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# Impact of Adoption of Aflatoxin Bio-Control on Maize Farmers' Income in Lere Local Government Area of Kaduna State , Nigeria.

*Balogun O.S, Emeghara U.U, Lorukooba M.M, Onwuegbunam N.E. Ayodele J.T, Bala U Suleiman, R and Agbomaka F.I

Federal college of Forestry Mechanization, Department of Agricultural Extension and Management Afaka, Mando Kaduna. Kaduna state, Nigeria
*Corresponding author: baaseg2006@yahoo.com, 07067766016

## ABSTRACT

Increased food quality improves competitiveness and subsequently revenue from exports.One factor reducing African agricultural commodity competitiveness for export is aflatoxin contamination. This study examined the adoption of Aflatoxin Bio-Control and its impact on Maize farmers' income in Lere Local Government Area of Kaduna State Nigeria. Primary data was collected from 120 maize farmers through a multistage sampling procedure. Logit regression, linear regression, Chow F-statistics and likert scale were used to achieve the study objectives. Results revealed that primary occupation ($\beta$ = 4.2827, p≤0.001), Membership of association/cooperatives ($\beta$=3.8035, p≤0.05), level of education($\beta$ = 0.807, p≤0.01) and access to credit ($\beta$=0.8079, p≤0.10) significantly influenced the likelihood of adoption. Primary occupation ($\beta$=716943,P≤ 0.001), production cost ($\beta$=-6.03447,P≤ 0.01)Household size ($\beta$=89311.45,P≤ 0.001), amount of credit received($\beta$=0.08124,P≤ 0.05), type of implement employed ($\beta$=27549.35,P≤ 0.05) and maize farm size ($\beta$=15879.53,P≤ 0.001)were the major determinants of farmers' income in the study area. Bio-control adoption was found to have significantly impacted the income of the farmers. The study identified cost of fertilizer procurement, cost of Aflasafe, storage facilities and extra labour incurred as serious constraints and recommends that maize farmers should join farmers association.

**Keywords:** Impact, Bio-control, Maize farmer, welfare and Kaduna State.

## Introduction

Maize is recognized as a major source of food and cash income crop among the predominantly small-holder farmers in Nigeria. It has evolved from a backyard crop to become the third most important, in terms of output and area cultivated after sorghum and millet (Mignouna *et al*., 2013). It is the most widely distributed cultivated crop with cultivation from the wet evergreen forest zone to the dry ecology of the Sudan savanna in Nigeria (Aliyu, 2015).

Maize has been put to a wide range of uses than any other cereal as human food, as a feed grain, as fodder crop, and for hundreds of industrial purposes because of it broad global distribution, its low price relative to other cereals, its diverse grain types, and its wide range of biological and industrial properties Ammani *et al.*, 2012). FMARD, (2011) as cited by Aliyu, (2015), observed that the importance of maize in the Nigeria economy is a reason for making it one of the seven crops included in the Agricultural Transformation Agenda (ATA) programme. Despite the importance of maize, about two third of maize produced in sub-shahara Africa (SSA) including Nigeria by resource-poor farmers are done under conditions that could predispose the crop to mycotoxin contamination. Mycotoxins in maize include aflatoxin, produced by *Aspergillus flavus* and *A. parasiticus*, and fumonisin, produced by *Fusarium verticillioides* (Williams *et al.*, 2005;Burger *et al.*, 2010). Many years, of neglect to regulate aflatoxin in the production of these food items and subsequent education of farmers on the harmful effects of toxins had impacted negatively on international trade with African economies losing about US$450 million each year due to lost trade (IITA 2012).

In recent years there had been increasing concern about mycotoxin contamination in tropical food systems (especially maize and groundnut) because acute exposure to high levels of aflatoxin can be fatal. Chronic exposure to mycotoxin contamination has been associated with growth stunting in children, immuno suppression and liver cancer (Williams *et al.*, 2004; Kimanya *et al.*, 2010). Also, farming household welfare has become a relevant issue to individuals, communities and the country (Grootaert, 1997; Omonona 2014). Aflatoxin lowers product quality and discounts export values, which leads to significant economic losses for the countries and the agents in commodity value chains. Moreover, losses from rejected export shipments and lower prices due to poor quality may exceed 100% if the product is destroyed and the exporter is paying for the shipping. In this context, the cost of complying with food safety and agricultural health standards has been a major source of concern in the international development community and for African economies.

