AAAE Conference Proceedings (2007) 111-118

# Determinants of adoption and intensity of use of balanced nutrient management systems technologies in the northern Guinea savanna of Nigeria

*Akinola A.A.[1], Arega D.A.[2], Adeyemo R.[1], Sanogo D.[3], Olanrewaju A.S.[3], Nwoke C.[3],*

*Nziguheba G.,[3] and Diels J.[4]*

*[1]Department of Agricultural Economics, Obafemi Awolowo University, Ile-Ife, Nigeria*

*[2]IITA, Lilongwe, Malawi*

*[3]IITA, Ibadan, Nigeria*

*[4]Katholieke Universiteit Leuven, Kasteelpark, Heverlee, Belgium*

**Abstract**

As part of a major effort to address soil fertility decline in West Africa, a project on Balanced Nutrient Management Systems (BNMS) has since 2000 been implemented in the northern Guinea savanna (NGS) of Nigeria. The project has tested and promoted two major technology packages, including a combined application of inorganic fertilizer and manure (BNMS-manure) and a soybean/maize rotation practice referred to as BNMS-rotation. This study employed Tobit model to examine factors that influence the adoption and intensity of utilization of BNMS technologies in the NGS of Nigeria. Results showed that less than 10% of the sample households adopted at least one of the two components of the technology package by the end of 2002. However, by 2005 the adoption of BNMS-rotation had reached 40% while that of BNMS-manure had reached 48%. A number of factors such as access to credit, farmers' perception of the state of land degradation, and assets ownership were found to be significant in determining farmers' adoption decisions on BNMS-manure while off-farm income was found to be significant in determining farmers' adoption decisions on BNMS-rotation. Extension services and farmer-to-farmer technology diffusion channels were the major means of transfer of BNMS technologies.

Key words: Adoption, BNMS-manure, BNMS-rotation, Northern Guinea Savanna (NGS).

## Introduction

Land degradation and soil nutrient depletion have become a menace to agricultural productivity and rural livelihoods in Africa. It has been argued that effective use of organic soil amendment methods in combination with inorganic fertilizer could help reverse the nutrient depletion trend. Such approach to tackle soil fertility problem formed the basis of a project on integrated soil fertility management (ISFM) known as the Balanced Nutrient Management System (BNMS) project in West Africa. The project developed and tested management practices that maintain or improve soil nutrients by promoting the use of locally available sources of plant and animal nutrients, maximizing their nutrients use efficiency, and optimizing their combination with inorganic fertilizers. Two technological packages have emerged as breakthroughs: (i) The BNMS technological package combining organic matter with inorganic fertilizer known as BNMS-manure treatment (BNMS-manure) and; (ii) the soybean/maize rotation with reduced fertilizer application to maize called BNMS-soybean/maize treatment (BNMS-rotation) (Vanlauwe et al. 2001). Evidence from on-station and on-farm researcher-managed trials indicated that combined application of organic and inorganic fertilizer inherent in BNMS technologies gives higher yields than any singular application of either input (Iwuafor et al. 2002; Wallays 2003; Ugbabe 2005). However, no study has so far looked into the adoption of these land improving technologies at farm level. Knowledge gaps exist on the level of adoption and utilization of the technologies. The objective of this paper is therefore to determine the rate and intensity of adoption of component as well as package BNMS technologies and analyze the socio-economic, demographic, institutional, policy and technology-related factors influencing the adoption and intensity of use of BNMS technologies.

## Methodology

***Theoretical model***

Tobit (As explained by Tobin 1958, McDonald and Moffit 1980 and Amemiya 1984) model was used in this study to analyze the socio-economic, demographic, institutional, policy and technology-related factors influencing the adoption and intensity of use of BNMS technologies.

***Data source and sampling procedure***

A household survey was conducted in eight demonstration and adaptation trial villages of BNMS technologies spread in three agricultural zones; Maygana, Birni Gwari and Lere. A total of 400 household heads were interviewed using a well-structured questionnaire. To determine household sample size per village, household heads in the villages were listed and random selection was made based on the population of each village. The share of total sample size in respective villages was as follows: Fatika (18.5%), Kaya (23.5%), Danayamaka (9.25%), Buruku (18.75%), Kufana (5.7%5), Kroasha (6.25%), Kadiri Gwari (9) and Kayarda (9%). The household survey was supplemented with community level survey using the Focus Group Discussion (FGD) method.

