



## **FACTORS INFLUENCING THE ADOPTION OF LIQUID FERTILIZER AMONG MAIZE FARMERS IN WESTERN AGRICULTURAL ZONE OF BAUCHI STATE, NIGERIA**

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### **ABSTRACT**

The study examined the factors influencing the adoption of liquid fertilizer among maize farmers in the Western Agricultural Zone of Bauchi State, Nigeria. A multistage sampling technique was used to select 201 maize farmers across three Local Government Areas namely Bauchi, Toro, and Tafawa Balewa. Primary data were obtained through structured questionnaires and analyzed using descriptive statistics and binary logit regression model. The results revealed that majority (78.1%) of the respondents were male and 85.6% were married, with 43.8% attaining secondary education and 25.4% tertiary education. More than half (59.7%) of the respondents were engaged in trading and 14.4% practiced crop farming. Major sources of information on liquid fertilizer were fellow farmers (81.6%), radio (64.7%), and agro-dealers (55.2%), indicating that informal and interpersonal channels play a dominant role in technology dissemination. The logit regression analysis revealed that farm size ( $P<0.05$ ), membership of cooperatives ( $P<0.05$ ), and access to extension services ( $P<0.01$ ) were negative and significantly influenced adoption of liquid fertilizers. On the other hand, access to credit facilities ( $P<0.05$ ) had a positive and significant influence on adoption of liquid fertilizer. The study concludes that socio-institutional factors such as cooperative membership, credit access, and extension support play critical roles in enhancing adoption of liquid fertilizer. It recommends that agricultural policies focus on strengthening cooperatives, improving access to affordable credit, and revitalizing extension services to promote efficient and sustainable use of liquid fertilizers among maize farmers.

**Keywords:** Liquid, Fertilizer, Maize, Farmers, Adoption

### **INTRODUCTION**

Agriculture is the backbone of Nigeria economy, despite being a leading producer of oil in the African region. Agriculture generated 30.9 percent growth in the economy outside the oil sector in 2021 (National Bureau of Statistics [NBS], 2021). The role of agriculture remains significant in the Nigerian economy despite the strategic importance of petroleum sector as a major contributor to Gross Domestic Product (GDP), agriculture provides employment for Nigerians and account for more than one/third of total GDP and labour force, (Food and Agriculture Organization Statistics [FAOSTAT] and World Bank, 2021). Agricultural sector contributes about 41% of the GDP and employs about 65% of the total population and 80% are rural population Central Bank of Nigeria (CBN, 2023). However, excessive real exchange rate appreciation and over valuation following the oil booms, along with distortions induced by an import substitution in detribalization policy, reduced agricultural competitiveness and investment (Zakariah, 2023).

Maize is a major cereal and one of the most important food crops in Nigeria. Its genetic plasticity has made it the most widely cultivated crop in the country from the wet evergreen climate of the forest zone to the dry ecology of the Sudan savanna. Being photoperiod insensitive, it can be grown any time of the year, giving greater flexibility to fitting into different cropping patterns. It is one of the dominant cereal crops in the Guinea and Sudan savannas in northern Nigeria (Kamara, *et al.*, 2020). Maize production is of utmost importance to the Nigerian economy, considering its commercial prominence and food values. Maize is one of the staple crops in Nigeria and featured among the major food grains produced in Nigeria. According to Bauchi State Agricultural Development Programme (BSADP, 2025) that the crop in terms of area (212,304.98 ha) in 2023, had



a total production volume of about 443,667.81 MT and in 2024, had a total production volume of about 465,861.80 MT with an area of (222,920.22 Ha) thus making it the largest producing area in the State. The BSADP (2025) reported that Western Agricultural Zone produced about 443,667.81 MT in the year 2024 which when compared to the year 2023 had an increased by about 1.55 %. This increase, according to them was as a result of adequate rainfall in western zone and adoption of liquid fertilizer application on maize farms.

