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Smallholder farmer's adoption intensity of genetically modified maize varieties in Thulamela municipality, Limpopo province, South Africa

Abstract

The issues embedded in the controversy surrounding genetically modified crops are varied and complex. Despite the benefits that come with cultivating these crops, adoption has been slow, especially by smallholder farmers. Primary objective of the paper was to analyze factors influencing adoption intensity of GM maize varieties in Thulamela municipality. Multistage random sampling procedure was used for data collection. Data were collected from farmers using a structured questionnaire. Descriptive statistics, tobit and probit regression models were used for data analysis. Results show that most (56.5%) of farmers were female, while the average age was 60.5 years. About 30.6% of the farmers had no formal education, average farming experience was 29.9 years. The most perceived costs (96.5% and 65.9%) were that GM are too expensive and are unavailable in the market respectively, while the most perceived benefits (94.1% and 75.3%) were that GM grow faster and increase production yield. Tobit regression revealed that farmer's perception that GM maize is pest resistant, affordable and highly preferred and TV as a primary media were positively significant in influencing adoption intensity of GM maize, while farming experience was negatively significant ($p < 0.05$). Probit regression results revealed that marital status, income from farming, purpose of farming, sources of finance to produce and farm size were statistically significant ($p < 0.05$) in influencing farmers' decision to adopt improved maize varieties. It was concluded that proper education for farmers on the attributes of GM crops would enhance their acceptability.

Keywords: genetically modified, maize, Limpopo.
JEL Classification: Q1, O3, O33.

Introduction

Genetically modified crops were first introduced in South Africa in 1996 (Thomson, 2003). South Africa was the first African Nation to commercialize GM crops with the planting of Bt Maize in 1998/89. South Africa produced about 66.4 million tonnes of white maize and 5.4 million tonnes of yellow maize at an average yield of 39t/ha and 4.7t/ha respectively (Grains South Africa, 2013). The new seed technology (GM) was first introduced to smallholder farmers by the owner of BT maize most widely used in South Africa, Monsanto. Monsanto identified and selected nine areas across Mpumalanga, KwaZulu-Natal, Eastern Cape and Limpopo Province in South Africa, where subsistence farmers or rural/ household producing maize under dry-land conditions were invited. Monsanto invited roughly 3000 small-holder farmers to workshops in their respective areas and informed them about the traits and characteristics of BT maize in their local language.

Introduction of new technology in any country always comes with challenges. This is because changes do not happen without fear, resistance and a lot of focus on the possible dangers. Sometimes those fears can be justified while at times they cannot. The question is often not whether we should adopt the new technologies that have been made available to us, but the challenge has been to rationally assess both the dangers and the opportunities associated with it and then work out the best policy for use and control of each new technology (Thomson, 2003). Farmers' decision to adopt or not to adopt is usually based on the profitability and risk associated with the new technology. Most adoption studies under smallholder production systems show that farmers are risk averse and follow a technological ladder in the adoption process. They will first adopt simple components and then move to complex ones and from cheaper to more costly technologies (Aloyce, 2000).

Thulamela municipality is rural area dominated with agricultural practices making it the second dominated sector in the area. Smallholder farmers dominate the area as compared to commercial farmers. Survey has shown that the areas of Venda are less poverty stricken and a large number of farmers grow maize in order to feed their households, and attempt to sell surplus (Gouse et al., 2006). Agricultural growth, poverty and food insecurity reduction in mainly dependent on the adoption of GMOs seeds and improved maize varieties. The effort of Limpopo Department of Agriculture is therefore aimed at improving adoption of GMOs and improved maize varieties by small-holder farmers by enhancing access to information, evaluating limitations influencing adoption resistance and remedies to overcome those limitations. Different studies have proved that despite great benefits that come with GMOs, many farmers are still resistant to adopting these seeds. This growing opposition to GMOs in Africa can best be described as a fear of the unknown, with little or no scientific merit. Smallholder farmers are risk averse, thus are usually the most resistant as compared to commercial famers. This might also be because their motivation differs, and profit maximization and surplus production is not always their key objectives, while the opposite is true for commercial farmers (Manes, 2010).

