**RUFORUM Working Document Series (ISSN 1607-9345) No. 14 (2): 437- 443.
Available from *http://repository.ruforum.org***

Research Application Summary

Adoption and welfare effects of integrated soil fertility management technologies among smallholder maize and pigeon pea farmers in Tanzania

Sanka, M.B., Diiro, G. M. & Hillbur, P.
College of Agriculture and Environmental Science, Department of Agribusiness and Natural Resources Economics, Makerere University, P.O. Box 7062, Kampala, Uganda
Corresponding Author: sankamarco@yahoo.com

Abstract

This study analyzed farmer adoption of integrated soil fertility management (ISFM) and its impact on household welfare in Babati district, Tanzania. Cross-sectional survey data collected from a random sample of 500 maize and pigeonpea farmers in Babati district was used. Data were collected through face to face interviews using a semi-structured questionnaire. In this study, an adopter of ISFM was defined as the farmer household using at least 50% of the ISFM package including at least one improved crop variety and one type of fertilizer. The study used a probit regression model to quantify the determinants of adoption of ISFM whereas the impact of adoption were estimated using a propensity score matching technique. Results showed that 49.4% of maize and pigeon pea farmers in Babati district used ISFM technologies. Results of the probit regression analysis showed that household size, value of livestock owned, value of household assets, farm size, agricultural training and access to credit ($P<0.05$), education of the household head and extension services ($p<0.1$) increased farmer adoption to ISFM. However, participation in off-farm activities ($P<0.05$) reduced the likelihood of adoption of ISFM. The welfare effects of adoption showed that ISFM can generate sizeable gains in maize and pigeon peas yields, and increase household per capita consumption and food security status of adopting households in the study area ($P<0.05$). This study revealed that adoption of ISFM can increase welfare of smallholder farmers in Tanzania. There is need to strengthen agricultural extension services through agricultural training on ISFM. Further, it is vital that farmer access to ISFM package is increased and improved through access to affordable credit subsidies on agricultural inputs.

Key words: Access to credit, adoption, Babati, Tanzania

Résumé

Cette étude a analysé l'adoption de la gestion intégrée de la fertilité des sols (ISFM) par les agriculteurs et son impact sur le bien-être des ménages dans le district de Babati, en Tanzanie. Des données recueillies à partir d'un échantillonnage aléatoire de 500 producteurs de maïs et de pois de pigeon, dans le district de Babati ont été utilisées. Ces données ont été recueillies au moyen d'entretiens individuels et de questionnaire semi-structuré. Dans la présente étude, l'adoptant a été défini comme le ménage d'agriculteur employant au moins 50% du paquet de la technologie, y compris au moins une variété de culture améliorée et un type d'engrais. Un modèle de régression probit a été utilisé pour quantifier les déterminants de l'adoption de la technologie alors que l'impact de l'adoption a été estimé à l'aide d'une technique de correspondance de score de propension. Les résultats ont montré que 49,4% des agriculteurs de maïs et de pois dans le district de Babati utilisent la technologie. Les résultats de l'analyse de régression probit ont montré que la taille du ménage, la valeur du bétail possédé, la valeur des actifs des ménages, la taille de l'exploitation, la formation agricole et l'accès au crédit (p <0,05), l'éducation du chef de ménage et les services de vulgarisation (p<0.1) ont augmenté le degré d'adoption de la technologie par les agriculteurs. Cependant, la participation aux activités hors ferme (P <0,05) a réduit la probabilité d'adoption. Les effets de bien-être de l'adoption ont montré que la technologie peut générer des rendements importants de maïs et de pois, et augmenter la consommation par habitant et la sécurité alimentaire des adoptants dans la zone d'étude (P <0,05). Cette étude a révélé que l'adoption de la gestion intégrée de la fertilité des sols peut améliorer le bien-être des petits agriculteurs en Tanzanie. Il est nécessaire de renforcer la vulgarisation agricole par une formation agricole sur la gestion intégrée de la fertilité des sols. En outre, il est essentiel que l'accès des agriculteurs au paquet de la technologie soit augmenté et amélioré grâce à l'accès aux subventions abordables de crédit sur les intrants agricoles.

