ECONOMIC IMPACT AND DETERMINANTS OF ADOPTION OF
IMPROVED MAIZE PRODUCTION TECHNOLOGIES

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Abstract: The problem of what production technologies to adopt, and the degree to which farm operations should be improved for attainment of optimum economic benefit have remained undetermined. This study analysed the economics and determinants of adoption of the improved maize (Zea mays) production technology package in Oyo State of Nigeria. A multistage sampling procedure was employed to select one hundred and twenty maize producing farmers for the study in 2016. Data for the study were collected using a structured questionnaire and analysed with descriptive statistics and adoption index, regression analysis and the standard enterprise budgetary analysis. Results from the regression analysis showed that variables such as sex, farming experience, years of education, extension visits, and level of awareness of the technologies had a significant and positive influence on the adoption of improved maize technologies in the study area. Findings from the budgetary analysis revealed that improved maize production technology adopters made ₦438,367.23 compared to ₦374,426.44 profits per hectare of maize produced by the non-adopters during the year of survey. The results further revealed that on every naira invested in maize production, the adopters were able to make ₦7.64 in return compared to ₦6.00 returns by the non-adopters. There is the need for an increase in awareness of maize production technologies among the farmers, through the extension agents and social networks in order to increase the level of adoption of maize technologies.

Key words: adoption index, economic analysis, maize production, maize farmers.

Introduction

A fundamental source of agricultural transformation is technological change, which accompanies the introduction of modern agricultural technology and improved cultivation practices in the context of developing countries, such as sub-

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Saharan Africa (Otsuka, 2016). Increasing agricultural productivity using improved agricultural technologies that enhance sustainable food and fibre production is critical for sustainable food security and economic development (Mwangi and Kariuki, 2015). This study considered maize production technologies because maize is the most widely-grown staple food crop in sub-Saharan Africa (SSA) occupying more than 33 million hectares each year (FAOSTAT, 2015). The crop covers nearly 17% of the estimated 200 million hectares of cultivated land in sub-Saharan Africa, and is produced in diverse production environments and consumed by people with varying food preferences and socioeconomic backgrounds. Nigeria has been reported as the tenth largest producer of maize in the world, and the largest maize producer in Africa (IITA, 2012). Maize has grown from what used to be a back yard crop in the forest zone to a largely commercial crop grown now mostly in the savannahs of Nigeria. It is grown all over the country but concentrated in Oyo, Kwarra, Niger, Kaduna, Nasarawa, Bauchi, Plateau, Taraba, Gombe and Adamawa (FMARD, 2015). It is an important cereal crop that has assumed the status of a cash/food crop. Maize plays a predominant role in the farming systems and diets of millions of Nigerians. It is a very versatile crop since it is used for domestic consumption in addition to its industrial use by flour mills, breweries, confectioneries and animal feed manufacturers. This crop can be grown all year round provided there is available water. Consequently, increasing maize yields and its cultivation, particularly in high production potential areas of the country like Oyo State, can push a second maize green revolution. Maize is always preferred over any other crop including cassava because most of the world’s civilizations developed around grains rather than tuber crops (Fakorede, 2001).

Despite the development and introduction of maize production technologies such as improved seed varieties, fertilizers, pesticides, herbicides, planters and irrigational systems by the existing research institutes such as the International Institute of Tropical Agriculture (IITA), National Cereal and Research Institute (NCRI) to increase the maize productivity level in Nigeria, maize average yield is still found to be very low (1/3 tons/ha) compared to its potential yield (Babatunde et al., 2008). To advance in the understanding of the economic impact and determinants of the adoption of the maize production technology package, this study explores the impact on net revenue from maize production. The following research questions drive this study:

i) What is the level of awareness of maize production technologies among farmers in the study area?

ii) What are the determinants of the adoption of the maize production technologies?

iii) What is the economic impact of the adoption of the maize production technologies?
Based on the literature review and new statistical evidence, this study attempts to analyse maize, required technologies to realise major productivity gains, and desirable government policies. More specifically, the study has the following objectives:

(i) to analyse the awareness level of maize production technologies among farmers in the study area;

(ii) to determine factors affecting the adoption of maize production technologies, and

(iii) to estimate the economic impact of the adoption of improved maize production technologies on net revenue from maize production in Oyo State, Nigeria.

