International Journal of Agricultural Science, Research and Technology in Extension and Education Systems (IJASRT in EESs)
Available online on: http://ijasrt.iau-shoushtar.ac.ir
ISSN: 2251-7588 Print
ISSN: 2251-7596 Online
2019: 9(1):19-34

Received: 11 March 2018
Reviewed: 10 September 2018
Revised: 21 January 2019
Accepted: 29 January 2019

Effects of Adoption of Improved Maize Technology on Yield among Smallholder Maize Farmers in the Bawku West District of Upper East Region of Ghana

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Abstract

For over a decade now improved maize technology constituting a package of fourteen production recommendations have been developed and disseminated to maize farmers in the Bawku West district of the Upper East region through the district department of agriculture. This paper presents findings of a study conducted to assess the level of adoption of these production recommendations and its effect on yield among smallholder farmers in the district. Through multi-stage sampling techniques, 400 maize farmers were surveyed with personal interviews, focus group discussions and observations employed in gathering data. Descriptive and inferential statistics were employed in analyzing the data and results presented in tables and graphics. Many (44%) of the farmers surveyed were found to have been practicing most of the production recommendations. The study found significant and positive relationship between level of adoption and yield. Adoption of many production recommendations guarantees high yield. Also, age, gender, household size, farm size of maize credit, labour and experience were found as significant determinants of yield. Education and training aimed at improving farmers understanding and skills regarding the practice of maize production recommendations should be strengthened and organized regularly.

Keywords: Yield, Adoption, Improved Maize Technology, Productivity

1. Introduction

Agriculture continues to be an important sector in Ghana's economy notwithstanding the structural transformation of the Ghanaian economy resulting in the service sector overtaken agricultural sector as the leading contributor to GDP in recent times (GOG, 2017 & GSS, 2017). Agricultural sector still remains the highest employer in the country, providing direct employment to about 36% of the active labour force and indirectly employing additional 35% of the labour force through agro-processing, marketing and supply of agricultural inputs and services (GOG, 2017).

However, agricultural sector's contribution to Ghana's GDP has seen decreasing trend over the last decade. Being the leading contributor to GDPfor several years, agricultural sector now trails behind the Service and industrial sectors. In 2016 agricultural sector's share of GDP was 20.3% compare with54.4% of the service sector and 25.3% for the industrial sector (GOG, 2017). Notwithstanding, agriculture still remains the backbone of rural economy in Ghana serving as the main source of livelihood for majority of rural dwellers.

Despite government'slong standing commitment to agricultural modernization(MOFA, 2016 & 2012), rudimentary technologies are still used to produce 80% of the country's agricultural output by smallholder farmers (MOFA, 2012). The poor performance of the agricultural sector observed in recent times had partly been blamed on low technology adoption and lack of modernization of agricultural practices. However, agricultural growth has been aptly demonstrated to have a positive link with overall national development (Juma, 2015; Timmer, 2002). To harness the potential of agricultural sector to propel national development, successive and current governments have been implementing policies, programmes and reforms aimed at promoting technology adoption and overall modernization of agricultural production (GOG, 2017; MOFA, 2010; MOFA, 2012).

Low technology adoption and poor agricultural investment have accounted for the low yield and low productivity observed among major crops such as maize in Ghana. Yields obtained by smallholder maize farmers in Ghana seldom go anywhere near the attainable yields; creating wide yield gaps and low productivity (IFPRI, 2013; MOFA, 2012). As observed in IFPRI (2013) and also in MOFA (2011), yields are generally less than half of economically attainable yields for staple crops such as maize and rice. National average yields of maize stands at 1.7 metric tons/hectare, far below on-station and on-farm trials average yield of 4 tons/hectare (IFPRI, 2013). High technology adoption and agricultural mechanization, particularly use of improved varieties, best agronomic practices, use of fertilizer, post-harvest management and access to market, have been noted as the only way to improve maize productivity and bridge this huge yield gap (IFPRI, 2013 and MOFA, 2012).

Several agricultural productivity enhancement interventions such as Ghana Grain Development Project (GGDP) , Food Crop Development Project, the Sasakawa Global 2000 maize improvement project have been implemented bring to bear the necessary investment in research and development aimed at developing the maize sub-sector. As a result, many production recommendations ranging from use of improved seeds, best agronomic practices, soil and water conservation practices, used of fertilizer, post-harvest management among others have been disseminated to farmers for the past two decades.

Notwithstanding, many studies still identified the cause of low productivity of maize to low adoption of productivity-enhancing technologies, including improved varieties and management practices, and low use of purchased inputs, especially fertilizer (IFPRI, 2014, MOFA, 2010 and MOFA, 2012). This paper therefore presents findings of a study conducted to assess the uptake of maize production recommendations among smallholder farmers in the Bawku West District of Ghana and the effect of level of adoption of these technologies on maize yield.

Literature Review

Maize production in Ghana

Maize (Zea mays), is the most-produced cereal worldwide. In Africa alone, more than 300 million people depend on maize as their main food crop (IPBO, 2017). Maize occupied more farmlands than any other staple crop in Africa. Maize occupies 24% of all farmlands used in the cultivation of major Africa staples crops such as cassava, sorghum, millet, groundnut, rice, cowpea among other (Abate, 2015). The leading producers of maize in Africa are South Africa, Nigeria, Egypt, Zimbabwe, Ghana, Kenya, Angola, Mali, Tanzania, Mozambique, Zambia, Uganda, Ethiopia and Benin. According to Abate (2015) these countries accounted for 72% of total maize produced in Africa in 2014.

However, maize production in Africa is continuously and severely affected by a number of threats, ranging from weeds, insects, bacteria, viruses, nematodes, fungi infestation to low quality seed (Thierfelder & Prasanna, 2013).

As a result, on average, growth in maize productivity across Sub-Saharan Africa (SSA) appears stagnant. However, some significant progress is being realised in some countries brought about through improved technology adoption, increasing investment and agricultural mechanization (Abate, 2015).

In Ghana maize is a versatile crop; grown across a broad range of agro-ecological zones across the country. Since its introduction in Ghana in the 16th century, maize had established itself as an important food crop grown throughout the country. It is grown in the forest, transition and the Guinea Savannah ecological zones – which comprises of upper west, upper east and northern regions. In 2011, production was highest in Brong Ahafo, which accounted for 27% of national production, followed by Eastern (20%), Central (12%), Ashanti (12%), and Northern (11%) (IFPRI, 2013). Maize enjoyed a wide coverage in terms of cultivation, partly because it is the largest staple crop in Ghana and contributes significantly to consumer diets. It is the number one crop in terms of area planted (about 1,000,000 hectares) and accounts for 50-60% of total cereal production (MOFA, 2012).

