DRIVERS OF AWARENESS AND ADOPTION OF MAIZE AND SORGHUM TECHNOLOGIES IN WESTERN KENYA

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Abstract

Despite extensive promotion of maize and sorghum cultivars adapted to multiple stresses through public, private and research institutions' extension initiatives in Western Kenya, the adoption of such technologies by small scale farmers is low and production of the two crops is not only declining, but also continues to fall behind potential. Production of maize and sorghum are not only below 0.5 t/ha against a potential of 3-4 t/ha, but also declining. The objective of the study was to not only characterize awareness and adoption of maize and sorghum cultivars adapted to moisture stress, striga, low fertility acid soils and aluminum toxicity, but also isolate factors influencing their adoption. Data was collected from five sites in Nyanza and Western provinces using systematic sampling to generate a sample of 100 farmers. Data was analyzed using descriptive statistics and a probit model. Results show that gender, age, farm size, income, and access to extension influence adoption of maize and sorghum technologies. It is recommended that policies should consider household structure, empower them economically and improve access to extension services to enhance adoption of maize and sorghum technologies.

Keywords: drivers, adoption, maize and sorghum, technologies, Western Kenya

1. Introduction

Food and nutrition insecurity is a major problem in western Kenya, which is home to more than 15 million people who derive their livelihoods from agriculture. About 4.5 million people from the region experience serious food and nutrition insecurity, largely due to drought, low soil fertility, soil acidity, pests and diseases (FEWSNET, 2009). In this region, sorghum (*Sorghum bicolour (L.) Moench*) and maize (*Zea mays (L.*) are the two major staple food crops and sources of livelihood. These crops are produced by smallholder farmers (SHF) who use low levels of inputs and have limited access to new technologies. Consequently, sorghum and maize grain yields are low and declining, normally less than 1.0 ton and 1.5 tons /ha, respectively (FAOSTAT, 2006). It is predicted that in the marginal areas of Eastern Africa including the dry land areas of western Kenya, global climate change will cause more food deficit, increasing vulnerability of the local population. If not checked, drought, soil acidity and other environmental stresses prevalent in western Kenya may prevent the country from realizing the vision 2030 and the Millennium Development Goal (MDG) No. 1 which commits countries to halving poverty and hunger by 2015.

Maize and sorghum production and yield per unit area in Kenya is affected by many factors. Among the most important are total planted area and productivity. There is limited scope for expanding cultivated land under maize production since unused land is diminishing or is of marginal quality or just unsuitable for maize production. Producing higher maize yields on existing cultivated land is therefore the surest way of generating the extra maize grain required to feed the nation. However, this is curtailed by multiple stresses such as drought, soil acidity, low available phosphorus, and striga infestation. Even though, locally based research initiatives in Western Kenya have generated and disseminated maize cultivars adapted to these multiple stresses, adoption rates still remain very low and maize production continues to fall way behind potential.

In many parts of Kenya, sorghum remains an important crop for rural food security. Since many sorghum producing areas still experience periodic food deficits, production must be increased in order to ensure food security. The growing of improved sorghum varieties in Kenya has been promoted by not only public agricultural extension service, but also private extension initiatives and outreach arms of research institutions as one of the ways of achieving this. However, the adoption of technologies associated with these varieties by small scale farmers is still low resulting, probably, in the low production of the crop.

In Kenya, Striga infestation is most severe in Nyanza and Western provinces. Despite extensive promotion of both maize and sorghum cultivars tolerant to striga infestation by ministry of agriculture and other research institutions' initiatives in western Kenya levels of adoption are low and the weed continues to wreak havoc on production of the two crops in the region. With the above background several questions can be raised. What is the level of awareness among farmers of maize and sorghum cultivars tolerant to drought, acidic soils, Aluminium toxicity and striga infestation in western Kenya? What is the level of adoption of some of these technologies and what influences the adoption behaviour? In an attempt to address the aforementioned questions, the objectives of the paper are to characterize the level of awareness and adoption of maize and sorghum cultivars adapted to drought, aluminium toxicity, low fertility acid soils and striga infestation and to assess factors affecting their adoption.

