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Determination of Adoption Traits and Key Production Constraints of Improved Maize Varieties Using Participatory Research Appraisal

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Authors' contributions

This work was carried out in collaboration among all authors. Author CAD designed the study and wrote the first draft of the manuscript. Author PFR reviewed the manuscript and managed the literature search. Author EAO performed the statistical analysis and managed the literature search. Author EB collected data at Ejura Sekyeredumasi district and managed the literature search. Author PYD collected data at Wenchi Municipal district and managed the literature search. Author FOA collected data at Nkoranza North district and managed the literature search. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Maize is a staple crop critical to the food security and livelihoods of millions of smallholder farmers in Sub-Saharan Africa. Despite the availability of improved maize varieties, adoption rates among farmers remain suboptimal. Understanding the traits that drive adoption and

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identifying key production constraints is essential for the development and dissemination of varieties that meet farmers' needs.

Aims: This study aimed to identifying the most valued traits of improved maize varieties from the farmers' perspective, assessing the socio-economic and biophysical factors influencing the adoption of these varieties and identifying the main production constraints faced by farmers in different agro-ecological zones.

Study Design: The study was conducted in three regions representing diverse agro-ecological zones. A multi-stage sampling technique was used to select a representative sample of maize farmers. Data collection involved focus group discussions (FGDs), key informant interviews (KIIs), and household surveys. PRA tools such as pairwise ranking and matrix scoring were employed to capture qualitative and quantitative data on adoption traits and production constraints.

Place and Duration of Study: The study took place at Ejura Sekyeredumasi, Nkoranza South District and Wenchi Municipal district, between June 2017 and December 2017.

Methodology: Descriptive statistics were used analyzed the demographic characteristics of maize farmers as well as socioeconomic factors influencing the adoption of improved maize farming technology using SPSS 16 version. Data collected included; socio-demographic characteristics, adoption of improved maize varieties and constraints to maize production.

Results: The results showed that about 78 % and 18 % of farmer respondents perceived that both fertilizers and improved seed were too expensive. Other constraints to maize production were drought, high cost of other agro-inputs, lack of improved cultivars and poor soil fertility significantly influenced the adoption of improved maize farming technologies in the area

Conclusion: The study underscores the importance of incorporating farmers' preferences and addressing context-specific production constraints in maize breeding programs. Enhanced extension services, improved seed distribution systems, and tailored agronomic practices are recommended to increase adoption rates and improve productivity. Participatory approaches in agricultural research are vital for aligning breeding objectives with the real-world needs of smallholder farmers, ensuring the relevance and impact of improved maize varieties in the Ghana.

Keywords: Maize; adoption traits; production constraints; participatory research appraisal; small holder farmers; Sub-Sahara Africa; improved maize variety (IMV); fertilizers; drought; agro-inputs; improved cultivars.

1. INTRODUCTION

Maize is a major food security crop in sub-Saharan Africa and most developing countries [1]. It is produced in various parts of SSA under diverse climatic and ecological conditions owing to its widespread adoption and adaptation [2,3,4,5]. The crop has become a major staple and cash crop for approximately three hundred million smallholder farmers in SSA [6,7,8,9,10]. It is also credited with the capacity to provide approximately 30 % of daily required calories for over 4.5 billion people in 94 developing countries [11,12,13]. According to FAOSTAT, [14], the daily per capita consumption of maize is estimated to be 53.2 g. Globally, demand for the cereal is expected to double by 2050 [15].

Increased maize production, however, has been challenged by several biotic and abiotic factors. High costs of improved seeds, inadequate production inputs and low adoption rates constitute some of the factors hindering enhanced maize production [16,17]. Despite availability of improved cultivar, low adoption rate of these cultivars exists among farmers due to the fact that they lack one or more of the critical farmer-preferred traits performing poorly under typical farmer's low input conditions [18,19,20]. As a result, most farmers continue to utilize existing and low yielding landraces [21,22]. Participatory Research Appraisal (PRA) will rapidly improve food security through the adoption of improved crops cultivars by farmers [23].

Considering that adoption of improved cultivars by farmers is key to increased production, it is important that farmers are involved in both identification of key preferences and more importantly in developing, testing and selection of new crop cultivars [24,25,19,26,3,27] Application of participatory research appraisal enables researcher access critical data for breeding from farmers (Rusinamhodzi et al., 2012) [27]. This approach is more effective when combined with others such as semi structured survey and focus group discussion [26,28] PRA, an active multi-

disciplinary research methodology, also utilizes a wide range of techniques or tools including matrix and pairwise ranking, focus group discussions, transect walks, seasonal calendars and historical times to extract information from farmers [29,30,28,31]

This approach is great in data collection and adaptable on the grounds that it should be possible in parallel with other survey techniques such as semi-structured interviews to determine the farmers' views in relation to the utilization of a specific innovation or product [24,1,32]. Therefore, the objectives of this study were to identify; (i) farmer-preferred traits in existing (selected) maize varieties and (ii) constraints to adoption of improved maize varieties among farmers

2. MATERIALS AND METHODS

2.1 Description of Study Area

The study was conducted at 27 selected locations in two districts namely, Nkoranza South and Ejura-Sekyedumasi and Wenchi Municipality. Wenchi Municipal is located in Bono region (Fig. 1), Nkoranza South district is in the Bono East region (Fig. 2) while Ejura-Sekyedumasi District is located in the northern part of the Ashanti region (Fig. 3) of Ghana. All the locations fall within the Forest Savannah Transition agro-ecological zone. Average annual rainfall values vary between 1140 and 1270 mm at Wenchi, 1200 and 1400 mm at Nkoranza South and 1200 and 1500 mm at Ejura-Sekyedumasi. All the districts are characterized by a bimodal rainfall regime (the major rainy season is April-July, while the minor season is August/September-November) and therefore have two crop growing seasons. Temperatures in the districts range from 21 to 30°C [33]. The main occupation of residents in these study areas are agriculture and maize is one of the most important crops.

