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New Technology and Emergence of Markets: Evidence from NERICA rice in Uganda

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Abstract

This paper examines the determinants of dropout and uptake rates of newly introduced crop, which is high-yielding but more subject to crop failure and labor intensive than subsistence crops. New Rice for Africa (NERICA) was introduced in Uganda as one of poverty alleviation programs by providing potential cash crops to rural households. Within 2 years, the early adopters stopped growing NERICA, while the others started growing it. It is found that the adoption and dropout of NERICA rice variety is determined by opportunity costs and risk faced by households.

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1. Introduction

When New Rice for Africa (NERICA) rice variety was released in Uganda, there was excitement because of its potential for decreasing poverty in rural areas. This view was supported by Kijima et al. (2008) who conducted simulation analyses and showed that the introduction of NERICA increased per capita income by 12%, decreased the poverty head count ratio by 5 percentage points, and decreased squared poverty gap from 22 to 15 without deteriorating income distribution.

This positive impact on income due to NERICA production was mainly due to its high yielding traits. According to Kijima et al. (2006), the NERICA's yield in 2004 was quite high in Uganda, which was twice as large as the average in sub-Saharan Africa. The high-yield is obtained because NERICA is soil-nutrient responsive. Since chemical fertilizer is rarely applied to rice in Uganda, therefore, it is a critically important question whether such high yields can be sustainable without replenishing soil nutrients for identifying the long-term potential of NERICA rice. This question has not been examined since the previous studies used the data collected just after NERICA was introduced in Uganda. In order to answer this question, the second NERICA survey was conducted in October 2007 and same households in the first NERICA survey in 2004 were revisited.

Another objective of this paper is to analyze the determinants of changes in adoption and dropout of rice cultivation in the last 2 years. In the first NERICA survey, input and output markets did not seem working since seed shortages and lack of access to traders and rice millers discouraged farmers to grow rice. Since rice is a new crop to sample households, introducing a new high-yielding variety may not guarantee for expanding the adoption.

It is widely believed that markets function ineffectively in Sub-Saharan Africa due to high transportation costs, high transaction costs, and imperfect contract enforcement (Kherallah et al. 2000). In the case of the first NERICA survey, rice production was not enough for markets to emerge, since it was conducted just after the release of NERICA. It is possible that rice millers and traders start business, as the rice production increases, which decreases transportation cost per unit for traders and increases demand for the service for rice millers. Since rice production in sample area is expected to increase after the first NERICA survey, the second NERICA survey may be able to capture the change in input and output markets.

The rest of this chapter is structured as follows. Section 2 briefly describes the adoption rate of rice and the characteristics of NERICA rice variety and explains how NERICA was introduced in Uganda. Section 3 presents the descriptive tables of

the data used in this study for characterizing the sample. Section 4 provides the empirical results on changes in adoption and drop rates as well as rice yields. Section 5 uses for the conclusions and policy implications.

2. Rice Production in Uganda

NERICA rice variety was invented by scientists of West Africa Rice Development Association (WARDA) by crossing the stains of African Oryza glaberrima and Asian Oryza sativa for high stress tolerance and high yields without any irrigation so as to match African environments. NERICA variety has early maturity, which allows planting a second crop, growing in areas with relatively short rainy season, and saving labor on weeding compared with other rice varieties.

NERICA rice was formally introduced in Uganda in 2002 and had been planted in a few districts for on-farm trials promoted by seed companies and the National Agricultural Research Organization (NARO). In the early 2004, the Vice President Initiative (one of the government's poverty eradication projects) began and widely distributed NERICA seeds as in-kind seed credit. Since then, it is known that the program has expanded the area coverage. However, as far as I know, there is neither statistics of total NERCIA rice adoption and area coverage in Uganda nor panel studies

on NERICA farmers.

