FOOD SECURITY RESEARCH PROJECT

ASSESSMENT OF THE FARM LEVEL FINANCIAL PROFITABILITY OF THE MAGOYE RIPPER IN MAIZE AND COTTON PRODUCTION IN SOUTHERN AND EASTERN PROVINCES

By

Stephen Kabwe, Cynthia Donovan, and David Samazaka

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Research Collaboration between the Food Security Research Project and the Golden Valley Agricultural Research Trust

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The work here does not reflect the official position of USAID nor GART. All errors are the responsibility of the authors.

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ACRONYMS

AMIC	Agricultural Market Information Centre
ASP	Agricultural Support Programme
CF	Conservation farming
CFU	Conservation Farming Unit
FSRP	Food Security Research Project
GART	Golden Valley Agricultural Research Trust
IMAG	Institute of Agricultural Engineering (Netherlands)
MACO	Ministry of Agriculture and Cooperatives
MSU	Michigan State University
OLS	Ordinary Least Squares
OPV	Open Pollinated Variety
ZMK	Zambian Kwacha
ZNFU	Zambian National Farmers Union

EXECUTIVE SUMMARY

With the risk of the drought in the agricultural production areas of Zambia, conservation farming (CF) was introduced as a set of technologies that can improve productivity while reducing plant stress due to moisture constraints. Under animal traction, CF involves using the Magoye ripper to minimize soil disturbance in land preparation and to help improve water conservation, thus enhancing farmers' land and labor productivity. This technology has been promoted by Golden Valley Agricultural Research Trust (GART) and other stakeholders in the agricultural sector in Zambia and shows promise in on-station and on-farm trials.

This research is based on actual farmer use of the ripper in Eastern and Southern Provinces in 2004/2005, a year with erratic rainfall and poor growing conditions in general. Thus, this research reflects how farmers apply the technology in combination with other cropping practices in cotton and maize production, and the outcome of its use under poor rainfall conditions, in comparison to animal traction ploughing. In this study, farmers were not directed, as in an on-farm trial, but used the rippers and other practices in their own way. The results show that the technology has benefits. When asked, the farmers identified various benefits to using the ripper. About 23% of the farmers indicated that ripped lines collected and conserved water such that crops in ripped fields were able to grow even during dry spells. The second most important benefit identified by the farmers was that the technology enables farmers to do early land preparation.

Farmers were also asked about problems with the rippers. As researchers anticipate, farmers mentioned the weed problem as the most important problem in ripped fields. The second most important problem was the rapid wearing out of the ripper tine, a problem compounded by lack of spare parts in local shops. For farmers who had ripped in previous years but discontinued in 2004/2005, they said that the main reason was the lack of animals or their animals were still small to use the ripper.

Researchers use regression analysis to understand the effect of various practices and factors on yields of maize and cotton. The results show that the ripper by itself did not have a significant direct effect on maize yield. However, farmers who used the ripper combined with nitrogen fertilizer applications saw significantly higher yields than just using the Magoye Ripper alone or fertilizer alone. Planting on coarse soils had a significant negative effect on maize yields, as did planting late, although the planting date results are confounded because planting late was most common in areas with lower rainfall. Results from cotton production show that there was no significant effect of tillage system on the cotton yield. For cotton, the most important factors were the plot size (negative relationship with yield) and the chemical packets applied (positive relationship with yield). The ripped plots were on average smaller, and farmers were able to manage their fields more intensively, getting higher yields in ripped than in ploughed fields.

In both cotton and maize, the net profits from ripped fields were higher than those from ploughed fields. The technology is clearly profitable on maize, controlling for other factors. For cotton enterprises, there was a positive profit in using the practices that were associated with the ripper farmers, even though we found no net effect of the ripper itself.

Various interventions are indicated by this research. Improvements on the ripper may be needed. Farmers cited the rapid wearing down of tine, and improved materials may be needed to strengthen the tine for use in some soil types. Strategies for overcoming the lack of animals

should be implemented and reinforced where they are already being undertaken. This includes continued efforts on animal disease control and eradication, and increasing draught animal stocks. These are critical for this labor reducing technology to be used. Private sector involvement in animal disease inputs and services is critical to ensure that restocking can be effective.

Private sector involvement can be enhanced with the ripper itself, to ensure spare parts. Stakeholders should continue efforts to partner up with the private sector traders and artisans in the areas in which the ripper is distributed to ensure steady supply of spare parts (tine, wings, bolts, and nuts) for the Magoye ripper. This would ensure continuity in the use of the technology, and farmers could enjoy the benefits of the technology.

In diffusion efforts, GART and other extension agents should continue to partner with the private companies that are working with farmers on the ground, such as Dunavant, Cargill (formerly Clark Cotton), and Continental Ginnery, who may be able to assist in coordination of training and provision of implements to their farmers. Unlike many new varieties of maize seed, minimum tillage agriculture is knowledge intensive technology that needs time and training for the benefits to be realized. Future work will be needed to evaluate adoption of the ripper and basins based on a targeted survey for the purpose which can evaluate extension methods and other factors that influence how well a farmer is able to realize benefits.

KEY WORDS: Conservation Farming, Magoye Ripper, Zambia.

1. INTRODUCTION

With the risk of drought in agricultural production areas of Zambia, especially in the southern zones, agricultural specialists have identified conservation farming (CF) as one way of reducing plant stress due to moisture constraints. Efforts in neighboring Zimbabwe had resulted in conservation farming techniques that were adapted to Southern African soils and production systems and were themselves based on developments of CF in the United States, Brazil and elsewhere. By the mid-1990s, farmers in Zimbabwe and other countries in the region saw reduced tillage methods as a way to mitigate against the adverse effects of droughts and erratic rainfall that threatened farm production. Reduced tillage is expected to increase moisture retention when it rains, and enable farmers to plant sooner after the first rains. As applied in Zambia, CF involves a recommended package of several key practices: dry-season land preparation using minimum tillage systems; crop residue retention; seeding and input application in fixed planting stations; and nitrogen-fixing crop rotations (Haggblade and Tembo 2003). In this report, our concentration is on animal-traction-based minimum tillage using the Magoye ripper where no other ploughing is done. Since its introduction in 1995, more than 2000 Magoye rippers have been distributed in Zambia. In this work, we seek to evaluate the performance of the Magoye ripper in comparison to animal-drawn ploughing in maize and cotton production as practiced by farmers in selected areas of Zambia, with a special focus on the profitability of ripping in their fields under their own management.

2. EVOLUTION AND DEVELOPMENT OF THE MAGOYE RIPPER

In the late 1990s in Zambia, as interest in CF grew, researchers were challenged to adapt existing tools to provide appropriate animal traction implements for minimum tillage, and hence the drive for the Magoye ripper. Many players have contributed to developing and diffusing this technology, and notable among them are the Golden Valley Agricultural Research Trust (GART), the Agricultural Support Programme (ASP) and the Ministry of Agriculture and Cooperatives (MACO) which provided a national policy promoting conservation farming (MACO 2004).

Originally developed to dig planting furrows in ploughed fields, the Magoye ripper was adapted to be used to dig planting furrows during the dry season in readiness for sowing with the first rains, without the need for overall ploughing. By limiting disturbance of top soils and enabling labor use in a relatively down time for labor, the Magoye ripper was thought to fill an important niche. It was an innovation of the Farm Power and Machinery Programme based at the then Magoye Regional Research Station through the Royal Netherlands-funded Animal Draft Power Project of the Dutch Institute of Agricultural Engineering (IMAG) in the late 1980s and early 1990s (Kaoma-Sprenkels, Stevens, and Wanders 1999). When GART was established, the research was incorporated into the activities of the Trust, with continued technical support of IMAG. Apart from refining the ripping systems, which defined the hands-on techniques, GART with feedback from farmers and other stakeholders modified the ripper tine from the original diamond shaped one suitable for soft soil conditions to one with a large cutting surface appropriate for drier soil conditions (Stevens et al. 2002). The modified tine enabled dry ripping particularly during the dry season months. Another version of the Magoye ripper called model 2 with a slightly sharper and narrower tine designed to penetrate to depths of 20-30 cm is also available.

Notwithstanding the efforts at promotion through farmer tests and demonstrations, adoption was initially slow. The efforts of GART in spearheading the adoption of the Magoye ripper began in 1999 and focused on developing ripper-based farming systems through wide testing both on research stations and on farmers' fields. About 60 farmers spread over eight prominent farming areas from Southern Province up to Copperbelt Province participated as the first test farmers. The majority of these farmers increased the land tilled under these methods from the original ¼ hectare requested for testing to three hectares within two seasons (Stevens et al 2002). The demand for early planting in cotton provided a great opportunity for wide promotion of the ripper to the cotton farmers. In 2002, GART adopted a strategy called accelerated adoption of conservation farming. This effort finally linked smallholder cotton growers that had access to draft power to the Magoye ripper through the procurement of 2000 rippers via the designated distribution channels of cotton distributors. Key to this was that the farmers had a stable output market. Prior to the procurement, the farmers were given a hands-on training of the Magoye ripper. Each cotton distributor was considered a lead farmer and received more training in order to be able to help supervise and instruct the other farmers in their zone.

Currently, there are efforts by other organizations such as Agriculture Support Programme (ASP) and the Conservation Farming Unit (CFU) that are promoting the ripper to farmers in localities that GART has not been able to reach. The CFU has embarked on an ox restocking in an effort to resuscitate the cattle stocks of farmers in Southern Province after the shock of more than 46% loss in the 1990s due to corridor disease (Bwalya 2000). As will be seen in the comments from farmers, addressing the animal constraint is a valuable activity.

In 2002, researchers with IMAG revisited a sample of 61 farmers out of their contact farmers to pose various questions and understand how the ripper is being used and identify concerns of the farmers (Stevens et al. 2002). These farmers received fairly intensive training from GART and so may not be typical of Zambian farmers as a whole, but the survey results were encouraging. The ripper was important in enabling minimum tillage under animal traction and farmers experienced either higher yields or comparable yields to their traditionally ploughed fields. The research pointed out key perceptions of the farmers and assessed the evolution in the three seasons of use. There was no estimate of the relative profitability of cropping under ripping versus traditional ploughs, such that further work was required. In addition, these farmers are a fairly select group and there was interest in understanding what would happen in less intensive extension areas.

Thus, this research seeks to fill in two particular areas of interest. One is to broaden the farmers interviewed for their perceptions on the use of the Magoye ripper. How many farmers who purchased them were using them each season? How is the ripper being used? What are the most important agronomic benefits identified by farmers due to the use of the ripper? What are the major problems identified by the farmers that have used the ripper? The second key aspect for this research was to understand whether or not the Magoye ripper was profitable for farmers when used as a minimum tillage instrument in the cultivation of cotton and maize. Finally, is the technology profitable at the farm level? This research is designed to assist the developers and extension stakeholders in understanding the role that the Magoye ripper can play at the household level and the main barriers to overcome if the technology is to be adopted on a larger scale.

3. PROCEDURES AND METHODS

3.1. Procedures

In 2004/2005, a farm level survey was designed collaboratively by FSRP and GART researchers, in consultation with specialists from MACO and Cargill Cotton Company (formerly Clark Cotton). The researchers initially selected four provinces for the work: Central, Copperbelt, Eastern and Southern. However, due to logistical and staffing concerns, Central and Copperbelt Provinces had to be dropped. From Eastern and Southern Provinces, 561 farmers who had purchased Magoye rippers were identified. Since resources were limited and the farmers were spread across a wide rural area, a system for selecting clusters of farmers was designed to make efficient use of time and transport. The selection was determined bearing in mind the location and the distance of farmers from each other. In some areas, only a few farmers had purchased rippers and access was limited, such that these areas were excluded.[1]

Considering this limitation, the depots/sheds in which farmers are found were grouped into zones in relation to the location and distance between them. There were nine zones created in Eastern Province and seven zones created in Southern Province. Totals of 210 and 261 farmers were identified in Eastern and Southern Provinces respectively. Therefore, about 84% of the 561 farmers lived in the areas that remained within the sample selection. Then 100 farmers per province were selected randomly from the lists of 471 farmers that remained in the selection sample. Ideally, the sample would have 50 "ripper" farmers and 50 "nonripper" farmers per province.

