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Cowpea cropping systems, traits preference and production constraints in the upper west region of Ghana: farmers' consultation and implications for breeding

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Abstract

Background Cowpea (*Vigna unguiculata* (L.) Walp) is used primarily as food for humans and feed for animals. It is also used for soil management within a cropping system. However, cowpea production is confronted with numerous challenges. As such farmers and consumers alike have certain preferences in terms of production and utilization. This present study investigated cowpea cropping systems, traits preference and production constraints among farmers in the Nandom, Lambusie and Lawra districts in the northern part of the Upper West Region of Ghana. A total of 306 farming households were sampled from the 3 chosen districts. Questionnaires and interviews were used for data collection. The IBM SPSS software, version 22, was employed to analyze the data using descriptive statistics, specifically frequencies, percentages and crosstabulations.

Results The study's results indicated that a majority (58.5%) of the cowpea farmers practice intercropping, whereas a minority (41.5%) practice sole cropping. The farmers intercropped cowpea with maize, millet, sorghum and yam. Farmers preferred cowpea varieties with the following traits: high yield, drought tolerance, early maturing, pest resistance, improve soil fertility, high price, high demand, better taste, less cooking time, storage quality, palatability and fast growing. Farmers indicated that susceptibility to storage pests, high pest incidence, late maturity, difficulty in harvesting, high input cost, small grain size, low yield, high disease incidence, poor colour, lack of improved variety, and drought are some constraints that hinder cowpea production.

Conclusion Results indicate a need for behavioural change communication to assist cowpea farmers to adopt improved and appropriate cropping systems. Farmers should be involved in cowpea technology development in order to understand their preferences and constraints to enable subsequent adoption of such technologies. The results from this study call for an interdisciplinary committee to plan and breed cowpea varieties that meet the needs of the farmers.

Keywords Cowpea breeding, Early maturing, Food security, Northern Ghana, Sustainable agriculture, Less cooking time

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Background

Cowpea (*Vigna unguiculata* (L.) Walp) is a versatile crop used as food for humans, feed for farm animals and as a soil fertility improvement/maintenance crop (in intercrop with cereals) is widely cultivated in Africa, Asia and America (Osipitan et al. 2021). The crop is believed to have originated from Africa before 2500 BCE (Herniter et al. 2020). Some studies via carbon dating in Ghana suggest that cowpea cultivation started prior to or between 2500–1500 BC (D'Andrea et al. 2007; Herniter et al. 2020). A total production of 8 million tons with an average yield of 1.4 tons/ha was reported in 2019 globally (Database 2021). Out of this, Africa accounts for 96.7% with Ghana ranking fourth to Nigeria, Niger and Burkina Faso (Omomowo and Babalola 2021; Osipitan et al. 2021).

The production of the crop is on the ascendency due to its relative ability to withstand drought compared to other legumes such as soybean and groundnut (Cui et al. 2020; Matsui and Singh 2003; Ravelombola et al. 2020). These make cowpea an important cash crop for farmers and their families around the world (Langyintuo et al. 2003). Cowpea is an excellent source of protein, fiber and micronutrients such as iron, zinc, magnesium, and calcium as well as rich essential amino acids (lysine and tryptophan) and vitamins (A, B and C) (Gonçalves et al. 2016; Osipitan et al. 2021). It is also a good source of bioactive compounds such as flavonoids and phenolics making it useful for its antioxidant property (Razgonova et al. 2022; Yadav et al. 2018). In terms of culinary uses, cowpea is used in stews, soups, and curries and also ground into flour and used to make a variety of baked goods (Yadav et al. 2018).

In Ghana, cowpea is grown largely in dry savanna zones where there is unimodal rainfall pattern between May and September with rainfall range of 500–1200 mm (Atiah et al. 2021). The northern Ghana produces ≈85% grain cowpea (Herniter et al. 2019), however this is inadequate for national demand leading an importation of significant quantity to balance the deficit (Quaye et al. 2011).

The crop is reported to be used primarily for soil management in United States (Osipitan et al. 2021). In Nigeria, the crop is used in relay cropping and mixed cropping (Mohammed et al. 2021). It is mostly intercropped with cereals like maize, sorghum and pearl millet (Akpalu et al. 2014; Ewansiha et al. 2014a; Horn and Shimelis 2020). The intercropping system reduces the use of synthetic fertilizers due to the ability of cowpea to convert and fix appreciable amount of atmospheric nitrogen into the soil (Mndzebele et al. 2020; Mohammed et al. 2022). On the other hand, production and utilization of cowpea is confronted with numerous challenges such as pests, weeds, diseases, lack of mechanized equipment suitable for harvesting, and other trait-related challenges (longer cooking time (Addy et al. 2020), and several others reported in similar studies (Bolarinwa et al. 2022; Gonçalves et al. 2016; Horn and Shimelis 2020; Mohammed et al. 2021; Omomowo and Babalola 2021; Osipitan et al. 2021).

