

Research paper

Bio economy Adoption Process of Agro-biotechnology Among Researchers in Nigerian Universities/ and Research Institutes: The Logistics Regression Approach

By

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Abstract

Food insecurity in most developing countries was as a result of their low/small scale of operation in farming enterprise resulting to low yields. To increase agricultural productivity, agro-biotechnology has been considered as a strong potential to improve agricultural production. This paper examined the biotechnology adoption scenario in Nigeria from the viewpoint of academic researchers. A purposive sampling technique was adopted and the target population was limited to 100 academic biotechnology researchers. Eighty percent of the researchers came from the Universities while 10 percent each were drawn from College of Agriculture and Institute of Agricultural Research respectively. Mean age was 44.5 years, mean teaching/research experience mean was 7.5 years. Logit model estimates for the study areas showed that the effect of the three independent variables,; level of knowledge, level of acceptance and level of transfer of technology were statistically significant at 5% level. These findings' revealing that knowledge about an innovation is an indicator of the level of adoption. As the awareness of knowledge increases, it is more likely that there will be a corresponding increase in the level of adoption. The acceptance variable has a positive impact on the decision to adopt biotechnology. The results of the findings of this study indicated that the level of knowledge, acceptance and transfer of technology have direct effect on the level of adoption of biotechnology innovations. Therefore, there is need for policies that will streamline agro-biotechnology programme in a sustainable way to for potential users.

Keywords: Starvation, Deficiency, Awareness, Agro-biotechnology, Scholastic

Introduction

Evidenced abunds in past studies and literature that hunger and poverty are closely linked (Apata, *et al*, 2011; ANAP, 2006; Oyeranti and Olayiwola, 2005; Okunmadewa, 2002). Hunger is as a result of lack of access to food (quality) to satisfy starvation. Poverty on the other hand has been hypothesised as lack of power to produce a desired result. Consequently, most farming households in developing countries lack the power to make enough provisions to meet food needs. Also, it has been documented that most African countries (25 African countries out of 38 worldwide) including Nigeria experience serious food emergencies (World Bank, 2008). The root causes of food shortages included natural disasters such as droughts, civil unrest and endemic diseases such as HIV/AIDS, malaria and tuberculosis. Others include economic constraints such as sharp declines in commodity prices, inefficient/insufficient policies, programmes and investments to increase agricultural productivity.

Past studies revealed that food insecurity in most developing countries was as a result of their low/small scale of operation in farming enterprise resulting to low yields (Oksana, 2005; Alayande and Alayande, 2004; Olayide *et al*, 1980). The low yield is attributable to low-level farm technology and productivity. In addition to the predominance of the use of traditional manual technology, traditional tools and equipment, limited use of improved

planting materials and fertilizer consumption. To improve low yields experienced by farmers, biotechnology has been advocated as a way of boosting agricultural production (Zilberman *et al*, 2010; Adeogun *et al*, 2008; Magaji, 2007). There is a school of thought that *said* introduction of biotechnology to agricultural production will improve the sector (Hussain *et al*, 2003; Santaniello, 2002, Flavel, 1999).

However, due to a multitude of problems faced by farmers in developing countries, biotechnology may not *completely* solve the problem of low yield in agricultural production *advocated by another school of thought* (Zilberman *et al*, 2010; Manyong *et al*, 2003; Huang *et al*, 2003). The problems of poor agricultural infrastructure, socio-economic barriers, lack of farm management skills and the degradation of natural resources still need to be tackled (Apata, *et al*, 2011; Olayemi, 1980). The challenge of increasing farm-level production in a sustainable manner (environmentally, economically and socially) is a very complex one, requiring an integrated *holistic* approach, of which agricultural biotechnology is but a component. However, modern biotechnology (*hereafter referred to as "agricultural biotechnology"*) has the potential to make crop breeding and crop-management systems in developing countries more efficient in generating improved crop varieties and higher yields.