Ghana is one of the major maize producers in SSA, accounting for about 9% of the total acreage cultivated in 2011 and 7% of the total acreage in West and Central Africa (Alene and Mwalughali, 2012). As shown in the figure 1, there had been a steady upward trend of maize output within the last five decades. Production of maize in Ghana had soared from just under 300Mt in the 1960s to about a million Mt in the 1990s and then a little under two million Mt in 2016. Apart from season fluctuation occurring in1983 in which there was sharp decline in production from 326,000Mt in 1982 to just 172, 000Mt in 1983, there had been a general increasing trend in maize production in country over the past decades.

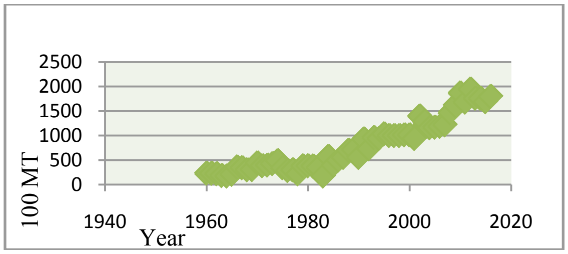

Figure 1. Trend of Maize Production from 1960 to 2016
Source: United States Department of Agriculture report on Ghana agriculture, 2017

Improved Maize Technologies

The maize sub-sector in Ghana had witnessed many projects and research activities aimed at improving maize production and productivity. Notable among them is the Ghana Grains Development Project (GGDP). The GGDP was a long-term programme focused on the maize sector development (IFPRI, 2013). In addition to its research component, the project supported a number of activities designed to improve the transfer of improved technologies generated through the project to farmers. The project's robust technology transfer model was reflected in three types of activities: (1) Building linkages between research and extension,(2) Providing support to extension activities, and (3) Strengthening seed production capacity

According to IFPRI (2013) the GGDP had achieved a number of notable successes. Several varieties were developed and disseminated under the project; many agronomic practices were evaluated; production guides were produced; and a heavy investment was made in extension and dissemination of improved technologies. Obatanpa, a quality protein maize variety developed through the project is now one of the popular maize varieties in Ghana and other countries in SSA (IFPRI, 2013).

Other notable programmes implemented in the maize sub-sector in Ghana included the Sasakawa Global 2000 programme and Food Crops Development Project (FCDP), in addition to several small projects focussed on seed multiplications (Manu, Fialor& Issahaku, 2012). Several farm demonstrations were conducted to test and promote modern varieties under the Sasakawa Global 2000 programme. One of the focused technology packages tested and promoted under Sasakawa Global 2000 was zero-tillage package, involving no ploughing, the use of herbicide in land preparation, line planting and mulching (IFPRI, 2013). Through collaboration with Crop Research Institute (CRI) of the Council for Scientific and Industrial Research (CSIR), Sasakawa Global 2000 with sponsorship from Monsanto, several farm demonstrations on zero-tillage and other improved maize technologies were tested and its adoption promoted among farmers (IFPRI, 2013 and Manu et al, 2012).

In continuation of activities started under the GGDP, the Food Crops Development Project (FCDP) was implemented in eight districts in various regions. The FCDP undertook many field and adaptive trials of many maize varieties, publication and distribution of maize production manuals, facilitating extension access, input provision, and capacity building on processing and marketing. Many impact assessment studies demonstrate positive impact of the FCDP's activities on maize productivity. A study by Manu, *et al*. (2012) shows that FCDP has provided greater access to credit, provided information about improved technologies, increased maize output, and improved food security compared with pre-project levels.

As part of the national food security and emergency preparedness and in line with agricultural modernization agenda several maize improvement technologies ranging from varietal development through good agronomic practices to mechanization and post-harvest management have been disseminated to farmers. Most of the efforts by the national research institutes in relation to maize are in varietal improvement and testing. Several trials on agronomic practices have also been conducted, mainly under GGDP and FCDP, on improved land preparation, row planting, fertilizer use, herbicide use, pest and disease control, and water management, among others (IFPRI, 2013).

Improved Maize Varieties: According to IFPRI (2013) twenty-seven improved varieties of maize have been released to Ghanaian farmers from 1960 to 2012. Varietal improvement and testing done by CRI and SARI have been focused on high yield, protein content (that is, quality protein maize [QPM]), tolerance to pests and disease (mainly blight, rust, streak, and stem borers), Striga resistant, kernel type, lodging resistance and early maturity. Two main varietals lines namely open pollinated and hybrid varieties with different improved traits such as pest/disease resistant, drought tolerant, striga resistant were the most popular among the many maize varieties released to farmers (Gomez, 2010& IFPRI, 2013).

Obatanpa, a medium-maturing open-pollinated QPM maize variety was released to farmers in 1992. But it had since remained the most popular and widely cultivated maize variety in Ghana (IFPRI, 2013). It has long been grown and as such adapted to the growing conditions in the lowland tropics and has been adopted extensively in Ghana and many other African countries (Sallah et al. 2003&Sallah*et al.,* 2003). According to IFPRI (2013) Obatanpa accounted for about 96% of certified seed produced from 2001 to 2011.

Recommended Ploughing and Zero tillage: Ploughing is one of the fundamental operations undertaken in conventional tillage. Conventional tillage practices modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistance, soil moisture content and porosity (Gomez, 2010 &Rashidi and Keshavarzpour, 2008).Papworth (2010) indicated that tillageinfluences crop growth and yields by modifying soil structure to facilitate air circulation and moisture holding capacity over the growing season.

In the 1980s, adaptive trials on zero tillage, or no-till, with mulching as a sustainable alternative to slash-and-burn was initiated by CRI in conjunction with the International Maize and Wheat Improvement Center (CIMMYT), Monsanto, and Sasakawa Global 2000 (IFPRI, 2013). Zero tillage, or no-till, is a management practice that involves no ploughing (no disturbance of the soil), no burning, using herbicide during land preparation, and planting into mulch.

Fertilizer Application: Maize is particularly sensitive to soil nutrient deficiencies, both major and minor nutrients. Amounts and types of fertilizer required will depend on soil type, cropping history and geographical location (Price, 1997&Gomez, 2010). Maize requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium for good growth and high yield. Nitrogen and phosphorus are very essential for good vegetative growth and grain development in maize production (Gomez, 2010).Fertilizer application is the most popular means of correcting soil nutrient deficiencies in soil nutrient amendment practices geared towards improving crop yields.

