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Level of Adoption and Perception of Farmers on Phosphorus Based Fertilizers for Cowpea Production in Katsina State, Nigeria

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Abstract

The study analyzed farmers' level of adoption and perception of phosphorus based fertilizers for cowpea production in Katsina state, Nigeria. A total of 153 cowpea farmers were sampled using a multi-stage sampling technique. Primary data was utilized in the study. The data was collected using a structured questionnaire by trained enumerators. Descriptive statistics, Kendalls' coefficient of concordance and acceptability index were employed for data analysis. The results showed that the mean age for cowpea farmers was 41 years. Distribution of the respondents by gender reveals that 85.6% were males and the remaining 14.4% were females. The result of farmers' perception of phosphorus-based fertilizer used shows a moderate agreement of 0.30 which indicates different perceptions among respondents. The study further revealed that the acceptability index of 6.54% was very alarming because cowpea farmers committed a small portion of their farmland toward adopting the technology. The level of knowledge of the cowpea farmers on phosphorus based fertilizers was very low, leading to a very low level of acceptance of phosphorus fertilizers in the study area. It was recommended that be made available and affordable to the cowpea farmers as this will increase the rate of technology adoption in the study area.

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Introduction

Cowpea (*Vigna unguiculata*) is a popular legume crop in many countries in Sub-Saharan Africa (SSA) and provides food for over 200 million people (Saba *et al.*, 2020). Cowpea is an animal feed and food crop grown in the semi-arid tropics covering Africa, Asia, Europe, the United States, and Central and South America. It originated and was domesticated in Southern Africa and was later moved to East and West Africa and Asia. The grains contain 25% protein and several vitamins and minerals. The plant withstands drought, performs well in a wide different types of soils, and being a legume replenishes low fertility soils when the roots are left to decay. It is grown mostly by small-scale farmers in developing regions where it is often grown with other crops as it tolerates shade. It also grows and covers the ground quickly and preventing erosion as well (Srinivasan *et al.*, 2021).

Cowpeas are cultivated usually by smallholder farmers using rudimentary systems as an intercrop or relayed after cereals leading to poor plant stands, shading effects by the companion crops, and competition between crops with negative consequences on the productivity of the

crop. This has been practiced by many farmers in the northern regions of Nigeria known for its substantial cowpea production (Saba *et al.,* 2021). Cowpea is an important economic crop because of its adaptability to different types of soil and intercropping systems, its resistance to drought, and its ability to improve soil fertility, prevent erosion and high protein level. During the dry season, the sale of the stems and leaves as animal feed also provides a vital income for the farmers (Srinivasan *et al.,* 2021).

Agriculture has always been a technology dependent and knowledge-based activity. The more the population increases, the more knowledge and technology are required to produce more. In view of such situation, the Nigerian government has been showing concern by encouraging farmers to adopt the new knowledge of modern science and technology to be able to produce enough that can feed the national teeming population (Joshua *et al.,* 2019). Recently, as a result of innovative technology, the federal government of Nigeria approved a newly developed Pod Borer Resistant (PBR) cowpea variety which received high demand from farmers for commercial farming. However, such a development may not necessarily yield impressive result if the farmers continue to rely on manure for fertilizing the soil, this is because scientifically, the composition of animal dung is less than one percent nitrogen and hence relying on it to produce food unanimously means abysmally poor nutrition for plants and its consistent use leads to soil depletion. Such conditions usually necessitate the application of improved technology such as phosphorus based fertilizers in order to regain soil nutrients (Kollo, 2021).

In Nigeria, studies affirmed that some cowpea farmers have the belief that cowpea does not need fertilizers application. Thus, the farmers have been traditionally producing the cowpea with a low application rate of phosphorus based fertilizers of 13kg/ha below the recommended rate of 40kg/ha on the farms (Ayodele and Oso, 2014). This consequently leads to the average yield of cowpea per hectare to only about 417kg/ha in Nigeria which is below the potential yields of between 1500 to 3000kg/ha (Joshua *et al.,* 2019). It is clearly known that increased crop growth and output are concerned with the application of recommended fertilizers used. In legumes particularly cowpea, phosphorus based fertilizers is a key to realizing a higher production rate and an active market for phosphorus based fertilizers in major cowpea production areas in Nigeria.

