.4	1.453	27.6
	Manure	7.8	1.30	2.34	60.8	1.205	38.8
Continuous sorghum	Zero	4.4	1.04	2.39	56.5	1.400	33.4
	Nitrogen fertilizer	6.4	1.09	2.21	60.7	1.286	33.2
	Manure	6.8	1.27	2.31	61.0	1.384	43.2
		---------------------------- F Probability --------------------------------					
Cropping sequence		<0.01	NS	NS	NS	NS	0.02
Fertilizer		<0.01	<0.01	0.02	<0.01	NS	<0.01
Cropping sequence * Fertilizer		<0.01	<0.01	0.05	<0.01	NS	0.06

Burkina Faso (pearl millet), Mali (pearl millet on sandy soil and grain sorghum on heavy soil) and Niger (pearl millet) in 2001. A randomized complete designed study was used with four replications. Treatments consisted of zero, microdose (capfull of complete fertilizer in the seed hill at planting), Microdose + 20 kg ha^{-1} P, microdose + 40 kg ha^{-1} P, microdose + 30 kg ha^{-1} N, microdose + 60 kg ha^{-1}, microdose + 20 kg ha^{-1} P + 30 kg ha^{-1} N, and microdose + 40 kg ha^{-1} P + 60 kg ha^{-1} N. Each plot was sampled prior to initiating the experiment so that soil nutrient levels after three-years could be determined. Grain and stover yield were collected and estimated net N and P removal calculated using data from Maman et al. [African Crop Science Journal 8: 35 - 47, 1995]. In addition, satellite studies were conducted on farms using zero, microdose and microdose + 20 kg ha^{-1} P or 20 kg ha^{-1} P + 40 kg ha^{-1} N treatments. One replication was planted per farm, and in the data analysis farms were considered to be replications.

Research Results

Analysis of variance indicated that grain and stover yields to fertilizer treatments varied by country and year. However, on the average, microdose fertilizer application increased grain and stover yield by 49%, with the 42 to 62% increase in all three countries (Table 2). Clearly the microdose application is a low cost investment that has a high probability to increase grain yields across the West Africa pearl millet production area. Yield responses were greater for P application than N application, but application of microdose plus 40 kg ha^{-1} P and 60 kg ha^{-1} N was required to maximize yields of grain and stover. Estimated net N and P removal indicated that the microdose and zero treatments remove approximately the same amount of P annually, and 25 to 34 kg ha^{-1} N. Applications of over 30 kg ha^{-1} N was necessary to replace removal in grain and stover. The data suggests that less than 10 kg ha^{-1} application is necessary to replace removal.

Pearl Millet -Cowpea Intercrop/Rotation Study (Samba Traoré - Mali)

Research Methods

A randomized complete block designed experiment to evaluate the interactive effects of intercropping and rotation of crops within intercropping systems was conducted at the Cinzana Research Station in 2000, 2001 and 2002. Recommended row intercropping systems was used with three genotypes, and rotation was incorporated by alternating the rows in the field. Grain yield and land equivalent ratios were determined, and data were analyzed using analysis of variance procedures.

Research Results

Intercropping usually reduces the grain yield of both intercropped species. In the intercrop system of rotating rows with cowpea over three years actually increased grain yield by 114 kg ha^{-1} over that of sole cropped millet, resulted in a land use of efficiency of 1.42 indicating a 42% increase use efficiency, and a substantial increase in profit. Although this presents some logistical problems in the field (i.e. marking rows), the increased productivity likely merits the extra management effort.

Zaï and Other Fertilizer Treatments on Grain Sorghum (Taonda Jean Baptiste - Burkina Faso)

Research Methods

A study was conducted at SARIA in 2002 and 2003 to compare a no fertilizer check (farmer practice), microdose fertilizer application at planting, Zaï with compost 300 g $hill^{-1}$ compost application and the recommended fertilizer rate of 75 kg ha^{-1} of 15-15-15 complete fertilizer at planting and 24 kg ha^{-1} N 45 days after planting.

Research Results

Microdose and recommended fertilizer rates increased grain yield by approximately 600 kg ha^{-1} stover yield by approximately 1000 kg ha^{-1}. The Zaï plus compost increased grain yield over the control by 1200 kg ha^{-1}, and stover yield increased by 2000 kg ha^{-1}. The water conservation and nutrient supplying of the Zaï plus compost system clearly increases yields greater than the other systems in the study.

Sorghum Production Practices for Dolo (Traditional Beer) Production in Burkina Faso (Siebou Pale)

Research Methods

Previous research has shown that the red grain sorghum varieties IRAT 9 and ICSV 1001(Framida) to be superior for

Table 2. Fertilizer treatment influence on pearl millet, grain and stover yield, and estimated net nutrient removal/addition (averaged over 3 years and 3 replications).

