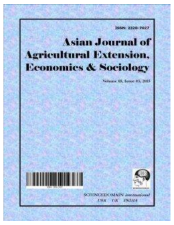

Asian Journal of Agricultural Extension, Economics & Sociology

26(1): 1-21, 2018; Article no.AJAEES.41366
ISSN: 2320-7027

Farmers' Ability to Identify Maize Traits and Their Implications on DUS Testing in Selected Agro-Ecological Zone

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Authors' contributions

This work was carried out in collaboration between all authors. Author CAD designed the study, wrote the protocol and wrote the first draft of the manuscript. Authors JSA and JNB are supervisors who reviewed manuscript and made the necessary corrections. Author PFR managed the literature searches. Author NEA managed the performed the statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2018/41366
Editor(s):
(1) Dr. Anthony N. Rezitis, Professor, Agricultural Policy, Department of Economics and Management, University of Helsinki, Finland and Department of Business Administration of Food and Agricultural Products, Universiy of Patras, Greece.
Reviewers:
(1) Kabi Pokhrel, Tribhuvan University, Nepal.
(2) Lawal Mohammad Anka, Nigeria.
Complete Peer review History: http://www.sciencedomain.org/review-history/25335

Original Research Article

Received 8th March 2018
Accepted 16th May 2018
Published 30th June 2018

ABSTRACT

Aims: To access farmers' ability to identify traits of their preferred maize varieties and their implication on DUS testing.
Study Design: Purposive Sampling of Maize farmers.
Place and Duration of Study: Data were collected from two (2) districts (Ejura-Sekyeredumasi and Nkoranza North) and villages of Wenchi Municipality of a selected smallholder farming area in Ghana using a survey covering one hundred and seventy (170) maize farmers in 2015.
Methodology: Results indicated a limited selection of hybrids and improved open-pollinated varieties (OPV) grown by farmers in the area under study. More than 90 % of the farmers grew local landraces (Abrohoma or Appiah and Denkyeaburo) and the majority of the farmers were

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males. The results showed that bulk of the farmers were illiterate and youth farmers showing great prospect to future farming. Hybrids and improved OPVs were planted by less than 10% of the farmers. Abrohoma landraces had a characteristic similar to the hybrids and OPVs according to their abilities and their preferred characteristics of maize varieties with high yield, tolerance to abiotic stress, yield stability, white grain color and drying and shelling qualities. Farmers were willing to grow hybrids and improved (OPVs) if their preference and availability were considered.

Conclusion: The results showed that breeding opportunity exists for improving the farmer's local landraces and their ability to check off type with their long years of experience in growing maize. Plant breeders can therefore take advantage of this by incorporating farmers preferred traits into existing high yielding varieties.

Keywords: Hybrids and improved open-pollinated varieties; Abrohoma or Appiah and Denkyeaburo.

1. INTRODUCTION

In sub-Saharan Africa (SSA) and the developing world, maize (*Zea mays L.)* is an important food security crop [1]. Under diverse climatic and ecological conditions, it is produced in different parts of SSA owing to its widespread adoption and adaptation [2,3,4,5]. Approximately three hundred million smallholder farmers in SSA, the crop has become a major staple and cash crop [6,7,8,9,10]. It has also been providing about 30% of the daily calories for more than 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 53.2g and its demand is projected to double globally by 2050 [15]. In Ghana, maize is the largest staple crop and contributes significantly to consumer diets [16]. It is also the number one crop in terms of area planted and accounts for 50-60% of total cereal production [17]. Maize demand has been projected to grow at annual compound rate of 2.6% between 2010 and 2015 [18]. Rising population, urbanization, and growing poultry and fish sectors in Ghana have contributed to increased demand for maize. Per capita consumption, mainly of white maize, grew only marginally from 38.4 kg in 1980 to 43.8 kg in 2011 [19]. Without productivity improvements, Ghana's Ministry of Food and Agriculture (MoFA) estimates that 267,000 metric tons of maize will have to be imported in 2015 to meet domestic demand [20]. Ghana is not self-sufficient in this most important staple crop, as Ghana has experienced average shortfalls in domestic maize supplies of 12% [18]. Maize yields in Ghana averaged 1.2–1.8 metric tons (mt) per hectare (ha), far below the potential yield of 4–6 mt/ha achieved in on-station trials [21] and over 8 mt/ha in the US [19]. High costs and the unavailability of production inputs reduce farmers' opportunity to use them, leading to low crop yields [22,23]. There has also been a low adoption rate of some improved cultivars because they lack one or more of the critical traits of farmers' preference, and most perform poorly under typical farmers low input conditions [24,25,26,27,28,29]. As a result, most of the farmers have continued using their own landraces [25,30] which are low yielding. Participatory will rapidly improve food security through improved adoption of farmers to newly improved crops cultivars [31].

Farmers should, therefore, be involved not only in identification of their key preferences, but also in developing, testing and selection of new crop cultivars to increase their adoption rate [32,3,33, 28,34,35]. The use of formal participatory research appraisal (PRA) can facilitate detection and collection of farmers' information for research [32,36], preferably when different tools such as semi-structured survey and FGD are used in combination [24,33]. Participatory research appraisal is an active multi-disciplinary research approach that uses a wide range of techniques or tools such as matrix and pairwise ranking, focus group discussions, transect walks, seasonal calendars and historical times to extract information from farmers [37,38,24,39]. This approach is powerful in data collection and flexible because it can be done in parallel with other survey techniques such as semi-structured interviews to determine the farmers' views regarding the use of a particular technology or product [40,1,35]. Focused group discussions are a form of interactive qualitative research in which a group of people are asked about their perceptions, opinions, beliefs, and attitudes towardsa product, service, concept, advertisement, or idea. The tool provides insights into farmers thoughts and a deeper understanding of the phenomena being studied and has been extensively used in maize breeding [38,41,29,42].