2. Methodology

2.1. Study sites

The survey was carried out in five sites, two in Nyanza province and three in Western Province. The sites included; Karungu, Sega (Nyanza), Matayos, Koyonzo, and Angurai (Western). Karungu is located 0° 51' 0" South, 34° 9' 0" East, at an altitude of about 1, 145 m. The area has low (250 - 750 mm), unimodal (March – May) rainfall, with low to medium (≈ 60%) reliability. The area is in the Lower Midland 4 (LM4) agro-ecological zone (AEZ) and is suitable for sorghum, cassava and sunflower. The soils are neutral, verticarenosol/vertisols of medium to low fertility. Sega site is located 0° 15›N & 34°20›E, at an altitude of about 1,200 m and receives the long rains between March–June (Jaetzold and Schmidt, 1983) and the short rains between September and December. The area is in AEZ LM 3 and is suitable for maize, sorghum, cassava and sunflower. Sorghum and maize are the priority cereals, but grain yield is affected by drought and soil acidity (pH < 5). The soils are orthicacrisol that contain toxic levels (33% saturation) of aluminium (Al) and low levels (3.0 mg/Kg soil) of available P (Obura et al., 2008; Kisinyo et al. 2009). Angurai is in Teso District and falls in AEZ LM3, characterized by a long (155 to 174 days) cropping season followed by a short (85 -104 days) second growing period (Jaetzold et al., 2005). Angurai receives 1300 mm of rainfall annually. The soils are acidic, ferralo-orthicacrisols with moderate to low fertility. Farmers in this region grow significant quantities of sorghum, which is mixed with cassava and used as a staple food. Koyonzo is in Matungu division of Butere-Mumias district. Matayos is in Busia District and is in AEZ LM3. The site lies at an altitude of 1,219 m, and receives 1,420 mm of rainfall annually, that comes in during the long and short rainy seasons. The soils are well drained, deep, red to dark red, friable Chromic Acrisols; partly petro ferric.

2.2. Data types and sources

Both primary and secondary sources of data were used. Both qualitative and quantitative data were collected. Types of data used in this study included general demographics of the respondents such as age, gender, education, household size and occupation among others; awareness, access and adoption of maize and sorghum technologies, resource endowments such number of livestock, acreage under key crop enterprises, sources of livelihoods, types and sources of maize and sorghum seed, marketed fraction and market outlet for seed and constraints in the maize and sorghum value chain, maize and sorghum production and yield levels, input usage and past production trends of maize and sorghum. The technologies under consideration were maize and sorghum varieties. These varieties have been bred and tried under multiple stresses under farmers' conditions in a participatory approach for more than 4 years at the 5 sites. The multiple stresses include moisture stress, aluminium toxicity, acidic soils and striga weed. Both local maize and sorghum varieties as well as cultivars generated through a participatory screening process by Moi University research team were at the disposal of farmers. The maize varieties at the disposal of farmers were hybrids (H505, H507, H511, H512, and H614), Duma, and Pwani. The sorghum varieties which were at the disposal of farmers had been screened for different tolerance to the aforementioned stresses. They included Nyadundo1 (drought, striga, aluminium), Nyadundo 2 (drought and aluminium), C26 (drought, Striga), P53B (Striga), T30B (Drought), ED95A (Aluminium and Phosphorous), E97 (Aluminium and Phosphorus), E94 (Aluminium and phosphorus), Seredo (Aluminium and Phosphorus), N57 (Striga), N68 (Striga), E16 (drought), E12 (drought), E15 (drought) and M45 (Striga). Farmers were therefore aware of existence these sorghum varieties. Primary data was obtained through a baseline survey while secondary data was acquired through perusal of government and private research documents, journals and other publications relevant to the study.

2.3. Sampling procedures

The target population was all maize and sorghum farmers in the five sites of Sega, Matayos, Koyonzo, Angurai and Karungu. A sample of 100 small holder maize and sorghum farmers were purposively selected from the five sites. In each site, 20 farmers were systematically selected. However, the first farmer was selected randomly and subsequent farmers selected by skipping every next sorghum/maize farmer.

2.4. Data collection instruments and methods

The main instruments used for data collection were questionnaires, interview schedules, observation, and focused group discussions. A mixture of enumerator administered questionnaires and interview schedules were used to retrieve information from farmers. Questionnaires and interview schedules were structured with both open ended and closed ended questions. Instruments of data collection were pre-tested in Sega site on 10 respondents to ensure reliability and validity and revised before embarking on the actual survey. To supplement information gathered using questionnaires, an interview schedule was used to collect information from key informants such as extension service providers from Ministry of Agriculture and non-governmental organizations and local leaders to facilitate formation of general opinion about behaviour of variables under investigation.

2.5. The probit model

In order to explain the behaviour of a dichotomous dependent variable a suitably selected Cumulative Distribution Function (CDF) was used. The logit model uses the cumulative logistic function. But this is not the only CDF that one can use. In some applications, the normal CDF has been found useful. The estimating model that emerges from the normal CDF is known as the Probit or Normit Model. The Probit model is expressed as (1):

$$probit(\pi(x) = \phi^{-1}(\pi(x) = \alpha + \beta x \quad (1)$$

Where is the inverse standard normal cumulative distribution.