Recent advances in agricultural applications of modern biotechnology showed a significant potential to contribute to sustainable gains in agricultural productivity, reducing poverty and enhancing food security in developing countries (Zilberman *et al*, 2010). Since agro-biotechnology has been considered as a strong potential to improve agricultural production, *therefore* the level of *its* adoption of *agricultural biotechnology* in Nigeria should be accelerated to change this potential to actual *improve gain*. Research institutes, Colleges of Agriculture and Universities *centres* play a great role in this context because they are the main providers of biotechnology *innovations*. Therefore this paper examines the biotechnology adoption scenario in Nigeria *and determine the factors influencing the process* from the viewpoint of academic researchers.

Conceptual Framework

Food security refers to the availability of food and one's access to it. A household is considered food secured when its occupants do not live in famine or fear of malnourishment. It has been *certified reported* by various authors that agriculture is the primary means by which man has satisfied the requirement for food and nutrition (ANAP, 2006). Due to increased farming for use in bio fuels, conversion of agricultural land to residential and industrial development, land use for agricultural purposes is gradually losing its place. Consequently, there is need to fashion a strategy that will maximise the availability of land for agricultural purposes. Researchers around the world have advocated the use of Agro-biotechnology as a strong potential to speed up the movement towards industrialization and securing food in most of the developing countries.

Wolf *et al* (2000) emphasised that there is a need for a linkage between innovators and industry. *The paper It was* argued that it is necessary to evaluate the market needs and the value *a of* new technology. *For this to happen, Consequently,* there is a need for *a* closer linkage between the researchers/innovators and the users of the innovations. Academic research centres as the *producers home* of the innovations are also directly involved in the process of adoption of innovations. *This is the conceptual construct of this study; to have an insight on the adoption process of biotechnology and factors influencing this process in Nigeria from the academics' point of view.*

Nigeria and Biotechnology:

There is a wide *array definition* of the term "biotechnologies" with different techniques and applications, for this study the term "biotechnologies" was captured by the

definition of Convention on Biological Diversity (CBD) that defines biotechnology as: "*any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use*". Evidenced from literature revealed that the Nigerian government believes in the opportunities offered by biotechnology to empower our farmers through increased productivity and as such this led the government in the to the creation of a National Biotechnology Development Agency (NABDA) (Magaji, 2007). This agency maintains collaboration with a large number of organizations in bringing improved technologies, including biotechnology products, to our farmers. NABDA also maintained a close team work with a sizeable number of scientists from Nigerian Agricultural Institutes and Universities.

Studies have shown that agricultural scientists in developing countries anticipated great benefits from biotechnology in the coming decades to help meet future needs for food and fibre. For example the commercial adoption of transgenic crops by farmers of transgenic crops has been one of the most rapid cases of technology diffusion in the history of agriculture (Adeosun *et al*, 2008; Magaji, 2007). In the last 20years, biotechnology has developed valuable new scientific methodologies and products, which need active financial and organizational support to bring them to fruition. So far, biotechnology has the greatest impact in medicine and public health. However, There are also a number of fascinating developments that are approaching commercial applications in agriculture (Magaji, 2007). This is a research relevance that needs to be investigated.

Agricultural research and technology development programmes

Agricultural research and technology development programmes started in Nigeria before the amalgamation of the Southern and Northern Protectorates into one country, Nigeria, in 1914 (Akinyosoye, 2006, Idachaba, 2000). The initiative It was the initiative of by the British colonial masters, with the establishment of a Botanical Station in Lagos in 1893, followed by experimental stations in Ibadan between 1899 and 1912 for improving the cultivation of rubber and cotton and the management of the forest of humid southern Nigeria.

From this modest beginning, the programmes have become expansive and the programmes covering the establishment and management of a number of national and international Research Institutes, Agricultural Universities, Faculties of Agriculture, Faculties of Veterinary Medicine and Colleges of Agriculture. These research Institutes are suppose to provide innovations and new technologyies to users and help in the process of facilitation and adoption to the ultimate end users.

Methodology

Sampling Procedures and Data Collection.

