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Economic Impact of Sorghum and Millet Technologies In Mali Agricultural Campaign 2010-2011

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INTSORMIL

ECONOMIC IMPACT OF SORGHUM AND MILLET TECHNOLOGIES IN MALI

AGRICULTURAL CAMPAIGN 2010-2011

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Front cover pictures are courtesy of Dr. Botorou Ouendeba (bouendeba@yahoo.com). Left picture: Two farmers hold project banner sign in Mopti (2011). Right picture: A farmer in Koutiala in a field of Grinkan (2011).

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Introduction

This bulletin presents the results of the 2010/2011 evaluation of the cropping season for the improved millet and sorghum technologies. These technologies were diffused by the production-marketing project of the IER-INTSORMIL program in Mali to improve food security and increase farmers' incomes. The evaluation has targeted three main components of the production-marketing project:

-Agricultural technology diffusion. This component consists in facilitating the adoption of improved varieties of millet and sorghum, expanding the use of moderate levels of inorganic fertilizer and providing technical support for a series of improved agronomic practices including water retention techniques.

-Adoption of better marketing strategies. This part of the project develops strategies to help farmers obtain higher prices through value added, group sales, storage and post-harvest selling

-Farmers' capacity building. This component supports the evolution of viable farmers' associations with strong organizational ability in grain storage and increased bargaining power for grain sales and input purchases. These associations become functioning marketing coops.

The project evaluation was conducted in the regions of Mopti, Segou and the district of Koutiala. The following sections present the results of the evaluation of yield improvement, return on marketing, farmers' capacity building and assesses the impact of the innovations on farmers' income in each region. A final section examines the differences in farmer performance (yields) by identifying the factors responsible for the differences between farmers using the same purchased inputs and supposedly following the same agronomic recommendations.

1. Mopti Region

1.1 Number of producers, areas and sample surveyed

In the region of Mopti, 300 hectares of the improved millet variety "Toroniou" were cultivated in 5 villages during the 2010-2011 agricultural campaign. These villages were Kanikombole, Kountogoro, Tere, Mougui and Oualo. All these sites were in their first year of participation in the project except Oualo. A sample of three villages was selected for the project evaluation and individual interviews were conducted with producers. This sample included the villages of Kanikombole, Kountogoro and Oualo.

In each of the new sites of Kanikombole and Kountogoro, 60 hectares of land have been planted. In the old site of Oualo, 120 hectares of the new millet variety have been cultivated including 60 new hectares of land (table 1.1.1). In all the villages surveyed, household heads were instructed by the program to provide areas to women to grow the improved "Toroniou" cultivar. So, women received small portions of lands where they work either individually or in groups. The land is authorized for them by the household head and the women control the output.

Table 1.1.1 General Situation of Producers surveyed in the Mopti Region in 2010

Villages	Total number of producers	Total area cultivated (ha)	Sample of producers surveyed per gender		Total number of producers surveyed
			Men	Women	
Kanikombole	105	60	30	20	50
Kountogoro	60	60	30	10	40
Oualo	36	120	26	10	36
Total	201	240	86	40	126

Source: Farm Household surveys

1.2 Yield Evaluation in the sites of Mopti

The yield evaluation in the Mopti sites revealed very good yield gains with the adoption of the improved millet variety as reflected by the results of both farmers' reported yields and crop cuts by the monitoring personnel (table 1.2.1). In Kani Kombole and Oualo, yields were 78 percent more than the yields of the local variety (table 1.2.2). In Kountogoro, the yield gain over the traditional cultivar was estimated at 84 percent (table 1.2.2). For this first year of participation in the project, the results of the new sites, Kani Kombole and Kountogoro reflect the strong interest manifested by producers participating in the project. These good results are explained by the high rainfall year and the good fertilizer response to the improved cultivar, the use of fertile lands near the house compounds, and the adherence to the improved agronomic practices recommended by the project.

Farmers applied organic fertilizer before plowing their lands although the number of carts of organic fertilizer varies significantly between villages and individuals. The highest quantity of organic fertilizer applied on the fields was found in Kountogoro on men's fields. Women's lands were not supplied with organic manure as those lands were far from the house compounds and the organic fertilizer resource was limited.

Ridging is traditionally done by producers except on very sandy soils. But none of the producers interviewed practiced tied ridging. The application method of chemical fertilizer application differed between villages. In the site of Kani Kombole, all producers interviewed side dressed the chemical fertilizer but in Kountogoro and Oualo the majority of the farmers broadcasted the DAP before plowing.[1]

Table 1.2.1 Results Comparison between Crop Cuts and Real Yields

		Crop Cuts (kg/ha)			Observed yields (kg/ha)		
		Average yield	Best yield	Lowest yield	Average yield	Best yield	Lowest yield
Kani Kombole	Improved variety (Toroniou)	1100	2440	500	1229	2000	700
	Traditional variety	-	-	-	692	738	450
Kountogoro	Improved millet	1144	1240	920	1048	1500	600
	Traditional millet	-	-	-	571	778	360
Oualo	Improved millet	1000	1800	640	956	1600	500
	Traditional millet	-	-	-	538	833	300

Source: 2011 Farm Household surveys and data collected from field technicians

Table 1.2.2: Yield Gains from the Adoption of the Improved Variety

Villages	Toroniou kg/Ha	Traditional kg/Ha	Difference kg/Ha	Yield Effect
Kani Kombole	1,229	692	537	78%
Kountogoro	1,048	571	477	84%
Oualo	956	538	417	78%

Source: 2011 Farm Household surveys

In all sites but Oualo, women did a better job improving yields than men (see table 1.2.3) although the difference in yield is not statistically significant. Women's results are very encouraging as they were able to achieve good yields despite the substantial constraints encountered including poor land quality, lack of access to organic fertilizer or to, agricultural equipment and lack of labor time especially to respond in a timely manner to seasonal demands.[2] The higher yield gains obtained by women over men can be explained by a more rigorous implementation of the cropping practices, particularly thinning. The plant density on women's fields was between 2 to 4 plants whereas men did less thinning. Some male farmers unfortunately still believe that the higher the plant density the better will be the

[1] We investigate the yield differences of the two methods of application at the end of this bulletin. Normally we expect side dressing to be much more efficient with broadcasting meaning more volatization and fertilizing the weeds between the plants.

[2] Women have to first perform labor services on the communal or family lands before they can attend to their private land holdings. Women are also pressed by multiple family responsibilities, gathering firewood, transporting water, taking care of children and preparing meals. There is some hierarchical division of responsibilities among women in the households.

harvest. Others revealed their preference for a higher plant density to cope with the risk of attack by insects or other types of crop failure.

Table 1.2.3: Difference in Yield between Men and Women for the Improved Millet

Villages	Kanikombole	Kountogoro	Oualo
Men's Yields (kg/ha)	1171	1030	991
Women's Yields (kg/ha)	1204	1100	864
Yield Difference (kg/ha)	67	70	-126

Source: 2011 Farm Households' surveys
[a] Average yield difference between the improved variety and the traditional cultivar
[b] Ratio between the average gain in yield and the average yield of the traditional cultivar

1.3. Cost of the Technological Package

The cost of the technology package in 2010 for the new producers was estimated at 36,900 CFA. The technology package included 1 sack of DAP, one sack of Urea, 8 kg of improved seeds and 1 pack of fungicide (tableau 1.2.3).