	Grain Yield				Stover Yield				Estimated Net Nutrient Removal/Addition	
Fertilizer Treatment	Burkina Faso	Mali	Niger	Mean	Burkina Faso	Mali	Niger	Mean	N	P
	kg ha^{-1}									
Zero	398	772	341	504	1072	1644	3006	1907	-34	-4
Microdose	646	1091	524	753	1735	2789	3033	2519	-25	-4
Microdose + 20 kg Pha^{-1}	844	1140	743	909	2039	2974	4121	3045	-43	+19
Microdose + 40 kg Pha^{-1}	904	1349	624	959	2009	3854	3264	3042	-44	+34
Microdose + 30 kg N ha^{-1}	657	1050	608	771	1600	2870	3882	2784	-11	-4
Microdose + 60 kg N ha^{-1}	727	1080	608	805	1716	3090	4113	2973	+20	-5
Microdose + 20 kg Pha^{-1} + 30 kg N ha^{-1}	941	1216	960	1039	2239	3630	4840	3569	-20	+13
Microdose + 40 kg Pha^{-1} + 60 kg N ha^{-1}	1108	1274	917	1100	2402	4231	4389	3674	+8	+33

dolo (traditional beer) production. A study was initiated in 2003 to develop production practice recommendations for grain yield and dolo quality. The study is being conducted with a randomized complete block and split plot treatment arrangement. The whole plot is water management (shallow cultivation control, tied ridges, manual Zaï, mechanized (animal traction Zaï, and dry soil tillage) and split plots of fertilizer levels (zero, micodose with 4g 15-15-15 per hill, recommended rate of 75 kg ha^{-1} 15-15-15 plus 50 kg ha^{-1} urea, and microdose plus 20 kg ha^{-1} P and 30 kg ha^{-1} N). Grain yield and quality tests associated with dolo production are being collected.

Research Results

In 2003, tied ridges and mechanized Zaï resulted in the highest yields for Framida, while tied ridges and dry soil tillage produced the highest yields for IR12. Also the microdose plus 20 kg ha^{-1} and 30 kg ha^{-1} produced yields that were more than 50% higher than all the other fertilizer treatments. Dolo quality tests are presently being conducted.

Nitrogen Use Efficiency (NUE) of Photoperiod Insensitive Sorghum Germplasm (Max Hernández, Leonardo García and Orlando Téllez - El Salvador and Nicaragua)

Research Methods

A three-year study was conducted at two locations in El Salvador and two locations in 2002 - 2003 in Nicaragua in 2002 - 2003, and three locations in Nicaragua and one in El Salvador in 2003 - 2004 with the objective to determine if NUE differences exist among photoperiod insensitive sorghum varieties and optimal N fertilizer rates for grain sorghum production, and to identify high NUE varieties. At each location either 24 or 13 lines from breeding programs were grown with and without N in a randomized complete block design with four replications. Grain and stover yield, and N concentration of grain and stover at harvest were collected, and agronomic characteristics. Data analysis was done using analysis of variance procedures.

Research Results

The El Salvador location in 2003 provided little useful information due to site selection of a soil with relatively high nutrient level. In Nicaragua, large differences among sorghum lines and locations were present, but a line by N level interaction was only present for one out of three locations. It appears likely that a wider range of germplasm will be needed to incorporate high nitrogen use efficiency into photoperiod insensitive varieties in Central America.

Determination of the optimum N application Rate for Grain Sorghum Production in the Pacific Zone of Nicaragua (Orlando Téllez Obregón, INTA, Nicaragua)

Research Methods

The white grain sorghum varieties (INTACNIA, RCV, Pinolero 1, and Tortillero Precoz) were grown in four years between 2000 and 2003 at the CEO experiment station near Leon, Nicaragua with N application rates of zero, 65, 129 and 194 kg ha^{-1} N. Grain and stover yield, and N concentrations were collected and analyzed using analysis of variance.

Research Results

Increasing N application from zero to 194 kg ha^{-1} increased sorghum grain yield quadratically from 2.1 to 3.9 Mg ha^{-1}, and the response would suggest that yields would be further increased with higher application rates. This yield response to N fertilizer application was consistent across varieties, except Tortillero Precoz had a small yield increase than other varieties between the highest N rates of 129 and 194 kg ha^{-1}. Economic marginal return analysis indicated that the optimal rate to recommend to producers is 129 kg ha^{-1}.