*Empirical model*

Collected survey data were analyzed using descriptive statistics and econometric models with the statistical software packages SPSS and LIMDEP. In this study, the dependent variable is the land area under each of the BNMS technology. The estimated model is specified by equation 8:

The multidisciplinary independent variables included farmer, farm and institutional factors postulated to influence technology adoption. These variables include age (*AGE*) of the household head in years, the household size (*HHSIZE*), measure of social interaction resulting from membership in farmers' organization (*SOCKAP*), off-farm income (*OFFINCOME*) measured in Nigeria naira (₦), livestock ownership (*LIVESTOCK*), measured in

Tropical Livestock Unit, access to credit (*CREDIT*), education of household head (*EDUCATION*) measured by the number of years of formal education. Others are perception of the state of land degradation and depletion (*PERCEPTION*), effective extension contacts (*EXTENSION*) measured by regularity of visits by extension agents, farm size (*FARMSIZE*), and asset (*ASSET*). Off farm income and asset ownership Naira values were transformed in natural logarithm. Social capital, access to credit and extension were included in the model as dummy variables. The rationale for inclusion of these factors was based on *a prior* of agricultural technology adoption literature.

## Results and discussion

*Socio-economic characteristics of sample households*

Table 1 shows survey results indicating the demographic and socio-economic characteristics among non-adopters and adopters of ISFM technologies

*Adoption typology, intensity of use and trend of BNMS technologies*

Figure 1 shows the adoption typology, while Figures 2 and 3 describe intensity of use and trend of adoption of BNMS technologies in the survey area. The data showed that 66% of IITA's staff and extension agents from the NARS were the main channel through which information concerning BNMS-manure was disseminated to the farmers, followed by farmer-farmer interaction that transferred the information to 19% of the respondents. National Agricultural Research Institute, local NGO and mass media transferred information about BNMS-manure to 15% of the sample households. The same trend was observed in the BNMS-rotation. About 64 % of the respondents had knowledge of the technology through IITA and extension agents, and 19% of the farmers had their own awareness of the BNMS-rotation through other farmers.

The results of FGD and descriptive statistics in this study have indicated the importance of extension service in the adoption and use intensity of BNMS technologies. By way of scaling the technology up and out, policies and strategies that improve access to extension services should be instituted. In line with this is an urgent need for upgrading the quality and adequacy of the extension services in target areas via better training for technical and communication skills. The results of the FGD have also made strong case for

$$Y_i = \beta_0 + \beta_{ii} AGE + \beta_2 HHSIZE + \beta_3 SOCKAP + \beta_4 OFFINCOME + \beta_5 LIVESTOCK + \beta_6 CREDIT + \beta_7 EDUCATION + \beta_8 PERCEPTION + \beta_9 EXTENSION + \beta_{10} FARMSIZE + \beta_{11} ASSET + \mu \quad (8)$$

**Table 1**. Demographic and socio-economic characteristics of farmers (mean)

| Variable | Non- adopters | Inorganic fertilizer only | BNMS manure | BNMS rotation | All sample |
|---|---|---|---|---|---|
| Age | 50 | 40.8 | 44.5 | 43.5 | 42.5 |
| Literacy rate (%) | 33.3 | 46.3 | 48.4 | 43.3 | 46.3 |
| Years of formal education of head | 5 | 8 | 7.3 | 7.3 | 7.6 |
| Household size | 9.7 | 10.6 | 12.4 | 12.6 | 11.5 |
| No. of adult males >15 | 2 | 3.3 | 3.7 | 3.6 | 3.5 |
| Farm size | 2.6 | 3.5 | 3.8 | 3.5 | 3.58 |
| Total livestock unit | 1.2 | 3 | 4.12 | 3.9 | 3.5 |
| Farm distance (km) | 3 | 4.5 | 4.8 | 5.4 | 4.7 |
| Perception (% degraded) | 33 | 82 | 94 | 72 | 83 |
| Extension contact (%) | 40 | 70 | 72 | 68 | 69.3 |
| Off-farm income (₦) | 2500 | 11,717 | 17217 | 19,615 | 14,579 |
| Access to credit (%) | 0 | 16 | 24 | 12 | 17.5 |
| Asset | 3,420 | 57915 | 53,122 | 25,579 | 50,129 |
| Membership of association (% belong) | 50 | 50 | 58 | 49 | 55 |

Source: Own survey.