Table 1.3.1. Cost of the Technological Package in the new sites of the Mopti Region

	Quantity/ha	Unit Price (F CFA/ha)	Total Cost (F CFA/ha)
DAP (1 sac=50kg)	1 sack	19,000	19,000
Urea (1 sac=50 kg)	1 sack	15,000	15,000
Seeds	8 kg	300	2,400
Fungicide	1 pack	500	500
Total			36,900

Source: author survey, questionnaires

In Oualo, the farmers' association provided 1 bag of DAP and 1 bag of Urea per hectare at 12,500 CFA per bag to members of the program before 2010. So, the cost of the technology package for the old producers was 25,000 CFA/ha. This was a subsidized cost of fertilizer that the association purchased with its revolving funds. So, the association was very entrepreneurial to purchase fertilizer at a subsidized price. The new members got unsubsidized fertilizer because officials in the program particularly the Regional Agricultural Department (DRA) provided fertilizer for the new members but were not eligible for the subsidized fertilizer.

1.4. Marketing Strategy

The application of the marketing strategy and the ability of producers to get higher market prices after harvest vary according to the associations' bargaining power and the capacity of the associations to search for higher paying markets.

In the different sites except Kani Kombole, the associations recovered the in-kind credit at the end of January. In Kani kombole, only women reimbursed their credit right after harvest. Men in this latter village paid back their loans at the end of April. Farmers' association in Kountogoro displayed the strongest bargaining power and dynamism in searching for higher market prices. Hence, it not surprising

that the association in Kountogoro got the highest sales and return on storage, 35 percent over the harvest price (table 1.4.1). In Oualo, the harvest price is much higher than in the other sites as this village is closer to the district town. Also, Oualo is well known for the cleanness of the millet grains since threshing is done by women off the ground using mortars and pestles. So, buyers are willing to pay a premium to get the higher quality grains. Indeed, when the association in Oualo was selling the improved millet at 165 CFA/kg in the summer of 2011 the market price was 150 CFA/kg in the village. Thus, producers in the association got an additional 15 CFA/kg for the quality of their grains in addition to the difference from the harvest price for an 18% total price advantage for the program.

Table 1.4.1 Price Effect from Storage and Clean Grain Production

Villages	Harvest price	Sales price	Gain due to storage and clean grains	Price effect
Kani Kombole	100	120	20	20%
Kountogoro	100	135	35	35%
Oualo	140	165	25	18%

Source: 2011 Farm Household surveys and authors' results

The producers' associations in the Mopti sites were able to recover 100 percent of the input credits. But, no producers sold additional grains to the association in excess of the credit reimbursement (table 1.4.2). The surplus of production after repaying the input credits was stored privately by individual producers and used for their consumption needs. Producers are aware of the importance of selling additional grains to the association to increase their revenues. However, meeting their subsistence needs took priority over monetary gains. Indeed, prior to the project with very low yields for the traditional millet cultivar, many farm households stated that they were food insecure. So, the surplus of production was basically aimed at addressing their consumption goals. In the future, as the area expands in the improved technology and farmers follow better the recommendations, farmers are expected to sell more through the associations.

Table 1.4.2. Stock Management by the Cooperative in Kani Kombole

Stock management (kg)	Total quantity reimbursed to the association (kg)
Village of Kani Kombole	24,000
Village of Kountogoro	18,000
Village of Oualo	24,000

Source: survey results

1.5 Impact on the revenue

By adopting the improved agricultural technologies of millet and good marketing practices, farmers in all sites obtained substantial gross revenue increases ranging from 55,000 to 62,000 CFA per hectare[3] (table 1.5.1). Most of the revenue gain came from the increased yields. The gains from marketing for individual farmers are still small because farmers did not sell any surplus of production

[3] Note that incomes are underestimated as we have not included the opportunity costs of the home consumption at the value when consumed. In future bulletins this will be included.

to the association in excess of the credit reimbursement. Rather farmers used the increased production after repayment for consumption and local sales (small quantities to buy local requirements). The associations did benefit from the higher prices and used the gains from storage as a revolving fund to purchase inputs for the next agricultural campaign. So, these gains were included in the calculations of the gross benefits to farmers because most of the benefits go to farmers through the revolving funds and other activities of the associations. The new millet technologies and storage practices resulted in positive net gains for the average farmer. These were excellent returns for the combined technology package and marketing strategy ranging from 51 percent to 89 percent. Farmers could have received even greater returns by allowing the association to sell more of their cereals once their consumption needs were satisfied. In the future we need to calculate the opportunity cost of the increased consumption depending upon when it is consumed and add this to the income estimates.

Table 1.5.1 Per- hectare gains from Production and Marketing in the Mopti Region

Village	Yield Gain	Gains from Increased Yield [a]	Gains from the Association storage[b]	Gross Revenue Gains[c]	Cost of Technological Package[d]	Net Gains[e]	Return on adoption[f]
	kg/ha	F CFA/ha	F CFA/ha	F CFA/ha	F CFA/ha	F CFA/ha	%
Kani Kombole	537	53,704	8,000	61,704	36,900	24,804	67%
Kountogoro	451	45,112	10,500	55,612	36,900	18,712	51%
Oualo	382	53,424	5,000	58,424	30,950	27,474	89%

Source: author's calculations

[a] Gains from increased yield are obtained by multiplying the yield gain with the harvest price

[b] Gains from storage to the association are per hectare amount of grain stored by the association multiplied by the difference between the harvest price and the association sales price. The gains in price were obtained by the association. We expect them to be divided among the members. Moreover, the association model of getting higher prices is expected over time to be obtained also by individual farmers contributing their grain to be sold by the association.

[c] the gross gains are the result of the sum of the gains from increased yield and the gains from the association storage

[e] the net gains are the result of the difference between the gross gains and the cost of the technological package. There would be some additional costs including increased labor from higher plant and weed density resulting from more fertilization. Also more labor would be required by the new operations especially thinning which farmers do not normally do and the split application of fertilizers.

[f] the return on adoption is the ratio between net gains and the cost of the technological package.

1.6 Conclusion

The adoption of the improved millet cultivar in the Mopti region translated into substantial yield gains. Yields increased by at least 50 percent for the average farmer over the traditional variety as the result of good rainfall year, use of inorganic and organic fertilizers and an improved millet cultivar, Toroniou.[4] In all sites, the producers' associations understood the importance of selling the stock of grains during the price recovery season in order to get a higher return from the price seasonality. The adoption of the new agricultural technologies and marketing strategies resulted in substantial net benefits and contributed to secure food consumption. Moreover, farmers could have obtained even greater monetary benefits if they had sold extra grains to the association above the required amount of

[4] The seed was not pure and farmers complained about it. In subsequent years better seed producers were utilized and seed quality was substantially improved. .

grains for the credit reimbursement. Nonetheless, as farmers become more experienced with the agricultural innovations, they will guarantee their subsistence needs and have greater incentive to embrace the marketing practices through the association in order to increase their incomes. Meanwhile, it is essential to strengthen farmers' association storage facilities and marketing ability. Moreover, increased sales through the associations by farmers may require a greater trust of the farmers in their associations.