Nitrogen Use Efficiency (NUE) of Photoperiod Sensitive (Maicillo Criollos) Sorghum Varieties for Relay Intercropping with Maize (Maximo Hernández - El Salvador)

Research Methods

Validation and transfer trials were conducted on 40 farms in collaborations with several NGOs. Validation trials with local variety with and without 47 kg ha^{-1} N, the new improved nitrogen use efficient variety 85SCP805 without N and with 47 kg ha^{-1} N were tested on hillside locations with poor soils. Plots were planted in June and harvested in December. In addition, the improved varieties 85SCP805, SOBERANO, CENTA S-3 and RCV were planted on 430 farms in Zone 3 to facilitate transfer to farmers fields, with 226 reports with results obtained.

Results

The improved variety 85SCP805 produced 130 kg ha^{-1} more grain than the local check without N application. Nitrogen application increased grain yield of 85SCP805 by approximately 700 kg ha^{-1}, and of the local check by approximately 300 kg ha^{-1}. In spite of the clear yield advantage of using the improved variety 85SCP805 with N application, the economic analysis indicated that the improved variety without N fertilizer application had the greatest net return due to the high local cost of N fertilizer. In the improved variety transfer plots, all improved varieties produced higher yields than the local check variety, with the previously released RCV consistently yielding better than the local check.

Simulation Modeling of Growth, Development and Yield of Pearl Millet in Nebraska and Niger
Dr. Gerit Hoogenboom, SANREM CRSP, University of Georgia, Griffin, GA

Methods

The CSM-CERES-Millet model of the DSSAT Version 4.0 was calibrated for conditions in Nebraska, USA and Sadore, Niger. The observed data for calibration were obtained from two experiments conducted at the University of Nebraska under rainfall conditions in 1995 and 1996. Daily weather records were obtained from an automated weather station located at Mead, Nebraska (latitude 41.25; longitude 96.58; elevation 366 m). The soil at the experimental site was a silty clay loam. The experiment included three pearl millet hybrids, i.e., 59022A x 89-083, 1011A x 086R and 1361M x 6Rm and two nitrogen fertilizer levels, i.e., a control with no N and 78 kg ha^{-1} of N.

For Sadore, Niger, two experiments were conducted in 1995 and 1996. The soil was sandy and the daily weather records were obtained from ICRISAT, Sadore, Niger (latitude 13.23; longitude 2.28; elevation 210 m). These two experiments consisted of three hybrids, i.e., Heini Kirey, Zatib and 3/4HK and two nitrogen fertilizer levels, i.e., a control with no N and 23 kg ha^{-1} of N.

The CSM-CERES-Millet model includes seven cultivar-specific coefficients that require modification for new cultivars that have not been previously used with the crop model. The specific cultivar coefficients adjusted for millet during the calibration process were:

- P1: Thermal time from seedling emergence to the end of the juvenile phase (expressed in degree days above a base temperature of 10ºC) during which the plant is not responsive to changes in photoperiod.

- P20: Critical photoperiod or the longest day length (in hours) at which development occurs at a maximum rate. At values greater than P20, the rate of development is reduced.

- P2R: Extent to which the phasic development leading to panicle initiation (expressed in degree days) is delayed for each hour increase in photoperiod above P20.

- P5: Thermal time (degree days above a base temperature of 10ºC) from beginning of grain filling (3-4 days after flowering) to physiological maturity.

- G1: Scaler for relative leaf size.

- G4: Scaler for partitioning of assimilates to the panicle (head).

- PHINT: Phylochron interval; the interval in thermal time (degree days) between successive leaf tip appearances.

The cultivar coefficients were determined in sequence, starting with the phenological development parameters, followed by the crop growth parameters. This order was required because of the dependence of the latter parameters on the performance of the vegetative and reproductive development simulations. An iterative procedure was used to select the most appropriate value for each phenological and development parameter. Emergence, flowering, and maturity dates, growth analysis data and yield were used to calibrate the performance of the CSM-CERES-Millet model. The combination of coefficients that resulted in the smallest RMSE and the highest d value were selected as final cultivar coefficients.

Results

The 1996 growing season in Nebraska was characterized by abundant rainfall, while the 1995 growing season had only a small amount of rainfall. The rainfall in Niger for the millet growing season was higher than the rainfall in Nebraska.

The CSM-CERES-Millet model was able to accurately simulate crop phenology for millet grown in 1995 and 1996 in Nebraska. The average days observed from planting to anthesis was 62, while the simulated value was 63, with relative low values for RMSE and high values for the d statistic. In general, millet yield for the conditions in Nebraska was accurately simulated for 1995 and was underestimated for 1996. In 1996, abundant rainfall resulted in an increase in observed and simulated yield when compared to 1995.

For the conditions in Sadore (Niger), the observed and simulated values for days from planting to anthesis and from planting to physiological maturity were very similar, indicating that millet phenology was very accurately predicted by the model.