Due to the nature of this research purposive sampling techniques was adopted. The target population was limited to 38 academic biotechnology researchers in Federal University of Technology Akure (FUTA), University of Ibadan, Federal College of Agriculture Akure and Moor Plantations, Ibadan. The data collection was done by means of a self administered questionnaire, which was developed by the researchers. The questions and their substance were build up based on the literature review and the local and social situation to ensure validity. The assumed questions were tailored to match the research context. The validity of the questionnaire was established by a panel of experts and through a pilot test carried at the Federal College of Agriculture, Akure. A pilot test was carried out to determine the validity and reliability of the questionnaire. The reliability was measured by using the Cranach's alpha internal consistency (Ary, *et al*, 2006, Lessinger, 1999). The calculated reliability coefficients for this questionnaire as a whole were equal to .716. The confirmed and coherent

questionnaire was distributed to the 40 (but 38 data were useful for subsequent analysis) biotechnology experts working as academics in biotechnology fields.

The data obtained data was were used to accomplish the logistic regression modelling for this study. Data were collected on household size, teaching and research experience, detailed information on various aspects of level of knowledge, amount of fund, level of acceptance and receptiveness, level of cooperation, level of transfer of technology and personal characteristics from the perspective of University/ and Research Institute biotechnology experts among others

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Estimation Procedure: Logistic Regression Model

The logistic regression has been acknowledged as a new method to obtain more exact estimates on the level of adoption in social sciences (Adeogun *et al*, 2008). The logistic regression is characterized with representing one or more independent variables that determine a dependent variable or outcome. This outcome is measured or recorded via a binary variable; the independent variable(s) on the other hand can be classified as Continuous, Mixed of Continuous and Categorical.

The goal of logistic regression is to find the best fitting model to describe the relationship between the dichotomous characteristic of interest (dependent variable = response or outcome variable) and a set of independent (predictor or explanatory) variables. Logistic regression generates the coefficients (and its standard errors and as well as significance levels) of a formula to predict a *Logit transformation* of the probability of presence of interest.

Therefore the present In this study, tends to analyse a problem with five independent variables namely: level of knowledge, amount of found, level of acceptance, level of cooperation, level of transfer of technology and rate of adoption, respectively was analysed. The level of adoption of biotechnology innovations is taking as the dependent variable.

The logistics regression is a model as

$$\text{Logit}(p_i) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 \quad (1)$$

Where p is the probability of presence of the i characteristic of interest. The logit transformation is defined as the logged odds:

$$\text{Odds} = \frac{p_i}{1 - p_i} \quad (2)$$

and therefore the Logits (natural logs of the odds), of the unknown binomial probabilities are modelled as a linear function of the X :

$$\text{Logit}(p_i) \text{ Ln} \left[\frac{p_i}{1 - p_i} \right] = \beta_0 + \sum_{j=1}^5 \beta_j X_j \quad (3)$$

(Retype equation 3 to make the denominator shift from the line)

The Logit model assumes that underlying stimulus index $\text{logit}(p)$ is a random variable, which predicts the i probability of biotechnology innovation adoption:

$$\text{Chance of adoption} = p_i = \frac{1}{1 + e^{-\text{Logit}(p_i)}} = \frac{e^{\text{Logit}(p_i)}}{1 + e^{\text{Logit}(p_i)}} \quad (4)$$

The above formulas have been used to calculate the probability of adoption of biotechnology innovations that is to predict the possibility and chances for the innovations to be adopted (Give ref).

Results and Discussions

The analyses of demographics of the respondents' were presented from in Table 1. The findings revealed that 55 percent of the researchers came from the Universities, 21 percent from College of Agriculture and 14 percent from Institute of Agricultural Research (Table 1). The mean age of the respondents was 44.5 years, while the mean teaching/research experience mean was captured as 7.5 years. The analysis also showed that the age of the participants were between 35 to 45 years. Evidence from literatures suggested that age and academic experience were the two major factors that affect the rate of innovations produced by academics (Farid, *et al*, 2010, Hilker and Hamilton, 1994).