2. Segou Region

2.1 Number of producers, areas and sample surveyed

The production-marketing project in the Segou region was expanded on 494 new hectares involving 8 villages and 330 producers in 2010.The Production-Marketing program only purchased the fertilizer and Sasakawa Global 2000 implemented the program.[5] The evaluation was based on 3 of the new sites specifically Bouadie, Diawarala and Tigui. Bouadie is the largest site with 150 ha cropped. Diawarala and Tigui have respectively 50 and 60 hectares of land in the project. The millet variety diffused under the IER-INTSORMIL program was the Toroniou cultivar. In Bouadie and Diawarala some producers were allowed to adopt the sorghum improved cultivar CSM E 63 since their heavier soils were more suitable for sorghum. The prime site of Tingoni was also visited during the evaluation to assess the sustainability of the project after producers' graduation from the program in 2009.[6]

In Segou, a very small number of women participated in the project in 2010 due to constraints on land access. So, the evaluation focused on men only, and the interviews targeted at least one third of the participants in the project in each site as reported in table 2.1.1 below.

Table 2.1.1 General Situation of Producers Surveyed in the Segou Region in 2010

Villages	Total number of producers	Total area cultivated (ha)	Total number of producers surveyed
Bouadie	103	150	35[g]
Diawarala		50	26[g]
Tigui	36	60	20
Tingoni	40	100	12
Total		360	93

Source: 2011 Farm Household surveys

2.2 Yield Evaluation in the sites of Segou

The 2010 agricultural season has been characterized by abundant rainfall in the Segou region with average rainfall estimated at 979 mm for the district of Baraoueli where all the project farms are located. With this large amount of rainfall, producers got good yields with the improved millet because

[5] Production-Marketing also sponsored a workshop after the harvest for millet food processors to interact with the representatives of these farmers' associations.

[6] Normally, once there are 150 ha and approximately that many farmers in the program, the village association graduates from our direct involvement. With their rotating fund they can continue purchasing inputs and they have storage facilities and even bank contacts. We come back periodically to evaluate how they are doing and specifically evaluate sustainability issues.

millet is traditionally grown on the plateau or slopes and on sandier soils.[7] Farm level average yields were between 1400 kg/ha and 1800 kg/ha (table 1.2.1). These are excellent millet yields. The highest average yield gains were obtained in Tigui with a 105 percent yield increase (1.78 tons/ha) over the traditional variety.

The relatively lower yields (1.4 t/ha) achieved in Diawarala resulted from some producers making poor choices of land for the project because they were uncertain about their participation. Producers received the technology package late due to technical difficulties with the banks in financing the inputs for the 2010 agricultural campaign. By the time farmers were able to obtain fertilizer with the bank financing most had already made their decisions regarding land allocation, and applied organic fertilizer onto these fields. Some producers even borrowed plots from neighbors or friends to be able to participate in the Production-Marketing project.

Overall, the high yield gain over the traditional variety was the result of a combination of factors including rainfall and implementation of the recommended agronomic practices. The main shortcoming in the application of the improved agronomic practices was the low supply of organic fertilizer on the land allocated to the improved variety. Most farmers consider chemical fertilizer as a substitute for organic fertilizer (compost of crop residues and cattle manure). Given the constraints on the availability[8] of organic fertilizer, it was mostly reserved for the traditional crops. So, chemical fertilizer was applied on the plots for the improved millet and organic manure was used on the traditional crops. Due to the strong complementarily between the two types of fertilizers this attitude needs to be changed.

Table 2.2.1: Yield Gains from the Adoption of the Improved Variety

Villages	Toroniou kg/Ha	Traditional kg/Ha	Difference kg/Ha	Yield Effect
Bouadie	1501	882	619	70%
Diawarala	1417	994	423	43%
Tigui	1780	868	912	105%
Tingoni	1671	1181	490	41%

Source: 2011 Farm Household surveys

2.3. Cost of the Technological Package

The technology package included 1 sack of DAP, 1 sack of Urea, 6 kg of the improved seed of millet and 1 pack of fungicide. The cost of the technological package was 37,000 CFA/ha. This cost of inputs was to be repaid in kind at or after harvest.

[7] In contrast sorghum is concentrated on the lowlands and on heavier soils. Here excess rainfall stays longer so flooding is a serious constraint in high rainfall years such as 2010. Sorghum can tolerate some flooding but it is not rice.

[8] The supply of organic fertilizer is often limited and aapplication in a plot at a household level depends on the availability of animal manure or compost of crop residues. Household with limited number of cattle or quantity of compost apply very small amounts of organic fertilizer on their plots. Also, the transportation of organic fertilizer to the fields is a challenge, so plots located further from the household coumpond generally do not receive organic fertilizer.

Table 2.3.1. Cost of the Technological Package in the new sites of the Segou Region

	Quantity/ha	Unit Price (F CFA/ha)	Total Cost (F CFA/ha)
DAP (1 sac=50kg)	1 sack	17,500	17,500
Urea (1 sac=50 kg)	1 sack	17,500	17,500
Seeds	6 kg	250	1,500
Fungicide	1 pack	500	500
Total			37,000

Source: Source: 2011 Farm Household surveys

2.4. Marketing Strategy

Farmers' associations in the villages of Segou had a credit recovery rate of 100 percent since every farmer participating in the program paid back the input loans. The total quantities of grains reimbursed and stored in each village are reported in table 2.4.1. In Bouadie, 60 T of grains were reimbursed and one producer sold 2 additional tons of grains through the association. In Diawarala 20 T of millet from the credit repayment were stored in the village warehouse. Farmers in Tigui stored 24.5 tons of Toroniou millet in the storage facility including 500 kg as a surplus of production from one producer. Farmers' association in the prime site of Tingoni collected 45 T of millet Toroniou with 35 T coming from the credit reimbursement and 10 T from the surplus of production of some producers after repayment of their credits. So there is increased confidence in the associations to sell for the individual farmers in addition to the repayment of the input credit.

Farmers' associations in the Segou region have established strong contractual arrangements with the PAM (food aid program supported by the Gates Foundation) and Mme Dem, a millet food processor. So, in Tigui and Tingoni the entire stock of grains was sold to the PAM and Mme Dem at 140.25 CFA/kg in the months of February and March. At that time, the local market price for millet was estimated at 115 CFA/kg. So, farmers in those villages earned an additional 25 CFA/kg or a 22 percent price premium for the quality of their grain by selling (also waiting for the post-harvest price recovery) to the millet food processor and the PAM institution. With the implementation of the marketing strategy and the sales of clean grains, the association captured a 40 percent price increase over the harvest price estimated at 100 CFA/kg (table 1.4.2).

In Diawarala, 11 T were sold to the PAM at 140.25 CFA/kg in February when the market price was at 115 CFA/kg and 4 T were sold to a private buyer at 125 CFA/kg at the end of May. This latter price was 5 CFA/kg above the market price. So, the weighted average return on storage and grain quality is estimated at 36 percent combining the gains from selling later and the quality price premium (table 1.4.2).

The association in Bouadie sold 55 percent of their grain stock to the PAM at 140.25 CFA/kg capturing an extra 25 F CFA/kg for the cleanness of their grains. The remaining stock was sold at 125 CFA/kg to a private buyer. Farmers were pressed to sell the remaining stock at this price to be able to recover the revolving fund and purchase the agricultural inputs for the next agricultural campaign as well as to avoid the risk of market price collapse in the hungry season due to government interventions or the release of community stocks. In the four villages the return on storage and the grain quality was evaluated at 31 to 40 percent compared with the price at harvest in the region (table 1.4.2).

