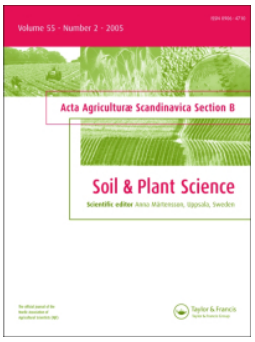

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Assessment of farmers readiness to adopt maize hybrid varieties for high productivity in Ghana

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ABSTRACT

The adoption of maize hybrids is essential to contribute to maize productivity and ensure self-sufficiency and food security. However, the adoption of improved varieties hybrids technology including in Ghana is very low. Farmers' socio-economic characteristics in relation to the adoption of maize hybrids, farmers constraints and readiness to adopt maize hybrids were assessed using a cross-sectional survey of 173 farmers in four regions in the forest-savannah agro-ecological zones in Ghana. The percentage of farmers that used hybrid seed in 2019 and 2020 were 32.4% and 22.5%, respectively. Of the four hybrids varieties grown, none was locally produced and over 83% of the farmers indicated readiness to adopt maize hybrid seed. The empirical model reveals that farmers readiness to adopt maize hybrids is positively influenced by gender, age, high yield and constraints variables such as high cost of production and pests and diseases.

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Adoption rate; farmers; maize; hybrid; Ghana; readiness

Introduction

Maize is an important cereal crop in Africa used for both food and non-food products. Maize has relatively high productivity, demands less labour and stores easily (Atlin et al. 2011; Waldman et al. 2017). The demand for maize for both human, animal feed and industrial use continues to increase locally and globally. In Ghana, maize is the most widely grown cereal by smallholder farmers across various agro-ecological zones due to its high adaptation to wide climatic conditions (Nketia et al. 2018). The Eastern, Ashanti and Brong Ahafo regions account for over 80% of total maize production in Ghana (Angelucci 2012). These regions fall within the forest and forest-savannah transition zones. Maize production in Ghana accounts for about 50% of the total area of local cereal crop production with yearly increment of 1.1% (Ragasa et al. 2013). Maize production in Ghana increased by 15.3% between 2016 and 2017 due to the 12.1% increase in cultivated land area and 3% increase in yield recorded (MoFA 2017). In 2019, Ghana recorded a total production of 2.7 million Mt, a 45% increase in production (FAO 2020).

Maize production in Ghana is gradually increasing; however, average maize yields of 2 Mt per hectare are recorded, and this is below economically attainable yields (Ragasa et al. 2013). Maize cultivation is dominated by open-pollinated varieties (OPVs) and landraces with few hybrids (Ragasa et al. 2013; Abate et al. 2017; Van Asselt et al. 2018). The National Agricultural Research Institutions have developed and released 55 improved varieties of maize including 29 hybrid maize varieties (CSIR 2019); however, none of these hybrids have been fully commercialised except those released on behalf of the multinational cooperation. It has been reported that although the Agricultural Research Institutions in Ghana release on the average seven new varieties, which also include hybrids every 10 years, the average varietal age of maize cultivated by farmers is 23 years (Ragasa et al. 2013). This is an indication that the adoption rate of improved varieties is very low in Ghana.

Several studies have shown evidence that hybrid seeds can significantly improve agricultural production (Harou et al. 2017) and its adoption has a positive impact on household welfare and food security (Jaleta et al. 2018; Ali et al. 2020). Ghana needs high-yielding maize hybrids to increase productivity, ensure self-sufficiency and food security. One of the means in achieving self-sufficiency and food security is through

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the promotion and adoption of hybrid varieties because of the huge yield advantage hybrids have over OPVs. An increase in the adoption rate of hybrid maize varieties could bring about a massive difference in yield obtained on farmers' fields in Ghana. This study seeks to assess the level of use of hybrid maize seed among farmers and their readiness to adopt hybrid maize varieties to boost maize productivity and increase food security.