Materials and Methods

Study area

The study was carried out in Oyo State of Nigeria which is one of the major maize producing states in Nigeria. The state is bounded in the north by Kwara State, in the east by Osun State and in the south by Ogun State. Oyo State is located in the south-western part of Nigeria. It is located between latitudes 7°34′ and 9°12′ north of the equator and longitudes 2°47′ and 4°23′ east of the meridian. The temperature is 27°C. The state produces an average of 171,666.67 tonnes of maize per cropping season (FAO, 2006) which is about 50% of maize in the south-western part of Nigeria. The Oyo State Agricultural Development Programme (OYSADEP) divided the state into 4 agricultural zones, namely: Ibadan, Saki, Oyo and Ogbomosho zones. These zones were further divided into agricultural blocks and each block contained different cells.

Sampling procedure and sampling size

A multistage sampling procedure was adopted for this study. The first stage was the purposive selection of the Ibadan/Ibarapa Agricultural Development Programme zone based on the intensity of maize production by farm households in the area. The second stage was also the purposive selection of two (2) blocks from the Agricultural Development Programme zone based on the high concentration of maize farmers in the area. The third stage was the simple random sampling of two (2) cells from the selected blocks. The fourth stage was the simple random selection of three (3) communities from each of the two (2) cells and the fifth and last stage was the random selection of ten (10) maize producers from each community based on the list of the registered farmers obtained from the OYSADEP to arrive at a total number of 120 respondents.
Types and method of data collection

The study was a cross-sectional survey of 120 maize farmers in the study area. Primary data were collected with the aid of a structured questionnaire. Secondary sources of information such as journals, internet, literature and textbooks related to this topic were also consulted to complement the primary data.

Analytical techniques

Descriptive analysis

Descriptive statistics such as the frequency table and percentage were used to carry out the socio-economic analysis of maize farmers and to analyse the various types of maize production technologies used by farmers in the study area.

Adoption index

The adoption of the number of improved practices is usually measured by an adoption score (number of improved practices used) or by an adoption quotient (number of improved practices used over a total number of recommended practices). This study computed the adoption index to find out to what extent a farmer adopted a whole set of maize production technologies following Tadesse (2008), as shown in equation 1:

\[ A.I. = \frac{1}{N_p} \sum_{i=1}^{n} \left[ \frac{PSA_i + SRA_i + PR_i + HBA_i + SDA_i + DSF_i + DPF_i + NPF_i}{SRA_i} \right] \]

where \( i = 1, 2, 3 \ldots n \),
\( A.I. \) = Adoption index of the \( i \)th farmer;
\( N_p \) = Number of practices;
\( PSA_i \) = Plant spacing used by the \( i \)th farmer (cm);
\( PR \) = Plant spacing recommended for the crop (cm);
\( SRA_i \) = Seeding rate used by the \( i \)th farmer (kg/ha);
\( SR \) = Seed rate per hectare (kg/ha);
\( FAD_i \) = Amount of fertiliser applied per hectare of area cultivated using improved maize varieties (kg/ha);
\( FR \) = Amount of fertiliser recommended for application per unit of area for improved maize production (kg/ha);
\( SDA_i \) = Seed dressing used by the \( i \)th farmer (g/kg of seed);
\( SDR \) = Seed dressing recommended for the crop (g/kg of seed);
\( HBA_i \) = Amount of herbicide applied per hectare of area cultivated using improved maize varieties (litre/ha);
\( HBR_i \) = Amount of herbicide recommended per hectare of area cultivated
Economic impact and determinants of adoption of improved maize production technologies

using improved maize varieties (litre/ha);

\[ DSA_i = \text{Date of sowing for the} \ i^{th} \ \text{farmer (months)}; \]
\[ DSR_i = \text{Date of sowing recommended for the improved maize (months)}; \]
\[ DSU_i = \text{Depth of sowing used by the} \ i^{th} \ \text{farmer (cm)}; \]
\[ DPR_i = \text{Depth of sowing recommended for the crop (cm)}; \]
\[ MPU_i = \text{Maturity periods used for harvesting maize by the} \ i^{th} \ \text{farmer (days)}; \]
\[ MPR_i = \text{Maturity periods used for harvesting the crop (days)}. \]