Scientists at the International Institute of Tropical Agriculture (IITA) in partnership with the U.S. Department of Agriculture–Agricultural Research Service, University of Ibadan, and University of Bonn developed Aflasafe, a natural, safe, and cost-effective bio-control product that drastically reduces aflatoxin contamination in food crops. This is aimed at improving health and income of farming families and consumers of these farm products. This product has been registered under the name Aflasafe™ in Nigeria for application to maize and groundnut crops (Bandyopadhyay *et al.*, 2016).Aflasafe biological control uses native strains of *A. flavus* that do not produce aflatoxins. These atoxigenic strains are applied to 'push out' their toxin cousins so crops are less contaminated, in a process called 'competitive exclusion'. Field testing of aflasafe in Nigeria has produced extremely positive results consequently aflatoxin contamination of maize and groundnut was said to have been consistently reduced by 80-90 percent (IITA, 2012; Banyopdhya *et al.*, 2016 and Aiyedun *et al.*, 2017). Decision to adopt and continue the use of agricultural technologies is hinged on relative advantage of the technology both in the short and long run. Small scale farmers keep evaluating accruing benefits of technologies from the stand view of many things including income and the overall welfare derivable from the innovations. When due consideration is given to the potential benefits of aflasafe™, it is ultimately smallholders and the nation at large who stand to gain the most.

It is against these back drops that the study attempts to answer the following research questions. What are the adoption determining factors of the Aflatoxin Bio-Control Programme among maize farmers in Lere local government area of Kaduna State? has the Aflatoxin Bio-control impacted positively on maize crop farmers' income and what factors affects income of maize farmers. Are there constraints to the use of Aflatoxin Bio-Control technology in the study area?

## Methodology

### Study Area.

The study was conducted in Lere local government (LGA), Kaduna state. The local government area was created in 1989, carved out of the former Saminaka LGA which was divided into two LGAs (Lere and Kauru) during the military administration. The local government covers about

256sqkm, with a projected population of about 458,600 (NBS, 2017). The local government is situated on the eastern part of Kaduna state, located between latitude 9°N and 10°N and longitude 8° and 9°of the prime meridian. It shares common border with Bauchi and Plateau state in the east.The climate is considerably good for arable crops; it falls in the guinea savannah vegetation zone. The major economic activities of its people are farming, rearing of animals/cattle, trading, fisheries and civil service. Rainfall extends to early October while the harmattan set in the mid October, November and extends to February(NBS, 2017).

**Sampling Technique and Data Collection.**

Primary data was used for the study. A multistage sampling procedure was used to select sixty (60) participants and sixty (60) non-participants for the study. The first stage involved purposive selection of two districts (Sabon-birni and Abadawa) where the bio-control was implemented. In the second stage, two villages each from each of the districts were randomly selected. The last stage involved purposive and random selection of sixty (60) participants and random selection sixty non-participants in the project. Data were collected through the use of structured questionnaire and was analyzed with the use of F-Chow test-statistics, multiple linear regression analysis and four (4) point Linkert scale.

**.Bio-Technology adoption Modelling/Model Specification**

A framework of a new approach to consumers' theory developed by Lancaster (1996); modified by Somda (2002) and adopted by Omolehin *et al.* (2007) was espoused for the study. Innovation/technology adoption is assumed to be an activity where technologies are inputs whereas the output is a collection of characteristics. It is also assumed in neoclassical economics theory that each decision maker is able to compare between two alternatives say "a and b" in a set of choices using indifference operator, If $a \geq b$, and the farmer "say" prefers a to b or is indifferent. Utility rankings are therefore assumed to rank collections of technology indirectly through the characteristics that they possess.