This study contributes information to further understanding the adoption process of new technologies among smallholder farmers. When a technology (a new idea or practice) is introduced to farmers, they go through a process to adopt or disregard the technology. Farmers' decision to try and adopt an innovation occurs over time as understanding and commitment increase. Awareness creation through activities such as demonstration trials and farmer field schools are carried out to drive the process of technology adoption among farmers. Farmers evaluate the risks and benefits and decide to either use or not use the technology. There is inadequate understanding of what happens during the process of adoption of technology or innovation (Glover et al. 2019). Technology adoption has often been perceived as readymade technological packages and artefacts and systems capable of being transferred smoothly from one setting to be adopted and implemented in another (Glover et al. 2016). This is based on the diffusion of innovation theory (Rogers 2003), and such conception of technological change tends to suggest technology adoption as a simplistic linear model, providing little insight into the intensity of adoption and dynamic process of adoption (Glover et al. 2019; Hermans et al. 2020). This paper focuses on what happens after a proposed technological change – maize hybrid – is introduced. Farmers' decision to adopt a technology occurs over time as understanding and commitment increase. When farmers are positively disposed to a technology, they embark on a process of adoption and various pathways of change emerge. This paper focuses on providing information on maize farmers preference and use of maize hybrids, barriers to adoption and farmers readiness to adopt maize hybrids.

Materials and methods

Study area

The study used a cross-sectional survey of maize farmers in the forest-savannah transition zones. The forest-savannah transition agroecological zone is the major maize growing zone in Ghana. It is considered the food hub of the country and holds great potential for increased food productivity (Addai and Owusu 2014; Ayivor et al. 2015). The forest-savannah transition zone was specifically selected to investigate farmers use and readiness to adopt improved hybrid maize seeds to increase productivity per unit area. A multistage sampling approach was used in selecting districts, communities and respondents. Five districts were selected across four regions (Bono East, Brong Ahafo, Eastern and Ashanti regions) in the forest savannah transition zone (Figure 1). The regions and districts were purposively selected based on the importance of maize as a major crop in the farming systems and the availability of maize technology dissemination programs in the districts. The districts selected were Nkoranzah North in Bono East region, Dormaa West in the Brong Ahafo region, Kwahu Afram Plains South in the Eastern region and Ejura Sekyedumase and Sekyere East in the Ashanti region. Three communities were selected from each of the selected districts. The communities fall within the forest-savannah transition agro-ecological zones of Ghana. The forest-savannah transition zone covers about 28% of total area of land in Ghana. It receives a mean annual rainfall of 1300 mm with rainfall pattern characterised as bimodal. The major season starts from April to July with 100–120 days growing period, and a minor season from September to October with 60 days growing period. Temperatures range from 17°C to 33°C with the lowest recorded in August and the highest in December, January and February. The zone is considered as the food hub of the country and holds great potential for increased food productivity (Ayivor et al. 2015). The zone is characterised as one of the highest maize production zones in Ghana.

Study design, sampling and data collection

A farmer population list was obtained from the Department of Agriculture. A simple random sampling was used to draw a sample of 173 maize farmers (Table 1). A structured questionnaire was designed and used for data collection. The questionnaire comprised of both open and close-ended questions. The questions were grouped by themes so that respondents can focus, organise thoughts and reactions in responding to the questions (Fanning 2005). The themes focused on the socio-demographic information about the maize farmers, readiness to adopt hybrid maize seed, production of hybrid maize seed, farmers' choice of hybrid maize seeds, challenges with the use of hybrid seed, willingness to pay for hybrid seeds and opinions on measures to promote the use of hybrid seeds. Interviews were conducted using a face-to-face approach. The interviews were conducted in local language (Twi) for better