It is therefore based on the foregoing discussion, the work intended to analyze the objectives below:

1- Determine the perceptions of cowpea farmers on phosphorus based fertilizer application;
2- Determine the extent of adoption of phosphorus based fertilizer;

Conceptual Framework for cowpea production

The major concept of this study is the extent of adoption of phosphorus based fertilizers for cowpea production. As it can be seen in Figure 2, the conceptual framework shows the interrelated effects of the dependent and independent variables on the extent of adoption of phosphorus based fertilizers by cowpea farmers. The arrows indicate that farmers' characteristics (age, farming experience, level of education, household size, income, and contact with extension agent) together with the history of farmers in farm trials participation, may lead to the adoption of phosphorus based fertilizer in the cowpea production. This consequently can increase the total yield thereby increasing the crop income and simultaneously minimizes the farmers' fear of risk taking in adopting the technology. This may arouse the interest of more cowpea farmers to embrace the technology

which could in turn increase the extent of adopting the phosphorus based fertilizers in cowpea production.

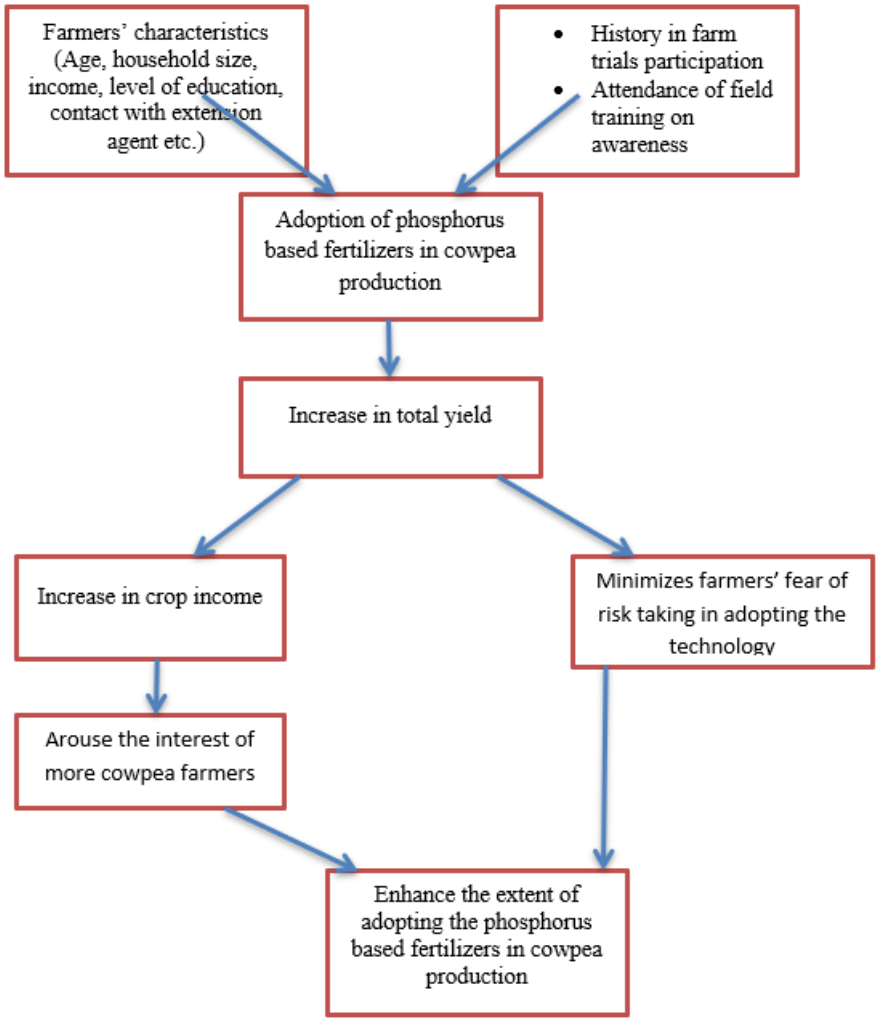

Figure 1. Conceptual framework for cowpea production

Review of studies on the perceptions of cowpea farmers on phosphorus based fertilizer application