There was a large difference in yield between Nebraska and Niger. Average observed yield for three hybrids for the two years was 2788 kg ha^{-1} for Nebraska and only 838 kg ha^{-1} for Sadore. The poor soil fertility conditions in Niger can explain in part these results as well as the low level of N that was applied.

The CSM-CERES-Millet model was able to accurately simulate growth, development and yield for millet grown in two contrasting environments, e.g., Nebraska, USA and Sadore, Niger, and under different management practices that included various hybrids and nitrogen fertilizer treatments.

Networking Activities

Workshops

American Society of Agronomy Meetings, Denver, CO. 2 - 6, Nov. 2003.

West Africa Principal Investigators Meeting Followed by UNL-213 Meeting, 17 - 22 April, Ouagadougou, Burkina Faso.

Max Hernández (El Salvador) and Orlando Téllez Obregón, PCCMCA Meeting, 18 – 22 April, 2004, San Salvador, El Salvador.

Research Investigator Exchange

Delon Kathol (U.S.) will complete his M.S. degree in the coming year. Nanga Kaye Mady (Chad) started an M.S. degree in May 2003 and should finish his degree in August 2005.

Research Information Exchange

Funds passed through to Burkina Faso, Mali and Niger to assist with collaborative research.

Pearl millet growth and nutrient uptake data was shared with Dr. Gerrit Hogenboom, Univ. of Georgia and SANREM CRSP for modeling research and development of decision aid tools.

Visited INTSORMIL research efforts in El Salvador and Nicaragua in Dec. 2003, and Burkina Faso in April 2004.

Seminar on "INTSORMIL Crop Management Research in West Africa and Nebraska" was presented at CIRAD, Montepellier, France, 15 April, 2004.

Publications and Presentations

Abstracts

Téllez Obregón, O. and Stephen C. Mason. 2004. PCCMCA L Reunión Anual, 18 - 22, 2004. San Salvador, El Salvador.

Hernandez, M. 2004. PCCMCA L Reunión Anual, 18 - 22, 2004. San Salvador, El Salvador.

Journal Articles

Maman, Nouri, D.J. Lyon, S.C. Mason, T.D. Galusha and R. Higgins. 2003. Pearl millet and grain sorghum yield response to water supply in Nebraska. Agron. J. 95: 1618 - 1624.

Traoré, Samba, S.C. Mason, A.R. Martin, D.A. Martinson and J.J. Spotanski. 2003. Velvetleaf interference effects on yield and growth of grain sorghum. Agron. J. 95: 1602 - 1607

Maman, Nouri, S.C. Mason and D.J. Lyon. 2004. Yield components of pearl millet and grain sorghum across environments in the Central Great Plains. Crop Sci. 44: (In Press).

Undergraduate Theses

Chepita Garcia y Yolanda Herrera.2004. Evaluacion de 16 lineas de sorgo en Zambrano, Masaya [Evaluation of 16 sorghum lines for nitrogen use efficiency at Zambrano, Masaya]. Universidad Nacional Agraria, Managua, Nicaragua

Ajax Fonseca, Lenin Lopez, Eliezer Manzanares y Francisco Calero. 2004. Evaluacion de 25 lineas de sorgo en San Ramon, Matagalpa (Evaluation of 25 sorghum lines for nitrogen use efficiency at San Ramon, Matagalpa). Universidad Nacional Agraria, Managua, Nicaragua

Ruby Altamirano y Mario Gadea..2004. Evaluacion del uso de frijol Mungo como fuente alternativa de N en sorgo en San Ramon, Matagalpa [Evaluation of mungbean as an alternate N source for sorghum at San Ramon, Matagalpa].Universidad Nacional Agraria, Managua, Nicaragua

Ramiro Manzanares y Roberto Hernadez. 2004. Evaluacion del uso de frijol Mungo como fuente alternativa de N en sorgo en Tisma, Masaya (Evaluation of mungbean as an alternate N source for sorghum at Tisma, Masaya). Universidad Nacional Agraria, Managua, Nicaragua

Alex Gonzalez y Willar Green. 2004. Evaluacion de 25 lineas de sorgo en Posoltega, Leon. (Evaluation of 25 sorghum lines for nitrogen use efficiency at Posoltega, Leon.) Universidad Nacional Agraria, Managua, Nicaragua

Maury Gurdian. 2004. Evaluacion de 16 lineas de sorgo en Posoltega, Leon. (Evaluation of 16 sorghum lines for nitrogen use efficiency at Posoltega, Leon.) Universidad Nacional Agraria, Managua, Nicaragua