The adoption index ranges from 0 to 1 depending upon the farmer’s degree of the technology adoption. The overall adoption indices of all the farmers were categorised into four distinct categories (non-adopters, low adopters, medium adopters and high adopters) following Maiangwa et al. (2007). The adoption score 0 point implies the non-adoption of the improved maize production package. If the index is above the value of 1, it indicates the farmers used some of the practices above the recommended rate.

Budgetary analytical technique

This was used to determine the economic benefits (profitability) of the adoption of maize production technologies among the adopters and non-adopters in the study area. While the gross margin could be regarded as the difference between the annual total revenue for each respondent and the variable costs directly associated with them, profitability is a measure of the level of performance using the available resources.

The gross margin is calculated as in equation 2:

\[ GM_i = TR_i - VC_i \]

where:

\[ GM_i = \text{Gross margin for the} \ i^{th} \ \text{maize farmer}; \]
\[ TR_i = \text{Total revenue for the} \ i^{th} \ \text{maize farmer}; \]
\[ VC_i = \text{Variable cost for the} \ i^{th} \ \text{maize farmer}, \] and
\[ i = 1, 2, 3…i^{th} \ \text{farmer}. \]

Total revenue for the \( i^{th} \) maize farmer represents the product of quantity of output of maize and the unit price of output for each respondent. Variable cost for the \( i^{th} \) maize farmer represents all the expenses for growing maize. This includes: cost of improved maize seeds, cost of fertilizers, cost of mechanisation, cost of labour, and cost of herbicides.

Profitability was measured using the returns on investment (ROI) estimated by dividing the revenue by the total cost. The total cost was estimated by adding the
total variable cost to the total fixed cost incurred during production.

**Regression model**

We used the ordinary least square multiple regression analysis to determine the determinants of the adoption of maize production technologies in the study area (See equation 3):

\[
Y_i = \beta_0 + X_i \beta_1 + u_i
\]

where:
- \(Y_i\) is the adoption of maize production technologies measured by the number of technologies used by the respondents in the last one year, \(i = \) the number of individual respondents 1, 2, 3;
- \(\beta_0\) is the constant term,
- \(X_i\) is the vector of independent variables,
- \(\beta_1\) is the vector of unknown coefficients,
- \(u_i\) is an error term.

The independent variables are defined as follows:
- \(X_1\) = Sex (1 = male, 0 = female);
- \(X_2\) = Age (years);
- \(X_3\) = Household size (number of household members);
- \(X_4\) = Farming experience (years);
- \(X_5\) = Farm size (hectares);
- \(X_6\) = Years of formal education (years);
- \(X_7\) = Awareness level (index), and
- \(X_8\) = Extension visits (numbers of contacts with extension agents in the past one year).

**Results and Discussion**

**Awareness level of improved maize production technologies**

The results in Table 1 reveal that the majority of maize farmers were both aware and tried the improved maize seed varieties (69.2%) and organic fertiliser (83.3%), but never adopted any of them.