Fertilizers are broadly classified into organic fertilizers and inorganic (chemical) fertilizers. To reach self-sufficiency, chemical fertilizers have been widely used by countries to increase crop yield. However, these chemical fertilizers are causing serious environmental pollution by reducing water-holding capacity in the soil and thus its fertility, increasing soil acidity, and reducing the number of microorganisms, resulting in nutritional imbalances in the soil (Nosheen *et al.*, 2021). In addition, these hazardous substances are not taken up by plants, but accumulate in ground water affecting the soil negatively. Therefore, it is vital to shift the focus to the production of safe and environmentally friendly methods for sustainable crop production. Liquid fertilizers are water-soluble formulations that are applied in a liquid form, typically through irrigation systems or foliar spraying. These fertilizers provide essential nutrients directly to plants, ensuring rapid absorption and reducing nutrient losses compared to traditional solid fertilizers. Liquid fertilizers are particularly advantageous for crops that require precise and immediate nutrient delivery, such as maize. Research has shown that liquid fertilizers can be applied more efficiently, enabling better control over nutrient application rates and reducing environmental impact Chadha *et al.*, (2021). The adoption of liquid fertilizers by maize farmers is a growing trend that offers significant potential to increase productivity, improve nutrient efficiency, and reduce environmental impact in agricultural systems. Despite their benefits, the extent to which liquid fertilizers are adopted by maize farmers varies depending on factors such as economic considerations, access to resources, knowledge, and infrastructure. Fageria *et al.* (2021) shows that maize farmers who adopt liquid fertilizers, especially through fertigation, experience higher yields compared to those using traditional solid fertilizers. Liquid fertilizers quick absorption by the roots and leaves helps address nutrient deficiencies more effectively, which is particularly beneficial in areas where soil fertility is low or degraded. This increased productivity provides an economic incentive for farmers to switch to liquid fertilizers.

Despite the potential benefits of liquid fertilizers in improving crop yields and reducing environmental degradation, their adoption remains low among farmers in western agricultural zone of Bauchi State. Empirical evidences have shown that inefficient fertilizer use contribute to soil degradation, water pollution and low crop productivity in the region. However, there is limited understanding of specific factors influencing farmer's decisions to adopt liquid fertilizers, hindering sustainable fertilizer use practices. Thus, it is based on this background that the researcher deems it fit to carry out research on the factors influencing the adoption of liquid fertilizer among maize farmers in Western Agricultural zone of Bauchi State, Nigeria. Understanding localized adoption dynamics will help design targeted interventions to improve input accessibility, extension services, and financial support. Given the potential benefits of liquid fertilizers and the existing challenges to their adoption, this study will be essential in identifying the key factors that influences maize farmers' decisions. The findings will be valuable for policymakers, extension officers, and development agencies in promoting efficient and sustainable liquid fertilizer use.