Recommended rates of fertilizer application depend on the agro-ecological zone, soil type, and cropping history. According to Gomez (2010) and IFPRI (2013) numerous trials were conducted under GGDP to derive these recommendations. Split application is recommended. Compound fertilizer (for example, NPK 15-15-15 or NPK 20-20-0) is recommended, and the starter fertilizer should be applied about 5 centimetres away from the hills at planting, and if not possible, just after germination (one to two weeks after planting). Sulphate of ammonia (N21 or S24) or compound fertilizer (NPK 20-20-0 or NPK 20-20-20) is recommended as a side-dress applied four to five weeks after planting at the soil surface (except for sloping fields) (IFPRI, 2013). Urea (N45) can also be used but needs to be buried in the soil for maximum benefit. Urea loses its nutrients easily, and if stored or sealed improperly for a year, it would not retain any nutrients.

Continue soil testing and adaptive trials are regularly being undertaken by research institutions in order to update farmers with recommended rate of fertilizer application specific to their location throughout the various ecological zones in the country (Gomez, 2010& MOFA/CRI/SARI, 2005)

Crop Protection: Methods employed to manage weeds in maize farms varies, depending on the situation, available research information, tools, economic situation, and experience of farmers (Monaco, 2002). Weed control is an important management practice in maize farming because of its direct effect on optimum grain and forage yield (Gomez, 2010). Weed control in maize can be carried out by mechanical and/or chemical methods.

The general rule is to keep maize plots free from weeds especially during the first 30 days of planting. CSIR and Ministry of Food Agriculture (MOFA) recommend the use of herbicide before and after planting. Glyphosate (for example, Roundup or Roundup Turbo) is a systemic herbicide and is recommended for controlling broad range of weeds two weeks before planting (IFPRI, 2013). Examples of formulations of herbicides that have been tested and are available in Ghana are Roundup (360 grams/liter of glyphosate) and Roundup Turbo (450 grams/liter glyphosate.

Recommended application issued by SARI for farmers in the northern savannah ecological zone is 2.5 to 4 liters of glyphosate (depending on the strength of its formulation) per 15-liter knapsack sprayer to spray a hectare. A second application is also recommended with lasso-atrazine to the soil immediately after planting. The recommended rate is about 4 liters of lasso-atrazine per 15-liter sprayer per hectare (MOFA/CRI/SARI 2005 as cited in IFPRI, 2013).

Plant Density, Spacing, and Row Planting: Plant configuration recommendations specifically on plant density, seeds per hill, spacing, timing, and planting in lines were developed in Ghana based on extensive on-station and on-farm trials mainly under GGDP and the Sasakawa global 2000 project. Trials concluded that planting density of about 56,000 to 76,000 plants per hectare (based on two-seeds-per-hill planting) or approximately 20 kilograms of seed per hectareis recommended (IFPRI, 2013 and MOFA/CRISARI, 2005). Farmers have been used to planting as many as five seeds per hill, and researchers examined the effect of number of seeds per hill at different plant densities in several on-station trials which was replicated on – farm adaptive trials leading to the recommended rate of two seeds per hill planting.

Harvesting of Maize: Most maize is harvested by hand in Ghana, especially among smallholder farmers. By hand or mechanical picker, the entire ear is harvested which then requires a separate operation of a maize sheller to remove the kernels from the ear (Gomez, 2010). Information of timely harvesting by harvesting at the correct moisture level and proper harvest handling and storage have been disseminated to farmers under many of the maize improvement projects (IFPRI, 2013 and MOFA/CRI/SARI, 2005). However, traditional method of harvesting maize is still being used by farmers.

2. Materials and methods

The study was conducted in the Bawku west District of the Upper Region. The District was selected because it is among the major maize growing districts in the region. The Bawku West District can be located within the north-eastern area of the Upper East Region and lies roughly between latitude 100 30'N and 110 10'N and between longitudes 00 20'E and 00 (GIS, 2014). The District shares boundary to the North by the Province of Zabre in neighbouring Burkina Faso, to the East by the Binduri and Garu-Tempane Districts, to the West by the Talensi and Nabdam Districts respectively and to the South by the MamprusiEast District to the South.

Agriculture constitutes the dominant economic activity in the district with more than 80% of the active population deriving their income and livelihood from agriculture. The main livelihood activities in the District are crop farming, livestock and other agriculture related activities such as agro-processing and food preparation. The main agro – processing in the area arepito brewing, shea butter extraction, groundnut oil extraction, malt production, rice processing and dawadawa processing. The total arable land in the Districts is 58,406ha (District Department of Agriculture, 2017).

Population and Sample Size Determination

All maize farmers in the district constituted the population of the study. These farmers have been introduced to the various maize technologies by extension officers. List of maize farmers in all the 24 operational areas in the district was sourced from the District Department of Agriculture. From the list it was realised that about 5,750 farmers were introduced to the improved maize technology and they constitute the sampling framework from which the sample size was drawn. Cochran's (1977) sample size determination formula was employed in determining the sample size.

Applying Cochran (1977), sample size (n) computation formula as:

$$n = \frac{N}{1 + Ne^2}$$

Where n = sample size

N = population of maize farmers who have been introduced with the technology

e = marginal error (5%)

Information gathered from MOFA in the district gave the total number of maize farmers who have been introduced to the improved maize technology as 5,750 farmers. Thus N = 5,750

$$n = \frac{5{,}750}{1 + 5{,}750(0.05)^2} = 373.4$$

Thus n = 374 maize farmers. Adding 10% for unforeseen circumstances brings the total sample size targeted as 411 maize farmers. However, 11 farmers sampled could not be reached for interview. Therefore the sample size used in the study is 400 maize farmers.

Multi-stage sample procedure was employed in selecting respondents for this study. The District (Bawku West) was purposively selected because is one of the leading maize producing districts in the upper east region. Also many NGOs such as Techno – Serve Ghana, ADVANCE USAID and ADDRO are actively working in the District to promote adoption of appropriate technologies among smallholder farmers. This was followed by stratified random sampling techniques in which the district was stratified along the 24 MOFA operational areas. The 24 operational areas were found not to differ much by the number of maize farmers per the records of AEAs operating in the areas. As a result 17 farmers were selected from 16 operational areas and 16 farmers from the remaining 8 operational areas. From the list of maize farmers introduced with the improved maize technology, lottery method of simple random sampling techniques was applied in sampling respondents from each operational area.

Figure 2. Map of Bawku West District
Source: GIS (2014)

Data collection and Analysis

Both primary and secondary data were sourced from the sampled farmers and the district department of agriculture and the NGOs working in the district to help improve agricultural practice. Focus group discussions, observations and interviews were employed in gathering mainly primary data from the sampled respondents. Secondary data were sourced from documents on technology transfer and maize production in the District from the department of agriculture for the study.

