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TECHNICAL EFFICIENCY IN COWPEA (*Vigna unguiculata*) PRODCTION IN KANKE, PLATEAU STATE, NIGERIA

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ABSTRACT
Cowpea farmers in sub-Saharan Africa obtain low yields; sole cropping system with the use of improved technologies can yield 1,500-2,000 kg/ha of cowpea. However, 200-500 kg/ha yield is obtained by smallholder farmers. It is a multipurpose crop and despite its importance, high level of inefficiency in its production persists. Therefore, the determinants of efficiency in cowpea production were analyzed; the decline in cowpea yield in the study area was attributable to several socioeconomic variables. Multistage sampling technique was used to select 70 cowpea farmers from the study area. Primary data was collected using structured questionnaires. Descriptive statistics and stochastic frontier production function were the analytical techniques adopted. The results indicated that the socioeconomic characteristics of the respondents significantly affected cowpea production. The mean technical efficiency index was 0.59. Furthermore, the stochastic frontier analysis revealed that coefficients of farm size (0.297), labour (0.394), quantity of seed (0.433) and agrochemicals (0.057) were all positive and statistically significant. Also, the inefficiency model revealed that the coefficients of household size (-0.284), education (-0.493) farm experience (-0.402), extension contact (-0.45) and access to credit (-0.255) were negative but statistically significant. Thus, the significant variables were the determinants of technical efficiency in cowpea production. The identified constraints adversely affected farm productivity and efficiency. Formation of cooperatives, adoption of measures that improve access to agricultural credit, agro-services centers, input supply, technology transfer and subsidies; extension services, information exchanges and market linkages are recommended to mitigate technical inefficiency in cowpea production among smallholder farmers.

Keywords: Stochastic frontier; Technical efficiency; Cowpea, inefficiency

INTRODUCTION
Cowpea is an important food legume grown in the semi-arid tropics, covering Africa, Asia, Southern Europe and Central South America (Davis *et.al*. 2013). The largest production is in the moist and dry Savannas of Sub-Saharan Africa (SSA), where it is intensively grown as an intercrop with other cereal crops like millet, sorghum and maize as well as rice fallows [International Institute of Tropical Agriculture (IITA), 2020]. The grains contain 25% protein and several vitamins and minerals. The plant tolerates drought, performs well in a wide variety of soils, and being a legume replenishes low fertility soils when the roots are left to decay (IITA, 2020). Its ability to replenish soil nitrogen gives it a key position in the modern crop farming system in rotation with other crops, with the view for long term sustainable agricultural development prospect. It is grown mainly by small-scale farmers in developing regions. It also grows and covers the ground quickly, preventing erosion (IITA, 2020). Cowpea is a popular leguminous crop in Africa which is also known as 'beans' in some Anglophone countries and 'niebe' in the Francophone countries. Economically, cowpea production is an important crop in the domestic trade of developing countries; it serves as a source of income for all participants in the crop value chain. Cowpea's high protein content, its adaptability to different types of soil and intercropping systems, its resistance to drought, and its ability to improve soil fertility and prevent erosion makes it an important economic crop in many developing regions. The sale of the stems and leaves as animal feed during the dry season also provides a vital income for farmers (IITA, 2020). Cowpea forage is a significant animal feed, mainly during the dry season when demand is at its peak. More than 7.4 million tons of dried cowpeas are produced worldwide, with Africa producing nearly 7.1 million. Nigeria, the largest producer and consumer, accounts for 48% of production in Africa and 46% worldwide (IITA, 2020). Approximately 64% of the estimated annual global cowpea grain production is grown in west and central Africa, which also account for 80% of total production in Africa (Singh *et.al.* 2002). The bulk of cowpea production in Nigeria is done mainly in the semi-arid zone of Nigeria (IITA, 2011). The region produces about 1.7 million tons from 40 million hectares. This represents over 60% of the total production [Food and Agricultural Organization

