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Research Article

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Soil Fertility Management Practices among Smallholder Cereals Producing Farmers in Dutsin-Ma Local Government Area of Katsina State, Nigeria

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Abstract

Scientific methodologies have been employed to assess soil fertility in Nigeria and other African nations. Nevertheless, there are discrepancies between the scientific procedures employed and the farmers' perceptions regarding soil fertility. This study examined the soil fertility management strategies employed by smallholder farmers engaged in grain production in the Dutsin-Ma Local Government area of Katsina State, Nigeria. The data was obtained by a random sampling method, consisting of 120 cereal producers. This dataset was then subjected to analysis using both descriptive statistics and a logit regression model. The results of the study indicate that a significant majority (91%) of farmers who are married possess land, with a substantial proportion (78.3%) acquiring it mostly through inheritance. The findings indicate that a significant proportion (77.5%) of farmers surveyed do not possess membership in cooperative groups, while a relatively small percentage (15.8%) have established contact with extension personnel. The findings additionally demonstrate that the mean age of farmers is 48 years, and the average farm size is 3 hectares. Furthermore, most of the farmers, approximately 52%, possess formal education. The findings indicate that a limited proportion (37.5%) of farmers possess knowledge regarding soil fertility, primarily relying on observations related to soil color and texture. The research region revealed that most farmers employed crop rotation, fallow farming, and manuring as management strategies to mitigate the reduction in soil fertility. The statistical analysis reveals that the level of education ($p<0.01$), farming experience ($p<0.1$), and Government source of input ($p<0.1$) are important variables that have an impact on farmers' understanding of soil fertility within the research region. Farmers were identified as facing various challenges, including soil degradation, limited financial resources, drought and flooding, and the high cost of fertilizer for soil management. There is a necessity to offer novel approaches for educating farmers about soil fertility and its associated management techniques within the designated study region.

Keywords: Fertility, Management, Soil, Cereals Farmers, Smallholder, Practices

1. Introduction

There are various types of soil in Nigeria, each existing in unique ecosystem and possessing distinct fertility status [1]. It is well known fact that high fertility soils contain high nutrient concentrations [2]. Crop cultivation year after year depletes soil fertility; hence, depleted nutrients must be replenished for a subsequent crop to thrive in the same environment [3]. Enough nutrients can be supplied to the crop by fertile soils for the duration of the growing season. Owing to this, larger yields per unit area can be obtained in fertile soils as opposed to low-fertility soils [4]. The connection between plant development and production depends on the degree of soil fertility found in a particular area [5]. The primary causes of the changes in soil properties include topographical factors, vegetation mix, and prevalent weather patterns [6]. A wide range of exogenic factors, such as land use and farming systems and input management practices cause and/or exacerbate soil fertility loss [7]. Smallholder farmers have limited capacity to control most of these factors [8]. Given their vast experience in land cultivation, it is obvious that farmers ought to play a significant part in stabilizing agricultural land management. Farmers frequently use soil fertility indicators, such as crop yields, soil depth, drainage, wetness, slow plant development, leaf coloration, and other features, to evaluate the fertility of their soil [9]. There seems to be a possible bias on the part of specialists, including soil scientists, regarding the information that farmers have about soil fertility. However, research has shown that small-scale farmers are rather adept at identifying differences in fertility between various kinds of agricultural regions [10]. Nesme et al.

found evidence of possible bias among specialists, including soil scientists, regarding farmers' awareness of soil fertility [3]. On the other hand, nothing is known about farmers' opinions on overall soil fertility, health, function, and fertilization recommendations [11].

Scientific techniques for assessing soil have been used in studies on the fertility of the soil carried out in Nigeria and other African nations. Numerous results have been obtained from these investigations [12]. However, farmers' perceptions of soil fertility is not in line with scientific methods. Petrescu-Mag further states that farmers must be included in any thorough analysis of soil functions [13]. Considering this, this study examines how cereal farmers perceive methods for managing soil fertility. To effectively disseminate appropriate technology for on-farm assessments, it is necessary to understand the degree of knowledge that farmers possess regarding soil health and quality.

