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Full Length Research Paper

FARMER'S KNOWLEDGE AND PERCEPTION OF INTEGRATING PHOSPHORUS FERTILIZER AND MULCHES IN COWPEA PRODUCTION

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ABSTRACT

Cowpea (*Vigna unguiculata* (L.) [Walp] is increasingly sought for its high nutritional content, climate resilience, and ecological function in improving soil fertility. Cowpea production is hindered by an array of biotic and abiotic factors, such as pests, drought, low soil fertility, notably phosphorous (P), and farmers' limited knowledge of the importance of mulching and phosphorous application. A survey was done between September 2022-April 2023 to determine the available cowpea management techniques and assess farmer's knowledge and perception of integrating mulches and phosphorous fertiliser cowpea production in Karingani Ward, Chuka Sub-County, Tharaka-Nithi County. Data collected was analyzed using Statistical Packages for Social Scientists (SPSS) software version 21.0. Frequencies and percentages present descriptive statistics, while the Binary logistic model measured the relationship between the categorical target variable and the independent variables. The study findings showed that cowpea farming is dominated by males (60%) of aged 40-60 (53%), and most 50% attained the primary level of education. Most farmers 83% are small farm-holders relying on rainfed farming, of which long rain occurs between March and June, and short rain is received from August and December with

91% response rate. The cowpea variety M66was the most preferred indicated by 60% response rate for sale and consumption and most farmers 85% obtained planting seeds from the previous harvest. Drought, low soil fertility, and some pests were found as the key cowpea production constraints. Further, most farmers59% applied NPK during planting and they conquered that phosphorous fertilizer is an essential macronutrient in cowpea production. However, it was found that most 71% apply inappropriate amounts of fertilizers as they depend on visual estimation. The findings are crucial for developing ways to increase cowpea yield among smallholder growers, particularly in Tharakanithi County, where subsistence farming is common. Increased cowpea production through proper use of inputs such as P fertilizers and mulching could potentially assist Kenya reduce its enormous imports of cowpea grain from neighboring nations. The study also found that P-containing fertilizers integrated with plastic mulch are critical production inputs for increasing cowpea output in the region and in places with similar traditional farming practices. The study will benefit breeders, development partners, extension personnel, and other stakeholders in cowpea value chains. The study recommends that both genders and youths to actively participate in cowpea farming and farmers should be provided with extension services to boost their farming knowledge.

Keywords: Cowpea; Mulching; Phosphorus application; Management practices; Farmer's knowledge and perception

1. INTRODUCTION

Cowpea originated in Africa with significant social and economic importance in the developing world. It is one of the versatile crops increasingly sought after for its climate resilience and ecological role in improving soil fertility, provision of animal feed, and human food production, particularly in dry land ecologies under the threat of climate change. It is used as "climate-smart" and "smart food". The crop's inherent resilience and hardiness enable it to remain suitable in the production regions even under climate change (Ojiewo *et al.,* 2018; Yuvaraj *et al.,* 2020). Biological nitrogen fixation (BNF) is one of the significant advantages of cowpea production in cropping systems because its nodules are associated with soil-dwelling bacteria, Bradyrhizobia, which can fix approximately 240 kg per ha of atmospheric nitrogen and make 60-70 kg per ha nitrogen available to succeeding crops grown in rotation. (Crops Research Institute, 2006). The crop is also well-known for its smothering nature and drought-tolerance ability (Nikhitha *et al.*, 2023).

Plant-based proteins are considered vegan food, provide ample amino acids, are directly absorbed by the body, and help treat various disease ailments. Moreover, the proteins derived from plant-based foods are rich in fibre, polyunsaturated fatty acids, oligosaccharides, and carbohydrates. Hence, they are mainly associated with reduced cardiovascular diseases, low-density lipoprotein (LDL) cholesterol, obesity, and type II diabetes mellitus (Guasch-ferre *et al.*, 2019). Cowpea also contains anti-diabetic, anti-cancer, anti-hyperlipidemic, anti-inflammatory, and anti-hypertensive effects (Jaythilake *et al.*, 2018). Furthermore, magnesium and tryptophan-rich foods are essential for relaxing and soothing the body. High amounts of iron in the crop aid in reviving the body's red blood cell count, negating anaemia (Carneiro da Silva *et al.*, 2018).

Additionally, due to its protein's techno-functionality, cowpea is a crucial ingredient for the food industry and other production companies because of its functional properties and nutritional characteristics, determining their value as ingredients in food products (Khattab *et al.*, 2009). Thus, cowpea production has to be increased since convenience foods containing significant amounts of cowpea are widely consumed, substantially increasing the demand for cowpea grain (Mune *et al.*, 2014; Peyrano *et al.*, 2016).