This study is significance in that there is limited empirical evidence on adoption of GMOs and improved maize varieties at local level. Several studies have been conducted on the adoption of genetically modified maize and improved varieties in South Africa (e.g. Abidoye & Mabaga, 2013; CAST, 2005; Cellini et al., 2004; Fernandez-Cornejo et al., 2001; Sauer & Zilberman, 2010; Traxler, 2004; Van den Berg, 2013) however, they were done at a national level. It was found that at most one study that was done at provincial level which was at KwaZulu-Natal. Therefore results obtained at national level may not necessarily be a true representation of what is happening at local level. Limpopo province was one of the nine areas which were chosen by the owner of Bt maize (Monsanto) alongside the farmers from Mpumalanga, KwaZulu-Natal and Eastern Cape. Although the farmers were given information about the traits, characteristics and benefits of *Bacillus thuringiensis* (Bt) maize, others were still left unconvinced to adopt the seeds. There is therefore a necessity to investigate factors behind their resistance, particularly in Thulamela municipality of Limpopo Province.

This paper aims to provide sufficient evidence on the factors influencing adoption intensity of genetically modified maize varieties in Thulamela municipality. Therefore, empirical results obtained will not only serve as reference for the future researchers but will also benefit the Department of Agriculture and related organizations through policy recommended, on how to improve adoption GM maize by small-holder farmers. These will help increase productivity in order to ensure food security and enhance agricultural growth.

1. Methodology

1.1. Study area. The study was conducted in Thulamela Municipality which was established in 2000 in terms of Local Government Municipality Structure Act 177 of 1998. The ancient Thulamela settlement, which has now been declared a national heritage site, is situated north of Kruger National Park, at the Punda Maria gate in Limpopo province. The study area was selected because of its rich agricultural potential. Thulamela municipality is dominated by small scale farmers that are engaged in various irrigation schemes that belong to various associations (IDP Review, 2012).

1.2. Source of data. The study used primary data which were collected using a structured questionnaire. It was used to interview sampled farmers on socio-economic characteristics that affect their adoption intensity of GM maize and improved maize varieties. Data were also collected on the perception of farmers on GM maize attributes affecting their adoption.

Multistage random sampling procedure was adopted. At first stage, Thulamela municipality was selected from four municipalities under the Vhembe District in Limpopo province. Second stage, 6 irrigation schemes were selected out of 23 lastly, 15 farmers were randomly selected from each irrigation scheme depending on their availability and willingness to participate. Therefore, a total of 90 smallholder maize farmers were sampled. However, Out of the 90 questionnaires that were distributed, only 85 were properly filled by the respondents and were therefore used for final analysis. Two statistical tools were adopted, SPSS version 22 was used to analyze descriptive statistics and STATA version 12 was used to analyze tobit and probit models.

1.3. Methods of data analysis. *1.3.1. The probit model.* It was adopted in this study due to its binary response, in order to identify socio-economic factors influencing adoption of improved maize varieties. The dependent variable (Y_i) will be binary with values of 1 if farmers have adopted improved maize varieties and 0 otherwise.

A generic Probit model is stated as:

$$X_{i,j} = \alpha_j + \beta_j \sum_{j=1}^{n} X_{i,j} + e_i, \tag{1}$$

where Y_i is the dependent variable (adoption of improved maize varieties), $X_{i,j}$ is the explanatory variable of J of ith farmer (See Table 3.1); $\alpha_j ... \beta_j$ are the estimated parameters; e_i is the error term.

1.3.2. The tobit model. It is a statistical model proposed to describe the relationship between a non-negative dependent variable Y_i and an independent variable (or vector) x_i. The model supposes that there is a latent (i.e. unobservable) variable Y_1^*. Tobit regression was employed in order to analyze the socio-economic factors influencing adoption intensity of GM maize varieties by smallholder farmers in Thulamela municipality. Adoption intensity in this content will be determined by number of hectares planted with GM maize divided by the total land area.