A study by Quaye et al. (2011) in Ghana (Accra and Kumasi) revealed that consumers prefer cowpea varieties based on cleanliness, colour, cooking time, taste, seed size, weevil damage, dryness. Langyintuo et al. (2004) reported that grain size, testa colour, testa texture, eye color and damage levels are key consumer traits for cowpea in Ghana and Cameroon. In order to breed for demand-driven cowpea varieties in Ghana, it is imperative to know the cropping systems, farmers production constraints and their traits preference. Knowing these will serve as incentives for farmers adopt improved cowpea varieties to be bred. Also, consumers will be willing to pay a premium for cowpea variety produced by farmers that match their preferences (Langyintuo et al. 2004). From above background, the present study was undertaken to identify cowpea cropping systems, traits preference and production constraints among farmers in Upper West Region of northern Ghana to lay foundation for cowpea breeding and promotion.

Materials and methods

Description of study areas and sampling procedure

The study was undertaken in the Upper West region (10.2530° N, 2.1450° W) in the northern part of Ghana located in Guinea Savannah belt. The region shares boundaries to the north and west with Burkina Faso and Côte d'Ivoire, respectively (Fig. 1). It also shares borders to the east with the Upper East and south with Northern region (Fig. 1). The region occupies approximately 12.7% of the total land area of Ghana. Among prominent crops produced in the region include maize, rice, sorghum, cotton and cowpea. The region has a single rainy season from April to September, with mean annual rainfall of about 115 mm, and followed by harmattan characterized by prolonged dry season with cold and hazy weather from early November to March (Ghana Statistical Service 2013; Subaar et al. 2018). Prior to the onset of early rainfall in April, the region experiences an intense hot weather. The region has nine administrative districts (Fig. 1).

Cowpea is cultivated in all the nine districts. Based on data obtained from agriculture extension officers in the Ministry of Food and Agriculture (MoFA), Nandom (10.8323° N, 2.8178° W), Lambusie-Karni (10.8344° N, 2.5792° W) and Lawra (10.6294° N, 2.8378° W) districts were purposefully selected. Specifically, Brutu (10.8532° N, 2.7606° W), Karni (11.0990° N, 2.6934° W) and Babile