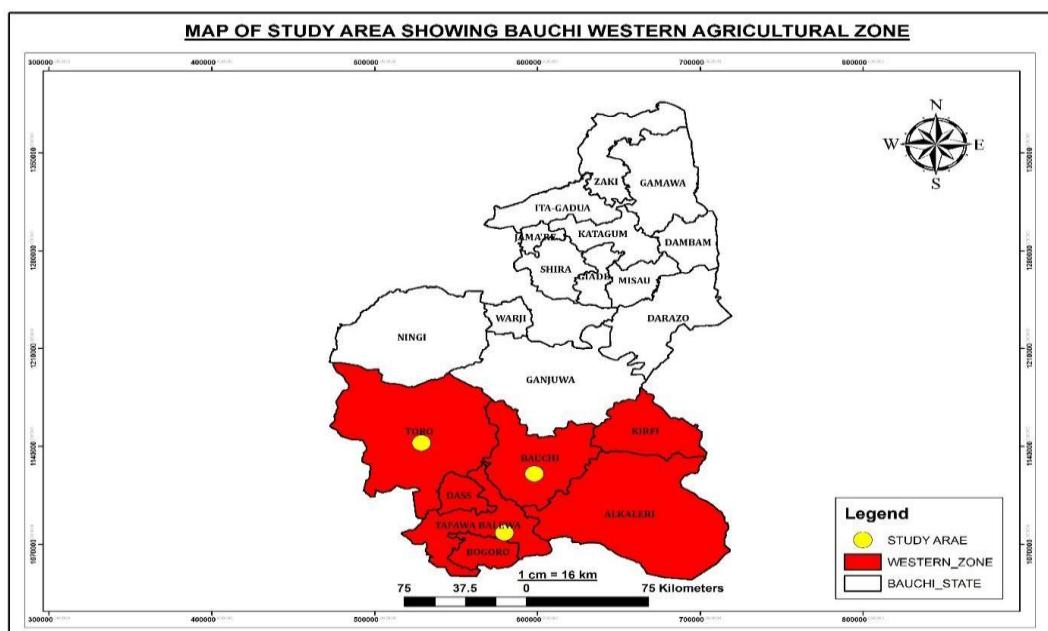
The study was to examined the factors influencing the adoption of liquid fertilizer among maize farmers in Western Agricultural zone of Bauchi State, Nigeria. The specific objectives of the study are to:

- i. identify the socio-economic characteristics of the respondents in the study area;
- ii. identify the sources of information on liquid fertilizer among the respondents on liquid fertilizer;
- iii. determine factors that influence the adoption of liquid fertilizer among the respondents;

## METHODOLOGY

### The Study Area

The study was carried out in Western Agricultural Zone of Bauchi State, Nigeria. Western Agricultural Zone of Bauchi State consists of seven (7) Local Government Areas (LGAs) which include Alkaleri, Bauchi, Bogoro, Dass, Kirfi, Tafawa Balewa and Toro. It is located in the northeastern region of the Federal Republic of Nigeria and occupies a total land area of 549,260 km<sup>2</sup> (BAGIS 2024). The State is geographically located between Latitudes 9°0.3' and 12°0.3' North of the Equator and Longitude 9°0.5' and 11°0 East of the Greenwich meridian (Chiroma *et al.*, 2021). The State has a population of a projected figure of 1,856,858 people at 3.8% growth rate per annum (NPC, 2025). The zone is characterized by two distinct vegetation zones which include Northern Guinea Savannah and Sudan Savannah (Chiroma *et al.*, 2021). The zone experiences both wet and dry season with temperatures ranging between 15-29.7 °C in January to 23-32.4 °C in June with an average relative humidity of 40.1 percent. It is also characterized with an average annual rainfall of 85.6mm Chiroma *et al.*, (2021). Agriculture and livestock farming are the major economic activities. Crops cultivated include, maize, rice, sesame, groundnuts, millet, sugarcane etc.



**Figure 1:** Map of Bauchi State showing the Study Area

The vegetation consists of grassland interposed with trees (up to 6m high) and shrubs. The trees normally occur singly or in cluster with shrubs underneath. The effect of cultivation however, reduced the vegetation in most part of the area, most important trees and shrubs found in the study area include; *Cassia stabericina*, *Isoberlinaspp*, *Albida*, *Khayasenegalensis*, *Tamarindusindica*, *Phoenicdactylifera* (BSADP, 2013).

### Sampling Technique and Sample Size

A multi-stage sampling technique was used in selecting the respondents from the study area. In the first stage, three (3) LGAs were purposively selected from the Western Agricultural Zone, namely Bauchi, Tafawa Balewa and Toro. Secondly, four (4) villages were Purposively selected from the selected LGA's due to high concentration of maize production in the LGAs. The selected villages were Tashan Mai Alewa, Liman Katagum, Kangere and Gubi Dam from Bauchi LGA, while Rishi, Tilden Fulani, Rimin Ziyam and Zull from Toro LGA and Burga, Dajin, Bununu and Lere from Tafawa Balewa LGA given a total of twelve (12) villages. Finally, 201 respondents were randomly and proportionately (5%) selected from the study area.