Semi-structured questionnaire was developed and validated by experts and pre-tested in two communities in the Nabdam district. The questionnaires were administered to the sampled farmers in their own dialect (Kusaal). Since the lead researcher and the research assistants could speak the language, language barrier was not a problem. Farmers were interviewed in their homes and farms, which allowed enumerators to also observe farmers' practices relevant to the study.

Guided by check list, nine (9) focus group discussions were held in which farmers discussed issues ranging from maize production, technology adoption, access to agricultural information, challenges and constraints limiting their technology adoption. The nine focus group discussions were facilitated by the researcher and supported two research assistants.

In examining the level of adoption of improved maize technology among maize farmers in the Bawku West District' descriptive statistics was used to analyse the number of production recommendations adopted by a farmer. From MOFA and the three NGOs disseminatingbest maize production practice to farmers, it was gathered that the improved maize technology being disseminated comprises of 14 production recommendations. Respondents were asked to indicate how frequent they follow these production recommendations in their maize production process. Three point Likert scale as 1- if always follow a production recommendation, 2 - if sometime follow and 3 - if a farmer do not follow a production recommendation at all, were used in scoring farmers' adoption of production recommendations.

Respondents who were always following more than half (at least 8) of the fourteen (14) production recommendations were classified as high adopters, otherwise low adopters. The analysis was done with the aid of SPPSS version 20 and the results presented in graphs and tables.

3. Results and discussion

Adoption of maize production recommendations

Interactions with management of the District Department of Agriculture and NGOs working in the area of agricultural development in the district through in-depth interviews revealed the depth of efforts made to improve maize production and challenges encountered in promoting technology adoption. According to District Extension officer and supported by reviewed of document at the district library, production of maize gained prominence in the District in the early 1990s. He explained that'*many maize production technologies have been disseminated to farmers in the district but not much have been achieved in terms of adoption as some farmers stills relied on their rudimentary technologies in undertaking their maize production'*.

The improved maize technologies being disseminated to farmers in the District, is made up of a package of fourteen (14) production recommendations which maize farmers are expected to apply. These recommendations includes improved seeds, improved land preparation, spacing and row planting, timely and appropriate weed control, timely and appropriate rate of fertilizer application, appropriate sowing and spacing, timely harvesting and improved storage facilities as well as crop insurance. However, crop insurance has been recently introduced under Ghana Agricultural Insurance Pool. The Bar graph shown in the Figure 3, presents distribution of respondents' frequent of usage of the various production recommendations. The 14 production recommendations are made up of:

Use of improved certified seed

Farmers are educated to use improved seeds from certified source. According to IFPRI, (2013) twenty-seven improved varieties have been released from 1960 to 2012. Varietal improvement and testing done by CRI and SARI are focused on high yield, protein content (that is, quality protein maize [QPM]), tolerance to pests and disease (mainly blight, rust, streak, and stem borers), Striga resistance, kernel type, lodging resistance, and early maturity.

Among these improved varieties Obatampa, wandata, mamaba, abontim, pannar and pioneer have been promoted in the district and widely cultivated. However, access to improved seeds from certified seed grower has always been the concern of both extension officers and farmers. As shown in figure 2, only 29% of the 400 farmers interviewed indicated that they always used improved and certified seeds, while about two –third (63%) said they sometimes used improved certified seed and only 9% indicated that they never used the improved certified seed. Farmers in the area traditionally, select and stored seed from their previous harvest for use as seeds. This finding compare fairly well with IFPRI (2013), which found low level of used of certified seeds among farmers.

Farmers were of the view that their own seeds were more familiar to them and they found them more appropriate and tastier in preparing their local dishes, and that they were experienced in cultivating their local varieties. Similar reasons were assigned to low adoption of improved varieties of maize in Asiedu – Darko (2014).

Cost and difficulties in finding certified seeds of improved varieties also featured prominently in farmers' reasons for not adopting the cultivation of improved and certified maize varieties. Farmers who always or occasionally used certified seed varieties stated that high yield, drought tolerant, resistant to pest and disease were their key motivation for adopting the use of improved and certified seeds. One participant at the focus group discussion expressed his opinion as: '*even though it is expensive but it is good against drought, disease and yieldmore ..... so that why I always prefer it to my own stored seed*s' (a participant at a FGD at a Zebillacommunity).

Land/preparation/Ploughing

The way and method by which land is prepared for crop cultivation have direct effect on crop growth and performance. As a result, the production recommendation disseminated to farmers in the study area also covered appropriate land preparation methods and the require ploughing method, depth and appropriate time before seed sowing.

As shown in the Figure 2, the majority (76%) of the respondents followed the recommended ploughing method in preparing their land for maize growing while only 23% and 2% indicated that they sometimes and had never followed the recommended ploughing method respectively. Lack of access to timely tractor services and cost of hiring tractor were the main reason some of the respondent cited for not ploughing their lands or doing it at the right time. They were also of the view that, most of them do not own the tractors and as such cannot dictate to them to adjust the disc to ensure recommended ploughing depth. A participant at a focus group discussion indicated that '*the agriculture people should tell the tractor operators and owners to adjust their disc in line with what is being recommended ... I do not owned tractor and I had to literately beg to hire their service, how can I then now turn around to ask them to adjust their disc* ..'(Participant at FGD at Binaba community).

Zero tillage

Ploughing is one of the fundamental operations undertaken in conventional tillage. Conventional tillage practices modify soil structure by changing its physical properties such as soil bulk density, soil penetration resistant, soil moisture content, soil porosity and soil air (Gomez, 2010; Rashid & Keshavarzpour, 2008). Papworth (2010) indicated that tillage influences crop growth and yields by modifying the physical structure of soils to allow for smooth aeration, water penetration and moisture holding capacity. Even though zero tillage, which was promoted strongly under GGDP with many demonstrations and adaptive trials, conducted in all the ecological zones in Ghana, it was emphasised more for farmers in the forest and middle belt. However, based on the soil type and land condition, some areas in the savannah ecological zone also applied zero tillage.

Analysis of farmers response to the question on whether they always used zero tillage in preparing their land for sowing revealed that only 8% of the respondents always followed the zero tillage land preparation method, with 30% and 62% respectively indicating that they sometimes followed it and had never followed it (see figure 2). Very few farmers (8%) actually used zero tillage in preparing their maize lands. They cited reasons ranging from the nature of their soils, high cost of roundup weedicide and lack of information and knowledge about zero tillage for their low adoption of zero tillage. The reasons provided on the nature of their soils and lack of information on zero tillage are similar to IFPRI (2013), observations, who argued that zero tillage had been much promoted in the forest zone and in the middle belt but not much encouraged in the savannah areas because of the hard nature of the land and soils.