In a study conducted by Saba *et al.* (2020), the authors surveyed 420 farmers across three major cowpea producing states in Nigeria. The data collected was analyzed using descriptive statistics, factor analysis and logit regression. A five-point Likert scale consisting of seven questions was used to determine the perceptions of farmers with regard to the use of phosphorus-fertilizers in cowpea production. The result of their analysis shows that the Likert item "phosphorus accelerates cowpea output" is considered as the acceptable perception by cowpea farmers with an average of 4.37 followed by 2.97, 2.94, 2.90 and 2.80 as the mean of the following Likert items: "Phosphorus use increases the cost of production", "Not using phosphorus due to prior knowledge", "I do not use phosphorus due to unavailable in the market" and "I do not use phosphorus because it is costly" respectively.

Another research was carried out by Matias *et al.* (2021) on the perception and adoption of new agricultural technologies in Northern Inland Mozambique. The authors assessed the perception and the level of

adoption of a set of agricultural technologies in the study area. Two key actors were taken into consideration in the study. These actors include technicians, who are the local government officials and are responsible for the adoption of agricultural technologies in the area. The data was collected through surveys with 10 technicians (20% women) and 8 extension farmers (37.5% women), assessing their perception of the adoption of agricultural technologies in Chitima, Mozambique between 2012 and 2017. Results show that the farmers do not care about the type of technology as long as it increases the crop yield and income. According to 70% of the technicians; the adoption of agricultural technology is mainly due to its resistance to the dry season. However, 88% of the extension farmers have the perception that yield improvement leads to the adoption of agricultural technology**.** The variation between the perceptions of both groups could lead to misunderstanding since a technology that improves resistance to the dry season might be affecting yield improvement too.

According to research carried out by Newton (2020), the author adopted a dichotomous logit regression model to quantitatively measure demographic variables that affect the acceptance of farming technology. Moreover, FGD consisting of 28 respondents has been introduced in the study area (Lurambi, Shianda, Malava and Ikolomani), to determine an in-depth understanding of farmers' perspectives on technology adoption. The focus group participants included farmers recruited from among survey participants. The qualitative research instrument sought to answer three questions, (RQ1) what are farmer attitudes and perceptions towards agricultural technologies; (RQ2) what socio-cultural values influence farmers' choice of agricultural technologies; and, (RQ3) what are the sources farmers used for obtaining information on agricultural technology?. The findings revealed that farmers have the perception that agriculture remains the major source of income, and they will consistently depend on the present and potential technologies to improve crop output.

Review of studies on the level of adoption of phosphorus based fertilizer

The work of Bashir *et al.* (2018) in Taraba state. The study found out the cowpea production technologies available to the respondents among which fertilizer application was included and the authors assessed the respondents' extent of adoption of each cowpea production technology. The findings of the study revealed that the prepared inorganic fertilizer rates for cowpea production are SSP prior to sowing at 200kg/ha. The minority of the farmers (8%) had knowledge about the innovation of inorganic fertilizer, 10% were interested in the adoption of inorganic fertilizer application rate for cowpea production. Most of the respondents (58.7%) had adopted the technology. The farmers indicated that the soil was fertile to support cowpea production in the study area and they would use available inorganic fertilizer on their cowpea farms.

