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# Adoption and compliance with Council for Scientific and Industrial Research recommended maize production practices in Ashanti region, Ghana

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## Abstract

**Purpose** – There is a huge gap between actual and achievable yields of maize which threatens household food security in Ghana. Low adoption of improved maize production technologies coupled with poor compliance with Council for Scientific and Industrial Research (CSIR) recommended maize production practices is identified as the cause of low yields. This study assessed farmers' compliance with CSIR recommended production practices and its effects on yield.

**Design/methodology/approach** – Using a structured questionnaire, a cross-sectional survey of 150 respondents were interviewed for the study. Descriptive statistics, awareness and compliance indices, probit model and Garret ranking technique were the methods of analysis employed in the study.

**Findings** – The results showed that farmers are highly aware, have adopted and hardly comply with standards of applications of CSIR recommended production practices. Farm size, age, educational level and female gender significantly influenced compliance with recommended production practices. Also, compliance with recommended production practices increase maize yield.

**Originality/value** – Policies aim at addressing yield gap in maize production should be targeted at improving farmers' level of compliance with production practices by addressing some constraints through farmer credit and subsidy programmes to help farmers increase their level of compliance. The fact that farmers have adopted recommended production practices does not necessarily mean they will have higher yields. The study generates important insights about how well farmers have been adhering to standards of adoption of recommended production practices.

**Keywords** Adoption, Compliance, Improve technology, Maize, Production practices, Yield

**Paper type** Research paper

## 1. Introduction

Maize is counted as one of the three cereal crops (others include rice and wheat), which are considered very important worldwide and widely distributed cereals in terms of cultivation (Frova *et al.*, 1999). It is an important staple crop in Ghana representing over half the total cereal production and grown in all the agro-ecological zones in the country (Akramov and Malek, 2012). Generally, maize is the most consumed staple food in Ghana with expanding production since 1965 (Morris *et al.*, 1999; MOFA, 2015a, b). Most of the maize produced in Ghana goes into food consumption and therefore it is arguably an important crop for food security with a 43.8 kg/head as its per capita consumption (Abdulai *et al.*, 2018). Maize is also a useful crop as it serves as feed for livestock and a primary material used in the production of several industrial products (Abayomi *et al.*, 2006). With a greater proportion of maize supply channelled to Ghana's food consumption, increasing its productivity is an important factor for meeting food security in the country (Wongnaa and Awunyo-Vitor, 2019).

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Despite the enormous contribution of maize to Ghana's economy, the average maize yield in Ghana is low and remains one of the lowest in the world, much lower than the average for Africa south of the Sahara (Yeboah, 2013; Ragasa *et al.*, 2014; Wongnaa and Awunyo-Vitor, 2019). For instance, land productivity is estimated at a third of its potential yield per hectare (OECD, 2008 cited in Wolter, 2008). In the year 2014, the International Food Policy Research Institute (IFPRI) and Ghana's Ministry of Food and Agriculture (MOFA) also estimated the average yields of maize under rain-fed conditions for smallholder maize farmers in Ghana to be 1.73 metric tonnes/ha and 1.92 metric tonnes/ha respectively (MOFA, 2015a, b; Andam *et al.*, 2017). Consequently, through spatial analysis, a reduction in maize production by 10% has been predicted in Ghana by 2050 if strategies are not devised to increase productivity, a situation which threatens Ghana's food security (Thornton *et al.*, 2009).

Poor compliance with recommended production practices is counted among the reasons for lower yield recorded in Ghana (WAB, 2008). This paper addresses four questions, viz. *Q1*: To what extent are OPVs farmers aware of the recommended production practices set by the CSIR and what production practices are adopted the farmers in the study area? *Q2*: To what extent do the farmers comply with the production practices and what factors influence farmers' compliance with these practices? *Q3*: Is there a yield gap between farmers who comply with these recommended practices and those who do not comply? and *Q4*: What are the major challenges farmers face in complying with recommended practices? Continuous use of traditional farming activities, soil infertility accompanied by inadequate use of chemical fertilizers, use of low yielding varieties, improper plant stands or spacing, wrong sowing date, harvesting of maize at an undesired moisture content for storage as well as poor weed, disease and pest control management seriously account for low maize yield achieved in Ghana (WAB, 2008; Aikins *et al.*, 2012; Issa *et al.*, 2016). Even in regions where there is high adoption of improved varieties, potential yields are hampered by poor compliance with management practices (Agyare *et al.*, 2014; Afful, 2015). For instance in Ghana, using data from nine of the former ten regions (i.e. apart from Greater Accra Region), on average, 270 kg of fertilizer is recommended to be applied per hectare which includes 47 kg nitrogen (N), 20 kg phosphorus (P) and 20 kg potassium (K), but maize farmers apply just about 50–60% of this recommendation by CSIR (probably due to some farmers' perception that their soils were already fertile and they did not need fertilizer) (Ragasa *et al.*, 2014). Therefore, in assisting maize farmers to increase productivity, the aim must not only target mere adoption of productivity-enhancing technologies, but emphasis must also be placed on compliance with recommended standards of adoption of technologies and practices (Awunyo-Vitor *et al.*, 2016).

The contributions of the present study are threefold. First, it provides information about farmers' level of compliance with recommended maize production practices which helps identify areas which when tackled, will effectively ensure better compliance. Second, the study establishes the relationship between compliance with recommended production practices and yield which allows government and stakeholders seeking to close the maize yield gap to consider compliance when devising their strategies. Third, assessing the challenges facing farmers' compliance with agronomic practices in maize production as suggested by CSIR will help the extension division of the Ministry of Food and Agriculture (MOFA) to know how to carry out their duties on the field by looking out for solutions to these challenges. The rest of the paper is organized as follows. The next section briefly discusses the literature on maize farmers' compliance with recommended production practices and its relation with yield. Section 3 presents the research methodology employed in the study. Section 4 presents the results and discussion. Finally, Section 5 presents the conclusions and policy recommendations.