Soil and Water Management for Improving Sorghum Production in Eastern Africa

Project UNL 219
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Summary

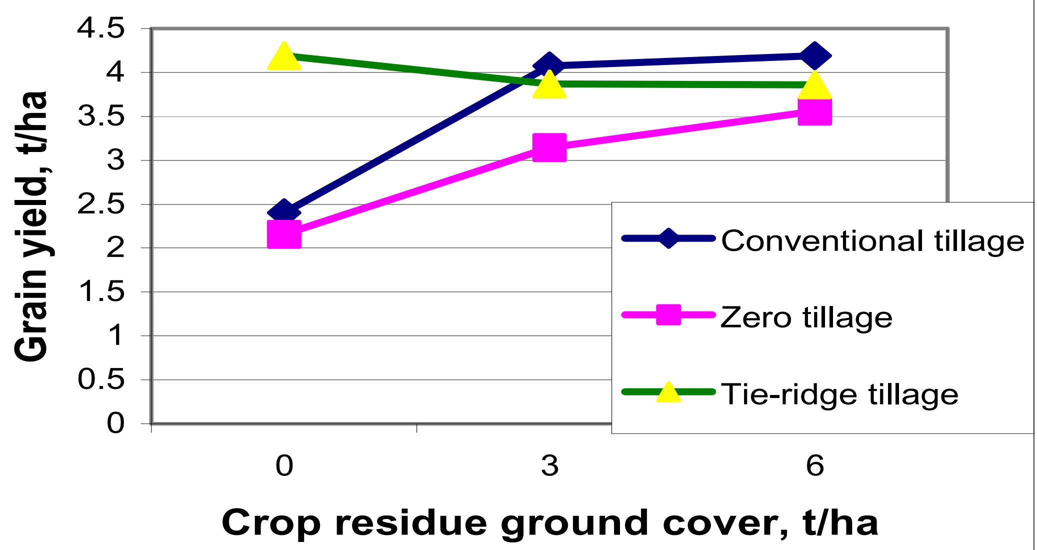
Opportunities to increase yield or to reduce production costs have been identified while promising research continues. Researchers working with farmers in Ethiopia have verified that tie-ridge tillage can result in higher yields in many places. They have tentatively identified likely niches and opportunities for tie-ridge tillage and for tie-ridging and planting implements; research is continuing in four semi-arid sorghum production areas. Low levels of fertilizer and manure use, nitrogen credits from legumes in rotations, and research with farmers for the development of a reduced tillage system are being addressed in two semi-arid areas of eastern Uganda using participatory approaches. Soil properties have been related to P availability for diverse soils of Ethiopia, Uganda and Mozambique; the importance of termite activity to P sorption on sandy soils has been determined. The second year of research on the use of starter fertilizers for no-till sorghum production in eastern Nebraska was completed with a total of 12 trials conducted in 2002 and 2003; the results show little profit opportunity for the use of starter fertilizer with typical planting dates. Seeking to improve the productivity of no-till sorghum production systems, research on occasional tillage for no-till situations was started in 2003.

Improved institutional capacity has been achieved in Ethiopia and Mozambique. Two students completed their M.S. degrees at Alemaya University with partial support from this project. Their thesis research focused on water management for sorghum production; results will be presented at the 2004 ASA annual meeting. Soares Xerinda reported results of his research at the 2003 ASA annual meeting, and has completed his oral defense. Two international students are involved in the occasional tillage research, one for his Ph.D. dissertation and another for an M.S. thesis; the research is partly supported by INTSORMIL. The project supports the research of another graduate student on strategic lime placement for amendment of sandy soils. Data was collected for sorghum production areas of Ethiopia, Kenya and Uganda. A GIS referenced database is to be created that should be valuable to regional networking activities. Dr. Wortmann visited collaborators and research areas in Ethiopia and Uganda.

Objectives, Production and Utilization Constraints

- Evaluate tie-ridge and row-planting implements with farmers under their management at four locations in Ethiopia.
- Co-supervise soil and water management research projects of two M.Sc. students at Alemaya University.
- Conduct research with farmers in four villages in Eastern Uganda to evaluate soil fertility management practices and to develop a reduced tillage system with farmers.
- Explore opportunities for collaboration in Tanzania.
- Complete research on P sorption for soils of central and northern Ethiopia, eastern Uganda, and southern Mozambique.
- Define sorghum production areas and collect data for Ethiopia, Uganda and Kenya.
- Conduct research on starter fertilizer use in Nebraska under rainfed no-till conditions.
- Continue mentoring of an INTSORMIL sponsored graduate student at UNL.
- Initiate a study on the effect of occasional tillage on no-till sorghum-soybean systems.
- Initiate a study on the effect of pH stratification and localized lime placements on sorghum yield.

Fig. 1. Tillage and ground cover effects on sorghum yield in the Central Rift Valley of Ethiopia. LSD 0.05 for the interaction was 0.89 t/ha.



