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ANALYSIS OF FACTORS INFLUENCING SUSTAINABLE ADOPTION OF IMPROVED MAIZE TECHNOLOGIES AMONG SMALLHOLDER FARMERS IN UGENYA SUB-COUNTY, KENYA

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ABSTRACT: *Most smallholder farmers who account for more than 70% of the maize produced in Kenya are perpetually food insecure and stuck below poverty level. Sustained maize yield increase largely depends on long term adoption of modern farming technology. However, despite the high yields associated with modern maize technology promotion during and shortly after implementation phase of many projects, sustainability of the technologies still remains a challenge for smallholder maize producers in Kenya. The objective of this study was to analyse factors that influence sustainable adoption of maize technologies beyond the promotion phase among smallholder farmers in Ugenya Sub-County. An ex post facto research was carried out where one hundred and eighty eight smallholder farmers were selected through simple random sampling from purposively selected study population in Ugenya Sub-County. The data was subjected to Independent 2-Sample T-Test and multiple regression analysis. Maize yields obtained by inputs subsidy beneficiaries and non beneficiaries during post-subsidy support phase were not statistically significant ($p>0.05$). Except for on-farm labour availability and farmer's farming experience ($p<0.05$) all other socio-economic, technical, management and institutional factors known to influence farming technology adoption had no significant influence on average maize yield ($p>0.05$) in the study area. The study recommended that smallholder farmers should operate under a functional structure such as farmers' association that will support timely access to key factors of production, optimize on benefits of the economies of scale, enforce sustainable practices and serve as a linkage to key enterprise value chain actors.*

Keywords: Sustainable, adoption, technologies, smallholder

INTRODUCTION

The world population currently stands at about 7 billion but is expected to reach about 8 billion by the year 2024 creating higher demand for food, water, energy, and employment (UN, 2014). The latest Food and Agriculture Organization (FAO) estimates indicate that about 805 million people (13.5%) globally are estimated to be chronically undernourished, and a bigger proportion of this population live in the developing world (FAOSTAT, 2013). While the first Millennium Development Goal (MDG) on hunger target was within reach in other parts of the world, there was however insufficient progress in sub-Saharan Africa (SSA) which carries the majority of world's most hungry people (FAOSTAT, 2013). In Sub-Sahara Africa (SSA) agriculture is the major

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economic activity that plays a central role in economic development and its performance is reflected in the performance of the entire economy of many countries (GoK-V2030, 2007; Byerlee and Eicher, 1997).

Research has developed appropriate maize production technologies towards increasing yields. High yielding maize varieties suitable for the prevailing agro-ecological conditions in Ugenya sub-county have successfully been demonstrated on farmers' fields yielding more than 4.5tons, and up to 7 tons per hectare under good management practices with use of adequate fertilizer application based on soil analysis recommendations (GoK-SRA, 2004; GoK-Siaya, 2013). Despite the temporary impact associated with technology promotion initiatives during and shortly after the implementation phase, long term adoption of the technologies still remains a challenge for many smallholder farmers in Kenya (GoK-ASDS, 2010; GoK-FSR, 2014). Available statistics indicate that on average maize production in Kenya is far below the optimal potential of 4.5 tonnes per Ha and its production is generally on the decline among smallholder farmers (Olubandwa *et al.*, 2010). The low productivity implies need for relief food and social support programmes to sustain the livelihood of citizens (GoK-CAADP, 2010).

Food security and poverty alleviation can be attained through increase in agricultural production, which is only possible through sustainable diffusion of modern farming technologies (Uaiene R.N, *et al*, 2009; GoK-ASDS, 2010; Olubandwa *et al.*, 2010). Technology diffusion is influenced by a series of factors which include inputs and technicality of agronomic practices, government policies, soil quality, management practices, damage from pests and diseases, access to credit, age of operator, level of farm operator education, size of operation and specialization (Nyoro *et al*., 2007; Caswell, *et al.*, 2001; GoK-NAAIAP, 2013). While findings of low levels of technology adoption are well documented, few studies have attempted to explain the reasons for the slow rate of adoption, particularly among smallholder farmers (Uaiene R.N, *et al*, 2009). The objective of the study was to analyse factors determining sustainable adoption of maize production technologies beyond the initial promotion phase among smallholder farmers. Understanding these factors is essential in the promotion for sustained agricultural production (Uaiene R.N, *et al*, 2009).

MATERIALS AND METHODS

Study Area

Ugenya Sub-county is one of the six sub-counties comprising Siaya County in Western Kenya and is divided into four Wards. The sub-county lies at an altitude between 1,200 and 1,400 meters above sea level; longitude of $34^0 5''$E and $34^0 14''$E; latitude of $0^0 7''$N and $0^0 13''$N and covers an area of 322.3 Km^2 (GoK-Siaya, 2013) Annual rainfall is 1200-1500mm, with temperature regime ranging from 15-30 ^oC and mean annual evapo-transpiration of 1800-2000 mm. Estimated population is 113,843 people with 18,874 farm families (GoK-KNBS, 2009). The total population of the study area was 9,567 smallholder households engaged in maize production in the two selected Wards (West and North Ugenya). The purposively selected accessible population was 600 smallholder maize growing farmers who received maize inputs subsidy support in the year 2010 (Gok-Siaya, 2013). Non beneficiary households in the selected Wards who did not received the subsidy support served as the control.