Matrix and pairwise rankings are important tools in focus group discussions that aid scientists to assess and rank the relative importance of farmers' traits of economic importance, their preferences and production constraints. The tools can produce sound results if they are used in combination with some techniques, e.g., triangulation or probing [26,38,43,44]. A semi-structured interview is an important survey technique used to identify farmers' ideas. It works best as a complement to other qualitative research such as focus group discussions (FGD) [43,41,28]. Therefore, the objective of this study was to determine farmers preferred maize varieties and assess farmers' perception of basic morphological and physiological characteristic of varieties used by farmers and their personal involvement.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The research was conducted in three districts; Wenchi Municipal and Nkoranza in the Brong Ahafo region and Ejura-Sekyeredumasi in the Ashanti region of Ghana. The three districts are located in the agro-ecological zone of the transformation of forest savannah. The district of Ejura Sekyeredumasi is found in the northern part of the Ashanti region and the municipality of Wenchi in the western part and the district of Nkoranza in the central part of the Brong Ahafo region. The average annual rainfall varies between 1140 and 1270 mm at Wenchi, between 1200 and 1400 mm at Nkoranza and between 1200 and 1500 mm at Ejura-Sekyeredumasi. Ten villages (Ejura Sekyeredumasi), eleven (Nkoranza North) and five (Wenchi) were selected in each district using expansion agents based on maize production volumes, accessibility and presence research activities.

Villages considered within Ejura -Sekyeredumasi District include; Miminaso #1, Miminaso #2, Nyame Beyere, Bayere Nkwanta, Aframso, Teacherkrom, Yaabraso, Kobriti, Franti and Sekyeredumasi as shown in Fig. 1. Their attitudes and coordinates are shown in Appendix 1.

Villages considered at Nkoranza District includes; Bredi, Prusu, Nkankama, Nyame Beyere, Ayirede, Grumakrom, Dandwa, Akropong, Abuontem, Barnofour and Donkor Nkwanta as shown in Fig. 2.