1.1 Cowpea production trends and production constaints

Worldwide production estimates over 8.99 million metric tons of dry cowpeas produced in an area of 14.91 million ha. In Africa, total dry cowpea production estimates over 8.70 million metric tons produced in an area of 14.67 million ha, of which 86% is contributed by Western Africa, mainly Nigeria and Niger, with 6.3 million tons (FAOSTAT, 2021). In Kenya, the crop is one of the most important grain legumes in the eastern semi-arid regions. The total area under production is estimated to be 235,734 ha, yielding 25,260 tons of dry cowpea per ha (FAOSTAT, 2021). The crop has been grown mainly in arid and semi-arid lands (ASALs), including eastern and coastal counties (Njonjo *et al.*, 2019; Owade *et al.*, 2020). The crop accounts for around 16% of Kenya's pulse production, with 90% growing in eastern Kenya, primarily Kitui, Machakos, Makueni, Embu, and Tharaka Nithi Counties. (Muniu, 2017). Regarding to productions, yields have been increasing in some countries could be due to better cultivars and more intensive use of modern technology. However, in Kenya, there has been a slow progression, crop production is still low. Low yield is brought about by both biotic problems (e.g., insect pests, diseases, and parasitic weeds) and abiotic constraints such as low soil fertility, drought and heat (ICRISAT, 2017). Low soil fertility can be ascribed to deficiencies in phosphorus in the soil (Bationo *et al.*, 2002). The devastating effects in food supply chains caused by these factors build uncertainties in food availability.

Farmers have tried several methods to reduce pest infestation, such as biological methods, cultural methods, chemical methods, and pest resistance approaches, but the pests still cause detrimental effects on production (Owade *et al.*, 2020). Many farmers have embraced the use of pesticides and herbicides as the best means of insurance in protecting and preserving their crops from pests' wanton destruction, despite the fact that many are not adequately equipped with personal protective equipment and are unable to read pesticide product labels (Mobolade *et al.*, 2019). Poor education and awareness, limited agricultural subsidies, the desire for cheap chemicals, and many other factors may contribute to the setbacks and continued use of harmful chemicals in developing countries. Growing evidence shows farmers and their families may be predisposed to severe and immediate health risks linked with pesticides, although the impacts are undetected in many cases. Chemicals perpetually end up in the soil as a result of dispersion through washing water, over application, and farmers' failure to follow usage recommendations, shifts in soil ecosystems and microflora. Furthermore, persistent pesticides seep into water bodies, causing nuisance and mortality to aquatic ecological diversities while also contributing to climate change in developing nations (Nicolopoulou-Stamati *et al.*, 2016).

Therefore, due to the growing environmental concerns and demand for healthy and safe food, the dependence on chemical input-based agriculture is phased out in fever of more environmentally friendly methods (Yadav *et al.*, 2023). Mulching and phosphorous fertilizer integration is novel for pest management, improving soil eco-health, and increasing cowpea production. Mulches help regulate soil temperature, it has been found that heat stress above a threshold temperature of 16 °C can cause a 4 to 14% loss in pod set and grain yield, depending on cultivars (Hall, 2004). In addition, organic mulches, such as straw or wood chips, provide the site for beneficial insects such as ladybugs and ground beetles, which feast on common garden pests such as aphids and caterpillars, lowering their populations. Further, mulching reduces unproductive evaporation from the soil surface. Therefore, availing more water for transpiration in water-limited conditions for maintaining plant water status (Chakraborty *et al.*, 2008).

Due to climate change, drought has been established as disastrous and causes catastrophic damages to food availability in Kenya (GoK, 2019). Mulching is acrucial method for soil moisture conservation. However, mulching alone is insufficient for proper plant growth. Inadequate soil nutrients greatly reduce agricultural productivity, exposing people to food insecurity. Low soil fertility can be attributed to phosphate deficits (Bationo *et al.*, 2002). Cowpeas require phosphorus (P) for them to thrive and develop properly. It has a significant role in early root formation, crop quality, more effective disease tolerance, seed formation, and various biochemical processes such as photosynthesis, respiration, energy storage and transmission, cell division and enlargement (Johnston & Syers, 2009; Maharajan *et al.*, 2017).

Phosphorus (P) is an essential macronutrient for several plant cell macromolecules, including DNA, RNA, ATP, and phospholipids, and is required for optimal plant growth and development. Moreover, it stimulates production of secondary metabolites like phenolic and terpenes, making plants less suitable for insect pests. Phenolic substances like tannin and lignin dissuade herbivores (antifeedants) or are directly poisonous (insecticidal) to insect pests. It has been found that they slow insect growth, block enzyme function, and disrupt cell division increasing their mortality rate. Terpene compounds such as monoterpenes, sesquiterpenes, and terpene polymers obstruct phosphorylation, interfere with neuronal transmission, and some, like latex, suffocate insect pests by blocking spiracles (Tholl, 2006). Also, P has been found to increase shoot rigidity, which improves insect and disease resistance (Razaq *et al.*, 2017).