The Tobit Model equation is given as:

$$Z_i = \varnothing + \lambda_j \sum_{1=j}^{n} X_j + v_i.$$

where Z_i is the dependent variable (Adoption intensity of GM maize varieties) and X_s are defined in Table 1 below).

Table 1. Description of variables in the probit and tobit model

Variable	Description	Apriori expectation
GENDER	1 = Male; 0 otherwise	+/-
AGE	Age (in years)	-
FEDUC	Level of education (1 = Formal education; 0 otherwise)	+
MARSTU	Marital status (1 = Married; 0 otherwise)	+/-
HH	Household size (in number of persons)	+
FARMINC	Income received from farming	+
SGINC	Income received from social grant (child grant or old pensioner's grant)	+
NONFINC	Income received from non-farming activities (permanent wage income)	+
RADIO	Radio as primary media (1 = Access to radio; 0 otherwise)	+
TV	TV as primary media (1 = Access to TV; 0 otherwise)	+
CONSALE	Purpose of farming (1 = Both household consumption & market sales; 0 otherwise)	+
FARMEXP	Experience in maize farming (in years)	+
SOURFIN	Source of finance/funds to operate the farm (1 = Own finance; 0 otherwise)	+
FARMZ	Farm size (in hectares)	+
LVLCOMT	Level of commitment to the far (1 = Fulltime; 0 otherwise)	+/-
PRIOCP	Primary occupation (1 = Farming; 0 otherwise)	+/-
LOWPRDCT	GM maize reduces production costs (1= Yes, 0 otherwise)	+
PESTRES	GM maize are pests resistant (1 = Yes, 0 otherwise)	+
AFFORDA	GM maize seeds are affordable (1 = Yes, 0 otherwise)	+
HIGHLYPRE	GM maize are highly preferred by consumer (1 = Yes, 0 otherwise)	+

Source: Field survey, 2014.

2. Results and discussion

2.1. Distribution of socio-economic/demographic characteristics of the maize farmers. Table 2 shows that that majority (59.0%) of farmers were between the ages of 51-70 years, while 19.9% and 21.1% were between the ages of 31-50 and 71-90 years respectively. The mean of the age was 60.5 years. This could negatively influence adoption of GM seeds since relatively older farmers are found to be less likely to adopt new technology. Howley (2012) proved that older farmers are more conservative, less flexible and more sceptical about the benefits of new technology. About that 43.5% of the respondents were male while 56.5% were female. This implies that there were more females engaged in agricultural activities than males in the study area.

In terms of educational level, Table 2 shows that 30.6% of the farmers had no formal education. It was further observed that amongst literate farmers, 41.2% of them had primary education while 17.6% and 10.5% had secondary and tertiary education respectively. This indicates that there is high illiteracy level in the study area which might have a negative effect on adoption of GM seeds. Farmers have different purpose or motivation for farming, the descriptive results below show that 85.9% of the farmers engaged in farming in order to feed their households and sell surpluses to generate income. While 5.9% of farmers produce with the aim of generating income only, 4.7% produce to feed their household only and the remaining 3.5% had other reasons for producing, which may be research (testing a new cultivars).

About 45.9% of farmers had access to radio as their primary source of information, this might be due to the fact that average age of the respondents was 60 years and social science studies confirmed that elderly people prefer radio than other kinds of media. The second preferred media was television with 25.9%, while 11.8% and 5.9% had access to newspaper and internet as their primary source of information respectively. It was also observed that 10.5% of farmers had no access to any kind of media. Majority (91.8%) of the farmers received their household income from farming, while 63.6% receive social grant with 45.9% getting old pensioner's grant and 17.7% getting child grant. Marital status reflects that majority (67.0%) of the respondents were married while 7.1% of the respondents were single and 25.9% were widowed. The results also revealed that majority (37.6%) of farmers had farming experience of 31-45 years. It was followed by (34.1%) of farmers with 15-30 years of farming experience, while 16.5% and 11.8% were the farmers with experience of less than 15 years and more than 46 years respectively. Farmers' average farming experience was 29.9 years. Many years of farming experience may positively influence adoption of GM seed. This goes in line with the findings of Howley (2012) that accumulated years of experience may help farmers in crop selection and enable them to evolve the farming practices that are most suitable to their fragile environment.