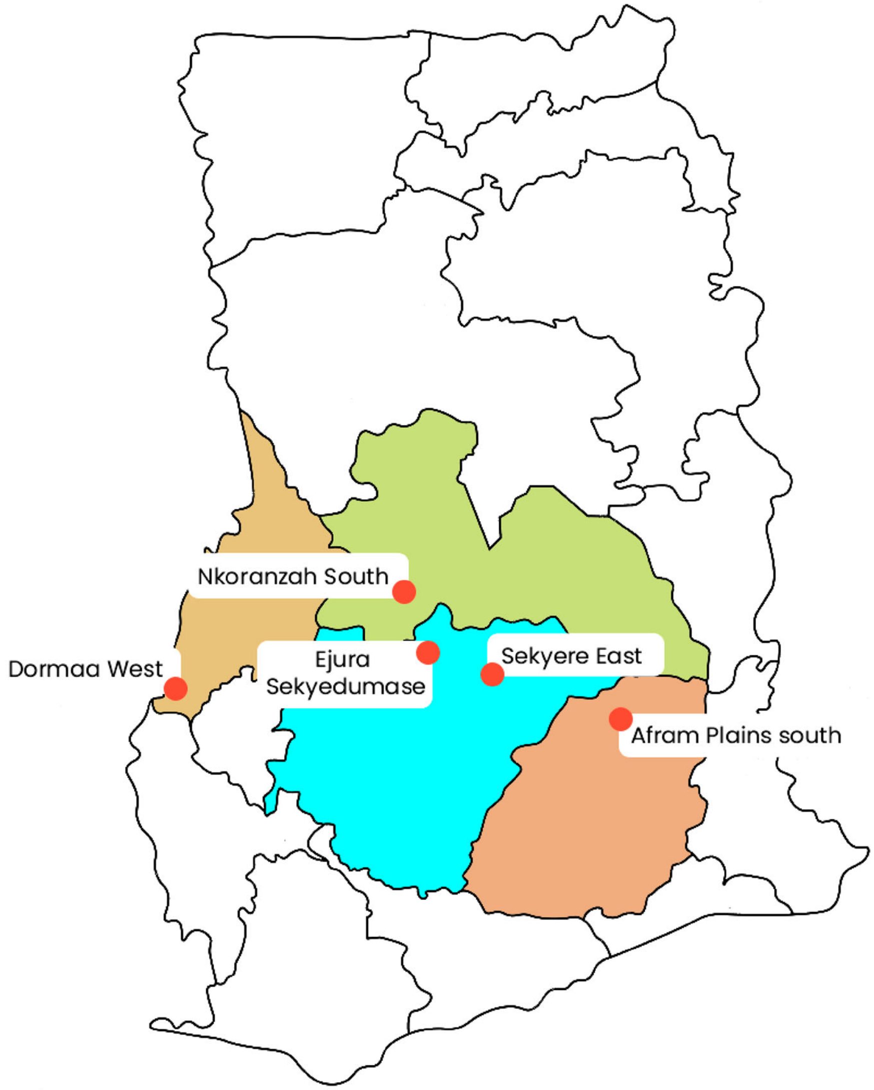

Figure 1. Map of Ghana showing study area.

understanding. The questionnaire was pretested with 20 farmers and revised prior to the actual survey. The survey length was for 20–25 min to improve response rate and avoid respondent fatigue. The survey was conducted between August and October 2020. The interviews were conducted by researchers from the West Africa Centre for Crop Improvement (WACCI), University of Ghana. Interviews were conducted with the head of the farming households.

Table 1. Study regions, districts and number (*N*) of farmers interviewed.

Region	District	*N* (%)
Bono East	Nkoranzah South	49 (28.3)
Brong Ahafo	Dormaa West	21 (12.1)
Eastern	Afram Plains South	36 (20.8)
Ashanti	Ejura Sekyedumase	52 (30.1)
	Sekyere East	14 (8.1)
	Total	173 (100)

The farmers were informed that they had a choice to opt out of the interview or to stop whenever they were no longer comfortable to proceed and that the information will be treated as confidential and anonymous.

Farmer's readiness to adopt maize hybrid for was assessed using a five-point Likert scale (1- extremely ready, 2- very ready, 3- moderately ready, 4- slightly ready and 5- not at all ready). Mean scores were calculated for all the items on readiness (Jenn 2006). Mean score of 1–1.80 represented extremely ready, 1.81–2.60 is very ready, 2.61–3.40 is moderately ready, 3.41–4.20 is slightly ready and 4.21–5 not at all ready. Data analysis was done using the Statistical Package for Social Sciences (SPSS version 24) and Stata (version 15) software. Descriptive statistics, logistic regression, mean comparisons, chi-square tests and Likert scales were used to derive the results.