According to published studies, using P-formulated fertilizers is a quick and straightforward fix for soils that are extremely deficient in P and have P-fixing characteristics (Kolawole *et al.*, 2008; Saidou *et al.*, 2012). However, majority of smallholder cowpea growers have not accepted this choice. Most farmers in developing nations are unaware that P is a yield-boosting component that must be given to their legume fields (Horn *et al.*, 2014). The high cost of fertilizers contributes to many smallholder farmers' reticence to utilize synthetic P fertilizer (Bationo *et al.*, 2002). Further, their unavailability in rural markets, where farmers could easily access is also a contributing factor (Olufowote & Barnes-Mcconnell, 2002). It is essential to note that phosphorus application alone is not sufficient for comprehensive pest management and increased cowpea production. Mulching and phosphorous fertilizer integration is crucial adaptation methods to counter a rise in food insecurity caused by various factors through pest management, improving soil eco-health, and increasing cowpea production.

Farmers' knowledge and perceptions of using P and mulches in cowpea fields have not been extensively investigated in Kenya's major growing areas. The study's underlying hypothesis was that farmers perceive P and mulches are unnecessary for cowpea farming. As a result, this study was designed and carried out to assess farmers' knowledge and perceptions of integrating mulch and phosphorous application in cowpea cultivation, to identify the factors that influence farmers' use or non-use of P and mulches in cowpea fields, and to identify production constraints in order to come up with improved cropping practices that improve food security.

2. METHODOLOGY

2.1 Site Description

The survey was done in Karingani Ward, Chuka Sub-County, Tharaka-Nithi County. The area lies at a latitude of 000, 07’ and 000, 26’s longitude 37^0 19 and370, 46’ east, and 1535 m above sea level. Receives about 1200 mm of rainfall annually, bi-modally distributed with long rains lasting from March to June and short rains from July to December. The yearly average temperature is around 20 °C, and the soils are mostly humic Nitisols that have weathered well and have moderate to high inherent fertility (Jaetzold & Schmidt, 1983. The study was done between September 2022 to April 2023, focusing on farmers in the area.

2.2 Research and questionnaire Design

Semi-structured questionnaires, developed and pre-tested by the research team, were used to gather information from farmers. The validity of the instrument was tested by a panel of expert scholars in social sciences. The panel of scholars recommended certain amendments in the wordings, number of items and arrangement of the scale. Those recommendations were effected in the instrument before data collection to the satisfaction. A pilot study was conducted to test the reliability of the Likert-type scales in the instrument. Reliability was established as the instrument recorded. A descriptive cross-sectional design was used as it helps in collecting in-depth quantitative data without altering prevailing conditions. It is also a cheap and effective method for describing and explaining findings related to the study area. Descriptive statistics were presented using frequencies and percentages, while the Binary logistic model measures the relationship between the categorical target variable and independent variables.

2.3 Sampling Procedure

A simple random sampling method was used where the sample items had equal and independent chances of being included in the sample. This method minimizes the potential for bias in the selection process, which is crucial for obtaining reliable and unbiased research resultsreported by Sugden *et al.*, (2000).

2.4 Target Population and Sample Size

The study focused on a total of 109,572 farmer households in Tharaka-Nithi County, according to the Ministry of Agriculture, Tharaka-Nithi County. The total population (N) was used to obtain the sample size (n) [Nassiuma, 2000].

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

Where,

N = population size; n = sample size; C = Coefficient of variation of 20% (To increase Precision, Reliability, Sensitivity and Comparability since data sets with lower coefficients of variation are often easier to compare, especially when working with multiple variables).

e = standard error of 0.02

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

Therefore, the sample size was

$$n = \frac{109572(0.2*0.2)}{(0.2*0.2)+(109572-1)*(0.02*0.02)}$$

n=99.909

=100 farmers

2.5 Data Collection

During the survey, farmers (both males and females) aged between 18 and 60 were interviewed using a semi-structured questionnaire within their farming areas. The questionnaire sought to assess farmers socio-economic factors, farming practices, production constraints, cowpea utilization, and perception of the integration of mulching and phosphorous application on cowpea production.

2.6 Data Analysis

The data collected was analyzed using SPSS version 21.0. Descriptive statistics were presented in percentages and frequencies. Further, the effects of socio-economic and farm characteristics on the farmers' perception of phosphorous fertilizers and mulches importance in cowpea production were analyzed using a Binary Logistic Regression Model. The independent variables were the socio-economic factors and farm characteristics, while the dependent variable was the farmers' perception of the importance of phosphorous fertilizers and mulches in cowpea production.