Mots-clés: Accès au crédit, adoption, Babati, Tanzanie

Introduction

In Sub- Saharan Africa (SSA) soils are massively depleted due to immense pressure on arable land caused by increasing population density and declining soil fertility. Yet the cost of fertilizers is far too high to be afforded by resource-poor farmers (Vanlauwe *et al.,* 2010). The Government of Tanzania has recently developed an Agricultural Sector Development Strategy (ASDS) aimed at transforming agriculture from subsistence to a commercial activity and targeting poverty reduction of the rural population (URT, 2012). The ASDS promotes a wide range of agricultural development interventions to enhance productivity of smallholder farmers across the country. One of the important interventions promoted by the Government and the development partners to address soil degradation and declining productivity is the integrated soil fertility management (ISFM) technique (Vanlauwe and Zingore, 2011). Integrated soil fertility management (ISFM) involves the use of improved crop varieties, inorganic fertilizers, organic fertilizers and adaptations (Kimaro *et al.,* 2009; Chivenge *et al.,* 2011). The use of ISFM is believed to be a cost effective approach for farmers to replenish soil fertility in SSA (Vanlauwe and Zingore, 2011).

Despite the targeted effort and financial resources invested in promoting ISFM in the Babati district of Tanzania, the rate of adoption and expected gains in productivity resulting from ISFM use remains uncertain. This study examined the adoption and productivity impact of ISFM technologies among smallholder maize and pigeon pea farmer households in Babati district. A better understanding of ISFM adoption and its impact on productivity is useful for policy decision-making in Tanzania and elsewhere.

Material and Methods

Data collection. The study sample was drawn from the current 2062 smallholder farmers directly participating in Africa Rising Project. The sampling frame was formed by lists of ISFM adopters and non-adopters. The study was based on data from 500 respondents of smallholder farmers' households, which was about 24.27% of the total households, in which 247 were adopters and 253 were non-adopters. Data were collected through face to face interviews using a semi-structured questionnaire with individual farmers who formed the core of the study. Village leaders guided and trained enumerators (participated in pre-testing) to respective farmers for the study. Farmers who could not be accessed at the time of interviewed were replaced by others based on the list provided by village leaders. The primary data collected were on household characteristics, land ownership, asset holding, knowledge on maize and pigeon pea varieties, use of organic and inorganic fertilizer, farm size, harvest of maize and pigeon pea, livestock ownership, sources of household income, food security, household expenditure and membership in different organization among others.

Analysing the Determinants of ISFM Adoption. Descriptive approaches were used for computation of level of adoption of ISFM by identifying the technology packages that the farmers were using, the components of the ISFM package that farmers use in pigeon peas and maize. In the study, the rate of adoption were captured as a binary variable, and defined an adopter as a farmer using at least 50% of the ISFM package including at least one improved crop variety and at least one fertilizer. This study examined factors that influence adoption of ISFM using probit model, this is because dependent variable considered in this study is dichotomous in nature (Feder *et al.,* 1985). Probit was chosen because it was found to be convenient over the logit. Farmers' decisions to adopt ISFM depend on characteristics of the farmers and farm; hence the decision of a farmer to participate is based on each farmer's self-selection instead of random assignment.

Estimating the Impact of ISFM Adoption. The Propensity Score Matching (PSM) procedure was adopted to generate comparable samples of the treated (adopters) and control (non-adopters), with similar characteristics. In essence, the matching models created the condition of an experiment in which adopters and non-adopters are randomly assigned, to allow the identification of a causal link between technology choice and outcome variables. The main purpose of the propensity score estimation is to balance the observed distribution of covariates across the groups of adopters and non-adopters (Lee, 2008). The balancing test is normally required after matching to ascertain whether the differences in the covariates in the two groups in the matched sample have been eliminated, in which case, the matched comparison group can be considered a plausible counterfactual (Ali and Abdulai, 2010).