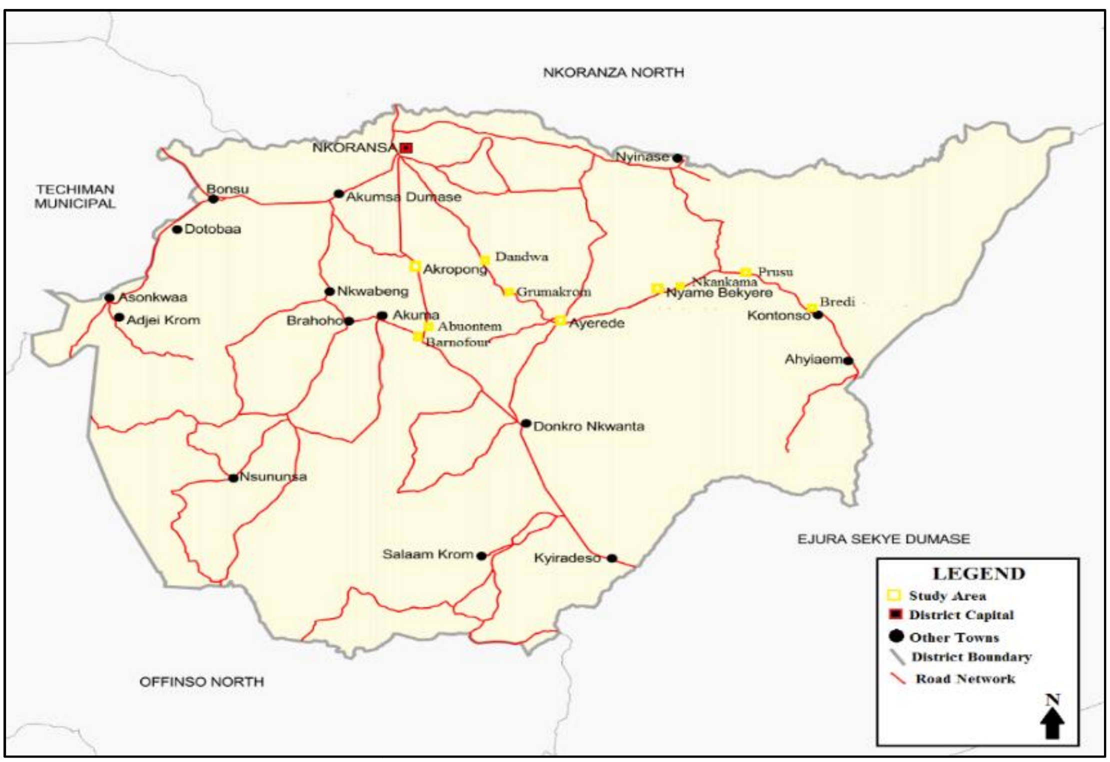

Figure 1. Map of Ejura-Sekyeredumasi municipal showing the study areas

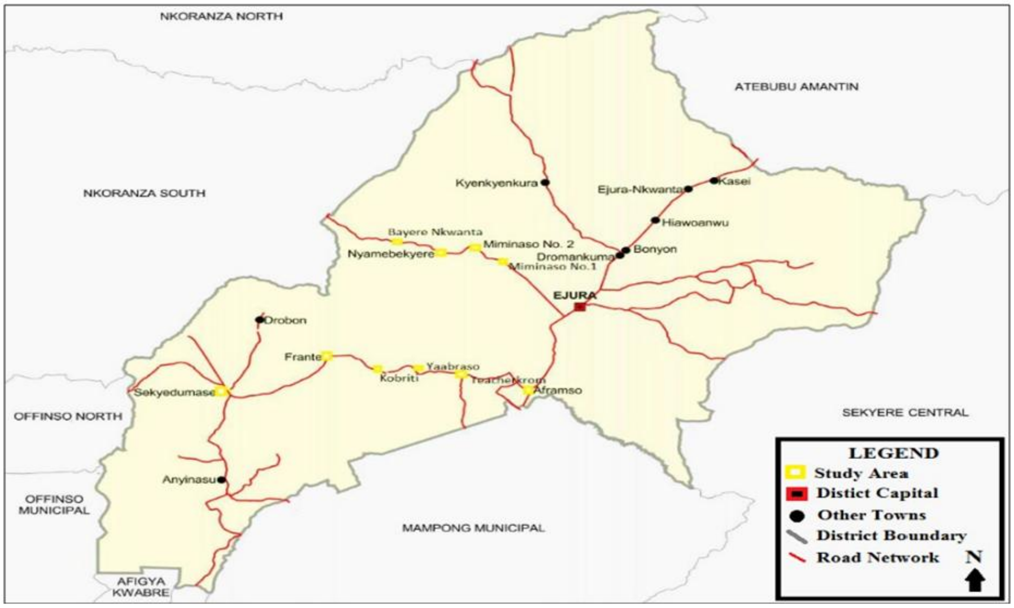

Figure 2. Map of Nkoranza South Municipal showing the study areas

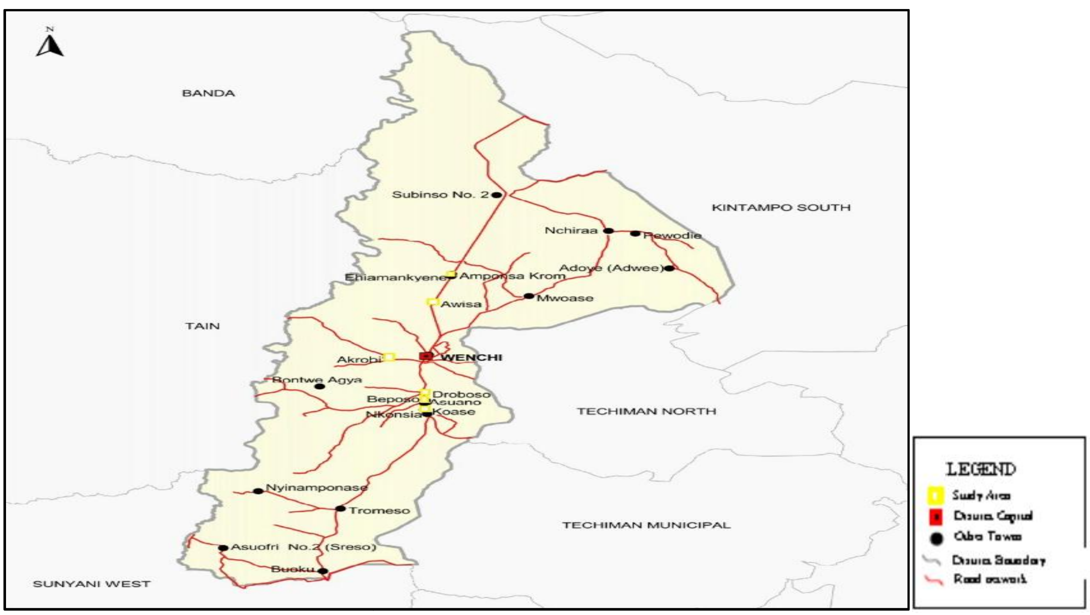

Figure 3. Map of Wenchi Municipal showing the study areas

Awisa, Amponsakrom, Akrobi Droboso, Beposo and Koaso were villages considered at Wenchi Municipal as shown in Fig. 3.

All districts are characterized by a bimodal precipitation regime (the main season is April-July, while the small season is August/September-November) and therefore have two growing seasons. Temperatures in the districts range from 21°C to 30°C. The main occupation in these districts is agriculture and maize or corn is one of the most important crops.

2.2 Selection of Farmers

One hundred and seventy small farmers participated in the study. They have been identified through local agents for agricultural extension. Participants were randomly selected, regardless of age, gender, experience or status in the community and others.

2.3 Survey Procedure and Data Analysis

Focus groups were organized in each village in each district. Each group consisted of 6-7 farmers. Prior to the group discussions, farmers were not informed that the purpose of the study was to provide basic identification of the morphological and physiological characteristics of some released varieties to avoid possible bias in their responses. All farmers in the focus group were maize farmers. The issues discussed include the early characteristics of leaves, leaves, stems and ears. Data were analyzed using SPSS version 16. Descriptive statistics such as the number of frequencies, percentages and graphs were used to describe the characteristics of the collected variables.

3. RESULTS

3.1 Socio-demographic Characteristics

A total of 170 respondents were sampled across 26 villages purposively selected from 3 Ministry of Food and Agriculture administrative areas namely Ejura Sekyeredumasi (Ashanti Region), Nkoranza North and Wenchi Municipal (Brong Ahafo Region). There were 73, 63, and 34 respondents respectively, in each district.

Sex distribution showed 85% male dominance over 15% female participation. It is widely believed in the Ghanaian setting that farming is the preserve of men [45] but [46] made reference to the fact that, female involvement in farming activities was on the increase. This could mean a change in the cultural orientation of the Ghanaian farming community on gender roles.

For this study and to better understand how age distribution affects production in agriculture, the working class was thus divided into youthful farmers (15-35) and matured and ageing farmers (46-64). The youthful farmers represent the more active farmers and the matured farmers represented the gradually aging farmers.

Matured farmers (58%) were in the majority as indicated in Table 1. Consistently at each location, the matured farmers were in the majority. Matured farmers served as a pool of experience for the youthful farmers on issues of crop production and marketing of output. [47] observed that age among other factors of production was not significant in determining productivity and that its effect was negligible. Respondents with no education were 44.1 % (Table 1). By implication, 66% of respondents has some level of education from basic to the tertiary level. This serves as a good prospect for technology adoption. [48], as well as [49], showed that agricultural technological practices and adoption are positively related to education. Years of formal education among responding farmers between 8 and 13 years.

Eighty-six (86) percent of respondents were married. Marriage in the Ghanaian setting is perceived to have a positive impact on farming. Married households have support for farm work from the spouse and children hence reducing the cost of labour. By virtue of the fact that farmers in the study area use family labour in their field activities, marital status could have a positive influence on maize production by reducing cost of hiring labour and ensuring efficiency since family labour would be motivated by the desire to get higher yields for a higher income.

As indicated in Table 1, in terms of the dominant profession, most (88%) of the respondents were farmers. Other professions representing the 8% of total respondents were Trading, Mining, Hair Saloon activities, driving, tractor operation, teaching and carpentry, whilst 4% were students and public workers (Table 1).

3.2 Personnel Involvement in Farming

Due to the purposive selection of maize growers, all respondents were predominantly maize growers. In relation to awareness of improved maize varieties, 93% of respondents were aware of varied types of improved maize varieties (Table 2). In a study on agricultural technology, [50] emphasized that awareness of a technology was premier in adoption and it was a period in which the existence of a technology is made known to the farmer. [51] also empirically showed that expertise sampled adoption rate is not a consistent estimate of the actual adoption rate of the population if it was not preceded by awareness. Awareness is therefore a pre-requisite for adoption.

