IITA
Research to Nourish Africa

ISMA

Integrated *Striga* Management in Africa

Mid-Term and Cost–Benefit Study of Smallholder Farmers in *Striga*-Infested Maize and Cowpea Growing Areas of Northern Nigeria

P. Amaza, M.B. Hassan, T. Abdoulaye, A. Kamara, and M. Oluoch

www.iita.org

Integrated *Striga* Management in Africa

Mid-Term and Cost–Benefit Study of Smallholder Farmers in *Striga*-Infested Maize and Cowpea Growing Areas of Northern Nigeria

P. Amaza, M.B. Hassan, T. Abdoulaye, A. Kamara, and M. Oluoch

IITA Ibadan, Nigeria
Telephone: (234-2) 7517472
Fax: +44 208 7113786
E-mail: iita@cgiar.org
Web: www.iita.org

To Headquarters from outside Nigeria:
IITA, Carolyn House
26 Dingwall Road, Croydon, CR9 3EE, UK

Within Nigeria:
PMB 5320, Oyo Road
Ibadan, Oyo State

ISBN 978-978-8444-52-7

Correct citation: Amaza P., M.B. Hassan, T. Abdoulaye, A. Kamara, and M. Oluoch. 2014. Mid-term and cost-benefit study of smallholder farmers in *Striga*-Infested maize and cowpea growing areas of Northern Nigeria. International Institute of Tropical Agriculture, Ibadan, Nigeria. 40 pp.

Printed in Nigeria by IITA

Cover photos:
Random sampling selection of farmers for household interview and focus group discussion on the economic importance of *Striga* and farming; Kadale community in Warji Local Government Area, Bauchi State

Contents

Tables

Figures

Acronyms and abbreviations

AAFT	Africa Agricultural Technology Foundation
BMGF	Bill and Melinda Gates Foundation
CBO	community-based organization
FAO	Food and Agriculture Organization
FOS	Federal Office of Statistics
GM	gross margin
LGA	local government area
ISMA	Intergrated *Striga* Management in Africa
IITA	International Institute of Tropical Agriculture
NGO	nongovernmental organization
NBS	National Bureau of Statistics
OPV	open-pollinated variety
SSA	sub-Saharan Africa
SPSS	Statistical Package for Social Sciences
TVC	total variable cost

Acknowledgement

The authors wish to thank all the extension agents, lead farmers, and local government leaders who helped provide the organization and information in the survey communities and villages. The contribution of George Ucheibe, Reuben Solomon, and Ibrahim Kadafur of IITA, Kano Station for assisting in the organization, supervision, data collection, and data cleaning of the survey is highly acknowledged. In addition, the authors wish to thank Joseph Mbavai, Mercy Achina, Lucy Kamsang, and Mohammed Jajua for their assistance in data entry.

Executive summary

The Bill and Melinda Gates Foundation (BMGF) provided a 4-year financial support to the International Institute for Tropical Agriculture (IITA) and other partners in 2011 to adapt and intensively promote proven integrated *Striga* management strategies in cowpea and maize farming systems in northern Nigeria and western Kenya, with the active participation of farmers, community-based organizations, extension workers, policy makers, and researchers. The objective of the project is to improve the livelihoods of over 25 million smallholder farmers in the immediate impact zones of the project in northern Nigeria (15 million) and western Kenya (10 million) in the long term by developing and implementing a robust "*Striga* threat reduction strategy" that identifies and strategically promotes scientifically proven technologies that work on smallholder farmers' fields and which have direct effects on stopping *Striga* emergence, reducing the *Striga* seed bank in the fields, improving soil fertility, and increasing crop yields.

The management technologies being promoted in Northern Nigeria range from cultural practices such as crop rotation of maize with soybean which stimulates *Striga* to germinate but which later dies in the absence of the maize host to latch onto; and using *Striga*-resistant maize and cowpea varieties.

The ISMA project is expected to end in 2015, thus, it is pertinent to carry out a mid-term evaluation of the project with respect to adoption and benefit-cost analysis of the *Striga* management technologies among farming households in the project areas and make a comparison with non-intervention areas. In Nigeria, the Integrated *Striga* Management in Africa (ISMA) project was implemented in Kano and Bauchi states, both located in the savanna agroecology of northern Nigeria. The mid-term evaluation will provide the basis to present ISMA's achievement to policy makers, NARES, private sector partners, the BMGF, and other development partners. The result will also guide the scaling-up and scaling out of the project to other parts of the savanna ecological zones of northern Nigeria. It is within this context that the study was planned. The objectives of the study were to:

- Capture the *Striga* management technology adoption process.
- Determine the choice of technologies and mode of farmer–technology linkages.
- Carry out a cost–benefit analysis of the ISMA technologies on maize and cowpea production.
- Suggest appropriate recommendations for the success of the ISMA project in Nigeria.

Data for the study was obtained mainly from primary sources. The data was collected using structured questionnaires administered to 643 farmers in Kano (n = 334) and Bauchi (n = 309) states. The secondary data used was the baseline survey of smallholder farmers in *Striga*-infested maize and cowpea growing areas of northern Nigeria carried out in 2011. The data was analyzed using both descriptive, partial budgeting, and inferential statistics. Descriptive statistics were used to categorize the respondents according to socioeconomic characteristics. Partial budgeting was used to estimate and compare the profitability of ISMA *Striga* control technologies with local technologies, while the inferential statistics examined the likelihood of adoption of the various ISMA *Striga* control technologies among the sample farmers.

The study results revealed that the mean age among the respondents was 42 years in Kano State and 41 in Bauchi State, while the average years of farming experience was 22 years in both states. The level of formal education among the farmers was generally low with less than 50% of the farmers attaining a level higher than primary education.

The study found that 74% of respondent farmers in Kano State and 77% in Bauchi State participated in on-farm trials in project intervention areas. No respondent farmer participated in on-farm trials in non-intervention project areas as there were no project activities in those areas. The attendance at farmers' field days followed a similar pattern in the project intervention areas, whereby 77% and 66% of respondent farmers in Kano and

Bauchi states attended field days, respectively. However, in the non-project intervention areas, though field days were not held in the project areas, 23% and 34% of respondent farmers in Kano and Bauchi states, respectively, travelled to attend field days held in project areas.

The benefit cost analysis of the ISMA *Striga* control technologies has demonstrated the good performance of some of the technologies in terms of combating *Striga* and increasing crop yields with some technologies being highly profitable. The relative profitability of the ISMA *Striga* management technologies has positive implications for adoption among farmers.

The surveyed farmers are quite satisfied with the level of performance of the *Striga* control technologies, and the quality and purity of seeds obtained under the ISMA project. The proportion of farmers that were very satisfied and somewhat satisfied (61% in Kano State and 92% in Bauchi State) is an indication of the efficacy of the *Striga* management crop technologies. This level of satisfaction has a positive impact on the adoption of *Striga* control technologies.

Within the project communities in Kano and Bauchi states, respectively, 57% and 84% of the farmers knew about the *Striga* resistant maize monocrop; 24% and 12% were aware of *Striga* resistant cowpea, and 72% and 91% knew about *Striga* resistant maize in rotation with soybean. The rates of adoption of *Striga* management technologies are significantly higher for *Striga* resistant maize in rotation with soybean (63% in Kano and 78% in Bauchi) and *Striga* resistant maize monocrop (47% in Kano and 70% in Bauchi). However, the adoption for the *Striga* resistant cowpea monocrop was relatively low at 18% and 7% in Kano and Bauchi states, respectively.

The important significant factors that influenced the likelihood of adoption of *Striga* management technologies among farmers include: participation in project on-farm trials, the number of males older than 18 years, attendance at field days, farming experience, yield per hectare, contact with NGO/Project extension agents, number of extension visits by public extension agents, and revenue from non-farm activities.

From the study, the following recommendations are suggested that will enhance adoption and improve the success of the project.

Adoption rates have shown farmers' preference for the following technologies: maize–legume rotations and *Striga* resistant maize varieties. Thus, there should be increased efforts to promote and make available these technologies for uptake by farmers.

- Farmers in the survey areas have shown a preference for growing cowpea as an intercrop with cereals often with maize, sorghum, or millet. Given the relatively low adoption rates for Striga resistant cowpea sole varieties, there is need for the project to consider the breeding of appropriate cowpea varieties that can be grown as an intercrop with cereals.
- To effectively control *Striga*, the project should link up with other organizations that have the mandate for crops such as sorghum and millet that are often grown as an intercrop with cowpea by farmers. This will facilitate the control of *Striga* in the project areas.
- The benefit–cost analysis has revealed the increased profitability of *Striga* management technologies, especially *Striga* resistant maize and maize–soybean rotation. There should be increased efforts to scale-up the promotion and dissemination of these technologies among farmers.
- The regression results have identified factors that influence the likelihood of adoption of Striga management technologies. These factors show the importance of field days and participation in project activities, extension agents, and yield per hectare. The yield per hectare has implications for breeding of varieties that are high yielding. This will further influence the increased likelihood of adoption of *Striga* control technologies.

Traditional uprooting method of Striga control. The uprooted *Striga* has been collected for feeding of livestock. Bebeji Local Government Area, Kano State

1 Background

Striga has a bigger impact on humans and agroecosystems worldwide than any other of the estimated 4100 parasitic plant species (Nickrent and Musselman 2004). All *Striga* species except *Striga angustifolia* (Don.) Saldanha are dependent on a host to establish themselves, which makes them obligate parasites. *Striga* causes annual losses estimated to be worth US$1 billion and affects the livelihoods of more than 100 million people in sub-Saharan Africa (AATF 2005).

In Nigeria *S. hermonthica* has invaded about 835,000 ha of maize, directly affecting approximately 20 million people (Lagoke et al. 1991; Woomer et al. 2008) and in the northeast, *Striga* infestation has reached epidemic levels in most cereals, with over 85% of fields planted to maize infested with the parasite and crop damage ranging from 10% to 100% (Dugje et al. 2006).

Importance of maize and *Striga*

Maize is one of the major cereal crops grown in the Guinea savanna zones of Nigeria. It currently accounts for approximately 20% of domestic food production in West and Central Africa and is one of the major cereal crops with between 30% and 40% of area under production in Nigeria (CIMMYT 1990; Kamara et. al. 2006). The per capita income of most countries in the zone is very low and rapid increases in the human population and exploitative use of non-renewable resources has worsened food shortages. Therefore, producing adequate food has become a major challenge. Maize has also achieved the highest growth rate of the major crops since the 1970s (Kamara et. al. 2006).

Maize is consumed in starchy form in a wide variety of gruel, porridges, and pastes. As income increases and the population rises across the region, the demand for maize for food, animal, and industrial use increases rapidly. In the past two decades, maize production has spread rapidly into the savannas, gradually replacing traditional crops, particularly millet and sorghum because of its high productivity in areas with good access to fertilizer input and markets (CIMMYT 1990; Fakorede et al. 1999; Smith et. al.1994).

Despite the high yield potential of maize, its production is faced with numerous constraints. One of these is the problem of *Striga* infestation, which significantly reduces grain yield. The AATF (2006) estimated 822,000 hectares of maize fields in Nigeria to be affected by *Striga*, accounting for approximately 34% of land infested in Africa. The effect of *Striga* on maize is reduction in grain productivity ranging from 20% to 100%, often leaving farmers with limited or no food grain at harvest (AATF 2008).

Importance of cowpea and *Striga*

Nigeria is the largest producer and consumer of cowpea, accounting for about 45 percent of the world's cowpea production (Dugje et al. 2009). This was supported by Jefferson (2005) who rated Niger Republic as the second largest producer of the crop in Africa and the third globally. Cowpea has many uses such as fodder for animals, it acts as a cover crop for soil, and has the ablity to fix nitrogen. For instance, the International Institute of Tropical Agriculture (IITA) (2004) postulated that in improved, dual-purpose cowpea intercropped with sorghum or millet, the cowpea can fix and return between 25 and 45 kg of nitrogen per hectare capable of reducing the nitrogenous fertilizer requirement for cereal by half. The grain, leafy greens, green pods, fresh shelled green peas, shelled, and dried peas are great sources of food and vegetable for human consumption.