**Table 1:** Sample Size Selection Plan

LGAs	Communities	Number of farmers	Sample size per sub-LGA	Sample size
Toro	Rishi	348	348	18
	Tilden Fulani	310	310	16
	Rimin Zyam	302	302	16
	Zull	259	259	14
Bauchi	Tashan mai Alewa	413	413	22
	Kangere	380	380	20
	Liman Katagum	405	405	21
	Gubi Dam	438	438	23
T/Balewa	Burga	225	225	12
	Dajin	206	206	11
	Bununu	281	281	15
	Lere	252	252	13
<b>Total</b>		<b>3819</b>		<b>201</b>

**Source:** Authors' Computation (2025)**Method of Data Collection**

Primary data was collected by means of structured questionnaire administered with the assistance of trained enumerators.

**Methods of Data Analysis**

Both descriptive statistics such as frequency, percentage and rank were used to analyze to achieve objective i and ii, while inferential statistics of logit regression was used to achieve objective iii.

**Logistic model specification**

To analyze the factors influencing the adoption of liquid fertilizer among maize farmers, the researcher specified suitable econometric models. In this research, the dependent variable is the farmers' adoption of liquid fertilizer, hence the nature of this dependent variable is dichotomous. Therefore, when the nature of the dependent variable is dichotomous the researcher can use either Binary Logit or Probit regression econometric analysis model (Gujarati, 2004). These two models (Binary logit or probit) are appropriate to analyze the dichotomies dependent variable. However, Binary logit model is very flexible and easy to use from mathematical point of view (Greene, 2003). Therefore, the researchers choose the binary logit model for factors influencing the adoption of liquid fertilizer among farmers in the study area. The functional form of the logit model is specified as follows:

$$P_i = E y \propto e = X_i \propto \frac{1}{1+e} (B B X 10 1 1+) \quad \dots(1)$$

$$1-P_i = \frac{1}{1+e} z$$

Equation (4) expresses the probability to adopt liquid fertilizer to a farmer as:

$$P_i = \frac{1}{1+e} z \quad \dots(2)$$

Therefore, we can write as;

$$\frac{P_i}{1-P_i} = \frac{1+e}{1+e} z \quad \dots(3)$$

Now,  $(P_i/1-P_i)$  is simply the odds ratio in favors of the user farmers. Finally, taking the natural log of equation we obtain.

$$Li = \ln \frac{P_i}{1-P_i} = Zi = b_0 + b_1 X_1 + b_2 X_2 + b_n X_n \quad \dots(4)$$

Where:

$P_i$  = the probability of liquid fertilizer adoption

$Zi$  = the function of explanatory variables ( $X_i$ ) which is also expressed as:  $\beta_0$  is an intercept.

$\beta_1, \beta_2, \dots, \beta_n$  = slopes of the equation in the model.



$i$  = the log of odds ratio, which is not only linear in  $X_i$  but also linear in the parameters.  $X_i$  = pre-intervention characteristics.

If the disturbance term  $U$  is introduced the logit model become

$$Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + U \quad \dots(5)$$

#### **Assumptions of logistic regression**

Logistic regression is quite different than linear regression in that it does not make several of the key assumptions that linear and general linear models as well as other ordinary least squares algorithm-based models hold so close. The main assumptions of logistic regression are:

- i. logistic regression does not require a linear relationship between the dependent and independent variables.
- ii. the error terms (residuals) do not need to be normally distributed.
- iii. homoscedasticity is not required.
- iv. the dependent variable in logistic regression is not measured on an interval or ratio scale.