Before NERICA was introduced, rice cultivation was not common in the most of Central and Western regions of Uganda, though the consumption of rice has been growing due to the rapid urbanization (UBOS 2002). According to Kijima and Sserunkuuma (2008) which used nationally representative survey conducted in 2003, namely RePEAT survey, the percent of households who grew rice in 2004 is 6.3% and is higher in Eastern region (12.6%) and is nil in Central (2.2%) and Western (0.5%) regions and those who grew lowland rice were located only in Eastern region.[1]

3. Data and Descriptive Statistics

3-1 Data and Sample

The data used in this paper was collected in October 2007. We revisited the sample households interviewed in March 2005. When the 2005 survey (NERICA 1 survey, hereafter) was conducted, the adoption of NERICA rice had just initiated and households growing NERICA rice were found only in areas with a NERICA seed dissemination program. Therefore, we intentionally selected 10 NERICA growing areas covering Central and Western regions. In each sample community, we draw a

[1] Although the adoption rate in Northern region is not available in RePEAT survey, ADC (2001) indicates that upland rice varieties were cultivated mainly in Northern regions in 2000.

random sample of 25 households who grew NERICA rice and 15 households who did not grow NERICA rice in the second cropping season of 2004 (Kijima et al. 2008). In the second NERICA survey (NERICA 2 survey, hereafter), there are attritions due to moving-out from sample areas, dissolution of households, and non-contact during the data collection period. In total, we have 346 sample households for the analyses.

3-2 Adoption

Table 1 shows the adoption rate of upland rice in the sample areas.[2] There are two cropping seasons within a year in Uganda. In the sample areas, the second cropping season is considered as main cropping season since the rainfall is more reliable than that in the first cropping season. Thus, households tend to grow rice in the second cropping season. If we look at adoption rates only in the second cropping season, the adoption rate of upland rice slightly increased from 20% in 2004 to 22% in 2006. For the first cropping season, the adoption rate declined from 11% in 2004 to 9% in 2007. The size of area planted to rice (among rice growing households) accounts for 21% of the size of land owned and for 11% of the size of land accessed (including land rented

[2] The adoption rate of upland rice is calculated from community (the lowest administrative unit, LC1) questionnaire in which the number of households and the number of households growing rice in the LC1 are asked retrospectively to LC1 chairman and informants on rice cultivation for each cropping season since 2004.

in) and has an increasing trend for both cropping seasons (0.36 to 0.41 ha).[3] The adoption of NERICA variety has been increasing since 2004 and 88% of the rice growers grow NERICA variety in 2007, while a small number of households (8% of rice growers) grow traditional rice varieties.

The first NERICA survey identified that a low adoption rate of NERICA variety was partly due to shortage of seeds (Kijima and Sserunkuuma 2008). When NERICA was released in Uganda, the seeds were distributed through NGO and NARO. There are two NERICA seed suppliers in Uganda. Most of their clients are donors for supplying seeds to the NERICA seed distribution programs. According to the Table 2, the main seed source has shifted from NGO and NARO to own self-produced seeds. The proportion of rice growers who used self-produced seed (both own and from other farmers) reached to 60% in 2006. These shifts should be accounted for by several changes. First, the seed distribution program currently supplies NERICA seeds mainly to the other areas, which makes donated seeds become less available in the sample areas. Second, NERICA distribution program also provide training on rice cultivation in which farmers learn how to "produce" seeds from their own harvests, leading to high usage of

[3] Average land owned and land accessed in the sample households are 1.98 ha and 3.80 ha, respectively.

self-produced seeds.[4] Given that self-produced seeds become more available, the stagnant adoption of upland rice does not seem to be due to shortage of seeds anymore. Further investigations on this matter are required.

Another constraint identified in the NERICA 1 survey is lack of access to markets for farmers to sell rice. According to Table 3, distance to rice miller is shortened to one-third and traveling time is halved. This means that there were new entries of rice millers who found the business profitable. The proportion of rice farmers who sold rice also increased from 82% to 91%, which suggests the improvement of market access. Forty five percent of rice sellers sold to traders from town and 74% of sellers sold rice at farm gate in 2006. These proportions have increased since 2004, suggesting that increase in rice production in sample areas attracts private traders and leads to the emergence of rice market.

These statistics suggest that seed shortage and lack of marketing do not seem a critical constraint for stagnant adoption of upland rice. Next, we examine the relationship between yield and adoption.

3-3 Yield

[4] Trainers recommend to purchase "treated" seeds after replanting twice since a possible mixture (contamination) of other varieties through own seed recycling leads to lower yields.

One of the NERICA's characteristics is its high yielding trait (WARDA 2001). According to Kijima et al. (2006), the yield was quite high in Uganda, which was twice as large as the average in sub-Saharan Africa. In Uganda, it is observed that chemical fertilizer is rarely applied, except a certain crops such as tobacco. Rice is not an exception. Whether such high yield can be sustainable without replenishing soil nutrients is a critically important question.