Despite its importance to the livelihoods of the majority of people in Nigeria, cowpea production is being threatened by *Striga* among other production constraints. The noxious parasitic weed *Striga gesnerioides* infects the roots of cowpea and can cause up to 50% losses in grain yield (Aggarwal and Ouredraogo 1989).

Overview of the agricultural sector in Nigeria

Nigeria is the most populous country in Africa, with an estimated population of about 160 million (2012) and currently growing at the rate of about 2.8 percent per annum. It lies wholly within the tropics, along the Gulf of Guinea in West Africa. It covers a geographical area of 923,768 square kilometers. This geographical area spans four broad ecological belts or zones, namely, the mangrove rainforest belt along the southern coast, the rainforest belts further inland, the Northern and Southern Guinea savanna belt in the central region, and the Sudan savanna and Sahel in the northernmost region of the country. The study area (Bauchi and Kano states) largely falls in the Guinea and Sudan savanna belt of the country.

An estimated 65 percent of the country's population lives in the rural areas where agriculture is the predominant occupation. It is estimated that about 70 percent of the rural population is engaged in agriculture (Muhammad-Lawal and Atte 2006). Generally, the agricultural sector is the single largest sector of the economy, contributing about 41 percent to the country's gross domestic product (GDP) with about 60 percent of the country's total workforce engaged in agriculture. The sector is also an important contributor to the nation's food security, foreign exchange earnings, and the supply of industrial raw materials (Olayemi et. al. 2004).

Nigeria has a total land area of about 98.3 million hectares. Although about 71.2 million hectares are cultivable, only about 34.2 million hectares or 48 percent are actually cultivated. Due to its high agroecological diversity, the country produces many agricultural products, consisting of a diverse range of staple food crops, cash and industrial crops, and livestock, fish and forest products. But overall, cereals, roots, and tuber crops constitute the largest category of agricultural products.

Nigeria is a nation of small-scale farmers who contribute over 90 percent of the country's total agricultural production. These farmers cultivate small land holdings, which are often less than two hectares in size and often in fragmented holdings.

The Integrated *Striga* Management in Africa (ISMA) Project

Striga infestation of cereal crops has had a negative impact on the livelihoods of smallholder farmers in Africa. To tackle this problem and improve the livelihoods of millions of smallholder farmers in northern Nigeria, IITA and partners CIMMYT, *icipe*, and BASF initiated a project in 2011, “Achieving Sustainable *Striga* Control for poor farmers in Africa”, also known as the Integrated *Striga* Management in Africa (ISMA) project, funded by the Gates Foundation. The project adopts and intensively promotes proven integrated *Striga* control strategies in targeted areas in northern Nigeria with the active participation of farmers, communities, extension workers, policy makers, and researchers.

Prior to the inception of the ISMA project, virtually all surveyed households in the study area were not aware of the improved *Striga*-control technologies (Mignouna et. al. 2013). Lack of awareness, resistance to change under the cover that traditional control practices are better, fear of technology failure, costs, and non-availability of *Striga*-resistant varieties were the major constraints to the use of improved technologies.

The ISMA project has been active for three years now. As the first phase of the project draws to an end in 2015, it is important to carry out a mid-term evaluation of the project. The mid-term evaluation will provide an opportunity to present ISMA’s achievement to policy makers, NARES, and private sector partners within and outside Nigeria, IITA, the BMGF, and other development partners. It will also guide the scaling-up and scaling-out of the project such as in other parts of the savanna ecological zones of northern Nigeria. It is within this context that the study was planned.

Objectives of the study

The mid-term household and cost–benefit survey aimed at understanding the changes since the inception of the ISMA project in 2011 that have occurred among smallholder farmers’ livelihoods in *Striga*-infested, maize and cowpea growing areas in two states of northern Nigeria; Bauchi and Kano. This is undertaken by specifically: (i) capturing the technology adoption process of *Striga* management technologies, (ii) determining the choice of technologies and mode of farmer–technology linkages; (iii) cost–benefit analysis of the ISMA technologies on maize and cowpea production; and (iv) making recommendations for the success of the project.

Maize-Soybean experimental and demonstration field, Ganjuwa Local Government Area, Bauchi State

Striga–Resistant cowpea field, Bebeji Local Government Area, Kano State

2 Methodology and Sampling

Study area

The study was conducted in the savannas of two states—Bauchi and Kano, located in northeastern and northwestern Nigeria, respectively (Fig.1). The locations were chosen because of the presence of severe *Striga* infestation in the farmers' fields.

Bauchi State lies between latitude 9°30' and 12°30' North and longitudes 8°45' and 11°0' East. The State occupies a total land area of 45,837 km^2, representing about 5.3% of Nigeria's total land mass (Adaba et al. 2008). The State spans two distinct agroecological zones: the Sudan savanna and the Northern Guinea savanna. Some smaller areas of the State fall under the Sahel savanna and the Southern Guinea savanna. According to the 2006 Census, the State has a population of 4,676,465. The State is bordered by seven states: Kano and Jigawa to the north, Taraba and Plateau to the south, Gombe and Yobe to the east, and Kaduna to the west.

The weather is hottest in the months of March to May, with temperatures rising up to 40.55 °C and coolest in the months of November to February when the temperature may fall as low as 9.11 °C The annual rainfall ranges from 700 to 1300 mm with a relative humidity of about 12% in February and 68% in August (Muhammad 2003).

Kano State is located at 12°37' North, 9° 29' East, 9°33' South, and 7°43' West. It is bordered by Jigawa State on the east, by Bauchi and Kaduna states to the south, and Katsina State to the west. It covers a land area of 20,760 km^2.

The State lies in the tropical wet and dry climatic zone. The average annual rainfall is about 1000 mm in the southern part of the state, 800 mm around metropolitan Kano, and about 600 mm in the northeast. The rainy season usually covers the months of April to October. This is followed by harmattan which usually begins in November and ends in February.

Kano State has a population of 9.4 million whose livelihood also depends on agriculture. The State largely falls within the Sudan savanna ecological zone. Agriculture is the largest sector in Kano State in terms of provision of employment and income to its populace. Over 70% of the working population is directly or indirectly engaged in agriculture-related activities. The farming practices are dominated by crop production and livestock-based production systems. The dominant crops include maize, cowpea, groundnut, sorghum, rice, and millet. The livestock types are mainly cattle, sheep, goats, and poultry.

The intensity of agricultural activities in the state has led to the development of specialized markets within the Kano metropolis for agricultural products. There are specialized markets for fruits and vegetables, cereals, groundnuts, tubers, and so on. Industrially, commerce is the second largest sector of the Kano economy. This state has witnessed tremendous growth in large, medium, and small-scale commercial outfits. Commercial activities include the sale and distribution of imported and locally made goods such as textiles, cosmetics, chemicals, pharmaceuticals, spare parts, vehicles, buildings materials, and electronics.

Sample selection and data collection

A multi-stage sampling technique was used to select respondents for the study. Two states—Kano and Bauchi—were purposely selected based on the areas where ISMA project is being implemented. In each of the two states, eight Local Government Areas (LGAs) were purposely selected; comprising five where the

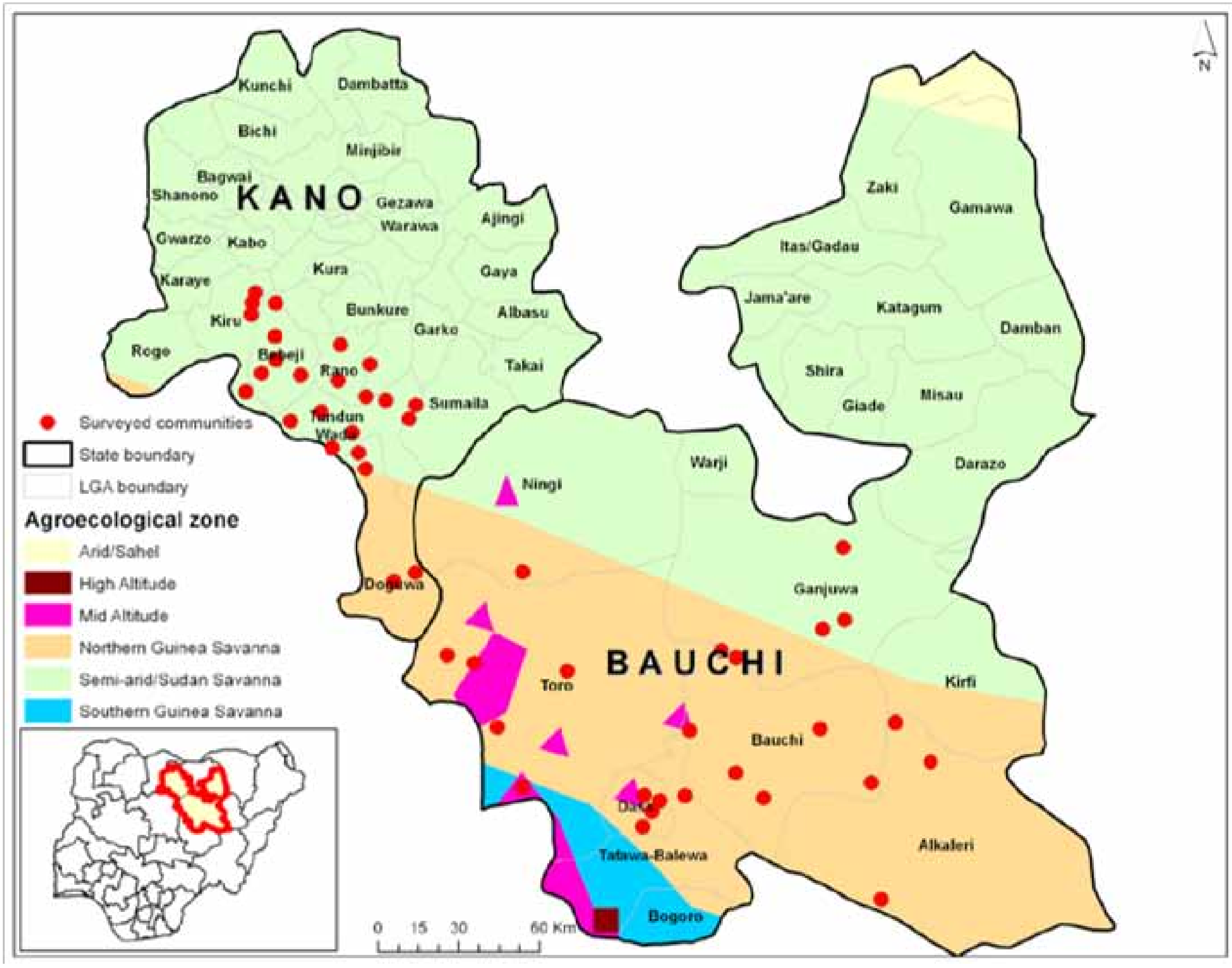

Figure 1. Location of Bauchi and Kano states.

ISMA is being implemnted and three non-ISMA project LGAs (counterfactual). In each of the selected sites, five participating communities were selected in each LGA, and farmers were randomly selected in each communuity. Thus, a total of 375 participating farmers were selected from the two states (treated group) with 179 and 196 participating farmers in Kano and Bauchi states, respectively. For non-project implementation areas (counterfactual), a total of 268 non-participating farmers were randomly selected from the two states, with 155 and 113 farmers seleted in Kano and Bauchi states, respectively. The total sample of 643 were selected farmers in both project and non-project areas of the two states (Kano - 334 farmers; Bauchi - 309).

The data was collected with the aid of structured questionnaires designed to capture farmer and household level information on a range of indicators related to *Striga*-infested maize and cowpea crops of both participating and non-participating farmers in the ISMA *Striga* control project communities. The questionnaire contained information on household demographic characteristics, intra-household decision making, productive resources endowment, production inputs, *Striga* extent, severity and control technologies, vulnerability, capital assets and livelihoods, livelihood strategies and outcomes and household expenditure. The pre-tested questionnaires were administered by trained enumerators prior to the actual data collection in February/March 2014.

Data analysis

The collected data were entered using SPSS spreadsheet. The data were analyzed using descriptive statistics, budgeting, and the Logit regression models. The analytical models are further discussed in this section.

Descriptive statistics

Frequency counts, cross tabulations, percentages, and mean computations and tests of significance were used to describe the variables in the study such as farmer-specific characteristics, household characteristics, adoption rates of improved ISMA technologies, etc. and these were presented in tables and charts.