2.2 Sampling Frame

The multi-stage sampling technique was used such that the 1st stage was the purpose selection of major maize production districts or municipal within the forest savannah transition. The 2nd stage was a proportionate sampling of maize production communities within a district or municipal depending on the number of communities. Figs. 1 to 3 depicts the number of communities sampled per district or municipality. The number of farmers sampled per community was dependent on the total number of maize farmers such that proportionate sampling was used.

Two hundred smallholder farmers participated in the study, comprising 60 respondents from Wenchi, 77 from Ejura- Sekyedumasi and 63 from Nkoranza South. The respondents were identified through Agricultural Extension Agents of the Ministry of Food and agriculture. Respondents were randomly selected from a purposive pool of maize farmers.

2.3 Data Collected

Primary data were collected through the survey. Data were collected using survey questionnaire which was administered through face to face respondents. Data collected included; socio-demographic characteristics, adoption of improved maize varieties and constraints to maize production.

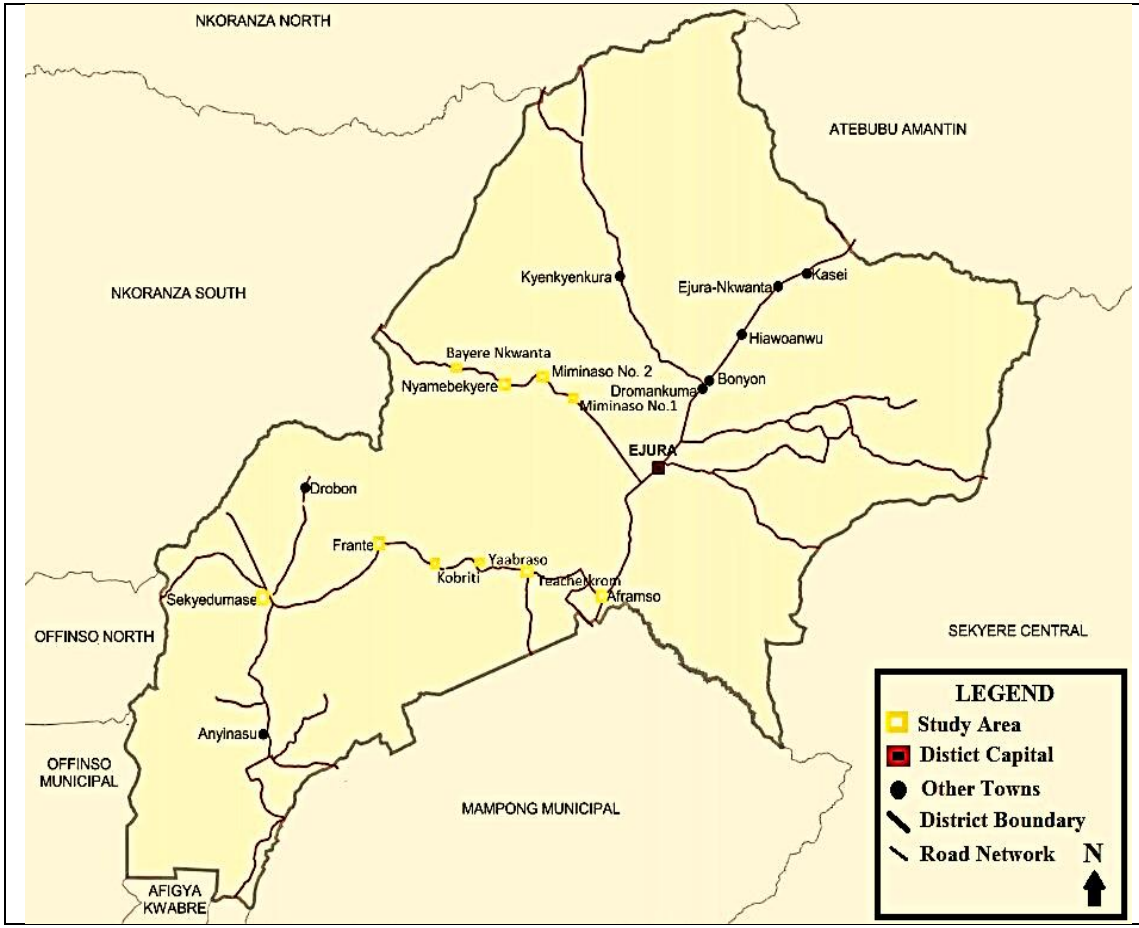
2.4 Data Analysis

Data were processed using SPSS version 16.0 and their standard deviation, chi square, frequencies, percentages, pair-wise ranking and descriptive statistics from data collected in each village followed by mean comparisons between villages. Data were presented in tables and charts.