Table 2. Socio-economic/demographic characteristics of the maize farmers

Socio-economic characteristics	Frequency	Percentage
Age (years)		
31-50	19	19.9
51-70	48	59.0
71-90	18	21.1
Gender		
Male	37	43.5
Female	48	56.5
Education level		
Primary level	25	41.2
Secondary level	15	17.6
Tertiary level	9	10.6
No formal education	26	30.6
Purpose of farming		
Marketing only	5	5.9
Household consumption only	4	4.7
Both consumption and marketing	73	85.9
Others	3	3.5
Media access		
Radio	39	45.9
TV	22	25.9
Newspaper	10	11.8
Internet	5	5.9
No access to media	9	10.5
Sources of finance to run the farm		
Own	74	87.1
Credit	4	4.7
Government	3	3.6
Others	4	4.6
Marital status		
Single	6	7.1
Married	57	67.0
Widowed	22	25.9
Farming experience		
Less than 15	14	16.5
15 – 30	29	34.1
31 – 45	32	37.6
More than 46	10	11.8
Total	85	100

Source: Field survey, 2014.

2.2. Distribution of mean and standard deviation of continuous variables. Descriptive statistics of continuous variables are presented in Table 3. As shown in the table, the mean of age of respondents was 60.53 years (SD = 13.19) demonstrating that most of the farmers surveyed were within the age of retirement of labor force with an average farming experience of 29.88 years (SD = 13.96). Results show that farmers were producing at a small-scale with an average land size of 1.53ha (SD = 0.83) with household farming income constituting an average of R1457.65 (SD = 3918.56). Average income received from social grant (including both child and old pensioners) were R849.74 (SD = 1523.29) as shown in the table, while the average income received from non-farming activities (permanent wage income) was R 5051.74 per month (SD = 5210.56).

Table 3. Distribution of mean and standard deviation of continuous variables

Variable	Description	Mean	Std. dev.
AGE	Age (in years)	60.35	13.19
HH	Household size (in number of persons)	6.38	2.42
FARMINC	Income received from farming	1457.65	3918.56
SGINC	Income received from social grant (child/old pensioner)	849.88	1523.29

Table 3 (cont.). Distribution of mean and standard deviation of continuous variables

Variable	Description	Mean	Std. dev.
NONFINC	Income received from non-farming activities	5051.74	5210.56
FARMEXP	Farming experience (in years)	29.88	13.96
FARMZ	Farm size (in hectares)	1.53	0.83

Source: Field survey, 2014.

2.3. Classification of sampled maize farmers. Table 4 shows that about 76.4% farmers who were growing hybrid seeds were in growing two varieties; SNK 2147 (white grain maize) and SNK 2778 (yellow grain maize) which are all products of Monsanto (pty) Ltd. The results also show that only 11.8% of the farmers in Thulamela municipality adopted genetically modified maize varieties. The GM variety that the famers were growing is P 2653W B (white grain maize) which is a product of Pioneer Hi-Bred currently known as Dupont Pioneer.

Table 4. Classification of sampled maize farmers

Category	Number of farmers	Percentage
Hybrids (white & yellow grain maize)	65	76.4
GM (white grain maize)	5	5.9
Both GM maize and hybrid seeds	10	11.8
Traditional/indigenous only	5	5.9
Total	85	100

2.4. Results of farmers' perception towards GM maize attributes. Previous studies suggest that farmer's perception of the varietal characteristics play a significant role in the seed selection decision. As argued by Ajzen (2006), individual perception about the possible outcome of behavior influences their decision to adopt or reject the said behavior. It is therefore important in this study to examine the extent to which farmers' perception about GM maize influence their intention or decision to adopt the seed. This section elaborates on the perception that farmers holds about GM maize characteristics, attributes, quality, benefits and costs.