## **RESULTS AND DISCUSSION**

### **Socioeconomic Characteristics of the Respondents**

The result from Table 2 presents the socioeconomic characteristics of the respondents. The results indicated that a majority (78.1%) of the respondents were male, while 21.9% were female. This shows that maize farming is largely dominated by men in the Western Agricultural Zone of Bauchi State. The result supports the findings of Yusuf *et al.* (2022), who reported that male farmers dominate most agricultural production activities in Northern Nigeria due to cultural norms and gendered access to productive resources such as land and credit. The implication of this finding is that interventions promoting liquid fertilizer adoption should ensure gender inclusivity by targeting female farmers through women's cooperatives and specialized training programmes. The finding further shows that majority (85.6%) of respondents were married. This finding implies that household stability and greater access to family labour for farm operations. This aligns with Olayemi *et al.* (2021), who noted that married farmers often pool labour and income for agricultural activities, which enhances productivity. Educationally, the result shows that a good proportion (43.8% and 25.4%) had secondary, tertiary education, respectively. This suggest a relatively high literacy level among respondents. This implies that most respondents possess the cognitive ability to understand and apply agricultural innovations such as liquid fertilizer. According to Mustapha and Dauda (2020), education enhances technology adoption by improving comprehension of technical instructions and risk perception.

**Table 2:** Distribution of Respondents According to their Socioeconomic Characteristics (n=201)

Variables	Frequency	Percentage
<b>Sex</b>		
Female	44	21.9
Male	157	78.1
<b>Marital status</b>		
Divorced	6	3.0
Married	172	85.6
Single	14	7.0
Widowed	9	4.5
<b>Educational level</b>		
Islamic Education	30	14.9
Primary Education	32	15.9
Secondary Education	88	43.8
Tertiary Education	51	25.4
<b>Membership of cooperative association</b>		
No	174	86.6
Yes	27	13.4
<b>Access to Credit Facilities</b>		
No	171	85.1
Yes	30	14.9
<b>Access to extension service</b>		
No	168	83.6
Yes	33	16.4
<b>Frequency of extension service</b>		
None	168	83.6
Annually	12	6.0
Quarterly	21	10.4
<b>Primary occupation</b>		
Agro-marketing	6	3.0
Civil service	31	15.4
Crop farming	29	14.4
Livestock farming	15	7.5
Trading	120	59.7

On the other hand, 13.4%, 14.9% and 16.4% of the respondents had access to cooperatives credit facilities and extension services. Meanwhile, majority (86.6%) of respondents were not members of cooperatives, (85.1% and 83.6%) had no access to credit and extension services, respectively. These indicates a weak institutional framework for agricultural support in the study area. This deficiency could constrain the adoption of new technologies since credit and extension contact are key enablers of innovation uptake (Akinbami *et al.*, 2022). The implication is that government and NGOs need to strengthen cooperative societies, provide affordable credit, and improve extension outreach in the region. The finding on primary occupation indicates that majority (59.7%) of the respondents were engaged in trading, followed by civil service (15.4%) and crop farming (14.4%). While 7.5% and 3% were engaged in livestock farming and agro-marketing. This suggests that maize farming serves as a supplementary source of income rather than a primary livelihood activity for most respondents. This has implications for technology adoption; part-time farmers may be less motivated to invest in innovations such as liquid fertilizer compared to full-time farmers.

#### Sources of information on liquid fertilizer

The result from Table 6 presents the major sources through which maize farmers in Bauchi State's Western Agricultural Zone obtained information about liquid fertilizers. The findings reveal that the majority of respondents received information through fellow farmers (81.6%), followed by radio (64.7%), and agro-dealers (55.2%). Other less frequently mentioned sources include social media (15.9%), television (12.9%), internet (6.0%), extension agents (5.0%), and training/workshops (1.5%). The dominance of fellow farmers (81.6%) as the primary source of information underscores



the strong role of peer-to-peer knowledge sharing and social networks in agricultural information dissemination within rural settings. Farmers tend to rely on one another for trusted and context-specific information, especially when formal extension services are weak. This finding agrees with Adewumi *et al.* (2022) and Mohammed *et al.* (2023), who reported that interpersonal communication and farmer associations serve as the most influential and credible sources of agricultural innovation in rural Nigeria.