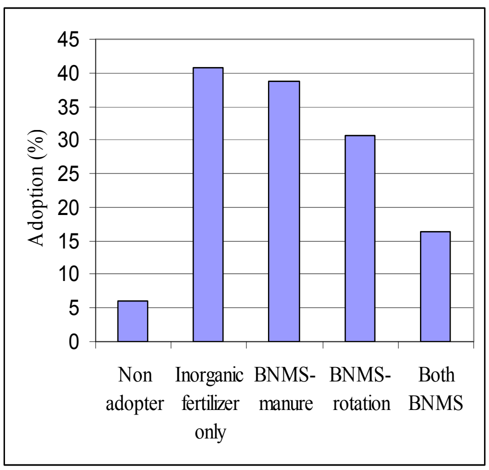


**Figure 1:** Adoption typology of ISFM technologies

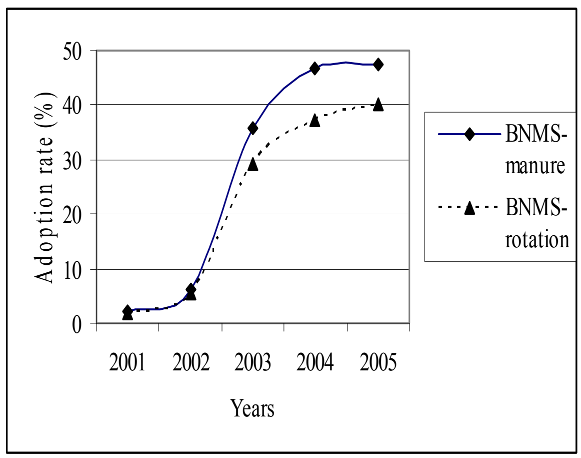


**Figure.3:** Cumulative adoptions of BNMS

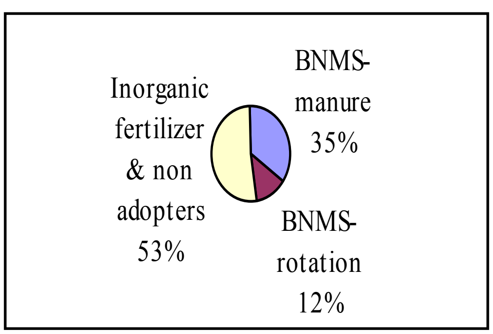


**Figure 2:** Intensity of use of BNMS technologies

**Intensity of use of BNMS technologies**

**Table 2**. Results of Tobit model of the adoption and intensity of use of BNMS-manure technology in the NGS

| Variable | Maximum likelihood estimate ($\beta$) | Change in probability of adoption $(\delta F(z)/\delta X_i)$ | Change in intensity of adoption $(\delta Ey^*/\delta X_i)$ | Total change $(\delta Ey/\delta X_i)$ | Total change via new adopters $\{Ey^*(\delta F(z)/\delta X_i)\}$ | Total change via current adopters $\{F(z)(\delta Ey^*/$ |
|---|---|---|---|---|---|---|
| Constant | -10.163*** | | | | | |
| | (-5.247) | | | | | |
| Age | 0.022 | 0.002 | 0.005 | 0.005 | 0.004 | 0.001 |
| | (0.874) | (0.876) | (0.875) | (0.874) | (0.874) | (0.872) |
| Hhsize | 0.042 | 0.003 | 0.010 | 0.010 | 0.008 | 0.002 |
| | (1.032) | (1.032) | (1.032) | (1.031) | (1.032) | (1.028) |
| Sockap | 0.077 | 0.006 | 0.018 | 0.018 | 0.014 | 0.004 |
| | (0.215) | (0.215) | (0.215) | (0.215) | (0.215) | (0.215) |
| Offincome | -0.048 | -0.004 | -0.011 | -0.011 | -0.008 | -0.003 |
| | (-0.378) | (-0.378) | (-0.378) | (-0.378) | (-0.378) | (-0.378) |
| Livestock | 0.021 | 0.002 | 0.005 | 0.005 | 0.004 | 0.001 |
| | (0.375) | (0.375) | (0.375) | (0.375) | (0.375) | (0.375) |
| Credit | 1.425** | 0.110** | 0.331** | 0.328** | 0.252** | 0.076** |
| | (2.135) | (2.124) | (2.136) | (2.117) | (2.124) | (2.085) |
| Education | 0.004 | 0.000 | 0.001 | 0.001 | 0.001 | 0.000 |
| | (0.066) | (0.066) | (0.066) | (0.066) | (0.066) | (0.066) |
| Perception | 2.709*** | 0.210*** | 0.630*** | 0.623*** | 0.478*** | 0.145*** |
| | (2.967) | (3.070) | (3.026) | (3.039) | (3.042) | (3.001) |
| Extension | 0.293 | 0.023 | 0.068 | 0.068 | 0.052 | 0.016 |
| | (0.496) | (0.496) | (0.496) | (0.496) | (0.496) | (0.495) |
| Farmsize | 0.053 | 0.004 | 0.012 | 0.012 | 0.009 | 0.003 |
| | (0.459) | (0.459) | (0.459) | (0.459) | (0.459) | (0.458) |
| Asset | 0.348** | 0.027** | 0.081** | 0.080** | 0.062** | 0.019** |
| | (1.968) | (1.960) | (1.973) | (1.962) | (1.966) | (1.940) |
| Log likelihood function | | -449 | | | | |
| $z$ | | 66 | | | | |
| $F(z)$ | | 0.23 | | | | |
| $f(z)$ | | 0.30 | | | | |
| $\sigma$ | | 0.26 | | | | |
| Model size (observations) | | 400 | | | | |