3. RESULTS

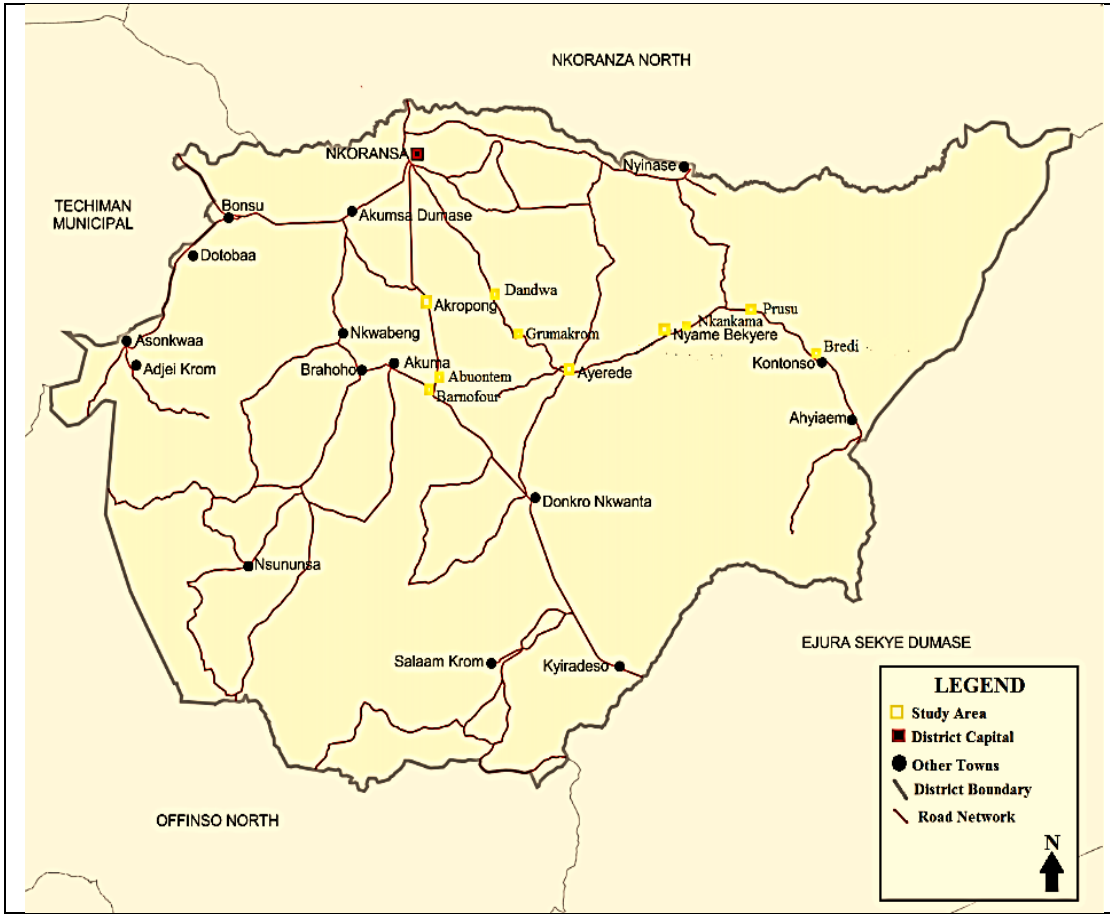
3.1 Demographic Characteristics in the Study Areas

Table 1 summarizes the demographic characteristics of the study areas. Maize farmers within the study area were between 36 and 60 years of age, followed by those between 15 and 35 years. However, very few farmers were above 60 years. For example, 44.2 % of farmers were between 15 and 35 years in Ejura-Sekyedumasi District, 36.5 % and 38.3 % in Nkoranza South District and Wenchi Municipal respectively. Between 36 and 50 years accounted for 50.6 % in the Ejura Sekyeredumasi District, 63.5 % in the Nkoranza South District and 55.0 % in the Wenchi Municipal. Farmers above 60 years accounted for 5.2 %, 0 % and 6.7 % for Ejura-Sekyedumasi, Nkoranza-South District and Wenchi Municipal respectively (Table 1). This suggests that young or the youth continue to move away from farming and migrating to urban areas in search for none existing jobs because farming to them, is not lucrative.



Miminaso #1	N 07^{O} 25. 224' and W 001^{O} 24. 774'
Miminaso #2	N 07^{O} 25. 691' and W 001^{O} 25. 378',
Nyame Beyere	N 07^{O} 25. 565' and W 001^{O} 26. 752',
Bayere Nkwanta	N 07^{O} 25. 888' and W 001^{O} 27. 392',
Aframso	N 07^{O} 81. 673' and W 001^{O} 23.398',
Teacherkrom	N 07 ^{O} 19. 534' and W 001 ^{O} 26. 063',
Yaabraso	N 07^{O} 19. 528' and W 001^{O} 27. 522'
Kobriti	N 07^{O} 19. 646' and W 001^{O} 28. 524'
Franti	N 07^{O} 20. 409' and W 001^{O} 30. 837'
Sekyeredumasi	N 07^{O} 18. 368' and W 001^{O} 34. 394'

Fig. 1. Map of Ejura-Sekyedumasi District and study area with their altitudes and coordinates as shown per legend (Ghana Statistical Service, Geographical Information System (GIS) Section, 2018)



Bredi	N 07° 29. 275' and W 001° 31. 782'
Prusu	N 07° 30. 558' and W 001° 33. 931'
Nkankama	N 07° 30. 041' and W 001° 35. 583'
Nyame Beyere	N 07° 29. 900' and W 001° 35. 973'
Barnofour	N 07° 26. 872' and W 001° 40. 387'
Donkor Nkwanta	N 07° 26. 054' and W 001° 39. 601'
Ayirede	N 07° 29. 024' and W 001° 38 355'
Grumakrom	N 07° 29. 856' and W 001° 39. 825'
Dandwa	N 07° 31. 046' and W 001° 40. 489'
Akropong	N 07° 30. 584' and W 001° 42. 067'
Abuontem	N 07° 28. 628' and W 001° 41. 913'

Fig. 2. Map of Nkoranza South District and study area with their altitudes and coordinates as shown per legend (Ghana Statistical Service, Geographical Information System (GIS) Section, 2018)