2.5. Farmers' perceived benefits of GM maize. The following Table 5, shows the perception of famers towards adoption of genetically modified maize varieties. It clearly portrays what famers perceive as benefits (pros) of growing GM maize. Farmers perception was based on their experience of the previous cropping season (for those farmers that have adopted) while other farmers' responds were based on the knowledge and information they had about GM acquired from either media, extension officers, peer-groups, seeds agents or other sources and also on their observation from farmers who have adopted, without having to grow it. Their perception was in comparison with the maize varieties they are currently growing (hybrid or indigenous).

The result shows that 75% of farmers believed that GM maize increases production yield. Farmers supported this statement based on the information acquired from seed agents during farmers' day events often held every year. Results further revealed that farmers strongly (94.1%) perceive that GM maize grow faster as compared to traditional maize and other hybrids while only 5.9% of the farmers disagreed. It was observed that this perception was mostly testified by the farmers who have adopted the seeds. Not many farmers were convinced that GM maize is resistant to pests and diseases however, 51.1% agreed that GM seed can withstand pests and diseases, farm lands in Thulamela Municipality are highly troubled by pests and diseases (IDP, 2009), which is possibly the reason why 48.9% disagreed. In terms of drought tolerance, only 29.4% of the farmers seem to believe that GM maize can withstand dry season while majority (70.6%) believed otherwise. The results further reveal that 2.4% and 3.5% of the farmers perceived that GM decreases production cost and that it is affordable respectively. This could be because many farmers believe that GM seed are expensive as compared to their hybrid and traditional seeds. Farmers however expressed that they are not well informed when it comes to their real market prices.

When it comes to high market value or better quality, not many farmers (16.5%) seem to believe that GM maize is of high/better quality as compared to other varieties of maize, this might be because majority of the farmers have not seen the quality of GM maize since they have not adopted it. Not many famers perceived GM maize to be nutritious, only 4.7% agreed, this was obviously due to the health issues concerning the healthiness of these varieties, since many of the farmers seems to be aware of the controversies surrounding health risks (Thomson, 2003). Besides the perceptions suggested by the researcher, farmer who have adopted GM maize (17.6%) did testify that GM maize save labor and water. This was the case because they didn't have to use a lot of water to irrigate since the maize was developing well with just rain water, and not too much labor was required as less maintenance was necessary.

Table 5. Perceived benefits of growing GM maize as indicated by farmers

Farmers perception	1 = Agree		0 = Disagree	
	Frequency	Percentage	Frequency	Percentage
High production output (Increased yield)	64	75.3	21	24.7
GM maize grow faster	80	94.1	5	5.9
High resistance to pests and diseases	44	51.1	41	48.9
GM maize is drought tolerant	25	29.4	60	70.6
Low production cost	2	2.2	83	97.8
They are affordable (not expensive)	3	3.5	82	96.5
High market value (better quality)	18	21.1	67	78.9
Highly preferred by consumer	14	16.5	71	83.5
Nutritious or Better taste	4	4.7	81	95.3
Labor saving	15	17.6	70	82.4
Save water	15	17.6	70	82.4

Source: Field survey, 2014.

2.6. Farmers perceived cost of GM maize varieties. Table 6 shows perceived costs of growing GM maize varieties as indicated by the farmers. Almost all (96.5%) the farmers seemed to believe that GM maize seeds are expensive as compared to the hyb-rids and traditional varieties that they are currently growing. This can be supported by price of maize in the last season (2013/2014) which was found to be R240 for hybrids SNK 2147 and SNK 27748 for 5kg available at NTK stores, while 5kg of GM (P 2653W B) was sold for R350 by Pioneer agent in the same season. About 54.1% of farmers had a perception that the pric-es of GM increases regularly which will tend increase production cost. These monetary factors are more likely to influence the farmers' decision to adopt the seed, as every farmer wishes to produce with the low-est possible cost and generate maximum returns. When it comes to production output/yield 16.5% of the far-mers seemed to believe that GM maize does not in-crease production yield whereas 83.5% seem to disag-ree. Many farmers (65.9%) had a perception that GM seed is not available in the market when needed. This perception can be sustained by the fact that farmers who have adopted the GM seeds bought them from an agent on farmers' day event since they were not avail-able in the market. A farmer cannot adopt a certain innovation if it not available in the input market (Fer-nandez-Coenejo, 2001).

