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Present characteristics of cowpea variety selection criteria vary significantly in major growing regions of Kenya

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Abstract

Cowpea (*Vigna unguiculata* L. Walp) is an important legume serving multiple roles for many low-income farmers. However, its productivity remains low and discrepancies exist in selection and acceptability criteria. Including farmer-preferences could help develop adoptable varieties. This study surveyed present production practices among 64 representative smallholders to inform breeding objectives. A cross-sectional survey design was used to collect data analysed using SPSS Software version 23. Education, land, drought, seed sources, improved variety, seed availability, and pests significantly (P<0.001) affected cowpea production. Most respondents were married, aged 31-40 years, and had primary, secondary or tertiary education. About 60.9% practiced mixed cropping, while 60.9% grew cowpea with multiple crop cycles. Whereas majority relied on rain, 32.8% strongly agreed that drought determined cowpea variety adopted. Acreage cultivated was <1 acre by 84.4% respondents. Farmers named 7 insect-pests as major threats, with aphids leading (67.2%). Five diseases were major constraints, with cowpea mosaic virus leading (64.1%). Majority (68.8%) grew cowpea for dual usage as grains and leafy vegetables. Farmer-preference revealed that leaf texture, seed colour and availability traits determine variety choice. Households totalling 46.9% preferred medium leaf texture with delicious (28.1%), sweet (26.6%) or bitter (12.5%) taste. There was a significant association between region and drought (χ^2=15.57, df=4, P=0.004), region and production purpose (χ^2=16.49, df=2, P=0.004), as well as region and utilisation (χ^2=8.44, df=1, P=0.004). In Western 38.2% and Eastern 63.3% respondents strongly agreed that drought was a constraint. A total of 70% and 52.9% respondents in Eastern and Western, respectively, grew cowpea as a mixed crop. Most respondents (47.1%) in Western grew cowpea for leafy vegetables, while 86.7% in Eastern grew for dual-usage. This study recommends use of present baseline information on key selection criteria in generating demand-led variety design during breeding.

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Introduction

Cowpea origin and utilisation

Cowpea originated from West and Central Africa from where it has spread to other parts of the world (Edeh and Igberi, 2012; Carvalho *et al.*, 2017). Presently, cowpea is among the most commonly cultivated lowland pulse crops in Kenya (Habte *et al.*, 2018). However, the crop is not yet widely adopted compared with the role it plays during climate change periods despite its excellent nitrogen fixation and adaptation to stressed environments. Rural families derive food, animal feed and income out of cowpea (Manda *et al.*, 2020). Moreover, it provides nutritious grains and serves as an inexpensive source of proteins (DaSilva *et al.*, 2021). Cowpea production is done for both seed grains and leafy vegetables. World production has reached 8.9 million tonnes on 15 million hectares (FAOSTAT, 2021). Global estimate shows Western and Eastern Africa are leading with 13.1 million hectares, yielding 8.1 million tonnes (FAOSTAT, 2021). The major cowpea producing East African countries are Kenya, Tanzania, South Sudan, and Uganda (Mamiro, 2011; Owade *et al.*, 2020). Kenya produces about 246,870 tonnes on 298,120 hectares, with 85% in the arid and semi-arid lands (ASALs) (Muniu, 2017). Assessing farmers' understanding of trait preferences, cropping systems and constraints is essential in achieving wide adoption of new production technologies, including varieties (Rusinamhodzi and Delve, 2011). Farmer participatory assessment approaches such as semi-structured questionnaires, participatory rural appraisal and focus group discussion help identify and document practices, preferred traits and perceived constraints (Rusinamhodzi and Delve 2011; Mohammed *et al.*, 2020). Since farmers are producers as well as consumers, a better understanding of their selection criteria in their area is critical in improving acceptance of newly developed varieties, and this can contribute to increased production and utilisation.