Table 2.4.1 Total Quantity of Grains reimbursed and Stored by Farmers' Associations

Villages	Reimbursement kg	Surplus Sales kg	Total Available kg
Bouadie	60,000	2,000	62,000
Diawarala	20,000	0	20,000
Tigui	24,000	500	24,500
Tingoni	35,000	10,000	45,000

Source: 2011 Farm Household surveys

Table 2.4.2 Price Effect due to Storage

Villages	Harvest Price* F CFA/kg	Weighted Sales Price F CFA/kg	Gain due to Storage and Clean Grains F CFA/kg	Price Effect (%) F CFA/kg
Bouadie	100	131	31	31
Diawarala	100	136	36	36
Tigui	100	140.25	40.25	40
Tingoni	100	140.25	40.25	40

*These prices are millet prices at harvest (December) in the main market of Konobougou where producers usually sell their grains.

2.5 Impact of Agricultural Technologies and Marketing Strategies on Farmers' Revenues

The analysis of the impact on farmers' revenues of new millet technologies and marketing strategies showed that the adoption of the new technologies generated large income gains for farmers with the highest gross revenue gains observed in Tigui and Bouadie (table 2.5.1). Those villages recorded excellent yield gains which have mainly driven the value of the total benefits. In the Segou region, the gains from storage are larger than in the Mopti region because producers were able to sell extra grains to the association after paying back their input loans. Producers in Tingoni have learned over time how to market their grains through the association and members are progressively developing confidence in the association. Hence, Tingoni obtained the highest gains from the implementation of the marketing strategy.

The village of Tigui located in the neighborhood of Tingoni was positively impacted from the successful marketing strategy in Tingoni. In all sites, the benefits earned from the extra sales of grains were redistributed back to producers who had provided a surplus of production to the association. The new technologies introduced in the Segou region led to large positive net benefits so they are very profitable for farmers, particularly in Tigui and Bouadie.

The highest returns were observed in Tigui and Bouadie villages where the net gains from the adoption of the agricultural technologies and marketing innovations were 102 percent and 191 percent higher than the costs of the technological package.

Table 2.5.1 Per Hectare Gains from Production and Marketing in the Segou Region

Village	Yield Gain	Gains from Increased Yield [a]	Gains from the Association storage[b]	Gross Revenue Gains[c]	Cost of Technological Package[d]	Net Gains[e]	Return on adoption[f]
	kg/ha	F CFA/ha	F CFA/ha	F CFA/ha	F CFA/ha	F CFA/ha	%
Bouadie	619	61,900	12,961	74,861	37,000	37,861	102
Diawarala	423	42,300	14,473	56,765	37,000	19,765	53
Tigui	912	91,200	16,435	107,635	37,000	70,635	191
Tingoni	490	49,000	18,113	67,096	39,500	27,595	70

Source: authors 'calculations

2.6 Conclusion

In the Segou region, the 2010 agricultural campaign was a very good crop year for the improved Toroniou cultivar and the new technologies. Farmers got excellent yield gains over the traditional variety particularly in Bouadie and Tigui due to the good rainfall and the adoption of improved agronomic practices. In all sites, the yield gains were enough to cover the cost of the technology package. The implementation of the marketing strategy was more successful in the Segou region because the new sites had learned from the marketing earlier experience of the prime site Tingoni. Producers in the Segou region have benefited from the implementation of the marketing strategies including storage and the price premium for the quality of their grains so they contributed more for the farmers' association to sell.

Farmers are beginning to allow the associations to sell some of their grains. However, the number of farmers selling their grains through the association is still low. In Tigui and Bouadie, less than 5 percent of farmers in the association sold their grains through the association and in Tingoni approximately 13 percent of producers entrusted the association to sell part of their grain in addition to reimbursement. So, more work need to be done in improving farmers' awareness about the benefits of collective storage, delayed sales, and sales through the associations. Farmers' associations were able to obtain access to premium markets including the PAM institution and a millet food processor who paid up to a 40 percent price premium over the market price for the quality of their grains. Hence, the high yield gains and the benefits earned from the marketing strategies resulted in substantial income increase for farmers especially in Bouadie and Tigui.

3. Sikasso Region/ District of Koutiala

3.1 Number of producers, areas and sample surveyed in Koutiala

In 2010, approximately 2500 new hectares of improved sorghum cultivar "Grinkan" were cultivated in the district of Koutiala. Most of this area increase was managed by IICEM in the scaling up process from our pilot project. The IER-INTSORMIL Production-Marketing project supported the IICEM expansion with technical inputs.

This analysis includes Garasso, our pilot project in 2008 and 2009. Garasso was not part of the scaling up process but with their revolving fund continued independently the program. We were interested in the sustainability there once the farmers' association and village graduated from the program.[9]

In 2010, Garasso was in its third agricultural campaign with the improved sorghum "Grinkan". During the year, 117 hectares of land had been cultivated with almost 100 producers. The number of hectares decreased from the 150 hectares in 2009 because many producers in surrounding villages including Zebala, Yafola, Mourasso, who were members of the farmers' association in Garasso, withdrew from this association and set up some autonomous organizations to participate in the scaling up activities of IICEM in 2011.

Besides Garasso the evaluation was also in three of the new areas in the scaling up process specifically Oumarbougou, Dougouan, and Zangasso. The numbers of producers participating in the project, the areas cropped, as well as the sample of producers surveyed during the evaluation are reported in table 3.1.1.

Oumarbougou, Dougouan and Zangasso had respectively 21 ha, 57 ha and 20 ha in the improved sorghum during their first production season. In 2010, IICEM innovated in establishing connections between farmers' organizations and the BNDA bank for the purchase of chemical fertilizer. At the last moment two other public institutions offered inorganic fertilizer at the lower subsidized price[10]. Among the new sites surveyed, only Oumarbougou and Zangasso accepted the bank loans. Dougouan 4 and 5 obtained chemical fertilizer for the improved sorghum with fertilizer loans from the CMDT at the subsidized fertilizer prices.

Table 3.1.1 General Situation of Producers Surveyed in the district of Koutiala in 2010

Villages	Total number of producers	Total area cultivated (ha)	Total number of producers surveyed
Garasso	100	117	41
Zanzoni	30	25	13
Oumarbougou	19	21	12
Dougouan 4 and 5	42	56.5	24
Zangasso	18	20	13
Total	209	239.5	103

Source: 2011 Farm Households' surveys

[9] Tingoni is a similar case of graduation from the pilot project stage in the Segou region.

[10] Rice, cotton, and corn producers were eligible for these subsidized loans but not sorghum and millet. This was changed in 2011 to include sorghum and millet. Evidentially, these public institutions could not find enough farmers for the fertilizers available for the rice, cotton, and maize.

3.2 Yield Evaluation in the Sites of Koutiala

The 2010 agricultural campaign was a difficult production season for the improved sorghum variety in Koutiala. It was characterized by delays in obtaining the fertilizer credit, poor quality of the improved seeds, and drought at the beginning of the season and excessive rainfall at the end of the campaign.

The rainfall for the 2010 cropping season is estimated at 1,260 mm which is 40 percent higher than the 900 mm annual average. The combination of adverse factors mentioned above has resulted in very low yield gains over the traditional variety. Only producers in the prime sites of Garasso and Zanzoni got average yields of the Grinkan cultivar above 1 T/ha which led respectively to a 28 percent and 11 percent yield increases over the traditional cultivar (Table 3.2.1). In those two sites two, the modest yield improvements can be explained by delays in planting due to drought at the start of the season and excessive rainfall at the end of the cropping season.