Table 6. Perceived costs of growing GM maize varieties as indicated by farmers

Farmers perception	1 = Agree		0 = Disagree	
	Frequency	Percentage	Frequency	Percentage
GM maize seeds are expensive	0.96	0.19	096	0.19
Regular increase in seed prices	0.54	0.50	0.54	0.50
Low production output (deceased yield)	0.16	0.30	0.16	0.30
Not available in the market when needed	0.65	0.39	0.65	0.39

Source: Field survey, 2014.

2.7. Perceived costs and benefits of improved maize varieties as indicated by farmers. Table 7 below demonstrates both the costs and benefits of growing improved maize varieties as indicated by farmers. Improved maize varieties (hybrids) mostly grown by small-holder famers in Thulamela municipality are SNK 2147 white grain maize and SNK 2778 yellow grain maize. The farmers indicated the benefits they reap form growing these varieties as well as the costs are based on their experience. A large number of far-mers (82.4%) indicated that hybrids seeds are afforda-ble as compared to GM seeds, 88.2% also indicated that the hybrids seeds are always available in the mar-ket when they want them. Results further portrait that 32.9% of the farmers indicated that hybrids varieties decreases production cost. However in terms of pro-duction yield 76.5% famers stated that, they get good returns form growing these varieties, these may justify low adoption intensity in the study area. In terms of diseases majority of farmers seemed concerned about pests, 82.4% of the farmers experiences a problem of pests and diseases every cropping season and lastly, 70.6% indicated that these varieties require a lot of irrigating during production.

Table 7. Costs and benefits of improved maize varieties as indicated by farmers

Items	Frequency	Percentage
The seed is affordable as compared to GM seed	70	82.4
The seed is always available in the market	75	88.2

Table 7 (cont.). Costs and benefits of improved maize varieties as indicated by farmers

Items	Frequency	Percentage
Low production cost compared to GM maize	26	32.9
High production yield	65	76.5
Low production yield	20	23.5
Attacked by pests and diseases	70	82.4
Require a lot of irrigation	60	70.6

2.8. Results of tobit analysis of factors influencing GM maize adoption intensity. Table 8 below shows the results from tobit model for factors influencing smallholder farmers' adoption intensity of genetically modified maize varieties. The Chi square of the likelihood ratio is statistically significant ($p < 0.01$), showing that the model fits the data well. The pseudo of coefficient of determination shows that 58.27% of the variations in adoption intensity of GM maize varieties have been explained by the included parameters. The results show that explanatory variables farming experience, TV (as a primary media) and farmers' perceptions that: GM maize is pest resistance, affordable and highly preferable by consumers are statistically significant at 5% and 1% level.

The results show that the number of years of farming experience was statistically significant ($p < 0.05$), implying one unit increase in years of experience, farmers adoption of GM is likely to decrease. This is contrarily to apriori expectation and Fernandez-Cornejo et al. (2001) findings that more experience in farming positively influences the likelihood of adoption, as it helps farmers to adjust to the changes required for each new agricultural technology. However, the results are in line with Kizilaslan (2009) that more experienced farmers are not likely to adopt new technology, possibly due to their being close to the end of their operating horizon, leaving less time to gain or enjoy returns from investment. TV was positively significant to GM adoption ($t = 2.22$; $p < 0.05$), which implies that access to TV is likely to increase adoption intensity. Access to media means access to sufficient information about GM maize varieties and its attribute which may positively influence adoption intensity.