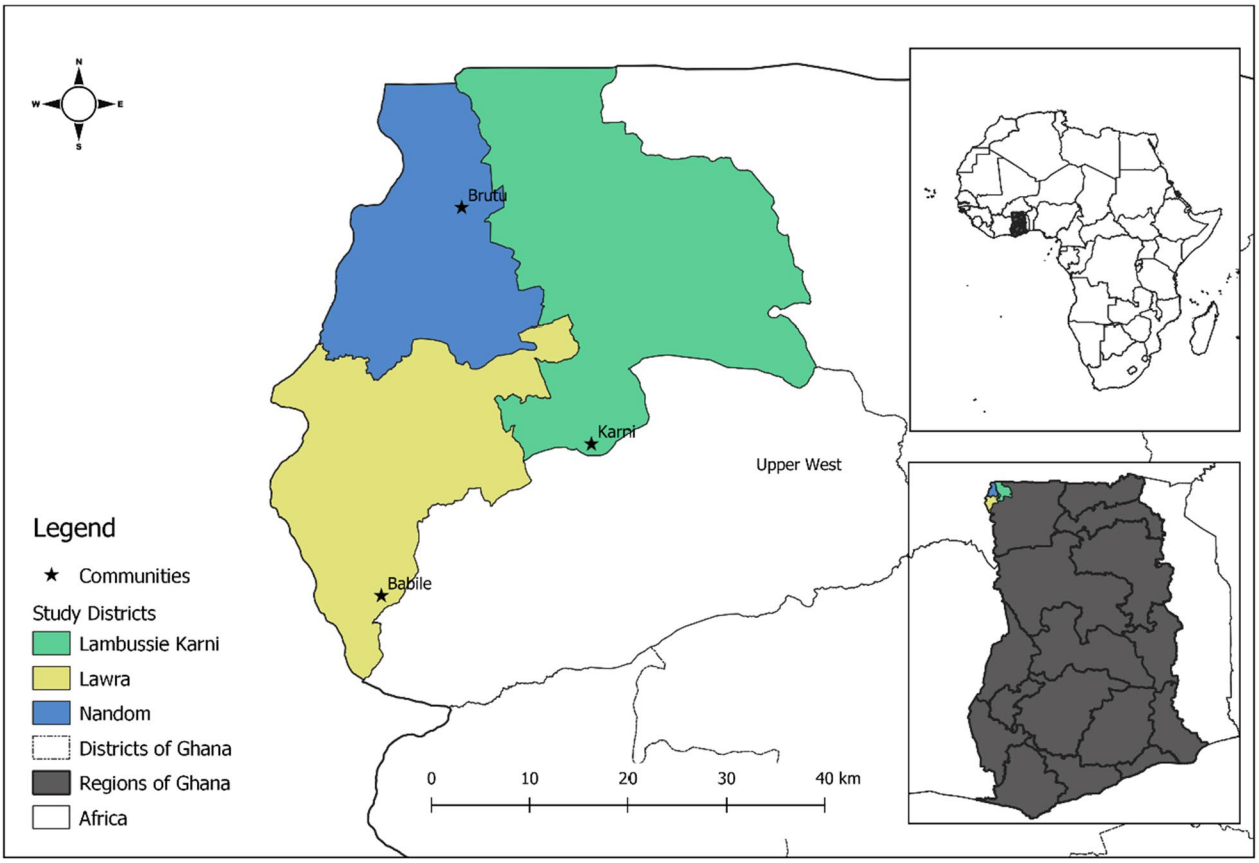

Fig. 1 Map of upper west region of Ghana Source: Authors' own construct

(10.5199° N, 2.83525° W) communities were selected from the three districts, respectively (Fig. 1; Table 1), to identify households involved in cowpea production. In all, one thousand and three hundred households were identified to produce cowpea in the three communities sampled (Brutu, Karni and Babile with 16.70, 24.70 and 58.60%, respectively) (Table 1). Following the formula proposed by Bartlett et al. (2001) with margin of error set at 5%, a total sample size of 306 households participated in this study. Based on the relative proportion of households in the three selected communities, 51 (Brutu), 76 (Karni) and 179 (Babile) cowpea farmers households were randomly selected from the list of the one thousand and three hundred cowpea farmers households in the three districts (Table 1).

Data collection and statistical analysis

Data were solicited mainly from primary source with the help of a structured questionnaire. The questionnaire consisted of four sections. First section was socio-economic characteristics of cowpea farmers. The second and third sections focused on cowpea cropping systems

Table 1 Number of cowpea farmers households in the selected districts and proportions selected to participate in the study

Communities[+]	Districts	Cowpea farmers households	Percentage (%)*	Sample size
Karni (11.0990° N, 2.6934° W)	Lambusie-Karni	321	24.70	76
Brutu (10.8532° N,2.7606° W)	Nandom	218	16.70	51
Babile (10.5199° N; 2.83525° W)	Lawra	761	58.60	179
Total		1300	100	306

[+] information in parenthesis represents global positioning system of the respective communities

* percentage of community relative to total cowpea famers households

and trait preferences, respectively. The last section aimed at asking questions related to cowpea production constraints.

The selected farmers (Table 1) were assured that information to be obtained will be treated with anonymity and will be used for only academic purposes. In addition, respondents were informed of the purpose of the research. Participants were made aware that no incentives will be provided to them and no harm was to be done against them. Respondents were further encouraged to seek further clarification on issues they found confusing during interviewing session.

With assistance of agriculture extension officers of MoFA in the respective communities, the selected cowpea farmers (Table 1) were interviewed in either local dialects (Dagaare) or English and their responses recorded in English. Data collected were coded and entered into IBM SPSS statistical software, version 22 (IBM Corp., Armonk, NY). Results obtained were summarized and presented by descriptive statistics, i.e., frequency tables and charts.

Results

Socio-demographic characteristics of the cowpea farmers

Out of the 306 cowpea farmers, 32% of them aged between 40 and 49 years. This was followed by the age brackets 30–39 years and 50–59 years with 23.2% and 22.5%, respectively, and the least age group (< 20 years) had 2% (Table 2).

Males dominated (77.8%) the study with females being the minority (22.2%). A majority of the cowpea farmers were found to be Christians (60.8%) and were followed by Muslims (23.5%) (Table 2). The study also found that most of the respondents had basic (28.7%) and secondary education (29.1%), while 22.2% of the respondents had no formal education. In terms of marital status, a majority (66.36%) of the respondents were married, while (16.34%) were single (Table 2).

Main occupation of respondents included crop production (30.10%), formal/government work (25.5%), trading (18.6%) and animal rearing (12.10%) (Table 2). From these, a majority (40.02%) of the respondents earn their livelihood from farming, whereas 19.3% and 22.9% of the respondents obtain their livelihood from trading and government work, respectively (Table 2).

Table 2 Socio-demographic characteristics of respondents in the study

Variables/responses	Frequency (n = 306)	Percent (%)
Age		
< 20 years	6	1.96
20–29 years	41	13.40
30–39 years	71	23.20
40–49 years	98	32.03
50–59 years	69	22.55
>59 years	21	6.86
Religion		
Christian	186	60.78
Muslim	72	23.53
Traditionalist	39	12.75
Others	9	2.94
Sex		
Male	238	77.78
Female	68	22.22
Level of education		
Basic education	88	28.76
Secondary	89	29.08
Tertiary	61	19.93
Non-formal education	68	22.22
Marital status		
Single	50	16.34
Married	203	66.34
Divorced	13	4.25
Widow	25	8.17
Separated	15	4.90
Main occupation		
Crop production	120	39.22
Animal rearing	46	15.03
Trading	59	19.28
Formal work/government	81	26.47
Main source of income		
Farming	136	44.44
Trading	73	23.86
Government	97	31.70

