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Disadoption of Improved Agronomic practices in Cowpea and Maize at Ejura-Sekyeredumase and Atebubu-Amantin Districts in Ghana

Patricia P. Acheampong[1], Patterson O. Bonsu[1], Hide Omae[2] & Fujio Nagumo[2]

[1] CSIR-Crops Research Institute, Ghana

[2] Japan International Research Center for Agricultural Sciences, Japan

Correspondence: Patricia P. Acheampong, CSIR - Crops Research Institute, Kumasi, Ghana. E-mail: ppacheampong@gmail.com

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Abstract

The improved cowpea and maize production methods developed in Ghana with the help of farmers are fundamental to increasing cowpea and maize productivity. Improved agronomic practices in cowpea and maize production believed to increase yield are row planting, the use of cover crops and the use of poultry manure. However, the practices are gradually losing their importance in cowpea and maize production. The paper therefore explores the extent to which various factors affect the disadoption of improved agronomic practices and reasons behind disadoption. Multistage sampling techniques were used to select hundred farmers from two cowpea and maize producing areas. Results revealed adoption of cover crops, row planting, poultry manure dropped from 13% to 6%, 99% to 53% and 77% to 10%, respectively. Financial constraint, difficulty in use, time and labour intensity were reasons for disadoption. Empirical results revealed that number of years in education, gender of farm household head, household size, access to extension and hired labour influenced disadoption of improved agronomic practices. Access to production inputs and continuous supply of information are important for farmers' continuous use of improved agricultural technologies.

Keywords: agronomic practice, cowpea, disadoption, Ghana, improved, maize

1. Introduction

Agricultural research and technological improvements are fundamental to increasing agricultural productivity to meet demand for food and in so doing reduce poverty. The impact of technological change to agricultural productivity in developing countries has been widely acknowledged (Sunding & Zilberman, 2000; Doss, 2006). Technological change can have massive effects on livelihoods; improved income, creation of labour opportunities for the poor, reduced food prices, environmental sustainability, and other sectors of the economy. In the world over where agricultural transformation process has been documented, agricultural productivity growth has been driven by improved farm technologies, including improved seeds, and improved agronomic practices (Gabre-Madhin & Johnston, 2002). In Ghana, improved agricultural technology has been stressed in key planning documents as an important means for achieving increased productivity (Ministry of Food and Agriculture, 2007; Ministry of Food and Agriculture, 2010).

The improved cowpea and maize production methods, developed in Ghana with the help of farmers, seemed to be particularly well suited to the needs of farmers and could be considered low-external input sustainable agriculture technologies. The methods include the use of improved disease resistance varieties, pre- and post-flowering insecticides, and improved agronomic practices (row planting, minimum tillage, spacing, fertilizer application etc). Most importantly, the methods have been repeatedly shown to double cowpea and maize yields in smallholder farmers' fields from the current average yield of 1.3mt/ha to yields of about 2.6mt/ha for cowpea and 1.7ha^{-1} to 6ha^{-1} in maize (Ministry of Food and Agriculture, 2013). Many setbacks account for the inability of farmers to produce enough cowpea and maize. Although there have been some technological changes in cowpea and maize research resulting in yield increases, there are still major constraints limiting higher productivity. How to reduce the wide gap between actual (on-farm) and potential (on-station) yields is the issue that needs to be addressed by both researchers and development workers. Whilst researchers follow recommended practices, smallholder farmers are unable to do so due to constraints of access to important inputs.

Social researchers have tried in many ways to explain agricultural technology adoption (Feder et al., 1985; Doss, 2006) for decades. The technology adoption literature has focused mainly on technology adoption by smallholder farmers in developing countries. Different factors, ranging from biophysical characteristics to socio-economic farm-household characteristics and institutional factors have been investigated for their influence on technology adoption. The most important factors limiting the uptake of new agricultural technologies includes: risk and uncertainty, knowledge and education, profitability, input availability, credit constraints, tenure security, labor availability, biophysical factors, market incentives and social networks (Marenya & Barrett, 2007; Kassie et al., 2009; Conley & Udry, 2010; Teklewold et al., 2013).