Empirical model

The use of binary choice models such as binary logit and probit model to explain the adoption of improved crop varieties have been well documented (Akudugu et al. 2012; Salifu and Salifu 2015; Danso-Abbeam et al. 2017; Acheampong et al. 2018; Chete 2021). The choice of logit model or probit is based on preference because both models give similar results except that the logit model assumes logistic distribution while the probit model assumes cumulative normal distribution (Dankyi and Adjekum 2007). The logit model is the most convenient model to use when there is a dichotomous response variable (dependent variable) and a mix of continuous and categorical independent variables. This study adopts the binary logit model to explain the probability of a farmer's readiness to adopt maize hybrids in the study area. That is, whether a farmer is ready to adopt as one (1) or not ready to adopt as zero (0). The explanatory variables include socioeconomic variables, constraint variables and crop traits variables. The logit model is specified as follows:

$$P\ (Y) = \frac{e^{\beta_0 + \sum_{i=1}^{n} \beta_i X_i}}{1 + e^{\beta_0 + \sum_{i=1}^{n} \beta_i X_i}}$$

The model can be linearised by taking the natural log as follows:

$$Y = \ln\left(\frac{P_i}{1 - P_i}\right) = \beta_0 + \beta_i X_i + \mu_i$$

where Y is the dependent variable (readiness to adopt maize hybrids), p_i is the probability of a farmer's readiness to adopt the maize hybrids, $1 - p_i$ is the probability of a farmer not ready to adopt the maize hybrids, β_0 is the constant term, β_i is the vector of the regression coefficient, X_i is the vector of explanatory variables and μ_i is the error term. The variables and their respective measurements are presented in Table 2.

Results

Socio-economic characteristics

Table 3 shows the socio-economic characteristics of the surveyed farmers. A total of 173 maize farmers were interviewed of which 74% were males and 24% were females. The average age of the respondents was 47 years (range was 20–75 years). The farmer could be grouped into five categories based on education with 13.3% having no formal education, 10.4% having primary education, 64.2% having high school education, 2.3% having vocational education and 8.1% having tertiary education. In generally, the farmers have had many years' experience in maize farming. About 13% of the farmers interviewed had less than 5 years' experience in growing maize, 54.4% of the farmers had between 5 and 20 years' experience and 30.1% had over 20 years' experience in maize farming.

Factors influencing farmers' adoption of maize hybrid seeds

Table 4 shows that only 49% of the farmers surveyed purchased seed of improved maize varieties (OPVs and/or hybrids) in 2019 and 2020. However, only 34% of the farmers indicated buying maize hybrids seeds within the period for planting. For the farmers who bought hybrid maize seeds, they mostly (66.7%) acquired the seeds from the district offices of the Ministry for Food and Agriculture (Table 4). The survey revealed that the hybrid varieties used by the farmers were Pan 12, Pan 53 Lake 601 and Pioneer in 2019 and 2020 (Table 5). The percentage of farmers that used hybrid seed in 2019 and 2020 were 32.4% and 22.5%, respectively. It was also observed that some farmers who used hybrids also planted other OPVs (data not shown).

The Binomial Logit Model estimates of the factors influencing farmers' readiness to adopt maize hybrid seed are presented in Table 6. The Wald chi^2 is statistically significant at 1%, showing that the regression

Table 2. Variables, description and measurements used to assess readiness to adopt maize hybrids,

Variable	Description	Measurement
Adopt	Ready to adopt maize hybrid	Yes = 1, Otherwise = 0
Gender	Sex of respondents	Male = 1, Female = 0
Age	Age of respondents	Years
Farm experience	Years spent in farming maize	Years
Education	Years spent in school	Years
High Yield	High yielding trait	Yes = 1, Otherwise = 0
High seed cost	High seed cost as a challenge with the use of hybrid seed	Yes = 1, Otherwise = 0
Pest and Disease	Pest and disease as a challenge with the use of hybrid seed	Yes = 1, Otherwise = 0
Access to inputs	Face with limited access to quality inputs	Yes = 1, Otherwise = 0
High cost of production	Face with high cost of production	Yes = 1, Otherwise = 0
Hybrid awareness	Aware of the released of new hybrid seeds	Yes = 1, Otherwise = 0

Table 3. Socio-economic characteristics of farmers surveyed for adoption of maize hybrids.