**Table 3: Distribution of Respondents According to their Sources of Information on Liquid Fertilizer**

Variables	Frequency*	Percentage	Rank
Fellow farmers	164	81.6	1 <sup>st</sup>
Radio	130	64.7	2 <sup>nd</sup>
Agro-dealers	111	55.2	3 <sup>rd</sup>
Social media	32	15.9	4 <sup>th</sup>
Television	26	12.9	5 <sup>th</sup>
Internet	12	6.0	6 <sup>th</sup>
Extension agent	10	5.0	7 <sup>th</sup>
Training and workshop	3	1.5	8 <sup>th</sup>

\*Multiple response

The significant role of radio (64.7%) further highlights its importance as a cost-effective and accessible medium for mass agricultural communication. Rural farmers often rely on radio programs delivered in local languages to obtain timely information on agricultural innovations. This finding corroborates Yahaya *et al.* (2021), who noted that agricultural radio broadcasts remain a key driver for awareness creation in regions where literacy levels are low and internet access is limited. The moderate influence of agro-dealers (55.2%) shows that commercial input suppliers play a growing role as information intermediaries. Agro-dealers often serve as both sellers and informal advisors, providing guidance on the application and benefits of farm inputs, including liquid fertilizers. However, the low percentages for extension agents (5.0%) and training/workshops (1.5%) reveal significant institutional weakness in the formal agricultural extension system in Bauchi State. This suggests that most farmers depend on informal sources, which may lead to misinformation or inconsistent adoption practices. Odeyemi and Yakubu (2022) and Abdulkarim *et al.* (2023) similarly found that weak extension-farmer linkages limit the depth and accuracy of farmers' understanding of new agricultural technologies. The low utilization of modern digital platforms such as social media (15.9%) and internet (6.0%) could be attributed to poor digital literacy and limited access to smartphones or stable internet connectivity among rural farmers. Yet, digital channels represent untapped potential for disseminating agricultural innovations among younger and more educated farmers, as observed by Eze and Okoro (2023).

#### **Factors Influencing the Adoption of Liquid Fertilizer among the Respondents**

The findings in Table 4 show that several socioeconomic and institutional variables influenced the adoption of liquid fertilizer among maize farmers. Farm size (-2.33) had a negative and significant ( $P<0.05$ ) relationship with adoption, implying that smaller-scale farmers were more likely to adopt liquid fertilizers compared to large-scale farmers. This could be attributed to the lower volume of input required on smaller plots and ease of management. Larger farmers, however, may prefer conventional fertilizer forms due to their operational scale and ease of bulk application. This result agrees with Abdulrahman *et al.* (2023) who reported that smallholder farmers are more flexible in adopting innovative technologies due to lower production risks and closer contact with extension agents. Similarly, Khan *et al.* (2022) found that smaller farms often demonstrate quicker adoption rates when inputs are affordable and require less mechanization.

Membership in cooperatives ( $r=-2.43$ ) also exhibited a negative but significant ( $P<0.05$ ) relationship, suggesting that non-members were less likely to adopt liquid fertilizers. Cooperative membership enhances farmers' access to information, training, and collective purchasing power for agricultural inputs. This finding aligns with Eze *et al.* (2021) who reported that cooperatives play a vital role in increasing technology dissemination and providing social capital for innovation adoption.

Access to credit ( $r=2.13$ ) facilities was positively and significantly ( $P<0.05$ ) associated with adoption, implying that farmers who had access to credit were more capable of purchasing liquid fertilizers. Credit availability reduces liquidity constraints and allows timely procurement of farm inputs. This is consistent with Audu *et al.* (2020) who noted that financial inclusion is a major enabler of agricultural innovation in Nigeria. Similarly, Oboh *et al.* (2022) emphasized that access to formal credit facilitates the adoption of capital-intensive technologies such as fertilizers and improved seeds.