Statistics (FAOSTAT) (2010). More than 12.5 million hectares are harvested worldwide, 98% of which is in Africa. Nigeria harvests 3.7 million hectares annually. The crop can be harvested in three stages: while the pods are young and green, mature and green, and dry (IITA, 2020).Sole cropping system with the use of improved technologies can yield 1,500 - 2,000 kg/ha of cowpea (Musa *et.al*. 2010). However, 200 - 500 kg/ha yield is obtained by small scale farmers who are the primary producers (Wakili, 2010). Efficiency and productivity potentials are high if the farmers use more improved seeds, have adequate labour supply, adopt agrochemicals and improved technology; and increase their farm holdings (Jirgi *et al*., 2010). In addition, cowpea production are done under rain fed systems, although it is drought tolerant, cowpea farmers in the dry savanna areas of sub-Saharan Africa obtain low yields, estimated at about 350 kg per hectare (IITA, 2020).It is cultivated primarily for grain, but also as a vegetable, fodder and cover crop. All parts of the cowpea crop are rich in nutrients and fiber. In Africa, households consume the young leaves, immature pods, immature seeds, and the mature dried seeds. The stems, leaves, and vines serve as animal feed and are often stored for use during the dry season. Most (52%) of Africa's production is used for food, 13% as animal feed, 10% for seeds, 9% for other uses, and 16% is wasted (IITA, 2020).

Despite its importance, there is still a high level of inefficiency in cowpea production in the region. This widening gap in the demand and supply for this crop is further exacerbated by a considerable decline in cowpea production and high population growth of about 3.5% per annum relative to food production growth of about 1.5% per annum (Girei *et al*., 2013). According to FAOSTAT (2010), food insecurity among households in developing countries is becoming a major threat, attributable to factors such as; inadequate capital, low adoption of production technology, poor extension contact, limited input delivery systems, policy and production constraints, climate variability, farm household demography, poor management practices, etc. Currently, cowpea is produced by small scale farmers using rudimentary implements. Coulibaly and Lowenberg-DeBoer (2002) affirmed that despite the importance of the crop in food security and poverty reduction; increased production, storage and marketing constraints that need redress persists. In the same vein, Obayelu (2013) noted that the average land holdings for most cowpea farmers are less than two hectares; while family labour remains an essential input. Land is based on communal ownership, inherited or rented with ease of outright purchase rare to come by. Capital is also a major limitation, with a few farmers having access to rural credit, coupled with weak sustainable production practices. This development raises pertinent questions as to the profitability and sustainability of cowpea production (IITA, 2011). One way smallholder farmers can achieve sustainable agricultural development is to raise the productivity of their farm by improving efficiency within the limits of the existing resource base and available technology (Dugje, *et al*.2009). Efficient use of various inputs is an important part of sustainability; which implies either fewer inputs to produce the same level of output or higher output at the same level of inputs. Cowpea yields in the study area over the years have been on the decline as posited by the respondents; and were attributable to factors such as inadequate capital, production inputs and labour supply; poor practices and technology adoption, smallholdings, low profitability and firm efficiency, etc. This study is justified given that most research on cowpea farming in the study area have focused on aspects of profitability with less emphasis on issues of productivity and its implications for sustainable agricultural development. Therefore, this study aims to analyze the determinants of inefficiency in cowpea production in smallholder farming systems in the study area; while the specific objectives are to;

i. describe the socioeconomic characteristics of cowpea farmers ;
ii. evaluate the efficiency index of cowpea production;
iii. determine the technical efficiency in cowpea production; and
iv. identify the constraints of cowpea production in the study area.

H_o: There is no technical inefficiency in cowpea production among farmers in the study area.

METHODOLOGY

Study area

The study was carried out in Kanke Local Government Area (LGA) of Plateau state, Nigeria. The Local Government Council headquarters is located in Kwal. Kanke LGA consists of four districts; Kabwir, Amper, Ampang, and Garram. It covers an estimated land area of 926km^2 and a population of 121,424 (NBS, 2013). Average rainfall per annum is 1,280mm, with an average temperature of 27^{0}C. The major food crops cultivated in the study area include; cowpea, sorghum, millet, upland rice, maize, yam and cocoyam (FAOSTAT, 2010). They are also involved in domestic rearing of various livestock such as; cattle, goat, poultry, piggery and dogs.

Sampling Procedure

Multistage sampling technique was used to select respondents for the study. The first stage involved the purposive selection of Kanke out of the 17 LGAs in the State; due to the prevalence of smallholder cowpea farmers in the area. The second stage involved the selection of two (2) districts (Amper and Ampang) in the LGA; also, two (2) communities from each of the selected districts [Amper (Gwamlar and Pibwir) and Ampang (Goktok and Shaktu)] where purposively selected; due to the prevalence of sole based cowpea production systems. The last stage involved the systematic random selection of smallholder cowpea farmers, using the compiled list by the local enumerators in the selected districts and communities, at constant proportionality of 0.1 (10%); which is the constant ratio or fraction of variable quantity to another to which it is proportional, seventy (70) respondents were selected for the study from a sample frame of 700 smallholders; and validated using raosoft sample size calculator at 90% confidence level and 10% margin error. The distribution is presented in Table 1.