Awisa	N 07° 48. 458' and W 002° 06. 077'
Amponsakrom	N 07° 51. 583' and W 002° 04. 925'
Akrobi	N 07° 44. 668' and W 002° 07. 822'
Droboso	N 07° 42. 308' and W 002° 06. 381'
Beposo	N 07° 41. 507' and W 002° 06. 371’
Koaso	N 07° 40. 808' and W 002° 06. 406'

Fig. 3. Map of Wenchi Municipal and study area with their altitudes and coordinates as shown per legend (Ghana Statistical Service, Geographical Information System (GIS) Section, 2018)

Table 1. Demographic characteristics of respondent in three districts in Ghana

		District of Respondent									
		Ejura-Sekyedumasi		Nkoranza-South		Wenchi		ALL		χ^2	SD
Variable	**Categories**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**		
Age of respondent	15-35yrs	34.0	44.2	23.0	36.5	23.0	38.3	80.0	40.0	5.464	0.559
	36-60yrs	39.0	50.6	40.0	63.5	33.0	55.0	112.0	56.0		
	>=60yrs	4.0	5.2	0.0	0.0	4.0	6.7	8.0	4.0		
	Total	77.0	100.0	63.0	100.	60.0	100.0	200.0	100.0		
Gender of respondent	Male	67.0	87.0	48.0	76.2	51.0	85.0	166.0	83.0	3.199	0.377
	Female	10.0	13.0	15.0	23.8	9.0	15.0	34.0	17.0		
	Total	77.0	100.0	63.0	100.0	60.0	100.0	200.0	100.0		
Highest formal education	No education	26.0	33.8	28.0	44.4	42.0	70.0	96.0	48.0		
	Formal education	51.0	66.2	35.0	55.6	18.0	30.0	104.0	52.0	18.204 *	0.501
	Total	77.0	100.0	63.0	100.0	60.0	100.0	200.0	100.0		
Marital status of respondents	Single	15.0	19.5	5.0	7.9	10.0	16.7	30.0	15.0	7.261	0.397
	Married	60.0	77.9	58.0	92.1	50.0	83.3	168.0	84.0		
	Divorced	1.0	1.3	0.0	0.0	0.0	0.0	1.0	0.5		
	Widowed	1.0	1.3	0.0	0.0	0.0	0.0	1.0	0.5		
	Total	77.0	100.0	63.0	100.0	60.0	100.0	200.0	100.0		
Personnel involvement in farming	Full time farmers	68.0	88.3	52.0	82.5	46.0	76.7	166.0	83.0	3.229	0.32
	Part time farmers	9.0	11.7	11.0	17.5	14.0	23.3	34.0	17.0		
	Total	77.0	100.0	63.0	100.0	60.0	100	200.0	100.0		

**chi square significant to adoption*

Farmers interviewed in the study area were dominated by male. About 83.0 % were male while 17.0 % were female. Male farmers who were also heads of households accounted for 87.0 % in Ejura-Sekyedumasi District, 76.2 % in Nkoranza South District and 85.0 % in Wenchi Municipal while female farmers ranged from 13.0 % to 23.8 % across all districts (Table 1).

Results on educational background indicated that most farmers interviewed had some level of formal education compared with those with no formal education (Table 1). Ejura Sekyedumasi and Nkoranza South Districts had high percentages of farmers recording formal education of 66.2 % and 55.6 % respectively, while, Wenchi had more farmers who has not had formal education (70.0 %).

Majority of farmers within the study area were married (84.0 %) compared to single (15.0 %) widowed and divorced farmers (0.5 %) each across all locations. Farming is the primary occupation by majority of farmers interviewed with 83.0 % as against 17.0 % part time farmers across locations. However, some farmers within the study areas were engaged in other activities such barbering, tractor operation, trading, employed in the education and civil service as their primary occupation (Table 1). This means maize production becomes their secondary occupation and were in a better position to mobilize resources from their primary occupation.

3.2 Farming System

For farmers who cultivate only maize, awareness and adoption of improved maize varieties and sources of maize seed for farmers in the study areas are presented in Fig. 4. Greater percentages were recorded across all locations where farmers cultivated maize (97.0 %), aware of improved varieties (94.0 %) but low percentage of 36.5 % was recorded for farmers who have adopted the use of improved maize varieties.

Farmers at Nkoranza South and Wenchi cultivated sole maize while farmers from Ejura-Sekyedumasi cultivated with other crops. This could be as a result of favourable environmental condition at the various study areas (Fig. 4).

Respondents in the study areas sourced their seed maize from farmer saved seeds, agro-dealers, seed companies, local markets and public research institutes. Among these sources, farmer saved seed was the most dominated source (83.0 %) across all locations. This was followed by private seed companies (49.0 %), Agro dealers (42.0 %), local market (15.0 %) and research Institutes (11.0 %) (Table 2).