Since all farmers in the study owned a ripper, a ripper farmer is defined in this study as a farmer who had at least one field of maize or cotton where the Magoye ripper was used in 2004/05 season for land preparation based on minimum tillage practices, with no prior ploughing that season. We did not consider a farmer a ripper farmer if he/she only used the ripper to create planting furrows after ploughing a field or used the ripper for weeding. Nonripper farmers in this study are those farmers who owned a ripper, but did not use it for minimum tillage land preparation in maize or cotton fields in 2004/05 season. This special definition of ripper and nonripper farmers is key to this work.

One problem results from the fact that the 100 randomly selected farmers were not evenly split between ripper and nonripper farmers. Earlier research indicated that there were a significant number of farmers who owned Magoye rippers and yet were not using them for the minimum tillage land preparation for which it was designed. As researchers visited the farmers, they intended to randomly select 50 ripper and nonripper farmers from each province respectively. A required number of 100 for nonripper farmers from both provinces was reached. However, a number of ripper farmers that were identified and randomly selected was less than the required number of 50 ripper farmers from each province. This resulted in not reaching a 200 sample of households that was required (Table 1).

Data collection was at both the farm and the field level, where a field is a contiguous block of land under a single cultivation system and crop. For ripper farmers, a possible total number of four fields were to be captured: one ripped field of maize, one ploughed field of maize, one

[1] Selecting the more accessible farmers may result in bias in the results. This question will be addressed later in the document.

Table 1. Type of Fields by Crop, Tillage System, and Province

		Province		
		Eastern	Southern	
Tillage type	Count	% of fields		Total % of fields
Maize Ripped field	55	40.0	60.0	14
Maize Ploughed field	143	51.7	48.3	37
Cotton Ripped field	61	34.4	65.6	16
Cotton ploughed field	125	56.0	44.0	33
Total fields surveyed	384	48.7	51.3	100
Total farmers surveyed	178	47.2	52.8	100

Source: FSRP/GART Ripper Study 2005

ripped field of cotton and one ploughed field of cotton. Therefore, a ripper farmer had a minimum of one ripped field and a maximum of four fields under consideration. On the other hand nonripper farmers had a minimum of one field (either maize or cotton) and a maximum of two fields, one for maize and one for cotton, under animal traction ploughing. We did not attempt to compare the animal traction methods to hand till methods here. Given that there were few ripper farmers in the population and not all farmers had the expected number of fields, the sample was slightly less than initially proposed. Table 1 shows the percentages of fields identified during the survey.

As indicated by the sampling, this study is not intended to be an adoption study. We deliberately sought equal numbers of ripper and nonripper farmers, in order to assess profitability. We excluded farmers who did not have rippers from the study, as a way to control for possible differences in production systems based on unobservable characteristics. Farmers who did not obtain rippers might have fewer resources or may be more risk averse as reflected in the production system. Instead, we use the farmers who own but did not use rippers as a control group to ripper farmers, for they had the ripper to use and yet decided not to use it.

Since ripper farmers were limited in number, we were unable to stratify the sampling based on gender. In earlier work, GART selected both male and female contact farmers for their outreach and the Stevens et al. 2002 report is based on that selection. Outreach through the cotton distributors was not as directly targeted for female farmers and so in Eastern and Southern Province we found fewer female farmers, only 3% of 178. This may also reflect the linkage of cash cropping cotton with male household heads. Thus, this research cannot directly address some of the gender issues raised in the earlier work by Stevens et al. (2002).

3.2. Survey Instruments

Three different survey instruments were used in this research. During the first round survey, Questionnaire 1 was designed to capture information on the plots related to the sample selection criteria. Then during the second round survey, Questionnaire 2 was designed to capture end of the season aspects as well as household characteristics, including demographics of the household. Furthermore, farmer perceptions on benefits and problems with the use of the Magoye Ripper were also captured in this instrument, in order to assess potential issues not addressed in the profitability work, but influencing use of the technology. The third instrument was the Diary Book in which production data, number of people, hours worked, the cost of doing the work for every farm activity related to the plots was recorded.

There are limitations with the data collection and sampling. As mentioned previously, this sample is not appropriate for adoption assessment. Several aspects would have benefited from researcher measurement, including the farm production and locally specific rainfall. Researchers did, however, measure land areas, given the documented problems of farmer estimated land areas (Haggblade and Tembo 2003). Rainfall is available only at a district level, not a very sensitive measure.

3.3. Methods

In this report, we first present descriptive statistics on the farmers using and not using the Magoye Ripper. Basic statistics on the perceptions of benefits and problems are reported as well to highlight the areas of concern for farmers, as well as expectations.

Total production on planted land is one of the key measurements that farmers think about when adopting a new technology. Will this technology increase what limited land can produce? In other words, will yields increase? To determine the potential impact of the Magoye Ripper technology and other factors on crop yield, ordinary least squares (OLS) regression techniques are used. Separate regression models were estimated for maize and cotton, based on the main production inputs and some potential shifters. These are descriptive regressions to look at the relationships between a range of traditional inputs and other factors in the maize and cotton yields of these farmers. One of the benefits of this type of analysis is that it helps control for the specific components in yield determination that vary among the farmers and can help us understand if ripping has a yield effect, a distinct from the quantity of fertilizers and other aspects, or possibly an interaction effect, in which the ripping increases the effectiveness of specific inputs. This type of analysis is common with observational studies as compared to on-station trials.

The basic regression model is the following:

Yield = f (inputs, other factors, interaction effects)

Under inputs we have such things as size of the plot, nitrogen applied per hectare and chemical packets used for cotton per hectare. Other factors include whether or not they used manure or ripping technology, location, rainfall, and how many days late in planting. The interaction effects include a combination of nitrogen fertilizer and ripping technology, under the hypothesis that ripping enables more efficient application and use of nitrogen applied, thus boosting the effect of nitrogen in ripped plots.

Yield, however, is not the only consideration in adoption of a technology by farmers. It is thought that farmers will continue using a Magoye ripper technology if the net benefits are higher under ripping technology than under tradition ploughing, considering the costs as well as benefits. There are several changes in the production system with the use of the ripper. Farmers may evaluate the higher yield against higher labor demand or higher capital costs.

One measure is profitability, in which the gross value of the production is compared to the total costs to capture net profit. In this research, the main components of cost were assessed and compared to gross production value under ripping and under traditional animal traction ploughing.

3.4. Regression Design

Prior to estimating the regressions for maize and cotton yields, we evaluated the distributions of the variables and determined the pair-wise relationships between the variables. In Table 2 we discuss the production variables used in the regressions, how they were estimated and their expected effect on yield. Size of a field is often an important factor. While estimates are calculated on a per hectare basis, production analysis suggests that there is decreasing production efficiency as land area increases, related to extensive farming as opposed to intensive farming. Farmers with smaller plots can more intensively control the production inputs and labor, and so the productivity of land, as measured by yield, can be expected to be higher for smaller plots. However, farmers with extremely small plots may not have the skills or be unable to take advantage of efficiencies. Therefore, the effect of the plot size on the yield of maize and cotton is ambiguous.

Regarding the inputs for maize, many farmers used a combination of basal fertilizer Compound D with 10N-20P-10K and top dressing fertilizer (urea) with 46% nitrogen formulation. The effect of fertilizer on maize crop is generally positive, unless excessive quantities are applied, or the fertilizer is applied inappropriately (poor timing, too close to the roots, etc.). The combination of fertilizer and tillage is expected to increase fertilizer's positive impact on yield of maize.

All cotton farmers used the chemical packets as distributed by the cotton companies and their distributors, but farmers may apply them in varying quantities per hectare, as the packets are uniform and the land sizes are not. The expected effect of chemicals on the yield of cotton is positive because the chemicals kill insects that may affect the yield negatively. Organic matter such as manure was used by some farmers, and is more common in Southern Province

Table 2. Expected Effects on the Yield of Maize and Cotton from Different Factors

Variables		Expected Effected on Yield[a]	
		Maize	Cotton
Plot size	Plot size in ha	+/-	+/-
Nitroha	Nitrogen applied in ha (kg/ha)	+	Na
Chemqty	Chemicals applied (packets/ha)	na	+
chem2	Chemical application squared	na	-
Tillage	Tillage system used (1=ripper)	+	+
Manuse	Manure used (kg/ha)	+	+
Hybrid	Hybrid used (1=yes)	+	+
Coarsest	Coarse soil type (1=yes)	-	-
daylate0	Planting days late (after Nov 20)	-	-
Tillchem	Chemical appl. X Tillage	na	0
Nitrotil	Nitrogen appl. X Tillage	+	Na
Rip use	Years of using the ripper	+	+

a/ + = Increase; 0 = no change; - = decrease; na = not applicable than Eastern. As found in the survey, its application is either large quantities or none, with no assessment of the quality or composition of the manure. Since relatively few farmers applied manure (only 20% of the full sample), manure use here is simply a (0,1) variable for use (=1) or not use (=0). However, the expected effect of manure application on the yield of the crops is positive since applied manure adds nutrients to the soil.

For this study, a tillage variable enters the yield determinants, with 1 for using the ripper for minimum tillage land preparation and 0 for traditional ploughing. A positive coefficient on the tillage variable would indicate that using the ripper for minimum tillage had a positive direct impact on yield, while controlling for the contributions of the other factors. In the case of the ripper, however, its effects on yield may occur indirectly. For example, ripping may be able to enhance the effectiveness of fertilizers through timeliness and efficient allocation along ripped furrows, so the interaction between ripping and nitrogen application may be important, as compared to a direct ripping effect.

In the survey, farmers were asked to classify the soil type of their field into three basic categories: coarse, medium, and fine. Coarse soils are usually less productive than the other two, and farmers tend to use those fields for standard ploughing rather than ripping. Our anticipated effect on yield is negative since coarse soils do not hold nutrients and water. This variable is a fairly “coarse” measurement itself, and future research will need to use soil samples to determine soil type with greater specificity and reliability. An interaction term was included to see if ripping might be able to help farmers overcome the negative effect of the coarse soils.

The expected effect of hybrid seed is positive at least partially because quality controls result in higher rates of seed emergence for hybrid seeds than for local seeds. The expected effect of planting after the optimal date on yield is negative. Other research tells us that maize yield may decline by 1.3% per day for every day past the first planting rains (Haggblade and Tembo 2003; Elwell 1995). In this study, there is an additional reason why the variable for late planting days has a negative impact on yield. Where late planting days were highest, the rainfall for the season was also the lowest, such that water stress combined with late planting for the season, a double hit on yields. Given the high correlation between late days and rainfall levels in the maize regressions, only late days is included, such that it incorporates the two effects.

There are slight differences in the variables included in the maize and cotton regressions. For example, while the majority of maize farmers used fertilizers at or below the recommended amount, many cotton farmers applied chemical packets at or above the recommended amount, due to the lumpiness of packets discussed earlier. Production theory tells us that there is likely to be a decreasing marginal gain in yield for those farmers using chemicals above the recommended rate, and thus for chemical applications we included a quadratic term (application squared) in the regression, with the expectation that it would have a negative coefficient. For maize, no quadratic term was needed since almost all farmers are in the range in which the marginal product is likely to be increasing at an increasing rate.