n represents total number of farmers interviewed

Cowpea cropping systems among farmers in the Upper West region of Ghana

As shown in Fig. 2A, the majority (58.5%) of farmers in the study area practice intercropping, whereas a minority (41.5%) practice sole cropping. From those practicing intercropping (179/306), a majority (120) of them intercrop with maize, followed by millet (48 farmers), sorghum (7 farmers) and yam (4 farmers) (Fig. 2B). These suggest that cowpea farmers in the studied districts mostly intercrop cowpea with cereals.

Cowpea farmers' traits preferences for production, consumption, fodder and market values

In order to know farmers' trait preference for production, consumption, fodder and market values, we further asked questions on their preferences. Regarding trait preference in terms of production value, farmers

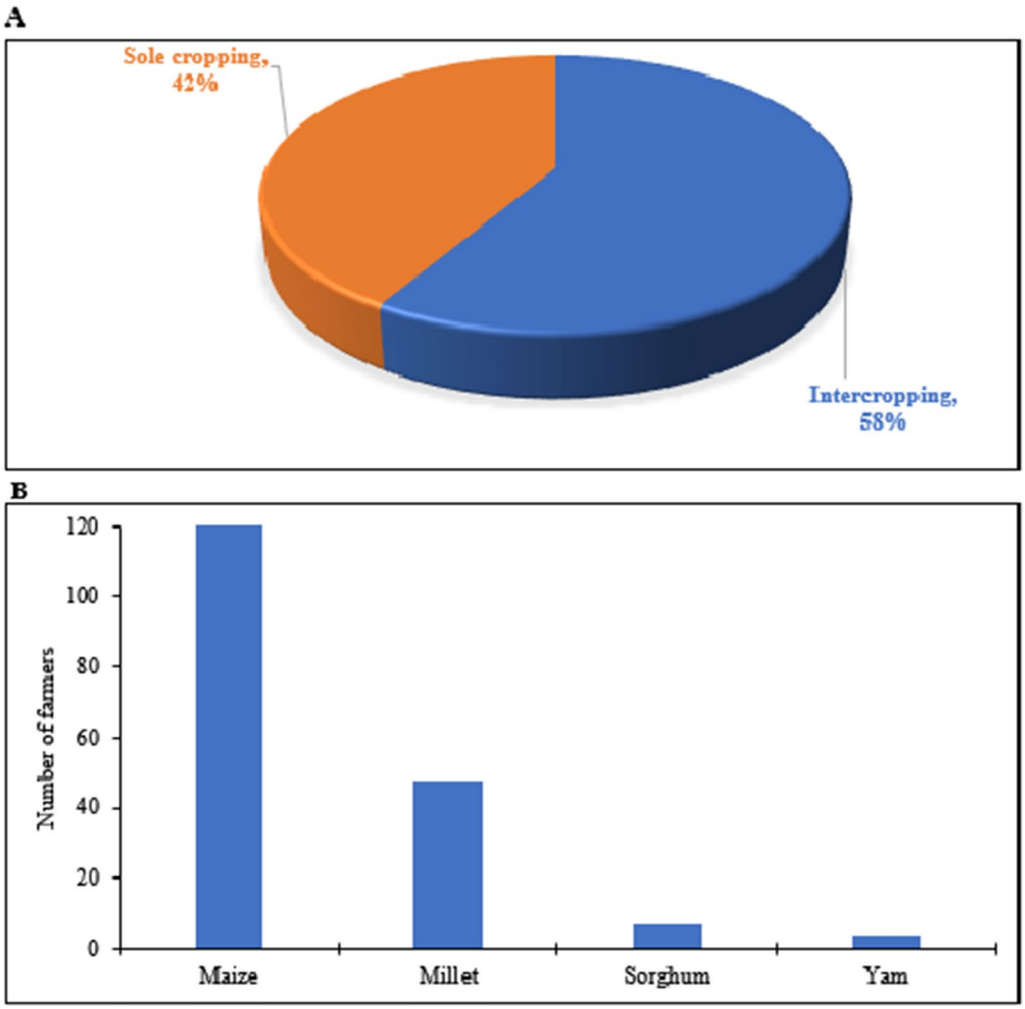

Fig. 2 Cowpea cropping systems **A** and crops intercropwith **B** among the cowpea farmers in the study area Source: Field survey, March 2022

preference followed high yield (67.32%) > drought tolerance (52.61%) > improve soil fertility (41.18%) > early maturing variety/pest resistance (30.01%) > fit into existing cropping system (21.24%) > disease resistance (12.75%) > high biomass (0.65%) (Table 3). Conversely, majority of intercropping farmers preferred cowpea

Table 3 Crosstabulation of cowpea cropping systems and production trait preferences