New technologies are poised to a number of characteristics that may influence its adoption hence adoption decision by the potential adopters. Also, given characteristics of the technology, other socio-economic and demographic characteristics of the farmers may influence technology adoption Omolehin e*t al.* (2007). Participation in the Bio control programme may likely be result of complex interaction between comparable technology characteristics and farmer's socio-economic and demographic characteristics. A logical function (Logit) was used to model farmer's participation in the Aflatoxin Bio-Control programme. If the perceived benefit derived from adopting maize Aflatoxin Bio-Control programme is denoted with b(C0) and b(0), respectively. Assuming $\beta_i$ is the discounted benefit from the production with or without the maize Aflatoxin Bio-Control programme and $I_i$ is the utility index of participating in Aflatoxin Bio-Control programme for individual ith. The index $I_i$ is a function of socio-economic characteristics of the farmer and his perception on participating in the maize Aflatoxin Bio-Control programme. The farmer's behaviour towards participation in the programme is described by equations (1-3).

$I_i = X_i\beta$ ... ... ... ....(1)

$\beta_i \leq 0 \; if \; I_i \; C(0, -\infty)$ ... ... ....(2)

$\beta_i \geq 0 \; if \; I_i \; C(0, +\infty)$ ... ... .(3)

Where $X_i$ is the vector of socio-economic and demographic characteristics of the farmer and his perception of participation in maize Aflatoxin Bio-Control compared with producing maize without bio-control while

$\beta$ is a vector of parameters to be estimated. As the value of the explanatory variables $X_i$ changes the value of $I_i$ varies on real number line. The larger the value of $I_i$ the greater the utility individuals receives from choosing to participate in the Bio-Control programme thus the greater will be the probability $P_i$ that individual $i$will adopt participation as an option, in other words, the discounted benefit from participating in Aflatoxin Bio-Control maize is greater than zero, that is, equation (3). The Observed outcome is that farmers will participate in Aflatoxin Bio-Control maize production. Conversely, if the utility index which measures the individuals propensity to participate in Aflatoxin Bio-Control maize production lies between zero and minus infinity equation (2). Moreover, the discounted benefit in participation in Aflatoxin Bio-Control maize production will be negative or equal to zero, and farmers will not participate in Aflatoxin Bio-Control maize production.

**Model Specification**: A dependent variable denoted by Y corresponding to respondent's adoption status was represented by a dichotomous choice; 1 for adopters and 0, otherwise. The logical function used is:

$$.P_i = F(l_i = F(X', \beta) \frac{1}{1+\exp(-X'.\beta)} \quad (4)$$

The estimable implicit form of the model following Gujarati and Porter. (2009) is expressed as shown below:

$$Ln\left(\frac{P}{1-P}\right) = Z_i = \beta_i + \beta \sum kX_i + \varepsilon_0 (5)$$

Y = $Ln\left(\frac{P}{1-P}\right)$ =access to credit (1 access, 0 otherwise)

$X_1$ = Age of households head (years), $X_2$= Marital status (1 married, 0 otherwise)

$X_3$ = Farming experience (years), $X_4$= Household size (Number of people per household)

$X_5$ = Years spent in school, $X_6$= Years spent in association $X_7$ = Amount of credit received, $X_8$ = Primary occupation (1 farmer 0 otherwise), $X_9$= Income generated from maize cropping (₦), , $\beta_0$ = constant terms, $\varepsilon_0$ = error term.

**Impact of the Aflasafe Bio-control on the Participants**

A method of regression discontinuity originally developed by Chow (1960), explored expanded and enhanced by Howard (2008) was applied to investigate the impacted outcome of the programme on the respondents. Cook, and Cambell (1979) had earlier demonstrated its effectiveness and usefulness in field research that does not have the constraints of laboratory research Howard (2008).

$$Y_{i1} = X_{i1}\beta_{i1} + e_{i1} \quad (6)$$

$$Y_{i2} = X_{i2}\beta_{i2} + e_{i2} \quad (7)$$

$$Y = X\beta + e \quad (8)$$

Where,

equations 6, 7 and 8 are regression equations for the adopters, non-adopters and pooled respondents respectively.

$Y$ = total income from maize (₦), $X_i$ = are vectors of selected variables and $e_i$ are error terms.