Budgeting

The budgetary technique was used to determine the profitability of using ISMA technologies in crop production. It provided actual information on farm-input use and costs, output and prices, and farmers' gross margins. The gross margin budget examines the returns to the farmers' resources, which consist of owned land, family labor, capital, and other production inputs. The procedure involved the estimation of the costs and returns from production data for the 2013 crop-production season. In developing the gross margin, estimates of production cost and gross revenue from crop outputs were collected from the cross-sectional survey data of the sampled farmers in both intervention and non-intervention project areas. In estimating the production cost, family labor cost which was not paid for by the farmers, was estimated as its opportunity cost by using the market wage rate for labor in the study area. The gross margin from production activities is the gross value of crop outputs less all the variable costs incurred on the same crops during the production year (2013).

The gross margin was estimated as

$$GM = \sum piqi - \sum rjxj \qquad (1)$$

Where:

GM = Farm gross margin
pi = Unit price of output i
qi = quantity of output i
rj = unit cost of the variable input j
xj = quantity of the variable input j

The Limited dependent regression model

The Logit model was used to examine the probability of adoption and the factors that likely influenced farmer's decision to adopt improved *Striga* management technologies. The choice of logit model was largely influenced by available data. In examining the likelihood of factors affecting the adoption of improved *Striga*-management technologies, the specific technologies that were promoted were treated individually.

The Logit regression model was employed to examine the factors that influence the likelihood of adoption of ISMA technologies by the adopters. In examining the likelihood of adoption, three ISMA technologies that were promoted were considered: *Striga*-resistant maize, *Striga*-resistant maize grown in rotation with soybean, and *Striga*-resistant cowpea varieties.

Specification of the Logit adoption model

The Logit model as been shown by Capps and Crammer 1985; Akinola 1987; Adesina and Zinnah 1993; and Adesina and Seidi 1995 to be more precise and appropriate in analyzing the relations involving binary dependent variable and a set of independent variables. The model assumes that a farm household's decision to adopt a given technology, Y_i, in a given period is assumed to be derived from the maximization of expected utility (increased yield and income). However, the utility derivable from any new technology depends on a vector of explanatory variables, Xi. Thus, the probability that a household will adopt an ISMA technology with an increased yield or income objective is a function of the vector of explanatory variables, Xi, the unknown parameters, βi, and the error term, μ_i, assumed to be independently N (0, σ^2) distributed, conditional on the X_i's. This is expressed as:

$$Y^* = X\beta + mi \qquad (2)$$

Y* is a latent variable (the expected utility) that is unobservable. If data for the dependent variable is above the limiting factor, zero in this case, Y_i is the dependent variable which is observed as a continuous variable (e.g., proportion of land area cultivated to crop ISMA technologies by the i^{th} household). If Y_i is at the limiting factor, it is held at zero.

This relationship is presented mathematically in the following two equations:

$$\mathbf{Y}_1 = \mathbf{Y}_1^* = \mathit{if}\ \mathbf{Y}_{1i}\ \mathbf{Y}_1 = 0\ \mathit{if}\ \mathbf{Y}_1^* < \mathbf{Y}_1 \qquad (3)$$

where Y_i is the limiting factor. These two equations represent a censored distribution of the data. The Tobit model can be used to estimate the expected value of Y_i as a function of a set of explanatory variables (X_i), which represents households' socioeconomic-, technology-, and institution-related factors, weighted by the probability that $Y_i > 0$. Since the disturbance term, μ_i, is a function of the independent variables, an attempt to estimate equation (2) using Ordinary Least Squares will result in biased and inconsistent estimates (Maddala 1983; Gujarati 2006). The use of maximum likelihood estimation guarantees that the parameter estimates will be asymptotically efficient for the appropriate statistical tests to be performed (Pindyck and Rubinfeld 1997). Maddala (1983) shows that the expected intensity of adoption, E(Y), is:

$$E(Y) = X\beta F(z) + \alpha\ f(z) \text{and } z = {X\beta}/{\alpha} \qquad (4)$$

Where F (z) is the cumulative normal distribution of z, f (z) is the value of the derivative of the normal curve at a given point (unit normal density), z is the Z-score for the area under the normal curve, and s is the standard error of the error term. The coefficients for variables in the model, β, do not represent marginal effects directly, but the sign of the coefficient will give information as to the direction of the effect.


Farmers children near a *Striga* management technology demonstration farm, Tudun Wada Local Government Area, Kano State

Description and measurement of variables in the Logit model
This section describes the variables included in the model based on the adoption literature and the reasons for their inclusion. The expected signs of the coefficients of the variables were predicted based on past studies, economic theory, and/or logical reasons.

To apply the empirical model of adoption a dichotomous choice situation as to whether or not a farmer adopts a particular improved ISMA technology and/or management practice is considered. This is taken as the dependent variable and it is hypothesized that the decision to adopt is influenced by the independent variables. The independent or explanatory variables include all those variables that are associated with the adoption of the ISMA technologies along with those whose evidences from previous studies have been inconsistent. They include farm characteristics, household demographic and socioeconomic factors, resource/technology, and institutional factors. These variables are discussed as follows:

Expected signs of independent variables

Farmer specific characteristics (age, gender, education levels, training, farm size, etc.)
Evidence from previous studies shows that the age of an individual affects his attitude to new ideas and may influence adoption in one of several ways. Younger farmers have been found to be more knowledgeable about new practices and may be more willing to bear risks and adopt a technology because of their longer planning horizons (Polson and Spencer 1991). Older farmers are less likely to adopt new ideas having gained more confidence in their old ways and methods. However, older farmers could also have acquired more experience, resources, or authority that may give them more possibilities for trying a new idea or technology. Generally, there is no agreement on the sign of this variable in the adoption literature as the direction of the effect is location and/or technology specific (Adesina and Zinnah 1993). The variable is measured in years.

***Gender of farmer**:* The sex of a farmer affects the adoption of a technology. This is because women farmers are generally perceived to face more constraints on their farms than men and this will negatively affect their adoption of new ideas. This variable is measured as a dummy where male farmers scored 1, and female farmers scored zero.

***Level of education**:* Education increases the ability to assess, interpret, and process information about a new technology, enhancing farmers' managerial skills including efficient use of agricultural inputs (Feder et al. 1985; Binam et al. 2004). It is therefore expected to have a positive impact on the decision to use or adopt a technology. It is hypothesized that acquisition of formal education is positively related to adoption behavior. It is measured as a dummy, and scored 1 if farmer has formal education and zero if not.

Labor: Adopting a new technology often implies a need for additional labor, such that labor availability is frequently associated with successful adoption. Hence, adoption of a technology is usually less attractive for farmers with limited labor or those operating in areas with less access to labor markets (Feder et al. 1985). It is measured in man-days and hypothesized to have a positive sign with the adoption of a technology.

***Farm size**:* This variable is expected to have a positive relationship with farmers' adoption decision as shown by various studies (Akinola 1987; Polson and Spencer 1991). Moreover, farmers with larger farms will be more willing to devote portions of the land to an untried, new technology compared with those with smaller ones. This is because, the larger the farm size cultivated, the higher the tendency to adopt. Therefore, farm size is expected to have a positive impact on adoption. The variable is measured in hectares.

Institutional factors (membership of association, distance to markets, distance to source of inputs, extension contact, extension visits, etc.

Membership of association: Membership of social organizations and cooperatives enhances the interaction and cross-fertilization of ideas among farmers. Thus, this variable is very important in the adoption of a technology since it indicates higher socioeconomic status. A positive sign is hypothesized on this variable. It is measured as a dichotomous variable with respondents' membership attracting 1 and non-membership, zero.

Extension contact: Farmers must have information about the intrinsic characteristics of ISMA *Striga* control technologies before they can consider adopting them or not. Contact with extension agents exposes farmers to information on new ideas and technologies and demonstrations by extension agents on a regular basis (Herath and Takeya 2003). It can therefore stimulate adoption (Polson and Spencer 1991). The impact of this information on adoption decisions vary, however, according to its channel, sources, content, motivation, and frequency (Ereinstein and Cadena 1997). Thus, based on the innovation–diffusion literature, the expected sign for the coefficient of this variable is positive. It is measured as the number of times the respondent has had contact with extension during the period.

Technology physical characteristics

Farmers make subjective inter-varietal comparison of the attributes of local *Striga* control and ISMA *Striga* control technologies and they adopt ISMA *Striga* control technologies only when they are perceived as having better characteristics than the local *Striga* control technologies.

Farmers involved in *Striga*-resistant on-farm maize demonstration, Bebeji Local Government Area, Kano State

3 Results and Discussion

Farmer's socioeconomic characteristics

The major socioeconomic characteristics of farmers covered in the survey are presented in Table 1. These characteristics relate to the relative frequency distribution of household heads by gender, age, farming experience, household size, nearest market distance, nearest extension office distance, marital status of household head, and major occupation of household head.

Gender and marital status

The pattern of gender distribution of farmers was similar across the states in both project intervention and non-intervention areas surveyed (Table 1). The similarity may be explained by similarity in cultural and socioeconomic conditions in the two states. There is also similarity in the marital status of the surveyed farmers. However, in relative terms, the percentage of monogamous male-headed households was marginally higher in Kano (non-project area). But there is similarity in polygamous household heads' marital status in both the project areas of Kano and Bauchi states.

Age and farming experience of household head

Age, in correlation with farming experience, has a significant influence on the decision-making process of farmers with respect to risk aversion, adoption of improved agricultural technologies, and other production related decisions (Amaza et.al. 2007; 2009). Furthermore, age is said to have a direct bearing on the availability and mobility of farm manpower, the ease with which improved practices are adopted and the size of farm area cultivated by the farmer at any given time. The mean age of the respondent farmers was 43 years in Kano State and 41 years in Bauchi State surveyed project intervention and non-project intervention areas (Table 1). There seems to be a dominance of aged farmers in the study area. This has adverse implications for increasing agricultural productivity, since maize and cowpea production are largely labor intensive. There is also a positive correlation between the age of farmers and the years of farming experience. The mean farming experiences of the respondents were 23 years and 21 years, respectively in Kano and Bauchi states (project areas); while for the non-project areas it was 21 and 22 years, respectively.

Household size

The significance of household size in agriculture hinges on the fact that the availability of labor for farm production, the total area cultivated to different crop enterprises, the amount of farm produce retained for domestic consumption, and the marketable surplus are all determined by the size of the farm household. The pattern of household sizes was similar across the two states. The mean household size for both states was 13 and 11 persons in project areas and non-project areas, respectively. But, in relative terms, the mean household size was higher in Bauchi State for both project and non-project areas.

Distance to nearest market

The distance to the nearest market has some influence on farmers' production decisions and adoption of agricultural technologies. Both states have similar distances. However, distance to market is marginally lower in the project areas in Kano (8 km) compared to Bauchi (9 km). Kano State has more opportunities for commercialization compared to Bauchi State. This factor seems to have contributed to the intensity of agricultural activities in the state, which has subsequently led to the development of specialized markets within the Kano metropolis for agricultural products, including those for, cereals, groundnut, fruit and vegetables, tubers, and so on.

Table 1. Characteristics of sampled farmers.

Variable	Project Area			Non-Project Area		
	Kano (N = 179)	Bauchi (N = 196)	Mean (N = 375)	Kano (N = 155)	Bauchi (N = 113)	Mean (N = 268)
Gender (%)						
Female	0.7	3.5	4.2	0	5.1	5.1
Male	99.4	96.5	195.8	100	94.9	194.9
Marital status of household head (%)						
Single	2.8	4.6	7.4	3.9	7.1	10.9
Monogamous	45.8	42.4	88.2	54.2	43.4	97.6
Polygamous	51.4	53.1	54.5	41.3	46.9	88.2
Divorced	0	0	0	0.7	2.7	3.3
Age (mean)	43.4	41.3	42.3	42.8	41.1	42.1*
Farming experience (years)	22.6	21.4	21.9	21.3	22.21	21.7
Household size (number)	11.4	12.9	12.24*	9.9	11.3	10.5
Nearest market distance (km)	7.7	8.9	8.3	8.5	7.3	8.0
Nearest extension office (km)	9.2	10.91	10.08*	8.3	10.8	9.3
Major occupation (%)						
Farming	81.0	84.2	165.2	87.1	88.5	175.6
Trading	11.7	6.6	18.4	9.0	7.1	16.1
Civil servant	3.9	4.1	7.9	2.6	1.8	4.4
Technical skills	0.6	2.0	2.6	0	0.9	0.9
Others	2.8	3.1	5.9	1.3	1.8	3.1

**Significant at 0.01; **at 0.05*

Nearest extension office

Table 1 further shows that the distance of the nearest extension office to the respondents is similar in both the project areas and non-project areas of Kano and Bauchi states. This suggests that farmers in the surveyed areas have the potential of having equal access to extension services.