Results and Discussion

Determinants of ISFM Adoption. The results of the probit regression analysis showed that education of the household head, household size, value of livestock owned, value of household assets, farm size, extension services, agricultural training and access to credit increase farmer adoption of ISFM. However, participation in off-farm activities, cost of ISFM package and distance to the agricultural office reduce the likelihood of adoption of ISFM (Table 1).

Table 1: Factors influencing adoption of ISFM in Babati District, Tanzania, 2015

Variables	Coefficients	Standard errors	Marginal effects	Z	p>|z|
Age of household head	0.01	0.01	0.01	1.01	0.31
Education of the household head	0.06	0.03	0.02	1.84	0.07
Gender	-0.16	0.14	-0.06	-1.11	0.27
Occupation	0.09	0.11	0.02	0.86	0.39
Family size(log)	0.43	0.17	0.17	2.48	0.01
Leadership role	0.29	0.19	0.11	1.53	0.13
Distance to the trading centre (Km)	0.08	0.06	0.03	1.36	0.17
Access to agricultural extension	0.32	0.19	0.13	1.67	0.09
Distance to agricultural offices	-0.02	0.02	-0.01	-0.78	0.44
Training in agriculture	0.27	0.13	0.12	2.00	0.05
Access to credit	1.03	0.24	0.36	4.24	0.00
Total land owned(log)	0.47	0.12	0.19	3.90	0.00
Livestock value (log)	0.04	0.01	0.02	3.31	0.00
Off-income (log)	-0.03	0.01	-0.01	-3.35	0.00
Cost of ISFM package	-0.03	0.04	-0.01	-0.74	0.46
Asset value (log)	0.34	0.07	0.13	4.85	0.00
Constant	-6.32	1.01		-6.24	0.00

n= 500; prob>chi2 =0.000; pseudo R squared = 0.2555

Source: survey data, 2015

Impact of ISFM Adoption. Results of the welfare effects of adoption of ISFM showed that ISFM can generate sizeable gains in maize and pigeon pea yield, increase household per capita consumption and food security status of adopting households. The results also showed that average yield of maize and pigeon pea for adopters was 1,145.97 kg/ha and 112.90 kg/ ha respectively, compared to 771.45 kg/ha^{-1} and 61.42 kg/ha for non-adopters in that order. This represents a yield gain of about 32.68% for maize and 45.60% for pigeon peas due to adoption of ISFM. The household per capita expenditure was estimated at 161.26 USD for adopting households compared to 108.54 USD for non-adopting household indicating 32.69% gain in purchasing power. Further, results also showed that household food insecurity access scale was lower among adopters (2.92) compared to (3.31) for non-adopters (Table 2).

Table 2: Estimation of ATT: Effects of ISFM Adoption on Household Welfare

Outcome variables	Nearest neighbour matching			Kernel matching			Radius matching		
	ATT	Control	T-stat	ATT	Control	T-stat	ATT	Control	T-stat
Per capita expenditure	161.26	108.54	2.26	161.26	117.60	1.99	161.26	116.85	2.06
Yield of pigeon pea (kg/acre)	278.99	142.22	3.95	278.99	154.76	2.61	278.99	151.76	2.71
Yield maize (kg/acres)	2,831.75	3,732.16	-0.96	2,831.75	2,123.34	1.03	2831.75	1,906.28	1.36
HFIAS	2.52	2.46	0.15	2.52	2.62	-0.22	2.5	2.6	-0.29

Note; During data collection, the official exchange rate averaged about TShs 1700 per US$1. HFIAS = Household food insecurity accessible

Conclusions

The adoption rate of ISFM in Babati district is higher compared to the rates of agricultural technology reported in the previous studies in Tanzania. Findings show that adoption of ISFM increased with household size. A higher ratio of household members who contribute to farm work is generally associated with a greater labour force available to the household for timely operation of farm activities. Furthermore adoption of ISFM is positively influenced by education level of the household head. Farmers with more education might be aware of more source of information and be more efficient in evaluating and interpreting information more correctly than their counterparts. Further, educated household heads have the ability to receive, decode and understand information in making decisions.