Ridging

Making ridges by raising and loosing soil before planting had been also recommended for farmers in the district. Making ridges before planting seeds or making ridges to protect maize plant stands from falling have not been widely followed. Results of analysis indicate that about a third (32%) said they always make ridge, while 30% and 38% indicated that they sometimes make ridges for maize plant and that they had never make ridges in their maize farms respectively.

Harrowing

Harrowing at the recommended depth of 25cm has been disseminated to farmers in the district. Farmers are being encouraged to harrow their lands after ploughing to further loosen the soil and reduce bulk density and improve soil aeration. However, analysis of the data indicated that just about 5% of the 400 respondents indicated that they always harrowed their lands after ploughing before planting while 42% and 53% respectively indicated that they sometimes harrowed their lands and never harrowed at all. They cited cost as the reason why they are not harrowing their lands. Poor access to tractor services was also mentioned as one of the reasons why they do not undertake harrowing of their land before sowing.

However, some respondents considered it to be a waste of time and resources. At the focus discussions, participants were of the view that this recommendation of harrowing is meant for rich farmers who have tractors or money to waste. They argued that they are yet to see the significant contribution of harrowing to yield. Their understanding of the purpose of harrowing is only to level the land for ease sowing. This clearly demonstrated that farmers need more information on the relevance of some of the production recommendations, as they are struggling to see the link between them and yield.

Spacing and row planting

Recommendation for plant spacing (planting distance) varies between open pollinated varieties (OPV) and the hybrid varieties. For OPV the recommended planting distance recommended for farmers in the district is 80cm between rows and 40cm between plants and hybrid 75cm between rows and 25cm between plants.

Planting in row with the recommended spacing are rarely followed by farmers in the study area. As shown in the Figure 2, about 21% always followed the recommendation of sowing in line with the appropriate spacing, while 40% indicated that they sometimes followed the recommendation and 39% said they have never followed the recommendation at all. Respondents interviewed cited reasons such as labour intensive nature of row and line sowing and lack of appropriate farm tools to practice the recommended spacing as being responsible for their low level of adoption of this recommendation. Also time constraint and competing demand for their labour were highlighted in the focus group discussions as a reason for their inability to adopt the technology of row planting and following the recommended plant spacing. A participant at one of the focus group discussion queried '*where do they expect us to get the time, manpower, rope, tapes and pegs to use in sowing in line when we have other farmlands to take care of*'(participant at FGD at Binaba community).

First fertilizer application

As captured in the maize production guide for farmers in the district, the recommended rate of compound fertilizer (NPK) for OPV is three 50kg bags per acre and four 50kg bag per acre in the case of hybrid variety. The guide clearly states that application of compound fertilizer should be done within the first week of sowing. This application should be repeated in 4 weeks' time because soil nutrients level in the area is not good. Deep placement and covering (dip and buried method) are encouraged in order to ensure effective utilization of fertilizer by plants and reduce losses due evaporation and leaching. Analysis of data gathered revealed that overwhelming majority (90%) of the respondents always followed the recommendation of first fertilizer application. However, only 7% indicated they sometimes followed the recommended rate of application while 3% indicated that they have never followed recommended rate.

Second fertilizer application

For second application of fertilizer or what is referred to as 'top dressing' one and half 50kg bags of Sulphate of Ammonia (SA) or urea per acre is recommend for OPV and two 50kg bags in the case of hybrid varieties. The application should be done six week after sowing. When using compound fertilizer such ACTYVA or EXTRA-K for top addressing or second fertilization application, farmers are require to repeat the application.

Farmers' compliance of these recommendations regarding second fertilizer application was assessed and the results presented in the Figure 2. As shown in the Figure, about 40% of the respondents said they always followed the recommended rate of second fertilizer application, with 46% indicating that they sometimes followed while 13% said they have never followed it at all.

From the results, it clear that most farmers applied second fertilizer application with only 13% indicating they do not. Due to poor soil fertility of most arable lands in the District, as observed by the district extension officer, farmers who failed to apply fertilizer usually get very low yield. As such the direct effect of the fertilizer application and yield is so obvious for farmers to see and this is driving the adoption of fertilizer application.

Also the government fertilizer subsidy programme which was reintroduced in 2008 have helped in stabilizing fertilizer prices making it easy for farmers to plan and purchase fertilizer for their farms. However, in spite of the subsidy programme, some farmers still complain of high cost of fertilizer and poor access due to poor road network and lack of effective fertilizer delivery system within the District.

Weed control

Weed control in the District is mostly done manually in which farmers use traditional hoes and cutlasses to mechanical remove weeds. However, the use of chemical weed control in which farmers applied herbicide to control weeds is increasingly gaining prominent in the area. Weed control is an important management practice for maize production that should be carried out to ensure optimum grain and forage yield (Gomez, 2010).

The production recommendation, require farmers to undertake weed control twice at different stages within the maize lifecycle. For the first weeding it is recommended to use pre-emergence weedicides immediately after sowing or manual weeding two weeks after sowing. Farmers who sprayed their farms with pre-emergence weedicides do not need to weed two weeks after sowing because the farms will still be free of weeds. Analysis of the study data indicates that majority (73%) always practiced the first weeding recommendation, while 27% indicated that they sometimes practiced first weeding. While some of them applied pre-emergence weedicides, other weeds manually two weeks after sowing.

The second weeding is expected to be done four weeks after sowing. As shown in the Figure 2, only 30% said they always followed the second weeding recommendation, while many (42%) have never followed it and 29% indicated that they sometimes followed the second weeding recommendation. Thus many respondents do not follow the second weed control recommendations. They cited competing demand for their labour, because they are multi-crop farmers, and high cost of weedicides as reason why they are unable to do the second weeding.

Harvesting at the right time

Manual harvesting of maize is the norm in the district, as it is the case for many smallholder farmers in Ghana. As such it is a labour intensive activity and because many farmers harvest their maize around the same time, the traditional norms of farmers assisting each other in undertaking farming activities is extremely challenged. Information on harvesting at the correct moisture level and proper post-harvest handling and storage had been disseminated to farmers by extension officers in the district. However, farmers still practice the traditional method of harvesting maize.

Harvesting at the right time and with the right moisture level is critical in reducing post-harvest losses. As shown in the Figure 2, just only 23% indicated that they always harvest their maize crops following recommended harvesting time, while majority (65%) said they have never followed the recommendation of harvesting at the right time, with only 13% indicating that they sometimes harvest their maize crops at the right time. They explained that during harvesting time they have competing demand on their labour because they grow many crops such that they are sometimes not able to harvest their maize at the right time.