## 2. Literature review

### *2.1 Importance of maize to Ghana's economy*

Cereals are the most consumed and widely cultivated arable crops in Ghana (Danso-Abbeam *et al.*, 2017). Accounting for 55% of all cereals produced, maize is Ghana's most important cereal (Angelucci, 2012). It is widely cultivated by most households in the country. The poultry and livestock industries also largely rely on maize for production since it serves as an important component of feed for livestock and poultry (Danso-Abbeam *et al.*, 2017). In addition, it is used in manufacturing other food products like starch, oil, syrup and flakes and maltodextrins (Danso-Abbeam *et al.*, 2017). It also serves as an important crop for food security because of its enormous consumption by most people in the country and also the fact that it occupies the largest area under crop cultivation in the country (MOFA, 2015a, b).

### *2.2 Yield gap and yield potential in maize production*

Yield gap, defined by Alam (2006), is the difference between potential and actual farm yield which is controllable through research, extension services and government interventions. Yield gap in maize production can be divided into three unique types (Tran, 2004; Mondal, 2011). The first, which was revealed by Tran (2004), can be assessed through the difference between the varietal potential yield and the experimental station trial yield. The second is the yield gap between experimental station and farm potential yield (Tittonell *et al.*, 2008) whereas the third type has to do with the yield gap between potential and achievable farm yields (Subedi and Ma, 2009) which mostly happen due to poor land management practices and compliance with production inputs (Tran, 2004). Potential yield refers to the maximum yield that can be achieved on farmers' fields when improved seeds are used and proper management practices are carried out (Afful, 2015). Yeboah (2013) emphasized the presence of yield gap among farmers and scientists yields in Ghana which required the attention of stakeholders in the maize industry to devise strategies aimed at bridging the gap. Example, according to MoFA (2011), in Ghana, maize grain average yield attained on the field is around 1.7 t/ha whiles the estimated attainable yield is about 6.0 t/ha. In addition, van Loon *et al.*, 2019 discovered maize average yield in Ghana to be only 20% of potential yield. Other relevant studies by FAOSTAT (2018) empirically demonstrated average yields of maize fluctuating between 1.2 and 1.9 metric tons per hectare, whiles their on-station and on-farm trials show achievable average yield of 4 and 2 metric tons per hectare respectively in Ghana.

FAO (2000) perceived four reasons for the existence of yield gaps in maize production, viz. biophysical (climate in area, soil type, accessibility to water, disease and pest), management (selection of varieties, source of seed, tillage practices and productivity of input), socio-economic status (household income, household size, knowledge and tradition) as well as institutional innovation advancement like market value and land tenure arrangements. According to Tran (2004), yield gap can be bridged by intensive research and extension activities related to crop management and effective policies as well as institutional aid that can increase farm input access.

### *2.3 Issues of compliance with production practices*

More than 30 improved varieties of maize were developed and released in Ghana between 1942 and 2014 (Ribeiro *et al.*, 2017). Despite the efforts made by agricultural extension personnel in helping to make these varieties available to farmers, maize productivity is still low (Ribeiro *et al.*, 2017; Yeboah, 2013; Ragasa *et al.*, 2014; Wongnaa and Awunyo-Vitor, 2019). The low productivity of maize could be linked to low adoption of productivity enhancing technologies like improved varieties, recommended production management practices, fertilizers, insecticides, pesticides, etc. (Ragasa *et al.*, 2013). Seasonal rainfall distribution is mostly characterized as the most limiting factor in rain-fed agriculture system. However, rainfall does not totally contribute to this problem because, even in growing seasons where there is adequate distribution of rainfall, yields are still constrained by soil infertility and poor compliance with recommended production practices (Sanchez, 2002). For instance, pesticides use is still not common among maize farmers as over 95% of maize farmers in Ghana do not use it (Wongnaa and Awunyo-Vitor, 2018).

### *2.4 Adoption of productivity enhancing technologies*

Timely access to the right information on any program can be a determining factor of adoption (D'Emden *et al.*, 2006). However, smallholder farmers may not be accessible to adequate information and outreach and might also not get the equipment or the needed training to adopt good practices (Prokopy *et al.*, 2014). Further assertion was made by Prokopy *et al.* (2014) that, the source of the information is essential in farmers' decision-making. According to the study, the family, dealers in farm chemicals and fertilizers, seeds and crop consultants, etc., constitute the key sources of information needed to take a decision on whether to adopt recommended agricultural production practices. Lubell and Fulton (2008) also identified networking between agencies, businesses and farmers as well as farmer-to-farmer communication as playing an important role in farmers' decision making process and therefore could influence adoption of productivity enhancing technologies. According to Rezvanfar *et al.* (2009), extension services contribute to the adoption process by delivering effective and timely information on production practices as well as new technologies to farmers. The study also added that proximity to extension agents increases rate of adoption.

### *2.5 Factors that affect farmer's decision to comply with a specific crop production practice*

Compliance among smallholder farmers is viewed as an individual farmer's decision. According to Ogola *et al.* (2015), a farmer's decision to comply with a practice can be explained as a function of the farmers' characteristics, characteristics of the farm and characteristics of the crop. The likelihood that a farmer will decide to comply with a particular recommendation is given by the probability that the satisfaction obtained from that alternative is higher than the satisfaction the farmer would receive from any other alternative and hence with a decision to comply or not, the farmer will prefer the alternative which maximizes his/her satisfaction (Chantalakhana, 1999). Factors including income generated from off-farm activities, capital availability, produce prices, price of purchased or hired land, educational status and training as well as availability of family labour also affect the decision of smallholder farmers to comply with recommended agricultural production practices (Ogola *et al.*, 2015).

### *2.6 Standards of applications of CSIR recommended production practices*

Poor performance in terms of productivity of maize yield has been attributed to drought during its early growth stages, low soil nutrient especially nitrogen and phosphorus as well as possible diseases and pests infestations. However, Adu *et al.* (2014) further mentioned some other factors contributing to the decline in maize production. Among this include poor farm management practices like inappropriate planting time, low plant populations, poor systems of weed control, lack of credit accessibility, poor processing and storage conditions leading to high post-harvest losses, low input use among maize farmers most especially fertilizer and improved seeds as well as bad fertilizer application practices. According to Adu *et al.* (2014), the recommended production practices for open pollinated maize varieties considered in this study include land preparation, planting, fertilizer application, weed management, pest and diseases control and harvesting.