Disadoption is an important issue in the study of agricultural technologies adoption in helping to identify factors that boost long-term adoption or use of technologies. Neill and Lee (2001) documented that farmers in Honduras disadopt the practice of legume-maize crop rotation at a rate of 10% per year due to emergence of weed species that increase labor requirements. This increased labor requirement has also been noted as a reason for the disadoption of the Systems of Rice Intensification (SRI) in Madagascar (Moser & Barrett, 2006). Moreover, Marenya and Barrett (2007) also found that farm size, value of livestock owned, off farm income, family labor supply, educational attainment, and female household head are significant factors in discouraging farmers' use of integrated natural resource management practices in Western Kenya. Further, Wendland and Sills (2008) document that household preference; resource endowments, risk and uncertainty affect household's decisions on continued use of soybeans in Togo and Benin.

Improved agronomic technologies are seen by agricultural researchers and extension personnel as prerequisite for increased agricultural productivity. In the forest savannah transition agroecological zone, many improved agricultural technologies were disseminated to farmers by the Ghana Grains Development Project. A study by Dankyi et al. (2006) reported of 100% adoption rate of many improved agronomic practices in the Forest Zone. Farmers agreed that by adopting improved production technologies, their yields and overall production increased, and they made more profit from cowpea and maize cultivation. Despite their obvious benefits and intensive extension efforts we find that adoption rates have generally been reduced, the average rate of disadoption (the percentage of households who have tried the method but who no longer practice it) has been high. The purpose of this study was to explore factors influencing farmers' decision to discontinue the use of improved technologies and to make recommendations for future use of agricultural technologies. This study thereby raises a number of questions about improved cowpea and maize technologies: What drive farmers to disadopt improved agronomic technologies? What socioeconomic factors affect continuous use of improved technologies?

2. Research Methodology

2.1 Study Area

Data was collected from Ejura Sekyere-dumase district in Ashanti region and Atebubu Amantin district of the Brong Ahafo region. The region lies between longitudes 0°15′W and 2°25′W, and latitudes 5°50′N and 7°46′N. It has the wet semi-equatorial climate with double maximum rainfall ranging between 170cm and 185cm per annum. Temperature is fairly uniform ranging between 27ºC and 31ºC. Ashanti Region has two vegetation zones, the wet semi-equatorial forest zone which covers more than half of the Region and the transitional savannah woodland which covers the north-eastern parts of the Region. The Ashanti Region has two major soil types, the Forest and savannah Ochrosols. The soils have a fairly high moisture holding capacity (Adu, 1992). The soils are good for cereals and legumes production.

2.2 Sampling and Data Collection

Multistage sampling technique was used to select the respondents. A purposive sampling strategy was used to select the districts with predominant cultivation of maize and cowpea. Purposive sampling ensures that certain important segments of the target population are represented and also allows selection of rich information that provides insight into the issues of central importance to the research (Patton, 1990). This was followed by a purposive sampling of five villages each from each district using a list of maize and cowpea villages provided by the District directorate of Agriculture and based on proportion of cowpea and maize production. Finally a simple random sampling was then used to select 50 farm households each from each of the selected districts making a total of 100 farm households. The selections were done from a list of maize and cowpea farm households. The sample frame consisted of all farmers of cowpea and maize farm households from each of the selected villages. Using structured questionnaire, data on general household and socio-economic characteristics (e.g. age, education, gender, farm ownership, land size) and on institutional factors (e.g. access to credit, access to extension) was collected. Trained enumerators who were well informed about the objectives and contents of the survey administered the questionnaire.