The same pattern (what pattern?) applies for to working experience, where those with less than 10 years of experience were more innovative while a significant decrease was noted among those in the range of 11 to 15 years. This pattern can be attributed to the academic system of promotions and salary increments. The new academic staffs are more eager and enthusiastic (to do what?). They are energetic and driven by future prospects in their work environment. Later on as documented by past studies Hhowever as they settle down, the number level of innovation appears to decide, decline perhaps due to complacency.

Given new perspectives for change and growth in subsequent years, the academic members get renewed vigor and work harder. This could explain the trend as seen above. The final part of the data on demography dealt with job designations of the respondents. The participants were categorized into three groups: Senior lecturers, Lecturer I and lecturer II. It was observed showed that those in lecturer II category had the highest productivity rate of 50 percent while Ssenior lecturer category recorded the lowest. Since there were no significant differences among the groups, with respect to academic designations, this cannot be considered as a differentiating factor.

Table 1: Demography Variables of the Respondents

Institutions	Male	Female	Total (%)
University of Ibadan	18	7	25 (24.%)
Obafemi Awolowo University, Ile-Ife	14	6	20
University of Benin	13	7	20
Federal University of Technology Akure	9	6	15 (26%)
Federal College of Agriculture, Akure	6	4	10 (21%)
Institute of Agricultural Research, Ibadan	5	5	10 (14%)
Total	65	35	100
Variables/Academic Status			
Senior Lecturer	15	8	23 (11%)
Lecturer I	20	11	31 (39%)
Lecturer II	30	16	46 (50%)
Age (years) (Mean)	47.2	41.8	44.5
Teaching/Research Experience (Mean)	8	7	7.5

(55 percent of the researchers came from Universities; there's no 55 in the table)

The data analyses on factors influencing adoption processes were carried out using SPSS 17 and LIMDEP 6.0 software and were used to derive estimates for the rate of biotechnology innovation adoption. The results of the compilation tests of model coefficients were presented from Table 2. Table 2 shows the chi-square goodness-of-fit test of the scope of the study and determines that the step is justified. Here the step is defined from the constant-only model to the all-independents model. When as here the step was to add a variable or variables, the inclusion is justified if the significance of the step is less than .05. Therefore, the likelihood ratio chi-square of 40.078 with a p -value of .000 shows that the outcome model as a whole fits significantly.

Table 2: Collection Tests of Model Coefficients

Step		Chi-square	Significant
1	Step	40.078	.000
2	Block	40.015	.010
3	Model	41.010	.015

Source: Computer Results, 2011 (*"Computer Results" - not a valid reference source*)

Table 3 presents the most important and applicable results for this study. The Logistic regression analysis showed that all coefficients simultaneously are statistically different from zero and the test of significance helped in explaining the decisions on the adoption of biotechnology innovations. The parameter estimates for the model were evaluated at 5% level of significance. Logit model estimates for the study areas (Table 3) showed that the effect of the three independent variables, namely level of knowledge, level of acceptance and level of transfer of technology were statistically significant at 5% level. These results are consistent with a number of theoretical and empirical studies revealing that knowledge of an innovation is the first step in the decision-making process (Farid, 2010, Rogers and Shoemaker, 1971 and Rogers 1995). Also, the works of In similar studies, Harryson *et al.* (2007) and Chong *et al.* (2009) were of the opinion noted that knowledge is an independent variable that determines the level of adoption of an innovation.

The studies reaffirmed that knowledge gained from the Research Institutes/Universities benefits users more and accelerates the level of adoption. The findings of this study are in line with the validations given above these observation as they showed the negative signs and significance of level of knowledge variable. Research Institutes/ and Universities researchers are of the view that level of knowledge is an important factor in determining the adoption level of innovation by biotechnology users. Knowledge about an innovation is an indicator of the level of adoption. As the awareness of knowledge increases, it is more likely that there will be a corresponding increase in the level of adoption. Level of knowledge about biotechnology innovations on the other hand contributes to low adoption rate. The findings indicated that another source affecting the process of adoption of biotechnology innovation is acceptance. The acceptance variable has a positive impact on the decision to adopt biotechnology Innovation (Table 3).