Variables		Number of participants by gender		Total	
	YES	NO	*N* (%)		
Gender	Male	55	73	128 (74)	*N* = 168
	Female	3	37	40 (23.7)	
Age (years)	Under 20	0	2	2 (1.2)	*N* = 167
	21–30	5	10	15 (8.7)	
	31–40	12	32	44 (25.4)	
	41–50	16	27	43 (24.9)	
	51–60	13	21	34 (20.2)	
	61 and older	11	18	29 (16.8)	
Education	No formal education	3	20	23 (13.3)	*N* = 169
	Primary	1	16	17 (10.4)	
	High School	43	68	111 (64.2)	
	Vocational	1	3	4 (2.3)	
	Tertiary	10	4	14 (8.1)	
Maize farming experience (years)	Less than 5	8	15	23 (13.3)	*N* = 168
	6–10 years	6	18	24 (13.9)	
	11–15 years	16	18	34 (19.7)	
	16–20 years	9	26	35 (20.8)	
	More than 20	20	32	52 (30.1)	
Farm size in 2020 (acres)	Less than 5	25	67	92	*N* = 173
	6–10	14	21	35	
	11–15	6	7	13	
	16–20	4	1	5	
	Above 20	9	14	23	

coefficients are statistically different from zero or unequal. This goodness-of-fit statistic implies that the explanatory variables jointly explain farmers' readiness to adopt maize hybrids. The Pseudo R^2 together with the Wald > chi^2 indicate the overall fitness of the logit model for this study. The results revealed that gender, age, high yield trait and constraint variables such as pests and diseases, and high cost of production positively influence farmers' readiness to adopt maize hybrids. Gender and age of respondents were statistically significant at 5% ($P < 0.05$), whereas high yield as crop trait, high cost of production, pest and diseases being constraint variables were statistically significant at 1% ($P < 0.01$).

The main reason why farmers did not adopt hybrid seeds is a lack of awareness or knowledge of maize hybrids (33%) and their yield potential (Table 7). This was followed by the high cost of seed (25%) and inconsistent availability of maize hybrid seeds (21%). The results revealed that 83.8% of the farmers would be willing to use maize hybrids in the 2021 planting seasons, 6.4% stated no interest to use hybrid and 9.3% were undecided (Table 8). For the category of farmers willing to use hybrid in 2021 reasons provided includes the benefit of high yields from hybrids. However, 16.8% percent would prefer to have it as a demonstration trial on their fields. Farmers' rating of their readiness to adopt maize hybrid for the next production season ranged from 1.25 for land preparation to 4.83 for irrigation (Table 9). The main limitations to farmers' readiness identified are with access to credit, mechanisation and irrigation.

Table 4. Farmers' source and use of maize hybrid seeds.

Variables	Response of farmers	N (%)
Do you buy maize seeds?	Yes	85 (49.1)
	No	86 (50.3)
Do you buy maize hybrid seeds?	Yes	59 (34.1)
	No	112 (64.7)
Source of maize hybrid seeds used in planting?[a]	Seed company/ Seed grower	4 (7.02)
	Agro-input shop	14 (24.56)
	Ministry of Food and Agriculture district Office	38 (66.7)
	University	1(1.75)

[a]Farmers who indicated that they did not buy hybrid seed for planting were not included in the analysis.

Table 5. Varieties of maize hybrids planted by farmers in 2019 and 2020.

		Number of farmers (%)	
Hybrid varieties[a]	Source	2019	2020
Pan 12	Imported	19 (11)	8 (4.6)
Pan 53	Imported	17 (9.8)	10 (5.8)
Lake 601	Imported	15 (8.7)	18 (10.4)
Pioneer#	Imported	5 (2.9)	3 (1.7)
Total		56 (32.4)	39 (22.5)
#Not under subsidy			

#Not under subsidy in the Planting for Food and Jobs initiative.
[a]Some farmers also cultivated open pollinated varieties like Obatanpa, Abontem and Aburohemaa.

Discussions

This study revealed that the adoption of hybrids among farmers in Ghana is still relatively low. As shown in

Table 6. Binomial logit model estimates of the factors influencing farmers' readiness to adopt maize hybrids.