The criteria of the various production practices to which farmers are to comply according to the CSIR are further briefed in Table 1.

Table 1.
CSIR specific recommendations on applications of the various production practices

| Production practice | Recommendation |
|---|---|
| Land Preparation | The use of tractors to till or plough the land, harrows to harrow the land before planting and Incorporation of organic manure into the soil before planting |
| Planting Date | Major season: late March–April and Minor season: July–August |
| Seed sowing depth | 3–5 cm depending on soil type |
| Seeding rate | Planting 1 seed per hill |
| Plant spacing | 75 × 25 or 70 × 30 |
| Type of fertiliser to use | Application of NPK and top dress with Urea or Sulphate of Ammonia |
| Time of fertiliser application | Apply NPK within first 10 days after planting and top dress at the $4^{th}$ to $6^{th}$ week |
| Fertilizer application rate and placement methods | 2 bags NPK and 1 bag of Urea or sulphate of Ammonia per acre for OPVs and 4 bags of NPK and 2 bags of Urea or Sulphate of Ammonia per acre for Hybrid varieties |
| Type of weedicides used | Weedicides approved by extension officers in my area |
| Volume of weedicide application | Volume prescribed by the product manufacturer or extension officers |
| Time of application | Prior to fertilizer application or few days after weed emergence |
| Pesticides to use | Type recommended by extension officers |
| Directions for application | As prescribed by the product manufacturer or extension officers |
| Maturity or time for harvesting | Harvesting with 75–90 days after planting |

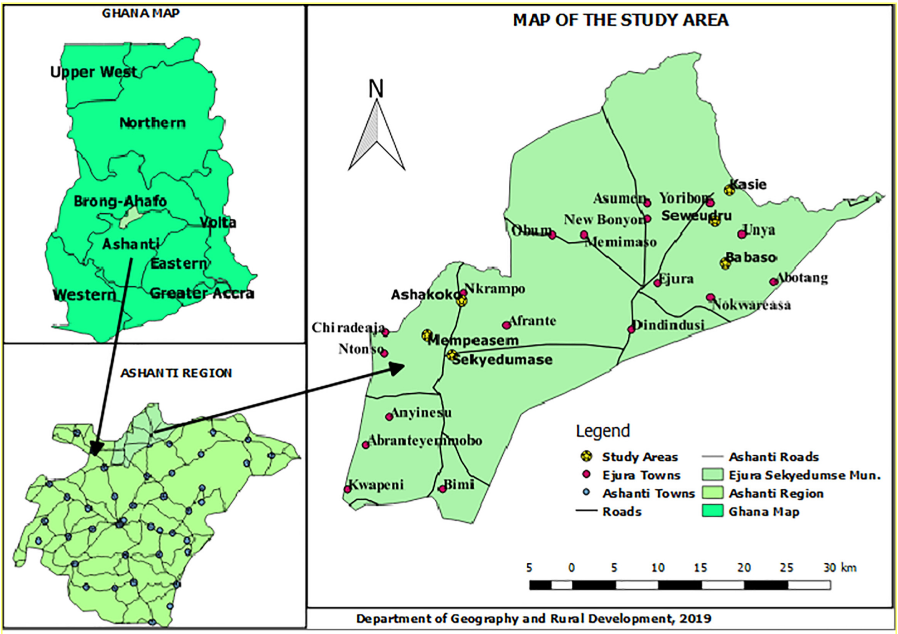
## 3. Methodology

### *3.1 Study area*

Ejura-Sekyedumase Municipality is among the 27 districts/municipalities within Ashanti region. It was established under legislative instrument 1400 (L. I. 1400) on November 29, 1988. It was created from Offinso and Sekyere districts. The location of the district can be traced between Latitude 7°9' N and 7°36'N and Longitude 1°5'W and 1°39' W. The land area is large to about 1340.1 square kilometres and occupies approximately 7.3% of entire Ashanti region. Estimated population of the municipality according to 2010 Population and Housing Census (PHC) is 85,446, representing 1.8% of population in the entire region. About 50.2% constitute males, whereas 49.8% represent females. The municipality's vegetation type to a large extent is determined by the climatic conditions and topography in the area. The vegetation to the north side of the municipality is characterized by sparse derived deciduous forest vegetation. The common species of grass in the district include *Beckeropsis, Andropagon*, *Rottbela* and *Plasmodium*. Some common trees easily found include *Damella, lophira*, *Butyrospermum* and *vitex*. The topography and climatic conditions of the area give a favourable condition for food crops cultivation. There are two main rainfall patterns in the municipality viz. the bimodal pattern usually experienced in the south and the unimodal pattern usually experienced in the north. The actual rainy season is mostly observed between April and November. Rainfall varies annually between 1,200 and 1,500 mm with extremely high relative humidity during rainy season; 90% mostly recorded in its peak in June and 55% recorded in February. The Municipality experiences intense solar radiation during dry season. The northeast trade wind is also a character in the area which annually blows very dry and dusty winds in all parts of the municipality during the dry period. High temperature with monthly average of 21–30 °C is ideally experienced. Due to the harsh weather and intense radiation, maize production is not a year-round activity as it is done at predetermined time periods where the weather records low temperatures. Plants may suffer from heat stress leading to crop loss if the appropriate planting period is not observed by farmers. The warmest months are January to April and July to August are months usually recorded as the coolest. The most dominant income generating activity is agriculture, which employs almost 60% of households. Trading, some institutional workers, manufacturing and professionals (mainly teachers) are next to agriculture as the source of income to households in the municipality. The Agriculture sector is characterized with both crop and livestock production. In the municipality, different types of crops are grown. The dominant ones include maize, rice, groundnuts, cassava, yam, beans, etc. Crops are mostly grown for purposes of subsistence. Nevertheless, crops like maize, watermelon and beans are mostly under commercial production. The municipality is also characterized by different tribes with Akan ethnic group being the largest ethnic group. Some of the tribes include Dagombas, Dagaatis, Hausa, Grumas, Nchumurus, Kotokolis and Konkomba. Figure 1 presents the map of the study area.