In the model, the variables take the value of 1 with a probability of p and 0 with the probability of q=1-p (Holm & Stegare, 2017). If X is a random variable, then:

$$\Pr(X=1)=p=1-\Pr(X=0)=1-q \quad \text{.........} (i)$$

A random variable is distributed according to a Bernoulli distribution if it is binary. Bernoulli models use logistic regression, where:

$$Log\,[\frac{p}{(1-p)}] = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \varepsilon_i \quad \text{.........} (ii)$$

In this case, p indicates the perception of farmers on the importance of using phosphorous and mulch in cowpea production, with "1" representing farmers whose opinion was "yes" phosphorous and mulches are essential. In contrast, "0" indicates those who opposed (unimportant). The logistic regression model with Bernoulli distribution that was used for the current study to determine the effect of socio-economic and farm characteristics on the farmers' perception expressed as follows:

$$Y = \log(\frac{p}{1-p}) = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \cdots \beta_nX_n + \varepsilon_i \quad \text{.........} (iii)$$

where Y is farmers' perception of the importance of phosphorous and mulch in cowpea production, α is the intercept, $\beta_1 - \beta_n$ are regression coefficient, ε_i Is the error term designed to capture the effects of unspecified variables in the model. The α and βs are the parameters for estimation. X_1......X_n, the independent variables include age, gender, education level, land size, farming system, cowpea yield, and presence of drought, type of fertiliser used, access to new farming technology, cowpea utilisation, and moisture conservation method.

3. RESULTS AND DISCUSSION

3.1. Descriptive Statistic of Cowpea Farmers

In the study, 100 respondents were issued with semi-structured questionnaires. The response rate was 100%, which was high, thus validating the results obtained from respondents. Mugenda & Mugenda (2012) indicated that a response rate of over 70 % is suitable and sufficient.

3.2. Gender, Age, and Level of Education of the Household Head

The study sought to comprehend the socio demographic traits of the cowpea producers in the study area. The study findings showed that most respondents were males (60%), and (40%) were female. This implies that male's dominate in cowpea production in the study area. The age range of cowpea growers was also the study's goal and it was found that majority of respondents (53%) were between the ages of 41 and 60, with most of them being under 50 years, 34% were found to be between the ages of 31 and 40, 12% were found to be between the ages of 21 and 30, and 1% were under the age of 20. Regarding education level achievement, it was found that farmers in the study area attained formal education at (50%) primary education, 44% secondary education, and 6% attained higher education (Table 1).

Regarding to farmers' gender, Agriculture is hardly an exception when it comes to gender inequality. The gender of farmers matters, particularly in areas where family labour is common. Men are more likely than women to put more effort into running the farm and providing the necessary horsepower, which boosts labor productivity and lowers the cost of non-family labour. It is also possible to link this to the study area's strong religious beliefs, cultural norms, and stereotype specialization prohibiting women from working on farms or doing the arduous labour required producing cowpeas. Danquah *et al.* (2009) report similar findings that most farming is dominated by male gender.

Further, the study findings agree with those of Mohammed *et al.* (2023), who found that most wheat farmers in the growing area were males. Additionally, the study findings agree with those of Hellin *et al.* (2010), whofound that the production and sale of cowpeas is a male activity. However, the findings contrast with those of Nkongolo *et al.* (2009), who found that women are the leading cowpea producers. Regarding the age category of farmers, it was observed that most were in their prime years (40–60), which implies that most respondents were in their prime years of productivity. The study on age was relevant since it influences the availability of labour for carrying out farm tasks. This study's findings on low youth participation, agree with those of Afande *et al.* (2015), whore port that Kenya struggles with low youth participation in agricultural and subsistence agriculture, such as cowpea production.

However, the study findings contrast with those of Owade *et al.* (2020), who found that the youths dominated cowpea farming in the study area. Education is important to the improvement of agricultural productivity such that formal education opens the mind of the farmer to knowledge, Keeping the farmers abreast with changing innovations and ideas and allowing them to share experienced gain (Oduro-ofori *et al.*, 2015). The educational attainment of cowpea farmers in the study area varied significantly, which could be attributed to various factors such as the region, socio-economic conditions, cultural context, poverty, and limited infrastructure contributing to most farmers' only attaining primary education. Farmers' attainment of formal education, implies that were somehow literate and aware of crop farming.