The F-Chow Statistics is specified as shown in equation (9) below.

$$\text{F- Chow} = \frac{(e'e - e_1'e_1 - e_2'e_2)/p}{(e_1'e_1 + e_2'e_2)/(n+m-2p)} \quad (9)$$

Where,

$e'e =$ Sum of squared residual from pooled data, $e_1'e_1 =$ Sum of squared residual from pooled data, $e_1'e_1 =$ Sum of squared residual from participants, $e_2'e_2 =$ Sum of squared residual from non-participants, $NM =$ Number of observations in each group and $P =$ total number of parameters.

**Constraints Associated with Aflasafe Adoption**

Weighted mean analysis was employed to evaluate the perceived constraints. For each constraint, respondents were asked to respond to the rated scale and responses were recorded and summed up to obtain the weighted scores. The weighted scores are then divided by the sample size of the respondents to obtain the weighted means measured on a 4-point rating scale of Very serious = 3, Serious = 2, Fairly serious = 1and Not a constraint = 0. The cut-off point mean for the constraints is 1.50. Mean cut-off point ≥ 1.50 is categorized as very serious

Constraint and not a major constraint for any mean ≤ 1.50.

VS - Very Serious (3 points)
S - Serious (2 points)
FS - Fairly Serious (1 points)
NC - Not a Constraint (0 points)

The mean for each of the constraint

$$=\frac{3(\mathrm{VS})+2(\mathrm{S})+1(\mathrm{FS})+0(\mathrm{NC})}{S} \qquad (10)$$

**Results and Discussions**

**Factors Affecting Adoption of Aflasafe$^{\mathrm{Tm}}$**

The Logit regression of factors affecting adoption of Aflasafe in Lere L.G.A is presented in table 1 Freeman *et al*. (2008) as cited in Fatoki and Odeyemi (2010) and Iyanda *et al*. (2014) noted that when reporting the results of a logistic regression analysis estimated odds ratios, the regression coefficients, their confidence intervals and associated P-values should be presented. In addition, it is necessary to give some information about the goodness of fit of the model. The coefficient of the likelihood ratio of the estimated model was -24.921, a Chi-square value of 107.06 with a ($p \leq 0.001$) indicating a good fit.

The result shows that a number of socio-economic variables significantly influenced adoption of the Aflasafe in the study area. These factors include primary occupation, membership of association/cooperatives, level of education and access to credit.

Membership of association was found to be significant at 5% level. The result shows that being a member of farmer's association increased the probability of adopting the technology by 24.0%. The result supports Augustine and Mulugetta (2005) and Balogun *et al* (2011) that in most farming communities' farmers form or join associations in order to have better access to information and to benefit from economic and spiritual gains.

Level of education can have a serious effect on decision making especially on whether or not to adopt new innovations. The coefficient of the year spent in school is positive and significant at 10% level. The result reveals that an additional year spent in school by farmer increased likelihood of adoption decision of the new technology by 5.3%. It is often assumed that educated farmers are better able to process information and search for appropriate technologies to alleviate their production constraints. The result agrees with Augustine and Mulugetta (2005), that exposure to information reduces subjective uncertainty; hence increases the likelihood of adoption of new technologies.

Farmers can invest in new technologies either from past accumulated capital or through borrowing from capital markets. But lack of sufficient accumulated savings by smallholder farmers could prevents them from having the necessary capital for investing in new technologies. The estimated parameter obtained for access to credit t has a positive sign and significant at 10% level implying that having access to credit increased the likelihood of Aflasafe adoption decision of farmers by 83.0%. In literature, it has been argued that the lack of credit is a constraint to adoption. The result is in consonance with Ouma *et al*. (2006); Omolehin *et al*. (2007); Ayinde *et al*., *(*2010); Idrisa *et al*. *(*2012) and Obayelu *et al*. 2016) that socio-economic characteristics of farmers such as access to credit or cash resources have a positive influence adoption rate of new agricultural technology among farmers. Furthermore, the study show that the tendency to adopt Aflasafe by farmers who took faming as primary occupation was significant at1% level; indicating that practicing farmers are more likely to adopt Aflasafe than those who took farming as part time.