Evaluation of some variables resulted in their exclusion from estimations. Rainfall is an obvious variable to include in rain fed agricultural production. However, in these data, we only have a district level estimate of the rainfall which does not reflect the variability within districts noted during our conversations with farmers. Using the rainfall information would be similar to using a district dummy, a very blunt instrument, given the low number of districts in each province. Also, rainfall was found to be, on average, twice as high in Eastern Province as in Southern Province during the 2004/2005 season. For that reason, the provincial variable for Eastern Province in the cotton regression may capture some of the magnitude of that effect. In maize, there was a high negative correlation between number of days late in planting and rainfall, such that only one of the two variables could be included in the regressions. Thus for maize, “days late” incorporates effects of both planting date and rainfall.

Another aspect excluded from the regressions was the information on weeding. If all plots experienced the same weed pressure with similar planting densities, weeding timing and frequency would be useful in understanding yields. If you can control for all other factors, such as weed density and quality of the weeding labor, a farmer who weeds once late in the season would experience lower yields than a farmer who weeds in a more timely fashion. Unfortunately, since we do not have a record of weed pressure, the number of times that a farmer weeds a field may reflect weed pressure more than it reflects weeding effectiveness. Thus the interpretation of a weeding variable in the yield determinants is in question. A field with extensive weeds will need more weeding than one with fewer weeds to obtain the same yield, all other things equal, so the contribution of each weeding is a function of weed pressure, timing, and quality of weeding.

4. RESULTS ON FARMER USE AND PERCEPTIONS

The earlier work of Stevens et al. (2002) indicated that the contact farmers saw various benefits as well as challenges with the Magoye ripper and CF technologies. Because profitability must be seen in a context and perceptions may indicate valuable aspects for further research, we elected to include questions on the farmer perceptions of performance, benefits and constraints. Also understanding how the farmers used the ripper in their fields is key to the interpretation of results. As Haggblade and Tembo (2003) found in their research, many farmers use the rippers for activities unassociated with minimum tillage land preparation.

4.1. Use of the Magoye Ripper

As noted earlier, GART distributed and sold the Magoye rippers to farmers of Central, Copperbelt, Eastern and Southern Provinces with collaboration from MACO and the cotton companies in 2002/03 agricultural season. Within this sample of farmers who bought the ripper, 44% were ripper farmers while 56% were nonripper farmers during 2004/05 seasons.

Table 3 shows how the sample is distributed between farmers with no experience with the ripper, farmers with at least 3 seasons of experience and farmers with some experience. The same percentage of farmers used the ripper all three seasons as those that never used the ripper (28%). Of the farmers who used it throughout the three seasons, three quarters of them were from Southern Province. Farmers in Southern tend to be close to the Magoye Research Station and have more opportunities for extension information and advice. There were more new users of the technology in Eastern Province than Southern Province during the 2004/05 season, reflecting a push for the technology for that season.

Table 3. Distribution of Farmers in the Sample and Their Experience with the Magoye Ripper, 2002/2003 – 2004/2005, by Province

	Eastern	Southern	Overall
Use of the ripper	% of farmers		Total %
Never used it during the three seasons	42	15	28
Used it all three seasons	15	39	28
Used it at least one season (but not 2004/2005)	32	43	38
Used it in 2004/2005 for the only time in the period	11	2	6
Total sample (in percentage of farmers)	100	100	100
Ripper vs. Nonripper in 2004/2005	Number of farmers		Total number
Ripper farmers	33	45	78
Nonripper farmers	51	49	100
Total Sample (number of farmers)	84	94	178

FSRP/GART Magoye Ripper Survey 2005

4.2. Most Important Benefits Perceived by the Farmers when Using the Ripper

Both the GART (2004) and CFU (2006) training materials cite a range of potential benefits of the Magoye ripper when used for minimum tillage land preparation. To get the farmers' viewpoint, this survey asked farmers who had used the ripper at least once in the previous three seasons about the two most important benefits with the Magoye ripper. Using weights of one for the most important and 0.5 for the second most important, Table 4 shows the relative importance of benefits that were cited. Not surprisingly, the farmers cited those highlighted by researchers. Better water harvesting in the furrows was frequently noted by the farmers, as shown in Table 4. About 23% of the farmers indicated that the technology was important because it enabled the crop to grow even when there was a dry spell. Early land preparation and planting were also cited as benefits. Among these farmers, 13% indicated that there was better seed emergence in ripped fields than in ploughed fields, especially important to farmers in Eastern Province (Table 4), a factor related to early land preparation and water harvesting with planting furrows.

4.3. Most Important Problems Identified by Farmer when Using the Ripper

As can be seen in Table 3, a high percentage of the farmers used the ripper for one or two seasons, but did not use it every season when they had it available. Farmers also do not use it on all their land. Researchers identified the farmers who used the ripper at least one season out of the previous three and asked them about problems they experienced with the ripper. Note that these farmers included both ripper and nonripper farmers, as long as the farmer had used the ripper at least once. The responses are reported in Table 5.

As noted in Haggblade and Tembo (2003), Stevens et al. (2002) and Keyser and Mwanza (1996), minimum tillage agriculture tends to suffer from higher weed pressure and requires more weeding than traditional ploughing. About 32% of the farmers in this study have indicated weeds as a major problem in ripped fields, but as will be shown below, they are developing ways to attack the problem.

Table 4. Perceptions of Benefits: Percent of Farmers Indicating Major Benefits after Using the Magoye Tipper at Least Once since 2002/03

	Eastern	Southern	
	%		Overall %
Ripped lines harvest and conserve water	13	30	23
Early land preparation of the field	21	22	22
Early planting of seeds	24	16	19
Good emergence	24	6	13
Higher yield	6	6	6
Finish the work fast	3	8	6
Others	9	12	10

Source: FSRP/GART Magoye Ripper Study 2005
Note: Responses have been weighted to account for the most important benefit and second important benefit. Most important benefit weighs 1 while second most important weighs 0.5

Table 5. Percent of Farmers Indicating the Major Problems after Using the Magoye Ripper at Least Once since the Distribution Program

	Eastern	Southern	Total
	% of farmers who indicated the problems		Overall %
Too many weeds in the ripped field	28.6	34.9	32.3
Tine wears down quickly	18.5	31.3	26.0
Nowhere to buy spare parts	35.3	3.0	16.5
No animals/animals are small	7.6	15.7	12.3
Ripper do not have wings	6.7	10.2	8.8
Others	3.4	4.8	4.3

Source: FSRP/GART Magoye Ripper Study 2005
Note: 125 farmers indicated two problems; 35 farmers indicated one problem and 18 farmers had no response, thus, a total of 285 responses among 178 farmers that responded.

Another issue is the durability and price of the ox drawn minimum tillage equipments. Greater durability and accessible prices for implements can increase the use of the technology by farmers (Mbanje, Twomlow, and O'Neil 2001) as well as improve the potential profitability. In doing land preparation with the Magoye ripper tine, about 26% of the farmers in this study indicated that the wearing down of the Magoye ripper tine was the problem (Table 5). The problem was less important in Eastern Province since for many farmers it was their first season.

The wearing down of the tine becomes a potentially very important problem when combined with the difficulties that farmers indicated with getting service and spare parts for the Magoye ripper. For 17% of the farmers, lack of locally-available spare parts was an important problem, and in Eastern Province this was the most important difficulty cited (Table 5).

Another potential supply problem is the lack of draught animals. Farmers must either own animals or be able to borrow or rent them to use the ripper. The lack of animals, particularly fully grown animals that are large enough to pull the ripper, was seen as a major problem by almost 16% of the farmers in Southern Province (Table 5). As pointed out in Bwalya's (2000) report, trials of the sub-soiler and the Magoye Ripper did not go well in Southern Province because of an outbreak of an epidemic that resulted to cattle deaths. Haggblade and Tembo (2003) indicated that markets for draught animals appear to be on the rise, and suggest that improved markets will assist in addressing this problem, but diseases and pests will continue to threaten livestock herds.

4.4. Non-use of the Magoye Ripper in 2004/05

In the previous section, we looked at the benefits and problems with the ripper among all the farmers who had used the ripper at least once. However, in this section the focus is on people who had bought Magoye rippers but did not use them in 2004/2005 season. Why did farmers not use the ripper in the most recent season? As expected and shown in Table 6, the farmers indicated problems that are similar to the problems indicated in Table 5. Animal stocks were a key problem for 31% of the households that did not use the Magoye ripper in 2004/05 season. They either did not have animals or the animals were too small to use. Over the long run, this is a serious constraint to adoption of animal traction technologies.

Table 6. Reasons for Not Using Ripper in 2004/05 Agricultural Season

	Eastern	Southern	
	%		Total %
No animals/animals are still small	27.5	33.3	30.7
The tine was blunt	7.8	34.9	22.8
No training on how to use the ripper was offered	23.5	15.9	19.3
No spare parts	13.7	-	6.1
Fear of weeds in the field	2.0	9.5	6.1
Ripper has no wings	3.9	-	1.8
Animals were sick/dead due to disease	-	1.6	0.9
Others	21.6	4.8	12.3
Sample Statistics (some households gave more than one reason)	51	63	114

Source: FSRP/GART Ripper Study 2005
Note: 14 households had two reasons; while 85 had one reason for not using the Magoye ripper and one had no reason. There were 78 households that gave reasons. Farmers using ripper in 2004/5 are excluded, therefore, there were 100 respondents and 114 respondents

The second major problem was with the ripper tine. About 23% of the households indicated that the tine was wearing out quickly. With the lack of local replacements or trained artisans for sharpening, this was a key constraint, as a dull tine means more work. The third most important reason stated by farmers was a perception that they were not adequately trained on how to use the ripper. The issue of the wings was raised in Eastern Province where demonstrations were completed with a Magoye Ripper that had wing attachments, but when the Magoye Rippers were distributed they did not have the wing attachments. This created some confusion among farmers as to whether the ripper would function properly without them.[2] This also corresponds to the complaints about lack of places to buy replacement parts, a problem frequently cited in Eastern Province.