Inadequate nutrient supply and water deficits are the primary production constraints addressed in this water and nutrient management research.

Research Approach and Project Output

Nutrient and water management research in Ethiopia. Research to evaluate tillage and implement options continued with trials established in four semi-arid sorghum production locations in 2003 and 2004 which vary in elevation from 1300 to 1800 m. The locations include Welench'iti, Miesso, Sirinka, and Mekelle at Abergele. Tillage treatments differ according to location but generally include some variation of the following:

- Traditional, e.g., tilled with *maresha*, broadcast sowing, and *shilishalo* for weed control.
- Tie ridging using modified *maresha* (a test implement) with tie ridges made before planting. Plant in the furrow with a row planter (test implement).
- In-furrow row planting with test implement but tie ridge at first weeding with the modified *maresha*.
- Conservation tillage or reduced tillage.

Nearly all farmers found tie-ridging to be superior to their typical practice of flat cultivation for runoff control and crop performance. Tie-ridging at planting was generally preferred with some suggesting rebuilding the ridges when the crop is 'knee high' and to control weeds. The tie-ridger was seen as culturally appropriate as it is a simple modification of the *maresha* and it was well rated for agronomic effectiveness, usability and affordability.

In his thesis research, Tewodros Mesfin's observed improved yield with tie-ridging than with no-till or conventional tillage in the Central Rift Valley with little or no ground cover by crop residues (Fig. 1). Application of 3 t ha^{-1} of crop residues after tillage resulted in significant yield increases for no-till and conventional tillage but had no benefit for tie-ridging which had a relatively high yield with no crop residue applied. Soil water availability was greater throughout the season with tie-ridging as compared to other tillage practices.

Gebreyesus Brhane completed his M.S. degree and evaluated various tie-ridging options for effects on soil water and crop yield in Tigray. Making the tie- ridges either before planting or at planting resulted in better soil water conditions and grain yield than tie-ridging at weeding time or with traditional tillage practices (Table 1). This research is being repeated in 2004, and a subset of the treatments is being evaluated at Nazret as well.

Preparations are underway to conduct training workshops for extension staff in early 2005 on practices to reduce water loss and to improve efficiency of water and nutrient use. Discussions are underway with partners in Ethiopia for a second phase in our support to soil and water management research in Ethiopia. Gebreyesus and Tewodros have been invited to visit UNL in 2004.

Table 1. Sorghum grain yield as influenced by tillage practices, Tigray, Ethiopia, 2003.

Treatments	Grain yield (t/ha)
Flat bed planting, traditional tillage	1.48
Tied-ridging four weeks before planting with planting in furrows	2.87
Tied-ridging four weeks before planting with planting on ridges	2.38
Tied-ridging at planting with planting in furrows	2.52
Tied-ridging at planting with planting on ridges	2.16
Shilshalo at four weeks after sowing	1.78
Tied-ridging at four weeks after sowing	2.12
LSD (P = 0.05)	0.725

Nutrient and water management research in Uganda. Research has been conducted with farmers in two communities each of Kumi and Katikwe Districts. Priority problems and research topics were determined with farmers in 2003. Following exploratory research during the first season of 2003, research protocols were revised. The second season of field research with the revised protocols is underway. Three research areas are being addressed: the use of low levels of fertilizer and manure; N credits from rotations with cowpea or green gram as compared to mucuna; and the development of a reduced tillage system with farmers. This research is to continue for another two seasons with the expectation of reporting results at the 2005 ASA meeting and decision on future directions when Dr. Kaizzi visits Nebraska in 2005.

Project activities in Tanzania. Communications with researchers at Ilonga ARC in Tanzania has not lead to a workplan; further discussion is planned for 2004-2005.

Phosphorus fixation of soil in Ethiopia, Uganda, and Mozambique. Phosphorus sorption isotherms were determined for 36 soil samples collected from Ethiopia, Uganda, and Mozambique. As termites have much influence on soil properties in Uganda and Mozambique, companion soil samples were also obtained from and near termite mounds. Percent clay content was generally well correlated with P sorption maximum. P sorption maximum increased moving south from Entisol and Inceptisol of northern Ethiopia to the more developed central and eastern vertic and/or calcareous soils. Phosphorus sorption maxima were 44 to 390% higher in sandy soils of Uganda and Mozambique with termite mounds as compared to the nearby sandy soils. The texture of soil in termite mounds was finer than for the surrounding sandy soil which accounts for some of the increase in P sorption capacity. P sorption maxima decreased by about 8% in fine-textured soil influenced by termites. P sorption of Uganda and Mozambique soils were well correlated with acid ammonium oxalate extractable aluminum but not iron. In sandy soils influenced by termites, there was also an increase in acid ammonium oxalate extractable aluminum. Correlation of acid ammonium oxalate extractable aluminum and iron with P sorption of Ethiopia soils was generally weak. This is probably due to the greater influence of carbonates on P availability in these soils as compared to aluminum or iron.