In a related study conducted by Solomon *et al.* (2021) on Perception and determinants of agricultural technology adoption in North Shoa Zone, Amhara Regional State, Ethiopia. The major objective of the study is to assess the perception and determinants of agricultural technology adoption. Data were collected from 796 farming households from four districts namely, Angolela Tera, Menz Gera, Minijar Shenkora and Moretna Jiru. During analysis purpose, a t-test and a binomial logistic model were employed. The result indicates that chemical fertilizer adoption showed that 542(68.22%) adopt chemical fertilizer. Age of the household head, household size, years of farming experience of the household head, and livestock owned is higher among chemical fertilizer adopting households and showed a

statistically significant difference among adopters and non-adopters at a 1% level of significance. Additionally, the adoption of chemical fertilizer among farmers participating in off-farm income generating activities and among farmers with social membership status is higher among adopters as compared to non-adopters and it is significant at a 1% level of significance. Like the improved seed, chemical fertilizer adopting households have a short distance to the nearest market (7.40 km) as compared to non-adopters (13.60 km) and the difference is statistically significant at a 1% level of significance. This is in line with the findings of this study where it was found that the cost of phosphorus based fertilizer is highly significant at 1% level. This shows that an increase in the cost of the fertilizer may increase the number of non-adopters of the technology in the study area.

Materials and methods

Description of the area

This research was carried out in Katsina State. The state has an estimated area of 23,983 square kilometers and also has an estimated population of 9,921,456 by 2021 (Ibukun, 2019). Katsina state is situated in the North-western part of the country and lies in between latitudes 11^0 03′ and 13^0 05′ N and longitudes 07^0 21’ and 09^0 02′ east of Greenwich Meridian and bordered by Niger republic to the North, Zamfara state to the West, Kaduna State to the South and Kano and Jigawa States to the East. The state has two climate seasons; dry and rainy seasons with a mean average rainfall of about 400-1300mm. The climate conditions favour the cultivation of the following crops such as maize, beans, millet, guinea corn, rice, and groundnut. The major livestock found around the state include goats, cattle, sheep, and poultries (Saleh and Oyinbo, 2017).

Sampling technique and sample size

Multi-stage sampling technique was employed for the study. The first stage, it consistspurposive selection of three major cowpeas producing Local Government Areas in Katsina state which include Kaita, Danja and Matazu. In the second stage, we employed a random selection of three villages from each of the three sampled L.G.As. Which makes them to be a total of 9 villages used for the study. The third stage is the application of the proportionate in order to select an appropriate number of farmers from the selected villages using the sample size of 153 out of 264 recommended by a sample size calculator (Raosoft, 2022).
The following expression of the proportionate sampling was used.

$$n = \frac{X}{D} \times N$$

Where:
n = Sample size of farmers selected per village
X = Number of farmers in a village
D = Total number of farmers in all villages.
N= Recommended sample size for the study by Raosoft sample size calculator.

The proportionate distribution of cowpea farmers is computed in the following table.

Table 1. Sample size of the farmers

S/No.	Zones	L.G.A	Village	Population of farmers	Number of farmers selected
1	Funtua	Danja	Kahutu	34	20
			Tandama	31	18
			Dabai	23	13
2	Ajiwa	Kaita	Dankama	28	16
			Yandaki	31	18
			Bado	26	15
3	Dutsinma	Matazu	Gwarjo	32	19
			Mazoji	28	16
			Sayaya	31	18
Total	**3**	**3**	**12**	**264**	**153**

Source: Field survey (2022).

Data collection

The study used primary data which was collected using a structured questionnaire and administered to the selected cowpea farmers by trained enumerators. The data collected include information on the socio-economic variables of the cowpea farmers, average yield obtained, quantity of phosphorus fertilizer applied, and perception of the cowpea farmers on the adoption of phosphorus based fertilizer.

Data Analysis

The data collected was analyzed by the use of analytical tools like descriptive statistics, Acceptability index, and Kendall's Coefficient of Concordance to achieve the stated objectives. To achieve objective 1 descriptive statistics and Kendall's Coefficient of Concordance were used, whereas Acceptability Index was used to achieve objective 2.