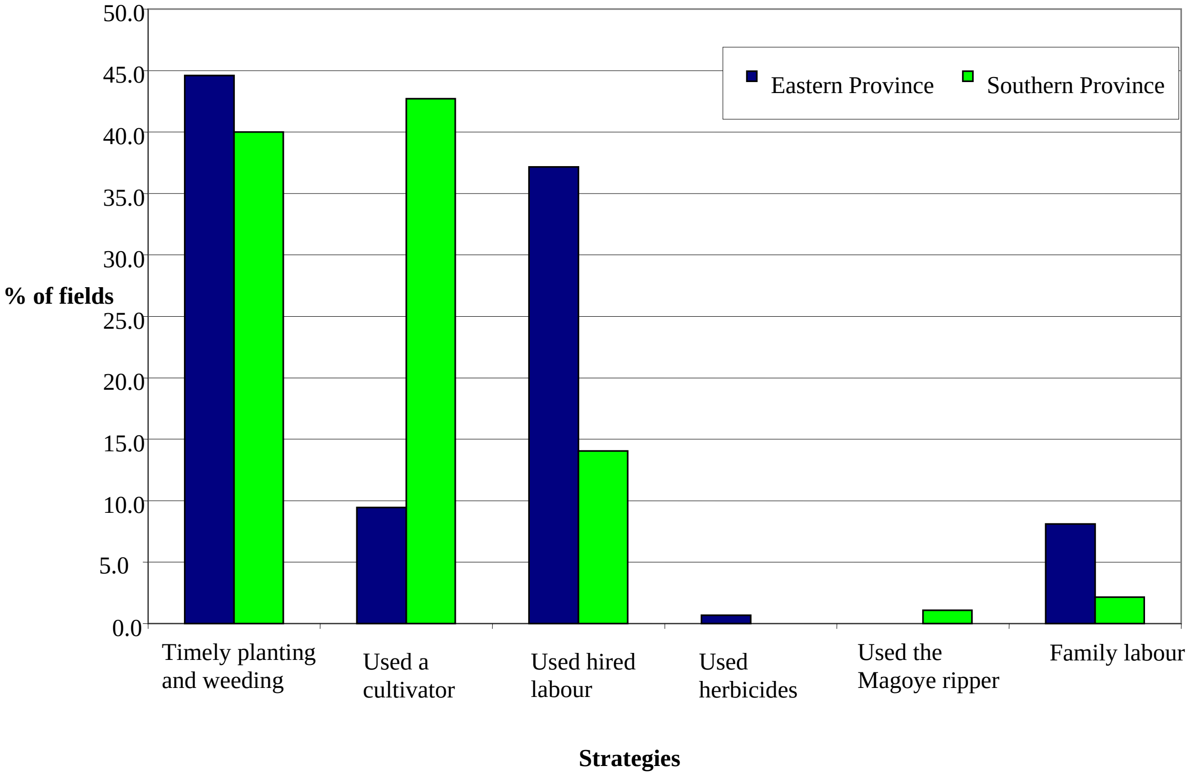
Interestingly, in spite of weeds as the major challenge in Table 5, only about 6% of the farmers indicated problems with weeds as a major contributing factor in not using the ripper. The problem was more important in Southern Province than in Eastern. As will be shown below, farmers developed strategies to deal with the weeds, but they were unable to develop such strategies to cope with lack of livestock and implements in poor condition.

4.5. Weeds

Although weeds can be a problem in traditional cropping, researchers, extension agents, and farmers all note that the problem can become more difficult under conservation farming (Haggblade and Tembo 2003; Bwalya 2000; Keyser and Mwanza 1996; Frans, McClelland, and Jordan 1991). With this in mind we asked the ripper farmers about the strategies that they used to overcome the problem of weeds in their ripped fields during the 2004/05 agricultural season. As shown in Figure 1, they use the strategy of timely planting and timely weeding. These results confirm what Stevens et al. (2002) found with the contact farmers. From the farmers' perspective, these strategies enabled them to manage weeds before they matured and this in turn reduced the weed seed bank in the soil.

[2] Annex Figure 5 A shows a farmer indicating where he expected the wings to be. He did not use the technology because he was thinking that it was not a complete implement.

Figure 1. Strategies Identified by Ripper Farmers as How They Coped with Weeds in Their Fields



If weeds are well-managed under conservation farming, weed pressure in fields reduces overtime. (Hartzler and Owen 1997). Mechanical weed control can also help to suppress weed population in the fields (Curran, Lingenfelter, and Garling 1996). About 43% and 10% of the households in Southern and Eastern Provinces respectively used a cultivator to weed the fields during 2004/05. The use of cultivators results in high soil disturbance which undermines the benefits on minimum tillage.

As pointed out in Stevens et al. (2002) report, the Magoye Ripper is used for other farm activities such as weeding if the ripper has extended wings. However, only 1% of the farmers said that they used the Magoye ripper for weeding in 2004/2005. During interviews, farmers indicated the desire to have wings on the ripper to make it more useful for weeding, so the lack of wings may have resulted in such low use rates for weeding. The other strategy available to farmers to use in coping with the weeds was the use of herbicides. Researchers hypothesize that labour is becoming scarce and expensive due to the outbreak of HIV/AIDS and that there are further benefits from not disturbing the top soil. However, from the strategies highlighted in Figure 1, herbicides are rarely used to overcome weeds. This could be due to lack of extension, lack of sales points for herbicides and applicators, and relatively high cost. Researchers indicate the option of using mulching and cover crops to lower weed pressure, but these farmers did not indicate that they used those methods in the ripped fields at all.

Table 7. Farmer Perceptions of Yields, Comparing Tillage System by Crop

	Province			
	Eastern		Southern	
	Maize	Cotton	Maize	Cotton
Perception	% of farmers			
Ripped fields had a higher yield	42	60	90	100
No difference in yields	25	10	0	0
Traditional ploughed fields had higher yields	33	30	10	0

Source: FSRP/GART Ripper Study 2005

4.6. Farmer Perceptions of Outcome

Farmers were asked about the outcome of this cropping season, comparing the plots with the ripper to the plots under traditional ploughing. This analysis is based only on farmers that had both fields (ripped and ploughed fields of maize or cotton). Almost all ripper farmers in Southern Province perceived yield benefits in using the ripper in both maize and cotton, and the majority of cotton farmers in Eastern province indicated yield benefits as well (Table 7). With maize farmers in Eastern the results were less conclusive. Since the farmers had already paid for the rippers and there was no continuing program for support, these researchers believe this to be an accurate recording of farmer perceptions and it generally coincides with observations in the field, although as we shall see, farmers changed more than just the tillage system between the plots. Since these are not on-farm trials with controlled treatments, farmers' results will vary due to a range of different practices, including how and when they used the ripper and other production methods.

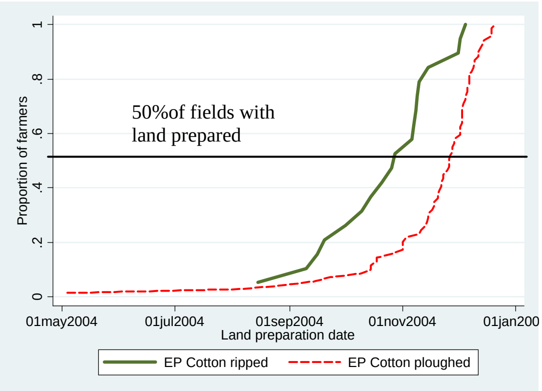
4.7. Field level Analysis

As pointed out in the introduction, we collected information from 384 fields across 178 farmers. Of these fields, 14% were maize ripped, 37% were maize ploughed, 16% were cotton ripped and 33% were cotton ploughed. Overall more ripper farmers were identified in Southern Province than in Eastern Province, such that more ripped fields, both maize and cotton, from Southern Province are represented in this study. It was more difficult in Eastern Province to locate ripper farmers. The Magoye Research Station has been carrying out trials and demonstrations for a longer period, while in Eastern Province the extension has been less intensive and the participating farmers are more dispersed.

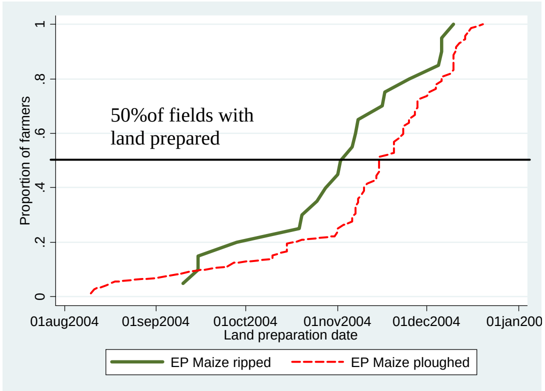
Figures 2, A-D. Land Preparation Dates for Maize and Cotton, by Province and Tillage System in 2004/05

Eastern Province

A. Cotton

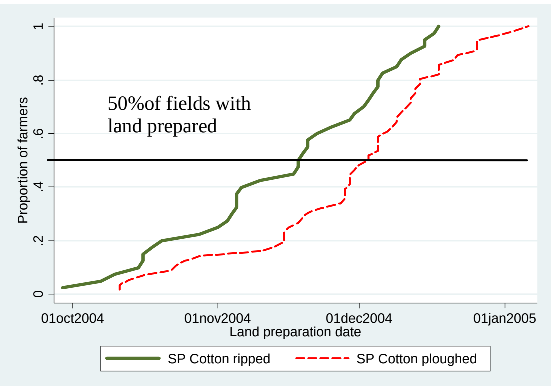


B. Maize

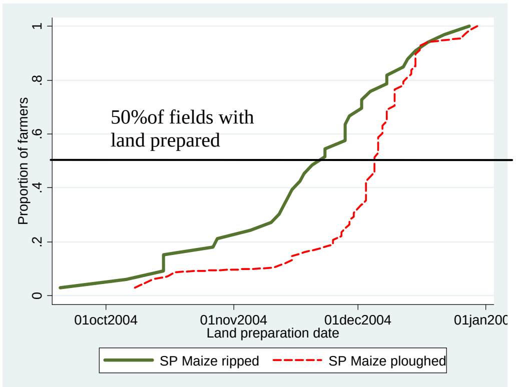


Southern Province

C. Cotton



D. Maize



Source: FSRP/GART Ripper Study 2005.
Notes: Graphs show the frequency distribution of fields based on date of land preparation.
Solid line to left means that ripping farmers prepared the land earlier.

4.7.1. Land Preparation

Literature tells us that the Magoye Ripper enables farmers take full advantage of the first rains for crop production because land preparation can be completed during the dry season, just after harvest, rather than after the first rains in planting seasons, typical timing for animal traction ploughing. This early land preparation is seen as a key benefit for the water retention in the furrows.

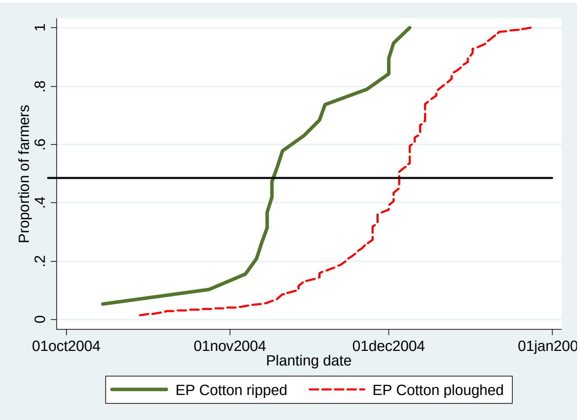
Figures 2 A-D demonstrate the distribution of land preparation dates according to province, tillage and crop. Overall, it can be seen that the ripped fields were prepared earlier than the ploughed fields. Contrary to extension recommendations, there were no cases of ripping for land preparation in the period right after the previous harvest. Based on responses by farmers in Eastern Province, (Figures 2 A and B) land preparation for 50% of the cotton ripped fields was done by last week of October 2004 whereas the majority of cotton ploughed fields were prepared after November 1. Land preparation for maize was more evenly distributed over time, yet more than 50% of the ripped fields were prepared before November 1 compared to mid November for the ploughed fields. For both maize and cotton under ploughing in Eastern Province, there was one case for each where land preparation was done in May (Cotton) and August (Maize).

Land preparation for cotton in Southern Province under ripping and ploughing started in October 2004 and ended about mid December for ripping and early January 2005 for ploughing. Low levels of rainfall in Southern Province may have resulted in the very concentrated land preparation dates for maize under ploughing. The rains generally came late, so that farmers urgently prepared land to enable maize planting before mid-December.