Drying cobs to the right moisture level

The recommendation given to farmers is to dry cobs a week long after harvesting before shelling. Farmers are required to dry their cobs in concrete or plastic floor free of moisture. Drying maize cobs to the right moisture level before dehusking or shelling is quite practiced with 38% and 52% respectively indicating that they ‘always’ and ‘sometimes’ followed the recommendation of drying their harvested maize cobs before shelling. However, majority (63%) of the respondents always followed the recommendation of drying their maize grain to the right moisture level before storage, while about a third (33%) said they sometimes followed the recommendation.

Market Sourcing

Sourcing market opportunities and accessing market information is critical in ensuring profitable maize production. Results of the analysis indicate that only 25% of the respondents indicated that they always practiced the recommendation of sourcing market information and opportunity of getting good price for their farm produce. While the majority (63) said they have never followed the recommendation of sourcing market information for their produce,only 12% indicating that they sometimes sourced market opportunity for their produce. Thus most maize farmers surveyed relied on the middlemen for pricing of their maize with little or no information on demand and market price of their produce. Some of them take loans from these middlemen to invest in their maize farms and are therefore obliged to sell to them irrespective of the market condition.

Adoption of Production recommendations

Farmers who always practiced the production recommendation were classified as adopted, since adoption is the continue use or application of innovation (Roger, 2003). However, those who sometimes practiced a given recommendations or had never practiced it were classified as non-adopted of the said the production recommendation.

Table 1 presents distribution of adoption of the various production recommendations in the improved maize technology package.

As shown in the table, about 29%, 78% and 35% have adopted the improved certified seed, ploughing at the right depth and making ridging recommendations respectively. Similarlythe overwhelming majority adopted first fertilizer application recommendation (90%), first weeding recommendation (74%) and drying of grain before storage recommendation (64%). Also some of the respondents adopted second fertilizer recommendation (40%), second weeding recommendation (31%), timely harvesting recommendation (24%) and market sourcing recommendation (25%).However, only 7%, 9% and 22% have adopted the harrowing, zero tillage and planting in row respectively.

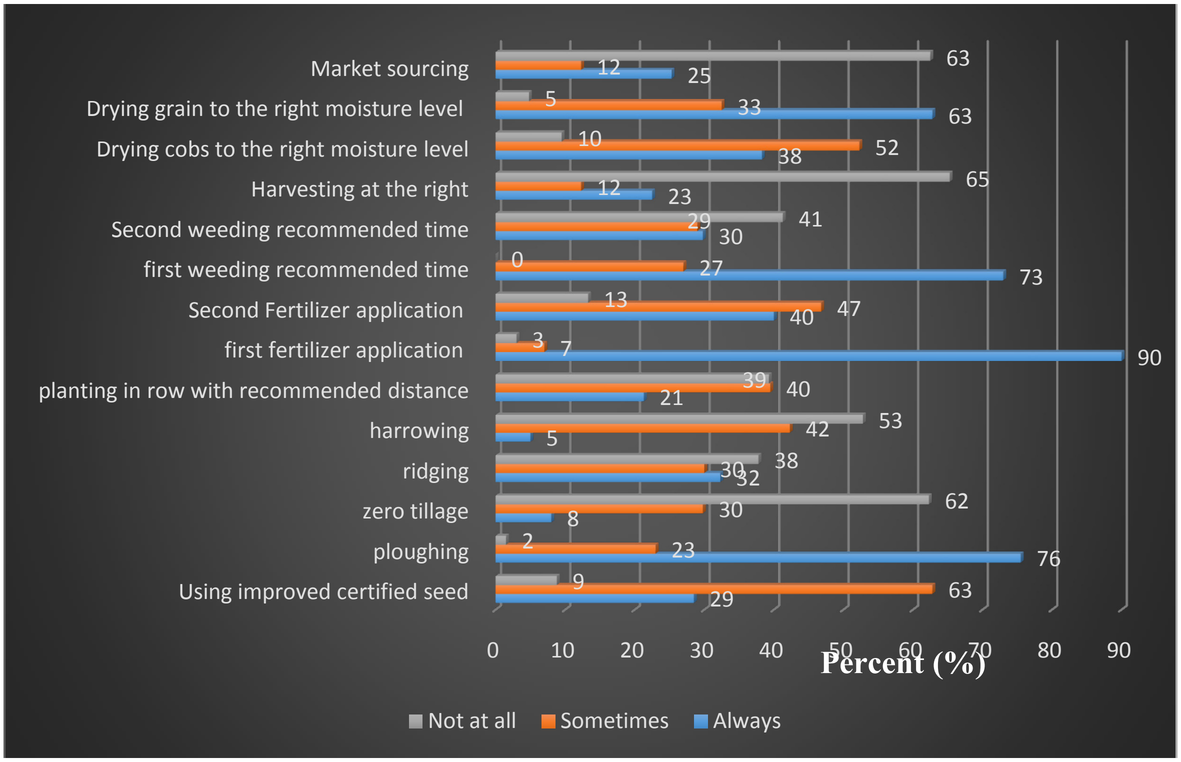

Figure 3. Bar graph showing distribution of usage of production recommendations
Source Analysis of Field Survey Data, 2016

Table 1. Distribution of adoption of various production recommendations

Recommendations	Number of Adopters	Percent (%)
Used of Improved certified seed	114	29
Ploughing	310	78
Ridging	139	35
Harrowing	28	7
Zero tillage	36	9
Planting in row with recommended planting distance	88	22
First fertilizer application at the recommended rate and time	361	90
Second Fertilizer	161	40
First weeding recommended time	294	74
Second weeding	122	31
Harvesting at the right	95	24
Drying cobs to the right moisture level	160	40
Drying grain to the right moisture level before bagging/storage	256	64
Market sourcing	101	25

Source Analysis of Field Survey Data, 2016

Number of Recommendations Adopted per respondents

Results from the analysis of the number of production recommendations adopted per respondent as shown in the figure 3, indicate that each one of the 400 farmers interviewed adopted at least three (3) production recommendations. As shown in the Figure 17% of the respondents adopted only three production recommendation, whiles 18% and 20% adopted four and five production recommendations respectively. Also 15% and 12% respectively adopted six and seven production recommendations.