In Dougouan, the average yield of the improved sorghum was low, approximately 900 kg/ha although still 15 percent more than the traditional cultivars' yields. The low yields for the improved cultivar are explained by the poor quality of the Grinkan seeds from the late rains of 2009[11] and the flooding at the end of the August. The poor seed quality resulted in multiple planting as well as decreased yields.

In Oumarbougou and Zangasso, the late purchase of chemical fertilizer added to the problems of poor seed quality and flooding in explaining the yield failures. Producers' associations in Oumarbougou and Zangasso obtained the bank loans in June and July when the cropping season was already well advanced. Thus, many producers had a late planting and selected poor areas with no land preparation to sow the improved sorghum seeds. In these two villages, we observed that producers did better with their traditional cultivar as compared to the improved sorghum. We also expect some diversion of the inorganic fertilizer from the improved sorghum field to other crop activities.

Table 3.2.1: Yield Gains from the Adoption of the Improved Variety

Villages	Grinkan kg/Ha	Traditional kg/Ha	Difference kg/Ha	% Difference
Garasso	1239	967	272	28%
Oumarbougou	663	931	-268	-29%
Dougouan 4 and 5	898	784	114	15%
Zanzoni	1017	913	104	11%
Zangasso	933	1183	-250	-21%

Source: 2011 Farm Households' surveys

[11] The late rains in 2009 resulted in high humidity and fungus problems at harvest resulting in the seed quality problem in 2010. The problem was even worse in the 2010 harvest. In 2011, we called off the program due to poor seed germination. In 2011 we focused on producing quality seed for 2012. Late rains create problems for both sorghum and maize all over the world.

3.3. Cost of the Technology Package

The technology package diffused was composed of 1 sack of DAP, 1 sack of urea, 8 kg of the improved seed. The fungicide for seed treatment was omitted from the program. The 2010 cost of the technology package varied per village depending on the negotiation power of farmers' associations with the fertilizer suppliers. These costs ranged from 28,400 CFA/ha in Zangasso and Zanzoni to 29,900 CFA/ha in Oumarbougou and Garasso.

Table 3.3.1. Cost of the Technology Package in the old sites of the District of Koutiala

Inputs		Garasso		Zanzoni	
Item	Qty/ha	Unit Price (F CFA/ha)	Total Cost (F CFA/ha)	Unit Price (F CFA/ha)	Total Cost (F CFA/ha)
DAP (1sac=50kg)	1 sack	13,750	13,750	13,000	13,000
Urea (1sac=50 kg)	1 sack	13,750	13,750	13,000	13,000
Seeds	8 kg	300	2,400	300	2,400
Total			29,900		28,400

Source: 2011 Farm Households' surveys

Table 3.3.2. Cost of the Technology Package in the new sites of the District of Koutiala

Inputs		Oumarbougou		Zangasso		Dougouan 4 and 5	
Item	Qty/ha	Unit Price (F CFA/ha)	Total Cost (F CFA/ha)	Unit Price (F CFA/ha)	Total Cost (F CFA/ha)	Unit Price (F CFA/ha)	Total Cost (F CFA/ha)
DAP (1sac=50kg)	1 sack	13,750	13,750	13,000	13,000	13,415	13,415
Urea (1sac=50 kg)	1 sack	13,750	13,750	13,000	13,000	13,415	13,415
Seeds	8 kg	300	2,400	300	2,400	300	2,400
Total			29,900		28,400		29,230

Source: 2011 Farm Households' surveys

3.4. Marketing Strategy

Despite the poor yields, the marketing strategy was effective in the villages of Koutiala. In the prime site of Garasso, the majority of producers (92 percent) handled their sales through the association. All producers reimbursed their credit, 352 kg/ha on average. A total of 106 tons of grains were stored in mid-January in the storage facility. At harvest time, the market price for sorghum was 75 CFA/kg. The association sold the grain in three sales. In April, 54.3 tons were sold at 115 CFA/kg to a merchant located in Bamako with the assistance of the AMEDD technician. During the same month, 3.5 tons was bought at 115 CFA/kg by a food processor in Sevare with the help of Dr Diourte from IER.

The food processor complained about the poor quality of grains which had many impurities. During the field interview, some producers revealed that they threshed on the ground because the "baches" (tarps) were not made available to them. The president of the association reported that they only received eight "baches" for all 120 producers. The demand for the "baches" being very high, producers, who did not want to wait for their turn, threshed their grains on the ground. Also, some new members were not even aware that they were expected to thresh their grains off the ground.

Finally, in May, the association sold 40.4 tons at 105 CFA/kg to a trader in Koutiala. The reason for this lower price is that producers were anxious to sell the remaining stock before the rainy season as the roads are barely passable when it rains. In summary, by storing their grains and selling later in the year, producers got a 48 percent return. In spite of these large returns on storage, producers in Garasso were unhappy with the market prices paid by the different buyers. They were expecting much higher prices and a larger price differential between the local and the improved variety in the market. This is a good development that they recognize that they should do better with a more aggressive marketing effort.

In Zanzoni, the rate of reimbursement of the input credit was about 80 percent, so 8.1 tons of improved sorghum was deposited for the credit reimbursement. Apparently, there is a problem of miscommunication and trust in the association because several members did not even know the exact number of sacks that they had to reimburse to the association. They paid back to the association the quantity of grains that they believed they had to reimburse based on their own calculation. A number of producers deposited 7.3 tons in the association storage facility as their surplus of production in addition to reimbursement. So, a total of 15.4 tons were stored by the association. This stock was sold in July during the hungry season at the very high price of 130 CFA/kg. The association prefers to wait until the lean season to sell their grains to be able to capture very large return on marketing, estimated at 73 percent in 2010.

In Dougouan, almost every producer was able to pay back his credit despite the adverse crop season. The reimbursement rate was 92 percent, so farmers deposited 18.2 tons for their credit reimbursements. Besides the credit reimbursement, 10.9 tons of additional grains including 5.6 of seeds produced were stored. Thus, 29.1 tons were available in the storage facility after harvest. Part of the harvest (3.6 tons) was sold to AMEDD for seed at 300 CFA/kg. The remaining quantity of seeds was mixed with the other grains and sold in the market. In the month of April, 14.3 tons were sold at 110 CFA/kg to a trader located in Koutiala. In May, the rest of the stock was sold to a merchant at 105.5 CFA/kg. Thus, the weighted sales price after harvest is estimated at 132 CFA/kg and the association got a return of 76 percent on their marketing including storage.

In the village of Zangasso 2, 70 percent of the producers reimbursed their credit in kind due to the poor harvest. The other 30% paid back their credit in cash. A total of 2.3 tons were collected by the association for the credit reimbursement and sold to the village cereal bank at 115 CFA/kg in May. The association was able to pay back their credit to the bank[12] during the same month.

Not every farmer in the site of Oumarbougou was able to pay back the input credit. The rate of reimbursement in sorghum grains was estimated at 74 percent. The association compensated for farmers who were not able to pay back their loans. The association recovered 4.7 tons by the end of April and sold the grains to a trader in Koutiala at 105 CFA/kg to be able to reimburse the bank loans. The association in this village did not benefit from the storage because its main concern was just to sell the grains at a market price which could guarantee the bank loan repayment.