### *3.2 Data collection*

Open pollinated maize varieties are cultivated in Ghana. However, it was observed that four varieties are cultivated predominantly in the study areas. For the purpose of this study, four varieties, viz. Obatanpa, Okomasa, Omankwa and Abontem, which were part of those considered by Ragasa *et al.* (2014) were selected. Farm-level primary data was collected from 150 smallholder open pollinated maize farmers using structured questionnaire. The study employed a multistage sampling technique for selecting the smallholders for interview which involved three stages. The Ejura-Sekyedumase district was selected due to the district's massive involvement in the regional as well as nationwide maize production, processing and export. Stage one involved random selection of three operational areas under MOFA operating zones in the area. All the names of zones were written on small pieces of papers separately and folded into a box. The box containing the folded papers was vigorously shaken and three was drawn out randomly from the box. Randomly selected zones were zone B, C and D which were Ejura zone, Babaso zone and Kasei zone respectively and this constituted stage one. Stage two involved random




**Source(s):** Department of geography and rural development (KNUST), 2019

**Figure 1.** Map of Ejura-Sekyedumase municipality

selection of two communities from each zone totalling six communities. These communities were Babaso, Kasei, Sekyedumase, Ashakoko, Mempeasem and Moshie Kura. Twenty-five farmers were interviewed in each community using simple random sampling technique in stage three. Both primary and secondary data were used in the study. In gathering information as a guide to the study, two agriculture-based offices were contacted for guidelines for the methods of data collection which include the maize department under the crops research institute in Fumesua (CSIR-CRI) and the Ministry of Food and Agriculture in the Ejura district (MoFA). At the crops Research institute, relevant information which include general overview of both open pollinated varieties and hybrid maize varieties as well as selection of study area and recommended production guide for maize were sourced while information such as maize production zones, number of OPVs farmers in each village under specific zones, provision of guidelines for questionnaire development and assisting in contacting farmers were gathered from the head office of Ministry of Food and Agriculture in the Ejura. Primary data was collected through face-to-face interviews using structured questionnaires. Data on characteristics of farmers such as age, gender, farming experience, educational level as well as other variables such as level of awareness and compliance, constraints to compliance were collected. Written documents such as research and analytical reports, journals among other publications were used to obtain data to support the findings of the current study. Questionnaires were developed for the collection of primary data from farmers. It included close and open-ended questions. Semi-structured interviews were conducted at the reconnaissance stage to help in the preparation of the structured questionnaire which will be used for the actual data collection for the study.

*3.3 Methods of data analysis*

Descriptive statistics, which include percentages and mean scores, were used to give a brief summary of socio-economic characteristics and adoption of recommended production practices. Also, a 3-point Likert scale was used to determine farmers' perception on awareness and compliance to recommended production practices set up for the study. The mean score $X$ of a perception statement on the Likert scale was computed as:

$$X = \frac{\{1(F1) + 2(F2) + 3(F3) + 4(F) + \ldots + n(Fn)\}}{N} \tag{1}$$

where $X$ is the weighted mean for each perception question or statement, $F$ is the frequency of respondents who chose a particular statement as 1,2 or 3, $N$ is sample size. The perception indices for awareness and compliance were therefore computed as:

$$\text{Perception index} = \frac{\sum X_i}{n} \tag{2}$$

where $n$ is the number of statements provided for each respondent. The 3-point Likert scale takes a ranked value of 1 if a respondent does not agree to a perception statement, 2 if less agree and 3 if highly agree.

The probit model was employed in analysing the factors influencing farmers' compliance with recommended practices. This is because, with the dichotomous nature of the dependent variable, a qualitative binary response model such as probit or logit is suitable as they give similar results. The probit model (Hosu *et al.*, 2015) is explicitly expressed as:

$$Z = Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + \varepsilon_i \tag{3}$$

where $Z = Y_i$ is the dichotomous dependent variable measured as a dummy (1 for compliance and 0 for no compliance), $\beta_0$ is the constant term, $\beta_1 - \beta_n$ are the regression coefficients,

$X_1 - X_n$ are the independent variables and $\varepsilon_i$ is the error term. Also, $f(Z)$ is the cumulative standardized normal distribution, given the probability of compliance ($P_i$). That is,

$$Z: \quad P_i = F(Z) \tag{4}$$

According to Hosu *et al.* (2015), estimates of the probit model require a definition of a variable $Z$, which is a linear function of variables that determine the probability. The probit model was employed because its outcome is confined to values 0 and 1, and also considers values from negative infinity to positive infinity. It was also used because, whether a coefficient has a negative or positive influence, it does not affect the probability in an increase or a decrease manner (Schroeter *et al.*, 2007; Wongnaa and Awunyo-Vitor, 2013). The relationship between an explanatory variable and the dependent variable is explained using the marginal effect which measures the partial change in the likelihood of compliance. The estimates of the parameters are obtained using the method of maximum likelihood and the marginal effect is given by:

$$\frac{\partial P_i}{\partial X_i} = \frac{dP_i}{dZ} \cdot \frac{\partial Z}{\partial X_i} = f(Z)\beta_i \tag{5}$$

Factors such as age of respondents, years of formal education, size of farm, years in farming activities and gender were the principal factors tested in the probit analysis. Following Wongnaa and Awunyo-Vitor (2013) on their study on the factors affecting loan repayment performance among yam farmers, the empirical model is specified as:

$$COMPL = \beta_0 + \beta_1 AGE + \beta_2 EDU + \beta_2 FSZ + \beta_2 SEX + \beta_2 EDU + FEXP + \varepsilon_i \tag{6}$$

where

*COMPL* = Whether or not a farmer was able to comply with recommended production practices (measured as a dummy, 1 for able to comply and 0 for not able to comply). This represents the dependent variable.

*AGE* = Age of farmer (in years),

*EDU* = Years in formal education,

*FSZ* = Size of farm,

*SEX* = Sex of farmer,

*FEXP* = Farming number years in maize production

$\varepsilon_i$ = Error term.