Cowpea utilisation preferences

Cowpea is mainly consumed as dry seed grains or fresh leafy vegetables, whereas dietary diversification has been employed over time as a strategy to improve nutritional status of the population. Cowpea leaves have richer nutritional composition than other grains (Abadassi, 2015; Kirakou, 2017; Kanali *et al.*, 2017; Owade *et al.*, 2020). The dual-purpose nature of cowpea offers versatility through utilisation as both leafy vegetables and seed grains from the same crop (Liyanage *et al.*, 2014; Ndiso *et al.*, 2016). Epidemiological evidence indicates that consumption of cowpea exerts protective effects against development of various chronic diseases (Khalid and Elharadallou, 2013; Trehan *et al.*, 2015; Perera *et al.*, 2016). Besides human nutrition, the herbage of cowpea is utilized as animal fodder during long dry seasons in semi-arid areas (Heuze *et al.*, 2015). In addition, cowpea has the ability to restore soil fertility through nitrogen fixation, making it a good plant species for crop rotation and cover cropping (Daryanto *et al.*, 2015; Wang and McSorley, 2018). Its wider ecological adaptation makes it a crop of choice during this era of climate change. It is reported to be well adapted to high temperatures and droughty conditions (Carvalho *et al.*, 2017). The global impacts of climate change together with other factors such as water unavailability, reduced land cover, decline in nitrogen cycling have increased concerns about achieving food and nutrition security, especially among resource-poor communities (Gregory *et al.*, 2000). To alleviate this situation, cowpea is gaining popularity in developing countries, especially in arid regions due to its resistance to drought (Abebe, and Alemayehu, 2022).

Cowpea production constraints

In Kenya, cowpea is widely produced for its leaves in Western and for its seed grains in Eastern, Coast and Nyanza regions (Rusike *et al.*, 2013). The plant is widely intercropped, particularly with cereals (Namatsheve *et al.*, 2020). Cowpea production is done mainly by subsistence farmers. Production potential is limited by diverse constraints that lead to low yields. The average yield in Kenya remains very low at 828.1 kg/ha, compared to potential yield of 1500 to 3000 kg/ha under optimal conditions (FAOSTAT, 2021). Lack of improved varieties, poor

agronomic practices, pests are constraints affecting cowpea production. The limiting factors can broadly be classified as biotic and abiotic stresses in different regions of Kenya. Among biotic stresses, disease and insect pests are leading (Oyewale *et al.*, 2014). The major seedborne disease is cowpea mosaic virus (CMV). Others are fungal and bacterial (Viswanatha *et al.*, 2011). Major insects include aphids, thrips, pod-bugs and weevils (Gbaguidi *et al.*, 2013). Aphids are leading as documented in various studies (Kusi *et al.*, 2010; Obopile and Ositile, 2010; Aliyu and Ishiyaku 2013; Souleymane *et al.*, 2013; Huynh *et al.*, 2013; Soffan and Aldawood, 2014; Smith and Chuang, 2014; Huynh *et al.*, 2015; Omoigui *et al.*, 2017; Togola *et al.*, 2017; Ouedraogo *et al.*, 2018).

Drought is a major abiotic constraint in semi-arid tropics due to erratic rainfall (Olajide and Ilori, 2017). It is usually subjected to drought stress at the seedling and terminal growth stages, leading to reduction in grain and biomass yields (Ibitoye, 2015; Iwuagwu *et al.*, 2017). During the vegetative phase, water deficit causes plant growth reduction, nutrient absorption alteration, increase in stomatal resistance, and decrease in gaseous exchange (Boukar *et al.*, 2018). Drought resistance mechanisms are four: avoidance, tolerance, escape and recovery (Manavalan *et al.*, 2009). Drought recovery is the ability of a plant to continue growing after drought injury. There is a need to establish effective breeding programmes that can develop high-yielding varieties adaptable to droughty conditions.

Cowpea varietal selection criteria

Cowpea production and utilisation potentials are constrained by discrepancies in selection criteria and local preferences (Ishikawa *et al.*, 2020). Acceptance of varieties varies by region, depending on environmental conditions, competing demands for food and cash, accessibility to markets and cultural preferences (Dugje *et al.*, 2009). Understanding farmers' knowledge is critical in increasing cowpea productivity and adoption of new farming technologies (Hoffmann *et al.*, 2018). However, farmers' knowledge documentation is not commensurate with changing times. Moreover, farmers and consumers have varied preferences for cowpea seed size and coat colour (Mishili *et al.*, 2009; Boukar *et al.*, 2018). Previously, relatively low level of adoption of improved cowpea varieties among smallholder farmers was probably due to non-availability of farmer and market-preferred traits (Mohammed *et al.*, 2019; Manda *et al.*, 2020). A small-scale farmer dealing with environmental and socio-economic conditions considers multiple objectives when selecting a cowpea variety. Furthermore, a farmer's acceptability often extends to multiple traits such as seed colour, texture, taste and size (Langyintuo *et al.*, 2004).