Table 1: Gender, Age, And Level of Education of Household Heads

Characteristic	Response	Frequency	Percent
Gender	Male	60	60
	Female	40	40
	Total	100	100
Age bracket	21-30	12	12
	31-40	34	34
	41 and above	53	53
	Less than 20	1	1
	Total	100	100
Level of education	Primary	50	50
	Secondary	44	44
	Tertiary	6	6
	Total	100	100

The study's findings contrast those of Danqual *et al.* (2019), who reported that farmers with secondary school education had the highest percentage compared to other levels of education.

3.3. Farming System Practiced, Farm Size, and Planting Season

The study sought to investigate the area's cropping system, farm size, and planting seasons. The sty study findings show that the majority of respondents, 68%, employ a monocropping system, while 32% practice intercropping, regarding cowpea farmers' farm size. It was found that 83% of respondents practice cowpea farming on < 1acre, 13% practice on >1-2 acres and 4% of farmers practice on >2 acres. The study findings based on planting season was found that 91% of respondents sow cowpeas twice a year, particularly during the wet seasons, whereas 7% sow at the start of the year (January-March) and only 2% sow at the end of the year [September-December] (Table 2).

The study findings indicate that most farmers prefer the monocropping system to the intercropping system. Monocropping might be preferred because it offers a higher level of risk management than intercropping since implementing targeted strategies to mitigate risks associated with pests, diseases, and adverse weather conditions is more manageable. Further, monocropping might allow farmers to optimize the use of resources such as land, water, and labour by maximising the efficiency of machinery and equipment, reducing the time spent transitioning between different crops. The study findings contrast with Aliyu *et al.* (2023), who reported that most cowpea farmers practice intercropping and a minority practice sole cropping. The study findings align with those of Njonjo *et al.* (2019), who found that farmers in different agroecological zones grew cowpeas in both intercropping and mono-cropping systems. Regarding cowpea farm size, farming is done on a small scale, probably due to land fragmentation.

The land could have been subdivided among family members as part of inheritance practices. Secondly, it could be due to limited financial resources, making it difficult for them to acquire large tracts of land. Nevertheless, they can use their knowledge and techniques to boost yield through effective management. The study findings are closely related to that of Njonjo (2019), who found that the area under legume in some parts of Makueni County ranged from 1.1 to 1.5 ha.

Table 2: Farming System Practiced, Farm Size and Planting Season

Characteristic	Activity	Frequency	Percent
Farming System	intercropping	32	32
	Mono-cropping	68	68
	Total	100	100
Farm size	<1 acre	83	83
	>2 acres	4	4
	1-2 acres	13	13
	Total	100	100
Planting season	Beginning of the year (Jan-march)	7	7
	End of the year (Sep-Dec)	2	2
	Across the year (twice a year wet season)	91	91
	Total	100	100

The findings create a research void in land tenure systems, and effects on crop production. The type of land development a farmer takes is determined by the kind of land ownership system, which is a crucial factor in agricultural production. The size of the entire farm aids the farmer in selecting the appropriate agricultural system and establishes the expected production level. The study findings revealed variability in the cowpeas production season. Most farmers depend on long and short rain, which occurs twice annually. The study findings concur with Ademe *et al.* (2020), who reported that rainfall is Ethiopia's most significant water supply for crop production. Its temporal and spatial variability causes severe food shortages and insecurity in the nation.

3.4. Cowpea Varieties Grown and Seed Source

This study sought to identify the cowpea variety grown and seed source. It was found that 60% of the respondents grow the cowpea variety M66 and 43% plant the Kundemboga. Study findings on seed sources show that the majority, 85% of the respondents, obtained seeds for sowing from the past harvest, whereas 24% got from agro-vet (Table 3).Cowpea variety M66 being the most preferred by the respondents may be linked to characteristics like high production potential, disease resistance, adaptability to various environmental circumstances, or acceptable agronomic attributes.

Table 3: Cowpea Varieties Grown and Source of Seeds for Sowing

Characteristic	Description	Frequency	Percent
Varieties	M66	60	60
	Kunde Mboga	43	43
Source of seeds	Agro vet	24	24
	From past harvest	85	85

Karanja *et al.* (2008) indicated that the cowpea variety M66 is a determinate, dual-purpose cultivar with significant vegetative development, drought tolerance, and quick growth. The crop's tolerance to aphids, thrips, and resistance to scab diseases and yellow mottle viruses may have also influenced its popularity (Kebede & Bekeko, 2020). Additionally, there is also a possibility that certified cowpea seeds may be scarce and costly in the area; hence, most farmers resorted to using widely accessible, cheap, non-certified seeds. It has been reported that 60-100% of farmers in developing countries obtain planting seeds from informal seed systems, which are farm-saved, market-sourced, or exchanged between farmers, most likely due to certified seeds being generally expensive. Farmers are unwilling to buy them (Njonjo *et al.*, 2019). Furthermore, Muthoni *et al.* (2013) reported that most Irish potato producers use non-certified Irish potato seeds, supporting the study findings.