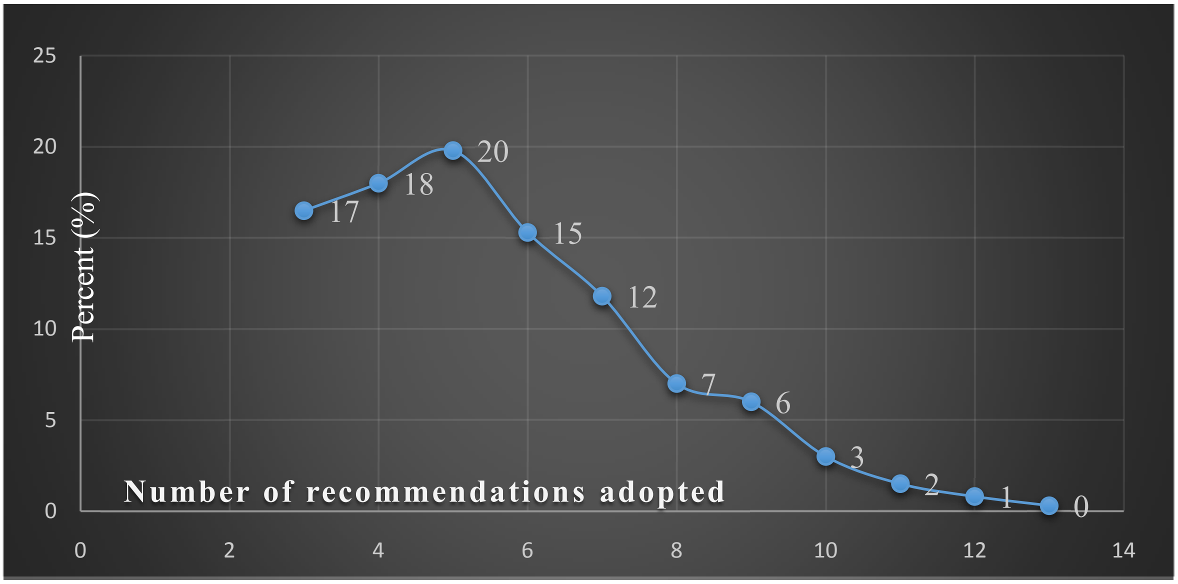

Figure 3. Scatter diagram of number of recommendations adopted
Source: Analysis of Field Survey Data, 2016

Level of Adoption

All the 400 farmers interviewed adopted at least three production recommendations. Implying none of the respondents could be described as non-adopter. However, there were wide variations of number of production recommendations adopted among respondents. Farmers who adopted more than half (at least eight) of the fourteen production recommendations in the package of improved maize technology were regarded as high adopters while those adopting less than half were classified as low adopters. Based on this criterion, about 44% of farmers were found to have adopted more than half of the production recommendations and as such were regarded as high adopters, while the reaming 56% adopted less than half of the production recommendation and as suchclassified as low adopters.

Thus, the majority (56%) of farmers in the district are still not applying most of the maize production recommendations disseminated to them. Salifu*et al.* (2015) found similar results regarding the adoption of improved maize varieties among farmers in the Wa Municipality of the Upper West region. Also,Singha and Baruah (2011) found that farmers were poor in adoption of recommendations of those relatively complex practices in nature such as seed treatment, application of manure and fertilizers and plant protection measures under different farming systems.

Analysis of the qualitative data gathered brought to fore some concerns farmers have about some of the production recommendations. In the view of farmers surveyed some of the production recommendations were complex, difficulty to adopt, too labour intensive, costly and time consuming. One participant at a focus group discussion expressed his feeling as '*the agriculture people think it is only maize that we grow, that why they want us to use all our labour and time to do planting in line, dip and buried of fertilizer application method among others*' (A participant at a FGD in Gore community). Another participant observed that '*if you don't go to school, you can't understand some of the things they are telling us to do'*(a participant at FGD in Zebilla….community).

Effect of level of adoption on yield

To access the effect of level of adoption on yield of maize, Analysis of Variance (ANOVA) was adopted to test the following hypothesis:

H_0: There is no significant difference between yield of high adopters and low adopters of improved maize technology.

H_a: There is significant difference between yield of high adopters and low adopters of improved maize technology.

Table 2a and 2b presents descriptive statistics and ANOVA table of yield of maize across level of adoption respectively. As shown in the Table 2a, the average yield of maize per acre of low adopters and high adopters respectively were 19.5 bags and 28.7bags. Thus farmers who adopted most of the production recommendations were producing about 9bags more per acre than those who adopted lesser production recommendation. It can therefore be argued that adopting more of the production recommendation brings more returns in terms of yield.

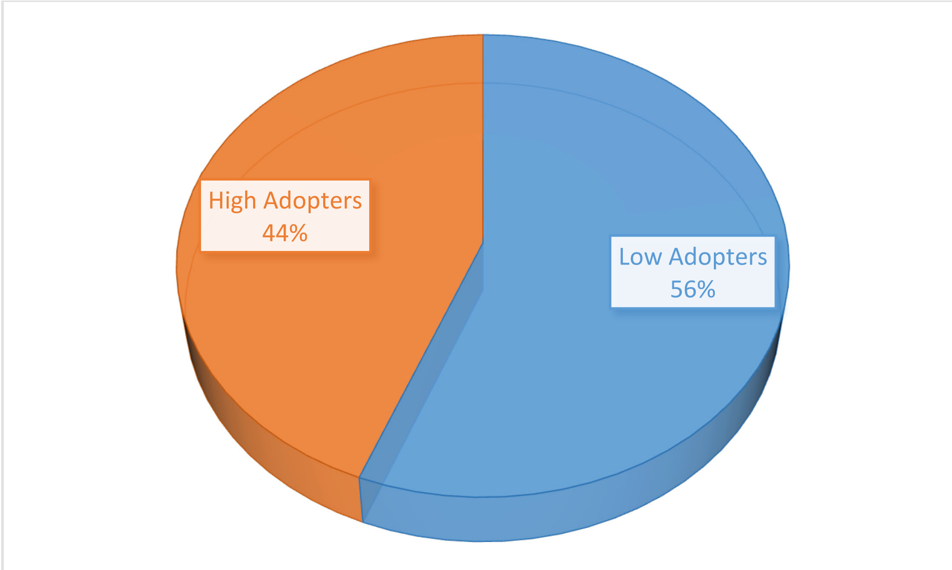

Figure 4: Pie Chart of level of adoption
Source: Analysis of field survey data, 2016

Table 2A. Descriptive statistics of yield across level of adoption

Level of Adoption	N	Mean	Std. Deviation	Minimum	Maximum
Low adopters	226	19.51	3.47	5.10	26.80
High adopters	174	28.70	4.02	11.60	32.81
Total	400	24.11	4.26	5.1	32.81

Source: Analysis of Field survey data, 2016

Table 2b. ANOVA table of yield of maize across level of adoption

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1732.381	1	1732.381	125.304	0.000
Within Groups	5502.518	398	13.825		
Total	7234.899	399			

Source: Analysis of Field survey data, 2016

Also as shown in the table 2b, the analysis of variance conducted with F = 123.304 (df = 1.398) established significant difference between average yield of high adopters and low adopters. This implies that the null hypothesis is rejected in favour of the alternative. Thus there is significant difference between yield of high adopters and low adopters of improved maize technology. As shown in the table 2a high adopters produced at an average yield of 28.7bags per acre compared with that of low adopters of 19.5bags per acres.