Yield gap analysis was carried on Obatanpa maize variety since it is the dominant variety among the respondents. When the test assumptions are met, the most suitable test for comparing two different mean samples is the independent sample $t$-test (Sawilowsky and Blair, 1992). This is given as:

$$t = \frac{x - \mu}{\sqrt{\frac{s^2}{n}}} \tag{7}$$

where:

$x$ is the sample mean, $S^2$ is the sample variance, $n$ is the sample size, $\mu$ is the specified population mean, $t$ is student $t$ quantile with $n$-1 degrees of freedom. In this analysis, the significance of the yield gap between farmers who comply with recommended production practices and those who do not comply was tested using Eqn (7). In categorization of farmers into complied and non-comply groups, farmers who fall under less complied and highly complied groups were all classified as complied group denoting a scale of (1) whereas those who fall under no comply group were classified as no comply denoting a scale of (0).

Finally, in analysing the constraints maize farmers face in complying with the recommended production practices in the municipality, the farmers were asked to rank the constraints in order of their severity to their maize farming businesses. By this ranking, one meant most severe and *n*, which is the last constraint, meant least severe. The order of merit assigned by the respondent was analysed using the garret ranking technique where the total score obtained from the respondent based on their perception of the constraints were divided by the total respondents to give their respective means. The garret ranking formula is given by:

$$\text{Percent position} = \frac{100 \times (R_{ij} - 0.5)}{N_j}$$

where,

$R_{ij}$ = Rank given to *i*th constraint by the *jth* individual and $N_j$ = Number of constraints ranked by the *jth* individual. Finally, the Garret's table is used to convert the estimated per cent positions into scores. Estimated mean score values for each factor was set in a descending order of magnitude. Constraints that recorded the highest mean value was ranked the most important constraint limiting OPV farmers ability to comply with the recommended production practices suggested by CSIR and the others followed in that order and this order is followed up to the least limiting constraint. Factors considered in this study include labour requirement for compliance, financial constraints, access to inputs, cost of inputs, access to extension services and owning multiple farms.

## 4. Results and discussion

### *4.1 Socioeconomic characteristics of respondents*

Tables 2 and 3 describe the socioeconomic characteristics of maize farmers. The results show that maize production in the study area is dominated by males (68.7%). However, the results also imply the potential of females succeeding in maize production. The dominance of males in maize production in the study area is expected as it has been reported in previous similar studies (Kuwornu *et al.*, 2013; Addai and Owusu, 2014; Wongnaa *et al.*, 2018). From analysis, the minimum and maximum ages of respondents are 15 and 72 years respectively with 41 years being the mean age. This shows that, maize farming in the district is done by matured people above youthful age as defined, youth is age group between 15 and 35 years (Ghana's national youth policy, 2010). Also, as earlier stated by Agyare *et al.* (2014), "the youths are not interested in farming". Majority of the respondents (56%) had no formal education and this could have a negative effect on compliance with recommended maize production practices by

**Table 2.** Descriptive statistics of relevant variables

| Variable | Max | Min | Mean | Std dev |
|---|---|---|---|---|
| Age of farmer (years) | 72 | 15 | 41 | 13.43 |
| Number of years spent in formal education | 18 | 3 | 10 | 3.63 |
| Farming experience (in years) | 59 | 1 | 16 | 13.27 |
| Farm size (hectares) | 21.20 | 0.2 | 2.74 | 2.54 |
| Number of bags harvested by farmer during the major season | 15.00 | 2.00 | 7.96 | 3.24 |
| Number of bags harvested by farmer during the minor season | 14.00 | 1.50 | 7.34 | 3.14 |
| Weight per bag in kg in the major season | 150.00 | 110.00 | 129.39 | 9.21 |
| Weight per bag in kg in the major season | 150.00 | 110.00 | 128.80 | 9.23 |

**Source(s)**: Field survey, 2019

| Variable | Frequency | Percentage |
|---|---|---|
| *Gender* | | |
| Male | 103 | 68.7 |
| Female | 47 | 31.3 |
| *Formal education status* | | |
| Formal education | 66 | 44 |
| No formal education | 84 | 56 |
| *Level of formal education attained* | | |
| Primary | 16 | 24.2 |
| Junior high school | 23 | 34.8 |
| Senior high school | 22 | 33.3 |
| Tertiary education | 5 | 7.6 |
| *Maize varietal distribution* | | |
| Obatanpa | 92 | 61.3 |
| Okomasa | 41 | 27.3 |
| Omankwa | 11 | 7.3 |
| Abontem | 6 | 4 |
| *Other off-farm income-generating activities* | | |
| Trading | 32 | 45.1 |
| Forestry | 5 | 7 |
| Services | 11 | 15.5 |
| Vocational | 19 | 26.8 |
| Other activities | 4 | 5.6 |

**Source(s)**: Field survey, 2019

**Table 3.** Other demographic characteristics of respondents

such farmers. For those who had formal education, majority (75.1%) had at least junior high school education. This compares well with similar results reported by Wongnaa *et al.* (2019). On average, a farmer had 16 years of farming experience. Similar to the findings of previous studies (Awunyo-Vitor *et al.*, 2016), generally, farm sizes were small averaging 2.74 ha. For the varieties cultivated by farmers in the study area, 61.3% of the famers cultivated Obatanpa, 27.3% cultivated Okomasa, 7.3% Omankwa and 4% cultivated Abontem.

### *4.2 Farmers' awareness of CSIR-CRI recommended practices*

Table 4 presents the levels of awareness of the recommended maize production practices by the respondents. The table also presents the average perception of the farmers about the recommended production practices. Following Lambrecht *et al.* (2014), the first condition that will influence a farmer to try a new technology is by creating the farmer's awareness of the existence of the new technology. The perception index for awareness was 2.79, suggesting the farmers were strongly aware of the recommended practices set up by CSIR-CRI.

Information diffusion and supply about a new technology and the intensity and type of campaign of the information is very important for speeding the rate of awareness of the technology (Lambrecht *et al.*, 2014). This is achieved through agriculture programmes sponsored on radio stations by the Ministry of Food and Agriculture in the study zone. The results imply that the extension services delivered in the study area is very effective in reaching out to farmers.