2.3 Analytical Framework

The probit regression model was used to determine the factors that influence farmers' participation in seed broadcasting due to the dichotomous nature of the dependent variable. The reasoning for the use of the probit model over the logit model is as a result of its ability to constrain the utility value of the decision to join variable to lie within 0 and 1, and its ability to resolve the problem of heteroscedasticity (Green, 2003). Participation in any improved agricultural technology was captured as a dummy variable with the value of 1 assigned to that farmer and 0 for otherwise. Following from Greene (2003), the binary probit for the two choice models can be written as:

$$Y_i^* \begin{cases} 1 & if \quad Y_i^* > Y \\ 0 & if\, Y_i^* \leq 0 \end{cases} \tag{1}$$

The probit model is given as:

$$p\left(Y = \tfrac{1}{X}\right) = F\left(XB\right) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{XB} e^{\frac{-(XB)^2}{2}dx} \tag{2}$$

Where:

$$X = (1, x_{1i}, x_{2i,}, \ldots\ldots, x_{ki}) \tag{3}$$

$$X = (\beta_0, \beta_1 \ldots\ldots, \beta_{k)} \tag{4}$$

The specific empirical model for the determination of factors influencing improved agronomic practices is given as:

$$Y_i = \beta_0 + \beta_1 gen + \beta_2 Age + \beta_3 edu + \beta_4 Exp + \beta_5 Fsize + \beta_6 HHsize + \beta_7 credit + \beta_8 hiredl + \beta_9 Extt + \varepsilon_i \tag{5}$$

Where Y_i and ε_i represents participation in an improved technology and error term respectively. The definitions of the potential explanatory variables and their a priori expectations are presented in Table 1. The marginal effect of the variables is calculated using the formula:

$$M\arg inal \qquad effects = \mathrm{B}_i\, \phi(Z) \tag{6}$$

Where B_i are the coefficients of the variables and $\phi(Z)$ are the cumulative normal distribution value associated with the mean dependent variable from the Probit estimation.

Table 1. Definition of variables and expectations

Variable	Definition	Expected sign
Gender	1= male;0= Female	+
Age	Age of farmer in years	+/-
Education	Education of farmer in years	+
Household size	Number of family members	+
Experience	Number of years in cowpea and maize farming	+
Farm size	Total land in acres owed by the farmer	+
Times of extension visit	Times of extension visit	-
Hired	Hired labour	-
Credit	Access to formal credit	+

2.4 Description of Variables Used in the Model

The gender of the farmer is a dummy variable that takes the value of 0 if the head of the household is female, and 1 if male. The general assertion is that women are generally discriminated against in terms of access to external inputs and information. Gender of the household head has been found to influence the decision to adopt new technologies (Langyintuo & Mekuria, 2005). Age may be found to negatively influence the decision to participate in new technologies or otherwise. It may be that older farmers are more risk-averse and less likely to be flexible than younger farmers and thus have a lesser likelihood of participating in new technologies. It could also be that older people have more experience and are in a better position to assess characteristics of new technology than younger farmers, and hence a higher probability of participation. The expected sign of the coefficient on age is therefore indeterminate.

Education and farming experience enhance the ability of farmers to perceive, to interpret correctly and to undertake actions that will appropriately reallocate their resources. More educated farmers are typically assumed to be better able to process information and search for appropriate technologies to alleviate their production constraints. Therefore education is expected to positively influence the decision to broadcast seeds of cowpea and maize varieties. Farming experience is also expected to positively influence the participation in improved agronomic practices in cowpea and maize varieties because experienced farmers have better knowledge and are able to make informed decisions.

Farm size has been found to influence participation in seed broadcasting positively (Langyintuo & Mekuria, 2008) indicating that households with larger land holdings allocate more land to improved varieties. Farmers with larger farm holdings are more likely to try new technologies as they can afford to devote part of their field to try out the new technology. It is hypothesized that larger land holdings will positively influence participation in seed broadcasting of cowpea and maize varieties.

3. Results and Discussion

3.1 Descriptive Statistics on Sampled Households

Table 2 presents the descriptive statistics of the key socio-demographic variables of the respondents. Of the total respondents 76% were males and 24% were females. The mean age was 41 years and Mean household size was

Table 2. Descriptive statistics of socio-demographic by survey districts

Variable	Pooled(N=100)	Ejura Sekyeredumase(N=51)	Atebubu Amantin(N=49)
Demographics			
Proportion of males	76.00	78.43	73.47
Proportion of females	24.00	21.57	26.53
Age of farmer (Years)	41.29	43.41	39.08
Number of family members	4.27	4.2	4.2
Number of years in Education	3.9	3.42	4.53
Number of years in farming	17.03	19.03	15.51
Farm characteristics			
Farm size(acres)	6.28	7.35	5.10
Land tenure			
Inherited	62.00	62.75	61.22
Purchase	8.00	7.84	8.16
Sharecrop	30.00	29.40	30.61
Soil fertility			
Rich	17	9.80	24.49
Medium	17	19.61	14.29
Poor	66	70.59	61.22
Institutional factors			
Access to extension	14.00	25.00	2.00
Access to credit	13.00	25.49	0.00
Hired labour	63.00	70.59	55.00