Creation of sorghum database for Eastern and Southern Africa. Working with sorghum researchers in Ethiopia, Kenya and Uganda, 19 sorghum production areas were delineated for these three countries. Production data have been obtained for Ethiopia at the wereda level and for Uganda at the county level while preparations have been made to obtain these data for Kenya. Attribute data were obtained through interviews with sorghum experts, primarily with the national research organizations, on 45 production constraints, preferences for 11 phenotypic characteristics, six socio-economic issues, six sorghum-cropping systems and management practices, and the importance of 15 uses of sorghum products. A contract has been made with a GIS person in Uganda to compile the data into database and GIS formats, integrate data with soil and climate layers, analyze it and create tables and maps. We plan to obtain similar data for Mozambique in 2004-2005, and for Tanzania and Eritrea by the end of 2005. Collaboration with ASARECA-ECARSAM and ICRISAT in this project has been explored, and we hope to obtain support when results for Ethiopia, Uganda and Kenya are presented.

Mozambique. Soares Xerinda is completing his M.S. degree at UNL in August of 2004 and plans to return to Mozambique in September, in time to conduct field research during the 2004-2005 seasons. A workplan has been developed for field research at Chokwe and Manica, and to interview farmers and extension workers experienced with reduced tillage options and working with Sasakawa-Global 2000 in the Manica area.

Starter fertilizer for no-till sorghum production in Nebraska. This work was conducted by Soares Xerinda in partial fulfillment of the M.S. degree. Twelve rainfed sorghum trials were established in eastern Nebraska at different sites and topographic positions. The combinations of sites, topographic positions, variety, and soil properties resulted in 15 environments. Three starter fertilizer placements were compared: in the furrow, over the row, and five cm to the side and five cm deep (5x5 cm). Starter fertilizer treatments were applied as liquid formulations containing N+P and N+P+S at the rates of 22.4 kg ha^{-1} each for N and P_2O_5, and 11.2 kg ha^{-1} S, but half rates were applied with the in-furrow placement. Ammonium sulfate (AS) was compared to ammonium thio-sulfate (ATS) as the S source. Early-season growth was increased with starter fertilizer application in most trials. Sorghum yield responded only to N+P+S placed 5x5 cm or in-furrow in 20% of the environments with increases of 0.5 to 1.0 Mg ha^{-1} (Fig. 3). Relatively warmer temperature associated with the traditional planting time (late May) of sorghum most likely reduced the probability of sorghum response to starter. Overall, yield response was more frequent in upland environments than in bottomlands where 5x5 and in-furrow placement were generally more effective than over-the-row placement. Soil P and organic matter level did not consistently correlate with sorghum starter fertilizer responsiveness. The effect of starter fertilizer on grain moisture reduction at harvest was more frequent than the yield

Fig. 3. Frequency of starter fertilizer effect on grain sorghum.

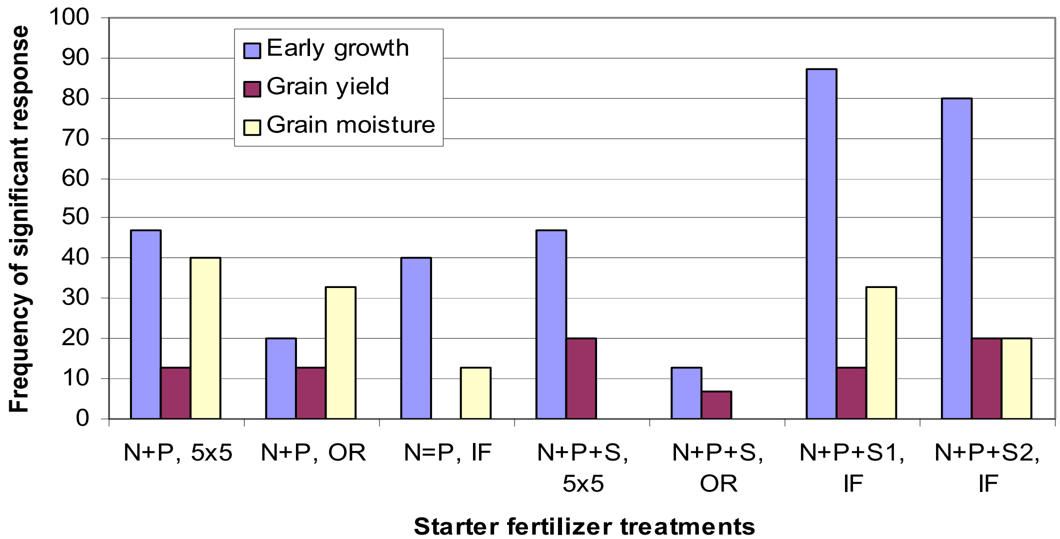


Table 2. Effect of one-time tillage in a no-till system on panicle number and size, and sorghum grain yield in eastern Nebraska.¥