**Table 4:** Factors Influencing the Adoption of Liquid Fertilizer among the Respondents

Variables	Odd Ratio	Std. Error	z	P z
Age	.9073583	.0457933	-1.93	0.054
Sex	.389336	.2862831	-1.28	0.200
Marital status	.4965776	.2550346	-1.36	0.173
Educational level	.9033146	.2408231	-0.38	0.703
Households size	1.259622	.1541372	1.89	0.059
Farming experience	1.051502	.0550148	0.96	0.337
Farm size	.4067029	.1572109	-2.33	0.020**
Membership of cooperative	.031436	.0448485	-2.43	0.015**
Major sources of farm capital	1.230824	.262329	0.97	0.330
Access to credit facilities	22.91175	33.66748	2.13	0.033**
Access to extension service	.1075453	.0674326	-3.56	0.000***
Primary occupation	1.254256	.3732701	0.76	0.447
Annual income	1	1.28e-07	0.55	0.584
Awareness on liquid fertilizer	.4682265	.5611996	-0.63	0.527
_cons	234141.4	767933.4	3.77	0.000***
Log likelihood	-58.59			
Pseudo R <sup>2</sup>	0.22			

\*\*\*\*Significant at 1% and 5%

Access to extension services ( $r=-3.56$ ) was found to be highly significant ( $P<0.01$ ) but negatively associated with adoption, indicating that farmers who received regular extension visits were more likely to have adopted liquid fertilizer. This supports the assertion by Oladimeji *et al.* (2021) that extension contacts enhance farmers' knowledge of modern technologies, leading to higher rates of adoption. The negative odds ratio in this case indicates that as the frequency of extension interactions increases, the likelihood of non-adoption decreases.

Other variables such as age, sex, education, and household size were statistically insignificant, implying they did not have a major effect on the adoption decision in this study area. However, household size was marginally significant, suggesting that larger households may provide the labor needed for fertilizer application and related tasks.

## CONCLUSION AND RECOMMENDATIONS

The study established that the adoption of liquid fertilizer among maize farmers in the study area is influenced by a mix of socioeconomic and institutional factors such as farm size, membership of cooperatives, access to credit facilities and access extension services. Conversely, limited cooperative participation and weak extension-farmer linkages constrained broader adoption.

Based on the study findings, the following recommendations are made:

- i. Government and microfinance institutions should provide low-interest loans tailored to smallholder farmers to enable the timely purchase and use of liquid fertilizers.
- ii. Bauchi State Agricultural Development Programme (BSADP) should recruit and train more extension agents to improve farmer outreach, demonstration activities, and awareness creation on liquid fertilizer benefits.
- iii. Encourage maize farmers to form or join cooperatives to leverage collective bargaining power for input purchase, access to training, and market linkages.
- iv. Organize regular training sessions and workshops for both male and female farmers, focusing on the preparation, application, and advantages of liquid fertilizers.



v. Utilize radio programs, mobile applications, and social media platforms to disseminate accurate and timely agricultural information, particularly to younger and literate farmers.

## REFERENCES

Abdulkarim, S. A., Musa, L. B., & Danladi, U. G. (2023). Institutional linkages and agricultural technology dissemination among smallholder farmers in Northern Nigeria. *Journal of Agricultural Extension and Development Studies*, **12**(3): 115–127.

Abdulrahman, M. I., Yakubu, A. B., & Sule, H. S. (2023). Farm size and innovation adoption among smallholder farmers in Northern Nigeria. *Nigerian Journal of Agricultural and Development Economics*, **9**(2): 62–74.

AdeWumi, K. O., Bello, T. A., & Musa, I. (2022). Social networks and diffusion of agricultural innovations among rural farmers in Southwest Nigeria. *African Journal of Agricultural Extension*, **30**(2): 98–108.

Akinbami, F. A., Ibrahim, Y. A., & Yusuf, M. S. (2022). Institutional constraints and technology adoption among farmers in Nigeria. *Agricultural Policy and Development Review*, **11**(4): 45–59.