4 persons similar to the regional average of 4.1 and national average of 4.4 persons in a family (Ghana Statistical Services, 2012). Mean years in education was 4 implying high illiteracy rates amongst respondents. However, experience in farming was quite substantial across the districts as the average experience in farming was 17years. Average farm size was 6.3 acres (2.52ha) higher than the national average landholdings of 2 hectares (Ministry of Food and Agriculture, 2013). Majority (62%) of respondents inherited the land they used for cultivation. Majority (66%) claimed that their land was poor in terms of soil fertility. This assertion makes the cultivation of cowpea-maize rotation necessary as cowpea has the ability to fix nitrogen thus enhancing the fertility of the soil. Poor access to extension may hinder farmers from accessing improved technologies. Few (14%) respondents across the study area reported of accessing extension services in 2013-2014 cropping season. Lack of credit serves as disincentive to accessing important inputs for many farm activities. Only a few (13%) respondents had access to formal credit across the district.

3.2 Previous and Current Adoption of Improved Cowpea and Maize Agronomic Technologies

Farmers' previous and current adoption of improved agronomic practices on maize and cowpea were sought. The improved cowpea and maize technologies were highly researched and introduced to farmers in the 1990s. Tables 3 and 4, show the proportion of farmers on previous and current adoption of improved cowpea and maize agronomic practices. The results showed that majority of respondents previously used recommended agronomic practices in maize and cowpea cultivation. For row planting previous adoption was massive as majority (99%) of respondents across the districts practiced row planting. Dankyi et al. (2006) in their studies of cowpea and maize technologies adoption in Ghana reported that almost all farmers interviewed practiced row planting. Farmers' previous adoption of most of the improved agronomic practices were not surprising as more than a decade ago the improved practices were developed with farmers in the study area. Participatory development of crop technologies is the way forward to increasing adoption of technologies.

Table 3. Proportion of farmers on previous adoption of improved maize and cowpea agronomic practices

Variable	Pooled(N=100)		Ejura Sekyeredumase (N=51)		Atebubu Amantin(N=49)	
	Yes	No	Yes	No	Yes	No
Use of cover crop	13.14	86.60	20.83	79.17	6.12	93.88
Selection of planting material from disease free and matured plants	98.99	1.01	98.00	2.00	100	0.00
Row Planting at recommended spacing	99.00	11.00	100	0.00	97.96	2.04
Monoculture for maximum yield	74.16	25.16	88.33	16.67	65.96	34.04
Application of fertilizers	84.85	15.15	94.00	6.00	75.51	24.49
Application of poultry manure	77.78	22.22	72.73	27.27	82.61	17.37
Appropriate weed control to avoid competition	96.91	3.09	97.92	2.08	95.92	4.08
Farm monitoring, uprooting and destruction of diseased plants	82.80	17.20	65.91	34.01	97.96	2.04
Establishment of fire belts	56.84	43.16	52.17	47.83	61.22	38.78
Timely harvesting	82.29	17.71	93.62	6.38	71.43	28.57

From Table 4 most people continued to use most of the recommended practices. However there were significant changes in the rates of adoption from previous rates of adoption for some of the improved agronomic practices. Specifically, adoption of cover crops, row planting, poultry manure dropped from 13% to 6%, 99% to 53% and 77% to 10% respectively. For the cover crops, the mucuna that was used as a cover crop is not used as food in the study area this might be the reason for its unpopularity in the study area. The finding is consistent with that of Ragasa et al. (2013) who found that farmers in the forest transition area in Ghana did not adopt cover crops due to nonuse of the introduced cover crop. For row planting it is difficult for most farmers to practice because it requires significant additional labor inputs and smallholder farmers who are already credit constrained is less able to take advantage of the technology. For instance 45% of cowpea and maize farmers in the study area reported practicing broadcasting whenever they were cash trapped. The significant drop in the rates of adoption of poultry manure might be due to availability and accessibility of the poultry manure in the study area. The difficulty in getting poultry manure in large quantities might have affected adoption. Boateng (2000) observed that Ghanaian farmers choose inputs based on factors such as availability and accessibility. Bulkiness, difficulty in transporting, offensive odour, among others (Alimi et al., 2006) discourage farmers from using poultry manure.