Table 4 indicates the average yield and the proportion of rice growers who obtained zero harvest from 2004 to 2007. There is no clear time trend in rice yield, while the yield in the first cropping season tend to be lower than that in the second cropping season. The proportion of growers with zero harvest is also higher in the 1st cropping season than in the 2nd cropping season. Lower yields and higher proportion of zero harvest in 2005 are likely to be associated with lower rainfall than average year. Even though the yield improved in the second season of 2006 and 2007, it is possible that only "better" farmers remain in rice cultivation, which has a positive effect on average yields. Though NERICA is an upland rice variety and is known to have a drought resistance, this may indicate that a lack of water can destroy the crop.[5] In this sense, rice cultivation is considered as riskier than subsistence crops. A possible

[5] As shown in Appendix Table 1, where the yields and percentages of zero yield separately for NERICA and non-NERICA rice varieties, in given year-season, the yield is higher and the percentage of zero yield is lower for NERICA variety than non-NERICA varieties.

reason for the stagnant adoption rate of upland rice in the sample areas may be the uncertainty of harvest in rice cultivation.

It is possible that geographical variations make the adoption patterns and average yields of NERICA different. Table 5 shows the adoption and yields by districts as well as the proportion of NERICA adopters in the second cropping season of 2004 who stopped growing rice. In Masindi district, average yield and adoption rate have increased. In Hoima district where average yield remains high over time, the adoption rate increased from 26% in 2004 to 67% in 2006. In districts with high adoption rate (Kibale and Kamwenge), farmers have received constantly high yields. To the contrary, in the other districts such as Mubende, Wakiso, and Mpigi, average yield was lower than that in the other districts and about half of the NERICA adopters stopped growing rice.

The changes in yields over time, however, can be explained by rice production and land management practices. Thus, we look at some of the variables related with rice production and land management practices in Table 6. To eliminate the seasonal effects and obtain relatively large number of observations, we show the results only for the second cropping seasons. Table 6 indicates that most of rice growers do not apply fertilizer (both chemical and organic) and the proportion of growers applying fertilizer

has decreased since 2004. This low application of fertilizer is partly explained by no access to fertilizer credit for rice production. Only credit available is for seeds. Instead, it is observed that farmers maintain soil fertility by crop rotation. In 2004, half of the growers used a plot which was fallowed in the previous season, while in 2006, the usage of fallowed land declined to 37% and more growers planted rice on plots that was planted to cereal crops in the previous season. This change in cropping pattern may result in lower yields in 2006 than in 2004.

As shown in Table 6, the irrigation is rarely available in Uganda in general, in the sample areas in particular. Instead, one fourth of growers utilize the flat-lowland plots which water from hill can run on, resulting in relatively high moisture contents. Related with the planting, the amount of seeds used is higher than the recommended level, which may result in low yields due to crowdedness.[6] Straight line planting and pure standing are common and there are no significant changes between 2004 and 2006.

In half of the sample areas, most of the households had never grown rice before NERICA was introduced. In the NERICA 1 survey, it was observed that knowledge about rice production was not enough among new rice adopters. Even so, Table 7 indicates that sample households did not have any training and extension service on rice

[6] Farmers are recommended to use 30kg of seeds per acre, which is equivalent to 74 kg per hectare.

cultivation in these 2 years. This may suggest that lack of training and extension services contributed to high dropout rates of rice cultivation and low yields in newly adopted districts (Wakiso, Mpigi, Mubende, Kiboga).

4. Empirical Model

4-1. Adoption and Drop-out of NERICA

Given the high dropout rates in our sample areas, it is necessary to examine the reasons. For this purpose, the sample households are divided into NERICA adopters and non-adopters in the initial period. The determinants of adopting NERICA variety are examined by using non-adopters sample, while the determinants of dropout of rice cultivation are analyzed by using NERICA adopter sample. As an initial point, year 2004 and 2005 are set in the analyses. The former is for examining the change between 2004 and 2006, while the latter is used for the change between 2005 and 2006.