**Table 1. The awareness level of improved maize production technologies.**

<table>
<thead>
<tr>
<th>Technologies</th>
<th>Not aware</th>
<th>Aware but never tried</th>
<th>Tried but not yet adopted</th>
<th>Adopted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved seeds</td>
<td>2(1.7%)</td>
<td>12(10%)</td>
<td>83(69.2%)</td>
<td>23(19.2%)</td>
</tr>
<tr>
<td>Organic fertiliser</td>
<td>1(0.8%)</td>
<td>1(0.8%)</td>
<td>100(83.3%)</td>
<td>18(15.00%)</td>
</tr>
<tr>
<td>Inorganic fertiliser</td>
<td>1(0.8%)</td>
<td>6(5%)</td>
<td>14(11.7%)</td>
<td>99(82.5%)</td>
</tr>
<tr>
<td>Knapsack sprayer</td>
<td>0(0.0%)</td>
<td>6(5.0%)</td>
<td>24(20.0%)</td>
<td>90(75.0%)</td>
</tr>
<tr>
<td>Pesticide</td>
<td>3(2.5%)</td>
<td>3(2.5%)</td>
<td>25(20.8%)</td>
<td>99(82.5%)</td>
</tr>
<tr>
<td>Improved pest scar device</td>
<td>1(0.8%)</td>
<td>61(50.8)</td>
<td>3(2.5%)</td>
<td>55(45.8%)</td>
</tr>
<tr>
<td>Seed planter</td>
<td>40(33.3%)</td>
<td>75(62.5%)</td>
<td>4(3.3%)</td>
<td>0(0.0%)</td>
</tr>
<tr>
<td>Tractor</td>
<td>1(0.8%)</td>
<td>33(27.5%)</td>
<td>75(62.5%)</td>
<td>11(9.2%)</td>
</tr>
<tr>
<td>Grain harvester</td>
<td>39(32.5%)</td>
<td>78(65%)</td>
<td>3(2.5%)</td>
<td>0(0.0%)</td>
</tr>
</tbody>
</table>
The most common maize production technologies farmers adopted in the study area were: inorganic fertilisers (82.5%), use of pesticide (82.5%), and use of knapsack sprayer (75.0). The least adopted technologies were: seed planter (0%), grain harvester (0%), tractor (9.2%) and improved pest scaring devices (45.8%).

Distribution of maize farmers by adoption index of production technologies

The results of categorisation of maize farmers on the adoption of improved maize technologies in the study area presented in Table 2 show that 12.5% of the sampled farmers lay in the low adopters’ category, 3.33% in the non-adopter category, 76.7% were medium adopters and only 7.5% were high adopters. This implies that the overall adoption of the maize technology package was lower than the rate recommended by the producers and extension agents. Most of the farmers in the study area used the maize production technology packages below the recommended rates.

<table>
<thead>
<tr>
<th>Adoption categories</th>
<th>Adoption index</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-adopters</td>
<td>0.00–0.009</td>
<td>4</td>
<td>3.3</td>
</tr>
<tr>
<td>Low adopters</td>
<td>0.01–0.33</td>
<td>15</td>
<td>12.5</td>
</tr>
<tr>
<td>Medium adopters</td>
<td>0.34–0.66</td>
<td>92</td>
<td>76.7</td>
</tr>
<tr>
<td>High adopters</td>
<td>0.67–1.00</td>
<td>9</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Economic impact of adoption of improved maize production technologies

The estimated economic impacts of the adoption of improved maize production technologies in the study presented in Table 3 show that maize farmers who are non-adopters of the production technology in the study area had an average total variable cost of production of $63,271.06/ha. Out of this amount, the cost of herbicides alone constituted about 43.16% ($27,309.33) followed by the cost of fertilisers, $24,405.33 (38.57%); and labour cost $5,812.65 (9.19%). Other costs incurred by non-adopter farmers were the cost of seeds ($5,206.25) and the cost of pesticides ($537.50). Contrary to expectation, for maize farmers who adopted maize production technologies, the total variable cost of production was found to be $55,412.57/ha. Out of this amount, the cost of fertilisers alone constituted about 48.20% ($26,710.67), followed by the cost of herbicides and chemicals $16,370.50 (29.55%) and labour cost took about 13.61% ($7,538.73). Hence, it
was clearly shown that maize farmers who adopted improved maize production technologies had higher profit than the non-adopters and in terms of the performance using the available resources, production of maize using the improved maize production technologies was more profitable. The results in Table 3 show that for every one naira invested by the non-adopters, only N6.00 was made in returns against N7.64 by the adopters. This implies that the adoption of maize technology in the study area leads to more profitability in maize production.