[12] Before the association paid back their credit, the bank had already withdrawn their principal repayment from their cotton account which had not been separated from the Grinkan account in the bank. Producers were unhappy about this situation because not every producer, who grows cotton in their association, grows also Grinkan. Mixing those two accounts creates some management difficulties.

Table 3.4.1 Total Quantity of Grains reimbursed and Stored by Farmers' Associations

Villages	Reimbursement kg	Surplus Sales kg	Total Available kg
Garasso	35,250	70,750	106,000
Oumarbougou	4,720	0	4,720
Dougouan 4 and 5	10,928.5	18,173.5	29,101
Zangasso 2	2,292	0	2,292
Zanzoni	8,138	7,295	15,432

Source: 2011 Farm Households' surveys

Table 3.4.2 Price Effect due to Storage

Villages	Harvest Price* F CFA/kg	Weighted Sales Price F CFA/kg	Gain due to Storage and Clean Grains F CFA/kg	Price Effect %
Garasso	75	111	36	48
Oumarbougou	75	105	30	40
Dougouan 4 and 5	75	132	57	76
Zanzoni	75	130	55	73
Zangasso 2	75	115	40	53

*These prices are millet prices at harvest (December) in the main market of Konobougou where producers

3.5 Impact on Revenue

The adoption of the improved sorghum technology and marketing strategies led to substantial net gains in the prime sites of Garasso and Zanzoni and a moderate net gain in the new site of Dougouan (table 3.5.1) in spite of the adverse weather conditions. In three of the villages but not in Dougouan and Zangasso, the returns on technology adoption are substantial as reflected by the results in table 3.5.1. Garasso and Zanzoni captured the largest returns because of their stronger experience with the improved sorghum cultivar and grain marketing. The introduction of the new technologies was not profitable in Oumarbougou and Zangasso as producers faced many technical difficulties already discussed above. In general, the implementation of the marketing strategies played a central role in increasing farmers' income.

Table 3.5.1 Per hectare gains from Production and Marketing in the Koutiala district

Village	Yield Gain	Gains from Increased Yield [a]	Gains from the Association storage[b]	Gross Revenue Gains[c]	Cost of Technology Package[d]	Net Gains[e]	Return on adoption[f]
	kg/ha	F CFA/ha	F CFA/ha	F CFA/ha	F CFA/ha	F CFA/ha	%
Garasso	197	14,739	32,512	47,251	29,900	17,351	58
Oumarbougou	-268	-20,105	7,453	-12,652	29,900	-42,552	-142
Dougouan 4 and 5	114	8,542	28,982	37,523	29,230	8,293	28
Zanzoni	204	15,296	33,950	49,247	28,400	20,847	73
Zangasso 2	-263	-19,688	9,168	-10,520	28,400	-38,920	-137

Source: author's calculations

3.6 Conclusion

The 2010 production season was very difficult for producers in the district of Koutiala. The adverse weather conditions, the poor quality of seeds, and delays in getting the bank loans for chemical fertilizer resulted in modest yield gains in the prime sites of Garasso and Zanzoni and poor yield results in the new sites. The poor yields were often compensated by the successful marketing strategies and several villages were very adept at this. Note that price increases ranged from 40 to 76% as compared with farmers selling cereal with impurities at harvest.

In the future the program needs to certify the seed quality before diffusion to producers. In 2011 season the Production-Marketing program was stopped in order to produce high quality seeds. Moreover, increased experience with the bank should enable more rapid allocation of credit as this is critical for producers using their good land in the program and following well the agronomy recommendations.

The marketing strategy was successful in Zanzoni and Dougouan because the associations were able to take full advantage of the price seasonality and thereby obtained higher returns on storage. Nevertheless, in these two villages, producers' awareness related to the financial benefits of collective storage and bulk sales need to be improved. In all sites, farmers' associations need to get access to premium markets in order to increase the return on storage and provide higher incentives for farmers in the program. Overall, the program has led to positive net benefits in the sites of Garasso, Zanzoni and Dougouan where producers have invested efforts into the marketing strategy and followed well the recommendations including utilizing good land areas.

General Conclusions

The evaluation of the production-marketing component of the IER-INTSORMIL program was conducted in 2010 in three main regions: Mopti, Segou and Koutiala. The results of this evaluation revealed that the adoption of improved millet agricultural technology entailed excellent yield gains in Mopti and Segou (principally a SSA program). In the Mopti region, new producers were very excited about the yield increase with the adoption of the higher yielding Toroniou cultivar and the use of fertilizer. With the yield improvements, producers were able to secure enough food for their consumption as opposed to the past years where they often faced food shortage. Women in the program were very satisfied by their higher yields and the resulting increase in consumption and income.

In the Segou region, yield gains were also excellent and the price increases even greater than in Mopti. Their advantage was longer experience in the region with the project and greater proximity to the major market and concentration of millet food processors in Bamako.

In contrast sorghum producers in the higher rainfall area, Koutiala, suffered from excessive rainfall, poor seed quality for the improved sorghum Grinkan and delays in getting the bank loans. Therefore, the yield results were reduced as compared with 2008 and 2009 in the old sites of this district and were poor in the new sites. Getting good seed quality and timely inputs are prerequisites for a successful agricultural technology program. Moreover, the flooding was a major issue reducing yields with the concentration of sorghum on the lowlands and heavier soils.[13]

In addition, producers need to be better monitored by technicians for a good implementation of the new agronomic practices. The regression analysis in the next section showed that the adherence to the recommended agronomic practices were generally significant in improving yields. To encourage higher participation of women in the program it is important to facilitate their access to better land, organic fertilizer, and agricultural equipment.

Farmers' associations benefited from the storage of the reimbursed grains by taking advantage of the price seasonality. However, in all villages except Garasso, only a small number of farmers relied on the association to sell contributed production in excess of reimbursement. After reimbursing the associations for their input credits, the surplus of production obtained with the adoption of improved varieties is generally kept to satisfy consumption needs or sold for some pressing household expenditures at harvest or post-harvest. So, it is important for the project to find mechanisms to release the liquidity constraints farmers' face at critical period of times when they have substantial cash needs. A credit inventory program might be indicated for this purpose. Also since most farmers for the 2010 program were in their first year of participation in the project, they will develop confidence in the association and benefit from the marketing strategy with a "learning by doing" process over time. Building trust and confidence with improved management will improve grain bulk marketing as well. To increase the return on marketing, farmers' associations must be able to improve their bargaining power, have access to high

[13] In 2011, the Production-Marketing Program of INTSORMIL ceased extension activities in sorghum to focus on seed production of Grinkan for 2012.

paying markets and develop strong contractual arrangements as producers in the Segou region achieved with the PAM and the Bamako millet food processors.

In terms of the project's perspective, with the scaling up of the areas cultivated for the improved varieties, it is essential to continue to expand demand for millet and sorghum through the development of new markets including food processing industry and the intensive poultry industry.

Koutiala region 2011: the project evaluation team in a Grinkan field.
Courtesy of Dr. Botorou Ouendeba.

Appendix: Econometric Analysis of 2010-11 Agricultural Campaign Yields

Introduction

After observing the performance of the farmers in the three regions, it is necessary to study what agronomic factors influenced the difference in yields in the improved variety in each region. In order to explain what factors influenced yield differences, a number of agronomic practices and factors are hypothesized to be significant in the performance of the improved variety. Since the inorganic fertilizer application is assumed to be the same across all farms in the program, the focus is on analyzing the difference in yields in terms of the agronomic practices farmers employ and other stochastic factors.