In relation to adoption, 38% of respondents who were aware of the improved varieties were actually growing them or had cultivated them in the last 5 years as indicated in Table 2. This could be due to many other factors as established by [52]. Low adoption was primarily due to lack of access to certified seeds and high cost of seeds and other agro-inputs such as herbicides and fertilizer among others.

Table 1. Socio-demographic characteristics of the farmers at Wenchi, Ejura-Sekyeredumasi and Nkoranza-North

Characteristic	Districts/Municipality			Overall mean
	Wenchi	Ejura-Sekyeredumasi	Nkoranza North	
Age of Respondent (%)				
Youth farmers (15-35 ages)	41.2	38.4	36.5	38.7
Matured farmers (36-60ages)	52.9	56.2	63.5	57.5
Aged (60 ages and above)	5.9	5.5	0	3.8
Gender of Respondent (%)				
Male	97.1	87.7	76.2	87
Female	2.9	12.3	23.8	13
Highest Formal Education (%)				
No Education	67.6	32.9	44.4	48.3
Primary	2.9	5.5	11.1	6.5
Middle/JHS	20.6	32.9	30.2	27.9
Secondary	8.8	19.2	12.7	13.6
Bachelor's Degree	0	9.6	1.6	3.7
Marital Status (%)				
Single	14.7	17.8	7.9	13.5
Married	85.3	79.5	92.1	85.6
Divorced	0	1.4	0	0.5
Widowed	0	1.4	0	0.5
Profession (%)				
Regular	0	4.1	0	1.4
Student	0	5.5	1.6	2.4
Farmer	91.3	89	84.1	88.1
Others	8.7	1.4	14.3	8.1

Table 2. Adoption studies of improved maize varieties (IMV) at Ejura-Sekyeredumasi, Wenchi and Nkoranza North

	Districts							
	Wenchi Municipal		Ejura-Sekyeredumasi		Nkoranza North		Total	
Awareness of improved maize variety								
	Freq.	**Perc (%)**	**Freq.**	**Perc (%)**	**Freq.**	**Perc (%)**	**Freq.**	**Perc (%)**
No	0	0	4	5.6	8	66.7	12	10
Yes	38	100	67	94.4	53	33.3	153	90
Total	38	100	71	100	61	100	170	100
Adoption of improved maize variety								
No	27	79.4	30	41.1	49	77.8	106	62.4
Yes	7	20.6	43	58.9	14	22.2	64	37.6
Total	34	100	73	100	63	100	170	100

It came to light that male farmers had a higher awareness (85%) than the female farmers, the adoption rate was higher in male farmers than the female farmers (Appendix 4).

Specific improved maize varieties considered for the study were Okomasa, Honampa, Obatanpa, Etubi, Enibi, Abeleehi, Mamaba, Dodzi, Akposoe, Dorke SR, Aburohemaa, Omankwa and Tintim. It is worth noting that the most grown varieties were Obatanpa (34%), Okomasa (25%), Abeleehi (19 %), Abontem (18 %), Omankwa (12 %) and Mamaba (11 %). Percentages are in absolute terms per variety (Appendix 3). Males predominated adoption across all the varieties.

On the identification of improved maize variety, highest number of male farmer was able to identify Obatanpa (21%) against 4% female. This followed by about 4% females and 15% males could identify Okomasa while 96% females and 85% males could not identify Okomasa based on their appearance. Honampa could be identified by only 4% males but no female could identify it. 8% female and 12% male farmers could identify the Abontem variety. Lastly, 4% females and 8% males identified Mamaba variety. The results showed that 1% of the male's farmers could identify the Etubi, Enibi, Akposoe, Aburohemaa and Omankwa varieties, whilst no female farmer could identify these varieties. Additionally, no farmer could identify Dodzi and Dorke varieties while 11% and 2% males indicated their ability to identify Abeleehi and Tintim varieties (Appendix 2).

Generally, the most identified varieties were Obatanpa (19%), Okomasa (14%), Abontem (12%), Abeleehi (11%) and Mamaba (8%) among others. The most important features of identification of the varieties were by the matured ear, matured leaf and yield potential of their preferred maize variety. As the case was with adoption, the male farmers were able to identify varieties by appearance more than the female farmers (Appendix 3).

4. DISCUSSION

Maize production in the agroecological zone of Ghana is dominated by smallholder farmers (SHFs). For their food security, income and livelihoods improvement, farmers identified maize as one of the major crops. The demographic approach of the house was incorporated into this investigation, on the grounds that the aftereffects of CIMMYT [53] demonstrated that distribution of assets, the extent of family exercises and data access by expansion administrations were fundamental for agriculturists help to receive breeds. [54] have demonstrated that "farmer/a rancher's choice to apply or dismiss another innovation is impacted by a blend of components identified with the farmer's objectives and constraints, for instance: the social-monetary states of the agriculturist; farmers (age, formal training) and the money related methods for the agriculturists (e.g. the family size work, the homestead measure/farm size and ownership of livestock). The high percentage of male farmers (87%) compared to female farmers (13%) who are engaged in maize production (Table 1) reflects the high commercial values of maize in the study areas. In Africa, men tend to grow crops which are considered profitable and women grow other food crops that are less profitable but useful for home consumption [55].

The use of matrix and pairwise ranking tools during group discussions (FGD) aided identification of most farmers–preferred traits, the predominately grown maize varieties and production constraints in the study areas. According to [23], maize traits of preferences to farmers influence the direction of breeding research and have been widely used in cultivar development and selection.

Farmers reported that farm inputs and recently army worm pest are important biotic constraints to maize production in the study areas of Ghana. Several PRA studies have reported similar constraints to maize production [56,57,58]. This study suggests that to improve maize productivity in the study areas, farmers have to use maize varieties with improved attributes such as resistance for MSV disease, insect pests (stalk borer and army worm in particular) and drought stresses.

In addition, [59] reported that farmers are not a uniform gathering; they contrast in their inclinations and needs to be taken into account in future crop improvement programs. For instance, eastern Kenya farmers suggested a preference for early maturity above yield, after that performance characters, such as corncob size, cereals, and tolerance to wheat. drought [60]. In a few groups in South Africa, [61] revealed that separated from traits related to yields, farmers often mention early varieties, hard endosperm species (flint) and good skin for the corn varieties they preferred. A study in Guinea's savannahs in Nigeria additionally discovered contrasts among farmers in their favored decision of maize varieties [62]. For instance, relatively market-oriented growers in communities in Nigeria's Borno State favored early-drought-resistant and high-yielding species [62]. Farmers of relatively low sorghum production in Kano State, Nigeria, on the other hand, prefer to use additional early varieties to ensure food security duringthe food shortage period instead of high-yielding species [62]. It is so significant to determine the characteristics of farmers in crop varieties or to include farmers in a varied selection process. This increases the probability for acceptance of varieties by farmers.