Traits	Cropping systems		Total (n*=306)
	Intercropping (n = 179)	Sole cropping (n = 127)	
High yield	113 (54.86%)	93 (45.14%)	206 (67.32%)
Drought tolerance	100 (62.11%)	61 (37.89%)	161 (52.61%)
Improve soil fertility	86 (68.25%)	40 (31.75%)	126 (41.18%)
Early maturing variety	49 (53.26%)	43 (46.74%)	92 (30.01%)
Pest resistance	53 (57.61%)	39 (42.39%)	92 (30.01%)
Fit into existing cropping system	41 (63.08%)	24 (36.92%)	65 (21.24%)
Disease resistance	22 (56.41%)	17 (43.59%)	39 (12.75%)
High biomass	1 (50.00%)	1 (50.00%)	2 (0.65%)

Values in parenthesis represent percentage of total number of farmers practicing either cropping systems relative to the total number of farmers who preferred that trait. n represents total number of farmers practicing each cropping system, n* represents total number of farmers interviewed.

varieties with high yield, drought resistant, improve soil fertility, early maturing variety, pest resistance, fit into existing cropping system and disease resistance compared to their counterpart sole cropping farmers.

Again, in terms of consumption value, 93.13% of the farmers indicated their preference for better taste (Fig. 3A). This was followed by farmers who preferred cowpea varieties that is cooked in less time (33.99%) and store well (20.26%). While other farmers preferred seed-related traits such as big seed size (9.48%), white/cream seed colour (6.54%), small seed size (1.31%) and mottled seed color (0.98%) (Fig. 3A).

Moreso, when it comes to trait preference for fodder value, palatability is the most preferred trait for a majority (89.54%) of the farmers, followed by fast growing ability varieties (16.01%), more fodder quantity with leafy (6.54%) and more durable fodder (4.90%) (Fig. 3B). Also, trait of cowpea for its market value is of great importance to farmers and with that 76.14% prefer cowpea variety that fetches higher price and again, 53.59% farmers were identified to prefer planting varieties that have high demand on the market (Fig. 3C). Other farmers prefer cowpea varieties with big seed size (9.48%), low price fluctuations (6.86%), white/cream seed colour (6.54%),