From the descriptive tables, the adoption and dropout of rice crop in the sample areas are expected to be a function of community characteristics, rather than household characteristics. Community characteristics include farm wage rate and producer price of other crops (maize, matoke, and beans), which are proxies of comparative advantage and the opportunity costs of rice production. This is because, if the producer price of

alternative cash crop is low, NERICA is more attractive to farmers, which results in higher probability of uptakes.

The other community-level variables are related with learning effects from neighbors. If neighbors are successful with rice cultivation, it is encouraged to adopt NERICA. Unlike Conley and Udry (2005), there is no information that each household learn from others. Since most of the sample households cultivate rice under rainfed conditions, higher average rainfall tends to result in higher yields, while higher variations of rainfall indicate the risk of rice cultivation.. Average and standard deviation of rainfall within the community are, therefore, used as proxies of the other members' realized yields and risk of rice production.

The probabilities of up-taking and dropping-out rice production are estimated by Probit model. The first two columns of Table 8 are for the determinants of dropout rate and the rest of the columns are for those of adoption rate. Columns 1 and 3 analyze the changes between 2004 and 2006, while columns 2 and 4 examine the changes between 2005 and 2006. The results on opportunity costs support the hypotheses: higher opportunity costs increase the probability of dropout (price of matoke in column 1 and farm wage rate for column 2); lower opportunity costs increase the probability of uptake (price of maize and price of matoke in column 4).

Household-level characteristics at the initial point of time are also controlled for.

On the results on suitability and risk of rice cultivation, there are only significant relationships in variations between 2005 and 2006 (columns 2 and 4). The higher the average amount of rainfall in 2005 is, the lower the dropout rate in 2006 is. As the standard deviation of rainfall that rice growers in the community received for 90 days after planting in 2005 is larger, the dropout rate increases. In contrast, the higher standard deviation of rainfall in 2005 decreases uptake rates in 2006. If standard deviation of rainfall increases by one standard deviation, the dropout rate becomes 71%, which is 24 percentage point increase. One-standard-deviation decrease of rainfall variation results in increase in uptake rate from 22% to 33%. This suggests that decrease in risk of rice production is a crucial factor for expanding rice production in sample areas.

The table indicates that both in dropout and uptake rates, most of the initial household characteristics do not have impact on uptake and dropout rates of rice production. This may suggest that rice is not restricted to resource rich households in terms of labor force and land. In addition, it should provide a great opportunity to migrant households who look for higher agricultural intensification and to ethnic group of Bakiga, which is well-known as hard-working people.

4-2. Rice Yield Function

To assess the determinants of rice yields, yield function is analyzed in this sub-section. It is important to examine whether NERICA variety increases rice yields even after controlling for household fixed effects and plot-level characteristics. Rice yield per hectare is calculated for each plot and only households with more than one plot are used for this analysis. Two specifications are shown in Table 9, where column 2 has extra explanatory variables (characteristics of decision maker on rice cultivation). Results are similar in terms of the coefficients and significance level.

First and most importantly, NERICA variety dummy has a positive and significant effect on rice yield. The coefficient suggests that NERICA variety can increase the yield by 500 kg per hectare on average, compared with non-NERICA varieties. The year of 2005, a drought year, tended to lower the yield as well as the yield is lower in the first cropping season when the rainfall tends to be less reliable. However, the amount of rainfall for 90 days after planting and a dummy variable of plot location in valley are not significant.

NERICA yields are significantly explained by differences in cropping patterns. If rice is grown after cereal crops, the yield is lower that when rice is grown after fallow.

In contrast, cultivating rice in the plot where tobacco was grown in the previous season increases rice yields. Besides cropping pattern, how to produce seeds by themselves may have impacts on rice yields, even though the coefficient of "Number of times that seed is self-produced" is not significant. This suggests that training on how to produce seeds out of their own harvests is urgently needed for enhancing the rice yield. Yield analyses suggest that NERICA can increase the yield by 0.5 ton (which is about 34% of average non-NERICA rice yield) on average. Combined with other better management, it is possible for rice yields to increase by more than 50%.

5. Conclusions

This paper overviews the changes in adoption and yields of NERICA rice variety from 2004 to 2006. NERICA was introduced in Uganda with excitement and expectations for reducing poverty in rural farm households. After 2 years, some could manage with this new opportunity for raising their income, while the other are disappointed with rice cultivation and returned to maize production.