Table 3. Analysis of the cost and returns of maize production of adopters and non-adopters per hectare per annum.

<table>
<thead>
<tr>
<th>Costs</th>
<th>Non-adopters</th>
<th>Adopters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Amount (₦)</td>
<td>% in TVC</td>
</tr>
<tr>
<td>Variable cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of fertilisers</td>
<td>24,405.33</td>
<td>38.57</td>
</tr>
<tr>
<td>Cost of pesticides</td>
<td>537.50</td>
<td>0.85</td>
</tr>
<tr>
<td>Cost of seeds</td>
<td>5,206.25</td>
<td>8.23</td>
</tr>
<tr>
<td>Cost of labour</td>
<td>5,812.65</td>
<td>9.19</td>
</tr>
<tr>
<td>Cost of herbicides</td>
<td>27,309.33</td>
<td>43.16</td>
</tr>
<tr>
<td>TVC</td>
<td>63,271.06</td>
<td></td>
</tr>
<tr>
<td>TFC</td>
<td>11,582.50</td>
<td></td>
</tr>
<tr>
<td>Revenue (₦)</td>
<td>449,280.00</td>
<td></td>
</tr>
<tr>
<td>GM (₦)</td>
<td>386,008.94</td>
<td></td>
</tr>
<tr>
<td>Net profit (₦)</td>
<td>374,426.44</td>
<td></td>
</tr>
<tr>
<td>ROI</td>
<td>6.00</td>
<td></td>
</tr>
</tbody>
</table>

Note: TVC is the total variable cost, TFC is the total fixed cost, GM is the gross margin and ROI is the returns on investment which is a measure of profitability.
Source: Data from field survey, 2016.

Determinants of adoption of improved maize production technologies

The literature on agricultural technology adoption is vast (Rogers, 2003; Sunding and Zilberman, 2001; Feder and Umali, 1993) and somewhat difficult to summarise (Uaiene, 2011; Muzari et al., 2012; Ochienno, 2014). Our empirical results presented in Table 4 show that sex was a positive and significant (P<0.01) variable that influenced the adoption of maize technologies in the study area. This implies that the adoption of improved maize production technologies was gender sensitive. Similarly, farming experience had a positive influence on the adoption of improved maize production technologies at the 5% level of significance. This implies that as maize farmers increased their adoption level they advanced in farming experience. A more experienced farmer may have a lower level of uncertainty about the innovation performance and also be able to evaluate the advantage of the technology being considered. The variable ‘Years of education’ was also seen to have a positive and significant (P < 0.01) influence on the
adoption of maize technologies in the study area. This implies that the more educated a farmer was, the more likely to adopt any innovation. The education level of a farmer increased his/her ability to obtain, process and use the information relevant to the adoption of a new technology (Mignouna et al., 2011; Lavison, 2013; Namara et al., 2003). The results further show that extension visits and awareness of the production technologies had a positive and significant (both at $P < 0.01$) influence on the maize production adoption in the study area. This implies that the more extension visits/contact and awareness information farmers received, the more likely they adopted the technology. This is in line other past studies such as Nguluu et al. (1996) and Genius et al. (2014) who respectively found that acquisition of information about a new technology determines the adoption of technology and access to extension services helps to spread information about a new agricultural technology and hence its adoption.