Variable	Coefficient	Dy/Dx	Robust Std. Err.	*P*-value
Gender	1.608**	0.329	0.705	.023
Age	0.075**	0.007	0.030	.012
Experience	−0.007	−0.002	0.022	.745
Education	0.078	0.018	0.073	.288
High Yield	6.513***	0.886	1.919	.001
High Seed Cost	1.009	0.247	1.065	.344
Pest and Disease	4.419***	0.709	1.667	.008
Access to Input	−2.447	−0.354	1.771	.167
High Cost of Production	5.336***	0.676	1.313	.000
Hybrid Awareness	0.725	0.178	1.228	.555
Constant	−8.488		1.910	.000
Observations	173			
Wald chi^2 (10)	50.63			
Prob > chi^2	0.000			
Pseudo R^2	0.736			

Table 7. Factors limiting farmers adoption of hybrid maize seeds.

Factors	Number of respondents (%)
No knowledge of maize hybrid	33 (29)
High seed cost	25 (22)
Inconsistent availability of seed	21 (19)
High cost of production	6 (5.1)
Poor seed germination	5 (4.5)
Pest and disease	3 (2.7)
Lack of finance	2 (0.18)
Limited access to labour	1 (0.9)
Difficulty in getting labour	1 (0.9)
Weak linkage between production and marketing	1 (0.9)
Limited irrigation facility	1 (0.9)

Table 4, the adoption rate of hybrids ranged from 32.4% in 2019 to 22.5% in 2020, an indication that more farmers used hybrid seed in 2019 compared to 2020. This adoption rate can be attributed to the impact of the cascade of government programs, including the Planting for Food and Jobs initiative (PFJ), Fertilizer Subsidy Program (FSP), and Modernizing Agriculture in Ghana (MAG) program. These programs focused on providing farmers with access to improved seeds, fertilisers and extension services including other technologies with the aim of achieving self–sufficiency in food production (FAO 2020). Many developing countries through its subsidy programs and investment in research and seed multiplication have promoted the use of hybrids (Smale et al. 2015; Waldman et al. 2017). Currently, in Ghana, the commercial seed of maize hybrids (local or imported) is highly subsidised to address the challenge with cost. While OPV is selling at US$ 0.52 per kg, hybrid is selling at US$ 0.87 per kg. However, smallholder farmers still indicated that cost of seed is a major challenge. Interestingly a decline was observed in hybrid seed usage among farmers in 2020. This can be attributed largely to delayed importation of hybrid seed arising from the impact of Covid-19 pandemic, including the inconsistency in seed supply, very low volumes of locally produced hybrid seeds, accessibility, inefficient seed production, distribution and poor-quality assurance systems.

The most popular hybrids utilised by farmers were all imported. The hybrids are Pan 12, Pan 53, Lake 601 and Pioneer (Table 5). It is worth noting that none of the locally produced hybrids featured in the list of hybrids utilised by the farmers. This is an indication that Ghana continues to rely heavily on importation of hybrid maize seeds as evident in the hybrid varieties used by the farmers. Further, it indicates that there is a challenge with the commercialisation of locally developed hybrids. The seed sector in Ghana is still in its fledging stage and, therefore, is faced with several challenges that limit the production of sufficient quantities of quality hybrid seeds (Tripp and Ragasa 2015; Poku et al. 2018) to meet the growing demand of maize for food, feed and industrial uses. Although hybrids have the potential to increase production and contribute to food and nutrition security, its adoption is still very low in Ghana. Smale et al. (2011) reported that the adoption of improved varieties is relatively low within smallholder farming communities in developing countries.

A number of studies have pointed out the influence of socio-economics (Wang et al. 2017), gender (Ouma

Table 8. Readiness of grain producers to increase capacity in 2021.