Assessing present cowpea production systems, major constraints, utilisation and preferences is crucial in establishing basic information for further research and policy directions, thereby optimizing the contribution of cowpea in improvement of community livelihoods and achieving food security in light of the existing climate change conditions and soil fertility problems. This paper reports present production practices, constraints and preferences obtained from 64 representative smallholder farmers in two selected major growing regions of Kenya that should inform future extension, improvement and breeding objectives of cowpea.

Materials and Methods

A cross-sectional survey design was used to assess farmer-preferred cowpea varieties and production systems in eight selected counties (Makueni, Kitui, Machakos, Tharaka-Nithi, Busia, Kakamega, Bungoma and Siaya) of Kenya. Purposive sampling and a questionnaire were used. The population comprised of cowpea farmers from the selected counties in Western and Eastern major growing regions (Table 1). The sample size 64 was derived using the formula by Nassiuma (2000), where a coefficient of variation of 20% is acceptable.

Sample size (n) $= \frac{NC^2}{C^2+(N-1)e^2}$

where:

n = sample size

N = population from which sample was obtained, which was given as 1,202,984
C = coefficient of variation was given as 20%
e = standard error was given as 0.025

Thus,

$$\text{sample size } n = \frac{1202984\,(0.2^2)}{0.2^2+(1202984-1)0.025^2} = 63.99659531,$$

giving 64 households.

The research tools included questionnaires used to collect information from farmers in the eight selected counties of Eastern and Western regions of Kenya. A pilot study was conducted among cowpea farmers in Mbeere, Embu, using 10 purposively selected households. For a descriptive survey, a piloting sample within the range of 1% to 10% of the prospective sample size is recommended (Mugenda and Mugenda, 1999). Piloting is crucial since it helps identify misunderstandings, ambiguities, redundant and inadequate items in the research instruments (Wiersma, 1995).

Questionnaire content validation was done to ensure it gathered the intended information accurately. Consistency of the questionnaire was assessed by administering it to different respondents during the pilot study and verification by the supervisors. Cronbach alpha was used to determine the reliability of the instruments using data obtained from the pilot study. Cronbach's coefficient determines how items correlate among themselves and tests internal consistency of the instruments. The instrument was considered reliable because the coefficients obtained were above 0.7 (Coolican, 1999). Data values were analysed using SPSS version 23 to determine cowpea production, utilisation and varietal selection practices in two major growing regions of Kenya.

Results and discussion

Present production practices

This survey established present cowpea production practices (Table 2). Respondents were mostly married (35.9% male and 64.1% female). Majority of them were aged 31 to 40 years (32.8%), thus indicating that majority were relatively adult men and women, which implies that farming in these communities might not be too lucrative to attract youths. Majority of respondents had at least formal education at primary (34.4%), secondary (46.9%), and tertiary (18.8%) levels. According to Tewodros *et al.* (2021), education level of farmers influences agricultural production decisions. When households are highly educated, there is increased diversification of income sources and improvement in household livelihood (Dessalegn and Ashagrie, 2016).

Table 1. Sampling frame.

Region	County	Households	Sample
Eastern	Makueni	149,980	8
	Machakos	161,864	9
	Mwingi	210,156	11
	Tharaka-Nithi	109,572	6
Western	Busia	152,608	8
	Siaya	102,792	5
	Bungoma	143,184	8
	Kakamega	172,828	9
Total		1,202,984	64

Source: Counties MOALF.