Table 4. Adoption and disadoption of improved agronomic technologies in 2013-2014 production seasons

Variable	Pooled(N=100)		Ejura Sekyeredumase (N=51)		Atebubu Amantin(N=49)	
	Continuous use	Discontinuous use	Continuous use	Discontinuous use	Continuous use	Discontinuous use
Use of cover crop eg mucuna	6.00	94.00	9.8	90.20	2.04	97.96
Selection of planting material from disease free and matured plants	96.00	4.00	94.12	5.88	97.96	2.04
Row Planting at recommended spacing	53.00	47.00	60.78	39.22	44.90	55.90
Monoculture for maximum yield	68.00	32.00	68.63	31.37	67.35	32.65
Application of fertilizers	82.00	18.00	90.2	9.80	73.47	26.23
Application of poultry manure	10.00	90.00	11.76	88.24	8.16	91.84
Appropriate weed control to avoid competition	94.00	6.00	92.16	7.84	95.62	4.08
Farm monitoring, uprooting and destruction of diseased plants	72.00	28.00	49.02	50.98	95.92	4.08
Establishment of fire belts	48.00	52.00	37.25	62.75	59.18	40.82
Timely harvesting	77.00	23.00	82.35	17.65	71.43	28.57

Table 5 shows farmers reasons for not planting in rows. Of the 45 farmers broadcasting seeds, 15% mentioned financial constraint as main reason for discontinuous use of row planting. Credit is very expensive in Ghana as commercial banks charge high interest rates and also demand collateral which prevents farmers from accessing credit. About 44 % mentioned difficulty in use as reasons for disadoption. Most of the technologies introduced to farmers deviate from farmers indigenous practices. Farmers were only planting at random with family labour. The new technology introduced requires farmers to purchase rope, line the rope in the field and then plant at a specified distance. They therefore find it difficult adapting to the new methods. Labour intensity and time consumption were cited by about 29% and 11% of respondents respectively as reasons for disadoption of row planting. Additional labour and time are required to line the rope and measure the distance for planting of the seeds. In seed broadcasting a person could plant a hectare of maize with ease. Increase labor requirement has been reported as main reason for disadoption of improved agronomic technologies (Moser & Barrett, 2006).

Table 5. Reasons for discontinuous use of row planting technology

Parameter	Frequency	Percent
Financial constraint	7	15.6
Time consuming	5	11.1
Difficult to use	20	44.4
Labour intensive	13	28.9
Total	45	100

3.3 Factors Influencing Disadoption of Improved Agronomic Practices

The probit model was used to estimate the parameters of the determinants of factors influencing disadoption of improved agronomic practices by farmers in Southern Ghana. The STATA software was used to estimate these parameters as well as the marginal effects. The McFadden R-squared value indicates that 51 percent of the variation in the dependent variable was explained by the independent variables. The significant Wald X^2 of 245.51with 9 degrees of freedom indicates that at least one of the variables in the model had a significant effect on disadoption of improved agronomic practices.

Table 6. Determinants of factors influencing disadoption of improved agronomic practices in cowpea and maize production

Variable	Coefficient	Std err.	Marginal effect
AGE	0.0077	0.0150	0.604
YEARSEDU	0.4459	0.0299	0.000***
GENDER	0.6807	0.3179	0.027***
HHSIZE	0.2143	0.0162	0.074**
EXPER	-0.0128	0.0162	0.428
FSIZE	-0.0027	0.0318	0.931
EXTVISIT	-0.5161	0.3242	0.108*
ACREDIT	-0.0342	0.4449	0.939
HIREDL	0.5079	0.3084	0.094*
Number of observations	100		
Log likelihood	-116.49		
Mcfadden r-squared	0.51		

Note:***significant at 1%; **significant at 5%; *significant at 10%.