3.5. Farmers' Perception of Drought as a Constraint and Water Source Used in Cowpea Production

The study attempted to ascertain farmers' perceptions of drought as a constraint in cowpea output. It was observed that 84 % of farmers strongly agreed, 14% agreed, and 2% were unsure if droughts affect cowpea production. The study findings on water supply indicate that 94% of respondents rely on rain-fed farming, 4% on irrigation, and 2% on both means of water supply (Table 4). Drought was reported as a severe limitation in cowpea production by farmers during the study, which could be related to its adverse effects on crop growth and development. According to Lamaoui *et al.* (2018), a lack of moisture affects the intake of vital nutrients for plant growth and the capacity of seeds to germinate properly.

Table 4: Farmers' Perception of Drought as a Constraint in Cowpea Production and Water Source

Characteristic	Description	Frequency	Percent
Farmers perception	Agree	14	14
	Neutral	2	2
	Strongly agrees	84	84
	Total	100	100
Water supply	Irrigation	4	4
	Rain	94	94
	Both	2	2
	Total	100	100

According to Fahad *et al.* (2017), irregular rainfall in particular places discourages farmers from entering cowpea farming. Ayaa *et al.* (2018) identified inconsistent rainfall as one of the most common issues constraining output, resulting in poor production, and that most cowpea farmers rely on rain-fed farming. Furthermore, the study findings are closely consistent with those of Pinho *et al.* (2022), who reported that appropriately delivering water requirements to the plant enhances its physiological processes and promotes its growth and development. Soil Moisture Conservation Method and Type of Fertilizer Used in Cowpea Production. The study findings show that 59% of respondents mulch their crops using various mulching materials, whereas 41% of the farmers do not use any mulch on their farms. Concerning fertilizer used, 59% of respondents used NPK fertilizers, whereas 42% used Diammonium Phosphate fertilizer in their farms [DAP] (Table 5).The study findings on mulches imply that most cowpea farmers were aware of the importance of mulches, including moisture conservation, weeds suppression, temperature moderation, erosion control, and soil fertility improvement.

Table 5: Soil Moisture Conservation Method and Fertilizer Used

Characteristic	Description	Frequency	Percent
Soil moisture conservation	Use of mulch	59	59
	Not using mulch	41	41
	Total	100	100
Fertiliser used	DAP	42	42
	NPK	59	59

The study findings align with those of Bianch *et al. (*2017), who found that most farmers employ mulching to conserve soil moisture, and increased mulching is linked to higher crop yields and reduced soil runoff and erosion.

3.6. Farmers' Perception of Use of Phosphorous and Fertilizer Grade Used in Cowpea Production

The study sought to identify cowpea production constraints. The majority of the respondents (84%) strongly agree, 1% agree, 1% are unsure if phosphorous is important, and 1% disagree that phosphorous fertilizer is necessary for cowpea production. However, the study findings on fertilizer rate applied it was found that 71% of farmers do not measure fertilizer used in their farms, 12% apply 40 kg/ha, 10% apply 20 kg/ha, and 7% apply 60 kg/ha (Table 6).

Table 6: Farmers' Perception of the Use of Phosphorus Fertilizer and Rate Used in Production

Characteristic	Description	Frequency	Percent
Farmers perception	Agree	14	14
	Disagree	1	1
	Neutral	1	1
	Strongly agrees	84	84
Fertiliser rate used	20kg/ha	10	10
	40kg/ha	12	12
	60kg/ha	7	7
	Unknown	71	71
	Total	100	100

Production of cowpea, like other crops, experiences several biotic and abiotic stresses (Osipitan *et al.*, 2021; Addae-Frimpomaah *et al.*, 2022). Regarding P application, cowpea farmers were somehow aware of phosphorous fertilizers' importance in plant growth and development; hence, most applied during planting. The study findings agree with William *et al.* (2019), who found that most farmers apply phosphorous fertilizers during the agricultural season. The study findings on fertilizer rate applied indicate most farmers have limited knowledge of using appropriate fertilizer rates, as they depend on visual estimations of mounts to apply. Inappropriate fertilizer application could be due to limited access to information on the optimal quantities of fertilizers required for specific crops and unawareness of potential adverse effects of over or under-application. Also, this could be due to a lack of access to appropriate measuring tools or equipment in their local markets to measure fertilizer quantities accurately. Similar findings were found by Kaguongo *et al.* (2008), who found that most farmers do not measure fertilizer used.