At least 60.9% respondents practiced mixed cropping, while 35.9% monocropped. This result explains the importance of cowpea as a companion crop in cereal-legume cropping systems which are commonly adopted by farmers in Sub-Saharan Africa to avert risks of crop failure and distribute farm labour (Traore *et al.*, 2023). A proportion of 60.9% farmers grew cowpea with multiple crop cycles or regrowth, while 39.1% grew single crop cycle. This can be explained by cowpea being an annual crop with improved varieties being either extra early maturing in 60 days, early in 65 to 75 days, medium in 75 to 100 days, or late in >100 days. According to Boukar *et al.* (2020), farmers who grow cowpea with a single crop cycle usually choose day neutral, extra early or early maturing varieties, while multiple crop cycles prefer the dual-purpose and late maturing types. The baseline survey revealed that 39.1% respondents used the previous season's harvested seeds, as 10% obtained seeds from Agrovets, and 15.6% obtained from markets. The survey showed that 31.3% and

26.6% households used organic farmyard and inorganic fertilizer (diammonium phosphate-DAP), respectively. This is because cowpea is planted in relatively small land areas with limited use of organic or synthetic fertilizers. The small land sizes do not warrant heavy use of fertiliser inputs and this observation was in agreement with findings of Beye *et al.* (2022).

Table 2. Characteristics of present cowpea production practices in two regions of Kenya.

Variable	Category	Frequency	Percentage
Gender	Male	23	35.9
	Female	41	64.1
	Total	64	100
Age (years)	<20	1	1.6
	20-30	10	15.6
	31-40	21	32.8
	41-50	9	14.1
	51-60	12	18.8
	61-70	8	12.5
	>70	3	4.7
	Total	64	100
Education	Primary	22	34.4
	Secondary	30	46.9
	Tertiary	12	18.8
	Total	64	100
Cropping system	Mixed cropping	39	60.9
	Mono-cropping	23	35.9
	Missing	1	1.6
	Total	64	100
Growth habit	Single cycle	25	39.1
	Multiple cycles	39	60.9
	Total	64	100
Seed availability	Variety	14	21.9
	Farm-saved	32	50
	Market	10	15.6
	Donation	8	12.5
	Total	64	100
Seed source	Agrovet	7	10.9
	Previous harvest	25	39.1
	Market	10	15.6
	Agrovet + Past harvest	14	21.9
	Missing	8	12.5
	Total	64	100
Input	DAP	17	26.6
	Farmyard	20	31.3
	Compost	2	3.1
	DAP/FYM	5	7.8
	Missing	20	31.3
	Total	64	100
Land size	<1acre	54	84.4
	1-2acre	6	9.4
	>2acres	3	4.7
	Missing	1	1.6
	Total	64	100
Water source	Rain	39	60.9
	Irrigation	10	15.6
	Rain + Irrig.	5	7.8
	Missing	10	15.6
	Total	64	100
Drought	Strongly agree	21	32.8
	Agree	14	21.9
	Neutral	16	25
	Disagree	11	17.2
	Strongly disagree	2	3.1
	Total	64	100
Insect pests	Aphids	43	67.2
	Cutworms	6	9.4

	Bean fly	1	1.6
	Thrips	7	10.9
	Caterpillar	1	1.6
	Grasshopper	1	1.6
	Leaf miner	1	1.6
	Missing	4	6.3
	Total	64	100
Diseases	CMV	41	64.1
	P. mildew	9	14.1
	Anthracnose	2	3.1
	Leafspot	3	4.7
	Leaf rust	1	1.6
	Missing	8	12.5
	Total	64	100
Purpose	Consumption	16	25
	Sale	10	15.6
	Fodder	38	59.4
	Total	64	100
Utilisation	Leaf vegetable	20	31.2
	Seed grain	14	21.9
	Dual	30	46.9
	Total	64	100
Varietal selection	Pest resistance	15	23.4
	Taste	14	21.9
	Seed colour	12	18.8
	Availability	10	15.6
	Drought tolerance	9	14.1
	Missing	4	6.3
	Total	64	100
Seed colour	Red	14	21.9
	Cream	18	28.1
	Brown	2	3.1
	Black	10	15.6
	Grey	5	7.8
	White	4	6.2
	Variegated	11	17.1
	Total	64	100
Leaf texture	Soft	21	32.8
	Medium	30	46.9
	Rough	13	20.3
	Total	64	100
Leaf taste	Sweet	17	26.6
	Salty	5	7.8
	Sour	16	25
	Delicious	18	28.1
	Bitter	8	12.5
	Total	64	100

Acreage cultivated per farmer was small, measuring <1 acre (84.4% respondents). The results suggest that cowpea production is still at subsistence level and needs a lot of improvement in terms of constraints to its expansion. According to Kamara *et al.* (2018), farmers are likely to cultivate more land if crop yield is higher through introduction of improved varieties, as well as cultural practices.