The important factors that were measured in the three regions through farm surveys were:

1. Carts of Organic Fertilizer- The application of organic fertilizer with inorganic fertilizer is hypothesized to be one that improves yields even further. The cart is a tool that is used by farmer to transport their organic manure. The carts are assumed to hold an equal quantity of organic manure.
2. The use of ridging and tied ridging- Ridging is an agronomic technique used as a water conservation tool that is a labor intensive practice. The practice allows more water to get to the crop and militates against soil erosion and runoff. In Mopti, many farmers used ridging while in Koutiala and Segou, farmers use tied ridging which is an even more intensive practice that involves producing ridges that are both horizontal and vertical.
3. Upper land- In Koutiala and Segou data was collected on whether the farmer was farming upper land/slope land or lower land. In a generally higher rainfall year, farmers who are on upper land/slopes are less likely to be flooded and experience increased yields compared to farmers who are on low land and had waterlogged fields.
4. Plants per hole- The more plants that are left in a hole, the more competition for resources and hence the less likelihood that any one of the plants will do well. Thus, farmers are encouraged to thin their plants to no more than three plants per hole in order to ensure that there is good growth of the remaining plants.
5. Weedings- It is important for farmers to remove weeds so that the crops are obtaining the nutrients rather than weeds. The program recommends that farmers weed at least two times during the season.
6. Sidedressing Fertilizer- The program recommends the more time consuming task of applying fertilizer by sidedressing rather than broadcasting. By applying the fertilizer near the plant, this practice maximizes the productivity of the fertilizer by increasing the access of the plants to the fertilizer.
7. Replantings- If the area is having germination problems, then replanting can explain why some farms have higher yields than other. However, if the replanting is done too late, there could be a negative effect. Data was collected on whether farmers had to replant and in which month.

8. Person applying fertilization- If a child is applying the fertilizer, then we expect less attention to detail and a higher likelihood of broadcasting. This broadcasting and often not covering well the fertilizer have an adverse effect on yields. In the regressions the person applying the fertilizer(child or adult) interacted with the method of application reported (sidedress or broadcast)
9. Insect and flooding problems- Some farmers had problems with insects and pests and also some farmers had their land inundated or muddy. Each of these factors can cause a decrease in yields.

Model:

The model used to explain yields is a log linear model which was done to take account of the diminishing returns of organic fertilizer. The log-linear model also provides ease of reading results as the value of the coefficient multiplied by 100 signifies the percentage increase in the dependent variable caused by a unit increase in the independent variable.

The model is summarized as below:

Mopti:

$$\text{Ln Yield} = B_0 + B_1\text{Orgfert} + B_2\text{Ridge} + B_3\text{fourplants} + B_4\text{twoweed} + B_5\text{AdultSidedress} + B_6\text{AdultBroadcast} + B_7\text{ChildSidedress} + B_8\text{ReplantAugust} + B_{11}\text{InsectPest} + B_{12}\text{Flooding} + \text{Error}$$

Segou

$$\text{Ln Yield} = B_0 + B_1\text{Orgfert} + B_2\text{TiedRidge} + B_3\text{fourplants} + B_4\text{twoweed} + B_5\text{ReplantJuly} + B_7\text{Adultsidedress} + B_8\text{UpperLand} + B_9\text{HighHumidity} + B_{10}\text{Flooding} + B_{11}\text{MuddyLand} + \text{Error}$$

Koutiala:

$$\text{Ln Yield} = B_0 + B_1\text{Orgfert} + \text{B2TiedRidge} + B_3\text{fourplants} + B_4\text{twoweed} + B_5\text{ReplantAugust} + B_6\text{Adultsidress} + B_7\text{AdultBroadcast} + B_8\text{UpperLand} + B_9\text{Flooding} + \text{Error}$$

Table 4.2.1 below summarizes the description of each of the agronomic variables used in the regression. In addition to the agronomic variables, regressions were also done in each region with village dummy variables included. This was done in order to capture more variation in the data that was not observed through the agronomic variables only.

Table 4.2.1: Description of Agronomic Variables Used in Econometric Analysis

Variable	Description
Yield	Yield in kg/Ha
Orgfert	Amount of Organic fertilizer(carts)
Ridge	Dummy that has value 1 if ridging was done
Fourplants	Dummy that has value if farmer left 4 or more plants in hole
Twoweed	Dummy that has value 1 if two or more weedings was done
ReplantJuly	Dummy that has value 1 if a replanting was done in July
ReplantAugust	Dummy that has value 1 if a replanting was done in August
Adultside	Dummy that has value 1 if adult applied fertilizer by sidedress method
Adultbroad	Dummy that has value 1 if adult applied fertilizer by broadcast method
Childside	Dummy that has value 1 if child applied fertilizer by sidedress method
Insectpest	Dummy that has value 1 if farmer's plot was affected by insects or pests
Flooding	Dummy that has value 1 is farmer's plot was flooded
Upperland	Dummy that has value 1 if farmer's plot is on upper land
TiedRidge	Dummy that has value 1 if tied ridging was done
HighHumidity	Dummy that has value 1 if land had high humidity
MuddyLand	Dummy that has value 1 if land was muddy

Results:

The method used and the tables of results for each region are included at the end of the appendix. Generally the results of the agronomic variables seems to affirm the recommendations of the program in what practices are important and highlights the loss or gain in yields due to the performance or non-performance of such practices. There are obviously limitations to this study as there is an assumption that there was no diversion of inorganic fertilizer to the traditional plots by farmers as well as the assumption that farmers were honest about what practices they did while answering the interviewer. In addition while farmers may have done a practice, whether they did the practice to the quality desired cannot be measured in this study. Nevertheless the results yield useful analysis about the importance of certain practices that are complementary to inorganic fertilizer and high yielding varieties.

Mopti Region

Table 1 summarizes the regressions performed for millet in the Mopti Region. The results show that about 26 percent of the variation in the data was explained by the four regressions as evidenced by

the R squared value. There is a small but highly significant effect of using organic fertilizer. One extra cart of organic fertilizer can generate an increase of approximately 0.3 percent in yields which would be approximately 3.85 kg per hectare at the median yield. The other significant variables were four or more plants per hole (60.5 percent of sample farmers) which was significant at the ten percent level and had an effect of a 3.2 percent fall in yields or a loss of 35.2 kg per hectare at the median yield which seems to confirm that competition for resources can adversely affect yields. The presence of two or more weedings (97.6 percent of sample farmers) was significant at the ten percent level but the effect of it was large at around 29 percent or an additional 320kg per hectare at median yield. However the number of farmers who did not perform 2 or more weedings was 2.4 percent of the sample, so the sample may not show enough variance to make definite prescriptions on the weedings issue.

The practice of sidedressing both by children and adults yielded a net positive significant effect at the 5 percent level as against the base of broadcasting by children. The yield augmenting effects were 17 percent for adults and 22 percent for children which suggests that the method of application was more important in this area than whether adults or children had applied the fertilizer.