Note: *** = Significant at 1%, ** = Significant at 5%, * = Significant at 10%, Figures in parentheses represent asymptotic t-ratio

Source: Own computation

**Table 2**. Results of Tobit model of the adoption and intensity of use of BNMS-manure technology in the NGS

| Variable | Maximum likelihood estimate ( $\beta$ ) | Change in probability of adoption $(\delta F(z)/\delta X_i)$ | Change in intensity of adoption $(\delta Ey^*/\delta X_i)$ | Total change $(\delta Ey/\delta X_i)$ | Total change via new adopters $\{Ey^*(\delta F(z)/\delta X_i)\}$ | Total change via current adopters $\{F(z)(\delta Ey^*/$ |
|---|---|---|---|---|---|---|
| Constant | -10.163*** | | | | | |
| | (-5.247) | | | | | |
| Age | 0.022 | 0.002 | 0.005 | 0.005 | 0.004 | 0.001 |
| | (0.874) | (0.876) | (0.875) | (0.874) | (0.874) | (0.872) |
| Hhsize | 0.042 | 0.003 | 0.010 | 0.010 | 0.008 | 0.002 |
| | (1.032) | (1.032) | (1.032) | (1.031) | (1.032) | (1.028) |
| Sockap | 0.077 | 0.006 | 0.018 | 0.018 | 0.014 | 0.004 |
| | (0.215) | (0.215) | (0.215) | (0.215) | (0.215) | (0.215) |
| Offincome | -0.048 | -0.004 | -0.011 | -0.011 | -0.008 | -0.003 |
| | (-0.378) | (-0.378) | (-0.378) | (-0.378) | (-0.378) | (-0.378) |
| Livestock | 0.021 | 0.002 | 0.005 | 0.005 | 0.004 | 0.001 |
| | (0.375) | (0.375) | (0.375) | (0.375) | (0.375) | (0.375) |
| Credit | 1.425** | 0.110** | 0.331** | 0.328** | 0.252** | 0.076** |
| | (2.135) | (2.124) | (2.136) | (2.117) | (2.124) | (2.085) |
| Education | 0.004 | 0.000 | 0.001 | 0.001 | 0.001 | 0.000 |
| | (0.066) | (0.066) | (0.066) | (0.066) | (0.066) | (0.066) |
| Perception | 2.709*** | 0.210*** | 0.630*** | 0.623*** | 0.478*** | 0.145*** |
| | (2.967) | (3.070) | (3.026) | (3.039) | (3.042) | (3.001) |
| Extension | 0.293 | 0.023 | 0.068 | 0.068 | 0.052 | 0.016 |
| | (0.496) | (0.496) | (0.496) | (0.496) | (0.496) | (0.495) |
| Farmsize | 0.053 | 0.004 | 0.012 | 0.012 | 0.009 | 0.003 |
| | (0.459) | (0.459) | (0.459) | (0.459) | (0.459) | (0.458) |
| Asset | 0.348** | 0.027** | 0.081** | 0.080** | 0.062** | 0.019** |
| | (1.968) | (1.960) | (1.973) | (1.962) | (1.966) | (1.940) |
| Log likelihood function | | -449 | | | | |
| $z$ | | 66 | | | | |
| $F(z)$ | | 0.23 | | | | |
| $f(z)$ | | 0.30 | | | | |
| $\sigma$ | | 0.26 | | | | |
| Model size (observations) | | 400 | | | | |