Major occupation of household head

The majority of the respondents, 81% and 84% of the respondents in project areas) and 87% and 89% in non-project areas in Kano and Bauchi states, respectively, consider farming their predominant occupation. This finding has an important implication for farm production decisions by the households. The dependence of farm-families on farming as the predominant occupation may have a positive or negative effect on agricultural production, depending on the availability and allocation of household resources. In a situation where farm-families have capital constraints due to low income from farming, there is likely to be heavy reliance on family labor and low input technology to carry out farming operations. Consequently, in the event of crop failure or low yields due to *Striga* infestation, farm-families are likely to be faced with the problem of food insecurity arising from both lack of availability and lack of accessibility to sufficient food.

Human capital

Many studies have shown that human capital which includes level of education, skills, participation in on-farm trials, attendance at field days, and so on helps farmers to use production information efficiently, as a more educated person acquires more information and, to that extent, is a better producer (Lockheed et al. 1980; Phillips, 1994, Wang et al. 1996; Yang 1997). The level of farmers' education is believed to influence the use of improved technology in agricultural production and, hence, farm productivity. In some studies in Nigeria (Durojaiye and Olanloye 1992; Awolola 1995) it was reported that education contributed positively and significantly to agricultural production.

The educational level of household heads (Table 2) shows that the level of formal education among the farmers is generally low. In relative terms, farmers in Kano attained higher levels of formal education compared with farmers in Bauchi State in both project and non-project areas. This low educational level seems to account for the predominance of traditional practices in crop production and the associated low input technology. This phenomenon tends to result in low productivity.

Participation in on-farm trials and field days create demand for ISMA *Striga* control technologies. The level of farmers' participation in on-farm trials and attendance of field days is presented in Table 3. In the project area, 74% and 77% of survey respondent farmers in Kano and Bauchi states, respectively, participated in on-farm trials. As expected, no respondent farmer participated in an on-farm trial in non-intervention project areas as there were no project activities.

The attendance at farmers' field days followed a similar pattern in the project intervention areas, whereby 77% and 66% of respondent farmers in Kano and Bauchi states attended field days, respectively. However, in the non-project intervention areas, field days were not held although 23% and 34% of respondent farmers in Kano and Bauchi states, respectively, travelled to attend field days held in project areas. Information about such field days might have emanated from the media, other farmers in project communities, or even extension agents involved in the ISMA project. This might have influenced the farmers' decision to attend the field days. It is plausible that the level of farmers' participation in on-farm trials and attending field days influences the adoption levels of ISMA *Striga* controlled technologies.

Table 2. Educational level of respondents.

Variable	Project Area			Non-Project Area		
	Kano (N = 179)	Bauchi (N = 196)	Mean (N = 375)	Kano (N = 155)	Bauchi (N = 113)	Mean (N = 268)
Educational level	Percent of farmers					
None	23.5	15.8	20.3	24.5	23.9	24.4
Primary school	26.8	21.9	48.8	30.3	21.2	51.6
JSS	6.2	9.7	15.8	5.8	6.2	12.0
SSCE	21.8	20.9	42.7	12.3	14.2	26.4
OND/NCE	4.5	9.2	13.7	5.8	7.1	12.9
HND, degree, and above	3.4	1.5	4.9	2.6	0.9	3.5
Others	14.0	20.9	34.9	18.7	26.6	45.3

Table 3. Participation in on-farm trials and attendance at field days.

	Project Area		Non-Project Area	
Participated in on-farm trial[1]	**N**	**%**	**N**	**%**
Kano	133	74.3	0	0
Bauchi	151	77.0	0	0
Attended field days				
Kano	137	76.5	42	23.5
Bauchi	130	66.3	66	33.7

[1]*Participation refers to members of a CBO which leads the farm trials*

Farmers responding to questions from an enumerator during household survey; Yamrat village, Bauchi Local Government Area, Bauchi State


Farmers involved in *Striga* and herbicide resistant on-farm maize demonstration, Bebeji Local Government Area, Kano State

4 Adoption of ISMA technologies

Awareness of ISMA technologies

In the adoption process of a new technology, farmers must first of all be aware of the new technology, including its advantages before they accept and adopt the technology. In the ISMA project communities in Kano and Bauchi states, respectively, 57% and 84% of the farmers knew about *Striga* resistant maize monocrop; 24% and 12% were aware of *Striga* resistant cowpea, and 72% and 91% knew about *Striga* resistance maize in rotation with soybean (Table 4).

On the contrary, in the non-intervention survey areas, the proportion of farmers that were aware of the ISMA *Striga* management technologies was considerably much lower for all the three ISMA *Striga*-management technologies at 18% and 14% for *Striga* resistant maize; 16% and 3% for *Striga* resistant cowpea monocrop, and 14% and 3% for *Striga* resistant maize in rotation with soybean in Kano and Bauchi states, respectively. The level of awareness of these farmers in the non-intervention project areas is likely influenced by two factors. First, 24% and 34%, respectively, of farmers in ISMA non- intervention communities attended field days that were held in ISMA project areas (Table 3). This might have created awareness among such farmers in non-project intervention communities. Secondly, awareness could have been created through farmer-to-farmer information sharing between farmers in the ISMA project intervention communities and non-ISMA intervention communities. Farmer-to-farmer extension is an informal system in which an individual farmer in a community assists other farmers by sharing information on improved technologies with other farmers (Gwary 2008). Such information sharing is critical to adoption and facilitates the use and therefore the adoption of technologies. This factor plausibly influenced the awareness of the ISMA *Striga* controlled technologies in the non-ISMA project areas.

Table 4. Percentage distribution of knowledge of integrated *Striga* management technologies among farmers in project intervention areas

ISMA crop technologies	Project area		Non-project area	
	Kano	Bauchi	Kano	Bauchi
	Percent of farmers that knew about ISMA technologies			
Striga resistant maize	56.8 (96)	83.5(137)	17.5 (27)	14.0 (17)
Striga resistant cowpea	24.4 (44)	12.2 (23)	15.6 (24)	2.5 (3)
Striga resistant maize in rotation with soybean	71.8 (122)	90.5(152)	14.3 (22)	2.5 (3)

Numbers in parentheses are number of respondents.

Table 5. Comparison of awareness of knowledge of ISMA *Striga* management technologies during the Baseline survey and the current mid-term survey (% of farmers that were aware).

ISMA *Striga* control technologies	Kano		Bauchi	
	Baseline survey (2012) (n = 300)	Mid-term survey (2014) (n = 334)	Baseline survey (2012) (n = 300)	Mid-term survey (2014) (n = 309)
Striga resistant maize	26.0	56.8	8.0	83.5
Striga resistant cowpea	20.0	24.4	5.7	12.2
Striga resistant maize in rotation with soybean	30.3	71.8	19.3	90.5

The relatively higher proportion of farmers in the project communities that were aware of the respective ISMA crop technologies is directly associated to the promotion of ISMA *Striga* controlled activities, including mobilization of farmers. The social mobilization has positively influenced the adoption rates of ISMA *Striga* controlled technologies as shall be examined later.

A comparison of awareness of knowledge of *Striga* controlled technologies before the ISMA project intervention (baseline) and the current ISMA *Striga* controlled technologies is presented in Table 5.

The awareness level of ISMA *Striga* controlled technologies was dismally low prior to ISMA project intervention at 6%, 8%, and 19% and 20%, 26%, and 30% for *Striga* resistant cowpea sole crop, *Striga* resistant maize sole crop, and *Striga* resistant maize in rotation with soybean respectively, in Bauchi and Kano states.

Analysis of the two-survey data revealed that the ISMA project has, over a period of two years, significantly raised the level of awareness of knowledge of *Striga* control technologies in the project areas by over 100% for all the three *Striga* control technologies in the project areas with the exception of *Striga* resistant cowpea sole crop in Kano State, which was 83%.

Choice of technologies *(adopters and non-adopters in project intervention areas; and counterfactual areas in Bauchi and Kano States.*

The proportion of farmers that adopted the respective ISMA crop technologies in project intervention and non-intervention areas is presented in Figure 2.

In the ISMA project areas, the rates of adoption are significantly higher as expected for *Striga* resistant maize in rotation with soybean (63% in Kano and 78% in Bauchi) and *Striga* resistant maize monocrop (47% in Kano and 70% in Bauchi). The high adoption rates for *Striga* resistant maize in rotation with soybeans and *Striga* resistant maize monocrop varieties validates the gravity of *Striga* menace in cereals production in the study

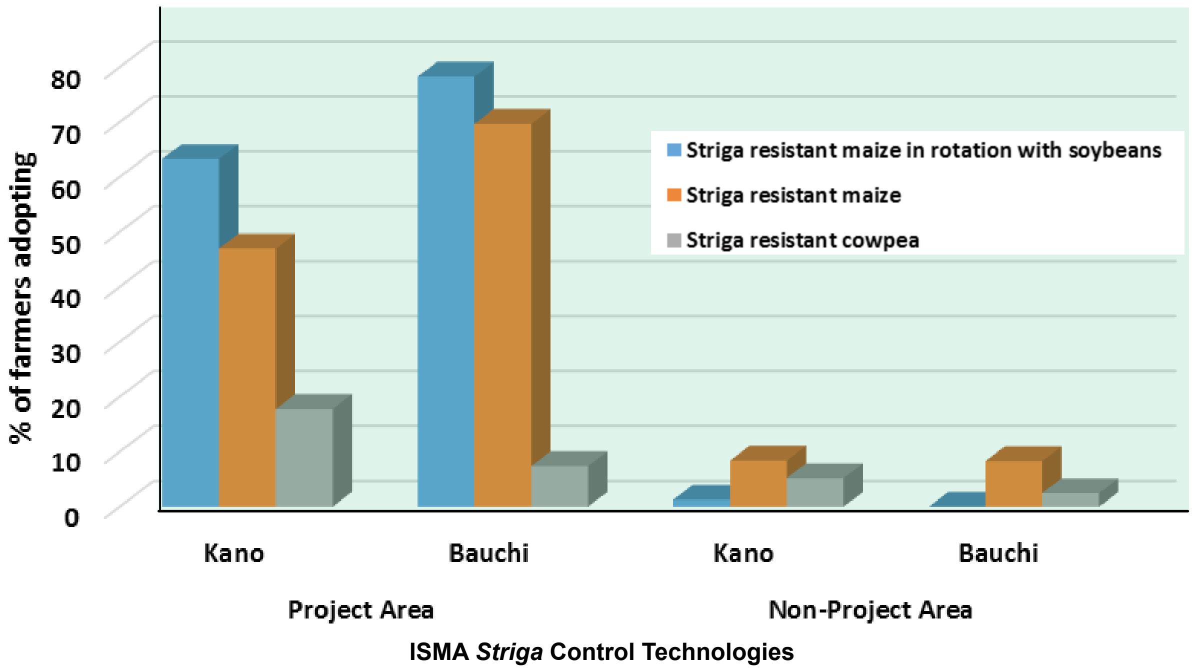

Figure 2. Adoption rate of ISMA crop technologies in Kano and Bauchi states.

areas. In addition, the adoption rates is in conformity with an adoption rate of 84% for new maize varieties in the PROSAB project area of Borno State, Nigeria (Ellis-Jones et. al. 2009). However, the adoption for *Striga* resistant cowpea monocrop was relatively low at 18% and 7% in Kano and Bauchi states, respectively. The relatively low rates of adoption of *Striga* resistant cowpea monocrop is likely associated with the farmers' preferred cropping system where they prefer to grow cowpea as an intercrop with cereals such as maize, sorghum, or millet. Thus, the growing of *Striga* resistant cowpea monocrop does not seem to fit the farmers' preferred cropping pattern. Within the ISMA project communities, adoption rates for all the ISMA crop technologies are relatively higher in Bauchi State, except for *Striga* resistant cowpea. Kano farmers may have several other options in controlling *Striga* since they have more access to input dealers particularly the use of imppved seeds, fertilizer and pesticides. Kano State also has several other agricultural development programs run by NGOs.