Replanting in August(4.03 percent of sample farmers) was also highly significant in all regressions with an average 43.5 percent yield loss due to such, but the prevalence of this was quite low. Care must be taken in interpreting this variable though. What this indicates to us is that those who replanted in August due to a range of problems experienced a significant drop-off in yield. However when land gets inundated or pests attack crops, it normally is recommended that farmers replant the crop. The failure to replant could mean zero or a poorer performance in yield than replanting the crop. However the results do suggest that early detection of problems and replanting is important as the yield effects for farmers who replanted earlier were not significant.

The presence of ridging, insect and pest problems, flooding and adult broadcasting were not significant in the econometric analysis.

Segou Region

Table 2 summarizes the results for millet in the Segou Region. In general an impressive 55 percent of the variation was explained by the variables used in the four regressions.
An extra cart of organic fertilizer had a 1.2 percent net positive effect on yields (18kg per hectare at median yield) and was significant at the 1 percent level. Tied ridges had a 21 percent effect at the 5 percent level, but there was little variation as 93.4 percent of farmers performed the practice. Farmers who had to replant in July (7.9 percent of sample farmers) also experienced a 23 percent negative effect on yields (5 percent significance), but the same analysis expounded above about replanting must be taken into account. The three types of problems in plots, humidity(1.3 percent), flooding(5 percent) and muddy land(1.3 percent) all had highly negative effects and were significant at the 1 percent level(although it is not possible to draw conclusions on such since very few samples had these problems).

Upper Land (68 percent of sample farmers) was highly significant and had a 19 percent positive effect on yields (significant at 1percent level). This is largely due to the heavy rains that were present in the region during the agricultural season. With heavy rainfall, upper lands will still have adequate moisture but the lower lands will be saturated and soggy. In a slightly more average or lower rainfall year, it is likely that farmers who plant on upper land and on slopes would have generally lower yields than those situated on the lower lands. Lowlands tends to have heavier soils and have benefitted over time from the run off of the topsoil from the plateau and the slopes and the heavier soils hold water longer.

The presence of two or more weedings, four or more plants per hole and adult sidedressing were not significant in the regression. All farmers did sidedressing in the region and there was no significant difference between child and adult application.

Koutiala Region

Table 3 summarizes the results for the regressions for sorghum cultivation in Koutiala. Around 25 percent of the variation in data was captured in this regression. In this region, organic fertilizer was not significant in the regression and its usage was relatively low (15.8 percent of sample farmers). This is largely due to the heavier soils that exist in this region. The manure would make them even heavier holding longer the excess water. Heavier soils already have a strong structure without additional organic fertilizer, and can hence hold water and nutrients better. Soils on the lowlands tend to be heavy and hold nutrients and water better than lands on the slope and plateau.

Tied ridging (68.4 percent of sample farmers) had a 26 percent effect on yields (265kg per hectare at median yield) and was significant at the 5 percent level. The use of upper land (47.4 percent of sample farmers) had a very high effect of 35.4 percent on yields (significant at 1 percent level) which seems to be validated by the above average rainfall that the region experienced. In a year with significant flooding it was thus very important for more lands in the upper land to be planted. This is confirmed by the fact that flooding (24 percent of sample farmers) that some farmers experienced had a 45 percent negative effect on yields at 1 percent significance.

The presence of two or more weedings, four or more plants in a hole, adult sidedressing and adult broadcasting did not have a significant effect in any of the regressions and for the most part had relatively small coefficients. This is probably due to the relatively high prevalence of most farmers in the region performing the appropriate practices necessary. In addition replanting in August (12.63 percent of farmers) were not significant.

Conclusions

Generally the results of the econometric analysis affirm the net positive effects of following the practices recommended by the program. In lighter soil areas (millet zone, slopes and plateau), it is important that famers use adequate amounts of organic matter in conjunction with applying the full recommendation of inorganic fertilizer. In addition the practices of ridging(tied ridging) and sidedressing of fertilizer were identified as important to increasing yields and the program needs to continue to encourage the adoption of such practices in spite of their relatively labor intensive nature. There were certainly some areas within the regions which were exceptional performers and attained the best returns on investment in the regional analysis of yields and returns.

There were some challenges in the season including insect and pest attacks as well as flooding and in some instances very late replanting was observed and had a large, negative effect on yields. Farmers this year, who planted on the upper lands, had generally higher yields due to the above average rainfall. However it is generally still recommended that farmers plant the improved sorghum on the more fertile lowlands.[14]

Overall, the results show that farmers are generally following the practices the program recommends for success with some areas for improvement. If farmers can achieve mastery in improving yields with the new varieties, then the program can focus more on the participation of farmers in the farmers association as well as contracts and financing issues to take advantage of improved yields and boost incomes.

[14] With the late season drought of 2011 this point was clear as then the advantage in higher yields was again on the lowland with the heavie soils holding the available water better.

Regression Analysis Results

Table 1: Regressions of Log Yield on Various Agronomic and Location Variables in Mopti

	Agronomy Regression	Average yield effect at median yield(1100kg/ha)	Average or % observed
	log yield		
Constant	6.41517***	-	-
Orgfert	0.0035***	3.85	23.66 carts
Ridge	0.099	108.9	98.40%
Fourplants	-0.032	-35.2	60.50%
twoweed	0.291*	320.1	97.60%
ReplantAugust	-0.435***	-478.5	4.03%
adultside	0.17**	187	37.90%
adultbroad	0.017	18.7	29.03%
childside	0.212**	233.2	18.50%
insectpest	-0.101	-111.1	15.30%
flooding	-0.0065	-7.15	5.65%
No. of Observations	124		
R squared	0.2586		
Adjusted R squared	0.193		

*,**,*** represent significance at the 10, 5 and 1 percent level respectively

Table 2: Regressions of Log Yield on Various Agronomic and Location Variables in Segou

	Agronomy Regressions	Average Yield Effect at median yield (1500kg/ha)	Average or % observed
	ln yield		
Constant	7.017	-	
Orgfert	0.012***	18	3.07
tiedridge	0.210**	315	93.40%
Fourplants	-0.054	-81	32.89%
UpperLand	0.191***	285	68.42%
twoweed	0.001	2.1	76.30%
ReplantJuly	-0.227**	-340.5	7.89%
adultside	0.0810597	121.5	39.47%
High humidity	-0.453***	-679.5	1.32%
Flooding	-0.858***	-1287	5.26%
MuddyLand	-0.390***	-585	1.32%
No. of Observations	76		
R squared	0.5532		
Adjusted R squared	0.4845		

*, **, *** represent significance at the 10, 5 and 1 percent level respectively

Table 3: Regressions of Log Yield on Various Agronomic and Location Variables in Koutiala

	Agronomy Regressions	Average yield effect at median yield(1000kg/ha)	Average or % observed
	ln yield		
Constant	6.534	-	-
Orgfert	-0.0013	-1.3	5.21
tiedridge	0.265**	265	68.40%
Fourplants	-0.015	-15	7.37%
UpperLand	0.354***	354	47.36%
twoweed	-0.003	-3	81.05%
ReplantAugust	-0.213	-213	12.63%
adultside	-0.127	-127	4.21%
adultbroad	0.081	81	71.57%
Flooding	-0.457***	-457	23.15%
No. of Observations	95		
R squared	0.2525		
Adjusted R squared	0.1733		

*, **, *** represent significance at the 10, 5 and 1 percent level respectively

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All remaining errors in the report are the responsibility of the authors.

Garasso, 2010: A farmer appreciating a Grinkan panicle. Courtesy of Dr. Botorou Ouendeba.