Note: *** = Significant at 1%, ** = Significant at 5%, * = Significant at 10%, Figures in parentheses represent asymptotic t-ratio

Source: Own computation

**Table 3**. Results of Tobit model of the adoption and intensity of use of BNMS-rotation technology in the NGS

| Variable | Maximum likelihood estimate | Change in probability of adoption | Change in intensity of adoption | Total change | Total change via new adopters | Total change via current adopters |
|---|---|---|---|---|---|---|
| Constant | -1.590** | | | | | |
| | (-2.294) | | | | | |
| Age | 0.011 | 0.002 | 0.002 | 0.002 | 0.001 | 0.000 |
| | (1.131) | (1.135) | (1.135) | (1.134) | (1.134) | (1.129) |
| Hhsize | -0.011 | -0.002 | -0.002 | -0.002 | -0.001 | -0.000 |
| | (-0.737) | (-0.739) | (-0.739) | (-0.739) | (-0.739) | (-0.738) |
| Sockap | -0.088 | -0.016 | -0.017 | -0.013 | -0.010 | -0.003 |
| | (-0.525) | (-0.526) | (-0.525) | (-0.526) | (-0.526) | (-0.525) |
| Offincome | 0.158*** | 0.029*** | 0.031*** | 0.023*** | 0.019*** | 0.005*** |
| | (3.228) | (3.408) | (3.325) | (3.319) | (3.334) | (3.215) |
| Livestock | 0.022 | 0.004 | 0.004 | 0.003 | 0.003 | 0.001 |
| | (1.103) | (1.107) | (1.106) | (1.105) | (1.106) | (1.101) |
| Credit | -0.417 | -0.078 | -0.081 | -0.062 | -0.050 | -0.012 |
| | (-1.485) | (-1.506) | (-1.495) | (-1.495) | (-1.496) | (-1.486) |
| Education | -0.017 | -0.003 | -0.003 | -0.003 | -0.002 | -0.001 |
| | (-0.753) | (-0.756) | (-0.755) | (-0.755) | (-0.755) | (-0.754) |
| Perception | -0.787*** | -0.147*** | -0.153*** | -0.117*** | -0.094*** | -0.023*** |
| | (-3.072) | (-3.150) | (-3.134) | (-3.094) | (-3.111) | (-2.991) |
| Extension | 0.133 | 0.025 | 0.026 | 0.020 | 0.016 | 0.004 |
| | (0.591) | (0.594) | (0.592) | (0.592) | (0.592) | (0.592) |
| Farmsize | -0.008 | -0.002 | -0.002 | -0.001 | -0.001 | -0.000 |
| | (-0.201) | (-0.201) | (-0.201) | (-0.201) | (-0.201) | (-0.201) |
| ASSET | 0.039 | 0.007 | 0.008 | 0.006 | 0.005 | 0.001 |
| | (0.637) | (0.638) | (0.637) | (0.637) | (0.637) | (0.637) |
| Log likelihood function | | -210 | | | | |
| | | -24 | | | | |
| | | 0.15 | | | | |
| | | 0.23 | | | | |
| | | 0.12 | | | | |
| Model size (observations) | | 400 | | | | |

Note: *** = Significant at 1% , ** = Significant at 5% * = Significant at 10%, Figures in parentheses represent asymptotic t-ratio .Source: Own computation

organization of field days (Fields days provide the farmers, extension agents, and researchers to interact and share ideas and experiences on a given technology ) as a good strategy for promoting the adoption of BNMS technologies. Discussions in the group meetings also revealed the importance of the concept of farmer-to-farmer diffusion for scaling up and out the adoption of BNMS technologies. This concept has worked effectively in northern Nigeria for the dissemination of improved cowpea seeds among farmers (Alene and Manyong 2006). The results of the econometric model have shown the importance of access to credit and household assets endowment in increasing the cropping areas under the BNMS-manure technology. Household assets represent alternative source of credit to the rural dwellers in northern Nigeria that helps in solving liquidity problems in the area. Policy intervention that institutionalizes micro-finance activities targeting existing adopters of the BNMS-manure technology in the rural area will help solve the problem of low access to credit. The results have also shown the important role of off-farm income in increasing the adoption and use intensity of BNMS-rotation practice and the scale up and out of the technology. Extra earnings from off-farm activities helped small-scale farmers' households overcome serious liquidity constraints in the study area. This off-farm income enables them to buy improved seeds of soybean even during the critical liquidity scarcity time of the year. Therefore, strategies designed to increase off-farm income earning activities should be encouraged.