Descriptive statistics

This involves a tabular presentation of the mean, percentages and frequency of the data to be analyzed. It summarizes and organizes the characteristics of the data to be collected. Thus, the findings related to Likert scale items derived from the sample were presented. Excel version 2010 was used during descriptive analysis.

Kendall's Coefficient of Concordance

Kendall's coefficient of concordance was proposed by Maurice G. Kendall and Bernard Babington Smith in 1938. Kendall's coefficient of concordance is a non-parametric statistic that can be used in measuring the trend of agreement among several quantitative or semi-quantitative variables that assess a set of interests. It measures the association between the perceptions of the raters. The value of the coefficient ranges between zero and one (Kendall, 1938).

A type of psychometric response scale (Likert scale) in which respondents specify their level of agreement to test a statement typically in five-point was also employed to source the figures that was used in the computation of Kendall's coefficient of concordance which determine the perception of cowpea farmers on phosphorus fertilizer. The liker scale options are as follows:

1= strongly disagree
2= disagree
3= undecided
4= agree
5= strongly agree

$$w = \frac{12s}{m^2(n^3 - \mathrm{n})}$$

Where:
W = Kendall's coefficient of concordance
S = Sum of squares of the deviation of each Ri from the mean
R_i = Row sums of ranks
m= Number of raters
n= Number of items being ranked

Kendall's Ratio:
w = 0.10 = weak agreement
w = 0.30 = moderate agreement
w = 0.60 = strong agreement
w = 1.0 = perfect agreement

Acceptability Index

The acceptability index was proposed by Waugh (1982) and used by Engmann (1993) to estimate the intensity of the use of technology. The acceptability index is estimated as the percentage of sampled farmers using the technology multiplied by the percentage of the land area being used for the technology.

The Waugh acceptability index is preferred because it takes into account both the proportion of farmers using phosphorus based fertilizer as well as the proportion of land area committed to the use of the phosphorus based fertilizer. Hence, it considers the distribution of land amongst various crops in mixed cropping systems undertaken by small-scale farmers. An index that accounts for only the proportion of farmers using the technology may give a

wrong perception because the number of users of technology does not necessarily inform us on how much of their land they are applying the technology. Similarly, an index based on the proportion of land subjected to the technology does not indicate how many of the target farmers have embraced the technology and are using it (Kwadzo *et al.,* 2010). The index is expressed as follows:

Acceptability Index = (F1 / F2) x (AL1 / AL2) x 1…….. (i)
Where:
F1 = Number of sampled farmers using phosphorus based fertilizer,
F2 = Total number of sampled farmers
AL1 = Total land area committed to the phosphorus based fertilizer
AL2 = Total land area used for cowpea cultivation by the total number of sampled farmers.

Results and Discussion

Socio-economic characteristics

The finding in Table 2 shows that the respondents have a minimum age of 20 years and a maximum of 72 years with a mean age of 41 years. The highest percentage (32.7%) were within the age of 30-39 which indicates them to be active in carrying out their farming activities. This indicated that most of the respondents are adult farmers. Hence, accepting and adopting new innovations seems to be easier in the area. Age is a very important factor that determines how active an individual farmer can be, which at the same time affects their farming activities. The finding is in line with the result of Tijjani *et al.* (2015) in Katsina where they disclosed that (77.3%) of the cowpea farmers are within the range of age of 20 to 49 years. The result on the gender revealed that the majority of the farmers (85.6%) were males while 14.4% were females. This indicates that males are the major cowpea farmers in the study area. This implies that females are left behind in terms of cowpea farming in the area. This could be a result of cultural or traditional practices where males mostly do not allow their fellow wives to participate effectively in outdoor business activity. The finding of this work is in line with Bishir *et al.* (2018) where a similar result was obtained in Taraba State of Nigeria.