### *4.3 Adoption of recommended maize production practices*

In Table 5, we present the adoption of the various recommended production practices for successful maize production. The results show that most of the production practices

**Table 4.**
Farmers level of awareness of CSIR-CRI recommended practices

| Recommended practices | Not aware 1 | Less aware 2 | Highly aware 3 | Mean score |
|---|---|---|---|---|
| There is existence of ploughing activities | 0(0) | 0(0) | 150(100) | 3.00 |
| There is existence of land forming activities such as harrowing | 15(10) | 0(0) | 135(90) | 2.80 |
| In the major season, seeds are planted within late March to April | 0(0) | 4(2.7) | 146(97.3) | 2.97 |
| In the minor season, seeds are planted within July and August | 0(0) | 5(3.3) | 145(96.7) | 2.97 |
| The recommended planting depth is 3–5 depending on the soil type | 62(41.3) | 36(24) | 52(34.7) | 1.93 |
| It is recommended to, plant one seed per hill with both open pollinated and hybrid varieties | 76(50.7) | 16(10.7) | 58(38.7) | 1.88 |
| It is recommended to plant in rows | 2(1.3) | 1(0.7) | 147(98) | 2.97 |
| It is recommended to fill vacancies as soon as seedling emerges | 0(0) | 2(1.3) | 148(98.7) | 2.99 |
| A planting distance of 75 × 25 or 70 × 30 should be practiced | 4(2.7) | 46(30.7) | 100(66.7) | 2.64 |
| The application of chemical fertilisers such as NPK, Urea or Sulphate of Ammonia is recommended | 0(0) | 0(0) | 150(100) | 2.97 |
| Application of 2 bags of NPK per hectare within the first 10 days after planting and top dressing with 1 bag per hectare of urea or sulphate of ammonia at the 4th to 6th week of planting | 16(10.7) | 42(28) | 92(61.3) | 2.51 |
| In the entire production period, only two types of fertiliser applications are required | 3(2) | 17(11.3) | 130(86.7) | 2.85 |
| The recommended methods of fertiliser placement such as side and ring placement | 0(0) | 1(0.7) | 149(99.3) | 2.99 |
| There are chemical weed control methods | 0(0) | 0(0) | 150(100) | 3.00 |
| There are prescribed volumes of weedicide to use | 1(0.7) | 1(0.7) | 148(98.7) | 2.98 |
| All weeds should be cleared prior to fertiliser application | 0(0) | 1(0.7) | 149(99.3) | 2.99 |
| The best time to control weeds is between the 4th and 6th week after planting | 14(9.3) | 49(32.7) | 87(58) | 2.49 |
| There is existence of Chemical method of controlling pests and diseases | 0(0) | 2(1.3) | 148(98.7) | 2.99 |
| There is a prescribed volume of chemical to mix each knapsack fills | 1(0.7) | 1(0.7) | 148(98.7) | 2.98 |
| The best time to control disease and pest is immediately after signs and symptoms are observed | 0(0) | 1(0.7) | 149(99.3) | 2.99 |
| The time period for harvesting is 75–90 days after planting | 18(12) | 23(15.3) | 109(72.7) | 2.61 |
| Total awareness perception index | | | | 2.79 |

**Source(s)**: Field survey, 2019

considered in the study were adopted by farmers in the municipality. Practices such as harrowing, manuring, depth of seed placement and planting one seed per hole were however poorly adopted. This compares well with Kelly (2006) that there is low adoption of some recommended agricultural production practices in Sub-Saharan Africa countries. Various factors, comprising biophysical, farm-household, socio-economic and institutional characteristics were identified in most literatures to have some positive impact on technology adoption in Ghana (Lambrecht *et al.*, 2014; Wongnaa *et al.*, 2018). Also decision making in technology adoption is poorly understood by most farmers (Doss, 2006). In addition, adoption cannot gain success without first creating farmers' awareness about the new technology. This was emphasised by Asuming-Brempong *et al.* (2011) that, there will be

| Production practice | Freq not adopted | % Not adopted | Freq adopted | % Adopted | Adoption |
|---|---|---|---|---|---|
| The practice of tillage activities such as ploughing | 20 | 13.3 | 130 | 86.7 | Adopted |
| The practice of land forming activities such as harrowing | 134 | 89.3 | 16 | 10.7 | Not adopted |
| The practice of land improvement activities such as manuring and composting | 135 | 90 | 15 | 10 | Not adopted |
| The practice of row planting | 2 | 1.3 | 148 | 98.7 | Adopted |
| Planting in major season, late March–April and Minor season, July–August | 14 | 9.3 | 136 | 90.7 | Adopted |
| Sowing at a depth of 3–5 depending on the type of soil | 124 | 82.7 | 26 | 17.3 | Not adopted |
| Planting at a rate of one seed per hill | 122 | 81.3 | 28 | 18.7 | Not adopted |
| Planting at a spacing of 75 × 25 cm or 70 × 30 cm | 44 | 29.3 | 106 | 70.7 | Adopted |
| The practice of filling of vacancies immediately after seedling emergence | 5 | 3.3 | 145 | 96.7 | Adopted |
| The practice of fertilizer application including top dressing | 1 | 0.7 | 149 | 99.3 | Adopted |
| Method of fertilizer placement | 3 | 2 | 147 | 98 | Adopted |
| The use of chemical means of controlling weeds | 12 | 8 | 138 | 92 | Adopted |
| The use of chemical means of controlling diseases | 18 | 12 | 132 | 88 | Adopted |
| The use of chemical means of controlling pests | 24 | 16 | 126 | 84 | Adopted |
| Harvesting within 75–90 days after planting | 54 | 36 | 96 | 64 | Adopted |

**Source(s)**: Field survey, 2019

**Table 5.** Adoption of recommended practices by CSIR-CRI

a strong increase in the rate of adoption of new technologies if awareness of the technology is created.