Table 1: Sample Frame

S/No	District	Communities	Sample frame	Sample size (10%)
1	Amper	Gwamlar	170	17
		Pibwir	201	20
2	Ampang	Goktok	182	18
		Shaktu	147	15
	Total		700	70

Source: Field Survey (2019)

Method of Data Collection

Primary data was collected using well-structured questionnaire in line with the objectives of the study. Data on the socioeconomic characteristics (age, family size, marital status, education, farm experience, extension contacts; access to credit, extension visits and membership of cooperatives), production inputs (farm size, labour supply, quantity of seed and agro-chemicals used) and farm output; as well as information on cowpea production constraints in the study area were collected over a period of fifteen (15) weeks.

Analytical Techniques

Descriptive statistics (frequency distribution, percentages and means) and stochastic frontier production function analysis were used for data analysis.

Stochastic frontier production function model

The stochastic frontier production frontier model as adapted from Battese and Coelli (1995); in its implicit form is presented in equation 1:

Y_i =exp (X_i; β + V_i - U_i) …………………. (1)

Where:

Y_i = output of the i_{th} farm; i = 1, 2, - - - - - - - - - n; X_i = vector of input quantities of the i_{th} farm; β = vector of unknown parameters to be estimated; V_i = error components of disturbances which are assumed to be normally distributed N(0, δ_V^2)and independent of U_i, (assumed to account for measurement errors and other factors beyond farmers' control); U_i = non-negative random variables associated with the technical inefficiency of production.

The stochastic frontier production function model used for this study is presented explicitly in equation 2;

$L_nY_i = \beta_0 + \beta_1 l_nX_1 + \beta_2 l_nX_2 + \beta_3 l_nX_3 + \beta_4 l_nX_4 + (V_i – U_i)$ …………………. (2)

Where:

L_n = natural logarithm; Y_i = Cowpea yield of i^{th} farmer in (kg); X_1 = Farm size (hectares); X_2 = Farm labour (man-days); X_3 = Quantity of cowpea seed used (kg); X_4 =Quantity of agro-chemical used (litres) (lt); $\beta_0 – \beta_4$ = Parameters to be estimated; V_i = N (0, δV^2) as defined above; and U_i = N (0, δU^2) as defined above.

The inefficiency model; factors responsible for technical inefficiency in cowpea production is presented as:

$U_i = \delta_0 + \delta_1Z_1 + \delta_2Z_2 + \delta_3Z_3 + \delta_4Z_4 + \delta_5Z_5 + \delta_6Z_6$…………………. (3)

Where:

U_i = Technical inefficiency of the i_{th} farmer; Z_1 = Age of cowpea farmer (years); Z_2 = Household size (number of people); Z_3 = Educational level (years spent in school; Z_4 = Farming experience (years); Z_5 = Extension contacts (number of visits); Z_6= Access to credit (amount received in ₦); and $\delta_0 – \delta_6$ = Unknown parameters to be estimated.