The result further shows that respondents have a minimum household size of 0 and a maximum of 30 with a mean of 10. The highest of the respondents (39.9%) have a household size of 6-11 persons which indicates that they may have easy access to family labour and at the same time reduce the cost of cowpea production. The result may also imply that most of the respondents in the area engage their family members in farming activities. This may increase the number of farmers in cowpea production which may in turn increase productivity.

The farmers have a minimum farming experience of 4 years and a maximum of 50 years with a mean of 21 years. The highest of the respondents (33.3%) spent about 13 to 21 years in cowpea production with a mean of 21 years. This shows that the farmers had a relatively long experience in cowpea farming. Hence, there is a high possibility that the farmers to adopt new farming technologies. Farming experience is a key variable that can depict the performance of a farmer because many farmers learn from their previous farming experience to improve their productivity. Thus, the higher was the farmer in farming activities the more it is expected for the farmer to solve some farming problems.

The result of educational attainment indicated that the highest of the cowpea farmers (35.3%) had Qur'anic education. This indicates a high possibility of accepting any technology in their cowpea production as Qur'anic education encourages contemporary technology. Consequently, farmers with formal education are typically believed to be able to process information and look for effective technologies to alleviate their production constraints. The belief is that formal education gives farmers the ability to perceive, interpret and respond

to new information much faster than their counterparts without formal training. Also, a cowpea farmer with formal education would be expected to have better agricultural management skills than one who has less or no formal training. This finding disagrees with the work of Sani *et al.*, (2014) in the Bichi local government area of Kano state where most of the cowpea farmers had formal education, from primary to post-secondary.

As for the extension visit, the results indicate that the majority of the cowpea farmers (80.4%) have zero number of extension visits. Extension contact aids farmers in understanding modern innovations, which ultimately help farmers to adopt modern technologies. The adoption of agricultural technologies is highly facilitated by the work of extension officers towards introducing and demonstrating to the farmer how to utilize the technologies. However, (80.4%) of respondents indicated that they had zero contact with the extension agents but adopted the practice on their own, through trial and error, or with the help of fellow farmers. This lack of extension contact with extension officers neglects the basic role of extension agencies are supposed to play in technology diffusion and adoption which could be as a result of inadequacy or incompetency of the extension workers or insufficient logistics for the extension worker to meet these farmers or lack of confidence of the personnel to be aware with the technical aspect of the technology to be transferred to the farmers. These findings tally with the results of Bishir *et al.* (2018) in Taraba state where cowpea farmers in the study area (100%) attested that they have never been visited by an extension agent even once in their lifetime.

Table 2. Socio-economic characteristics

Socio-economic variables	Frequency	Percentage
Age		
20-29	24	15.7
30-39	50	32.7
40-49	37	24.2
50-59	37	24.2
60-69	2	1.3
70-79	3	2.0
Minimum Maximum Mean	20 72 41	
Gender		
Male	131	85.6
Female	22	14.4
Household size		
0-5	41	26.8
6-11	61	39.9
12-17	39	25.5
18-23	9	5.9
24-29	0	0.0
30-35	3	2.0
Minimum	0	
Maximum	30	
Mean	10	
Farming experience		
4-12	38	24.8
13-21	51	33.3
22-30	40	26.1
31-39	18	11.8

40-48	3	2.0
49-57	3	2.0
Minimum	4	
Maximum	50	
Mean	21	
Highest educational level		
Primary	35	22.9
Secondary	33	21.6
Tertiary	12	7.8
Qur'anic	54	35.3
Informal/Adult	19	12.4
Number of extension visits		
Once in a week	2	1.3
Once in two weeks	9	5.9
Zero visit	123	80.4
Total	**153**	**100**

Source: Field survey (2022).