The probit model is an alternative to the logit model and does not show the structural problem such as the linear probability model. There are a lot of similarities and minor differences between a logit and probit model. The chief difference between logit and probit is that the logistic model has slightly flatter tails. The normit or probit curve approaches the axes more quickly than the logistic curve. Qualitatively, logit and Probit models give similar results and the estimates of parameters of the two models are directly comparable (Vasisht, 2002). The study employed the Probit model to evaluate the adoption of maize and sorghum cultivars adapted to multiple stress such as drought and striga in Western Kenya. It was assumed that there is a latent, or unobserved, variable Y* which is generated from a familiar looking model:

$$Y^{*} = \beta^{'} X + e \quad (2)$$

Where β is a K-vector of parameters, x is a vector of explanatory variables and e ~ N(0; 1) is a random shock. We observe y = 1 if y* > 0 and y = 0 otherwise.

In this study, the model was specified as follows;

$$Y = \beta X + e \quad (3)$$

Y = a vector of farmer's adoption of stress tolerant maize/ sorghum cultivars

X = a vector of independent variables including:- demographic characteristics**,** farm size, area allocated to maize/ sorghum, household size, Age, education, gender, occupation, income, yield of maize/ sorghum. Since the level of awareness among farmers of existing stress tolerant maize/ sorghum technologies was low models were estimated for adoption of moisture stress tolerant sorghum and striga tolerant maize in western Kenya.

2.6. Data processing and analyses

All questionnaires and interview schedules were sorted and coded before inputting in the appropriate software. Data was then analyzed using Statistical Package for Social sciences (SPSS) version 17.0 and Ms-Excel. Descriptive statistics such as measures of central tendency, bar charts and cross tabulations were used to describe the socio-economic indicators of households and to characterize awareness and adoption of multiple stress tolerant sorghum and maize technologies. Regression analysis was used to determine the cause and effect relationship between variables under study.

3. Results and discussions

3.1. Characterization of awareness and adoption of maize/sorghum technologies

Farmers were asked if they were aware and used locally available multiple stress tolerant sorghum and maize varieties. Table 1 shows awareness among farmers of multiple stress tolerant sorghum and maize technologies. The general level of awareness among farmers of existing multiple stress tolerant sorghum cultivars was very low in the entire sample and replicated across experimental sites. While 17-18% of all respondents were aware of Al tolerant sorghum and maize cultivars, only 41% were aware of moisture stress tolerant sorghum and maize varieties.

Table 1. Awareness in percentage of sorghum and maize technologies across the study area

Location	Stress tolerant		Aluminium tolerant		P-efficient		Striga tolerant	
	Sorghum	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum	Maize
Koyonzo	5	6	4	5	3	4	5	6
Angurai	5	4	2	2	2	3	5	5
Matayos	12	12	4	4	5	6	11	13
Sega	14	14	7	7	10	10	14	15
Karungu	5	5	0	0	0	0	3	3
Total	41	41	17	18	20	23	38	42

Source: Authors' Survey, 2011

While 20-23% of respondents were aware of P-efficient sorghum and maize cultivars, 38-42% of them were aware of striga tolerant sorghum and maize cultivars. That implied that less than half of the farmers were not aware of the multiple stress tolerant maize and technologies calling for more awareness campaigns to enlighten farmers on the existing multiple stress maize and sorghum tolerant technologies. However, Koyonzo, Angurai and Karungu require more awareness campaigns. The relative level of awareness of moisture stress and striga weed was high across all the sites. This could point to the devastating effects of the two challenges in the study area.

Table 2 shows adoption of multiple stress tolerant sorghum and maize cultivars. The general level of adoption of multiple stress tolerant sorghum and maize cultivars by farmers was too low in the entire study area and across the experimental sites. Less than 10% of respondents had adopted any of the four sorghum technologies. The story was the same for maize technologies with exceptions of P-efficient and striga tolerant maize cultivars which were adopted by 23 and

Table 2. Adoption in percentage of sorghum and maize technologies across the study area

Location	Stress tolerant		Aluminium tolerant		P-efficient		Striga tolerant	
	Sorghum	Maize	Sorghum	Maize	Sorghum	Maize	Sorghum	Maize
Koyonzo	1	1	0	0	0	4	0	6
Angurai	2	3	1	1	1	3	2	5
Matayos	1	3	1	1	1	6	1	13
Sega	3	3	1	1	3	10	5	15
Karungu	0	0	0	0	0	0	0	3
Total	7	10	3	3	5	23	8	42

Source: Authors' Survey, 2011

42 % of respondents respectively.Among adopters of striga tolerant maize majority came from Sega and Matayos experimental sites. That implied that enough sensitization may have been undertaken at the two sites calling for more sensitization in the other sites. It could also point to striga weed being a more devastating problem in the study area than the other multiple stresses thus eliciting more adoption.