RESULTS AND DISCUSSION

Socioeconomic Profile

Table 2 revealed that the mean age of the respondents is 33 years and most (57.1%) of them were in the age bracket of 20-59 years; implying that most cowpea farmers in the study area were in their economically active age and thus will be able to undertake rigorous activities of cowpea farming. This is in conformity with the position of Musa, *et.al*. (2010) who also reported similar findings with crop farmers. Also, most (58 %) of the cowpea farmers were male. The predominance of the male gender in cowpea production could be attributed to the fact that the enterprise is labor and time demanding, which their female counterparts could not possibly provide, considering their social roles in household management. This is in conformity with Musa, *et al*. (2010) who reported similar outcomes. The mean farming experience was 13 years and most (72.9%) of the respondents had 10-19 years of farming experience; implying that the cowpea farmers had adequate farm experience as such they are expected to adjust and adopt new technologies that would stimulate increased production. Most (64.3%) of the respondents are married, and this could be responsible for the relatively large family size in most households. Average family size was 9 people and most (74.3%) of the respondents had households with ≤14 members; this has a relationship with family labor typified of the agrarian community. Also, large households can be advantageous in farming as labour may be derived from family members who are eligible to work; this is in conformity with the position of Onuwa, *et.al*., (2021a) who reported that, the higher the household size the more the supply of family labor and less cost on hired labor required for production activities. The mean years spent in school among respondents was 10 years. Most (52.9%) of the respondents spent 7-12 years with prospects to attain secondary education. The level of literacy among the respondents may facilitate the choice and process of adoption of farm practices, technology and innovation; and better ability of impacting knowledge and skills for adoption of an innovation. The average farm size of the respondents was 1.2ha. This is due to the land tenure or ownership system in the study area, which results to fragmentation of farmlands; implying that most of the respondents had smallholdings and as such subsistent production was prevalent in the study area. The average quantity of labour per hectare was 115 man-days; implying that cowpea production is relatively labour intensive and adequate labour supply is an integral component of agricultural production. The average quantity of seed and agrochemical used per hectare were 6kg and 8 litres respectively. This result corroborates with the findings of Mailumo *et al*. (2017); Onuwa *et al*. (2020) who also reported similar results in their studies on groundnut production. Most (80%) of the respondents do not belong to cooperatives. This could limit their access to agricultural information, credit, technology and innovations; and new farming practices that will enhance their firm efficiency and productivity. Agricultural cooperatives and societies provide its members with opportunities for information exchanges and shared experiences. This result corroborates with the findings of Ogundari and Ojo (2006) who reported similar outcomes. Also, the average amount of credit received per respondent was ₦101,500 and most (70%) of the respondents have received credit facilities of ≤₦199,999; however this amount was grossly inadequate and the need for additional farm capital for agricultural production among respondents in the study area still persists. Additionally, extension contact in the study area was limited (0.71) and to some extent non-existent; and most (81.4%) of the respondents had ≤3 extension contacts in all their years of farming experience. Thereby, further limiting their access to information on new production techniques, practices innovations and farming technologies that enhance firm efficiency. Farmers are more likely to adopt agricultural technology when interacting with extension personnel; regular extension contact motivates and exposes the farmers to innovations and gives them information on how to implement production systems adopted. Omonona *et al*. (2010) also posited that extension visits results to increased adoption of agricultural technology and improved firm efficiency and productivity among smallholders.

Technical Efficiency Index of Cowpea Farmers

The distribution of farmers' technical efficiency index derived from the analysis of the stochastic frontier (production function) analysis is presented in Table 3. The efficiency index of the sampled farmers was less than unity (1) (i.e., <100%); implying that all the farmers in the study area were producing below maximum efficiency frontier. From the observed range of technical efficiency across the sampled farmers, the maximum technical efficiency index was 0.94 (94%), while the minimum technical efficiency index was 0.10 (10%). The mean technical efficiency index was 0.59 (59%); implying that the farmers in the study area were able to obtain average of 59% optimal output from a given mix of production inputs. This indicates that, there is room for increasing technical efficiency in cowpea production by 41%. The magnitude of the mean technical efficiency of the farmers is a reflection of the fact that most of the sampled farmers carry out cowpea production under technically inefficient conditions which may involve the use of local inputs, technology or practices.

Table 2: Socioeconomic Characteristics of the Respondents

Variable	Mean	Frequency	%
Age (years)			
≤19		11	15.7
20-59		40	57.1
≥60	33.3	19	27.2
Gender			
Male		41	58.6
Female		29	41.4
Experience (years)			
≤9		10	14.3
10-19		51	72.9
≥20	13.4	9	12.9
Marital status			
Married		45	64.3
Single		25	35.7
Family size			
≤14		52	74.3
≥15	9.2	18	25.7
Education (years)			
Primary(3-6 years)		16	22.9
Secondary(7-12 years)		37	52.9
Tertiary (≥13 years)		4	5.7
Informal (≤2 years)	10.1	13	18.6
Farm size (ha)			
≤1.9		47	67.1
2.0-3.9		13	18.6
≥4.0	1.2	10	14.3
Labour (man-days)	115		
Seed quantity(Kg)	6		
Agrochemical (lt)	8		
Cooperative membership			
Yes		14	20.0
No		56	80.0
Credit Access (₦)			
≤199,999		49	70
≥200,000	101,500	21	30
Extension contact			
≤3		57	81.4
≥4	0.71	13	18.6

Source: Field survey (2019)

From this estimation, maximum technical efficiency is not yet achieved suggesting a need for more effort at improving efficiency of cowpea farmers in the study area. The distribution of technical efficiency index of the farmers revealed that, most (20%) of the cowpea farmers had technical efficiency index of between 0.60-0.69; 18% had technical efficiency index of between0.30-0.39 and 1% of the cowpea farmers had technical efficiency index between 0.10-0.19. This corroborates with the findings of Binuyo *et* *al*. (2020); Wakili (2010); Kareem, *et.al*. (2008) who also reported similar results on technical efficiency index.