Despite the good number of farmers involved in the PRA study and their response on various issues pertaining maize production, most of them failed to give the actual yield from their fields because they account only the final crop yield harvested and not considering the maize eaten as a green cob. This is a challenge that needs to be considered when conducting survey with farmers. Another challenge was the fact that female farmers could not talk with full freedom in presence of their husbands, especially in some villages.

5. CONCLUSIONS

The current study identified the most important farmers-preferred traits and constraints that limit maize production in the study areas. Farmers reported that high grain yield, disease resistances and drought tolerance are the most preferred traits for maize in the study areas of Ghana. Farmers' preferences play a role in the adoption process of new products or technologies and have been widely studied elsewhere. To enhance maize productivity, farmers-preferences need to be integrated from the initial stages of breeding and technology development for successful adoption by end-users. Knowing farmers' preferences and production constraints identified in the study area will be useful to maize breeders to enhance the productivity of maize in Ghana.

ACKNOWLEDGEMENT

We wish to acknowledge the West Africa Agricultural Productivity Programme (WAAPP) for the financial support for the study and Crops Research Institute, Kumasi, Ghana.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Appendix 1. Names of districts, villages, attitude and coordinates

Ejura Sekyeredumasi District: Placeand Altitude	Coordinates
Miminaso #1 (236 m)	N 07^{O} 25. 224' and W 001^{O} 24. 774'
Miminaso #2 (226 m)	N 07^{O} 25. 691' and W 001^{O} 25. 378'
Nyame Beyere (287 m)	N 07^{O} 25. 565' and W 001^{O} 26. 752'
Bayere Nkwanta (300 m)	N 07^{O} 25. 888' and W 001^{O} 27. 392'
Aframso, (162 m)	N 07^{O} 81. 673' and W 001^{O} 23. 398'
Teacherkrom (189 m)	N 07^{O} 19. 534' and W 001^{O} 26. 063'
Yaabraso (197 m)	N 07^{O} 19. 528' and W 001^{O} 27. 522'
Kobriti (270 m)	N 07^{O} 19. 646' and W 001^{O} 28. 524'
Franti (250 m)	N 07^{O} 20. 409' and W 001^{O} 30. 837'
Sekyeredumasi (310 m)	N 07^{O} 18. 368' and W 001^{O} 34. 394'
Nkoranza District: Place and Altitude	**Coordinates**
Bredi (248 m)	N 07^{O} 29. 275' and W 001^{O} 31. 782'
Prusu (185m)	N 07^{O} 30. 558' and W 001^{O} 33. 931',
Nkankama (191m)	N 07^{O} 30. 041' and W 001^{O} 35. 583'
Nyame Beyere (210 m)	N 07^{O} 29. 900' and W 001^{O} 35. 973'
Ayirede (232 m)	N 07^{O} 29. 024' and W 001^{O} 38 355'
Grumakrom (257 m)	N 07^{O} 29. 856' and W 001^{O} 39. 825'
Dandwa (295 m)	N 07^{O} 31. 046' and W 001^{O} 40. 489'
Akropong (265 m)	N 07^{O} 30. 584' and W 001^{O} 42. 067'
Abuontem (278 m)	N 07^{O} 28. 628' and W 001^{O} 41. 913'
Barnofour (215m)	N 07^{O} 26. 872' and W 001^{O} 40. 387'
Donkor Nkwanta (225 m)	N 07^{O} 26. 054' and W 001^{O} 39. 601'
Wenchi Municipal, **Place and Altitude**	**Coordinates**
Awisa (311m)	N 07^{O} 48. 458' and W 002^{O} 06. 077'
Amponsakrom (298 m)	N 07^{O} 51. 583' and W 002^{O} 04. 925'
Akrobi (246 m)	N 07^{O} 44. 668' and W 002^{O} 07. 822'
Droboso (265 m),	N 07^{O} 42. 308' and W 002^{O} 06. 381'
Beposo (260 m)	N 07^{O} 41. 507' and W 002^{O} 06. 371’
Koaso (258 m)	N 07^{O} 40. 808' and W 002^{O} 06. 406'

Appendix 2. Level of identification and specific part of identification of improved variety at Ejura Sekyeredumasi, Nkoranza North and Wenchi

	Gender of Respondent									
Varieties	Can they identify by appearance				If yes can they identify them by part					
	Gender (%)	Yes	No	Total	Ear	Silk	Leaf	Yield	None	Total
ABELEEH	Female	8	92	100	8	0	0	0	92	100
	Male	12	88	100	9	0	1	1	89	100
	Total	11	89	100	17	0	1	1	81	100
MAMABA	Female	4	96	100	4	0	0	0	96	100
	Male	8	92	100	8	0	0	1	91	100
	Total	8	92	100	7	0	0	1	92	100
ABONTEM	Female	8	92	100	4	0	0	4	92	100
	Male	12	88	100	8	0	0	3	88	100
	Total	12	88	100	8	0	0	4	89	100
DODZI	Female	0	100	100	0	0	0	0	100	100
	Male	0	100	100	0	0	0	0	100	100
	Total	0	100	100	0	0	0	0	100	100
AKPOSOE	Female	0	100	100	0	0	0	0	100	100
	Male	1	99	100	1	0	0	0	99	100
	Total	1	99	100	1	0	0	0	99	100
DORKE SR	Female	0	100	100	0	0	0	0	100	100
	Male	0	100	100	0	0	0	0	100	100
	Total	0	100	100	0	0	0	0	100	100
ABUROHEMAA	Female	0	100	100	0	0	0	0	100	100
	Male	1	99	100	1	0	0	0	99	100
	Total	1	99	100	1	0	0	0	99	100
OMANKWA	Female	0	100	100	0	0	0	0	100	100
	Male	1	89	100	7	0	1	3	89	100
	Total	9	91	100	6	0	1	3	91	100
TINTIM	Female	0	100	100	0	0	0	0	100	100
	Male	2	98	100	1	0	0	1	98	100
	Total	2	98	100	1	0	0	1	98	100