In the non-ISMA intervention areas, the adoption rates were considerably lower ranging from zero to 1% for *Striga* resistant maize in rotation with soybean; 5% and 7% for *Striga* resistant cowpea monocrop in Bauchi and Kano states, respectively, and 8% for *Striga* resistant maize monocrop in both states. This significantly low rates of adoption of ISMA crop technologies in non-ISMA intervention areas are expected given the relatively lower levels of awareness of the ISMA *Striga* management technologies among farmers in non-project areas. It is possible that the relatively low rates of adoption of the respective *Striga* management technologies in the non-intervention areas, without any promotional efforts, might have been influenced by farmer-to-farmer technology sharing between farmers in the ISMA project communities and those farmers in the non-intervention communities.

The adoption rates of ISMA *Striga* control technologies before the ISMA project intervention (2012) compared with two years after ISMA intervention (2014) is presented in Figure 3.

The figure reveals a similar trend in the adoption rates of ISMA *Striga* control technologies with the level of knowledge awareness of ISMA *Striga* control technologies presented in Table 5. The adoption rates had increased by well over 100% for all the three technologies under consideration. In addition, there is a positive correlation between the levels of knowledge awareness and the adoption rates of ISMA *Striga* control technologies prior to project intervention and three years after intervention (2014). The changes in the adoption rates prior to the ISMA project intervention and three years after intervention (Fig. 3) clearly demonstrate the effectiveness of the ISMA project in influencing the changes in adoption rates of the ISMA *Striga* control technologies.

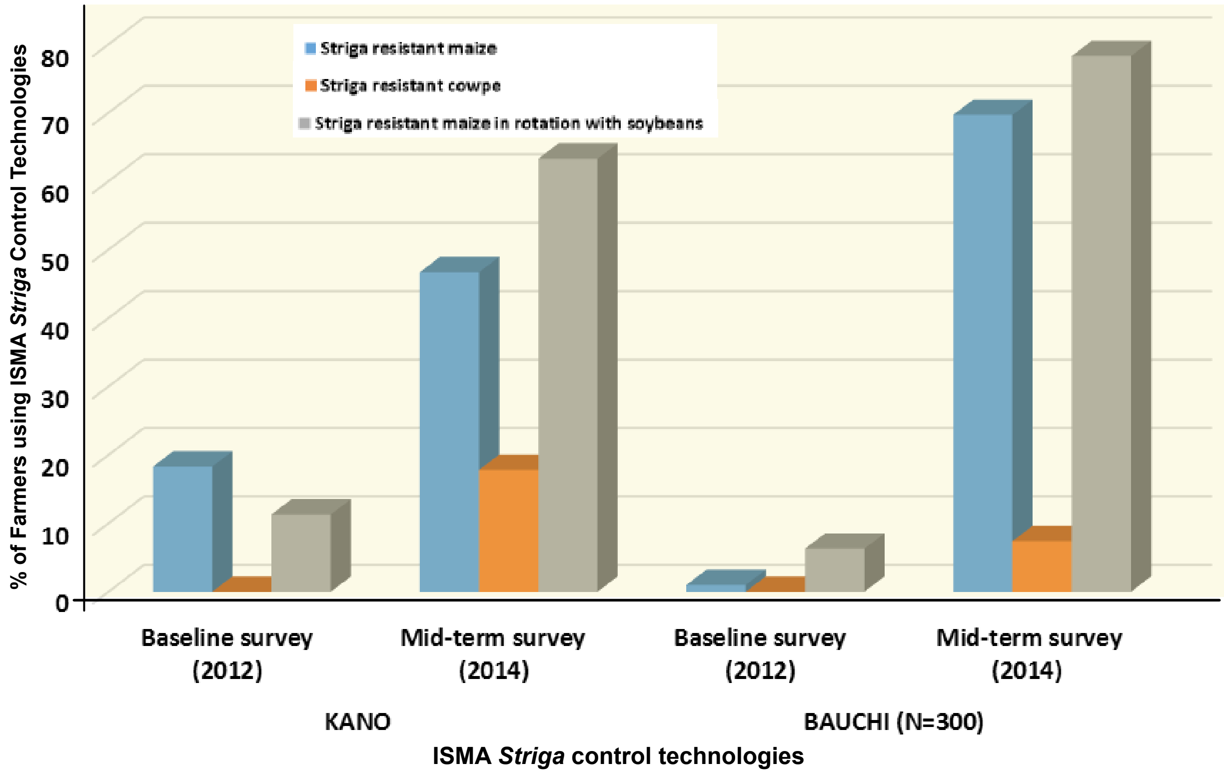

Figure 3. Comparison of adoption rates of ISMA *Striga* control technologies before ISMA project intervention (2012) and current mid-term period (2014).

Women farmers participating in the Focus Group Discussion. Gwaltukulwa Community, Dass Local Government Area, Bauchi state

Table 6. Average areas of land planted with following ISMA technologies in the project areas.

ISMA Striga management technologies	Kano		Bauchi	
	n	Land area (ha)	n	Land area (ha)
Striga resistant maize	86	1.80	95	2.11
Striga resistant maize in crop rotation with legumes	24	1.71	3	1.67
Striga resistant cowpea	22	1.50	10	1.70

Area planted with ISMA crop technologies

The mean area planted with improved varieties by the adopters of ISMA *Striga* management technologies is presented in Table 6. As presented, the mean area planted by the farmers that adopted *Striga* improved varieties was 1.8 ha and 2.2 ha, while the mean area planted with *Striga* resistant maize in crop rotation with legumes was 1.71 ha and 1.67 ha in Kano and Bauchi states, respectively. The mean area planted with *Striga* resistant cowpea was 1.50 ha in Kano State and 1.70 ha in Bauchi State. Prior to the implementation of the ISMA *Striga* management technologies project, there was a low level of awareness on improved *Striga* control technologies, thus their level of use is very low or zero (Bauchi State)

It can be observed that, among the adopted ISMA *Striga* management technologies, *Striga* resistant maize has the highest degree of adoption in terms of proportion of land area under the crop technologies in both States. Following *Striga* resistant maize, *Striga* resistant maize in crop rotation with legumes and *Striga* resistant cowpea are the second most preferred crop technologies in Kano and Bauchi States, respectively.

Factors influencing adoption of ISMA technologies

In analyzing the factors that influence the likelihood of adoption of ISMA crop technologies among the sample farmers, a logit model was estimated using dummy variables (1, 0) for adopters and non-adopters as the dependent variable. Household characteristics and other production factors are explanatory variables. The estimate function is as follows:

Adoption = f (Sex, Mstatus, Education, Experience, Revenue, Contact, Yield, Colcw, Thincom, Yrsmember, Male2, Female2)

Where:

Adoption = dummy variable (where 1= adopters of improved ISMA technologies and 0= otherwise and dependent variable
Sex = Gender of household head (dummy variable where 1 = Male and 0 = female)
Mstatus = Marital status of household head (dummy variable 1 = Married and 0 = otherwise)
Education = number of years of formal education of household head
Part = participation in on-farm ISMA trial
Field day = Attended ISMA field day
Experience = Number of years household head has been farming
Male = Number of males in household > 18 years old
Female = Number of females in household > 18 years old
Extension Contact1 = Extension contact with public extension agents
Extension Contact2 = Extension contact with NGO/Project extension agents’ public extension agents
Visit 1 = Number of visits of public extension agents contact
Number of visits of NGO/Project extension agents
Revenue = dummy variable (where 1 = farmer has other sources of income and 0=otherwise)
Yield = cowpea yield in kg/ha
Thincom = Frequency of extension visit (number)
Yrsmember = Number of years farmer has been member of CBO (not part of the data collected)
Male2 = Number of men (> 18 years) in the household
Female2 = Number of females (> 18 years) in the household
Yield = Yield per ha

The logit regression results (Table 7) indicate that participation in on-farm demonstration trials, number of males that are more than 18 years old, attendance at ISMA field days, farming experience, yield per hectare, contact with NGO/Project extension agent, number of extension visits by public extension agents, and revenue from non-farm activities had significant effects in influencing the likelihood of adoption of ISMA crop technologies among farmers in the study area.

The gender variable was significant at 5% where at least one of the ISMA technologies was adopted. This implies that male farmers had more likelihood of adopting any of the ISMA crop technologies. Men have relatively better access to agricultural resources, including land, inputs, credit, and so on.

Participation in on-farm ISMA demonstration trials by the sample farmers was significant in influencing the likelihood of adoption of *Striga* resistant maize varieties in the study area. This is not surprising because such participation could lead to so many benefits to the farmers. For instance, 1106 farmers, representing 72% of farmers that received ISMA seed varieties participated in the on-farm trials. Other forms of assistance are technical assistance, provision of inputs, and training. This assistance derived from participation in on-farm

Table 7. Coefficients of Logit regressions for ISMA technologies.

	ISMA *Striga* management technologies			
Variables	*Striga* resistant maize	*Striga* resistant maize in crop rotation with Soybean	*Striga* resistant cowpea	At least one of the ISMA technologies
Sex	0.9655909	0	0	1.90754**
Marital status	0.0798092	–1.347985	–0.1545608	0.0857013
Years of education	0.0327439	0.000416	–0.0335922	0.0269559
Participation in on-farm ISMA trial	**1.28211***	0.0231625	**1.820063***	1.96438
Attended field day	0.2771916	**2.088849****	–0.7428214**	**0.6238789***
Farming experience	0.0056123	-0.024084	0.0208618	**0.0084016***
No. males > 18 years old	–**0.5754939***	0.2150097	–0.2130295	–0.0666246
No. females > 18 years	––0.0436045	0.200571	0.0734849	––0.0790928
Extension contact with public extension agents	0.3260643	––0.9463226	––0.1962776	0.3365844
Contact with NGO/ Project extension agents	**0.7911757****	––0.5347126	–0.143	**0.6082852****
Number of visit of public extension agents	––0.0242826	–0.0109925	–0.0271334	**–0.0403028****
Number of visit of NGO/ Project extension agents	0.0035968	–0.0021973	0.0004023	–0.0035397
Revenue (other sources of income aside from farming)	0.0411249	0.0355806	**0.7990623****	0.2381651
Yield per ha	**0.0041386***	**0.0178964***	**0.0013529****	
Constant	**–4.267565***	**–3.916558***	**–3.290019***	**–4.313329***
Model statistics				
No of observations	495	488	488	502
LR chi2	281.03	47.41	37.64	176.3
Log likelihood	–155.2341	–32.611948	–138.05463	–247.65779
Pseudo R-square	0.4751	0.4209	0.12	0.2625
Dependent variable (Y) = Adoption (where 1 = adopters, 0 = Non Adopters				

**Significant at 5%; *significant at 1%.

demonstration trials is likely to motivate farmers to adopt ISMA crop technologies. In developing countries such as Nigeria, farmers may be willing to try some technologies such as *Striga* resistant maize varieties but they may not have the necessary capacity to do so. If such farmers get some form of assistance, such as access to ISMA seed varieties, ISMA technologies management practices and inputs such as fertilizer, agrochemicals, etc., they are likely to adopt the technologies.

Attending field days significantly influenced the likelihood of adoption of *Striga* resistant maize in crop rotation with legumes and *Striga* resistant cowpea in the study area. Field days are a practical forum where technologies are displayed and this can create demand for such technologies among participating farmers.

Farming experience also significantly determined the likelihood of adoption of at least one of the ISMA crop technologies. The significance of farming experience is derived from the fact that farmers often learn a lot by "doing", thus farmers who have longer years of farming experience are likely to adopt an improved technology compared to farmers with less years of farming experience.

The total number of males over 18 years of age is significant in determining the likelihood of the adoption of *Striga* resistant maize. This is a significant factor that influences likelihood of adoption for its role in providing manual labor for the adopters of ISMA *Striga* management technologies.