Would you consider increasing your capacity to use hybrid in 2021?					
Yes – 145 (83.8%)		No – 11 (6.4%)		Not decided 16 (9.3%)	
Reasons		*Reasons*		*Reasons*	
Access to seed	17(9.8)	Experienced low yields with hybrids	2(1.2)	Want to compare yields	8 (4.6)
Early maturing	12(6.9)	Don't have the capacity to go into hybrid production	1(0.6)	Unavailability of hybrid seeds	2(1.2)
High yield	74 (42.8)	Hybrid seeds are expensive	1(0.6)	Conditional based on access to land	2(1.2)
Profitable/ Increase income	14 (8.1)	Limited capital	1(0.6)	Conditional, based on access to capital	3(1.7)
Setup on-farm trials/demonstration and compare hybrid maize with other varieties	29 (16.8)	No premium market for hybrid	3(1.7)	Will go for hybrid if planting late	1(0.6)
		Old age	1(0.6)		

Table 9. Descriptive statistics on farmers readiness towards adoption of maize hybrids.

Factors	*N*	Min.	Max.	Mean	Std. dev.	Readiness
Land for production	152	1	5	1.25	0.757	Extremely ready
Pest and disease management	148	1	5	1.93	1.092	Very ready
Access to quality seed	152	1	5	1.95	1.028	Very ready
Labour	152	1	5	2.01	1.866	Very ready
Postharvest management	152	1	5	2.08	1.182	Very ready
Access to input	152	1	5	2.18	1.011	Very ready
Forecasting of seed demand	152	1	5	2.39	1.158	Very ready
Access to capital	152	1	5	2.52	1.302	Very ready
Marketing capacity	152	1	5	2.56	1.418	Very ready
Mechanisation	151	1	5	3.19	1.745	Moderately ready
Access to credit	150	1	5	3.60	1.515	Slightly ready
Irrigation	152	1	5	4.83	0.698	Not at all ready

Note: 1 – Extremely ready, 2 – Very ready, 3 – Moderately ready, 4 – Slightly ready, 5 – Not at all ready.

and De Groote 2011; Wang et al. 2017; Gebre et al. 2019), agro-ecological variables, sources of farm information and farmers' attitude (Magnan et al. 2020; Tegbaru et al. 2020) towards the adoption of improved maize varieties. As shown in Table 6, gender, age, high yield trait, pests and diseases and high cost of production positively influenced farmers' readiness to adopt maize hybrids. Our data is in consistence with findings by Ouma and De Groote (2011) who reported that gender was the most influential factor in determining farmers' use of maize hybrid given that men have a 55% higher probability than women. The influence of age on farmers' readiness to adopt maize hybrids implies that a unit increase in a farmer's age will increase readiness to adopt maize hybrids, all things being equal. Our data is in consistent with findings by Danso-Abbeam et al. (2017) who reported that the probability of adopting improved maize variety was higher among older farmers compared to young farmers in Ghana. On the contrary, Salifu and Salifu (2015) found age to negatively affect farmers' choice of improved maize varieties in the Wa Municipality of Ghana. Farmers who consider high yield as a factor that influences their choice of seeds will be more ready to adopt maize hybrids. Our data is in consistent with findings by Ayamga (2018), who found high yield as a major determinant of farmers' choice of hybrid seeds in Tamale.

In Ghana, smallholder farmers are mostly constraint with low productivity and hence the decision to adopt a new variety, to an extent, depend on whether the new variety has an advantage of higher yields. Farmers with this high-yield knowledge will be more ready to adopt improved maize seeds because hybrid seeds are mostly high-yielding (Akpo et al. 2021). Pests and diseases as a constraint were found to be positively affecting farmers' readiness to adopt maize hybrids. The finding implies that farmers who are faced with a high prevalence of pests and diseases will be more ready to adopt the maize hybrids that are resistant to pests and diseases (Akpo et al. 2021). A similar finding has been reported by Ribeiro et al. (2017), who found pests and diseases as a major constraint to maize productivity in Ghana. In that same study, farmers preferred pests and disease-resistant maize varieties. Moreover, Alhassan et al. (2016) reported pests and diseases as a discriminating variable separating farmers into adopters and non-adopters of improved maize variety in the Upper West Region of Ghana. This result suggests that farmers are ready to accept maize hybrids that are resistant of pests and diseases.