Table 3: Distribution of Respondents Based on their Technical Efficiency Index

Efficiency index	Frequency	Percentage (%)
0.10 – 0.19	1	1
0.20 – 0.29	8	11
0.30 – 0.39	12	18
0.40 – 0.49	8	11
0.50 – 0.59	7	10
0.60 – 0.69	14	20
0.70 – 0.79	11	16
0.80 – 0.89	6	9
0.90 – 0.99	3	4
Minimum 0.10		
Minimum 0.94		
Mean 0.59		

Source: Computed from Stochastic Frontier analysis results (2019)

Stochastic Frontier Production Function Analysis

The maximum likelihood estimates of the parameters of the stochastic frontier production model for cowpea production are presented in Table 4. The Table contains the estimates of parameters of the stochastic frontier (production function) analysis, the inefficiency model and the variance parameters of the stochastic frontier model. The sigma-squared (0.798) was statistically different from zero at 5% ($p \leq 0.05$) level of significance. This indicates a good fit and the correctness of the specified distributional assumption of the composite error term.

The estimated value of gamma *(ϒ)* parameter (variance ratio), which is associated with the variance of technical inefficiency effects in the stochastic frontier model, is estimated to be 0.817, this value implies that technical inefficiency is highly significant in the production activities of cowpea farmers, suggesting that systematic influences that are unexplained by the production function were the dominant sources of random errors. This means that more than 81% of the variations in output among the cowpea farmers are due to farmer efficiency differentials. This confirms that in the specified model, there is presence of stochastic (one-sided) error component and therefore the null hypothesis can be rejected.

The estimated stochastic frontier function shows that all the coefficients had the expected sign, The coefficients of farm size, labour, quantity of seed and agrochemicals were all positive which conform to a priori expectations, indicating that an increase in these variables will lead to an increase of the output of the farmers in the study area. Amaza *et al*., (2006), and Onuwa *et al*. (2021a) also reported a positive and significant relationship between these variables and technical efficiency. This suggests that a percentage increase in any of the production input would lead to a percentage increase in output, *ceteris paribus*.

The coefficient of farm size (0.297) was positive and statistically significant at 5% level ($p \leq 0.05$), implying that a 1% increase in the use of land will increase output by about 2.9 % and *vice versa*. This is in line with the study of Binuyo *et al*. (2020) who also reported similar results. The coefficient of labour (0.394) is significant at 1% level ($p \leq 0.01$) and it is positively related to cowpea output. This implies that, an increase in man-day of labour by 1% would increase cowpea output by 3.9%. In that regard labour is needed in carrying out essential farm operations such as weeding, insecticide application and harvesting is not expected to be a limitation. This is in line with the study of Onuwa *et al*. (2021a) who reported that farmers concerned with farm efficiency would aim at maximizing their output per unit of resource used, especially the amount of farm labour employed. The coefficient of seed quantity (0.433) was positive and statistically significant at 5% level ($p \leq 0.05$), implying that a percentage increase in the quantity of seed planted would result in an increase in cowpea output. This corroborates with the findings of Shehu *et.al*. (2007) who also reported similar results. The coefficient of agrochemicals (0.057) was statistically significant at 5% level (p≤0.05). This means that a 1% increase in the quantity of agrochemicals used in cowpea production would increase cowpea output by 0.57%. The use of agrochemicals reduces fatigue and drudgery associated with weeding and enhances cowpea yield. Agrochemicals also enhance productivity and also enable farmers to cultivate large hectares of land which in turn brings about increase in output. This corroborates with the findings of Onuwa *et.al*. (2021b) who also reported similar results.