Varieties	Gender of Respondent									
	Can they identify by appearance				If yes can they identify them by part					
	Gender (%)	Yes	No	Total	Ear	Silk	Leaf	Yield	None	Total
OKOMASA	Female	4	96	100	0	0	0	0	100	100
	Male	15	85	100	10	0	0	4	86	100
	Total	14	86	100	9	0	0	4	88	100
HONAMPA	Female	0	100	100	0	0	0	0	100	100
	Male	4	96	100	3	0	0	1	96	100
	Total	4	96	100	3	0	0	1	96	100
OBATANPA	Female	4	96	100	0	0	0	4	96	100
	Male	21	79	100	14	1	1	6	79	100
	Total	19	81	100	12	1	1	6	81	100
ETUBI	Female	0	100	100	0	0	0	0	100	100
	Male	1	99	100	1	0	0	0	99	100
	Total	1	99	100	1	0	0	0	99	100
ENIBI	Female	0	100	100	0	0	0	0	100	100
	Male	1	99	100	0	0	0	1	99	100
	Total	1	99	100	0	0	0	1	99	100

Appendix 3. Level of adoption on gender based of improved variety at Ejura Sekyeredumasi, Nkoranza North and Wenchi

	Adoption of improved maize varieties			
Varieties	**Responses (%)**	**Yes**	**No**	**Total**
OKOMASA	Female	20	80	100
	Male	26	74	100
	Total	25	75	100
HONAMPA	Female	0	100	100
	Male	5	95	100
	Total	4	96	100
OBATANPA	Female	28	72	100
	Male	35	65	100
	Total	34	66	100
ETUBI	Female	0	100	100
	Male	1	99	100
	Total	1	99	100
ENIBI	Female	0	100	100
	Male	1	99	100
	Total	1	99	100
ABELEEHI	Female	12	88	100
	Male	20	80	100
	Total	19	81	100
MAMABA	Female	8	92	100
	Male	12	88	100
	Total	11	89	100
ABONTEM	Female	16	84	100
	Male	19	81	100
	Total	18	82	100
DODZI	Female	0	100	100
	Male	0	100	100
	Total	0	100	100
AKPOSOE	Female	0	100	100
	Male	1	99	100
	Total	1	99	100
DORKE SR	Female	0	100	100
	Male	0	100	100
	Total	0	100	100
ABUROHEMAA	Female	0	100	100
	Male	1	99	100
	Total	1	99	100
OMANKWA	Female	0	100	100
	Male	14	86	100
	Total	12	88	100
TINTIM	Female	88	12	100
	Male	90	10	100
	Total	89	11	100

Appendix 4. Farmers knowledge on their desired trait at Ejura-Sekyeredumasi, Wenchi and Nkoranza-North

	Varieties																					
	Okomasa		Honampa		Obatanpa		Abeleehi		Mamaba		Abontem		Omankwa		Abrohoma		Dobidi		Abrodenkye		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
ANTHOCYANIN PRESENT VAR1																						
Yes	2	13.3	0	0	9	47.4	1	16.7	1	50	0	0	0	0	9	8.9	1	10	1	25	24	14.1
No	2	13.3	0	0	5	26.3	4	66.7	1	50	2	25	0	0	35	34.7	6	60	1	25	56	32.9
DO NOT KNOW	11	73.3	2	100	5	26.3	1	16.7	0	0	6	75	3	100	57	56.4	3	30	2	50	90	52.9
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
SHAPE OF TIP VAR1																						
YES	4	26.7	0	0	6	33.3	0	0	1	50	1	12	0	0	19	18.8	1	10	0	0	32	18.9
NO	0	0	0	0	1	5.6	0	0	0	0	0	0	0	0	11	10.9	2	20	0	0	14	8.3
DO NOT KNOW	11	73.3	2	100	11	61.1	6	100	1	50	7	88	3	100	71	70.3	7	70	4	100	123	72.8
Total	15	100	2	100	18	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	169	100
IF Q4.1 IS YES, HOW? VAR1																						
POINTED	0	21.1	0	0	0	15.6	1	100	4	21	0	0	5	16	0	0	0	0	0	0		100
POINTED TO ROUND	3	21.1	0	100	1	28.1	0	0	4	21	1	100	9	28		75	0	0		100	0	0
ROUND	1	31.6	5	0	0	37.5	0	0	6	32	0	0	12	38		25		83	0	0	0	0
SPATULATE	0	26.3	1	0	0	18.8	0	0	5	26	0	0	6	19	0	0		17	0	0	0	0
Total	4	100	6	100	1	100	1	100	19	100	1	0	32	100		100		100		100		100
LEAF ANGLE BETWEEN BLADE AND STEM VAR1																						
YES	4	26.7	0	0	2	10.5	0	0	1	50	1	13	0	0	9	8.9	1	10	1	25	19	11.2
NO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0	0	1	25	5	2.9
DO NOT KNOW	11	73.3	2	100	17	89.5	6	100	1	50	7	88	3	100	88	87.1	9	90	2	50	146	85.9
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
IF 4.2 IS YES, HOW? VAR1																						
SMALL	0	0	1	66.7	0	100	0	0	6	40	1	100	0	0	8	40	0	0	5	50	0	0
LARGE	2	100	1	33.3	1	0	1	0	3	40	0	0	0	0	8	40	6	40	5	50		100
VERY LARGE	3	0	0	0	0	0	0	100	0	20	0	0	1	100	4	20	6	60	0	0	0	0
Total	5	100	2	100	1	100	1	100	9	100	1	100	1	100	20	100	10	100	50	100		100
INCLINATION OF BLADE VAR1																						
YES	1	6.7	0	0	0	0	0	0	1	50	1	12.5	0	0	1	1	1	10	1	25	6	3.5
DO NOT KNOW	14	93.3	2	100	19	100	6	100	1	50	7	87.5	3	100	100	99	9	90	3	75	164	96.5
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100