Tillage practice	Grain yield	Panicles	Panicle wt.
	kg ha^{-1}	per ha	g panicle^{-1}
No-till	7.20 a	124189 ab	56.4
Disk	7.18 a	139043 a	52.1
Chisel, 8”	5.17 b	99028 c	52.1
Chisel, 12”	5.86 ab	113559 bc	51.5
Moldboard plow	6.79 a	131320 ab	51.6

¥ Means with the same letter are significantly different at P = 0.05.

increase. Starter fertilizer reduced grain moisture at harvest by 9 to 28 g kg^{-1} in 25% of the environments. The NP 5x5 cm and over-row, and the NPS ammonium sulfate in-furrow resulted in higher frequencies of grain moisture reduction at harvest. It is expected that responses to starter fertilizer would be greater if sorghum is planted earlier than the traditional planting time of eastern Nebraska. However, with the traditional planting time of late May, moisture reduction at harvest could be beneficial.

Additional starter fertilizer research is being conducted for early-planted no-till sorghum. We are also investigating the interaction of row cleaning with starter fertilizer application in this research.

Soybean N credit verified for grain sorghum in Nebraska. This field research was put on hold in 2003 due to time constraints but 11 trials have been established in three southeast Nebraska counties in 2004.

Occasional tillage to improve the no-till sorghum-soybean rotation. Research is underway to determine the effects of one time tillage in no-till systems on crop performance, soil C dynamics, and on soil chemical, physical and microbiological properties. Two graduate students, Juan Pablo Garcia and Andres Quincke, are involved in this research. The effects of four tillage practices, conducted in one year only, relative to continuous no-till, and the effects of P management regimes are being evaluated. For his Ph.D. dissertation, Andres is investigating the effects of: soil C dynamics and microbial activity; crop yield; and soil physical properties. Juan Pablo is doing his M.S. research to investigate effects on: nutrient redistribution with tillage, mycorrhyzal colonization, and plant nutrient uptake. Tillage was done when soil temperature was low and the resulting CO_2 emissions were similar with tillage as compared to no-till. Nutrients, which were highly stratified with no-till, were best redistributed with the moldboard plowing. Yield was similar for no-till, disking and moldboard plowing, but reduced with chisel plow tillage, apparently due to reduced panicle number and size (Table 2). Various aspects of this research, including treatment effects on yield and soil organic matter, will continue for another five years. First year preliminary data of this research was presented at the 2003 ASA meeting.

Soil pH stratification and localized liming on sandy soils. Research is underway to evaluate the effects of soil pH stratification and localized lime application on sorghum yield, nutrient uptake, root distribution and surface area, soil and solution chemistry, and mycorrhizal establishment. A M.S. graduate student, Greg Miller, is conducting this research in 2004 and 2005.

Networking Activities

We are planning to cooperate with different projects/organizations/departments in Ethiopia to conduct training for extension staff on soil and water management. The USAID Amhara Rural Development Project (Dr. Brhane and Dr. Fakaru) will partner with USAID-INTSORMIL to conduct a soil and water management-training event in the Amhara region in February-March 2005. The ASARECA-ECARSAM network apparently has had financial constraints and we have not identified any opportunities for collaboration. The development of the sorghum production database is expected to be a valuable resource for future networking activities as it will strengthen the basis for germplasm and information exchange, identification of screening environments, constraints prioritization, etc.

Publications and Presentations

Miscellaneous

Wortmann, C. 2004. Nebraska trials test starter fertilizer in no-till sorghum. Crop Watch Newletter 04-7. Available at http://cropwatch.unl.edu/.

Wortmann, C.S., S.A. Xerinda, M. Mamo, and C. Shapiro. 2003. Starter fertilizer for row crop production under no-till conditions in eastern Nebraska. Proceedings of the North Central Regional Extension and Industry Conference, Des Moines, IA, Nov. 19-20, 2003. Also presented at UNL Agronomy and Horticulture Highlights in Dec. 2003.

Abstracts

Quincke, J.A., C. Wortmann, M. Mamo. 2003. Effect of occasional tillage of no-till systems on soil carbon. Agron. Abstr. #614154, CD-ROM. Amer. Soc. of Agron., Denver, Colorado.

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