The Inefficiency Model

The variables of the inefficiency model were modeled to explain the determinants of inefficiency of production among the cowpea farmers. The sign of the variables in the inefficiency model is very important in explaining the observed level of Technical efficiency of the farmers. A negative sign implied that the variable had the effect of reducing technical inefficiency, while a positive coefficient indicate that the variable has the effect of increasing inefficiency. The results of the inefficiency model showed that all the included variables except age had the expected sign. The coefficient of age was estimated to be positive, which suggests that the variable enhances technical inefficiency of the farmers in the area of study.

The coefficient of age (0.348) was positive and statistical significant at 5% level (p≤0.05), which implies that older farmers tend to be more technically inefficient due to the fatigue and drudgery associated with cowpea production. This corroborates with the findings of Kareem *et al*. (2008) who also reported similar results. The coefficient of family size (-0.284) was negative but statistically significant at 5% level (p≤0.05). The negative coefficient implies that as the number of household members who are eligible to work increases, cowpea production invariably becomes less inefficient; hence, the additional workforce among farm households will provide labour supply utilized for carrying out various farming activities. The implication for such farm households may result to increased farm operations and expansion due to more labour supply. Thus, an increase in the eligible workforce facilitates efficiency in agricultural production (Modu *et al*., 2010).

The inefficiency model also revealed that the coefficient of educational level (-0.493) was negative but statistically significant at 5% level (p≤0.05). Suggesting that the literacy level of the cowpea farmers affects their technical inefficiency. The implication is that farmers that have high level of education tend to be more receptive in adopting improved farming technology and hence increase their output level which is consistent with the findings of Onuwa *et al*. (2021a) who also reported similar results.

Farming experience: The inefficiency model also revealed that the coefficient of farming experience (-0.402) was negative but statistically significant at 1% level (p≤0.01). This implies that farmers with more years of farming experience tend to be more efficient in cowpea production; farmers with more years of experience tend to become more efficient through ‘learning-by-doing’. This corroborates the findings of Fasasi (2007) who also reported similar results.

Extension contact: The coefficient of extension contact (-0.45) was negative but statistically significant at 5% level (p≤0.05), Suggesting that extension visits to farmers affect their technical efficiency. The implication is that farmers that have more extension contact tend to be more exposed to and informed about improved production methods and technology which in turn increase their efficiency in farming and hence increase their output level. This is also consistent with the findings of Omae *et al*., (2011); Onuwa *et al*. (2021a) who also reported similar results.

Access to credit: The coefficient of access to credit had a (-0.255) was negative but statistically significant at 5% level (p≤0.05). Suggesting that access to credit by farmers reduces their technical inefficiency in cowpea production. The implication is that farmers that have more access to agricultural credit become more efficient in farming; agricultural credit increases their capacity to scale up their productive capacity, output level and facilitate adoption of improved technology. This corroborates with the findings of Onuwa *et.al*. (2021b) who also reported similar results.

Constraints to Cowpea Production

The results in Table 5 revealed that the constraints of cowpea production enterprise in the study area include; inadequate capital (97.1%); this was attributable to poor access to financial information and services among smallholders in the area. Poor access to agricultural credit (94.3%); this was due to the inability of most respondents to provide the necessary requirements for the processing of their credit applications. High cost of improved production inputs (91.4%); resulting from the prevailing market rates of most agro commodities which are inflated due to economic volatility. Inadequate extension contact (84.3%); attributable to poor extension service delivery systems and policies.

Table 4: Technical Efficiency Analysis of Cowpea Production

Variable	Parameters	Coefficient	Standard Error	T-ratio
Production model:				
Constant	β_0	3.472***	0.216	16.07
Farm size (X_1)	β_1	0.297**	0.116	2.56
Labour (X_2)	β_2	0.394***	0.108	3.648
Quantity of seed (X_3)	β_3	0.433**	0.130	3.330
Agrochemicals (X_4)	β_4	0.057**	0.021	2.714
Inefficiency model:				
Constant	δ_0	0.211**	0.087	2.425
Age (Z_1)	δ_1	0.348**	0.136	2.558
Family size (Z_2)	δ_2	-0.284**	0.109	-2.605
Educational level (Z_3)	δ_3	-0.493**	0.181	-2.724
Farming experience (Z_4)	δ_4	-0.402***	0.107	-3.757
Extension contact (Z_5)	δ_5	-0.45**	0.173	-2.601
Access to credit (Z_6)	δ_6	-0.255**	0.10	-2.55
Diagnostic statistics:				
Sigma-squared	σ^2	0.798***	0.225	3.497
Gama	Υ	0.817		
Log likelihood		-78.53		