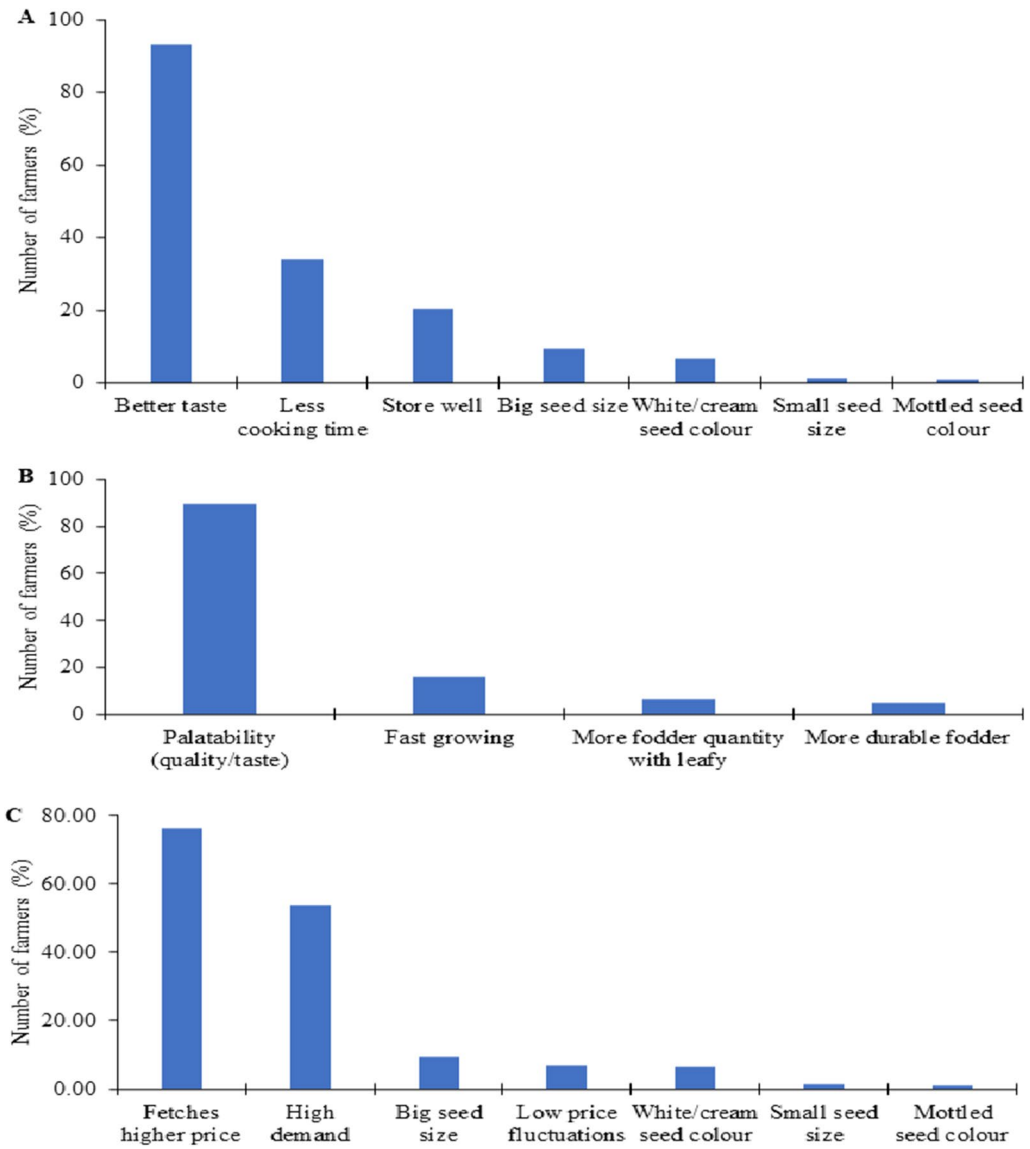

Fig. 3 Trait preferences among cowpea farmers in thestudy area. **A** For consumption value. **B** For fodder value. **C** For marketvalue Source: Field survey, March 2022

small seed size (1.31%) and mottled seed colour (0.98%) (Fig. 3C).

Cowpea production constraints among farmers in the Upper West region of Ghana

Production of cowpea like other crops experience a number of biotic and abiotic stresses (Addae-Frimpomaah et al. 2022; Banla et al. 2018; Baoua et al. 2021; John and Fielding 2014; Lobulu et al. 2019; Osipitan et al. 2021), therefore this section sought to identify cowpea production constraints in the study areas. It was observed that a majority (64.71%) of the farmers indicated susceptibility of cowpea to storage pest as the major constraint (Fig. 4). This was followed by high pest incidence (50.98%), late maturity or long duration (33.66%), difficulty in harvesting (29.08%), high input cost (20.26%), small size grains (10.13%), low yield (9.8%), high disease incidence (5.56%) and poor colour of cowpea (4.25%). Other constraints encountered by cowpea farmers include inadequate access to improved variety/drought challenges (3.59%), poor seed quality (1.96%), poor seed germination (0.98%), low pod filling, poor fodder quality (0.65%) and poor taste/low recovery or shelling percentage (0.33%) (Fig. 4).

Discussion

To increase cowpea production and utilization in Ghana, the present study was undertaken to identify cowpea cropping systems, traits preferences and production constraints in one of the leading producing regions in Ghana.

It was observed that males predominantly engaged in cowpea farming in the study area (Table 2). This finding is similar to Akpalu et al. (2014) who found that females' involvement in cowpea farming in Ghana is generally low. Women mostly in some African countries are engaged in carrying out other activities within the cowpea value chain while their male counterparts are engaged in the main farming activities (Iya and Kwaghe 2007). According to (Rahman 2008) and (Akpalu et al. 2014) women are rather engaged in post-harvest operations like threshing and winnowing. In places where culture and social norms influence the behaviour of people, women are not mainly involved in physical farm operations (Rahman 2008). However, this finding is in contrast with (Nkongolo et al. 2009), who found that women are the main farmers of cowpea. The results on farmers' level of education show that those having tertiary education are the least (19.93%) (Table 2). As suggested by Reimers and Klasen (2013) farmers who are advanced in education are able to combine different resources in their possible way and make efficient use of them towards production and productivity. In terms of technology, well-educated farmers are fast in adopting the best ones to boost production and attain more returns (Adetonah et al. 2016; Asadullah and Rahman 2009).

Intercropping is a popular farming system among farmers globally ((Ewansiha et al. 2014b; Horn et al. 2015; Olufajo and Singh 2002; Singh and Ajeigbe 2007) and in Ghana (Akpalu et al. 2014). In the study area, a majority