That could be attributed to the low levels of awareness among farmers of the existing multiple stress tolerant sorghum and maize cultivars in their neighbourhoods since majority of the farmers were known to work with technologies they understood. This calls for awareness campaigns in the entire study area in order to trigger interest in the multiple stress tolerant crop technologies

3.2. Probit regression results

Table 3 shows probit regression results for adoption of stress tolerant sorghum. Results show that age, social capital, sorghum farm, income and extension advice were significant and positively influenced adoption of moisture stress tolerant sorghum. These results are consistent with Okuthe *et al.*, (2000) findings that farmers' adoption of improved sorghum varieties and technologies depend on household size, income, farm size, age, education attainment and gender of household head. However, while Okuthe focused on Ndhiwa Division in Nyanza Province, this study covered parts of Nyanza and Western provinces. He also used chi-square to determine the relationship between the independent variables and the dependent variable while this study fitted a probit model to unravel drivers of adoption of sorghum/maize production technologies. It is also consistent with Adesina et al (1995) findings in his study in Burkina Faso and Guinea on farmers' perceptions and adoption of new agricultural technologies. However, the range of variables used in this study while they cut across socio-economic, demographic and institutional factors they do not include farmers' subjective perceptions of the characteristics of new agricultural technologies.

The positive relationship implies that older people are more likely to adopt stress tolerant sorghum than young people which is attributable to the fact that sorghum as a crop is mainly consumed by older generations who have valued the crop through the years as opposed to young

Table 3. Regression results for moisture stress tolerant sorghum

	Coefficients	S.E.	Sig.
Age			
Gender	-3.656*	.057	.017
Education	.520	.665	.544
Group membership	.939**	.067	.003
Occupation	.581	.042	.435
Sorghum acreage	.805*	.155	.016
Income	.034*	.011	.043
Advice	.823*	.114	.050
Farm	-.887*	.078	.024
Constant	-23.520	5757.000	.997

-2 Log likelihood → 26.610; Cox & Snell R Square → 0.500; Nagelkerke R Square → 0.695 Omnibus test for model coefficients – Chi-square → 156.906; Hosmer&Lemeshow test – Model Chi-square → 2.116; Sample Size → n = 100

Source: Author's Survey Data, 2011

people who view sorghum as an inferior cereal. In addition, older people retain ownership of farm assets, including land and welcome ideas that promote enterprises they engage in. Social capital enhances adoption of stress tolerant sorghum technology since members of groups seek information and share it among themselves. Groups also make it economical to get attention of technology innovators rather than the technology innovators targeting individual farmers; which may be expensive on the part of the technology innovators.

On the contrary, gender and sorghum farm even though significant, negatively influenced adoption of moisture stress tolerant sorghum. The results indicated that an increase in the number of male headed households by one unit would bring about a decrease in the log of odds in favour of adoption by 3.656. The converse is also true. This was expected because sorghum farming is usually a preserve of women especially in the Western part of Kenya. In that light therefore, women would be more willing to take up stress tolerant sorghum that would guarantee them better returns even when rain fails or is erratic.

Land size allocated to sorghum was found to influence adoption of stress tolerant sorghum among small holder farmers in Western Kenya. Its coefficient was positive and significant at 5 percent implying that a unit increase in the land size allocated to sorghum leads to an increase in the log of odds in favour of adoption of stress tolerant sorghum by 0.805. This means that small scale sorghum farmers who have allocated a larger portion of their land on sorghum production are more likely to adopt the technology than those who have allocated a small portion. That is reasonable because large scale sorghum producers should find it economical to take up new technology as opposed to small scale producers.

The positive relationship between income and adoption of stress tolerant sorghum implies that economic empowerment of small holder farmers opens opportunities for them to adopt technology. That is justifiable because new technologies come at a cost and only those with adequate financial resources can afford them. That was expected because most smallholder farmers in Western Kenya depended entirely on subsistence agriculture as their major source of livelihood (93%), and only 4% had formal employment while 3% had small scale business enterprises. That implies that farmers have limited scope to earn income; the situation is further aggravated by low prices for their produce and high input prices.