Livestock value and asset value were found to influence positively the uptake of ISFM probably because livestock are important source of organic manure and cash in the study area. Assets were noted as an indicator of wealth, hence having them offer a better propensity to purchase farm inputs such as improved seed and fertilizers that are needed for adoption of ISFM. Further, agricultural training and extension services influenced adoption of ISFM, suggesting that agricultural training is an important factor in adoption of new technology since training impart farmers with necessary knowledge on the use of the technology. In addition access to credit was also found to influence adoption of ISFM in the study area. Farmers who have access to credit can minimize their financial constraints and buy agricultural inputs more readily. When credit constraints are binding, however, the ability to borrow and availability of collateral can be the determinant of adoption of new technology. Findings show that adoption of ISFM can increase welfare of smallholder farmers in Tanzania. Furthermore off-income was found to influence uptake of ISFM in the study area. The negative relation between off-farm income and adoption of ISFM could probably be because respondents who were engaged in off-farm activities were having small farm size for agricultural activities, and that farming activities are not their main occupation. They thus devote most of their time on off-farm activities with less time for farming activities.

Conclusion

The positive benefit of engaging in ISFM in the study area calls for concerted efforts to increase uptake of ISFM among smallholder farmers. In particular, there is need to strengthen agricultural extension services through agricultural training on ISFM. Further, it is vital that farmer access to ISFM package is enhanced through providing access to affordable credit services and subsidies on agricultural inputs. The government needs to take the lead in technology promotion and dissemination, awareness campaigns for ISFM packages and creating an enabling environment for effective participation of private sectors in promotion of ISFM. The study also demonstrated that the use of ISFM increases household per capita expenditure, crop yield in kg/hectare and reduces the household food insecurity access scale among ISFM adopters.

Acknowldegement

We thank the Innovation Agricultural Research Initiative (iAGRI) for funding this study. This paper is a contribution to the 2016 Fifth African Higher Education Week and RUFORUM Biennial Conference.

References

Ali, A. and Abdulai, A. 2010. The adoption of genetically modified cotton and poverty reduction in Pakistan. *Journal of Agricultural Economics* 61 (1): 175-192.

Amani, H. K. R. 2005. Making agriculture impact on poverty in Tanzania: The case on non-traditional export crops. A policy dialogue for accelerating growth and poverty reduction in Tanzania. ESRF, Dar es Salaam.

Chivenge, P., Vanlauwe, B. and Six, J. 2011. Does the combined application of organic and mineral nutrient sources influence maize productivity? A meta-analysis. *Plant and Soil* 342 (1): 1-30.

Feder, G., Just, R. E. and Zilberman, D. 1985. Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change* 33(2): 255-298.

Kimaro, A. A., Timmer, V. R., Chamshama, S. A. O., Ngaga, Y. N. and Kimaro, D. A. 2009. Competition between maize and pigeonpea in semi-arid Tanzania: Effect on yields and nutrition of crops. *Agriculture, Ecosystems and Environment* 134 (1): 115-125.

Lee, W. S. 2008. Propensity Score matching and variations on the balancing test. pp. 27–28. In: Third Conference on Policy Evaluation, ZEW, Mannheim, Germany, October

URT, 2012. National Agriculture Policy. Ministry of Agriculture, Food Security and

Cooperative. Dar es Salaam, Tanzania.

Vanlauwe, B. and Zingore, S. 2011. Integrated soil fertility management: an operational definition and consequences for implementation and dissemination. *Better Crops* 95 (3): 4-7.

Vanlauwe, B., Bationo, A., Chianu, J., Giller, K. E., Merckx, R., Mokwunye, U. Ohiokpchai, O. and Smaling, E. M. A. 2010. Integrated soil fertility management operational definition and consequences for implementation and dissemination. *Outlook on Agriculture* 39 (1): 17-24.