The survey showed that 60.9% households relied on rain and about 32.8% strongly agreed that drought constraint was a factor that determined adoption of cowpea production technologies, as well as selection of cowpea varieties to grow. This response implied that drought stress was a major consideration while adopting and selecting cowpea varieties to grow in these two regions of Kenya.

According to Nkomo (2021), cowpea is more drought-tolerant than many other crops, although its productivity is negatively affected by prolonged drought. Kenya experiences bimodal rains with the longest falling from March and shortest from October. These two rainy seasons are interspersed by dry seasons when drought is experienced (Jaetzold *et al.*, 2006).

Table 3. Association between region and characteristics of cowpea production.

		Eastern region		Western region	
Variable	Category	Frequency	Percentage	Frequency	Percentage
Cropping system	Mixed	21	70	18	52.9
	Monocrop	9	30	14	41.2
	Total	30	100	32	94.2
Size of land	<1acre	23	76.7	31	91.2
	1-2acre	6	20	2	5.9
	>2acres	1	3.3	1	2.9
	Total	30	100	34	100
Drought	Strongly agree	8	26.7	13	38.2
	Agree	4	13.3	10	29.4
	Neutral	6	20	10	29.4
	Disagree	11	36.7	0	0
	Strongly disagree	1	3.3	1	2.9
	Total	30	100	34	100
Purpose	Consumption	13	43.3	3	8.8
	Sale	0	0	10	29.4
	Fodder	17	56.7	21	61.8
	Total	30	100	34	100
Utilisation	Leafy vegetable	4	13.3	16	47.1
	Dual	26	86.7	18	52.9
	Total	30	100	38	100

Farmers identified seven insect pests as major threats to cowpea production. Aphids were the most frequent (67.2%), followed by thrips (10.9%) and cutworms (9.4%). In addition, five diseases were reported to be major constraints to cowpea production, with cowpea mosaic virus being the most frequent (64.1%), followed by powdery mildew (14.1%). These findings confirm the report of Asiwe (2009) that insect pests especially aphids and viral diseases constitute a major constraint to cowpea production. The results also confirmed the reports of previous studies on the importance of these biotic factors in cowpea production (Souleymane *et al.*, 2013; Huynh *et al.*, 2015). The present findings indicate the need to breed cowpea varieties that are resistant to these important insect pests, diseases and drought in order to increase yield and sustain cowpea productivity.

Majority of farmers (68.8%) grew cowpea for both grain and leafy vegetables purposes. According to Mamiro *et al.* (2011), cowpea is grown for its leaves and grains which are used as relish or side dishes with staple foods. Thus, breeding high yielding cowpea varieties should contribute to food security and improve income generation to alleviate poverty.

Preference results indicated that farmers generally preferred important traits such as seed colour, availability and leaf texture when choosing cowpea variety (Table 2). The colour identified by farmers included: Red 21.9% (from light red to dark red), cream 28.1%, white 6.2% with varying eye colour (black, brown, grey), black 15.6%, brown 3.1% and variegated 17.1% (with cream, black and grey spots).

This implied that breeding objectives must be geared toward developing cowpea varieties with different seed coat colours to meet farmers' and consumers' preferences. This finding is in line with that of Alidu (2019). Imbuhila *et al.* (2015) found that knowledge of cowpea seed traits is important to farmers because they select cowpea seed based on seed coat colour, seed size, taste and relative resistance to diseases. Households use cowpea varieties because of their taste, where 46.9% respondents preferred medium leaf texture with delicious taste, while 26.6% and 12.5% preferred sweet and bitter taste, respectively. This information is a baseline for understanding key farmer selection criteria in utilization of cowpea as a vegetable and/or grain seed which can be used in generating a demand-led variety design for cowpea.