Table 3: Analysis of Maximum Likelihood Estimates

Step	Independent Variable	Coefficients	Standard Error	Significant Levels
1	Level of Knowledge X_1	-3.012	0.873	0.000
	Amount of fund X_2	0.458	0.215	0.175
	Level of Acceptance X_3	2.153	0.518	0.002
	Level of Cooperation X_4	0.815	0.614	0.182
	Level of transfer of Technology X_5	1.792	0.815	0.014
	Constant	-7.185	2.152	0.020

Source: Computer Results, 2011 (*“Computer Results”- not a valid reference source*)

This is in line with the works of Boon and Holmes (1991) and Cahill *et al.*, (1990) empirical studies that have noted the importance of trust as one of the indicators affecting adoption based on technology acceptance models. The literature further indicates that Furthermore, the adoption of new technology is a function of profitability, riskiness, initial capital requirement, complexity and availability (Rogers, 1995; Byerlee and Polanco, 1986; and Feder, 1982). The positive sign and significance of the acceptance variables in this study imply that acceptance is a second major factor according to magnitude of coefficient that will promote adoption of innovation by biotechnology users.

The significant result for transfer of technology in the present research study showed that this it is the third another important factor encouraging users of biotechnology to adopt biotechnology innovations. Empirical results of most studies support this finding. This is was presented as an important element by Cottrill *et al.* (1989) whereas they confirm nothing that technology transfer and diffusion of innovations provide the link between technology development and utilization, hence transferring work of technology developers into the hands of end users. The potential of new technologies cannot be fully realized without the successful movement of technology out of a development laboratory and into a user's environment. The national policy includes development innovation in academic biotechnology research, biotechnology industry and transfer of technology (ToT).

The dissemination model of technology transfer takes the view that transfer is best accomplished when experts transfer specialized knowledge to a willing receptor (Farid *et al.*, 2010, ANAP, 2006, Rogers, 1995). As expected, The findings of present research this study also support that transfer of technology is a significant predictor. Based on data available from websites of According to National Bureau of Statistics (NBS, 2011) and Central Bank of Nigeria (CBN, 2011) the support given to the innovation or new technology users is in the form of loans, grants and funds. Therefore, it is important for biotechnology users to be familiar with types of assistance and the nature of their utilization (NBS, 2011 and CBN, 2011). The findings illustrate that provision of funds does not have a significant impact on the decisions to adopt biotechnology innovation by users.

However, these findings are contrary to empirical results of previous studies, which found finance as an essential factor affecting adoption decisions (Rogers, 1995; and Panatanali, 1987). This could be due to the fact that grants are given to researchers for innovation purposes but it is not ration upon them to produce suitable and profitable innovations according to users' needs. Researchers may devote their efforts to produce new biotechnology products without considering the price information or the needs and demands of the biotechnology users. The effect of cooperation has been studied in earlier researches, such as Veugelers and Cassimanb, (2005), Schartinger *et al.* (2002), Schibany *et al.* (1999),

Rosenberg and Nelson, (1994), and Mansfield, (1991), and Farid, (2010). These researchers argued that gaining basic science, applied science, experimental development, measurement and testing, consulting services, funds and grants, are important reasons for cooperation between companies and universities.

However, the findings of the current study do not support that of the earlier mentioned studies are differed from earlier report of modelled as a linear function of the X_i

The results showed that the cooperation variable is not a statistically significant factor. This implies that academic centres generally do not believe in the effect of the rate of extension services' in enhancing the level of adoption. The estimated model is used to predict probability of adoption of biotechnology innovations created by Nigerian Universities for biotechnology users, the results show that the cooperation variable is not a statistically significant factor. This implies that academic centres generally do not believe in the effect of the rate of extension services' in enhancing the level of adoption. The estimated model is used to predict probability of adoption of biotechnology innovations created by Nigerian Universities for biotechnology industry from the perspective of university biotechnology experts:

$$\text{Logit}(p_i) \ln \left[\frac{p_i}{1-p_i} \right] = \quad (5) \text{ (Lines 322-329 is repetition)}$$