Moreover, high cost of production as a constraint to maize production positively affects farmers' readiness to adopt maize hybrids, as revealed in our study (Table 6). This is in consistence with findings by Akudugu et al. (2012), that farmers are more willing to adopt new agricultural technology when the expected benefit from the technology is higher than the existing one. The expected benefit includes reducing the cost of production and consequently resulting in a higher return for adopters. It is worth mentioning that the non-significant variables such as education, farming experience and awareness in this study have been reported in previous studies as factors explaining farmers' adoption of improved maize varieties (Salifu and Salifu 2015; Danso-Abbeam et al. 2017; Chete 2021). Education, for instance, will develop farmers' capacity to access technical information, which will positively influence adoption. It is known fact that education both formal and informal empowers farmers by providing opportunity to understand, acquire and use new technologies, including improved seeds (Doss and Morris 2000).

Several factors have been attributed to the low adoption of maize hybrid seeds, including inefficiencies in the seed system, which limits availability, accessibility and affordability, distribution and poor-quality assurance systems by national seed programs (Poku et al. 2018). The top three factors preventing the adoption of hybrids among smallholder farmers who did not use hybrids were lack of knowledge of hybrids, high cost of seed and inconsistent availability of seed (Table 7). Furthermore, our data revealed that although the adoption rate is relatively low about 83.8% of the farmers indicated readiness to use maize hybrids in the 2021 growing season (Table 8). However, 16.8% would need on-farm/demonstration trials established on their farms to compare hybrid maize with other varieties. Our data is in consistence with studies by Van Asselt et al. (2018) that farmers are ready to adopt new high-yielding maize technologies when exposed to demonstration trials. Farmers experiment in technology adoption process in deciding on the adoption of a new technology (Whitfield 2015). When farmers are introduced to a new hybrid variety, they often experiment by planting a small portion of their farmland with the new variety to make comparison with their known varieties. It was observed in this study that in addition to planting hybrid seed some of the farmers also used other improved OPVs such as Obatanpa, Abontem and Aburohemaa.

The use of hybrid varieties offers an opportunity to improve the food and income of farmers by increasing productivity per unit area. This is particularly important with the knowledge that human population is increasing and land for crop production remains finite. There is a need for continued awareness creation to drive the adoption of hybrid maize among maize farmers in Ghana. Based on the Likert scale, farmers are very ready to adopt maize hybrid but are faced with limitations such as access to credit, farm mechanisation and irrigation (Table 9). Studies have indicated that agricultural mechanisation significantly raises the productivity of maize (Takeshima et al. 2018; Kirui 2019). However, agricultural mechanisation in Ghana is still very low, although agriculture in recent years has become more intensive with increasing demand for mechanised farm operations (Diao et al. 2014; Daum and Birner 2020). Kirui (2019) revealed that on the average only 12% of households in Ghana have access to tractors. In Ghana, private sector-led mechanisation supply chain is being employed where commercial and medium-scale farmers own tractors and provide hiring services to smallholder farmers (Houssou et al. 2015; Diao et al. 2018). In addition, access to credit and capital for farm operations was an influencer on the decision to use hybrid. Akudugu (2016) reported a significant relationship between farmers' access to informal credit, farm size and agricultural productivity. Namara et al. (2014) also reported lack of access to irrigation as a constraint limiting agricultural productivity in Ghana. Mechanisation, access to credit and irrigation are crucial for the adoption of hybrid seed. Irrigation is critical to mitigate the effects of climate change arising from unpredictable rainfall patterns and drought spells. Climatic change is a global concern that threatens crop production, and the sub-Saharan region remains the most vulnerable to climate change due to high climate variability, over-dependence on rain-fed agriculture and lack of sufficient economic capacity to respond to climate change (Sultan and Gaetani 2016). It is worth noting that land for production was the least rated factor identified by farmers to influence their decision to utilise hybrid in the subsequent cropping season. This indicates that for the majority of the smallholder farmers interviewed access to land for cultivation was not a limiting factor.

There is a need to address the constraints in the supply of locally produced hybrids and to empower the seed sector to boost agricultural productivity. The inefficiencies in the local seed system can be addressed through investment in research and seed production. Feeding the rapidly growing population and meeting the Sustainable Development Goal 2 'Zero hunger' requires innovative agricultural interventions. This includes but not limited to the use of improved crop varieties such as hybrids that are climate-resilient, access to credit, agricultural mechanisation and availability of irrigation.

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Data availability

Data for the study can be made available upon request.

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