The positive and significant relationship between extension and adoption of stress tolerant sorghum implies that farmers who received extension advice were more likely to adopt the technology than those who did not. That is justifiable because extension agents bring to the attention of farmers existence, benefits and costs of various technologies. About 39% of farmers reported to have received extension advice in the previous year on sorghum production. That could explain why this technology had not been widely taken up by farmers in the study area.

The negative and significant relationship between total land size owned by households and adoption of stress tolerant sorghum implies that as the total land owned increased, there was a tendency for farmers to abandon sorghum farming and move to other crop enterprises like maize, sugarcane, and tobacco as was observed in the sampled sites. That was so because farmers being economically rational would seek to engage in a bigger scale in those farming activities that yield more output and therefore income. Almost all farmers who were engaged in growing sugarcane and tobacco as cash crops never allocated any land to sorghum production. Table 4 shows probit regression results for adoption of striga tolerant maize.

Table 4. Regression results for striga tolerant maize

Variable	Coefficients	S.E.	Sig.
Maizefarm	.869*	.456	.050
Income	.521**	.011	.008
Advice	1.881**	1.051	.004
Occupation	1.862*	.875	.033
Member	2.199*	.912	.016
Education	.445	.567	.433
Gender	.217	.974	.824
Age	.064*	.037	.041
Constant	-10.936**	3.182	.001

2 Log likelihood → 26.539; Cox & Snell R Square → 0.560; Nagelkerke R Square → 0.714 Omnibus test for model coefficients – Chi-square → 179.314; Hosmer&Lemeshow test – Model Chi-square → 2.908; Sample Size → n = 100
Source: Author's Survey Data, 2011

Results show that maize farm, income, extension, occupation, social capital and age positively and significantly influenced adoption of striga tolerant maize variety. The positive relationship between maize farm area and adoption of striga tolerant maize implies that small scale maize farmers who have allocated a larger portion of their land on maize production are more likely to adopt the technology than those who have not. That scenario is attributed to the willingness of large scale producers to adopt new maize technologies due to their economies of scale compared to small holder producers. The positive relationship between income and adoption of striga tolerant maize among smallholder farmers in Western Kenya implies that well endowed small holder farmers would easily take up technology unlike their poor counterparts. This is true because new technologies come at a cost and it is only reasonable that those with enough income afford them. The positive relationship between extension and adoption of striga tolerant maize cultivar implies that farmers who received extension advice were more likely to adopt the technology than those who did not. Extension advice on the existence, benefits and costs of striga tolerant maize is therefore critical for triggering adoption of the aforementioned technology. About 39% of farmers reported to have received extension advice in the previous year on maize production which explains why the technology had not been widely taken up.

The positive and significant relationship between occupation of the household head and adoption of striga tolerant maize implies thatfarmers with other livelihood sources adopted technology easily since this economically empowered them to secure new technologies. Businesses and formal employment expand farmers' scope to earn income and therefore afford technology.

Social capital positively influenced adoption of striga tolerant maize variety by smallholder farmers in Western Kenya. This is consistent with the finding in the previous section that famers who work in groups are well placed to better engage in their farming activities. Group intervention is crucial and cost-effective for such category of farmers.

The positive and significant relationship between gender of household head and adoption of striga tolerant maize implies that an increase in the number of male headed households by one unit would bring about an increase in the log of odds in favour of adoption by 0.64 which was expected because men make most of the decisions affecting households including farming decisions.

The positive and significant relationship between adoption of striga tolerant maize and age of respondents implies that older people were more likely to adopt striga tolerant maize varieties than young people. That was expected because older people were the land owners and owners of other farm assets and therefore could take the initiative to invest in new technologies when they were assured of increased returns from such technologies. Furthermore, the role of older people as household decision makers gives them a head start in making choices that are supposed to benefit the households at large. In addition, older people are often charged with the great responsibility of providing food and fibre to the members of the households and therefore will be willing to take up technologies that guarantee them better yields.

4. Conclusions

It is concluded that the level of awareness and adoption of multiple stress maize and sorghum cultivars were generally low in the study area and across the experimental sites. This calls for awareness campaigns to enlighten majority of the farmers on the existence and availability of multiple stress tolerant maize and sorghum cultivars in their neighbourhoods. The major drivers of adoption of moisture stress tolerant sorghum and striga tolerant maize were indentified. Drivers of moisture stress tolerant sorghum were age, social capital, area allocated to sorghum, income and extension advice. On the other hand, drivers of striga tolerant maize were area allocated to maize, income, extension, occupation, social capital and age. It is recommended that policies that seek to improve adoption of multiple stress tolerant sorghum and maize technologies in Western Kenya should consider the household structure, empower them economically, enhance social capital and improve access to extension services.

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