The three variables which describe farmers' perception towards the attributes of GM maize varieties had positive relationship with adoption of GM. If the number of farmers who perceive that GM maize is pest resistant increases by one unit, GM adoption is likely to increase. Crops that are pest resistant are likely to decrease production cost, because they will limit the use of fertilizers and pesticides which are expensive to purchase, therefore farmers are more likely to adopt those crops (Thomson, 2003). Furthermore, farmers perception that GM maize is affordable was positively significant at ($t = 2.94$; $p < 0.01$), which implies that if the number of farmers who perceive GM maize to be affordable increase by one unit, GM adoption will increase as expected. Furthermore, the perception that GM maize is highly preferred by consumer is also positively related to adoption of GM maize and statistically significant ($p < 0.05$). This entails that for each unit increase in the number of farmers with this perception, the expected value of GM adoption will increase. It is an undeniable fact that every producer wishes to produce and sell products that are highly desirable and preferable by consumers in order to attain maximum profit.

Formal education was apriori expected to have a positive influence on adoption, however the results below illustrate a negative relationship. Feder et al. (1993) and Fernansez-Cornejo et al. (2001) revealed that farmers with higher educations or greater access to agronomic information through extension agents or seed suppliers, for example, tend to adopt more quickly. However negative relation in this study can be justified since illiterate level was high in the study area with 30.6% and 41.2% of the farmers not having formal education, and only having only primary education respectively. Age of the respondent is in line with apriori expectation, which was a negative influence. Average age of the farmers in the study area was 60.5 years, which is regarded as late adulthood when human being is no longer very active (Robinson, 2012). Studies have shown that older smallholder farmers are risk averse and are the most resistant to new technology adoption.

Table 8. Tobit regression results of factors influencing farmers GM adoption intensity

Variables	Coef.	Std. err.	t	$P > \|t\|$
GENDER	.0599089	.1855429	0.32	0.748
AGE	-.0060612	.0085463	-0.71	0.480
FEDUC	-.0693236	.2075525	-0.33	0.739
FARMEXP	-.0316165	.0086649	-3.65	0.000**
LOWPRDCT	.3027447	.2339057	1.29	0.200
PESTRES	.683042	.3509672	2.60	0.011**
AFFORDA	1.030117	.263067	2.94	0.004*
HIGHLYPRE	.4344443	.1703625	2.55	0.013**
RADIO	.3536303	.2934932	1.20	0.232
TV	.6001061	.2707095	2.22	0.030**
CONSALE	-.1275095	.3154962	-0.40	0.687
CONS	-.093502	.528108	-0.18	0.860

Notes: LR Chi^2 (11) = 58.27; Prob > Chi^2 = 0.0000; Pseudo R^2 = 0.6565; (**) Significant at 5%, (*) Significant at 1%.

2.9. Results of probit analysis of factors influencing adoption of improved maize varieties. The results presented in Table 9 show probit results for analyses of factors influencing adoption of improved maize varieties. The pseudo adjusted coefficient of determination shows that the model explained 31.66% of the variations in the probability. The computed chi square for the likelihood ratio is statistically significant ($p < 0.01$). This shows that the model appropriately fits the data. The estimated model coefficients, associated with p value ($P > |z|$), and marginal effects of the explanatory variables selected for predicting farmer's adoption decision are presented in Table 6. Out of the variables that were included, marital status, income received from farming, purpose of farming, source of finance/funds to run the farm and farm size were statistically significant at 5% and 1%.

Marital status was statistically significant ($p < 0.01$), implying that as the number of farmers who are married (67%) increase by one unit, the probability of adopting improved varieties will be increase with a margin of 0.4577. Farmers who generate a greater proportion of their monthly household income from farming have a high probability of increasing their adoption of improved varieties, with a marginal parameter of 0.458 indicating a variation in earnings from farming as a ratio of household monthly income increases by one unit. Purpose of farming significantly ($p < 0.05$) reduces the probability of adopting improved varieties. This might be because among the farmers farming for both purpose of consumption and sale, their primary objective may be household consumption above making profit, therefore they may not be driven to adopt improved maize varieties.