Table 1: Logit Regression of Factors Affecting Adoption of Aflasafe in Lere L.G.A

| Variables | Odd Ratio | P – Values | Conf (95%) | Marginal Effect |
|---|---|---|---|---|
| Age | -0.0664 (0.0459 ) | 0.148 | 0.86-1.02 | 0.0044 |
| Marital Status | -0.1498 (0.9290) | 0.872 | 0.14-5.32 | -0.0098 |
| Farming Experience | 0.7210 (0.8962) | 0.421 | 0.35-11.91 | 0.0472 |
| Household Size | 0.9880 (0.1075) | 0.409 | 0.71-1.14 | 0.0064 |
| Education | 0.8079* (0.4365) | 0.064 | 0.18-1.04 | 0.0530 |
| Years spent in association | 3.8035** (1.551) | 0.009 | 2.59-777 | 0.2494 |
| Gender | 1.2471 (0.9165) | 0.174 | 11.28-465 | 0.0818 |
| Primary Occupation | 4.2827*** (0.9487) | 0.000 | 0.58-20.97 | 0.2808 |
| Amount of credit received | 2.800* (1.4500) | 0.053 | 1-1 | 1.8300 |
| Log likelihood | -24.9218 | | | |
| Chi2 P<0.001 | 107.06*** | | | |

. ***P<0.001, ** P<0.05 and *P<0.1

Table 2 presents the factors affecting the income of maize farmers in the study area. The analysis was carried out for the entire respondents, that is, pooled and the sub-groups (that is, participants and non-participants). The findings indicate low adjusted $R^2$ values of 67%, 68% and 56% for pooled, adopters and non-adopters respectively this means that about 67%, 68% and 56% of the variations in income of entire respondents, adopters non-participants were explained by the variables included in the various regressions. This result also indicates that the coefficients of primary occupation, household size, credit received, farm size and type of implement employed had positive sign and significant relationship with income of maize farmers in the study area. Production cost was also significant but had a negative effect on income implying that the higher the money expended on production the lower the income realised by the farmers. Furthermore, the level of education of adopters played significant role in the amount of income realised. The significant relationship of household size with income of the Aflasafe project participants' and all the farmers' income means that an additional member to the household increased income for all the farmers and Aflasafe project participants' at 1% level. There is a tendency to take advantage of ready family labour to leverage on large household size for promptness in farm operation and reduction in labour cost in the study area. Furthermore, the result shows that farm size has a positive sign and significant at 1% level for both pooled and adopters. A unit increase in maize farm size of farmers increased income accruing to him. The study agrees with Ayinde *et al.* (2010) that expansion of the land area devoted to maize resulted in increased in production output; hence higher income.

Table 2: Factors affecting the income of maize farmers in the study area

| Variables | Pooled | t-value | Adopters | t-value | Non- Adopter | t-value |
|---|---|---|---|---|---|---|
| Age | -2825.69 (12107.8) | -0.23 | -10777.14 (27918.8) | 0.39 | -647.97 (3047.6) | 0.21 |
| Marital Status | -67869.25 (273185.4) | -0.25 | -44517.98 (699046.5) | 0.06 | -62021 (58872.6) | 1.05 |
| Prim.Occ. | 716943*** (212222.5) | 3.38 | 201639.9*** (41400.8) | 4.87 | -135677.3** (55929) | 0.02 |
| Production cost | -6.03447* ( 3.01338 ) | -2.00 | -24.69194* (14.07191) | 1.75 | -102316.9* (53836.8) | 1.90 |
| Household size | 89311.45*** (20313.7) | 4.40 | 162479.1*** (39975.8) | 4.06 | 1674.15 (5576.3) | 0.30 |
| Level of education | 41577.41 (82034.7) | 0.51 | 140957.9** (52535.5) | 2.68 | 6366.2 (21469.9) | 0.30 |
| Yrs of memb in asso. | 4134.82 (14029.1) | 0.29 | 36838.16 (34022.51) | 1.08 | 7736.9** (3018.7) | 2.56 |
| Credit Received. | 0.08124** (0.02811) | 2.89 | 13.72533** (6.0325) | 2.27 | 7891.0** (2946.5) | 2.61 |
| Maize farm size | 15879.53*** (5155.7) | 3.08 | 48037.61*** (13256.83 ) | 3.67 | 135677.3 (55929.9) | 2.43 |
| Type of Implement Employed | 27549.35** (10748.9) | 2.56 | 14239.77 (480587.3) | 0.03 | 113294.8** (54854.7) | 2.07 |
| Constant | -219194 (833973.9) | -0.26 | -1758810 (2067163) | 1.68 | 564757.8 (181860) | 1.86 |
| $R^2$ | 0.6728 | | 0.6819 | | 0.5627 | |
| Adjusted $R^2$ | 0.5927 | | 0.5096 | | 0.5014 | |