Table 4. Determinants of adoption of maize production technologies.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficients</th>
<th>Standard error</th>
<th>t-Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.36520***</td>
<td>0.1150905</td>
<td>3.1731670</td>
</tr>
<tr>
<td>Sex</td>
<td>0.44220***</td>
<td>0.1257208</td>
<td>3.5173348</td>
</tr>
<tr>
<td>Age</td>
<td>0.000503</td>
<td>0.0016977</td>
<td>0.2961985</td>
</tr>
<tr>
<td>Household size</td>
<td>0.0090656</td>
<td>0.0070366</td>
<td>1.2883498</td>
</tr>
<tr>
<td>Farming exp.</td>
<td>0.00564**</td>
<td>0.0023582</td>
<td>2.3919360</td>
</tr>
<tr>
<td>Farm size</td>
<td>0.0236697</td>
<td>0.0160067</td>
<td>1.4787373</td>
</tr>
<tr>
<td>Years of education</td>
<td>0.04858***</td>
<td>0.0035028</td>
<td>13.8705197</td>
</tr>
<tr>
<td>Awareness index</td>
<td>0.15267***</td>
<td>0.0328187</td>
<td>4.6520475</td>
</tr>
<tr>
<td>Extension visits</td>
<td>0.07233***</td>
<td>0.0246693</td>
<td>2.9392017</td>
</tr>
<tr>
<td>F-statistics</td>
<td>35.8271</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p-value</td>
<td>0.0010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-squared</td>
<td>0.6552</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Observation</td>
<td>120</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ***, *** are the 5% and 1% significance levels respectively.
Source: Computed from data collected from field survey, 2016.

Conclusion

This study reveals that the majority (76.7%) of maize farmers in Oyo State were medium adopters of improved maize production technologies. The adoption of maize production technologies in the state was also found to be attributable to multiple factors like the sex of the farmers, farming experience, years of education, extension visits, and awareness level of farmers about the technologies. The adoption of maize production technology was more profitable in the study area. While on every naira invested in maize production, the adopters were able to make N7.64 in return, the non-adopters made N6.00. There is a need for an increase in the awareness level of maize production technologies through the extension agents
and social networks if the level of adoption of maize technologies is to be increased in the study area.

References


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EKONOMSKI UTICAJ I DETERMINANTE USVAJANJA POBOLJŠANIH TEHNOLOGIJA PROIZVODNJE KUKURUZA

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R e z i m e

Poteškoće oko toga koju proizvodnu tehnologiju usvojiti, i mere do koje bi trebalo poboljštati poljoprivredne operacije za postizanje optimalne ekonomske korist i ostaju neutvrđene. Ovim istraživanjem se analizira ekonomska i determinante usvajanja paketa poboljšanih tehnologija proizvodnje kukuruza (Zea mays) u Državi Ojo u Nigeriji. Korišćena je višestepena procedura uzorkovanja kako bi se odabralo sto dvadeset poljoprivrednih proizvođača kukuruza za istraživanje u 2016. godini. Podaci za istraživanje su prikupljeni pri korišćenju strukturiranog upitnika, i analizirani su uz pomoć deskriptivne statistike i indeksa usvajanja (engl. adoption index), regresione analize i standardnih oblika kalkulacija za pojedinačne linije proizvodnje. Rezultati regresione analize su pokazali da promenljive kao što su pol, iskustvo bavljenja poljoprivredom, godine obrazovanja, posete savetodavaca, i nivo svesti o tehnologijama imaju značajnog i pozitivnog uticaja na usvajanje poboljšanih tehnologija za kukuruz u ispitivanom području. Rezultati analize standardnih oblika kalkulacija za pojedinačne linije proizvodnje su pokazali da su poljoprivrednici koji su usvojili poboljšane tehnologije proizvodnje kukuruza zaradili 438.367,23 naira u odnosu na profit od 374.426,44 naira po hektaru kukuruza koji su ostvarili poljoprivrednici koji nisu usvojili poboljšane tehnologije za proizvodnju kukuruza tokom godine istraživanja. Rezultati su dalje pokazali da na svaku nairu uloženu u proizvodnju kukuruza, poljoprivredni proizvođači koji su usvojili poboljšane tehnologije zaradili su 7,64 naira zauzvrat u poređenju sa prihodom od 6,00 naira koji su ostvarili poljoprivredni proizvođači koji nisu usvojili poboljšane tehnologije. Postoji potreba za povećanjem svesti o tehnologijama proizvodnje kukuruza među poljoprivrednim proizvođačima, uz pomoć savetodavaca i društvenih mreža, kako bi se povećao stepen usvajanja tehnologija za kukuruz.

Ključne reči: indeks usvajanja, ekonomska analiza, proizvodnja kukuruza, poljoprivredni proizvođači kukuruza.

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