The probability that a company will adopt a biotechnology innovation, for any units are allocated to this study's predictors, is given by

$$\text{Chance of adoption} = p_i = \frac{1}{1 + e^{-\text{Logit}(p_i)}} \quad (6)$$

According to these researchers, the empirical model is used to draw economic justifications for strategies to improve biotechnology innovation in Nigeria. The probability of adoption shows clearly that the percentage change of biotechnology adoption by companies when any unit is allocated to the predictors. (Lines 331-338 are presented in ambiguous manner; could be expunged)

Conclusion

The results of the findings of this study indicated that the level of knowledge, acceptance and transfer of technology have direct effect on the level of adoption of biotechnology innovations. Therefore, there is need for policies that will streamline agro-biotechnology programme in a sustainable way to potential users. Also, policies that will advance agricultural research institutes to help boost agricultural biotechnology activities, increasing outputs and improving income of agricultural entrepreneur is are advocated. Hunger and poverty reduction must be addressed for the country's stability by integrating modern agriculture with traditional food production system and to make sure that food and agricultural varieties, which were not part of the traditional food system, are introduced into the country to expand the food and agricultural product base.

This study has highlighted the benefits of agricultural biotechnology from the view points of academic. These benefits will, however, will reach poor farmers only if the innovations are closely linked to the farmers' needs and if a national research system is properly developed. Agricultural biotechnology can increase yields, improve the environment by decreasing the use of chemical inputs, cooperate in contribute to reducing soil erosion, and decrease the need for new land to respond to the increase in food demand. However, it is not wise to raise unreasonable expectations about what agricultural biotechnology can do. Agricultural biotechnologies are not the magic silver bullet that will eliminate food insecurity and poverty. The spread of a message that is unrealistically optimistic would be ethically wrong, economically erroneous, and politically counterproductive. Nevertheless, agricultural

biotechnology can support efforts aimed at increasing the agricultural production and improving the income of small-scale farmers in Nigeria. Having highlighted the benefits of Agricultural biotechnology, there is thus the need to examine an agricultural biotechnology and agricultural productivity.

References

- Adeogun, A., Ajana, A.M., Ayinla, A., Yarhere M.T. and Adeogun, M.O. 2008. Application of Logit Model in Adoption Decision: A Study of Hybrid Clarias in Lagos State, Nigeria. *American-Eurasian J. Agricultural & Environmental Sci.*, 4: 468-472.
- Akinyosoye, V.O., 2006. Government and Agriculture in Nigeria: Analysis of Policies, Programme and Administration. Macmillian Nigeria Publishers Limited, Ibadan, Nigeria.
- Alayande, B., Alayande, O., 2004. A quantitative and qualitative assessment of vulnerability to poverty in Nigeria. Being paper submitted for presentation of CSAE Conference on poverty reduction, growth and human development in Africa, March, 2004
- Apata, T.G., Folayan, A, Apata, O.M. and Akinlua, J. 2011: The Economic Role of Nigeria's Subsistence Agriculture in the Transition Process: Implications for Rural Development. 85th Annual Conference of the Agricultural Economics Society (U.K.) Warwick University, U.K., 18 - 20 April 2011
- Assessment of Nigeria Agricultural Policy (ANAP) study, 2006. Agriculture in Nigeria: Identifying opportunities for increased commercialization and investment. IITA press, IITA Ibadan.
- Ary, D.J., A. Razavieh and C. Sorensen, 2006. Introduction to Research in Education. Thomson Wadsworth
- Boon, S.D. and Holmes, J. D. 1991. The Dynamics of Interpersonal Trust: Resolving Uncertainty in the Face of Risk. In *Cooperation and Prosocial Behavior*, Eds., Hinde, R.A. and Groebel, J. Cambridge, UK: Cambridge University Press, pp: 190-211.
- Byerlee, D. and Polanco, E.H. 1986. Farmers' Stepwise Adoption of Technological Package: Evidence from the Mexican Altiplano. *American J. Agric. Economics*, 68: 520-527.
- Cahill, A., Stevens, J and Laplante, J. 1990. The Utilization of Information-Systems Technology and Impact on Organizational Decision-Making. *Knowledge-Creation Diffusion Utilization*, 12: 53-79.
- Central Bank of Nigeria (CBN) 2011. Agricultural Data. www.cenbank.org accessed 12th July, 2011
- Chong, A.Y, Ooi, K.B., Lin, C., and Murali, R, 2009. Factors Affecting the Adoption Level of C- commerce: An Empirical Study. *J. Computer Information Systems*, 50: 13-22.
- Cottrill, C.A., Rogers E.M. and Mills, T. 1989. Co-citation Analysis of the Scientific Literature of Innovation Research Traditions. *Knowledge-Creation. Diffusion Utilization*, 11: 181-208.
- Farid, H., Silong, A. D. and Sarkar, S.K. 2010: Application of Logit Model in Innovation Adoption: a Study on Biotechnology Academic Researchers in Malaysia. *American-Eurasian J. Agric. & Environ. Sci.*, 9 (3): 282-287, 2010.
- Feder, G., 1982. Adoption of Interrelated Agricultural Innovation: Complementarily and Impact of Risk, Scale and Credit. *American J. Agric. Economics*, 64: 94-101.
- Flavell, R. 1999. Biotechnology and Food and Nutrition Needs. Brief 2 of 10 in: *Focus 2: Biotechnology for Developing Country Agriculture* (ed. G.J. Persley). International Food Policy Research Institute, Washington, D.C., October 1999. 2 p.
- Harryson, S., Kliknaite, S and Dudkowski, R. 2007: Making Innovative Use of Academic Knowledge to Enhance Corporate Technology Innovation Impact. International