### *4.4 Compliance with recommended production practices*

Table 6 presents farmers' compliance with the recommended maize production practices. The mean compliance scores of individual recommended practices are also presented. As indicated in the table below, compliance levels are categorized into scales of no compliance (0–1), less compliance (1–2) and high compliance (2–3). The results show that the overall compliance index for the study was 1.99, indicating that, in general, there was less compliance with recommended production practices among the farmers. The implication is that, though farmers make use of recommended production practices, they do not strictly obey the rules governing their application. This result is in connection with that of Afful (2015) which reported that genetic yield gains in maize production are dampened with bad production practices even in areas with high adoption of technologies as fertilizer and other practices use remained limited. Also, Issa *et al.* (2016) observed that, notwithstanding the introduction of improved maize varieties, there is still low production due to inability of farmers to comply with recommended production practices. Added to this is in partial support with Sanchez (2002) which reported that maize yield is restricted by soil infertility and poor compliance with key production practices.

| Recommended practices | 0–1 No comply | 1–2 Less comply | 2–3 Highly comply | Mean score |
|---|---|---|---|---|
| The use of tractors to till or plough the land | 22(14.7) | 2(1.3) | 126(84) | 2.69 |
| The use of harrows to harrow the land before planting | 135(90) | 3(2) | 12(8) | 1.18 |
| Incorporating organic manure into the soil before planting | 132(88) | 10(6.7) | 8(5.3) | 1.17 |
| Planting date (major season: late March–April and Minor season: July–August) | 9(6) | 52(34.7) | 89(59.3) | 2.53 |
| Depth of sowing (3–5 depending on soil type) | 119(79.3) | 25(16.7) | 6(4) | 1.25 |
| Seed rate (Planting 1 seed per hill) | 123(82) | 7(4.7) | 20(13.3) | 1.31 |
| Plant spacing (75 × 25 or 70 × 30 ) | 43(28.7) | 59(39.3) | 48(32) | 2.03 |
| Type of fertiliser used (Application of NPK and top dress with Urea or Sulphate of Ammonia) | 19(12.7) | 52(34.7) | 79(52.7) | 2.40 |
| Time of application (Apply NPK within first 10 days after planting and top dress at the 4th to 6th week) | 47(31.3) | 77(51.3) | 26(17.3) | 1.86 |
| Frequency of application (Apply Once for NPK and Urea or Sulphate of Ammonia) | 29(19.3) | 37(24.7) | 84(56) | 2.37 |
| Rate of application (2 bags NPK and 1 bag of Urea or sulphate of Ammonia per acre for OPVs and 4 bags of NPK and 2 bags of Urea or Sulphate of Ammonia per acre for Hybrid varieties) | 61(40.7) | 68(45.3) | 21(14) | 1.73 |
| Method of placement (Method approved by extension officers in my area) | 19(12.7) | 41(27.3) | 90(60) | 2.47 |
| Type of weedicide used (weedicides approved by extension officers in my area) | 24(16) | 51(34) | 75(50) | 2.34 |
| Volume of application (volume prescribed by the product manufacturer or extension officers) | 47(31.3) | 73(48.7) | 30(20) | 1.89 |
| Time of application (Prior to fertilizer application or few days after weed emergence) | 26(17.3) | 59(39.3) | 65(43.3) | 2.26 |
| Type of pesticide (Type recommended by extension officers) | 43(28.7) | 42(28) | 65(43.3) | 2.15 |
| Volume to apply (As prescribed by the product manufacturer or extension officers) | 56(37.3) | 61(40.7) | 33(22) | 1.85 |
| Time of harvesting (Harvesting with 75–90 days after planting) | 54(36) | 71(47.3) | 25(16.7) | 1.81 |
| Regular visit to the farm and taking immediate actions to problems during production period | 17(11.3) | 51(34) | 82(54.7) | 2.43 |
| Total compliance index | | | | 1.99 |

**Source(s)**: Field survey, 2019

**Table 6.**
Farmers' compliance with recommended production practices

The estimated coefficients of the probit model, along with the levels of significance and marginal effects are shown in Table 7. The results present the factors influencing farmers' compliance with the recommended maize production technologies. Characteristics of farmers such as farm size, age of farmer, years in formal education and gender (female) were the principal factors found to have positive significant influence on farmers' compliance with recommended maize production practices. The coefficients and marginal effects of variables representing farm size, years in education, age and gender (female) are positive for compliance and are all significant at 10, 5, 5 and 1% respectively. The marginal effects show that, an increase in farm size by a one acre has the tendency to increase compliance by 2.2%. The positive effect on farm size on compliance is on the premise that, maize farmers with large farm sizes have already assumed some risk and therefore, will do the best they can to maximize yields. As explained by Abdu (2019), as farm size increases, farmers stand the chance of gaining more profit because they are able to produce more for the market and this gives them the financial strength to purchase inputs such as fertilizer, chemicals and other farm inputs necessary for production.

Also, a unit increase in education has the tendency to cause an increase in compliance by 4.8%. The positive effect of education on compliance could be due to the fact that, farmers with some appreciable level of formal education, can read and understand new technologies, hence they are able to use inputs as at when and how they are to be used. The results of this study corroborate the findings of some previous studies. For instance, Nkonya *et al.* (1997) reported a positive influence of education on adoption and the extent of adoption of genetically modified maize seed.

The marginal effects have also revealed that, an increase in farmer's age will increase the likelihood of compliance by 0.1%. The positive effect of age on compliance could be due to the fact that, as farmers become old, they become resource constrained and would like to produce the best out of the limited resources. Also, being a female farmer will increase the probability of compliance by 44.4%. The positive effect of gender (females) on compliance could be the fact that females are more "instruction-takers" than their male counterparts and hence, they obey more instructions from extension officers than their males. A similar study relating to compliance with loan repayment by Wongnaa and Awunyo-Vitor (2013) reported that females will more likely have loan repayment ability than males. Ragasa *et al.* (2013) and Mulwa *et al.* (2017) also identified female gender to have a positive and significant effect on adoption of improved agricultural technologies. Further explanation came up that, this could be due to the fact that females are more discipline as compared to males and will comply with all the rules governing production resources made available to them.