Association of region and characteristics of cowpea

A total of 70% and 52.9% farmers in Eastern and Western, respectively, grow cowpea as a mixed crop on small parcels of land (<1 acre). Less land was used in Eastern (76.7%), compared to Western (91.2%). Mixed cropping is preferred due to the importance of cowpea as a companion crop in cereal-legume cropping systems commonly adopted by farmers in Sub-Saharan Africa to restore soil fertility, avert risk of crop failure, and distribute farm labour (Daryanto *et al.*, 2015; Wang and McSorley, 2018; Traore *et al.*, 2023).

There was a significant association between region and drought constraint (χ^2 =15.57, df = 4, P = 0.004) (Table 4). Response options were five, namely: strongly agree, agree, neutral, disagree, and strongly disagree.

Table 4. Chi-square test on association between region versus drought constraint, cowpea purpose or utilization.

Attribute		χ^2 - value	df	*P*-value
Region vs. Drought constraint	Pearson Chi-Square	15.573[a]	4	0.004
	Likelihood Ratio	19.868	4	0.001
	Number of Valid Cases	64		
Region vs. Cowpea purpose	Pearson Chi-Square	16.485[a]	2	0.004
	Likelihood Ratio	20.773	2	0.000
	Number of Valid Cases	64		
Region vs. Cowpea utilization	Pearson Chi-Square	8.438[a]	1	0.004
	Continuity Correction	6.941	1	0.008
	Likelihood Ratio	8.922	1	0.003
	Number of Valid Cases	64		

In Western region, 38.2% of respondents strongly agreed that drought is a constraint, while 26.7% of the respondents in Eastern region strongly agreed (Table 3). This may be the reason why farmers from Western region grow cowpea during all their growing seasons, whereas those from Eastern region grow in short rain seasons. The findings were in line with Bolarinwa *et al.* (2021) that many farmers grow cowpea under rain-fed conditions, thereby becoming vulnerable to drought stress when the rains fail.

There was a significant association between region and cowpea purpose (χ^2 = 16.49, df = 2, P = 0.004) (Table 4). The available cowpea purposes were three, namely: household consumption, sale and fodder. Household purpose led in Eastern that is located in ASALs (Muniu, 2017), while fodder-purpose led in Western located in rainy zone (Rusike *et al.*, 2013).

The association between region and cowpea utilisation was significant (χ^2 = 8.44, df = 1, P = 0.004) (Table 4). Most (47.1%) of the farmers that grew cowpea for leafy vegetables and fodder were from Western region, while those growing cowpea for dual usage as leafy vegetables and seed grains were from Eastern region (86.7%) of Kenya. This is due to prioritization of harvesting of seeds over leaves as it has been established in other studies that harvesting of leaves reduces seed grain yield (Saidi *et al.*, 2010). Mamiro *et al.*, (2011) reported a range of 10 g to 500 g daily per capita consumption of cowpea leaves in season among households. Harvesting of cowpea leaves is usually abandoned to allow for development of cowpea grains.

Conclusions and recommendations

The present survey identified present production constraints, farmers' preferences and important reasons for growing cowpea. The results will guide formulation of good farmer-consumer oriented breeding objectives that should contribute to resolving constraints that presently curtail the realization of cowpea production potential in the two main growing regions of Kenya. In addition, the results will be helpful to breeders and agronomists

starting a new cowpea improvement programme to be commensurate with present times and hence improve chances of adopting resultant technologies to enhance cowpea productivity and utilisation in Kenya for food and nutrition security.

Breeding programmes should consider farmers' preferred traits in varietal improvement. Activities such as participatory appraisal, field demonstration, on-farm trials, stakeholder workshops and training should be conducted to create awareness on yield and economic potential of cowpea. Farmer participation in agricultural activities should be enhanced through farmers who have first-hand experience of the new technologies or contact with extension officers providing technical advice for increase of cowpea production. To maximize benefits of germplasm exchange, while minimizing potential negative impacts, it is recommended to promote exchange among farmers, as well as conservation of local genetic resources, thereby ensuring crop improvement efforts are sustainable in the long-run.

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