Source: Field survey (2019); *** Significant at 1% ($p<0.01$) level; ** Significant at 5% ($p<0.05$) level

Poor access to improved production technology (67.1%); this is also attributable to the lack of synergy between agricultural technology and innovation development and smallholders in rural and agrarian communities, which is further aggravated by poor extension delivery systems, which would have been saddled with task of agricultural information dissemination. Pest and disease infestation (57.1%); resulting from the poor adoption of improved farm practices, innovations and technologies. All the constraints identified by the farmers were critical and adversely affected farm productivity and technical efficiency of cowpea production in the study area. This corroborates with the findings of Mailumo *et al*. (2017); Onuwa *et.al*. (2021b) who also reported similar results in their respective studies on groundnut and cucumber production.

Table 5: Distribution Based on the Constraints of Cowpea Production

Constraints	Frequency*	Percentage (%)
Inadequate capital	68	97.1
Poor access to agricultural credit	66	94.3
High cost of improved production inputs	64	91.4
Inadequate extension contact	59	84.3
Poor access to improved production inputs	47	67.1
Pest and disease infestation	40	57.1

Climate change (variability)	36	51.4
Market proximity	30	42.8

Source: Field survey (2019); * = Multiple responses allowed

CONCLUSION AND RECOMMENDATIONS

This study analyzed the technical efficiency of cowpea production in Kanke LGA, Plateau State, Nigeria. The results of the study revealed that the socioeconomic profile of the farmers affected their level of cowpea production in the study area. The study also revealed that the efficiency index of the farmers was less than unity (1) (i.e. <100%) implying that all the farmers in the study area were producing below maximum efficiency frontier. The mean technical efficiency index was 0.59; implying that the cowpea farmers were able to obtain average of 59% optimal output from a given mix of production inputs. The results of the stochastic frontier analysis revealed that coefficients of the variables included in the model significantly affected the technical efficiency of cowpea production. Thus, the socioeconomic factors of respondents affected firm efficiency and productivity. Also, the farmers were producing below maximum firm efficiency; implying that the respondents were unable to obtain optimal output from their mix of production inputs. Additionally, the variables including farm size, labour supply, seed quantity, agrochemicals, age, family size, extension contact and credit access in the regression model significantly affected technical efficiency of cowpea production among smallholders. Further, all the constraints identified by the farmers were critical and adversely affected farm productivity and technical efficiency of cowpea production in the study area; hence, the pertinent need to mitigate this trend exists. In view of the above background, the following recommendations are suggested to mitigate production constraints and improve technical efficiency of cowpea production:

i. Farmers should be encouraged to form cooperative societies to pool productive resources together and improve their access to agricultural credit and agricultural inputs.
ii. Formulation and implementation of policies that improves smallholder farmers access to agricultural credit. Due to high cost of investment in cowpea production, the need for adequate capital for production activities cannot be over emphasized. It is recommended that formal financial institutions, government agencies and non-governmental organizations involved in agricultural funding should implement policies and measures that mitigate financial bottlenecks such as cumbersome credit application requirements, delayed disbursement, etc.
iii. Establishment of additional agro services centers in rural and agrarian communities to complement the efforts of Agricultural research institutes; for more efficient development and effective supply of improved cowpea varieties, agrochemicals for pest and disease management, etc.; and partnerships with agro allied industries and other stakeholders that provide agricultural subsidies at commercial scale for farmers in the study area.
iv. Extension service: There is need to enhance the efficiency of cowpea farmers in the study area. Capacity building for cowpea farmers can be achieved through extension education and information dissemination of updated knowledge on new innovations, agronomic practices, technology, pest and disease management, climate information etc., to boost their farm productivity to target farmers.
v. Formulation of policies and adoption of measures that facilitates effective input supply to smallholders such as improved seed, agrochemicals, etc.; and mitigates bottlenecks across the various levels of agricultural value chain (production, storage, processing, marketing, etc.).
vi. Adoption of appropriate agricultural technologies, innovation and techniques relative to farm sizes by smallholder farmers is strongly recommended; and at the appropriate time and subsidized rates, to facilitate efficiency in farm operations such as: land preparation, tillage, weed and pest control, etc.
vii. Improving agricultural information exchanges and market linkages between cowpea farmer's and agro commodity and input markets; through improved extension contacts and farmers' cooperative participation.

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