There are encouraging findings that some markets have emerged. Even though marketing and seed shortage were serious problems in most of our sample areas in 2004, availability of NERICA seeds and access to traders and rice miller improved

after rice production has increased in these areas. At this point, fertilizer credit for rice is not available. As the demand for fertilizer credit increases, such credit market may also emerge.

In addition, dividing the success or failure can be accounted for by the opportunity costs of rice production and the risk and suitability of rice production under rainfed condition. Since rice cultivation needs more labor compared with the other crop production such as cooking banana and maize, farmers do not find rice production attractive, unless there is no other lucrative cash crops and wage labor available. Risk of rice production measured by standard deviation of rainfall increases the dropout rate and decreases uptake rate of rice production. Since traditional food crops are more resistant to drought and local environment, households under high risk of loosing all the harvests seem to dropout rice production.

The determinants of rice yield are examined by using household-fixed effects model. Even after controlling for household's time-invariant unobservables, NERICA variety is found to increase the rice yield, compared with the other varieties, and the incremental effect is about 0.5 ton. Further analyses are needed on whether this high yield results in higher profits and improvement of welfare.

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Table 1. Adoption of NERICA

Year	season	% of households growing rice*	Average area planted to rice (ha)	% of NERICA	% of non-NERICA MV	% of TV	% of unknown
2004	1	11.4	0.36	66.0	9.4	9.4	13.2
2004	2	20.1	0.38	75.2	3.0	8.9	7.4
2005	1	9.2	0.36	76.1	3.0	4.5	13.0
2005	2	20.2	0.40	77.6	5.4	7.5	7.5
2006	1	10.0	0.42	69.6	0.0	4.3	13.0
2006	2	22.2	0.41	86.4	0.8	8.0	3.2
2007	1	9.4	0.41	88.0	0.0	8.0	4.0

* Calculated from LC1 questionnaire,

Table 2. Seed Source

Year	season	% of own recycle seeds	% of obtained from other farmer	% obtained from private company/ traders	% obtained from NGO, NARO, NAADS etc
2004	1	11.5	13.5	7.7	67.3
2004	2	23.6	15.6	9.5	51.3
2005	1	38.2	11.8	4.4	45.6
2005	2	42.6	9.5	17.6	30.4
2006	1	59.1	13.6	13.6	13.6
2006	2	44.4	16.7	19.0	19.8
2007	1	40.0	8.0	32.0	20.0

Table 3. Rice Marketing

	2004(2)	2005(2)	2006(2)
Distance to rice miller (km)*	7.3	2.6	2.1
Traveling time to rice miller (minutes)*	60.0	36.1	29.8
% of growers with positive harvest	93.1	85.8	91.3
% of growers with positive harvest who sold	82.0	87.5	91.4
% of sellers sold at farm gate	53.5	66.1	73.5
% of sellers sold off harvest time	19.0	27.7	34.0
% of sellers sold to traders from town	34.2	39.3	45.3
% of sellers sold to local middleman	24.5	20.5	27.4
% of sellers sold to local individual and shop	12.9	13.4	6.6
% of sellers sold to retailer in town	5.8	2.7	2.8
Average price of milled rice (Sh received by farmers)**	829	842	843
Average price of paddy rice (Sh received by farmers)**	416	438	463

Source: * NERICA 2 LC1 level questionnaire. ** nominal price in shilling.

Table 4. Rice Yield

Year	season	Average yield (kg/ha)	s.d.	% of zero yields	Number of observations
2004	1	1650	1314	13.7	51
2004	2	2008	1845	5.1	196
2005	1	1239	1238	18.5	65
2005	2	1812	1458	13.6	147
2006	1	1378	1180	17.4	23
2006	2	2364	1617	7.3	124
2007	1	2160	1500	4.0	25

Table 5. Adoption by District

District	% of rice growers 2004 (2) **	% of rice growers 2005 (2) **	% of rice growers 2006 (2) **	% of dropout *	Average yield kg/ ha 2004 (2)	Average yield kg/ha 2005 (2)	Average yield kg/ha 2006 (2)
Masindi	5.4	7.9	11.6	8.3	1957	2134	3109
Kibale	63.0	61.7	59.3	4.2	2209	2297	2108
Kamwenge	35.8	31.1	33.2	3.3	2633	2475	2597
Hoima	26.0	46.9	67.1	4.2	2897	2546	2846
Wakiso	8.9	7.1	5.0	55.2	1741	972	1599
Mpigi	5.3	0.1	0.2	44.8	1416	652	(1118)+
Mubende	6.0	0.9	0.1	63.3	1666	1377	(3043)+
Kiboga	4.8	4.6	2.9	33.3	1780	1099	1142
Luwero	19.8	15.1	11.3	26.7	1971	1698	1836

* NERICA adopters in 2004 who stopped growing rice after that.