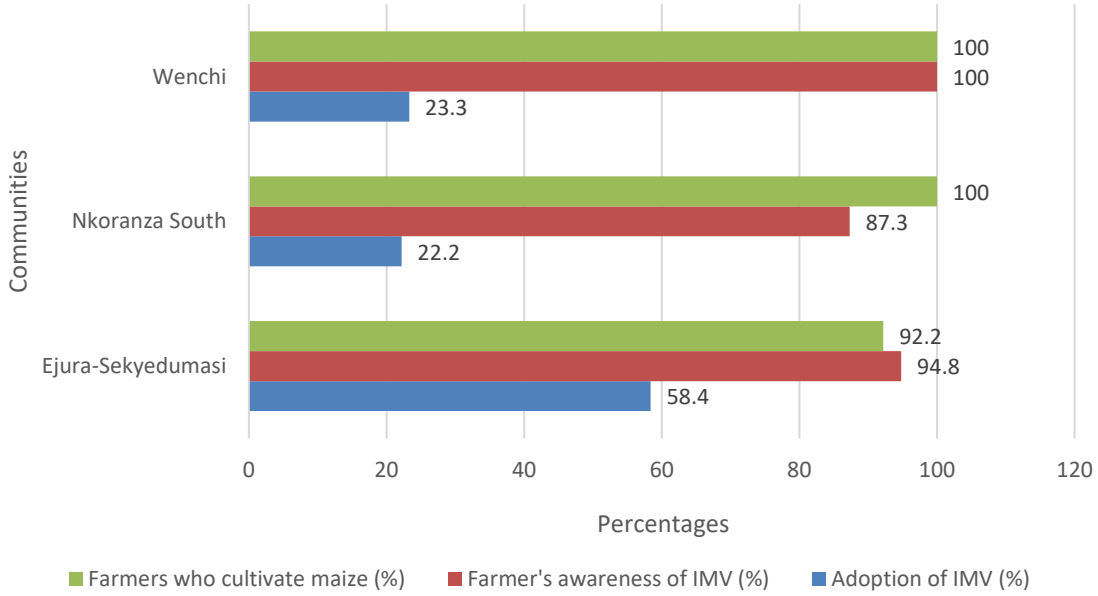


Fig. 4. Maize cultivation, awareness and adoption of improved maize varieties (IMV) across Ejura-Sekyedumasi, Nkoranza-South Districts and Wenchi Municipality

Ejura-Sekyedumasi District recorded majority famers obtaining their seed from farmers' saved seeds (39 %) with 35.1, 18.2 and 7.8 % from seed companies, Agro-dealers and local market respectively. Nkoranza South recorded a similar trend as Ejura-Sekyedumasi district where majority farmers obtained their seeds from Farmers' own fields (44.4 %) and private seed companies (22.2 %) with agro-dealers, public research institutions and local market 15.9, 9.5 and 7.9 % respectively. Farmers in Wenchi Municipality sourced their maize seed from farmers' saved seeds with highest percentage of 41.7 %, followed by Agro-dealers (30.0 %). The least percentages of farmers sourced their seeds from seed companies (13.3 %), research Institutions (8.3 %) and local markets (6.7 %). These results show that farmers' saved seed is an important source of seed in maize production. Notwithstanding, they supplemented the seed from the markets across locations (Table 2).

Maize was cultivated on farms ranging in size from less than 1 to 10 ha (Table 2). The data showed that about 61.5 % of farmers grew maize on small plots of land ranging in size less or equal to 1 ha, 27.0 % of farmers grew maize on between 1.5 to 3.0 ha with the rest being farmers' growing more than 3 ha (Table 2). In terms of maize production in the study area, levels of maize production ranged from 1 to 10 tonnes.

This is because maize farmers interviewed were small scale or small holder farmers and they were not ready to risk their investment in one crop production in case maize production fails in that season, hence undergoing other crop production aside maize production. This is translated in the output from the size of the farms which also requires high levels of farm inputs to produce more. The smaller the farm size, the lesser the farm input resulting in low yields.

About 81.5 % of maize produced ware sold directly for sale to earn cash and about 18.5 % of maize produced was used as household food. This trend was similar across all locations in for the study (Table 2).

3.3 Production Inputs and Cost for Maize

Table 3 summarizes the perceptions of farmers on the cost of inputs used in maize production. About 78.0 % of the interviewed farmers reported that the cost of seeds was too expensive. About 81.0 % of farmers responded cost of fertilizers to be too expensive in maize production (Table 3). Farmers expressed that cost of seeds and fertilizers were too expensive across all locations used for the study.

Governments of Ghana have and continue to help farmers to increase yields of farm produce by introducing social intervention in a form of subsidies to help farmer in reducing the cost of seeds and cost fertilizers, but farmers continue to complain that they do not get them.

3.4 Adoption of Maize Varieties in the Study Area

Farmers grow a range of maize varieties across the different districts of Ejura-Sekyedumasi, Nkoranza-South and Wenchi Municipality. The varieties differed across the locations used for the study (Table 4). Farmers grew the open pollinated varieties (OPVs) and local landraces. Obatanpa and Okomasa were the open pollinated varieties of maize grown across locations with 11.0 and 8.0 % respectively while the rest recorded less than 10 %. Local landraces (Aburohoma, Deakyeiburo and Dobidi) of 67 % as shown in Table 4.

Despite high use of improved maize varieties at Ejura-Sekyedumasi district farmers still use as much as 40.0 % of landraces in maize production as compared with Okomasa (13.0 %) and Obatanpa (13.0 %). The rest of improved maize varieties recorded percentage value less than 5.0 %. A similar trend was observed at Nkoranza South and Wenchi Municipality (Table 4).

3.5 Farmers-Preferred Traits of Maize

Farmers-preferred traits of maize are presented in Table 5. Highest mean yield (49.0 %), drought tolerance (18.0 %), early maturity (14.5 %) and traits such as large grain size, dense grain, storage pest resistance and others (good milling, grain palatability, intercropping suitability) were below 5.5 % (Table 5).

High yield (53.2 %) and early maturity (13.0 %) were the main traits as indicated by farmers interviewed from Ejura-Sekyedumasi district. Farmers from Nkoranza-South and Wenchi Municipality indicated high yield and drought tolerance of maize varieties as preferred across all locations (Table 5). This could be attributed to the closeness of the Forest, Transition to the savannah ecological zone where drought is the main hindrance to high yields. Breeders therefore must develop varieties that are ecological zone specific for favourable environmental conditions.