Results also portray that source of finance to run farm (1= own finance, 0 otherwise) was negatively significant ($z = -2.39$, $p < 0.05$), to adoption of improved maize varieties, this entails that a unit increase in the number of farmers using their own source of finance for farming, there will be a decrease in the probability of adopting improved varieties. The reason for this might be that smallholder farmers lack the capacity to deal with the possible fall outs of new improved technologies. This can be supported by Feder (1993) findings that, credit and off-farm income play a role in a farmer's decision to adopt a new technology, especially if the new technology requires higher fixed costs. Farm size was apriori expected to have a positive relationship with adoption of improved varieties since increased farm size might imply more land is available for cultivation of improved seeds. However the results proved that a unit increase on farm size will lead to a decrease in adoption of improved maize varieties with a margin of 0.3316. This may be because a farmer may decide to put land in use for growing other crops but maize, which possibly generates greater returns as compared to maize. Results can also be supported by few studies that found that small farms are highly risk averse concerning new technology due to limited size and uncertain outcomes from the technology. Farm size was statistically significant at 1% level.

Table 9. Probit regression results of factors influencing adoption of improved maize varieties

Variables	*dy/dx*	Coef	Std. err.	*Z*	*P* > |*z*|
GENDER	.0112503	. 0293082	.4316629	0.07	0.946
AGE	-.0019565	-.0050941	.0196314	-0.26	0.795
FEDUC	-.1086983	-.2887612	.4146343	-0.70	0.486
MARSTU	.4576602	1.221316	.4525618	2.70	0.007**
HH	.0148075	.0385536	.0825572	0.47	0.641
FARMINC	.0000422	.0001099	.0000538	2.04	0.041**
SGINC	.0000824	.0002146	.0004108	0.52	0.601
NONFINC	-.0000201	-.0000522	.0000493	-1.06	0.290
RADIO	.0057645	.0150115	.4575811	0.03	0.974
TV	-.0300456	-.0778568	.4788031	-0.16	0.871
CONSALE	-.3454621	-1.134217	.4788031	-2.12	0.034**
FARMEXP	.0071322	.0185698	.0169206	1.10	0.272
SOURFIN	-.4719489	-2.005175	.8392712	-2.39	0.017**
FARMZ	-.3315561	-.863258	.3239253	-2.66	0.008**
CONS		2.558393	1.642944	0.119	0.119

Notes: LR chi2 (14) = 37.13, Prob > chi2 = 0.0007, Pseudo R2 = 0.3166, (*) significant at 10%, (**) significant at 5%, (*) dy/dx is for discrete change of dummy variable from 0 to 1.

Conclusion

It is an undeniable fact that every new technology takes time to be fully adopted; studies proved that smallholder farmers are the most resistant as compared to large commercial farmers. Beside the fact that smallholder farmers' main objective is often to feed their household, they are mostly reluctant to take risk, which means accepting the bargain with an uncertain payoff rather than another bargain with a more certain, but possibly lower, expected payoff. During data collection, the observation was that 14.1% of the farmers did not have knowledge of GM maize varieties. However form the remaining 85.9% who knew about the seeds, only 17.6% had adopted the seed from one of the six schemes sampled in Thulamela municipality. Amongst 17.6% of farmers who had adopted, more than half of them stated that the results obtained from the seed were not desirable. It can therefore be recommended that, DAFF, DRDLR and ARC should work together to improve the adoption of GM maize by establishing a functional regulatory board to work closely with the farmers in terms of educating them about the seeds and the benefits attributes that come with them in other to increase food security and household income from farming. This will encourage farmers to be competitive and motivate them to produce at commercial scale.

Farmers expressed that they did not get desirable results from the GM seeds which was sold to them by an agent during farmer's day event. This could have been a result of wrong implementation of the seeds, it can therefore be recommend that farmers should be provided with orientation on proper usage of seeds in order to achieve maximum benefits.

Finally, unavailability of seed and high cost of seed were the common factors influencing low adoption of GM, it can be recommended that the DAFF, DRDLR and ARC build a close relationship with the seed agents form the companies that sell GM seeds (Pioneer, Monsanto and Pannar) in order to ensure availability of the seed to the farmers when needed and at subsidized prices.

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