	Varieties																					
	Okomasa		Honampa		Obatanpa		Abeleehi		Mamaba		Abontem		Omankwa		Abrohoma		Dobidi		Abrodenkye		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
IF Q4.1 IS YES, HOW? VAR1																						
RE-CURVED	1	100	1	100	1	83.3	0	0	1	100	1	100	5	83		100		100		100		0
STRONGLY RE-CURVED	0	0	0	0	0	16.7	1	100	0	0	0	0	1	17		0		0		0		100
Total	1	100	1	100	1	100	1	100	1	100	1	100	6	100		100		100		100		100
DEGREE OF DIGZAGGING VAR1																						
NO	14	93.3	2	100	9	47.4	2	33.3	2	100	7	87.5	2	66.7	76	75.2	5	50	3	75	122	71.8
DO NOT KNOW	1	6.7	0	0	10	52.6	4	66.7	0	0	1	12.5	1	33.3	25	24.8	5	50	1	25	48	28.2
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
IF Q4.4 IS YES, HOW? VARIETY 1																						
ABSENT	14	100	2	100	9	100	2	100	1	50	7	100	2	100	76	100	5	100	3	100	121	99.2
STRONG	0	0	0	0	0	0	0	0	1	50	0	0	0	0	0	0	0	0	0	0	1	0.8
Total	14	100	2	100	9	100	2	100	2	100	7	100	2	100	76	100	5	100	3	100	122	100
ANTHOCYANIN COLORATION OF BRACE ROOT VAR1																						
YES	0	0	1	50	3	15.8	0	0	1	50	1	12.5	2	66.7	3	3	2	20	1	25	14	8.2
NO	1	6.7	0	0	1	5.3	0	0	0	0	1	12.5	0	0	19	18.8	0	0	1	25	23	13.5
DO NOT KNOW	14	93.3	1	50	15	78.9	6	100	1	50	6	75	1	33.3	79	78.2	8	80	2	50	133	78.2
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
TIME OF ANTHESIS, 50% OF PLANT VAR1																						
YES	13	86.7	1	50	17	89.5	6	100	1	50	7	87.5	3	100	48	47.5	7	70	2	50	105	61.8
NO	1	6.7	0	0	1	5.3	0	0	0	0	1	12.5	0	0	5	5	0	0	1	25	9	5.3
DO NOT KNOW	1	6.7	1	50	1	5.3	0	0	1	50	0	0	0	0	48	47.5	3	30	1	25	56	32.9
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
ANTHOCYANIN COLORATION AT THE BASE OF FLOWER VAR1																						
YES	1	6.7	0	0	1	5.3	0	0	1	50	1	12.5	0	0	1	1	0	0	0	0	5	2.9
NO	1	6.7	0	0	0	0	0	0	0	0	0	0	0	0	13	12.9	0	0	0	0	14	8.2
DO NOT KNOW	13	86.7	2	100	18	94.7	6	100	1	50	7	87.5	3	100	87	86.1	10	100	4	100	151	88.8
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
ANTHOCYANIN COLORATION OF FLOWER EXCLUDING BASE VAR1																						
YES	1	6.7	0	0	1	5.3	0	0	1	50	0	0	0	0	0	0	0	0	0	0	3	1.8
NO	1	6.7	0	0	0	0	0	0	0	0	0	0	0	0	6	5.9	1	10	0	0	8	4.7
DO NOT KNOW	13	86.7	2	100	18	94.7	6	100	1	50	8	100	3	100	95	94.1	9	90	4	100	159	93.5
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100

	Varieties																					
	Okomasa		Honampa		Obatanpa		Abeleehi		Mamaba		Abontem		Omankwa		Abrohoma		Dobidi		Abrodenkye		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
ANTHOCYANIN COLORATION OF ANTHER VAR1																						
YES	1	6.7	0	0	1	5.3	0	0	1	50	0	0	0	0	0	0	0	0	0	0	3	1.8
NO	1	6.7	0	0	0	0	0	0	0	0	0	0	0	0	9	8.9	1	10	1	25	12	7.1
DO NOT KNOW	13	86.7	2	100	18	94.7	6	100	1	50	8	100	3	100	92	91.1	9	90	3	75	155	91.2
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
DENSITY OF SPIKELET VAR1																						
YES	1	6.7	0	0	0	0	3	50	0	0	0	0	0	0	1	1	0	0	0	0	5	2.9
NO	0	0	0	0	0	0	0	0	0	0	1	12.5	0	0	0	0	0	0	0	0	1	0.6
DO NOT KNOW	14	93.3	2	100	19	100	3	50	2	100	7	87.5	3	100	100	99	10	100	4	100	164	96.5
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
ANGLE BETWEEN MAIN AXIS AND LATERAL BRANCHES VAR1																						
YES	0	0	0	0	0	0	0	0	1	50	0	0	0	0	0	0	0	0	0	0	1	0.6
DO NOT KNOW	15	100	2	100	19	100	6	100	1	50	8	100	3	100	101	100	10	100	4	100	169	99.4
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
INCLINATION OF LATERAL BRANCHES VAR1																						
YES	0	0	0	0	0	0	0	0	1	50	0	0	0	0	0	0	0	0	0	0	1	0.6
NO	0	0	0	0	1	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.6
DO NOT KNOW	15	100	2	100	18	94.7	6	100	1	50	8	100	3	100	101	100	10	100	4	100	168	98.8
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
NUMBER OF PRIMARY LATERAL BRANCHES VAR1																						
YES	0	0	0	0	0	0	0	0	1	50	0	0	0	0	0	0	0	0	0	0	1	0.6
NO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	25	1	0.6
DO NOT KNOW	15	100	2	100	19	100	6	100	1	50	8	100	3	100	101	100	10	100	3	75	168	98.8
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
TIME OF SILK EMERGENCY (50% OF PLANT) VAR1																						
YES	13	86.7	2	100	18	94.7	5	83.3	2	100	6	75	1	33.3	66	65.3	7	70	3	75	123	72.4
NO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0	0	4	2.4
DO NOT KNOW	2	13.3	0	0	1	5.3	1	16.7	0	0	2	25	2	66.7	31	30.7	3	30	1	25	43	25.3
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
ANTHOCYANIN COLORATION OF SILK VAR1																						
YES	7	46.7	0	0	15	78.9	0	0	0	0	0	0	0	0	7	6.9	1	10	0	0	30	17.6
NO	2	13.3	0	0	0	0	0	0	0	0	0	0	0	0	5	5	0	0	0	0	7	4.1
DO NOT KNOW	6	40	2	100	4	21.1	6	100	2	100	8	100	3	100	89	88.1	9	90	4	100	133	78.2
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100