## References

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

Amemiya, T. 1984. "Tobit models: A survey." Journals of Econometrics 24: 3-61

Alene, A. D., Poonyth, D. and Hassan, R. M. 2000. "Determinants of Adoption and Intensity of Use of Improved Maize Varieties in the Central Highlands of Ethiopia: A Tobit analysis".

Agrekon 39 (4): 633-643.

Alene, A. D. and Manyong, V. M. 2006. "Farmer-to-Farmer Technology Diffusion and Yield Variation among Adopters: The Case of Improved Cowpea in Northern Nigeria". Agricultural Economics 35: 203-211.

Bamire, A.S., Fabiyi, Y.L and Manyong V. M. 2002. "Adoption Pattern of Fertilizer Technology among Farmers in the Ecological Zones of South-Western Nigeria: A Tobit Analysis". Australian Journal of Agricultural Research 53: 901-910.

Feder G, Just R.E. and Zilberman D. 1985. Adoption of Agricultural Innovations in Developing Countries: A survey. The University of Chicago: 255-299.

Iwuafor, E. N. O., Aikou, K., Vanlauwe, B, Diels, J., Sangiga, N, Lyasse, O Deckers, J, and Merckx, R. 2002. On –farm evaluation of the contribution of sole andmixed applications of organic matter and urea to maize grain production in the savanna. In: B. Vanlauwe, J. Diels, N. Sangiga and R. Merckx (eds.), Integrated Plant Nutrient Management in Sub-Saharan Africa. CABI Publishing, New York.

Lapar, M. L. A and Pandey, S. 1999. "Adoption of Soil Conservation: The Case of the Philippine Uplands". Agricultural Economics 21: 241-256.

Manyong, V. M., Houndekon, A.V. 1997. "Land tenurial systems and the adoption of mucuna planted fallows in the derived savannas of West Africa". Paper Presented at the Workshop on Property Rights, Collective Action and Technology Adoption. ICARDA. November 22-25. Aleppo, Syria.

McDonald, J. F. and Moffit, R.A. 1980. "The Uses of Tobit analysis". Review of Economics And Statistics 62: 318-321

Negatu, W. and Parikh, A. 1999. "The Impact of Perception and Other Factors on the Adoption of Agricultural Technology in the Moret and Jiru Woreda (district)". Ethiopia Agricultural Economics 21: 219-229.

Nkonya, E., Schroeder T. and Norman, D. 1997. "Factors Affecting Adoption of Improved Maize Seed and Fertilizer in Northern Tanzania." Journal of Agricultural Economic*s* 4: 1-12.

Shiferaw, B. and Holden S. T. 1998. "Resource Degradation and Adoption of Land Conservation Technologies in the Ethiopian Highlands: A Case Study in Andit Tid, North Shewa. Agricultural Economics 21: 241-256.

Tobin, J. 1958. "Estimation of relationships for limited dependent variables". Econometrica 26: 26-36.

Ugbabe, O. O. 2005. Economic analysis of Balanced Nutrient Management Technologies for maize Production in Kaduna state, Nigeria. An Unpublished MSc Thesis Submitted to Ahmadu Bello University, Zaria.

Vanlauwe, B., Aihou, K., Aman, S., Iwuafor, E.N.O., Tossah, B.,Diels, J., Sanginga, N., Lyasse,O., Merckx, R. and Deckers, S. 2001. "Maize Yield as Affected by Organic Inputs and Urea in the West African Moist Savanna". Agronomy Journal 93: 1191-1199.

Wallys, K., Tollens, E. and Manyong V. M. 2003. Socioeconomic Analysis of Promising Balanced Nutrient Management Systems in Northern Nigeria. A MSc. Thesis, KU, Leuven.

Zeller, M., Diagne. A. and Mataya C. 1998. "Market Access by Smallholder Farmers in Malawi: Implications for Technology Adoption, Agricultural Productivity and Crop Income". Agricultural Economics 19: 219-229.