Table 2. Source of maize seed, production area, yield and uses of produce in three districts of Ghana

		District of Respondent								
Variable	**Categories**	**Ejura-Sekyedumasi**		**Nkoranza-South**		**Wenchi**		**All**		
		Freq.	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**χ2**
Source of maize seed	Farmers' saved seeds	30	39.0	28	44.4	25	41.7	83	41.5	17.387 *
	Seed companies	27	35.1	14	22.2	8	13.3	49	24.5	
	Local market	6	7.8	5	7.9	4	6.7	15	7.5	
	Agro-dealers	14	18.2	10	15.9	18	30.0	42	21.0	
	Research institutions	0	0.0	6	9.5	5	8.3	11	5.5	
	Total	77	100.0	63	100.0	60	100.0	200	100.0	
Farm size (in ha) used for maize production	≤ 1	48	62.3	41	65.1	34	56.7	123	61.5	9.208
	1.5-3	19	24.7	20	31.7	15	25.0	54	27.0	
	3.5 -10	9	11.7	2	3.2	11	18.3	22	11.0	
	>10	1	1.3	0	0.0	0	0.0	1	0.5	
	Total	77	100.0	63	100.0	60	100.0	200	100.0	
Maize production (in tonnes)	1.1-3	38	49.4	41	65.1	34	56.7	113	56.5	7.658
	3.1 -10	31	40.3	21	33.3	24	40.0	76	38.0	
	>10	8	10.4	1	1.6	2	3.3	11	5.5	
	Total	77	100.0	63	100.0	60	100.0	200	100.0	
Use of maize	Household food	4	5.2	16	25.4	17	28.3	37	18.5	14.876
	Sold to earn cash	73	94.8	47	74.6	43	71.7	163	81.5	
	Total	77	100.0	63	100.0	60	100.0	200	100.0	

**chi square significant to adoption*

Table 3. Cost of inputs for maize production with Ejura-Sekyedumasi, Nkoranza-South and Wenchi

	District of Respondent							
Responses	**Ejura-Sekyedumasi**		**Nkoranza-South**		**Wenchi**		**All**	
Cost of seeds	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Too Expensive	64	83.1	53	84.1	39	65.0	156	78.0
Affordable	13	16.9	10	15.9	21	35.0	44	22.0
Total	77	100.0	63	100.0	60	100.0	200	100.0
Cost of fertilizer								
Too Expensive	62	80.5	47	74.6	53	88.3	162	81.0
Affordable	15	19.5	16	25.4	7	11.7	38	19.0
Total	77	100.0	63	100.0	60	100.0	200	100.0

**chi square significant to adoption*

Table 4. Adoption of maize varieties using pair-wise ranking across three districts of Ghana

	District of Respondent							
Varieties	**Ejura-Sekyedumasi**		**Nkronza-South**		**Wenchi**		**All**	
	Freq	**%**	**Freq**	**%**	**Freq**	**%**	**Freq**	**%**
Others (Aburohemaa, Denkye aburo etc.)	40	51.9	50	79.4	44	73.3	134	67
Obatanpa	13	16.9	5	7.9	4	6.7	22	11
Okomasa	13	16.9	1	1.6	2	3.3	16	8
Abontem	4	5.2	3	4.8	3	5	10	5
Abeleehi	4	5.2	2	3.2	0	0	6	3
Honampa	1	1.3	0	0	5	8.3	6	3
Omankwa	1	1.3	1	1.6	2	3.3	4	2
Mamaba	1	1.3	1	1.6	0	0	2	1
Total	77	100.0	63	100.0	60	100.0	200	100.0

**chi square significant to adoption*

Table 5. Farmers-preferred maize traits across the three districts of Ghana

Farmers Preferred Maize Traits	District of respondent								
	Ejura-Sekyere		Nkoranza-North		Wenchi		All		χ^2
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	
High yield	41	53.2	29	46.0	28	46.7	79	49.0	35.53 *
Drought tolerance	9	11.7	10	15.9	17	28.3	24	18.0	
Early maturity	10	13.0	4	6.3	15	25.0	19	14.5	
Large grain size	6	7.8	5	7.9	0	0.0	11	5.5	
Multiple ears	2	2.6	4	6.3	0	0.0	6	3.0	
Storage pest resistance	4	5.2	2	3.2	0	0.0	6	3.0	
Dense grain	4	5.2	5	7.9	0	0.0	9	4.5	
Others (Good milling, grain palatability, intercropping suitability)	1.0	1.3	4.0	6.3	0.0	0.0	5.0	2.5	
Total	77.0	100.0	63.0	100.0	60.0	100.0	160.0	100.0	

**chi square significant to adoption*

Table 6. Major constraints affecting maize production at the study areas

Main Constraints	District of respondent								
	Ejura-Sekyere		Nkoranza-North		Wenchi		All		
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	χ^2
Drought	19	24.7	16	25.4	28	46.7	63	31.5	20.761 *
High cost of agro inputs	24	31.2	21	33.3	17	28.3	62	31.0	
Inadequate improved cultivar	21	27.3	24	38.1	7	11.7	52	26.0	
Poor soil fertility	13	16.9	2	3.2	8	13.3	23	11.5	
Total	77	100	63	100	60	100	200	100	

**chi square significant to adoption*

3.6 Major Constraints of Maize Production of Farmers across the Study Area

Table 6 presents the major constraints identified by farmers as affecting maize production in the study areas. Farmers identified drought, high cost of agro-inputs, poor soil fertility and unavailability of improved maize cultivars were the main major constraints of maize production across the three locations with representing 46.7, 28.3 and 13.3 % respectively. Farmers in Wenchi did unavailability of improved cultivar as a major constraint (11.7 %) as shown in Table 6.