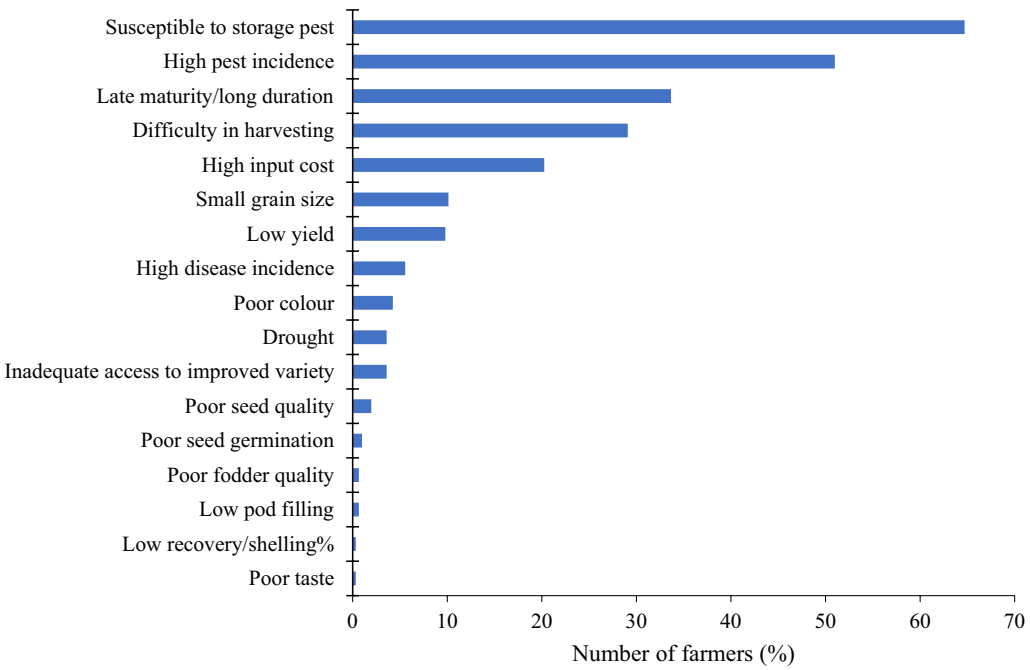

Fig. 4 Production constraints encountered by cowpea farmers in study area Source: Field Survey March, 2022

(58%) of the farmers practice intercropping (Fig. 2A). Cowpea is intercropped with other crops such as maize, millet, sorghum, and yam (Fig. 2B). Farmers in the study area usually intercrop cereals, especially maize and cowpea. However, intercropping cowpea with yam is not common in the region. In this cropping system, maize is cultivated first followed by the legume because of its shorter production period compared to maize (Sagar et al. 2020). The region is not known for yam production and the crop is only grown in a couple of settlers' communities (https://mofa.gov.gh/site/sports/district-directorates/upper-west-region/285-lambussie-karni, accessed on 12/05/2023). Also, the tillage method for growing yam is mounding which does not favour intercropping. This may inhibit the easy farm operation such as weed and pest control, fertilizer application and harvesting of the intercropped crop. Furthermore, almost all households in the study area produce maize and keep livestock. Because of the crop-livestock integrated system most farmers intercrop maize with cowpea for both food and fodder (Akakpo 2020). As indicated by Kyei-Boahen et al. (2017) farmers use intercropping because a minimum to no amount of fertilizers would be required since cowpea is a source of nitrogen supplement. It could also be that farmers are unwilling to farm separately as a result of the high cost of farming. Aside that, 42% of the respondents cited of practicing sole cropping (Fig. 2A). Other scholars have argued that sole cropping of cowpea has lots of advantages over intercropping like increased crop yield, suppressing weed growth and harvesting (Ewansiha et al. 2014b; Olufajo and Singh 2002). Therefore, Ewansiha et al. (2014b) emphasized that intercropping system is associated with fewer plant population and low grain yield, shading effect of other cereal crops, overcrowding of crops, diseases and pest infestation.

From this study, it was realized that most (67.32%) of the farmers prefer high yielding cowpea varieties in terms of their production value (Table 3). This is because farmers are rational people and, hence they take rational decisions with the primary focus of increasing their production and profit margins. This finding agrees with Asrat et al. (2010) who opined that yield is an important characteristic of farmers' crops and variety choices. Drought tolerance is also sought after by farmers (Table 3). Cowpea is fairly drought-tolerant and thrives well in poor soil conditions (Obatolu 2003; Olajide and Ilori 2017). However, anytime drought occurs during the agricultural cycle, it typically has a negative impact on the crop's growth, production, and yield quality (Bacharou Falke et al. 2019). According to Hamidou et al. (2013); Hamidou et al. (2012); (Kambiranda et al. 2011), the time, intensity, and length of the drought affects the yield of the crop. Physiological characteristics such as leaf area, stomatal conductance, transpired water, osmotic adaptations, and transpiration efficiency are related to drought tolerance (Clavel et al. 2005; Puangbut et al. 2009).

Early maturity is another trait cowpea farmers prefer (Table 3). Given the short duration of rains in the study area, it is apropos for farmers to cultivate varieties that are early maturing in order to escape the prolonged drought spell and its implications on pests and diseases incidence, crop growth, development and yield (Martey et al. 2022). Almost all the farmers prefer cowpea varieties with better taste and takes less cooking time when considering consumption value (Fig. 3A). The cowpea grains are used to prepare different meals in the Ghanaian society, such as 'koose', 'tubani', 'tuozaafi', while others freshly cooked cowpea pods serve as a delicacy in most households prior to main field crop harvest. The dry grain of the white cowpea variety is found to have less cooking time as compared to the brown coloured varieties (Asfaw et al. 2011). The white cowpea variety according to the farmers can be stored for a longer period, and still possess the preferred characteristics. Farmers preferred cowpea varieties that are in demand and fetches higher price (Fig. 3C). Farmers have the perception that the white variety of cowpea looks healthy and attractive to consumers. This makes the variety to be preferred by majority of the people thereby increasing the demand and price of the variety. Harvested grains are processed and sold both locally and regionally. A larger proportion of cowpea produced in Africa and its environs are sold in the local markets (Beshir et al. 2019; Timko and Singh 2008).