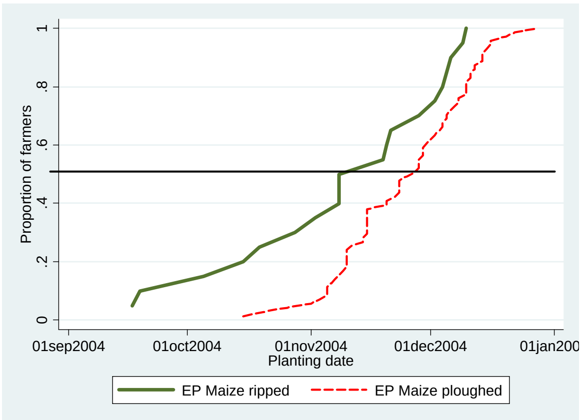
Figures 3, A-D. Planting Dates for Maize and Cotton, by Province and Tillage System in 2004/05

Eastern Province

A. Cotton

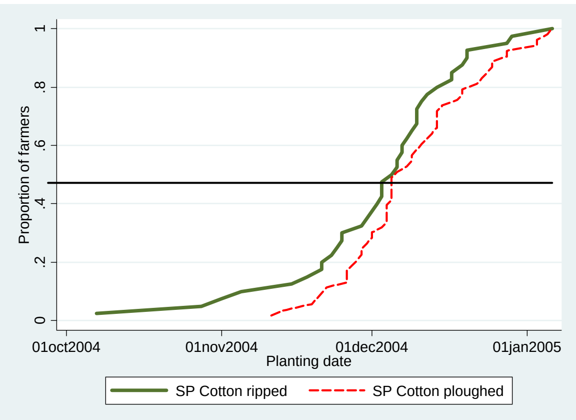


B. Maize

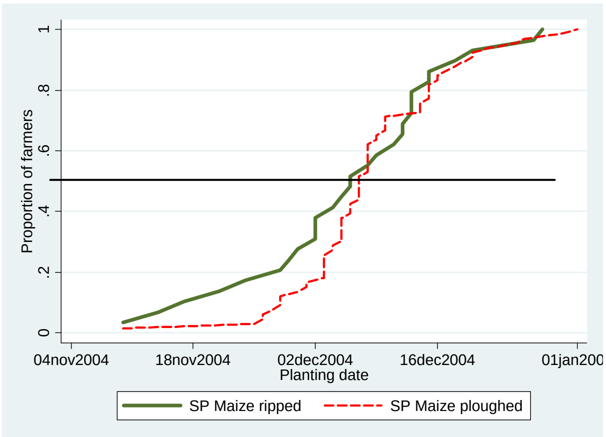


Southern Province

A. Cotton



B. Maize



4.7.2. Planting Dates

Time of planting is one of the factors that affects yield of a crop. Zambian maize breeders indicate that maize yield may fall by 1-2% for every day's delay in planting after the first planting rains (Haggblade and Tembo 2003). It is also found in this study that one day late in planting may result in 18kg per ha loss of maize, although it should be noted that farmers in areas with low rainfall planted late as they waited for rain, so the effect of rainfall confounds the effect of late planting. Figures 3 A-D show the planting dates of ripped and ploughed fields of Eastern and Southern Provinces. The graphs show the cumulative percentage of fields which were planted as the season progressed, with the solid lines representing ripped fields while dashed lines representing ploughed fields. Ripping farmers generally planted earlier than ploughing farmers in Eastern Province and about 50% of cotton ripped fields were planted by 10th November whereas it took until 4th December for the same proportion of ploughed cotton fields to be planted. For maize, the relative dates were 6th November for ripped fields and 26th November for ploughed fields.

The window of opportunity for planting in Southern Province for maize and cotton under ripping and ploughing was fairly short. It was found that 50% of ripped and ploughed fields were planted in the first week of December 2004. This pattern of planting could be attributed to the late coming of rainfall. Although ripped fields might have already had the land prepared earlier than ploughed fields, farmers had to wait until rainfall came.

4.7.3. Soil Type

Soil type may have various impacts on productivity in minimum tillage systems. Of key concern here is the relationship between soil type and the wearing down of the tine of the ripper, a problem cited by farmers (Table 6). Coarse soils may be associated with the tine

Table 8. Farmer-Declared Soil Type of Sampled Fields, by Province and Crop/tillage

Tillage	**Soil Type**	**Province**		
		Eastern	**Southern**	**Overall**
		Percentage of fields, among soil types		
Maize ripped fields	Coarse soils (sand)	23	6	13
	Moderate soil	59	82	73
	Fine soil	18	12	15
Maize ploughed fields	Coarse soils (sand)	38	20	29
	Moderate soil	45	62	53
	Fine soil	18	17	17
Cotton ripped fields	Coarse soils (sand)	19	13	15
	Moderate soil	67	82	77
	Fine soil	14	5	8
Cotton ploughed fields	Coarse soils (sand)	27	18	23
	Moderate soil	50	56	53
	Fine soil	23	25	24

Source: FSRP/GART Magoye Ripper Study 2005 wearing out more quickly. We asked the farmer to tell us the type of soil in his or her field, with categories of fine, moderate and coarse soil. Table 8 indicates that ripped fields, both cotton and maize, were more likely to be in moderate, rather than coarse or fine soils.

4.7.4. Field Size

Field level data were analyzed to evaluate possible differences in field sizes. Earlier research with GART contact farmers found that farmers' fields with ripping tended to be larger than those under ploughing (Stevens et al 2002). However, in this study it was found that the average area (in hectares) for sampled fields of both maize and cotton ripped fields by Province was less than the average area of ploughed fields (Table 9). The ripped fields may be smaller due to the problems identified earlier such as heavy weed pressure in the fields, young animals and the blunt tine.

In comparison with Table 9, Figure 4 compares the average area between ripped and ploughed fields using just farmers who had both fields for either maize or cotton. The size of ripped fields was clearly smaller although with a broader range when compared to that of ploughed fields for both crops in Eastern Province. In Southern Province, all ripped plots for maize were smaller than the ploughed plots, however for cotton there was an overlap of the distribution for cotton plots.

4.7.5. Other Input Use

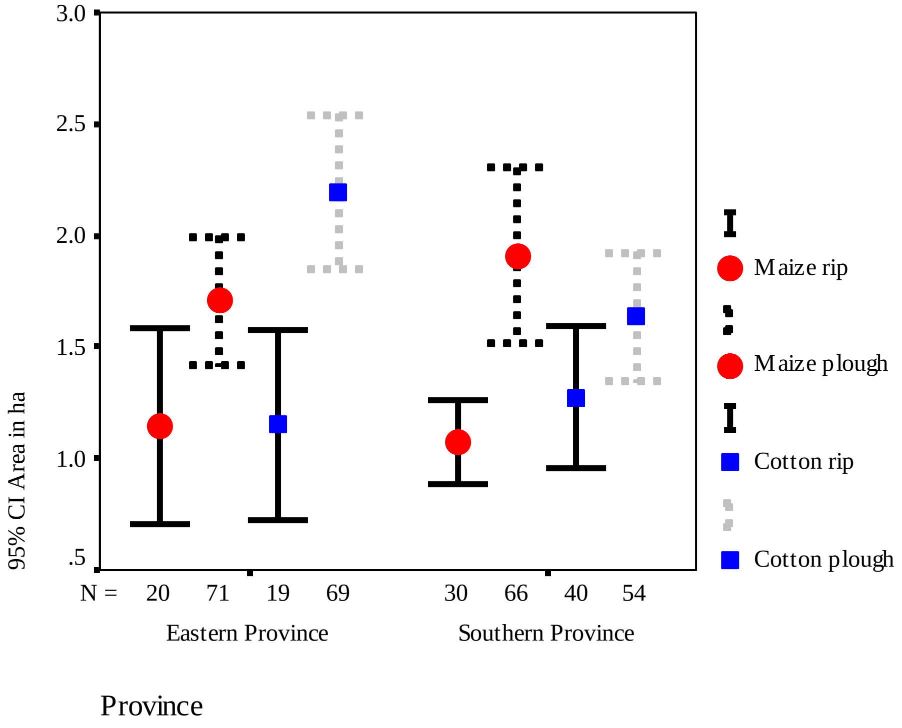
Manure was not used as commonly as expected, given that these farmers generally have animals for livestock manure. Only 50 farmers indicated using manure (19% of the sampled farmers in Southern Province and just 7% of sampled farmers in Eastern Province), with just two purchasing it (one from each province). Use of manure was concentrated among farmers in Southern Province who planted hybrid seed, indications of a technology link between maize hybrids and manure performance.

Table 9. Average Area of Fields (in Hectares), by Crop, Tillage System and Province

	Eastern			**Southern**			
Tillage type	**Mean Area**	**Max Area**	**Min Area**	**Mean Area**	**Max Area**	**Min Area**	**Overall Mean**
Maize Ripped field	1.14	3.65	.11	1.04	2.34	.25	1.08
Maize Ploughed field	1.67	7.83	.20	2.00	12.20	.27	1.83
Cotton Ripped field	1.20	3.79	.29	1.28	6.00	.29	1.25
Cotton ploughed field	2.18	6.37	.28	1.62	4.30	.29	1.93

Source: FSRP/GART Ripper Study 2005
There were 55 maize ripped fields, 143 maize ploughed fields, 61 cotton ripped fields and 125 cotton ploughed fields

Figure 4 . Comparison of Areas in Ripped and Ploughed Plots, by Crop and Province, Indicating Distribution around the Mean Area (in Hectares)



Source: FSRP/GART Magoye Ripper Study 2005.
Estimates based on farmers with one each of ploughed and ripped for the given crop.

Fertilizer was used by the majority of maize farmers using the ripper, although no macro nutrient fertilizer was used on cotton production in either province. The rate of use of fertilizer in maize fields (both ripped and ploughed) is less than the recommended rate (400kg/ha) though it is higher than the average fertilizer application rates for small and medium scale farmers of Zambia over the past 10 years (Haggblade and Tembo 2003). Table 10 shows the average kg per hectare of fertilizer (basal and top dressing) applied on ripped and ploughed fields of maize and the average number of packs of chemicals applied on a hectare of cotton. Due to the site-specific application of fertilizer in ripped fields, the recommended dose of fertilizer is lower than for fields under traditional ploughing. However, fertilizer was applied more intensively in this study in the ripped maize fields compared to ploughed maize fields.

In cotton farming, the cotton companies provide seed and pesticides to farmers through distributors in the case of Dunavant and through employees in case of Clark Cotton. Normally farmers get inputs in fixed, standardized packages for either one-hectare or one-half hectare. For one hectare, the standard pack consists of 30 tablets of Decistab, one litre of Wuxal/folifert/soloba and 200 milliliters of Marshal. Wuxal/folifert/solaba is the only micronutrient fertilizer in the package and normally macronutrient inorganic fertilizer is not part of the package. Farmers get chemical packs based on their area, rounded to one-half hectare areas, the minimum for the companies. Farmers did not purchase additional inorganic fertilizers for their cotton.