Contact with NGO/Project extension agents was highly significant in influencing the likelihood of adoption of ISMA crop technologies. The variable was positive and significant at 0.05 probability. This underscores the importance of NGO and/or the ISMA Project extension agents in promoting ISMA crop technologies among farmers and its role in exposing farmers to improved agricultural technologies. Access to extension services could be a measure of the information farmers obtain on production recommendations. In a study on the adoption of improved soybean seed in southern Borno State, Idrisa (2009) found that access to extension services was significant in influencing the likelihood of adoption among farmers. The frequency of extension visits by Public Extension agents was positive and also significant in influencing the likelihood of adoption of ISMA crop technologies among farmers. This is probably because most of the extension agents are from the Public Extension services of the ADPs who are also involved in the promotion of ISMA crop technologies among farmers in the study areas. This implies that when extension information or frequency of interaction with extension agent increases, the likelihood is that farmers can better comprehend the message and may adopt the technology.

The Logit results also reveal that other sources of revenue among farmers were significant in influencing the likelihood of adoption of *Striga* resistant cowpea varieties among farmers in the study area. The coefficient of the variable was positive, implying that farmers who depend on revenue from other non-farm sources had a higher likelihood of adopting the *Striga* resistant cowpea varieties compared to farmers who depend on farm sources of income. The majority of farmers in the study area are small-scale farmers who depend mainly on their farm produce for income. Cowpea is the main crop in the study area produced for both food and cash income generation, and which farmers use to solve their household problems and re-investment in their farm business. Farmers who have other sources of income have a greater incentive to adopt *Striga* resistant cowpea varieties to enhance both yield and income from sales.

The yield per hectare variable was significant in influencing the likelihood of adoption of the ISMA crop technologies that were promoted among the sample farmers. Farmers who obtain higher yield per hectare from crop production are more likely to adopt ISMA crop technologies. Higher yield implies that there will be a likelihood for farmers to earn higher revenue from the sales of such crops. Thus, they will be able to fund the purchase of associated inputs such as fertilizers, pesticides, herbicides, and so on. This possibly motivates them to adopt ISMA crop technologies.


Maize–Soybean rotation experimental and demonstration field, Ganjuwa Local Government Area, Bauchi State

5 Benefit-Cost of *Striga* management Technologies

Cost–benefit analysis

A summary of the benefit–cost computations of crops grown by adopters and non-adopters of ISMA *Striga* Management Technologies in Kano State is presented in Table 8.

The yields from crops presented in Table 8 revealed that crop yields were considerably higher for all crops grown by adopters and non-adopters of ISMA technologies. In the intervention areas, in the case of maize, yields were highest for hybrid maize varieties at 2400 kg/ha, followed by improved OPV maize sole at 1867 kg/ha and least for local maize varieties at 1283 kg/ha. For cowpea, yield was highest for improved cowpea sole at 775 kg/ha and lowest for local cowpea at 620 kg/ha. The improved OPV maize sole and improved cowpea sole are ISMA project *Striga* control varieties, which have the capability to mitigate the effect of *Striga* on the yields of maize and cowpea. In addition, the farmers in the project intervention areas gained from improved crop management practices promoted by the ISMA project. Hence, the use of *Striga* control technologies and crop management practices have contributed to the relatively higher yields obtained from these crops.

The revenue from crops was obtained by multiplying the output of various crops by their average market prices. Usually, factors such as crop output, varieties of crops grown, prices of crops, farm sizes, technologies used, cropping patterns, and general socioeconomic factors affect gross farm revenue. The relatively higher revenues from hybrid maize, improved OPV maize sole, and improved cowpea sole is directly related to observed higher yields from these crops.

Table 8. Summary of gross margin of crop technologies by adopters and non-adopters of ISMA technologies in Kano State, 2013.

Project Area	Local maize, sole	Hybrid maize, sole	Improved OPV maize, sole	Local cow-pea, sole	Improved cowpea, sole	Improved cowpea intercropped
Yield (Kg/Ha)	1283	2400	1867	620	775	650
Price (₦ /kg)	45	50	52	118	107	64
Revenue	57,071	121,072	96,133	73,333	83,266	41,600
TVC (₦/Ha)	23,947	24,440	23,861	22,356	19,718	18,450
GM (₦/ha)	33,124	96,632	72,272	50,977	63,548	23,150
Benefit/Cost Ratio	2.4	5.0	4.0	3.3	4.22	2.3
Non-project Area	**Local maize, sole**	**Hybrid maize, sole**	**Improved OPV maize, sole**	**Local cow-pea, sole**	**Improved cowpea, sole**	**Improved cowpea intercropped**
Yield (Kg/Ha)	800	900	1223	470	450	480
Price (₦ /kg)	48	55	54	95	96	85
Revenue	38,400	49,500	66,042	44,650	43,200	40,800
TVC (₦/Ha)	28,929	28,942	39,936	48,304	39,142	38,650
GM (₦/ha)	9471	20,558	26,106	–3654	4058	2150
Benefit/Cost Ratio	1.3	1.7	1.7	0.9	1.1	1.1

The total variable cost (TVC) comprises costs that change with the level of production. The farmer can control their level because they are incurred only during production. The variable costs of production comprise seeds, fertilizers, herbicides, pesticides, land preparation, planting, weeding, harvesting, transportation, storage, and so on. The level of TVC among the crops varies according to the variable inputs used in production. Expectedly, the variable costs are generally higher among the hybrid maize, improved OPV maize sole, and improved cowpea sole as the use of these technologies are associated with the use of inputs, such as fertilizers, herbicides, pesticides, and improved crop management practices. The use of these inputs tends to increase the level of TVC. However, the gains from revenue far outweigh the increase in TVC as revealed by their respective gross margins.

The adopters of hybrid maize attained the highest level of profitability with a gross margin ratio of 5.0, followed by improved sole cowpea with gross margin ratio of 4.2, and improved sole OPV maize with a gross margin ratio of 4.0. It is notable that improved sole cowpea and improved OPV maize are among the ISMA crop technologies that have been promoted among the farmers in the project area. The level of profitability achieved by these ISMA *Striga* control technologies further confirm the effectiveness of ISMA crop technologies in combating *Striga*, and thus improving crop productivity and incomes to farmers.

The table reveals that generally for all crops, the attained benefit cost ratio was relatively much higher for farmers that adopted ISMA technologies. In fact, the non-adopters of ISMA technologies who grew local cowpea have benefit-cost ratios less than 1, while those who grew improved sole cowpea and improved cowpea intercrop have benefit-cost ratio barely higher than 1.

Table 9 presents the summary of the benefit cost analysis of crops grown by farmers (adopters and non-adopters) in the areas surveyed in Bauchi State.

Similarly, Table 9 reveals that generally for all crops, the attained benefit–cost ratio was relatively much higher for farmers in the ISMA project areas of Bauchi State.

Table 9. Summary of gross margin of crop technologies by adopters and non-adopters of ISMA technologies in Bauchi State, 2013.

Project Area	Local maize, sole	Hybrid maize, sole	Improved OPV maize, sole	Local cowpea, sole	Improved cowpea, sole	Improved cowpea intercropped
Yield (kg/ha)	950	1753	1523	580	800	750
Price (₦ /kg)	55	59	60	118	90	95
Revenue	52,250	103,427	91,380	68,440	72,000	71,250
TVC (₦/ha)	24,255	32,731	37,520	32,316	22,705	36,570
GM (₦/ha)	27,995	70,696	53,860	36,124	49,295	34,680
Benefit/Cost Ratio	**2.15**	**3.16**	**2.44**	**2.12**	**3.17**	**1.95**

Non-project Area	Local maize, sole	Hybrid maize, sole	Improved OPV maize, sole	Local cowpea, sole	Improved cowpea, sole	Improved cowpea intercropped
Yield (Kg/Ha)	900	2150	1500	618	610	850
Price (₦ /kg)	55	55	54	95	100	110
Revenue	49500	118250	81000	58710	61000	93500
TVC (₦/Ha)	54966	55282	53056	59497	43284	54460
GM (₦/ha)	–5466	62968	27944	–787	17716	39040
Benefit/Cost Ratio	**0.90**	**2.14**	**1.53**	**0.99**	**1.41**	**1.72**

In the project areas, improved sole cowpea attained the highest level of profitability with a gross margin ratio of 3.17, closely followed by hybrid maize with a gross margin ratio of 3.16 and improved sole OPV maize with a gross margin ration of 2.44. It is notable that improved sole cowpea and improved OPV maize are also among the ISMA crop technologies that have been promoted among the farmers in the project area. The level of profitability achieved by these ISMA crop technologies further confirm the effectiveness of ISMA crop technologies in battling *Striga*, thus improving crop yields and farmers' livelihoods .

The benefit–cost ratio results suggest that returns are consistently higher in project areas compared to non-project areas. This can be due to three main factors working independently or together. First is selection bias. It is possible that at the inception of the ISMA project, the better-off farmers were selected to participate in the project. Thus, it is expected that these farmers are likely to perform better than those farmers in non-project areas. Secondly is the complementarity effect of technologies. During project implementation, the ISMA project intervention had facilitated farmers' access to Striga management crop technologies, management practices, and other inputs, such as fertilizers and seeds. These may have helped enhance farmers' production efficiency, and hence high increase in crop yields. Third is the spillover effect. The non-participant farmers (those not directly involved in ISMA project activities) within the ISMA project areas may have emulated the practices of ISMA project participants. Thus, this category of non-participant farmers will likely achieve higher crop yield levels through the 'learning by doing' practices of the participating farmers.

Farmers' perception of ISMA technologies advantages

The farmers' perceptions regarding the advantages of ISMA crop technologies are presented in Table 10. The table highlights that the most important characteristics of the ISMA crop technologies among these farmers as: higher yields, more tolerant to *Striga,* early maturity, more resistant to insects and diseases, more resistant to storage weevils, more resistant to wind and lodging, have better taste, bigger and multiple ears, more tolerant to drought, and bigger stalk than local or farmers' varieties. In the project communities, over 90% of the farmers

Table 10. Frequency distribution of farmers' perception about ISMA *Striga* Management Technologies in ISMA project areas.

	Kano (N = 171)					Bauchi (N = 162)				
	Perceptions about ISMA technologies					Perceptions about ISMA technologies				
Perception Statement	Strongly disagree (%)	Disagree (%)	Undecided (%)	Agree (%)	Strongly agree (%)	Strongly disagree (%)	Disagree (%)	Undecided (%)	Agree (%)	Strongly agree (%)
ISMA varieties have higher yield compared to farmers' varieties	0.6	0.0	2.9	55.6	40.9	0.6	3.7	4.9	16.1	74.7
ISMA varieties are more tolerant to *Striga*	0.0	0.0	2.3	52.6	45.0	0.6	0.0	5.6	19.8	74.1
ISMA maize varieties mature early	0.0	0.6	2.9	54.4	42.1	0.0	3.2	3.8	17.7	75.3
ISMA varieties are more resistant to insects and diseases	0.6	0.0	7.8	56.9	34.7	0.6	2.6	10.8	29.9	56.1
ISMA varieties are more resistant to storage weevil	0.0	0.0	8.2	58.5	33.3	1.3	2.5	15.8	35.4	44.9
ISMA varieties are more resistant to wind and lodging.	0.0	0.6	5.9	58.8	34.7	0.6	1.3	12.7	30.4	55.1
ISMA varieties have better taste when cooked	1.2	0.6	5.9	53.2	39.2	0.0	1.9	6.4	19.8	72.0
ISMA varieties have bigger and multiple ears than local varieties	0.0	0.0	3.0	55.0	42.0	1.3	6.9	7.5	20.6	63.8
ISMA varieties are more tolerant to drought	0.6	0.6	5.3	60.2	33.3	0.6	2.5	14.6	29.1	53.2
ISMA technologies have bigger stalk	11.1	7.6	4.1	57.3	19.9	40.3	30.2	10.7	9.4	9.4

had either strongly agreed or agreed that the ISMA technologies have higher yield levels, were more tolerant to *Striga,* matured early, were more resistant to weevils, insects, and diseases, were tolerant to wind and lodging, tasted better when cooked, had larger and multiple ears, and were more tolerant to drought than local or farmers' varieties.