** Calculated from LC1 questionnaire

+ The number of observation is only 4.

Table 6. Rice Production

	2004(2)	2005(2)	2006(2)
% of growers who applied fertilizer	12.9	8.1	7.1
% of growers who applied manure	2.5	0.7	0.0
% of growers who applied pesticides	2.5	3.4	6.3
% of growers who applied herbicides	3.5	4.7	3.2
% of growers who obtained fertilizer credit on rice	0.5	0.0	0.0
% of growers who obtained seed credit on rice	44.1	29.1	19.0
% of plots fallowed in previous season	49.5	41.9	37.3
% of plots virgin in previous season	5.9	3.4	3.2
% of plots with cereal crop in previous season	13.9	20.3	25.4
% of plots with root/tuber crop in previous season	5.0	8.1	6.3
% of plots grown rice continuously	12.9	12.8	7.1
% of irrigated plots	1.0	1.4	1.6
% of plots in valley (high moisture content)	24.3	25.7	23.0
Amount of seeds used per ha (kg)	86.9	85.9	97.0
% of plots with pure standing	94.6	90.5	92.9
% of plots with straight line planting	93.6	95.3	90.5

Source: NERICA 2 Household Survey

Table 7. Training and Extension

	During 2005(2) and 2006 (1)	During 2006(2) and 2007(1)
% of households without training on rice cultivation	85.3	84.1
% of households without extension service on rice cultivation	90.2	91.6
Average days of training on rice cultivation (among those who took training)	3.0	2.6
Average days of extension service on rice cultivation (among those who received extension service)	4.4	2.4

Table 8. Drop-out and Uptake of Rice (marginal effects are presented, not coefficients)

	Dropout 04-06	Dropout 05-06	Uptake 04-06	Uptake 05-06
Amount of rainfall for 90 days after planting	0.078	-0.256	-0.007	0.017
(100 mm)	(0.69)	(1.73)+	(0.16)	(0.68)
Standard of deviation of rainfall for 90days	0.036	1.637	-0.135	-0.325
(100 m)	(0.06)	(3.02)**	(0.95)	(1.85)+
Male adult wage for one acre ploughing (USD)	-0.008	0.026	-0.000	0.003
	(1.72)+	(2.38)*	(0.06)	(1.36)
Producer price of maize per kg (USD)	3.757	4.537	-0.184	-2.159
	(1.61)	(1.58)	(0.62)	(2.12)*
Producer price of beans per kg (USD)	0.009	0.006	0.005	0.015
	(0.89)	(0.46)	(1.17)	(1.87)+
Producer price of matoke per kg (USD)	0.252	-0.293	-0.109	-0.325
	(2.67)**	(1.01)	(1.21)	(1.80)+
Proportion of rice households	0.306	-0.521	0.028	-0.141
	(0.78)	(0.99)	(0.55)	(1.12)
Community area size per household	-2.369	4.292	-0.234	-1.390
(area size divided by number of households)	(0.45)	(0.49)	(0.32)	(0.76)
Traveling time to town (hour)	-0.181	0.027	-0.005	-0.080
	(0.80)	(0.11)	(0.16)	(1.13)
Distance to rice miller (km)	-0.004	0.012	0.000	0.006
	(1.68)+	(1.56)	(0.23)	(1.68)+
Proportion of households sold rice to trader	-0.003	0.004	-0.000	-0.001
	(1.59)	(1.30)	(0.34)	(0.79)
Number of household members	-0.019	0.005	0.000	0.002
	(1.25)	(0.23)	(0.12)	(0.40)
Proportion of male adult members aged 25 to 59	-0.443	-0.113	-0.044	0.099
	(1.14)	(0.13)	(0.98)	(0.99)
Proportion of female adult members aged 25 to 59	-0.456	0.172	0.042	0.238
	(0.81)	(0.23)	(1.07)	(1.61)
Female headed household = 1	-0.110	0.059	-0.005	0.034
	(0.79)	(0.23)	(0.36)	(0.75)
Migrant household =1	0.145	0.403	-0.006	0.105
	(1.41)	(1.95)+	(0.38)	(2.04)*
Ethinic group is Bakiga =1	-0.011	0.027	0.134	0.946
	(0.06)	(0.10)	(1.40)	(2.10)*
Head’s age	0.001	-0.007	-0.001	-0.001
	(0.38)	(1.18)	(1.49)	(1.26)
Head’s education (years of schooling)	-0.001	-0.005	0.000	0.000
	(0.30)	(1.34)	(0.32)	(0.65)
Per capita land owned (ha)	0.026	0.070	0.023	-0.006
	(0.54)	(0.46)	(1.16)	(0.45)
Household asset (thousand USD)	-0.286	-0.067	-0.009	0.094
	(1.77)+	(0.19)	(0.30)	(1.76)+
Value of livestock (thousand USD)	-0.045	0.032	-0.005	-0.003
	(0.61)	(0.26)	(0.31)	(0.08)
Observations (Pseudo R-squared)	227(0.18)	110(0.32)	118(0.43)	128(0.40)