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Sampling Procedure and Sample Size

Six hundred beneficiaries of maize input subsidy in the year 2010 were purposively identified and traced back to Ward, Sub-location and Village levels. Within each selected sub-location two representative villages were randomly identified. Through simple random sampling, 94 beneficiary and 94 non beneficiary farmers in the 8 selected villages were chosen for the study (Nassiuma, 2000). A checklist was developed for interviewing key informants from the County Agriculture Department and for focused group discussions with members of farmer groups to help in gathering in-depth information regarding the factors influencing sustainable maize yield increase in the study area.

Data collection and analysis

Structured researcher administered questionnaires were used for data collection after pre-testing to measure their pertinence as recommended by Kathuri & Pals (1993). A reliability coefficient of 0.90 was realised after the analysis which was above the 0.7 recommended by Borg and Galls (1989). The data collection tool was administered by the researcher to smallholder maize farmers. Key informants from County Department of Agriculture in Siaya County and local agro-inputs dealers were interviewed using an interview guide to obtain general farming information on the study area. Data was analysed using descriptive statistics, Independent 2-Sample T-Test and Multiple Regression model with the help of Statistical Package for Social Sciences (SPSS ver. 20).

RESULTS

Effect of subsidy on maize yield level during post-subsidy support phase

The observed mean maize yields per hectare were 1,880 ± 58 and 1,710 ± 67 kg for beneficiaries and non-beneficiaries respectively. At significant (2-tailed) value of $p>0.05$, there was no significant difference in average maize yield per hectare between inputs subsidy beneficiaries and non-beneficiaries during post-subsidy support phase (five years after project support).

Factors influencing sustainable adoption of improved maize technologies

The effects of the various factors included in the multiple regression analysis are shown in table 1. The regression coefficients of maize yield per hectare indicates that on-farm labour availability and farmer's farming experience were the only factors found to have significant influence on average maize yield ($p<0.05$). Fertilizer application, use of certified seed, access to inputs outlet, access to extension services, farmer's level of education, organic manure application, membership to farmers' association and access to produce market had no significant influence on average maize yield ($p>0.05$) in the study area, despite various research findings indicating that these factors play a significant role in the sustainable adoption of agricultural technologies.

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Table1. Multiple regression coefficients of maize yield (dependent variable) on ten independent variables

Independent variables	Regression coefficient	Significance (p- value)	R^{2*} (%)
Use of certified seed	0.054	0.607	-0.8
Fertilizer use	-0.116	0.264	0.3
Farmer's level of education	0.055	0.600	-0.8
On-farm labour availability	0.210	0.042	3.4
Farmer's farming experience	0.252	0.014	5.3
Access to extension services	-0.026	0.802	-1.0
Access to inputs outlet	-0.055	0.599	-0.8
Access to produce market	-0.075	0.475	-0.5
Organic manure application	0.001	0.994	-1.1
Membership to farmers' association	0.035	0.737	-1.0

R^2 is the percent prediction of the variability in each of the independent variables on the dependent variable.

DISCUSSION

Effect of subsidy on maize yield level during post-subsidy support phase

During the inputs subsidy support season, beneficiary farmers were able to embrace modern maize technology that resulted in yield increase from average of less than 2 ton to average of 3 tons per hectare. Over a period of time (5 years), beneficiary production level gradually declined nearly to the level of non beneficiaries. The findings are in line with the conclusion by Makokha *et al*. (2001), that adoption rate of maize production technologies is still low in most of the rural areas in Kenya with average maize yield at about 2 tonnes /ha, where potential yields of over 6 tonnes /ha are possible through increased use of fertilizer, improved seed, and crop husbandry practices.

Factors influencing sustainable adoption of improved maize technologies

Labour is the requisite means through which inputs and all other factors are manipulated into production. Labour availability affects timely implementation of key farm operations such as land preparation, planting, weeding and harvesting. Availability of adequate labour was therefore expected to result in sustained yield increase (table1), especially if quality seed and adequate fertilizers are used.

According to local extension experts, farmers with long farming experience are more likely to utilize technological practices better than beginners due to their enhanced resource mobilization and technical skills capacity thus accounting for their significant influence on maize yield in the study area as shown in table 1.

Appropriate use of fertilizer and improved seeds have been found to dramatically increase farm productivity and income if challenges of availability, accessibility, quality, affordability and management factors are addressed (Burk and Miguel, 2014; Butzer *et al*,. 2002; McGuirk and Mundlak, 1991; Uaiene *et al*., 2009). Besides smallholder farmers facing the aforementioned

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challenges in the study area, land degradation due to inadequate soil and water conservation measures further account for inefficient use of applied fertilizers as most of it is washed away by run-off. This in turn undermines potential gains of using certified seed and fertilizer hence the insignificant influence of their use on average maize yield (table 1).