Higher grain yield is a desirable quality that has the potential to enhance the farmers' income from sales of maize and cowpea and/or enhance households' food security. Good grain quality and early maturity of the maize and cowpea varieties are other desirable characteristics (Table 10).

Seed quality

Farmers' rating of the quality of seed with regards to purity of seed, germination percentage, and resistance to *Striga* is presented in Table 11. The purity of seeds obtained under the ISMA project is rated excellent by 44% and 76%; and very good by 34% and 70% of farmers in Kano and Bauchi States, respectively. Similarly, the germination percentage of seeds was rated as excellent by 34% and 70% of farmers in Kano State and 70% in Bauchi State.

The rating of seeds sourced from ISMA project is rated to be excellent by 35% and 77% of the farmers in Kano and Bauchi States, respectively. Seed quality in terms of seed purity, germination percentage, and resistance to *Striga* are desirable traits that have the potential to enhance the farmers' yield of maize and cowpea crops. This in turn boosts household food security through yield enhancement. In addition, the effect of planting quality seeds has some positive effects on income derived from sales of maize and cowpea.

Farmers' children near a *Striga* management technology demonstration farm, Tudun Wada Local Government Area, Kano State

Table 11. Frequency distribution of farmers' rating about purity of seed obtained under ISMA project in project areas.

	Kano (168) % distribution of farmers' rating				Bauchi (155) % distribution of farmers' rating			
Farmers' perception	Excellent	Very Good	Good	Fairly Good	Excellent	Very Good	Good	Fairly Good
Purity of seed as compared to farmers' own maize, cowpea, and soybean seed	44.0	35.1	15.48	5.4	76.1	16.1	7.1	0.7
Germination percentage of the varieties	33.9	37.0	25	4.2	70.3	17.4	10.32	1.9
Resistance of the seed varieties to *Striga*	34.7	37.7	23.4	4.19	76.6	14.3	0	9.1

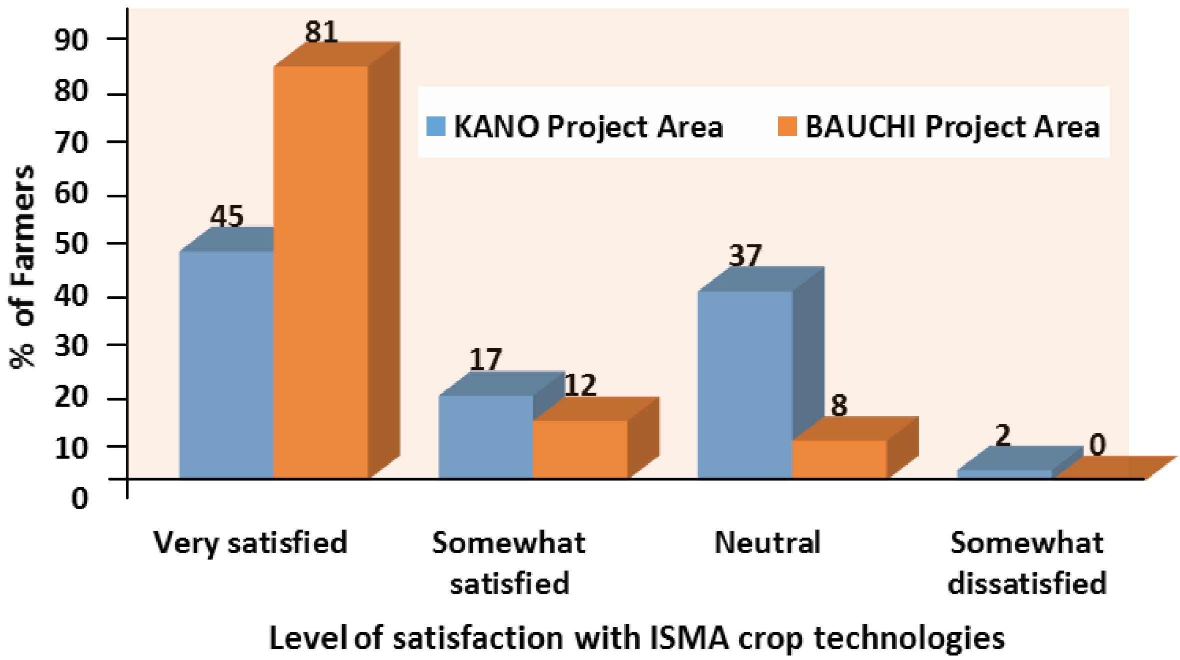

Figure 4. Farmers' perception of performance of ISMA technologies.

Performance of ISMA technologies

The overall performance of the project-based technologies was generally very satisfactory in the surveyed project areas (Fig. 4). The proportion of farmers that indicated that they were dissatisfied was non-existent in the project areas. The high proportion of farmers that were very satisfied and somewhat satisfied, which stood at 61% and 92% in Kano and Bauchi States, respectively, is an indication of the efficacy of the ISMA crop technologies.

Farmers' perception of constraints

The major constraints identified as affecting the production of maize and cowpea in the study area includes: *Striga*, lack of improved seeds, stem borer, termites, storage insects, lack of fertilizer, and lack of herbicides. Table 12 shows that *Striga* is the most important constraint affecting 92% and 94% of maize farmers in the project areas of Kano and Bauchi States, respectively. In the non-project areas, the problem of *Striga* infestation is also an important constraint affecting 94% and 80% of cowpea farmers in Bauchi and Kano States, respectively. These results justify the intervention by the ISMA project to promote ISMA *Striga* control technologies in the project areas of Kano and Bauchi States.

Table 12. Frequency distribution of the most important maize and cowpea constraints in project areas and non-project areas in Kano and Bauchi states.

Crop	Nature of production constraints faced by farmers	Project area		Non-project area	
		Kano	Bauchi	Kano	Bauchi
		Percent of farmers that indicated YES			
Maize	*Striga*	**91.62 (153)**	**94.**3 (166)	89.7 (131)	95.3 (102)
	Stem borer	64.0 (105)	51.6 (50)	77.1 (111)	65.2 (45)
	Storage insects	61.0 (97)	56.6(56)	73.2 (101)	60.6 (40)
	Low and erratic rainfall	48.0 (73)	21.4 (18)	47.2 (58)	21.4 (12)
	Water logging (flooding)	33.3 (49)	32.9 (27)	34.4 (43)	51.7 (30)
	Lack of improved seeds	73.8 (118)	39.8 (33)	92.9 (130)	53.9 (34)
	Lack of fertilizer	85.5 (141)	45.5 (40)	97.9 (138)	52.9 (36)
	Lack of herbicides	78.1 (128)	37.9 (33)	93.6 (131)	35.7 (20)
	Lack of pesticides	70.9 (115)	34.6(28)	88.5 (123)	34.0 (17)
	Other weeds	7.7 (3)	22.2 (4)	8.3 (4)	26.3 (5)
Cowpea	*Striga*	80.1 (117)	**96.8 (91)**	79.4 (85)	93.1 (54)
	Alectra	52.9 (73)	40.4 (19)	74.0 (77)	66.7 (18)
	Diseases	**85.1 (120)**	54.2 (26)	92.9 (104)	57.1 (16)
	Storage insects	83.6 (117)	62.9 (34)	90.1 (100)	75.9 (22)
	Low and erratic rainfall	43.9 (57)	12.8 (5)	35.1 (34)	17.4 (4)
	Water logging (flooding)	37.8 (48)	21.9 (9)	29.0 (27)	29.2 (7)
	Lack of improved seeds	75.5 (105)	44.2 (19)	90.4 (94)	52.0 (13)
	Lack of fertilizer	79.4 (112)	45.5 (20)	87.9 (94)	40.9 (9)
	Lack of herbicides	76.1 (108)	41.9(18)	93.5 (100)	38.1 (8)
	Lack of pesticides	76.3 (106)	45.5 (20)	95.3 (103)	35.0 (7)
	Other weeds	91.6 (153)	94.3 (166)	89.7 (131)	95.3 (102)

NB: Numbers in parentheses are number of respondents.

Perception of severity of constraints

About 33% and 27% of maize farmers in Kano and Bauchi States, respectively, perceived that the incidence of *Striga* is very severe; while 41% in Kano and 38% in Bauchi perceived *Striga* to be severe in the ISMA project areas (Table 13). Similarly, the severity of constraints in cowpea production follow a similar pattern with that for maize, where by 31% and 25% of farmers in project areas of Kano and Bauchi States, respectively, perceived that the incidence of *Striga* is highly severe; while 42% and 36% of the farmers indicated that the incidence of *Striga* was severe.

The level of severity of *Striga* among maize farmers in the non-project areas follow the same trend with 51% and 30% of farmers in Kano and Bauchi indicating a high severity while 34% and 51% perceived the *Striga* problem to be severe (Table 14). The severity of constraints in cowpea production follow a similar pattern with that for maize, where by 31% and 25% of farmers in project areas of Kano and Bauchi States respectively perceived that the incidence of *Striga* is highly severe. The level of severity of *Striga* among farmers is marginally higher in non-project areas as perceived by 36% and 28% of farmers in Kano and Bauchi States respectively. The inference that can be drawn from these results has further strengthened the justification for the intervention by ISMA project to promote *Striga* control technologies in Kano and Bauchi States.

Table 13. Percentage distribution of severity of constraints in maize and cowpea production in non-project areas of Kano and Bauchi states.

	Production constraints	Severity level of production constraints in ISMA project areas					
		Highly severe		Severe		Less severe	
		Kano	Bauchi	Kano	Bauchi	Kano	Bauchi
Maize	*Striga*	51.2	30.3	34.4	51.5	14.5	18.2
	Stem borer	40.9	23.4	38.2	31.9	20.9	44.7
	Termites	40.8	26.9	40.0	40.4	19.2	32.7
	Storage insects	35.3	23.8	41.2	45.2	23.5	31.0
	Low and erratic rainfall	29.3	14.7	29.3	26.5	41.3	58.8
	Water logging flooding	30.5	16.7	28.8	35.7	40.7	47.6
	Lack of improved seeds	56.3	31.9	21.1	36.2	22.7	31.9
	Lack of fertilizer	65.2	14.6	19.3	39.0	15.6	46.3
	Lack of herbicides	50.8	5.9	26.6	44.1	22.7	50 17
	Lack of pesticides	50.0	6.9	30.0	41.4	20.0	51.7
Cowpea	*Striga*	46.9	42.6	35.8	27.7	17.3	29.8
	Alectra	47.2	45.0	40.3	15.0	12.5	40.0
	Diseases	53.9	40.0	33.3	40.0	12.8	20.0
	Storage insects	62.2	33.3	24.5	44.4	13.3	22.2
	Low and erratic rainfall	32.6	20.0	41.9	26.7	25.6	53.3
	Water logging flooding	35.7	6.3	28.6	37.5	35.7	56.3
	Lack of improved seeds	56.7	4.0	18.6	52.0	24.7	44.0
	Lack of fertilizer	67.0	13.6	19.5	40.9	16.5	45.5
	Lack of herbicides	69.0	7.1	19.0	57.1	12.0	35.7
	Lack of pesticides	72.8	64.3	18.5	0.0	8.7	35.7
	Other weeds	100.0	0.0	0.0	0.0	2.0	0.0

Striga resistant Maize–Soybean rotation method for controlling *Striga,* Doguwa Local Government Area, Kano State

Table 14. Percentage distribution of severity of constraints in maize and cowpea production in the project areas of Kano and Bauchi states.