- 412 J. Technol. Management, 39: 131-157.
- 413 Hilder V., and Hamilton, W. 1994. "Biotechnology and Prospects for Improving Crop
414 Resistance," in C. Blak and Swettmore (Eds.), *Crop Protection in the Developing*
415 *World* (British Crop Protection Council: Farnham, 1994).
- 416 Hossain, M., Gollin, D. Gabanilla, V. Carrera, E. Johsion, N. Khush, S and McLaren, G.
417 2003 "International Research and Genetic Improvement in Rice: Evidence from Asia
418 and Latin America," in R. E. Evenson and D. Gollin (Eds.), *Crop Variety Improvement*
419 *and Its Effect on Productivity: The Impact of International Agricultural Research*
420 (CABI: Del'émont, Switzerland, 2003).
- 421 Huang, J., Hu, R., Pray, C., Qiao, F. and Rozelle, S. 2003. Biotechnology as an alternative to
422 chemical pesticides' case study of Bt cotton in China.
423 *Agricultural Economics* 29 (2003) 55-67
- 424 Idachaba, S. 2000. Instability of National Agricultural Research Systems in Sub-Saharan
425 Africa: Lesson from Nigeria, ISNAR Research Report 13, The Hague
- 426 Leisinger, K. 1999. Disentangling Risk Issues. Brief 5 of 10 in: *Focus 2: Biotechnology for*
427 *Developing Country Agriculture* (ed. G.J. Persley). International Food Policy
428 Research Institute, Washington, D.C., October 1999. 2 p.
- 429 Magaji, M. D. 2009: Biotechnology and Its applications in Agriculture. Paper presented at the
430 inaugural meeting of the Open Forum on Biotechnology (OFAB), Nigeria Chapter.
431 Sheraton Hotels and Towers, Abuja, 21st-24th July, 2009
- 432 Mansfield, E., 1991. Academic Research and Industrial Innovation. *Research Policy*,
433 20: 1-12.
- 434 Manyong, V. M., Kling, J.G. Makinde, K.O. Ajala, S.O and Menkir, A. 2003 "Impact of
435 IITA Germplasm Improvements on Maize Production in West and Central Africa," in
436 R. E. Evenson and D. Gollin (Eds.), *Crop Variety Improvement and Its Effect on*
437 *Productivity: The Impact of International Agricultural Research* (CABI: Del'émont
438 Switzerland, 2003)
- 439 National Bureau of Statistics (NBS), 2011: Agricultural Statistics and Data.
- 440 Okunmadewa, F., 2002. *Poverty and Agricultural Sector. Poverty reduction and the*
441 *agricultural sector in Nigeria*, edited by Foluso Okunmadewa, Elshaddai Global
442 *Ventures Ltd. Ibadan, Nigeria. (This reference is not cited in the text)*
- 443 Olayemi, J.K., 1980. Food crop production by small farmers in Nigeria: eds by Olayide, S.O.,
444 J.A. Eweka and V.E. Bello-Osagie, 1980 *Nigerian Small Farmers: Problems and*
445 *Prospects in Integrated Rural Development in Nigeria*. Centre for agricultural rural
446 and development (CARD), University of Ibadan, Nigeria publisher.
- 447 Oksana, N., 2005. Small farms: Current Status and Key Trends. In *Proceedings of Research*
448 *Workshop on the future of small farms Wye, Uk Organised by International Food*
449 *Policy research institute (IFPRI)/2020 initiative and Overseas Development Institute*
450 *(ODI) Imperial College, London*
- 451 Olayide, S., Eweka, J., Bello-Osagie, V., 1980: *Nigerian Small Farmers: Problems and*
452 *Prospects in Integrated Rural Development in Nigeria*. Centre for agricultural rural
453 and development (CARD), University of Ibadan, Nigeria publisher.
- 454 Oyeranti, O., Olayiwola, K., 2005. Policies and Programmes for Poverty Reduction in Rural
455 Nigeria. An interim Research Report Submitted to the African Economic Research
456 Consortium (AERC), Nairobi
- 457 Pantanali, R., 1987. Factors Affecting Farmers Adoption Rates in a Subsistence Economy. In
458 the proceeding of the 1989 Design of Agricultural Investment Projects – Lessons from
459 experience (FAO Technical Paper), pp: 2-5.
- 460 Rogers, F.M. 1995: *Diffusion of Innovations*. The Free Press, Collier Macmillan Publishing
461 Inc. New York