3.7. Insect Pests Affecting Cowpea Production

Cowpea production constraints were general to all farmers in the study area. The study findings indicate that bean aphids were the most common insect pest in cowpea production, with 99% of responses, followed by pod borers, with 89%. Cutworms obtained a score of 61% responses, while whiteflies received 2% responses. In terms of severity, aphids received a perfect score of 100% responses (Table 7). Bean aphids are the area's most common cowpea insect pest, which reduces crop production. High aphid infestation could be due to their reproductive solid capability (proliferation) and the ability of their populations to increase in favorable conditions.

Table 7: Insect Pests Affecting Cowpea

Insects Pests	Frequency	Percent
Aphids	99	99
Pod borers	89	89
Pod-sucking	2	2
Cutworm	61	61
Whiteflies	2	2
Most severe insect pest		
Aphids	100	100

Female aphids can produce many offspring without mating, and these nymphs can quickly mature into reproducing adults. Because of this rapid population expansion, aphids can multiply rapidly and cause substantial harm to cowpea crops. The study findings align with Karikari *et al.*

(2023), who found that cowpeas are susceptible to high pest incidence. Ayaa *et al*. (2018) rated similar challenges of pests constraining cowpea production. The study findings agree with those of Makoi (2019), who stated that any cowpea growth and development disruption, regardless of whether it results from biotic causes, can harm the crop's production and yield components. Aphids are also one of the most prevalent insect pests of cowpeas in Africa, according to Essien *et al*. (2020), which had a detrimental effect on crop productivity.

3.8. Type of Weeds Affecting Cowpea Production

During the study findings weeds were among cowpea production constraints experienced by farmers. Blackjack) was at the top ranked, indicated by (96%), responses followed by pigweedby 36% responses, grasses by 8%, and wandering jew by 1% (Table 8). High weed responses (blackjack) could be due to the weed being annual. Further, could be due to the having vigorous growth rate, allowing it to establish itself and spread across large areas quickly covering crops, gardens, and other desirable plants, depriving them of sunlight, nutrients, and water.

Table 8: Type of Weeds Affecting Cowpea Production

Type of weeds	Frequency	Percent
Blackjack	96	96
Pigweed	36	36
Grasses	8	8
Wandering jew	1	1

The study's findings agreed with those of Siniscalco *et al.* (2011), who reported that blackjack appears in all altitude zones distinct from the biological circumstances in place, demonstrating that it has qualities that make it well-adapted to various environments.

3.9. Technology Access

Study findings on technology access, most of respondents (87%) had no access to technology, and only 13% had access to technology through extension services. The study also intended to ascertain farmer uses of cowpeas, and it was found that most respondents (79%) grow the crop for household consumption and sale. In comparison, 12% grew the crop only for household consumption, while 9% sold the produce (Table 9). The study findings on technology access revealed that most farmers are unaware of the benefits of using technology in agriculture or may lack the necessary skills and knowledge to utilize it effectively. It is possible that access to relevant information, such as research findings, best practices, and success stories, can play a crucial role in encouraging farmers to adopt the technology. Limiting government initiatives, subsidies, or investment in rural areas could contribute to limited access to technology for farmers.

The study findings concur with Nyagaka *et al*. (2009), who found that most farmers limited access to extension services. Therefore, based on the study's findings, government and non-government entities must disseminate new technologies and innovations for cowpea production. As most farmers grew the crop for consumption and sales, the study's findings on cowpea use indicate that most farmers are aware of the crop's value to their health and as a source of revenue.

Table 9: Technology Access

Characteristic	Description	Frequency	Percent
Whether accesses technology	No	87	87
	Yes	13	13
	Total	100	100
Technology accessed	Soil testing	12	12
	Use of furrows	1	1
Cowpea utilization	Both	79	79
	Household consumption	12	12
	Sale	9	9
	Total	100	100

The binary logistic model determined farmers' perceptions regarding integrating mulches and phosphorous fertilizers in cowpea production. The binary logistic model was tested at a 5% significance level. The likelihood ratio Chi-square was 36.46 with a P-value of 0.0001<0.05, explaining that the model was statistically significant. The pseudo-R square was 0.4196, which shows that socio-economic and farm characteristics have a 41.96% effect on the farmers' perception regarding the use of phosphorous fertilisers and mulches in cowpea production. The model included several socio-economic and farm characteristics and found that education, gender, land size, farming system, type of fertiliser used in the farms, cowpea utilisation, and access to new farming technologies had no significant effect on the farmers' perception regarding the use of phosphorous fertilisers and mulches in cowpea production since their P-values were more than 0.05, the set standard level of significance for which the model was tested. However, age, cowpea yield, presence of drought, and moisture conservation methods used by farmers significantly affected the farmers' perception of the importance of phosphorous fertilisers and mulching in cowpea production. Their P-values were less than the standard level of significance of 0.05 (Table 10). Age had a positive and significant effect (P-value =

0.038<0.05) on the farmer's perception of the importance of phosphorous and mulching in cowpea production. As cowpea farmers age, they advance their perception of the importance of using phosphorous fertilisers in cowpea production.