Constraints of cowpea production are general to all farmers in the study area. Hierarchically farmers are faced with production constraints such as susceptibility to storage pests, high pest incidence, late maturity, difficulty in harvesting, high input cost, small grain size, low yield, high disease incidence, poor colour, lack of improved variety, drought, poor seed quality, poor seed germination, low pod filling, poor fodder quality, poor taste and low recovery (Fig. 4). These findings agree with some studies conducted in South Sahara Africa (Baoua et al. 2021; Boukar et al. 2013; Horn and Shimelis 2020; Olufajo and Singh 2002) and Europe (Lazaridi and Bebeli 2023). Cowpea's susceptibility to storage pests was discovered as the main production constraint in the study area. As pointed out by Tarver et al. (2007) and Tadesse et al. (2006) postharvest pest is a big problem for farmers in storing grains, for example, weevil destroys cowpea by making holes in the cowpea pod, destroying the economic value of the grain in a very short time. Additionally, it was discovered that late maturity and drought spells affect the production of cowpea in the study area (Fig. 4). This indicates farmers are still producing the

local cowpea varieties which take a longer period (125 days) to reach maturity. This then coincides with the prolonged drought spells in the Guinea Savannah zone. Lamaoui et al. (2018) assert that drought influences the uptake of essential nutrients for plant growth and the ability of the seeds to properly germinate. Fahad et al. (2017) claimed that erratic rainfall in certain areas makes farmers unwilling to enter cowpea production.

Implication for breeding

Technology developments should be done in a way that will involve all stakeholders. This will ensure that the technology being developed accentuates farmers preferences and in the same vein addresses their constraints. Such technologies could consider farmers socioeconomic characteristics which can foster their easy adoption and use. Hence, genetic improvements of cowpea should not only focus on high yielding, early maturity and drought tolerance but also palatability, less cooking time and pest resistance. Since these are also trait preference that drives demand and price which is of interest to farmers and consumers. Finally, scientist specifically cowpea breeders should make conscious efforts to bridge the knowledge and practice gap between researchers and farmers. This can be done by reaching out to the farmers through Behavioural Change Communication, which can be spearheaded by extension officers. Since farmers in some cases have no idea of the improvements undertaken by the scientific community thereby making adoption and use of such improvements low. Overall, the results from this study suggest the need to form interdisciplinary cowpea breeding committee comprising plant breeders, food scientists, soil scientists, mechanization experts, agricultural extensionists, socio-economics, among others to contribute to breeding cowpea varieties that meet the needs of the farmers. It is suggested that this study should be replicated in other agroecological zones of Ghana to enable triangulation of findings.

Conclusions

The study's results indicated that a majority (58.5%) of the cowpea farmers practice intercropping whereas a minority (41.5%) practice sole cropping in the study area. The farmers intercropped cowpea with other grain crops such as maize, millet, sorghum, groundnut, and soybean. Judging from production, market, consumption and fodder values farmers preferred cowpea varieties with the following traits: high yield, drought resistant, early maturing, pest resistance, improve soil fertility, high price, high demand, better taste, less cooking time, storage quality, palatability and fast growing. Results further revealed that some constraints hinder cowpea production, trait preference and utilization of the crop. Farmers indicated that susceptibility to storage pests, high pest incidence, late maturity, difficulty in harvesting, high input cost, small grain size, low yield, high disease incidence, poor colour, lack of improved variety, drought, poor seed quality, poor seed germination, low pod filling, poor fodder quality, poor taste and low recovery are some constraints that hinder cowpea production and utilization. The results from this study would lay foundation for demand-driven cowpea varieties breeding programmes for farmers and consumers in Upper West region, Ghana as a whole and Africa at large. In addition, agricultural extension workers and other stakeholders could leverage on the findings of this research to develop and promote farmer-friendly cowpea technologies to boast production and utilization as alternative source of protein for rural households.

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Author contributions

BK, AMA and IKA conceived, designed and supervised the study; MDM collected the data; BK and MDM analyzed the data. MDM and EA wrote first draft of the paper. BK and DBA revised the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The data presented in this study are available within the article.

Declarations

Ethics approval and consent to participate

The study was approved by graduate school of University for Development Studies. The informed consent of participants was always obtained verbally before the consultation/interview process was conducted, and the option to participate or withdraw from the conduct of the study, was orally given to the participants.

Consent for publication

Notapplicable.

Competing interests

The authors declare no competing interest.

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