- Rogers, F.M. and Shoemaker, F.F. 1971: Communications for Innovations: A cross culture approach, New York. The Free Press, Collier Macmillan Publishing Inc. New York
- Rosenberg, N. and R. Nelson, 1994. American Universities and Technical Advance in Industry. *Research Policy*, 23: 323-348.
- Santaniello, V 2002., "Biotechnology and Traditional Breeding in Sub-Saharan Africa," in T. M. Swanson (Eds.), *Biotechnology, Agriculture and the Developing World: The Distributional Implications of Technology Change* (Edward Elgar: Northampton, UK, 2002).
- Schartinger, D., C. Rammer, M.M. Fischer and J. Frohlich, 2002. Knowledge Interactions between Universities and Industry in Austria: Sectoral Patterns and Determinants. *Research Policy*, 31: 303-328.
- Schibany, A., L. Jörg and W. Polt, 1999. Towards Realistic Expectations. The Science System as a Contributor to Industrial Innovation. Study by the Working Association TIP in Commission of the Austrian Federal Ministries of Economic Affairs and Science and Transport, Seibersdorf/Wien, Austria.
- Veugelers, R. and B. Cassimanb, 2005. R&D Cooperation between Firms and Universities some empirical evidence from Belgian manufacturing. *International J. Industrial Organization*, 23: 355-379.
- Wolf, C.A., D.W. Dave and F.O. James, 2000. Economic Decisions in Biotechnology : Lessons for Small Firms. Paper presented at the 10th Malaysian Universities for biotechnology Congress, Chicago, Illinois. Retrieved 2007: Wolf_Christopher.PDF
- World Bank, 2008: World Development Report: Agriculture for Development Washington, D.C.,
- Zilberman, D., Ameden, H and Gregory, G and Qaim, M, 2010: Agricultural Biotechnology: Productivity, biodiversity, And intellectual property Rights. An Article Submitted to *Journal of Agricultural & Food Industrial Organization* Manuscript 1068. 25 pages