Perception of cowpea farmers on phosphorus based fertilizers

The findings in Table 3 reveal that cowpea farmers in the study area disagreed with the perception that phosphorus reduces crop growth and vigor. On the other hand, cowpea farmers strongly agreed that phosphorus based fertilizer increases cowpea yield while the cost of production was undecided. This shows that the cowpea farmers in the area are aware that the application of p.-based fertilizers in cowpea production is one of the measures that lead to higher productivity, even though they perceived that such measures consequently add to the total cost of production. It is expected that with the availability of capital, these farmers may adopt the use of phosphorus based fertilizers in cowpea production. The findings are consistent with that of Saba *et al.* (2020) in Northern Guinea Savannah of Nigeria where it was observed that the perception "phosphorus increases cowpea yield" is the most acceptable perception of phosphorus fertilizer by the cowpea farmers in the area. Furthermore, the cowpea farmers agreed that phosphorus use is labour intensive and time consuming. This indicates that the farmers are aware that they have to devote time to accurately apply phosphorus based fertilizers on their farms. Also, some respondents don't use phosphorus fertilizer because of no prior knowledge about phosphorus based fertilizer. This indicates that extension agents need to do more work toward educating farmers on the importance of using phosphorus based fertilizer in cowpea production as this will help farmers to realize the increase in their output of cowpea. The farmers agreed upon the perception that phosphorous fertilizer is expensive". This implies that phosphorus based fertilizers are expensive in the market thereby making it difficult for farmers to use it on their farms. Hence, supplying the phosphorus based fertilizers in the market at a subsidized rate by the government may arouse the interest of cowpea farmers to make use of the fertilizer during cowpea production. The overall Kendall's coefficient of concordance of 0.30 reveals that the perception of the cowpea farmers with regards to all perceived items was a moderate agreement which means different perception among respondents. This implies that there is no consensus in their perception on phosphorus based fertilizer use in cowpea production in the area.

Table 3. Farmers' perception on phosphorus based fertilizers

Perception	Mean score	Scored remarks
P reduces growth and vigor	2.42	Disagreed
P increases cowpea yield	3.81	Undecided
Phosphorus use increases the cost of production	4.01	Strongly agreed
Phosphorus use is labor intensive and time consuming	4.35	Strongly agreed
I don't use P because of no prior knowledge about it	3.25	Undecided
I don't use P because it is costly	4.03	Strongly agreed
I don't use P because it is not available in the market	3.40	Undecided
Kendall Coefficient	**0.30**	**Moderate agreement**

Source: Field survey (2022).

Level of adoption of phosphorus based fertilizers in cowpea production (Acceptability index approach)

The result in Table 4 reveals that the total number of cowpea farmers who used phosphorus based fertilizer was (30.7%) out of all the sampled cowpea farmers and the total land area committed to the phosphorus based fertilizer in cowpea production was 101.5 from the total land area used for cowpea cultivation by the farmers. This implies that the percentage of land committed to the phosphorus based fertilizer by cowpea farmers was estimated to be only 6.54%. This is considered very alarming because the farmers committed a small portion of their farmland towards adopting the technology. Even though these farmers had long farming experience and large household sizes but still have a low adoption rate of the technology which may be connected to the low extension contact as earlier reported. The result disagrees with the finding of Solomon *al.* (2021) in Ethiopia where it was pointed out that most of the farmers have adopted the use of chemical fertilizers in cowpea production.

Table 4. Level of adoption of phosphorus based fertilizers

Elements of acceptability index	Frequency	Percentage
Number of sample cowpea farmers using phosphorus fertilizer	47	30.7
Total number of sampled cowpea farmers	153	100
Total land area committed to the phosphorus based fertilizer in cowpea production	101.5ha	21.4
Total land area used for cowpea cultivation by the farmers	475ha	100
Acceptability index		**6.54**

Source: Field survey (2022)

Conclusions

Based on the research results it can therefore be concluded that most of the respondents are within their youthful age and may participate in several cowpea production activities, including adopting of phosphorus based fertilizers. There was a moderate agreement among the cowpea farmers in the perceived items of phosphorus based fertilizers in cowpea production. The farmland in which phosphorus based fertilizers were applied by the farmers in the study area was very small. It is therefore recommended that the cowpea farmers should expand the use of phosphorus based fertilizers to larger portions of their land.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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