Crop	Production constraints	Severity level of production constraints in project areas					
		Highly severe		Severe		Less severe	
		Kano	Bauchi	Kano	Bauchi	Kano	Bauchi
Maize	*Striga*	33.1	27.4	40.8	38.2	26.1	34.4
	Stem borer	31.5	16.9	33.9	22.5	34.7	60.6
	Termites	31.9	32.1	34.8	25.6	33.3	42.3
	Storage insects	23.3	13.2	40.5	36.8	36.2	50.0
	Low and erratic rainfall	19.2	9.6	33.7	15.4	47.1	75.0
	Water logging flooding	20.0	20.0	31.3	29.1	48.8	50.9
	Lack of improved seeds	43.8	27.3	20.4	41.8	35.8	30.9
	Lack of fertilizer	61.6	29.8	19.2	38.6	19.2	31.6
	Lack of herbicides	44.5	11.5	22.6	51.9	32.9	36.5
	Lack of pesticides	46.2	12.8	23.5	48.9	30.3	38.3
	Other weeds	0.0	0.0	0.0	100.0	0.0	0.0
Cowpea	*Striga*	31.0	24.7	42.2	32.9	26.7	42.4
	Alectra	25.3	21.4	36.3	25.0	38.5	53.6
	Diseases	38.6	17.2	40.2	31.0	21.3	51.7
	Storage insects	41.3	19.4	36.5	38.9	22.2	41.7
	Low and erratic rainfall	20.2	4.4	32.1	13.0	47.6	82.6
	Water logging flooding	27.0	20.7	23.0	20.7	50.0	58.6
	Lack of improved seeds	44.2	22.2	17.5	48.2	38.3	29.6
	Lack of fertilizer	49.2	20.0	20.0	53.3	30.8	26.7
	Lack of herbicides	50.0	17.2	12.9	51.7	37.1	31.0
	Lack of pesticides	60.2	22.2	8.9	44.4	30.9	33.3
	Other weeds	100.0	0.0	0.0	0.0	71.4	28.6

Implications of findings

The major implications of these findings are as follows:

- The benefit-cost analysis of ISMA *Striga* control technologies has demonstrated the good performance of the technologies in terms of combating *Striga* and crop yields. This has made crops produced using ISMA technologies very profitable. The relative profitability of the ISMA seed technologies has a positive impact on adoption among farmers.
- The surveyed farmers are quite satisfied with the level of performance of the *Striga* control technologies and the quality and purity of seeds obtained under the ISMA project. This level of satisfaction has a positive impact on the adoption on ISMA *Striga* control technologies boosting food crop production and food security.

The results of the farmers' perception of the most important constraints and severity of constraints have justified ISMA project intervention to mitigate the effect sof *Striga* in food crop production in northern Nigeria. The menace of *Striga* is a major obstacle in achieving food security in the savannas of northern Nigeria.


Striga resistant maize field, Doguwa Local Government Area, Kano State

6 Recommendations

- The adoption rates have shown farmers' preference for the following technologies: maize–legume rotations and *Striga* resistant maize varieties. Thus, there should be increased efforts to promote and make available these technologies that are showing good adoption rates for uptake by farmers.
- To help increase the adoption of *Striga* resistant cowpea, the ISMA project should link up with other organizations that have a mandate for crops such as sorghum and millet that are often grown as an intercrop with cowpea by farmers. The *Striga* control intervention technologies that also address the reduced infestation through *Striga* resistant sorghum and millet may help facilitate higher adoption of *Striga* resistant cowpea. This will result in better control of *Striga* in the project areas since both crops are the major host to *Striga*.
- The benefit–cost analysis has revealed increased profitability of ISMA crop technologies, especially *Striga* resistant maize and maize–soybean rotation. There should be increased efforts to scale-up the promotion and dissemination of these ISMA crop technologies among farmers.
- The regression results have identified factors that influence the likelihood of adoption of ISMA crop technologies. These factors show the importance of field days, participation in on-farm demonstration trials, extension agents, and yield per hectare of crop technology in influencing the increased likelihood of adoption of ISMA *Striga* management technologies.
- There is need for a data management/data monitoring unit within the ISMA project specifically for tackling impact variables for each technology in each region, community, and farmer typology. This will influence targeted intervention measures in areas and technologies with a higher chance of adoption; with a resultant increase in adoption levels.
- Given the positive performance of the project within a short span of two years, there should be an early impact assessment of the project in the near future to fully capture the impact of ISMA project on beneficiaries.

References

AATF (African Agricultural Technology Foundation). 2005. Controlling witch weed in sub-Saharan Africa. AATF Annual report. Nairobi, Kenya. http://www.aatf-africa.org/userfiles/Controlling%20witchweed%20in%20SSA_AATF_Annual-Report_2005.pdf.

AATF (African Agricultural Technology Foundation). 2006. Empowering African farmers to eradicate *Striga* from maize croplands. Nairobi, Kenya. 17 pp

AATF (African Agricultural Technology Foundation). 2008. Delivering the promise: impacting lives with new technologies. Annual Report 2006. AATF, Nairobi, Kenya. 39 pp.

Adaba, T.O., M. Adaba, and M.A. Hamid. 2008. Bauchi State: A historical perspective. Tim Communication Ltd., Abuja, Nigeria. 100 pp.

Adesina, A.A. and Seidi S. 1995. Farmers' perceptions and adoption of new technologies in Burkina Faso and Guinea West Africa. Agricultural Economics 13: 1–9

Adesina, A.A. and M.M. Zinnah.. 1993. Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. Agricultural Economics 9: 297–311.

Aggarwal, V.D. and J.T. Ouedraogo. 1989. Estimation of cowpea yield loss from *Striga* infestation. Tropical Agriculture 66: 91−92.

Akinola, A.A. 1987. An application of the probit analysis to the adoption of the tractor hiring service scheme in Nigeria. Oxford Agrarian Studies 16: 70–82

Amaza, P.S., J.K. Olayemi, A.O. Adejobi, Y. Bila, and A. Iheanacho. 2007. Baseline socioeconomic survey report: agriculture in Borno State, Nigeria. IITA, Ibadan, Nigeria. 42 pp.

Amaza, P.S., T. Abdoulaye, P. Kwaghe, and A. Tegbaru. 2009. Changes in household food security and poverty status in PROSAB area of southern Borno State, Nigeria. IITA, Ibadan, Nigeria. 84 pp.

Awolola, M. D. 1995). Education and farmers' motivation: The case of five villages in Zaria area of Kaduna State". Journal of Rural Development and Administration 27(2): 1–12.

Binam, J., J. Tonye, W. Njankoua, G. Nyambi, and M. Akoa. 2004. Factors affecting the technical efficiency among smallholder farmers in the slash and burn agriculture zone of Cameroon. Food Policy 29: 531–545.

Capps, O. and R. Krammer. 1985. Analysis of food stamp participation using qualitative choice model. American Journal of Agricultural Economics 67: 49–59.

CIMMYT. 1990. World maize facts and trends; realizing the potential of maize in sub-Saharan Africa. CIMMYT, El Batan, Mexico.

Dugje, I.Y., L.O Omoigui, F. Ekeleme, A.Y. Kamara, and H. Ajeigbe. 2009. Farmers' guide to cowpea production in West Africa. IITA, Ibadan, Nigeria. 20 pp.

Dugje, I.Y., A.Y. Kamara, and L.O. Omoigui. 2006. Infestation of crop fields by *Striga* species in the savanna zones of northeast Nigeria. Agriculture, Ecosystems and Environment 116: 251−252.

Durojaiye, B.O. and F.A. Olanloye. 1992. The Value of education in small-scale agriculture: some evidence from Ogun State, Nigeria. Oxford Agrarian Studies 20(2): 107–115.

Ellis-Jones, J., P. Amaza, and T. Abdoulaye, 2009. An early assessment of adoption and impact of PROSAB's activities. In Proceedings of a Stakeholder Conference, Sharing Experiences, PROSAB, Maiduguri, Borno State, Nigeria, 1–2 September 2009.

Erenstein, O. and I.P. Cadena. 1997. The adoption of conservation tillage in a hillside maize production system in Motozintla, Chiapas. NRG paper 97-01. Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT) Mexico D.F.

Fakorede, M.A.B., J.G. Kling, S.O. Ajala, and A. Menkir. 1999. Maize: varietal maintenance and breeder seed production. Pages 112–119 *in* Seed Technology: A Manual For Varietal Maintenance and Breeder and Foundation Seed Production, edited by A. Aliyu, A. Joshua, and P.O. Oyekan. National Agricultural Research Projects, Department of Agricultural Sciences, Federal Ministry of Agriculture and Natural Resources, Abuja, Nigeria.

Feder, G., R.E. Just, and D. Zilberman. 1985. Adoption of agricultural innovations in developing countries: a survey. Economic Development and Cultural Change 33: 255–296.

Gujarati, D.N. 2006. Basic econometrics, 4th edition, Tata McGraw-Hill Publishing Company Limited, New York. 1036 pp.

Gwary, M. 2008. Evaluation of the effectiveness of Participatory research and extension approach in promoting sustainable agriculture in Borno State, Nigeria. PhD thesis, Department of Agricultural Economics & Extension, University of Maiduguri. 197 pp.

Herath, P.H.M.U. and H. Takeya. 2003. Factors determining intercropping by rubber smallholders in Sri Lanka: A logit analysis. Agricultural Economics 29(3): 159–168.

Idrisa, Y.L. 2009. Analysis of the determinants of soybean production technology adoption by farmers in Southern Borno, Nigeria. Unpublished PhD Thesis submitted to the School of Postgraduate Studies, University of Maiduguri.

International Institute of Tropical Agriculture (IITA). 2004. Annual Report, Ibadan, Nigeria.

Jefferson, T. 2005. Cowpea: A versatile crop for hot dry conditions. Thomas Jefferson Agricultural Institute, West Nifong Boulevard, Colombia.

Kamara, A.Y., I. Kureh, IA. Menkir, P. Kartung, B. Tarfa, and P. Amaza. 2006. Participatory on-farm evaluation of the performance of the drought-tolerant maize varieties in the Guinea savannas of Nigeria. Journal of Food, Agriculture and Environment 4(1): 192–196.

Lagoke, S.T.O., V. Parkinson, and R.M. Agunbiade. 1991. Parasitic weeds and control methods in Africa. Pages 3−274 in Proceedings of the International Workshop on Combating *Striga* in Africa, edited by S.K. Kim. IITA, Ibadan, Nigeria.

Lockheed, M.E., D.T. Jamison, and I.J. Lau. 1980. Farmer education and farm efficiency: A survey. Economic Development and Cultural Change 29: 37–76.

Nickrent, D.L. and L. Musselman. 2004. Introduction to parasitic flowering plants. The Plant Health Instructor 13: 300–315.

Maddala, G.S. 1983. Limited dependent and qualitative variables in econometrics. Cambridge University Press, New York. 414 pp.

Mignouna, B.D, T. Abdoulaye, A. Kamara, and M. Oluoch. 2013. Baseline study of smallholder farmers in *Striga*-infested maize and cowpea-growing areas of northern Nigeria, International Institute of Tropical Agriculture, Ibadan. 60 pp.

Muhammad-Lawal, A. and O.A. Atte. 2006. An analysis of agricultural production in Nigeria. African Journal of General Agriculture 2(1): 1–6.

Muhammad, B.M. 2003. Bauchi State Economic, political and social survey. Regent Printing and Publishing Ltd., Kaduna, Open Press Ltd., Zaria. 341 pp.

Olayemi, J.K., A. Fadahunsi, A.O. Adejobi. 2004. The challenge of building democratic, sustainable peasants' societies for a developed Nigeria. Technical report presented at the Third World Forum Workshop, CESAG, 2–5 November, 2004, Dakar, Senegal.

Phillips, J.M. 1994.Farmer education and farmer efficiency: a meta-analysis. Economic Development and Cultural Change 43: 1439–1465.

Pindyck, R. and D.L. Rubinfeld. 1998. Econometric models and economic forecasts. (Fourth edition), McGraw-Hill, London. 634 pp.

Polson, R.A and D.S.C. Spencer. 1991. The technology adoption process in subsistence agriculture: the case of cassava in South Western Nigeria. Agricultural Systems 36: 65–77.

Smith, J., A.D. Barad, A. Goldman, and J.H. Mareck. 1994. The role of technology in agricultural intensification: the evolution of maize production in the northern Guinea savanna of Nigeria. Economic Development and Cultural Change 42: 537–554.

Wang, J., E.J. Wailes and G.L. Cramer. 1996. A Shadow-price frontier measurement of profit efficiency in Chinese agriculture. American Journal of Agricultural Economics 78: 146–156.

Woomer, P.L., M. Bokanga, and G.D. Odhiambo. 2008. *Striga* management and the African farmer. Outlook on Agriculture 37: 247−252.

Yang, D.T. 1997. Education in production: measuring labour quality and management. American Journal of Agricultural Economics 79(3): 764–772.