Table 10. Average Use of Inputs (per Ha) in Maize and Cotton Fields, by Type of Tillage and Province

	Eastern Province				Southern Province			
	Maize		Cotton		Maize		Cotton	
Input use	Ripper	Ploughing	Ripper	Ploughing	Ripper	Ploughing	Ripper	Ploughing
Number of sample plots	20	71	19	69	30	66	40	54
Seed								
% using HYV	65%	41%	100%	100%	97%	91%	100%	100%
kg/ha among users	17	20	25	17	15	16	20	17
kg/ha among all farmers	17	18	22	17	17	18	22	17
% using Local	35%	59%	0%	0%	3%	9%	0%	0%
kg/ha among users	23	20	0	0	50	20	0	0
kg/ha among all farmers	17	18	0	0	16	17	0	0
Basal fertilizer								
% who use basal	70%	70%	0%	0%	63%	61%	0%	0%
kg/ha among users	132	85	0	0	65	60	0	0
kg/ha among all farmers	92	73	0	0	92	73	0	0
Top dressing fertilizer								
% who use top dressing	75%	75%	0%	0%	60%	65%	0%	0%
kg/ha among users	141	79	0	0	56	63	0	0
kg/ha among all farmers	90	71	0	0	90	71	0	0
Manure								
% who use manure	20%	8%	10%	0%	33%	32%	0%	11%
kg/ha among users	1974	376	211	0	467	950	0	8
kg/ha among all farmers	1070	652	68	0	1070	652	0	68
Pesticides with nutrients (packs ha)								
% who use pesticides	0%	0%	100%	99%	0%	0%	100%	100%
No. packs among users	0	0	1.27	0.98	0	0	1.03	0.87
No. packs among all farmers	0	0	1.11	0.93	0	0	1.11	.93

Source FSRP/GART Magoye Ripper Study 2005

From the study, farmers applied relatively more chemicals in ripped fields than in ploughed fields (Table 10). Farmers might have planted more seed per station and then applied the chemicals accordingly. Usually farmers get one hectare or half hectare pack and they spray it all in the field they have. Since the mean area was less than one hectare in ripped areas, they may have applied more chemicals per hectare in those fields. In ploughed fields, farmers applied about one pack per ha.

4.7.6. Hiring of Labor and Animals for Land Preparation

Farmers tended to hire labor for particular activities. In both provinces and across crops and tillage methods, most of the labour used in land preparation was family labour with only about 10% of fields having either hired or a combination of hired and family labor (Table 11). For planting, only cotton fields in Eastern Province tended to have hired labor use. Weeding and harvesting are the two activities in which hired labor and combinations of family and hired labour were frequently found. It is here that the provincial differences stand out. Fields in Eastern Province are more likely to have hired labour, either alone or in combination with family labor. Households in Eastern Province were more likely to have contracted seasonal labor that helped in a whole range of activities. We do not know why this difference appears. It may be that labor markets are more developed in Eastern Province than

Table 11. Fields Cultivated Using Family Labour, Hired Labour, and Both Types of Labour, by Province, Crop, Tillage Method and Activity, 2004/05

		Eastern Province				Southern Province			
		Maize		Cotton		Maize		Cotton	
Activity		Rip	Plough	Rip	Plough	Rip	Plough	Rip	Plough
		% of fields with specific labor type							
Land preparation	Only Family	90	90	90	86	82	90	90	84
	Only Hired	5	3	5	8	9	9	5	11
	Both types	5	7	5	6	9	1	5	5
Planting	Only Family	95	92	74	85	94	99	98	98
	Only Hired	5	3	5	8	6	0	0	0
	Both types	0	5	21	7	0	1	3	2
Chemicals	Only Family	na	na	95	96	na	na	100	98
	Only Hired	na	na	5	4	na	na	0	2
	Both types	na	na	0	0	na	na	0	0
Fertilizer	Only Family	89	96	na	na	96	98	na	na
	Only Hired	6	2	na	na	0	0	na	na
	Both types	5	2	na	na	4	2	na	na
Weeding	Only Family	57	62	37	30	73	68	73	64
	Only Hired	10	10	16	7	3	4	5	4
	Both types	33	29	47	63	24	28	23	32
Harvesting	Only Family	67	84	47	49	97	93	80	80
	Only Hired	10	4	26	17	0	0	0	4
	Both types	24	12	26	34	3	7	20	16
Use of Hired Animal Draught Power for Land Preparation		5	10	0	12	12	9	5	16

FSRP/GART Magoye Ripper Study 2005

in Southern, with Malawian immigrants providing labor. Family labor in Eastern Province may have other income earning possibilities or households may have fewer members in Eastern, necessitating hired labor to complete tasks.

Animal draught power may also be hired in for ripping or traditional ploughing. Haggblade and Tembo (2003) cited the increase in rental markets for animal traction as a possible way to release the constraint of own animals for the work. In this research, as indicated in the last line in Table 11, we did not find a high percentage of farmers hiring in animals for land preparation, with no more than 16% of fields of any type prepared with hired animals. In general, it was more common to find hired animals used in ploughed fields rather than ripped field, with the exception of maize ripped fields in Southern Province.

5. RESULTS ON YIELDS AND PROFITABILITY

5.1. General Regression Issues

We will examine the results by crop since the modeling differed, but before that there is one major consideration on the overall modeling. Initially we found evidence in both maize and cotton that a standard assumption on constant variance for regression analysis might be violated. Ideally, the estimation should results in residuals that have a constant variance and a mean of zero, yet the initial regressions and hypothesis testing indicated that there might be a problem with the nonconstant variance, known as heteroskedasticity. Given the dispersion of the data and several possibly influential points, we elected to use heteroskedasticity-robust variance estimation procedures (Wooldridge 2002). The results presented here are based on such robust estimations.

5.2. Maize Results

Table 12 presents the results of the estimation of determinants of maize yields. As expected the amount of nitrogen applied has a significant and positive effect on the yield. It is a key nutrient that is rarely in sufficient quantity in Zambian soils and so application of nitrogen is one of the most strongly recommended practices for maize production here. The size of the field also significantly contributed to maize yields, such that a farmer with a smaller plot obtained a relatively higher yield. Smaller plots enable more intensive crop management. The type of soil is also quite important in yield determination. There were significantly lower yields on fields for which the farmer indicated coarse soils, most likely due to soil water retention properties, for water retention by coarse soils is quite low compared to fine soils.

Originally the regressions for maize included indicators for Eastern Province and for the number of days late in planting. There is a significant correlation between the two variables, and we have dropped the Eastern Province indicator from the regression. Concerning location, Namwala District shows yields which are significantly higher than those in the other four districts included here, controlling for the aspects already included in the model. The soils in the areas of Namwala where the farmers in the study were sampled are rich in organic matter as compared to soils elsewhere, and so this variable is capturing possible soil quality characteristics beyond texture.

While using the ripper for minimum tillage in dry season may enable farmers to plant earlier, not all ripper farmers completed land preparation and planting earlier than the traditional plough farmers. Thus we do not find the expected importance for the interaction variable between ripper use and days late, although each day late significantly reduces yield, by an estimated 18 kgs/ha for each day (Table 12). In terms of farmer experience, the use of the ripper in at least two of the previous three seasons did not have a significant effect on the yield. This variable may not have been able to capture the potential increased efficiencies as farmers develop skills.

Table 12. Determinants of Maize Yield

Dependent variables	Coefficient	Robust Std error	Robust t-stat	P>|t|	Sig.	Confidence Interval Min	max
Plot Size (ha)	-128.39	58.23	-2.20	0.03	**	-243.30	-13.47
Nitrogen (kg/ha)	10.41	2.40	4.33	0.00	***	5.66	15.16
Tillage (1=ripper)	-139.56	217.49	-0.64	0.52		-568.78	289.66
Manure Use (1=yes)	112.66	215.76	0.52	0.60		-313.15	538.47
Hybrid (1=yes)	259.61	277.34	0.94	0.35		-287.73	806.96
Coarse soil type (1=yes)	-390.22	146.07	-2.67	0.01	***	-678.49	-101.95
Planting days late (after Nov 20)	-18.31	6.02	-3.04	0.00	***	-30.19	-6.43
Nitrogen X Tillage	9.09	3.97	2.29	0.02	***	1.26	16.93
Used the ripper at least 2 out of past 3 years	50.24	143.53	0.35	0.73		-233.01	333.50
Namwala District	1155.02	371.82	3.11	0.00	***	421.21	1888.83
Constant	1005.90	313.71	3.21	0.00	**	386.79	1625.01

Linear regression	Number of obs = 174
	F(10, 163) = 10.54
	Prob > F = 0.0000
	R-squared = 0.3868
	Root MSE = 880.71

Source: FSRP/GART Magoye Ripper Study 2005.

Notes: Eastern Province excluded due to high correlation with Planting Days Late. Regression used robust errors, due to identified problems with heteroskedasticity.

A key finding in this research is that minimum tillage with the ripper did not have a significant direct effect on the maize yields. However, farmers who used the ripper combined with nitrogen applications saw significantly higher yields than just using the nitrogen alone. According to the GART Ripper Operators manual (2004), this would be expected as ripping enables the first rains to assist in more efficient localized placement of fertilizer. The Magoye Ripper is not a panacea but is designed to operate within a farming system to optimize production in synergy with other practices such as localized fertilizer application

The maize results were fairly stable to the addition of various interaction terms and those additions did not tend to increase the explanatory power of the estimations, so they have not been included here. Manure use and hybrid seed are both dichotomous (0,1) variables, and neither proves significant.

5.3. Cotton Results

The yield determinants estimation for cotton was slightly different from that for maize for several reasons that will be explained below as we discuss each variable. We note that the overall explanatory power of this regression is not as strong as for the maize (Table 13). As expected, the cotton results indicate the critical importance of the chemical packs distributed to the farmers. In the earlier section we discussed why a quadratic term might be useful for the chemical inputs. Both the level of chemical packs applied and the quadratic term are significant. The application of packs of chemicals contributed positively to yield, and the quadratic variable had the expected negative sign, indicating that there were diminishing marginal returns to the chemicals as the quantity rose.

The size of the field was once again important in determining yields, suggesting that more intensive cultivation occurred with the smaller fields thus generating higher yields, other things held constant. There were no other factors that were significant in explaining differences in yields between ripped and ploughed fields. The number of days late was not significant, suggesting that cotton is not as sensitive to planting date as is maize. For cotton, the relationship between days late and province was not strong and so both variables were able to be included here. Eastern Province yields do tend to be significantly higher than Southern Province. As indicated earlier, part of this reflects the higher rainfall in 2004/2005 compared to Southern Province. Planting in coarse soils does not have a significant effect on the yields, nor does farmer’s previous experience with ripping.

As with maize, we found no direct, individual impact of the ripper on yields, when we control for all the other aspects included here. Unlike maize, the coefficient on the interaction term between the tillage and the chemical applications was not significantly different from zero.

Table 13. Determinants of Cotton Yield

						Confidence interval	
Dependent variables	**Coefficient**	**Robust Std error**	**Robust t-stat**	**P>|t|**	**Sig.**	**Min**	**max**
Plot Size (ha)	-93.13	19.43	-4.79	0.00	***	-131.49	-54.76
Chemical application (packets/ha)	423.74	175.60	2.41	0.02	**	77.10	770.39
Chemical application squared	-150.24	57.35	-2.62	0.01	***	-263.46	-37.02
Tillage (1=ripper)	-160.11	183.77	-0.87	0.39		-522.87	202.64
Coarse soil type (1=yes)	-69.00	61.20	-1.13	0.26		-189.82	51.82
Planting days late (after Nov 20)	-1.19	2.41	-0.49	0.62		-5.95	3.57
Chemical appl. X Tillage	244.03	169.32	1.44	0.15		-90.20	578.26
Used the ripper at least 2 out of past 3 years	83.58	66.59	1.26	0.21		-47.86	215.02
Eastern Province	125.09	72.73	1.72	0.09	*	-18.49	268.67
Constant	542.38	134.20	4.04	0.00	***	277.46	807.29

Linear regression	Number of obs = 180
	F(9, 170) = 5.59
	Prob > F = 0.0000
	R-squared = 0.2075
	Root MSE = 388.43

Source: FSRP/GART Magoye Ripper Study 2005
Notes: Namwala District excluded for measurement problems. Regression used robust errors, due to identified problems with heteroskedasticity.

This is not surprising since the chemical packs are mainly for pest control and would not interact with the type of tillage system in the way that nitrogen fertilizer with ripping does for maize cultivation. Thus, for this production year among these cotton farmers, the minimum tillage land preparation with the ripper did not appear to be a key element in determining yields.