In addition, the major constraints varied from one location to the other meaning farmers were diverse in their ability to go for adoption of theses improved seeds. Ejura-Sekyedumasi recorded a highest (31.2 %) on high cost of agro-inputs, inadequate improved cultivars (27.3 %), drought (24.7 %) and poor soil fertility (16.9 %). Farmers at Nkoranza-South gave a highest score for inadequate improved cultivar (38.1 %), high cost of agro-inputs (33.3 %), drought (25.4 %) and the least percentage of 3.2 being poor soil fertility. Farmers at Wenchi scored drought (31.5 %) and high cost of agro-input (28.3 %), poor soil fertility (13.3 %) and the least lack of improved cultivar (11.7 %) (Table 6).

4. DISCUSSION

Maize production in the study areas were dominated by smallholder farmers. Farmers identified maize as one of the major crops for food security, income and livelihood. Majority of farmers within the communities were married and older than 40 years due to farmers' perception that marrying and having families (wives and children) will reduce cost of labour on farming and passing on the legacy of farming to their children when they are no more. However, the younger generation of farmers who see otherwise continue to move away from farming.

It was obvious from the study that the majority of the respondents who cultivated maize were within the economically active age group as the average age shows a relatively young population. Age is also considered to be a determinant of adoption of improved technology. Older farmers are supposed to have increased knowledge and experience over time and are able to evaluate information of technology than younger farmers [34,35].

Gender influences the adoption of technologies as it affects the sourcing of agricultural information and use. Female farmers are more risk loath [36] and perceptions that women are not supposed to be farmers also limit their accessibility to agricultural information sources [37]. The areas have been reported to have strong migrant labour links with urban areas and most of the men, have migrated and the movement in search for new opportunities were still taking place in significant numbers within the younger population or moving away from farming [38]. According to Kaaria et al., 2007, in Africa men tend to grow crops which are considered profitable while women grow other food crops that are less profitable but useful for home consumption. Therefore, the high percentage of male farmers (83.0 %) as compared to female farmers (17 %) in maize production reflect the commercial value of maize in the study area. The male dominance in study areas is in line with the general sex structure of agricultural production systems in sub-Sahara Africa. Maize production within the sub-region is male dominated due to the high labour required. Inequality in access to production resources have also been cited as one major factor for male dominance in production. Land tenure system in most countries relatively favour males leading to their dominance. Females often play subsidiary role in terms of providing meals for farm work, planting of seed and gathering of harvest produce.

The farmers in the communities were relatively literate, with more than half with formal education. Which could consequently affect their adoption of improved maize farming technology as enlightenment enhance people decision making and analysis of situations. Since, access to agricultural information is influenced by the farmer's level of education. Farmers with formal education stand a high chance of adopting a new technology to increase production. Education gives the farmer ability to derive, decode and evaluate useful agricultural information for production [39]. This relatively low level of education among the rural households may have negative impact on adoption of agricultural technologies. The mean years of schooling of the respondent farmers in the area also mean they are unable to read and write. High level of education among farmers would make them more responsive to many agricultural extension programmes and policies [40] leading to adoption of new and improved technologies. This implies that there will be efficiency in organizing trainings and involving farmers, in plant breeding

programmes since there will be less problems in understandings instructions for increased productivity. Educational background of farmers showed some significant association with adoption of improved varieties. Dissemination and adoption of improved seeds are affected by difference in educational attainment. Farmers at Ejura-Sekyedumasi and Nkoranza-South were more willing to adopt the use of improved seed due to high level of education. Promoting improved maize seed in Ghana will require the use of dissemination materials that relate more with farmers with no formal education. Techniques such as pictures and diagrams must be encouraged.

Education had positive influence on the adoption of improved maize farming technologies, the results have shown that education influence adoption positively. The implication of this is that higher educated farmers are likely to adopt improved maize farming technologies than farmers with low level of education. Educated farmers are expected to show better adoption of technology because of their ability to understand the benefits of technology adoption and the trust they have in extension officers [41]. However, this finding showed that majority of the respondent farmers had some form of formal education. Several studies on adoption have shown positive relationship between adoption and education [42,41,43,44]. However, variables such as marital status, age, marital status and experience showed positive relations with adoption but were non-statistically significant.

Farmers continue to see marriage as a source of reducing labour in farming and to maintain family legacy where children take up farming from their parents. Farmers solely depending on farming as their primary occupation with limited resources. The observed trend could be due to the fact that majority of the population in the Municipality are Moslems [45,46]. As marital status also influences the desire increase in productivity for family consumption and income is high among farmers who are married than their counterparts who are not married [47] consider revising the information/quotation from Opara as it contains many grammatical errors. Majority of these farmers were full time farmers and maize farmers. Farmers in the study areas also sourced their seeds for planting from saved seeds from previous farming season. Even though, an appreciable number of farmers would have preferred to buy improved seeds for planting, they are prevented by high cost and unavailability of improved maize seeds. In comparison to the findings by Byerlee and Heisey, [48], that small holder farmers in sub-Saharan Africa had holdings ranging from 0.5 to 3.0 ha, farmers from the study area produced on a comparatively low scale of about 1 ha or less per farmer. Majority of farmers across the various study areas were aware of improved maize varieties already in the system or the market but adoption was low at Wenchi and Nkoranza South as compared to farmers from Ejura-Sekyedumasi. This is due to the presence of agriculture company (Ejura Farms), Research Institute (CSIR-CRI, Agriculture College and MOFA) and effective extension services at the Ejura-Sekyedumasi leading to farmers being more aware, hence adopting them.