Number of years in education, gender of farm household head, household size, access to extension and hired labour influenced disadoption of improved agronomic practices in cowpea and maize in the study area (Table 6). Probability of disadoption is significantly related to the number of years a farmer had been to school. Every additional year added to the schooling year increases the probability of disadoption of improved agronomic practices. The effect of education on improved agronomic practices was expected a prior, however, the results was surprising since education was expected to reduce the probability of disadoption of improved agronomic practices. In this study the average number of years in schooling was about 4 years indicating that majority of the farmers were illiterates and this might have impacted on the overall results. Moser and Barrett (2002) found that more educated farmers were likely to continue the use of agricultural technology based on their study of disadoption of rice intensification in Madagascar contrary to the finding in this study. The results indicate that males are more likely to disadopt improved agronomic practices. Being male increases the probability of disadoption by 2.7 percent. Improved agronomic practices is time consuming and men find it difficult allocating more time to a farm activity than women as men use their time more on other nonagricultural activities. Household size correlated positively with disadoption of improved agronomic practices. The probability of disadoption of improved agronomic practices increases by 7.4% with 1% increase in the number of people in the household. The implication is that family labour is used more in nonagricultural activities. Farmers normally allocate family labour between on-farm and off-farm employment. Marenya and Barrett (2007) also found that family labor supply and educational attainment are significant factors in discouraging farmers' use of integrated natural resource management practices in Western Kenya, consistent with the study results. The results also revealed that the probability of disadoption of improved agronomic practices is correlated with hired labour. A percentage increase in hired labour resulted in 9% increase in disadoption. More labour is needed for lining and pegging, fertilizer application and many other improved agronomic practices. This result is consistent with Neill and Lee (2001) who found that farmers in Honduras disadopted the practice of legume-maize crop rotation due to increase labour requirement. The probability of disadoption of improved agronomic practices increases with less extension visits. The results revealed that a 1% decrease in extension visits increase disadoption by 10%. Continuous supply of information is important for farmers' continuous use of agricultural technology.

4. Conclusion and implication

The study has explored the previous and current adoption of improved agronomic technologies of maize and cowpea. Results revealed that majority of producers used improved agronomic practices. Most farmers however had stopped using improved agronomic technologies. For instance, adoption of cover crops, row planting, poultry manure dropped from 13% to 6%, 99% to 53% and 77% to 10% respectively. Reasons for disadoption include financial, labour intensity, time consuming and difficulty in use. The explanation for the disappointing adoption dynamics of improved agronomic practices is the intense labour requirement for the activities. There is weak agricultural financing in Ghana and most smallholder farmers choose to invest their savings on other household consumption requirements. Therefore smallholders rationally choose not to invest in improved agronomic practices thus the importance of labour intensity in explaining adoption patterns of improved cowpea and maize technologies cannot be underestimated. Lack of credit almost makes it impossible for farmers to adopt technologies especially those that require additional inputs like row planting and application of poultry manure. Cost of credit is too high in Ghana and Government intervention has, for the most part, been ineffective. For example interest rates are determined by private commercial banks who consider moral hazards and adverse selection as reasons for high interest rates. The requirements for loan acquisition due to the aforementioned reasons tend to result in the exclusion of small farmers from borrowing. The need for government intervention for access to credit is important if farmers were to switch to new agricultural technologies.

Education, gender of farm household head, household size, access to extension and hired labour are important significant factors determining disadoption. Since hired labour affected disadoption, the need for more mechanized agriculture throughout the country is imperative. Investment in agricultural mechanization will enable farmers to intensify production and increase productivity. Institutional factors such as access to extension and credit are also important in determining disadoption. Extension to farmer ratio is estimated at 1:1300 a situation that makes it practically impossible for many farmers to benefit from the services of extension officers. There is the need for more training and recruitment of extension agents to close the gap. Those already on the field are poorly resourced to undertake any effective actions. Extension must be resourced to enable regular supply of information to farmers to increase adoption.

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