5.4. Cost Components

There was great variability in the costs incurred by these farmers. Part of the variability is due to the prices for inputs and outputs, but the differences in production methods are even more important. As earlier observed, some farmers used fertilizers while some used manure and yet others used no additions to the soil. Some farmers purchased hybrid maize seeds, while other farmers used retained maize seed from the previous season's own production. Some farmers only weeded once whereas others weeded twice or more. Other practices varied as well. To calculate profitability at the farm level, we assessed various components of the cost and income structure (see MACO 2006 Crops Budgets). Most commonly, the average costs are used. For certain practices, we identify the mode (the most common value) or the median rather than the mean due to the influence of special cases.

The main costs incurred by all farmers are included in Tables 14 and 15 below in the estimates of the net income. These costs include labour costs for all activities: land preparation, planting, fertilizing in the case of maize, weeding, spraying of chemicals in the case of cotton, and harvesting. The tables also include the cost of input, fertilizer, chemicals, and seed. The other costs include the cost of implements (the Magoye ripper and the mouldboard plough) considering the three years of depreciation and potential use in other crops and activities. In calculating the cost of these implements the cost of the beam is excluded since its cost is minimal once we take depreciation into consideration.

The cost of seed was estimated based on the type of seed and the price of that seed on the market. For maize, public market and seed company prices were used; for cotton seed, the cotton company price was used. Cotton seeds were distributed by the cotton companies with a fixed price per variety: Dunavant distributed cotton variety F135 at a price of 1750 Zambia Kwacha (ZMK) per kilogram, whereas Clark Cotton distributed Chureza at a price of 1400 Kwacha per kilogram. For maize seed, the farmers used recycled at an average cost of ZMK 780 and open pollinated variety (OPV) at an average cost of ZMK 3,500 per kg. During the Magoye ripper study, specific maize hybrid varieties were not identified, such that the price of hybrid maize seed is the average of all hybrid maize seed varieties that were sold by the seed companies during the 2004/05 season. In our study the average price of maize hybrid seed was ZMK 6,600 per kg.

5.5. Income Side

In evaluating profitability of the ripper, we only look at the production system using the ripper for minimum tillage land preparation and the practices associated with it as practiced by farmers. The ripper is often used for other activities in addition to the land preparation under minimum tillage, but this research does not attempt to value those activities. The most common uses are in ripping planting furrows after ploughing and in weeding, and farmers may provide these services to other farmers. We have not assessed how that contributes to income, for there were only two out of 21 cases for which a payment was received. In the remaining 19 cases no payments (in cash or in kind) were indicated. Out of the 21 cases involved, farmers used the ripper in the period before the onset of rains, during a period of relatively low labor demand. Maintenance of the ripper would have had higher costs given these activities, especially sharpening the tine, but we have insufficient information to quantify the costs and benefits here. In this case, we are probably under-estimating the value of the ripper to the farmers.

The output prices of maize and cotton were used to compute the gross profit of each enterprise. The output price for maize was at ZMK 788/kg for Eastern Province and ZMK 772/kg for Southern Province. These output prices were determined considering the market price which FRA offered and what was offered by different traders at markets in provincials cities of Eastern and Southern Provinces. The collection of the traders' prices is done by Agricultural Marketing Information Centre (AMIC).

The producer price of seed cotton was determined by the cotton company. In this study there were three cotton companies with whom the farmers of the study worked. These were Clark Cotton in Eastern Province, Dunavant and Continental Cotton Company in Southern Province. The price of seed cotton per kg was ZMK 1180 for Clark Cotton, ZMK 1220 for Continental Cotton Company and ZMK 1200 for Dunavant. The average price of seed cotton per kg from the different prices offered by companies was ZMK 1200 per kg and is the one considered for the cotton budget.

5.6. Profitability Analysis of the Magoye Ripper

This section presents the results of an analysis of maize and cotton profitability, comparing results between ripping technology and traditional ploughing. In each case the yield result is based on the Eastern Province observed ripping average yield, which is then modified using the significant factors for change from the regression estimates. Thus for maize, the yield for Eastern Province ploughed is computed by taking the ripped average yield and reducing it due to less nitrogen applied, taking out the yield gain from the nitrogen with ripping, as well as planting on average four days later than ripper farmers. For Southern Province maize yields, there are adjustments for the changes in nitrogen application and days late as well, for both ripping and ploughing. In cotton yields, the adjustments to the Eastern Province ripping observed yields are made based on chemical packets use and an additional reduction when the farmer is in Southern Province, a reflection of the rainfall problems.

The results are reported on a per hectare basis and focus on the combination of practices observed with the farmers in each category. We assume that a farmer's decision on the use of the technology would consider both yield and net profit. The net profit is compared across the systems. Both systems necessitate the cost of maintaining draught animals and since those costs are difficult to evaluate and are spread across many activities on the farm, we do not include those costs here. We do include an assessment of additional cost for farmers who do not have their own animals and must hire, implicitly valuing own draught animal provision at the opportunity cost of using them to plough own land.

Profitability analysis under maize cropping shows that ripped fields had higher net profit per hectare than ploughed fields with an additional ZMK 575,800 in Eastern Province and ZMK 91,800 in Southern Province (Table 14). This could be attributed to the higher mean yield obtained from ripped fields than ploughed fields as a result of the following factors:

- ripper use which resulted in efficient use of fertilizer;
- plot size where smaller plots mean more intensive management under ripping and thus higher yield; and
- higher fertilizer application under ripping.

Total cost for maize under ripping was higher than under ploughing in Eastern Province because of the higher labour costs (Table 14 and Annex Tables 16 and 17). Of the total cost under ripping 48% can be associated with labour cost while 37% can be attributed to the cost of inputs. Total cost under ploughing shows that about 45% came from labour cost and 35% came from cost of the inputs. Even though total maize production cost per hectare was higher in Eastern Province, maize was more profitable there compared to Southern Province. Both labor and fertilizer costs were higher in ripped maize fields than in ploughed fields.

The profitability analysis of cotton in Eastern and Southern Provinces shows higher net profits per hectare for ripped fields than for ploughed fields. In Eastern Province, there was a difference of ZMK 43,300 and in Southern Province a difference of ZMK 55,800 (Table 15). Higher yield is a key source of the higher profits, and those higher yields were due to more efficiently managed smaller plot sizes and the relatively more concentrated use of the chemical packets the farmer used per hectare. We found no significant interaction effect with the ripper on the effectiveness of the chemical packets. The ploughed cotton fields in Southern Province were the least profitable of all the enterprises evaluated here.

Cotton ripped fields of Eastern and Southern Provinces had a higher total cost than ploughed fields. From the analysis of Eastern Province, it shows that 67% of the total cost under ripping could be attributed to the labour cost while 16% could be attributed to the cost of inputs. While for traditional ploughing, 60% of the total cost for cotton could be attributed to labour costs and 16% could be attributed to the cost of inputs.

Another aspect that is valuable to evaluate but which cannot be addressed here is yield risk. We cannot determine with this survey whether or not the ripper use can reduce production risk by facilitating water conservation or soil fertility enhancements over time. In a year with erratic and often low rainfall as was 2004/2005, the ripper performed well in maize particularly, confirming the results of research and lending credence to the belief that it is a valuable technology in the face of rainfall risk. Future work will need to evaluate over time and try to capture possible reduced weeding costs or improved soil quality of the technology.

Table 14. Profitability Analysis of the Magoye Ripper on Maize Production for 2004/05 Season

Profitability Analysis of the Magoye Ripper on Maize	Eastern Province		Southern Province	
	Maize ripped field	Maize ploughed field	Maize ripped field	Maize ploughed field
Output (kg/ha)[a]	2,350	1,479	1,224	1122
Output price (ZMK/kg)[b]	788	788	782	782
Gross Income per ha	1,851,800	1,165,452	957,168	877,404
Cost of labour (ZMK/ha)				
Land preparation	85,655	96,525	59,932	61,400
Planting	39,807	35,861	32,000	26,900
Fertilizer application	56,818	32,506	25,852	18,725
All weeding	108,594	108,003	90,000	86,139
All harvesting activities	126,538	63,776	56,675	50,252
Cost of Inputs(ZMK/ha)[a]				
Cost of fertilizer per ha	251,350	205,656	200,000	198,700
Cost of seed per hectare	66,545	56,250	93,714	103,920
Cost of the implement (ZMK/ha)				
Magoye ripper*	12,500		12,500	
Mouldboard plough*		43,700		43,700
Beam	12,500	12,500	12,500	12,500
Other Costs (ZMK/ha)				
Cost of sharpening the tine[a]	5,000	0	5,000	0
Cost of hiring animal to pull the plough or ripper	100,000	100,000	100,000	100,000
Total cost per ha	**865,307**	**754,777**	**688,173**	**702,236**
Net Income	**986,500**	**410,700**	**269,000**	**175,200**
Provincial difference (EP-SP)	**717,500**	**235,500**		

Source: FSRP/GART Ripper Study 2005, * The values of the Magoye ripper and mouldboard plough have been calculated considering the depreciation. The cost of the mouldboard plough is apportioned to the total area under maize, cotton and other crops grown by the farmers. The cost of the Magoye ripper is apportioned to the total the ripped fields of maize and cotton in equal amount since it is assumed the farmers only used the ripper in these crops. The cost of the beam is calculated considering the life span of about 15 years.
(a) and (b) asterisks show where the median and the mean have been used.

Table 15. Profitability Analysis of the Magoye Ripper for Cotton Production in 2004/05 Season

	Eastern Province		Southern Province	
	Cotton ripped (per hectare)	Cotton ploughed (per hectare)	Cotton ripped (per hectare)	Cotton ploughed (per hectare)
Output (kg/ha)[a]	1015	880	780	697
Output Price (Kwacha/kg)[b]	1200	1200	1200	1200
Gross Income per ha	1,218,000	1,056,000	936000	**836,400**
Cost of labour (ZMK/ha)				
Land preparation	99,502	80,451	51,484	71,020
Planting	43,478	28,369	30,287	30,800
All weeding	195,652	151,611	126,076	102,000
Spraying	65,217	39,735	20,339	17,200
All harvesting activities	95,588	72,438	78,600	66,800
Cost of Inputs (ZMK/ha)[a]				
Cost of chemical per ha	89,219	78,740	81,969	77,731
Cost of seed per hectare	27,379	23,275	29,678	25,363
Cost of the implements (ZMK/ha)				
Magoye ripper*	12,500		12,500	
Mouldboard plough*		40,200		40,200
Beam	11,500	11,500	11,500	11,500
Other Costs (ZMK/ha)				
Cost of sharpening the tine[a]	5,000	0	5,000	0
Cost of hiring animals to pull plough or ripper	100,000	100,000	100,000	100,000
Total cost per ha	**745,035**	**626,319**	**547,433**	**542,614**
Net Income	**473,000**	**429,700**	**388,600**	**293,800**
Provincial differentials (EP-SP)	**84,400**	**135,900**		

Source: FSRP/GART Ripper Study 2005, * The values of the Magoye ripper and mouldboard plough have been calculated considering the depreciation. The cost of the mouldboard plough in this budget is calculated considering the total area under maize, cotton and other crops grown by the farmers. The cost of the Magoye ripper is apportioned to the total the ripped fields of maize and cotton in equal amount since it is assumed the farmers only used the ripper in these crops. The cost of the beam is calculated considering the life span of about 15 years.
(a) and (b) asterisks show where the median and mean have been used respectively.