Although there was no statistically significant relationship between average maize yield and farmer's education level (table 1), generally more educated farmers are assumed to be better able to process information and search for appropriate technologies to alleviate their production limitations. More educated farmers are also expected to have access to more resources and therefore more likely to adopt new agricultural technologies as opposed to farmers with primary or no formal education (Gabre-Madhin and Johnston, 2002; Uaiene *et al*, 2009; World Bank 2007; Olubandawa *et al*, 2010). However, from the study, level of education of respondents does not seem to influence average maize yield because besides being poor, majority of farmers in the study area were either semi-illiterate or had primary school level of education.

There was no statistically significant relationship between average yield and access to extension services in the study area (table 1). However, according to Gabre-Madhin and Johnston (2002); and Sunding and Zilberman (2000), extension service is a core activity necessary to support agricultural development and farmers with access to extension advisory services are more likely to adopt new agricultural technologies. According to key informants, the effectiveness of extension services in the study area had declined over the last two decades due to a sharp reduction in operational budget and human resources in the sector hence accounting for its diminished influence on maize yield.

Similarly, there was no statistically significant relationship between average maize yield and access to inputs outlet (table 1). Inadequate economic capacity to invest in modern agricultural technologies is one of the cited constraints to agricultural production among smallholder farmers (Matthews-Njoku et al. 2009; ASDS, 2010; Lin, 1991). Smallholder farmers might find it difficult to buy farm inputs in sufficient quantity and within recommended time frame (Duwayri *et al*, 1999), even if the outlets are available within reach. Due to high poverty level prevalent in the study area (poverty index of 48%), most farmers have limited resources and are not credit worthy, hence unable to afford inputs. Absence of collateral (such as land title deeds) and high interest rates are some of the factors which restrict the availability of capital to the farmers even if the credit source is available (Chaudhary (2000). Many financial institutions continue to view smallholder farming as a risky business hence demanding difficult to fulfil collaterals before giving farming loan (MoA, 2014, Uaiene R.N, et al, 2009). Without credit farmers are hard pressed to finance inputs and capital investment crucial in sustainable technology adoption hence the lack of influence of inputs outlet on increased maize yield.

There was no statistically significant relationship between average maize yield and access to market in the study area (table 1), although access to market of agricultural produce and products is critical to increasing agricultural productivity and commercialization of enterprises (GoK-ASDS, 2010). According to local extension experts, despite the prevailing high market price for maize locally, marketing chain for the commodity is not transparent and consists of many players making it inefficient and unresponsive to producer returns.

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Equally, there was no statistically significant relationship between average maize yield and organic manure application in the study area despite the fact that increased organic manure application generally results in increased maize yields (table 1). Use of organic manure, besides its importance in improving soil structure and water retention, also adds essentials nutrients to the soil resulting in increased crop yields. Manure widely used by smallholder farmers to improve soil fertility, however, still has challenges with availability, accessibility, quality and affordability (Burk and Miguel, 2014; MoA, 2015). This accounts for lack of influence from the use of organic manure on average maize yield.

Farmers' associations play an important role in enhancing farmers' capacity to access supportive services along enterprise value chains as well as increased representation to lobby and advocate for their interests. However, in the study, there was no statistically significant relationship between average maize yield and membership to farmers' association (table 1). One key powerful determinant of technology adoption by smallholder farmers appears to be membership to farmers' association which facilitates fast agricultural development (Uaiene *et al*, 2009). Through economies of scale farmers' associations are instrumental in bulking, processing, transporting produce, and supplying farm inputs and equipment to members (ASDS, 2010). According to Gabre-Madhin and Johnston (2002) and Uaiene *et al*. (2009), households that are members of functional farmers' associations are more likely to adopt new agricultural technologies than non-members. Membership to farmers' association has the potential of creating confidence between farmers and financial institutions thus allowing farmers to have access to farm credit using their collective community assets as collateral (ASDS, 2010). Membership to farmers' association also appears to positively influence adoption of technologies by enforcing compliance of sustainable agricultural practices through rewarding compliance and sanctioning non compliance. According to local extension experts, however, existing associations or farmer groups simply serve as collective lobby organs for accessing external support. The Government and many development agencies have pegged membership to a group as a mandatory requirement for farmers to access support. There are therefore numerous weak existing farmer associations or groups conveniently formed to fulfil conditional requirements in order to chiefly access support from development partners. This explains the lack of significant relationship between average maize yield and membership to farmers' association as indicated in the study findings.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results and limitation of the study we conclude that smallholder farmers in Ugenya Sub-County had limited access to technical, management, socio-economic and institutional factors that are necessary for sustainable adoption of agricultural technologies. To facilitate resource-constrained smallholder farmers have adequate access to these factors, we recommend establishment and strengthening of functional farmers associations. This will enable the smallholder farmers to maximize on benefits of economies of scale in acquiring various factors of production; enforce set internal guidelines for sustainable farming practices through reward and sanction mechanisms; and forge strong linkage among all enterprise value chain actors.

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