	Varieties																					
	Okomasa		**Honampa**		**Obatanpa**		**Abeleehi**		**Mamaba**		**Abontem**		**Omankwa**		**Abrohoma**		**Dobidi**		**Abrodenkye**		**Total**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
INTENSITY OF ANTHOCYANIN COLORATION OF SILK VAR1																						
ABSENT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0.6
WEAK	2	20	0	0	2	10.5	0	0	0	0	0	0	0	0	10	9.9	1	10	0	0	15	9.1
STRONG	0	0	0	0	13	68.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	7.9
DO NOT KNOW	8	80	2	100	4	21.1	6	100	2	100	7	100	3	100	90	89.1	9	90	4	100	135	82.3
Total	10	100	2	100	19	100	6	100	2	100	7	100	3	100	101	100	10	100	4	100	164	100
ANTHOCYANIN COLORATION OF SHEATH VAR1																						
YES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	10	1	25	4	2.4
NO	2	13.3	0	0	0	0	0	0	0	0	0	0	0	0	7	6.9	0	0	0	0	9	5.3
DO NOT KNOW	13	86.7	2	100	19	100	6	100	2	100	8	100	3	100	92	91.1	9	90	3	75	157	92.4
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
LENGTH OF MAIN AXIS ABOVE LOWEST SIDE BRANCH VAR1																						
DO NOT KNOW	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
LENGTH OF MAIN AXIS ABOVE UPPER SIDE BRANCH VAR1																						
DO NOT KNOW	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
LENGTH OF SIDE BRANCHES VAR1																						
YES	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	0	0	1	0.6
NO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0.6
DO NOT KNOW	15	100	2	100	19	100	6	100	2	100	8	100	3	100	100	99	9	90	4	100	168	98.8
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
PLANT HEIGHT (TASSEL EXCLUDED) VAR1																						
YES	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
EAR HEIGHT VAR1																						
YES	15	100	2	100	19	100	6	100	2	100	8	100	3	100	100	99	10	100	4	100	169	99.4
NO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0.6
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
WIDTH OF BLADE VAR1																						
YES	0	0	0	0	0	0	1	16.7	1	50	0	0	0	0	50	49.5	2	20	0	0	54	31.8
NO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	6.9	0	0	1	25	8	4.7
DO NOT KNOW	15	100	2	100	19	100	5	83.3	1	50	8	100	3	100	44	43.6	8	80	3	75	108	63.5
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100

	Varieties																					
	Okomasa		Honampa		Obatanpa		Abeleehi		Mamaba		Abontem		Omankwa		Abrohoma		Dobidi		Abrodenkye		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
COB LENGTH VAR1																						
YES	15	100	2	100	18	94.7	6	100	2	100	8	100	3	100	89	88.1	10	100	4	100	157	92.4
DO NOT KNOW	0	0	0	0	1	5.3	0	0	0	0	0	0	0	0	12	11.9	0	0	0	0	13	7.6
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
COB DIAMETER VAR1																						
YES	15	100	2	100	19	100	6	100	2	100	7	87.5	3	100	95	94.1	10	100	4	100	163	95.9
NO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0.6
DO NOT KNOW	0	0	0	0	0	0	0	0	0	0	1	12.5	0	0	5	5	0	0	0	0	6	3.5
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
COB SHAPE VAR1																						
YES	15	100	2	100	19	100	6	100	2	100	8	100	3	100	99	98	10	100	4	100	168	98.8
NO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0.6
DO NOT KNOW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0.6
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
ROWS OF GRAIN VAR1																						
YES	4	26.7	0	0	1	5.3	0	0	1	50	0		0	0	8	7.9	0	0	1	25	15	8.8
NO	2	13.3	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	4	2.4
DO NOT KNOW	9	60	2	100	18	94.7	6	100	1	50	8	100	3	100	91	90.1	10	100	3	75	151	88.8
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
TYPE OF GRAIN (IN MIDDLE THIRD OF THE EAR) VAR1																						
YES	14	93.3	2	100	19	100	6	100	2	100	8	100	3	100	99	98	10	100	4	100	167	98.2
NO	1	6.7	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2	1.2
DO NOT KNOW	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0.6
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
COLOR OF TOP GRAIN VAR1																						
YES	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
COLOR OF DORSAL SIDE OF COB VAR1																						
YES	15	100	2	100	19	100	6	100	2	100	8	100	3	100	100	99	10	100	4	100	169	99.4
NO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0.6
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
ANTHOCYANIN COLORATION OF GLUMES OF COB VAR1																						
NO	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100

	Varieties																					
	Okomasa		**Honampa**		**Obatanpa**		**Abeleehi**		**Mamaba**		**Abontem**		**Omankwa**		**Abrohoma**		**Dobidi**		**Abrodenkye**		**Total**	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
INTENSITY OF ANTHOCYANIN COLORATION OF GLUMES OF COBS VAR1																						
ABSENT	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
LENGTH OF COB VAR1																						
SHORT	0	0	1	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.6
MEDIUM	0	0	0	0	0	0	0	0	2	100	8	100	2	66.7	1	1	8	80	2	50	23	13.5
LONG	15	100	1	50	19	100	6	100	0	0	0	0	1	33.3	100	99	2	20	2	50	146	85.9
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
LENGTH OF DIAMETER VAR1																						
SHORT	0	0	0	0	1	5.3	0	0	0	0	0	0	0	0	1	1	0	0	1	25	3	1.8
MEDIUM	0	0	2	100	1	5.3	0	0	2	100	8	100	0	0	100	99	10	100	3	75	126	74.1
WIDE	15	100	0	0	17	89.5	6	100	0	0	0	0	3	100	0	0	0	0	0	0	41	24.1
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100
COB SHAPE VAR1																						
CONICAL-CYLINDRICAL	13	86.7	0	0	3	15.8	1	16.7	1	50	6	75	0	0	4	4	8	80	2	50	38	22.4
CYLINDRICAL	2	13.3	2	100	16	84.2	5	83.3	1	50	2	25	3	100	97	96	2	20	2	50	132	77.6
Total	15	100	2	100	19	100	6	100	2	100	8	100	3	100	101	100	10	100	4	100	170	100

Peer-review history:
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