Audu, B. I., Nuhu, A. T., & Sadiq, A. M. (2020). Access to credit and adoption of modern farm inputs in Northern Nigeria. *Journal of Agricultural Economics and Policy*, **8**(1): 33–44.

Bauchi State Agricultural Development Programme (BSADP). (2025). *Annual report on maize production in Bauchi State*. Bauchi: BSADP.

Chadha, R., Kaur, P., & Sharma, R. (2021). Efficiency of liquid fertilizers in enhancing crop yield and soil health. *International Journal of Agricultural Research*, **16**(1): 77–85.

Chiroma, A. M., Danladi, M. U., & Abubakar, B. M. (2021). Climate and vegetation dynamics of Bauchi State, Nigeria. *Nigerian Journal of Environmental Studies*, **10**(1): 43–58.

Eze, C. N., & Okoro, U. J. (2023). Digital innovations and agricultural extension service delivery in sub-Saharan Africa. *Journal of Rural Development and Communication Studies*, **8**(2): 59–74.

Eze, N. E., Aliyu, I. D., & Ibrahim, Y. A. (2021). Role of farmer cooperatives in enhancing adoption of improved agricultural technologies in Northern Nigeria. *Nigerian Agricultural Journal*, **52**(1): 17–26.

Fageria, N. K., Baligar, V. C., & Jones, C. A. (2021). *Growth and mineral nutrition of field crops*. Boca Raton: CRC Press.

Gujarati, D. N. (2004). *Basic econometrics* (4th ed.). New York: McGraw-Hill.

Kamara, A. Y., Akinwale, R. O., & Ekeleme, F. (2020). Maize production and productivity in Nigeria: Issues and prospects. *African Crop Science Journal*, **28**(3): 345–359.

Khan, A. R., Bello, T. Y., & Lawal, M. I. (2022). Smallholder adoption of fertilizer microdosing in Nigeria's savannah region. *Journal of Agricultural Sciences and Policy*, **14**(1): 82–95.

Mustapha, A. Y., & Dauda, S. A. (2020). Education and innovation adoption among small-scale farmers in Northern Nigeria. *Nigerian Journal of Agricultural Research*, **7**(2), 110–122.

Nosheen, S., Bano, A., & Yasmin, H. (2021). Sustainable alternatives to chemical fertilizers: The role of bio-based and liquid fertilizers. *Frontiers in Environmental Science*, **9**(3): 45–60.

Olayemi, T. A., Ibrahim, M. J., & Gambo, H. (2021). Socioeconomic determinants of fertilizer adoption among maize farmers in Nigeria. *Journal of Development and Agricultural Policy*, **11**(3): 88–99.

Oladimeji, Y. U., Afolabi, J. A., & Ibrahim, H. (2021). Agricultural extension contact and adoption of improved technologies among rural farmers in North-Central Nigeria. *Journal of Agricultural Extension*, **25**(2): 102–113.

Odeyemi, A. A., & Yakubu, M. M. (2022). Institutional challenges in agricultural extension systems of Northern Nigeria. *Nigerian Journal of Rural Sociology*, **8**(1): 29–42.

Oboh, V. U., Adeola, G. F., & Ahmed, M. K. (2022). Financial inclusion and agricultural input adoption among smallholder farmers in Nigeria. *Development Studies Review*, **14**(2): 64–78.

Yahaya, M. K., Sani, A. B., & Garba, U. (2021). Agricultural information dissemination through radio in rural Northern Nigeria. *African Communication Review*, **9**(1): 33–47.



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Yusuf, I. A., Lawal, M. Y., & Bala, I. M. (2022). Gender participation in agricultural production in Northern Nigeria. *Journal of Agricultural and Rural Studies*, **10**(4): 71–84.

Zakariah, M. T. (2023). Exchange rate distortion and agricultural competitiveness in Nigeria. *Nigerian Journal of Economic Policy Analysis*, **18**(1): 102–117.