***P<0.001, ** P<0.05 and *P<0.1

**Impact of the Project on Participants Income**

The result in Table 3 presents the Chow F-test for Aflasafe$^{TM}$ Bio-Control impacted outcome on maize farmers income. The result reveals that there was evidence that the Bio-control project has positive impact on the income of participants. The Calculated F-value (4.96) was found to be greater than the critical F-value $(\alpha = .05, df = 11, 109) = 2.45$. This result is in agreement with those of Simonyan (2009) and Balogun *et al.*, (2020) who reported that Fadama II and Agricultural transformation

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projects in Nigeria had significant impacts on the beneficiaries.

Table 3: Chows F-Test for Aflasafe$^{TM}$ Bio-Control Impacted Outcome on Maize Farmers Income

| F-cal | F-tab | Decision Criteria | Remark |
|---|---|---|---|
| 3.03 | 2.45 | If F-Cal>F-tab, then there is evidence that participants in Aflasafe$^{TM}$Bio-control programme income significantly differ from those of non-participants. | The programme haspositively impacted the income of participants |

**Constraints to Aflasafe Adoption in Lere LGA. Kaduna State.**

Constraints associated with Bio-control aflasafe adoption in the study area is presented in Table 4 The frequencies of respondents perceived constraints were evaluated for easy accessibility of farmers to Aflasafe, additional labour cost, technicality of technology application, Marketability (commercialisation of product) and access to good storage facilities (warehouse for produce) and fertilizer procurement on a four (4) point weighted scale. The result shows that the major constraints identified by the farmers are fertilizer procurement cost, cost of Aflasafe, access to good storage warehouse for produce and labour involvement which were ranked 1$^{st}$, 2nd, 3$^{rd}$ and 4$^{th}$ respectively. Majority of the farmers see fertilizer procurement as the most serious constraint confronting them stating that, cost of fertilizer procurement and the Bio-control agent (Aflasafe) now constitute additional production cost for them.

Table 4 : Constraints associated with Aflasafe Adoption in the study area

| Items | Very serious | Serious | Fairly serious | Not a constraint | Total Score | Mean score | Rank | Remark |
|---|---|---|---|---|---|---|---|---|
| Easy accessibility | 23 | 25 | 38 | 35 | 157 | 1.30 | 5$^{th}$ | Not a serious constraint |
| Cost of production | 49 | 25 | 14 | 32 | 211 | 1.76 | 2$^{nd}$ | Serious Constraint |
| Ease of technology application | 25 | 33 | 18 | 51 | 159 | 1.32 | 4$^{th}$ | Not a serious Constraint |
| Marketability of product | 19 | 18 | 52 | 31 | 145 | 1.21 | 6$^{th}$ | Not a constraint |
| Storage warehouse | 45 | 25 | 17 | 33 | 202 | 1.68 | 3$^{rd}$ | Serious Constraint |
| Fertilizer procurement | 55 | 23 | 19 | 23 | 230 | 1.92 | 1$^{st}$ | Serious Constraint |

**Conclusion**

The study revealed that belonging to farmers associations, level of education, access to credit and nature of primary occupation were major drivers of farmers' decision to adopt the Aflasafe Bio-Control technology. Incomes of farmers were affected significantly by production cost, household size and Farm size. The programme was found to have impacted the income of bio-control adopters significantly. The study identified cost of fertilizer procurement; cost of Aflasafe, storage facilities and extra labour incurred as constraints and concludes that the Bio-control is a potential boost to maize commercialisation in Nigeria because of its significant positive impact on adopter's income and overall welfare. The study recommends that efforts should be intensified at implementing the Bio-control programme by focusing on farm input(fertilizer and Aflasafe™) price reduction policies targeted at these grain producing farmers.

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