6. IMPLICATIONS

In the early 1990s, researchers and extension agents introduced the Magoye ripper and other aspects of minimum tillage technology based on the promising results from on-station and on-farm trials. The results shown here also demonstrate promise, along with challenges and possible limitations. The survey was conducted in Eastern and Southern Provinces, areas which generally receive limited rainfall (between 800mm and 1000mm per year) and are prone to drought. The 2004/2005 agricultural season was a year of low and erratic rainfall, especially in Southern Province, a good test case for conservation tillage since water conservation with the furrows established before the planting rains are considered a major benefit. The research here found that yields were higher with both maize and cotton under ripping compared to ploughing, but those yield increases were found to be related to a combination of crop management practices, not just ripping. This was only a single season for analysis, and more evidence would be needed for greater reliability under a variety of climatic conditions.

The analysis shows that there is a positive link between ripping and fertilizer efficiency in maize cropping such that maize yields are higher with the combination of ripping and fertilize use than with fertilizer use alone, controlling for other factors. In cotton, no significant yield effect, direct or in interaction, was found for the ripper, although overall cotton yields for ripper farmers were higher.

An issue that bears analysis in future years is the timing of land preparation and planting. Farmers in this study did not complete land preparation at the end of harvest of the previous season, as recommended with the ripper, although farmers tended to complete land preparation in ripped fields earlier than in ploughed fields. For maize, that was found to result in significantly higher yields. Researchers had difficulty, however, distinguishing the effects of rainfall or planting date due to generally high correlation among factors. In Southern Province, with the late arrival of rain, farmers planted ripped and ploughed fields within a fairly narrow window, such that early land preparation in ripped fields did not necessarily lead to earlier planting of maize and cotton. That the farmers did not rip and plant their cotton earlier may be attributed to constraints on animals for animal traction. Research suggests that cotton is less sensitive to planting date than maize, so it would be logical to prioritize maize over cotton in the face of constraints.

In addition to these benefits, there were noted difficulties. All of the farmers in the study own a ripper, but not all farmers used the ripper in 2004/2005. Most farmers who had used the ripper at least once noted difficulties with increased weed infestation under ripping, but weeds were not the key reason cited when we asked nonripping farmers why they did not use the ripper in 2004/2005. They indicated other more difficult problems to resolve with the ripper. The ripper tine wears out relatively quickly and there are few locally available spare parts for the Magoye ripper, especially in Eastern Province.

Training issues were raised. In Eastern Province, farmers participated in demonstrations with the wings, however the Magoye rippers distributed did not have the extended wings. Unfortunately, the farmers felt that the Magoye rippers distributed were incomplete, so they were unnecessarily waiting for the additional parts. Follow-up training would have been able to explain this and other issues. In Southern Province, training was less of an issue and extension services were available closer to farmers' residences.

Farmers also raised the issue of spare parts and the difficulties of keeping the tine sharp. In Eastern Province, lack of spare parts was a key constraint to use, and involving local traders and artisans in ripper diffusion may help avoid this in the future. A constraint that is beyond local control is availability of good quality steel for use in fabrication of the tines. The cost of steel in Zambia is high and hinders most of these small rural artisans who could be making rippers and their spare parts. The duty on steel may need to be considered by policy makers if Magoye ripper development is a priority in the agricultural sector.

Problems with supplies of animals for drought power are not new to analysis of the ripper. Haggblade and Tembo (2003) indicated that constraints to animal draft power may be an important limiting factor which needs further evaluation. With the current research, farmers confirmed lack of animal draft to be a hindrance to wider use. There is some hiring in of animal traction services, especially in Southern Province, one practice that can help relieve the constraint; however it is not widespread among these farmers. Current efforts of the Zambian Government, the Conservation Farming Unit of the National Farmers Union (ZNFU), and the European Union involve the distribution of animals. This distribution programme may relieve major constraints and should enable adoption of minimum tillage in the area, particularly if combined with extension programs on the Magoye ripper and related technologies. Animal services should be provided as well to reduce the animal mortality.

There were several factors which might be important that we did not measure here. First, we did not include any value when the ripper is used in their fields for purposes other than minimum tillage land preparation. In addition, some farmers did gain income through lending or using the rippers in the fields of neighbors both for ripping and for just establishing planting furrows in ploughed fields. We did not estimate a value for that activity. Basically, if the ripper is not profitable in the farmer’s field for minimum tillage land preparation, it is unlikely to be profitable in other fields over the longer term. We do not evaluate its effectiveness or returns as an implement to construct planting furrows or weed in ploughed fields. Another factor that was not specifically valued here was the potential improvement in timing of activities. By shifting labor to nonpeak periods, the ripper enables the additional work mentioned above, but also may reduce the costs of labor for own fields.

7. CONCLUSION

Farmers in this study indicated important benefits in using the Magoye ripper: 1) harvesting and conserving water; and 2) early land preparation for early planting. In addition, they generally agreed that ripping enabled higher yields in their maize and cotton.

Farmers also identified problems with the ripper: 1) ripped fields tend to have more weeds; 2) the tine of the Magoye ripper wears down and needs frequent sharpening; and 3) spare parts for the ripper are not locally available. In addition, some farmers said that they did not have animals or their animals were too small, thus constraining their use of the ripper.

For maize profitability, the results were clear. Identifying and controlling for key production factors, the research has shown that the ripper when combined with nitrogen applications contributed to significantly higher maize yields than just using the Magoye ripper or inorganic fertilizers alone. Farmers who were more experienced in using the ripper did not obtain significantly higher yields, although ripped fields in general tended to have more fertilizer on their fields, which also improved yields. In Eastern Province, farmers prepared their ripped fields earlier and thus gained time in planting, compared to both ripped and ploughed maize fields in Southern Province, and compared to ploughed maize fields in Eastern Province.

For cotton profitability, the results were less encouraging given observed farmer practices. The combination of practices used on the ripped fields resulted in higher average cotton yields, but we did not find that the ripper itself contributed significantly to yields and thus to profits in cotton production. The amount of chemical packets applied played a key role in yield improvements, and there was no significant interaction with the tillage system. Another factor that was significant in cotton yields was the plot size. Overall, the cotton ripped plots were smaller than the ploughed plots, and more intensive cultivation of the small plots meant that the ripped fields had higher yields simply due to size. There is an important caveat: many of the ripped cotton fields were planted at the same time as the ploughed cotton fields, so the timing advantage associated with ripping was not observed.

The research demonstrates that the ripper was profitable as used by the farmers in Eastern and Southern Provinces in 2004/2005, particularly in Southern Province. Potential returns are higher when farmers take advantage of the early land preparation. Lack of draught animals can be a major constraint, for both ripper and animal traction land preparation and weeding. For agricultural development, investments in livestock herds and services will play a major role in improving land and labor productivity in the face of all the other challenges and stresses on Zambian farmers. A targeted adoption study for the ripper would be able to assess what this current research touched on in interviews with farmers, that disadoption or non-use rates could be high in some areas and quite low in other areas. The reasons for such adoption rates may hold the key for determining the future of minimum tillage systems in Zambia.

8. RECOMMENDATIONS

Our work with the farmers tends to support the recommendations of previous research (Stevens et al. (2002); Kaoma-Sprenkels, Stevens, and Wanders 1999):

- The Magoye ripper can be useful in protecting yields under stressful water conditions, as in Southern Province during the 2004/2005 season, so its promotion will be valuable for food security in the zone, as long as constraints noted below are addressed.
- Weed problem was cited by farmers as a main constraint, but farmers indicate that they are working with strategies to control weeds, particularly related to timing of weeding, and it does not seem to be the major problem preventing the use of the technology.
- Accessibility to animal draught power, either own or through the market, is critical, for lack of animals is a serious constraint.
- When the ripper had a breakdown (tine wears down, wings break down or are absent), the farmers were unable to locate a supplier of spare parts. Private sector development should be pursued to ensure that spare parts for the ripper (tine, wings, bolts and nuts) are made available in all the areas the ripper have been distributed.
- Wearing down of the tine was also one of the problems observed by farmers who used the Magoye ripper. Current work at GART with IMAG is looking at tine shape and composition to determine where stronger tines should be recommended, according to soil types and use.
- Training is one of the key elements for diffusion of this technology which combines several practices and is knowledge intensive, but an adoption study will help to identify the key training needed, as this need not be a block to adoption.
- In spreading the ripping technology, continued partnering of extension agencies with private companies working with farmers, such as Dunavant, Cargill Cotton Company, Mulungushi Cotton Company and Continental Ginnery, provides a market link and is valuable for coordination of training and provision of implements.

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ANNEX

Figure 5 A. Farmer Showing that the Ripper Has No Wings

Annex Table 16. Costs of Chemicals, Seed and Labor of Farm Activities per Ha for Cotton

		Eastern		Southern	
		Cotton			
		Ripped	Ploughed	Ripped	Ploughed
		Cost per ha			
Cost of Inputs per ha					
Chemicals	Median	89,219	78,740	81,969	77,731
	Mean	106,078	80,718	88,931	79,479
	Std Deviation	45,256	34,839	30,607	33,552
Seed	Median	27,379	23,275	29,678	25,363
	Mean	35,876	24,630	35,528	29,859
	Std Deviation	25,878	10,761	22,348	15,269
Cost of labor per ha					
Land preparation	Median	99,502	80,451	51,484	71,020
	Mean	99,521	90,311	60,696	72,186
	Std Deviation	45,095	48,497	36,153	40,920
Planting	Median	43,478	28,369	30,287	30,792
	Mean	50,249	38,444	35,000	36,199
	Std Deviation	24,253	27,417	28,445	26,711
All weeding	Median	195,652	151,611	126,076	101,662
	Mean	194,193	165,592	147,299	116,460
	Std Deviation	107,550	87,852	94,744	70,652
Spraying	Median	65,217	39,735	20,339	17,192
	Mean	73,306	52,385	27,404	24,276
	Std Deviation	43,199	32,775	18,857	18,734
All harvesting activities	Median	95,588	72,438	78,600	66,765
	Mean	107,343	83,244	88,014	75,288
	Std Deviation	80,638	53,714	55,240	43,393

Source: FSRP/GART Ripper Study 2005

Annex Table 17. Costs of Fertilizer, Seed and Labor of Farm Activities per Ha for Maize

		Eastern		Southern	
		Maize			
		Ripped	Ploughed	Ripped	Ploughed
		Cost per ha			
Cost of Inputs per ha					
Fertilizer	Median	251,350	205,656	200,000	198,666
	Mean	348,359	253,716	244,774	235,800
	Std Deviation	390,905	239,651	228,217	231,619
Seed	Median	66,545	56,250	93,714	103,921
	Mean	83,549	69,689	101,239	98,052
	Std Deviation	52,091	49,571	43,958	47,364
Cost of Labor per ha					
Land preparation	Median	85,655	96,525	59,932	61,422
	Mean	93,383	96,793	68,983	71,247
	Std Deviation	54,636	40,397	45,407	45,811
Planting	Median	39,807	35,861	31,969	26,871
	Mean	44,905	44,595	38,807	36,233
	Std Deviation	29,465	29,215	30,712	31,802
Fertilizer application	Median	56,818	32,506	25,852	18,725
	Mean	68,848	49,924	36,945	27,368
	Std Deviation	39,072	44,501	36,760	24,235
All weeding	Median	108,594	108,003	90,000	86,139
	Mean	156,550	135,251	127,765	103,462
	Std Deviation	120,819	93,666	107,922	72,727
All harvesting activities	Median	126,538	63,776	56,675	50,253
	Mean	130,629	80,496	68,870	63,566
	Std Deviation	73,602	69,953	42,815	51,472

Source: FSRP/GART Ripper Study 2005