*4.5 The yield gap in maize production*

The results on the analysis of the yield gap between the comply and non-comply group of farmers indicated that, there is a yield gap of approximately 0.579 tons/ha between the two groups (Table 8) and this was found to be significant at the 5% level. The null hypothesis

| Variable | Coefficient | Robust standard error | *Z* | Marginal effect (dy dx) | *p* > *Z* |
|---|---|---|---|---|---|
| Farm size | 0.067* | 0.038 | 1.83 | 0.022 | 0.067 |
| Farming experience | 0.006 | 0.024 | 0.23 | 0.002 | 0.816 |
| Years in education | 0.151** | 0.063 | 2.40 | 0.048 | 0.016 |
| Age | 0.002** | 0.019 | 0.08 | 0.001 | 0.016 |
| Gender (female) | 1.587*** | 0.520 | 3.05 | 0.444 | 0.002 |
| Constant | −2.275 | 0.886 | −2.57 | | 0.010 |

**Note(s):** (***) Indicates significance at the 1% level. (**) Indicates significance at the 5% level (*) indicates significance at the 10% level
**Source(s):** Field survey, 2019

**Table 7.** Factors affecting farmers' compliance with recommended production practices

| Compliance groups | *N* (%) | Mean | SD | Mean difference | Std. error difference | Significance level | *t*-value |
|---|---|---|---|---|---|---|---|
| No compliance | 53 (35.33) | 5.3868 | 3.22452 | 3.98434 | 0.41865 | 0.014** | −9.517 |
| Compliance | 97 (64.67) | 9.3711 | 2.81854 | | | | |

**Source(s)**: Field survey, 2019
(**) Indicates significance at the 5% level

**Table 8.** The yield gap between the complied and non-complied groups of Obatanpa maize variety farmers

which suggested a no significant difference in the farmer groups in terms of yield was therefore rejected.

Note that, the mean difference in the table above is estimated on bags per hectare of land cultivated. Converting these bags to tons based on USAID feed for the future standard (1 bag = 132 kg for the size four bag) gives 3.98434 (0.0011 × 132) = 0.579. Thus, on average, a farmer who does not comply with the recommended production practices stand a risk of losing 0.579 tonnes of maize per hectare of Obatanpa cultivated.

*4.6 Constraints to compliance with CSIR recommended production practices*

According to the results from the garret ranking technique (Table 9), the first three most limiting factors were lack or inadequate finance, cost of inputs and labour-intensive nature of some of the recommended maize production practices. This result is consistent with Yeboah (2013) who mentioned that, in Ghana, yield increase is limited with low education among farmers leading to low technology adoption, high fertilizer cost, inadequate inputs availability and credits. This could be due to the fact that, the small-scale nature of farms in the municipality has made it very difficult for farmers to secure credits to finance their maize farming business. Due to financial difficulties faced by farmers, they are unable to hire machinery to undertake farming operations, and hence farmers are forced to use their manual power in some instances which limit their ability to comply with some practices due to stress and some other limitations associated with the use of manual power. This result is in line with that of ISSER (2009), which reported that, the relatively high agricultural inputs cost and difficulty in accessing credit make it cumbersome for poor small-scale farmers to purchase inputs. As a result, most farmers apply fertilizer to some preferred crops which include rice, maize and vegetables and in instances where fertilizer is applied, the recommended rate of application is seldom used (UNEP-GEF Volta Project, 2010). Extension services was ranked the least severe constraint due to the active extension works and guidance in the farming communities and also through the formation of farmer groups which is headed by extension officers to help pass information relating to improvements in technologies to farmers within the shortest possible time.

## 5. Conclusion and recommendations

There is a huge gap between actual and achievable yields of maize which threaten household food security in Ghana. Low adoption of improved maize production technologies coupled with poor compliance with recommended applications are identified as the cause of low yields. This study assessed farmers' compliance with recommended production practices and its effects on yield. Generally, it can be concluded from the empirical results that, maize farmers are aware of recommended production practices. The survey showed that most of the production practices are adopted. However, the results revealed that most farmers do not

**Table 9.** Constraints to complying with recommended production practices

| Constraint | Total score | Mean score | Rank |
|---|---|---|---|
| Financial constraint | 11006 | 73.37 | 1st |
| Cost of inputs | 8510 | 56.73 | 2nd |
| Labour intensive | 8309 | 55.39 | 3rd |
| Multiple farms | 7073 | 47.15 | 4th |
| Access to inputs | 6811 | 45.41 | 5th |
| Weather conditions | 6762 | 45.08 | 6th |
| Extension services | 5799 | 38.66 | 7th |

**Source(s)**: Field survey, 2019

comply with standard applications of the recommended production practices since most farmers less comply. It can be concluded from analysis of factors influencing compliance that, an increase in a farmer's age, years in formal education, farm size and being a female farmer will increase compliance with recommended maize production practices. Non-compliance by male maize farmers should be of serious concern to policy-makers since over 60% of the maize farmer population in the study area has been reported as males. The results also revealed that, compliance with recommended production practices can be counted among the principal factors accounting for low yields in Ghana's maize farms. Finally, the major challenges farmers face in complying with recommended practices include lack or inadequate finance, cost of inputs and labour intensive nature of some of the recommended maize production practices.

Given that an increase in compliance with recommended production practices will close maize yield gap, policies by government and other key stakeholders aim at closing yield gap should aim at giving farmers the necessary assistance that will increase their level of compliance with the recommended maize production practices. This can be done by providing financial aid and input subsidy and delivery programmes through the government and other non-governmental organizations to farmers. The government finance aid and input dissemination and subsidy programmes should be very effective in disseminating financial aid and well subsidized inputs to farmers to address their constraints to compliance with good practices. Currently, Ghana government's flagship programme, Planting for Food and Jobs, is expected to support farmers with 50% subsidy of the cost of inputs (seeds and fertilizers) as well as provision of complementary services such as extension services and marketing of outputs. However, if a comprehensive programme aimed at making all farmers benefit from the programme is not put in place, farmers will continue to have challenges in complying with recommended production practices.

Also given that increase in level of formal education would increase compliance with recommended production practices, technology dissemination and yield improvement programmes in the maize production sector by stakeholders could aim at educating maize farmers. In addition, the Ministry of Food and Agriculture can collaborate with the Ministry of education to provide some sort of non-formal education to illiterate farmers prior to technology dissemination. Furthermore, agriculture "women empowerment programmes" should be promoted to help engage more women and also make them resource equipped in order to venture into maize production as women have the ability to comply with recommended maize production practices.

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