The marginal effects show that a unit increase in the farmer's age is associated with a 0.041 unit increase in the perception of using phosphorous fertilisers and mulches in cowpea production (Table 11). The model findings imply that as cowpea farmers get older, they learn and increase in knowledge on the importance of using phosphorous fertilisers and mulch in cowpea farming. Consequently, aged farmers are much more capable of using phosphorous fertilisers and mulch since they know the accompanying benefits. The farm output of cowpeas relates positively and significantly at 5% (P-value = 0.029) with the farmers' perception of the importance of phosphorous fertiliser use and mulching. The marginal effects show that a unit increase in cowpea yield is due to a 0.039 unit increase in the urge by farmers to use phosphorous fertilisers and mulch (Table 11). Drought as a constraint to cowpea production was significant at 1% (P-value=0.004<0.05). The model findings show that drought is a constraint in cowpea production, and its presence necessitates more use of phosphorous and mulch; otherwise, cowpea production would decline. The method of moisture conservation used by the cowpea farmers has a negative association with the farmers' perception and was significant at 1% (P-value=0.002<0.05).

Table 10: Logit Estimates for the Socio-economic and Farm Characteristics

Indicator	Coefficient	Standard errors	Z	P>(z)
Age	0.089	0.043	2.07	0.038
Gender	0.242	0.813	0.30	0.046
Education	0.599	0.769	0.78	0.436
Land size	-0.528	0.611	-0.86	0.387
Farming system	1.328	1.067	1.24	0.213
Cowpea yield	0.095	0.044	2.18	0.029
Presence of drought	-2.99	0.996	-2.91	0.004
Type of fertiliser used	0.592	0.882	0.67	0.502
Access to new farming technology	-0.565	0.357	-0.42	0.677
Cowpea utilisation	1.164	0.652	1.78	0.074
Moisture conservation	-3.172	1.028	-3.08	0.002
Number of observations	100			
Pseudo R Squared	0.4196			
LR Chi-squared	36.46			
Prob > chi2	0.0001			

Table 11: Estimated Marginal Effects of The Socio-economic and Farm Characteristics

Variable	dy/dx	Standard error	Z	P>(z)
Age	0.041	0.002	1.77	0.007
Gender	0.010	0.035	0.29	0.773
Education	0.025	0.034	0.73	0.465
Land size	-0.022	0.026	-0.83	0.404
Farming system	0.055	0.043	1.29	0.196
Cowpea yield	0.039	0.002	1.80	0.001
Presence of drought	-0.121	0.059	-2.05	0.041
Type of fertiliser used	0.025	0.0365	0.68	0.498
Access to new farming technology	-0.029	0.082	-0.35	0.725
Cowpea utilisation	0.049	0.031	1.55	0.122
Moisture conservation by mulch	-0.132	0.06	-2.22	0.026

The model findings show that the use of other methods of moisture conservation negatively affects cowpea production. There would be a possible decline in yield for farmers opting to use other methods instead of mulching integrated with phosphorous fertilisers in cowpeas.

CONCLUSION

The study found that most cowpea farmers in the area were males in the age bracket of 40-50, and the majority only attained primary education.Small farm-holders do cowpea farming in the area, and most produce cowpeas twice a year, relying on long and short rains. Cowpea M66 is the most preferred variety for sale and consumption. Further, most cowpea farmer's source planting seeds from the previous harvest. Regarding production constraints, drought-affected productivity, as indicated by most farmers; thus, most rely on rain-fed agriculture. Pests were also the biotic factors limiting output in the study area, specifically aphids and blackjacks. Most farmers apply NPK fertilizer on their farms, and they firmly agree that phosphorous fertilizers are critical nutrients in cowpea production. However, they apply inappropriate amounts. Cowpea growers in this study did not use recommended fertilizer rates for cowpea; they were thus inadvertently contributing to the low yield that characterizes African agriculture for most crops. On the basis of information obtained from the key informants during the surveys many of the farmers are willing to use P-based fertilizers like TSP and mulches if these are given to them or made available in the rural markets at subsidized prices and this will help in management of biotic and a biotic factors affecting crop production.

The study findings shows that it is important to consider farmers' knowledge and perceptions when designing new agronomic approaches, as this will greatly facilitate the diffusion and adoption of new and improved technologies among farmers. Our findings will inform the decision-making process and planning of programs aimed at improving sustainable cowpea food systems.It is recommended that both genders and youth should actively participate in cowpea production, and farmers should be provided with extension services to increase farmers' knowledge of cowpea production. There is need for further research in land tenure and its impact on cowpea production.

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