Determinants of yield of maize

In order to assess the effect of level of adoption on yield in a multivariate analysis, a doubled log production function was applied, with multiple linear regression model applied to analyse determinants of yield of maize. Descriptive statistics of the exploratory variables used in the model is shown in the Table 3.Also Table 4 presents the coefficients of the multiple regression analysis.

As shown in the Table 4 with F (14, 381) = 24.01 and Prob>F = 0, implies that the model is significant at less than 1% of significant. Also with adj R – Square of 0.54, indicates that about 54% of the variation in the yield of maize is jointly explained by the model.

Out of the fourteen (14) independent variables entered in the model, nine (9) variables, including level of adoption, were found to be significant determinants of yield. As shown in the Table 4, age, sex, household size, farm size of maize, farm size of other crops, credit access, labour, level of adoption and experience were found as significant determinants of yield. Only sex and farm size of other crops were found to be significant at 5%, while the remaining seven (7) variables were significant at 1%.

Also, as shown by the sign of the coefficients in table 4, only farm size of other crops and age of farmers were found to be negatively related to yield, while the remaining seven (7) variables were positively related to yield. Thus farmers who farm large acreage of other crops, part from maize, were more likely to have low yield. This is understandable, because, if a farmer cultivates many crops in different plots their time, labour and resource will be shared amongthem and that might affect the quality of agronomic practice he/she will undertake in the maize farm, and consequently yield of maize will be negatively affected. Also the negative relationship between age and yield implies that aged farmers were less likely to get high yield compared with younger ones.

However, sex is significant and positively related to yield, with an indication that male farmers were more likely to have higher yield compared with their female counterparts. Gender insensitive land tenure and access system in northern Ghana coupled with the fact that male have better access to extension and other agricultural services compared with female farmers. Such gender differentiated access to productive resource is bound to have negative effect on women farmers' productivity. Because of the male dominant in thecontrol of land tenure system, female farmers are usually given poor and infertile lands to cultivate and this definitely will have negative effect on yield.

Also household size and annual income are significant and positively related to yield. Thus larger household and household with more income were getting better yield than those smaller and poor households. These were expected because larger households will have large labour pool to draw from for their farm activities. Also high income household would be capable of obtaining the needed farm inputs such as tractor services and chemical fertilizer for their farms. Similarly, access to credit and labour were both significant and have positive effect on yield of maize. Thus respondents with access to credit were more likely to purchase recommended inputs such as chemical fertilizer and weedicide which guarantee improve and better yields.

Also level of adoption, measured as if 'high adopter = 1' or 'if low adopter =0' is significant and have positive effect on yield. Thus high adopters were found more likely to have higher yield compared with low adopters. This was anticipated because high adopters applied majority of the production recommendations disseminated, as part of the improved maize technology and as such are expected to produce efficiently and more productively.

Table 3. Descriptive Statistics of variable used in the model

Variable	Description	Mean	SD
Yield	Bags (mini bag) per acre	24.11	4.26
Level of adoption	Dummied as 1 if adopt more than half of the production recommendations and 0 otherwise	0.44	0.50
Age	In years	42.60	10.36
Sex	Dummied as 1 if male and 0 if female	0.75	0.43
Marital Status	Dummied as 1 if married and 0 otherwise	0.88	0.02
Literacy	Dummied as 1 if have can read and/or write and 0 otherwise	0.31	0.46
HH Size	Number of persons in a household	8.90	4.01
Member of FBO	Dummied as 1 if belongs to FBO and 0 otherwise	0.27	0.44
Experience	In years of farming maize	20.16	9.95
Farm Size of Maize	In acres	11.71	4.88
Farm Size Others	In acres	4.67	1.57
HH Annual Income	In GH C	9329.33	15773.86
Access to labour	Dummied as 1 if have full access to labour and 0 otherwise	0.49	0.50
Access to credit	Dummied as 1 if ever taken loan for farming and 0 otherwise	0.42	0.47
Extension contact	Number of extension visits received in a seasons	4.11	2.63

Table 4. Coefficient of multiple linear regression

Variables	Coefficient	Std. Err.	z
Age	-0.1050856***	0.0230451	-4.56
Gender	1.2765432**	0.64147900	1.99
Marital Status	0.0501912	0.1795776	0.28
Literacy	0.279645	0.3481293	-0.80
HH Size	0.6311119***	0.1669608	3.78
Member of FBO	0.1645739	0.3906754	0.42
Experience	0.1211668***	0.0232566	5.21
Farm Size of Maize	0.0492114**	0 .0201615	2.44
Farm Size Others	-0.1173383**	0.0471238	-2.49
HH Annual Income	0.1287453	0.7573252	0.17
HH Access to labour	2.2982176***	0.5847882	3.93
Access to credit	1.0213333***	0.2484667	4.11
Extension contact	0.0510123	0 .0446512	1.14
Level of Adoption	3.3296671****	0.6109481	5.45
_cons	2.46604	0.97162	2.54
Number of obs	395		
F(14, 381)	24.01		
Prob> F	0.000		
Adj R-squared	0.54		

Source: Analysis of Field survey data, 2016

4. Conclusion and recommendations

Less than half (44%) of the farmers surveyed have adopted majority of the fourteen (14) production recommendations in the improved maize technology package disseminated in the District. The study found significant relationship between level of adoption and yield of maize. It is therefore concluded that level of adoption of the improved maize technology significantly affect yield of maize. Farmers who adopted most of the production recommendations in the package of the improved maize technology were getting high yields and better productivity. Age, sex, household size, farm size of maize, farm size of other crops, access to credit access and labour, level of adoption and experience in maize production were found as significant determinants of yield. Education and training aimed at improving farmers understanding and skills regarding the practices of the production recommendations in the improved maize technology package should be strengthened and organized regularly by MOFA and other NGOs working to improve maize production in the District.Improving farmers' access to credit would assist in enabling them purchase and apply the recommended rate of inputs such as fertilizer and weedicide.

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