**, *, and + indicate 1, 5, and 10% of significance levels, respectively.

Table 9. Yield per hectare (Household fixed effects)

	(1)	(2)
Year=2005 dummy	-399.338	-391.433
	(3.15)**	(3.02)**
First season dummy	-283.606	-266.057
	(1.84)+	(1.70)+
Variety is NERICA =1	498.913	568.403
	(1.77)+	(1.88)+
Plot is in valley =1	-227.608	-234.779
	(0.80)	(0.82)
Rainfall amount for 90 days after planting	0.160	-0.041
	(0.21)	(0.05)
Number of times that seed is self-produced	-109.806	-91.335
	(1.56)	(1.20)
Rice is planted in straight lines	-270.308	-274.770
	(0.68)	(0.68)
Pure stand =1	314.054	283.245
	(0.84)	(0.73)
Walking time from homestead (minutes)	-0.390	-0.201
	(0.08)	(0.04)
In the previous season, the plot was under		
Rice	-38.073	-47.563
	(0.18)	(0.22)
Legume crop	-252.931	-249.855
	(0.99)	(0.96)
Tobacco	1,049.251	1,124.387
	(1.69)+	(1.69)+
Cereal crops (except rice)	-438.214	-421.537
	(1.92)+	(1.83)+
Root/ tuber crops	35.052	17.261
	(0.11)	(0.05)
Amount of DAP applied (kg)	9.481	9.473
	(0.66)	(0.66)
Amount of manure applied (kg)	-1.328	-1.810
	(0.13)	(0.17)
Decision maker’s characteristics		
Education (years of schooling)		77.578
		(0.46)
Female dummy		-247.303
		(0.19)
Age (years)		-59.155
		(0.32)
Rice growing experience (years)		-72.869
		(0.75)
Constant	1,923.879	4,316.653
	(3.07)**	(0.49)
Number of observations (plots) [number of households	566 [195]	566 [195]
R-squared	0.18	0.19

**, *, and + indicate 1, 5, and 10% of significance levels, respectively.

Appendix Table A. Yield of NERICA Rice Variety

Year	season	Average yield (ton/ha)	s.d.	% of zero yields	Number of observations
2004	1	1.69	1.22	11.8	34
2004	2	2.05	1.88	4.0	150
2005	1	1.19	1.21	19.6	51
2005	2	1.88	1.37	10.8	111
2006	1	1.70	1.23	12.6	16
2006	2	2.49	1.61	6.6	106
2007	1	2.28	1.53	0.0	22

Appendix Table B. Yield of Non-NERICA Rice Varieties

Year	season	Average yield (ton/ha)	s.d.	% of zero yields	Number of observations
2004	1	1.62	1.51	17.6	17
2004	2	1.93	1.85	8.5	47
2005	1	1.39	1.28	12.5	16
2005	2	1.54	1.71	21.2	33
2006	1	0.57	0.65	37.5	8
2006	2	1.66	1.54	11.8	17
2007	1	1.27	1.10	33.3	3