Maize farmers continue to rely on seeds from their own fields and local market because it is cheaper and readily available as at when they are needed for planting. This were very common among older or mature farmers who dominated the studies. Most young farmers who has had formal education would prefer sourcing their seed from Agro-dealers, seed companies and other sources in their communities. This could be due to lack of extension work and ineffective dissemination technique used for the studies making it not available and inadequate in their catchment area for maize cultivation.

The mean farm size of households in the study area was about 1.9 hectares. This small farm size shows that farmers in the area are smallholders (Table 5). This implies that greater proportion of the maize farmers in the area was smallholder maize farmers. This is an indication that farming in the area is at the subsistence level. This could constraint the adoption of improved technologies due to the small farm size [40]. One of the resources that are an indicator of wealth and proxy for social status and influence is land size which has influence on farmers in the study areas and in the country as a whole. The farmer's socio-economic characteristics that include level of education, farm size and farming experience influence the adoption of improved technologies [49].

Maize farmers were also aware of improved maize varieties in the system, but their low adoption rate was attributed to high cost of seeds and fertilizer. Farmers perception is a very important source of information for policy formulation and future research. Farmers preferred varieties whose seeds can be recycled

in their quest of reducing the cost of production. Acquiring certified seeds from agro-dealer or other places can increase yield. They also attribute low adoption certify seeds a positive association with high cost of Agro-inputs. However, there are barriers to adoption of improved maize technologies which include: unavailability of credit, inadequate capacity of seed companies impeding product delivery at large scale, lack of awareness, inadequate availability of improved maize seed, and unaffordable seed price [50,51]. Technology adoption is pro poor if it benefits the poor relatively more than non-poor [52]. Clearly, such innovation or technology must be affordable to the poor in the society. Furthermore, its benefit must also be significant relative to its cost (including the adoption risks it involves). Although the benefits and determinants of adopting new farm technologies are stressed in the literature, the impact of these new technologies on poverty reduction is not well articulated.

The selection of maize varieties in the community was not as diverse as has been reported from other communities in SSA. In total, farmers listed about seven improved varieties and three landraces. Farmers at Nkoranza-South District and Wenchi Municipality cultivates more landraces compared with those in Ejura Sekyedumasi probably due to better education by Agriculture extension Agency as compared with other study areas. Obatanpa was most planted, followed by Okomasa among selected maize varieties used for the study whilst local landraces were the greatest. Thus, the study showed that the adoption of these improved varieties was low, despite the release of over 40 maize varieties in the country. Farmers cited expensive seed, need for extra expensive inputs such as fertilizer and non-tolerance to acid soil or low nitrogen as their main reasons for not growing improved varieties. This finding is in agreement with reports by Aquino et al. [53] FAO and CIMMYT, [54] that, although improved superior varieties have been developed in most countries of SSA, the majority of the small holder farmers still relied on unimproved open pollinated varieties for their plantings. This was partly because the OPVs were easy to multiply and therefore cheaper and readily available [55]. This could be attributed to their understanding of using quality seed to improve production hence sticking to their informal seed system where they save seeds for next farming production.

Farmers preferred growing the landraces mainly for its early maturity, recycled seed, tolerance to acidic soils and drought and satisfactory yields even during bad seasons. In general, high yield, drought tolerance, early maturity and large grain size were their preferred maize traits. This agrees with findings by Magorokosho, [55] on landraces collected from Malawi, Zambia and Zimbabwe, whereby farmers kept landraces because of their taste, tolerance to abiotic and biotic stresses, early maturity and yield stability. Most of these farmers grew the improved varieties and preferred them because they are prolific, giving two or three cobs per plant.

Drought and cost of seed were the most important factors considered by farmers when choosing a variety, with most farmers desiring varieties with seed that could be recycled and their ability to withstand the changing environment. Although, the farmers preferred growing their local varieties for taste, they still preferred high yield. Early maturity and low cost of inputs were also important characteristics considered by farmers. The farmers planted early to escape drought and thus preferred early maturing varieties. Obatanpa was chosen because of its high yielding ability and a medium variety (110 days), farmers prefer planting it in the wet season followed by Okomasa also high yielding and late variety (120 days). These improved OPVs were preferred mainly because farmers could recycle their seed unlike hybrid and yields more as compared with landraces.

Farmers indicated they would want to grow improved varieties, but only if cost of seeds and other inputs required are subsidized, and characteristics they preferred were incorporated into these varieties. Additionally, most of the farmers cultivated maize purely for existence, therefore, there is no incentive for them to buy maize seeds at relatively higher cost. Nevertheless, opportunity exists for improving the landraces for yield and still maintain the other characteristics preferred by the farmers or introduce other improved open-pollinated varieties which incorporate the farmers' preference. When this is done, there is likelihood of increasing their adoption rate by farmers, which will enhance their productivity.

Farmers' main constraints differed across location by small holder farmers with small similarities among them, which can be due to changes in different ecological zones and accessibility of improved maize cultivar coupled

with high cost of inputs used in production. Hence breeders have to develop cultivars or varieties based on these main constraints in agriculture [56-61].

5. CONCLUSION

The study utilized PRA to interact with farmers with view to identify the most important farmers-preferred traits and constraints limiting adoption of improved maize varieties and subsequently increased production in the study areas. High grain yield, drought tolerance and early maturity constituted the preferred traits. Further, drought, poor soil fertility, and cost of both fertilizers and improved seed were identified as major constraints. Knowledge of preferences of farmers and production constraints identified in the study area will be useful to maize breeders in releasing specific varieties for specific agro-ecological zones or areas to enhance the productivity of maize in the Ghana.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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