2. Methodology

2.1 Description of the Study Area

Dutsin-Ma Local Government Area (LGA) is among the thirty-four (34) LGAs that constitute Katsina State. The geographical coordinates of the local government are situated at Latitude 12027′18″ N and Longitude 70 29′29″E. The Dutsin-Ma Local Government Area (LGA) encompasses an approximate land area of 552.323 square kilometers and was reported to have a population of 169,829 individuals according to the 2006 national census conducted by the Federal Republic of Nigeria (Federal Republic of Nigeria, 2012). The Local Government Area (LGA) in question is geographically adjacent to six other LGAs within Katsina State. These include Kurfi to the North, Charanci, Kankia, and Matazu to the East, Dan-Musa to the South, and Safana to the West, as documented by the National Population Commission in 2010. The Local Government Area (LGA) is situated inside the Sudan Savanna region of Katsina State. The predominant agricultural produce in the region encompasses a variety of crops, namely sesame, maize, millet, sorghum, cowpea, and groundnut. The types of livestock that are often raised in the area encompass cattle, sheep, goats, poultry, and fish. The Dutsin-Ma region is situated inside a tropical continental climate. The annual precipitation levels in this zone exhibit a range of 1000 to over 800mm in the vicinity of Dutsin-ma. This refers to a yearly temperature range of 29°C to 31°C. The climate exhibits significant variations in accordance with the months and seasons.

2.2 Sampling Procedure

A multistage sampling strategy was employed in the study. Out of the eleven wards in the Dutsin-Ma LGA, three were chosen at random in the first stage through balloting. The second stage involved selecting two villages or communities on purpose due to the intensification of cereal crop production in the chosen wards, and the third stage involved using the Yamane formula to determine the sample size of the farmers to reach the required number of respondents, as shown in Table 1. The requisite sample size was systematically sample randomly from the list of farmer's population there by making 120 farmers for the study.

LGA	Wards	Villages	Population of cereals farmers	Sample size
DUTSIN-MA	Dabawa	Tashar mai alewa	25	17
		Fasada	30	21
	Dutsin-ma A	Dantakiri	23	16
		Gobirawa	30	21
	Kutawa B	Kutawa	35	24
		Rumawa	30	21
		TOTAL	**173**	**120**

Source: KTARDA, 2023 [14].

Table 1: Sampling Summary

3. Method of Data Collection

This study acquired primary information through the administration of both closed and open-ended structured questionnaire central to achieving already predetermined objectives by the researcher and trained enumerators that understand language of the respondents. The collected data contained information's on the socioeconomics characteristics; perception of the farmers on soil fertility, attributes of soil fertility known by the farmers; soil management practices used by farmers and challenges faced by farmers on using soil management practices

3.1 Tools of Data Analysis

Descriptive statistics such as frequency and percentages and logit regression model were used in achieving objectives of the study.

3.2 Logit Regression Model

A logit regression model is a statistical analysis method that can be used to model the relationship between an ordinal response variable and one or more explanatory variables. The dependent variable in this case is a dummy variable carrying 0 for the farmers that are have no awareness on soil fertility and 1 for the farmers that have awareness on soil fertility.

$P(Yi=1)=1/\ 1+e^{-\beta 0+\ \beta iXi}$…… (i)

Where P (Yi= 1) is the probability that farmers have awareness on soil fertility and P(Xi = 0) is the probability that farmers are have no awareness on soil fertility. Z_i are the function of a vector of the independent variables. The model can therefore be expressed as;

$1\text{-}P\ (Yi=1) =1\text{-}[1/(1+e^{-zi})] = 1/(1+ e+z)$…….. (ii)

$P(Yi=1)/1\text{-}\ P(Yi=1) = (1+e^{zi})/(1+e\text{-}zi) = ez$……..(iii)

The explicit form of the model can be written as;

$Y=F(X_1,X_2,X_3,X_4,X_5,X_6, X_7, X_8,X_9…X_n$……..(iv)

The Explicit form can be written as

$Y= \beta_0+ \beta_1X_1+ \beta_2X_2+ \beta_3X_3+ \beta_4X_4+ \beta_5X_5+ \beta_6X_6+ \beta_7X_7+ \beta_8X_8+ \beta_9X_9+ \beta_{10}X_{10} + ei$

Y= (Awareness of farmers on soil fertility) (Yes= 1, No = 0, β0 = the intercept, e_i= the error term)

X_1= Educational level (Primary =1, Secondary =2, Tertiary = 3)

X_2 = Age (Years)

X_3= Major occupation (Trading =1, Framing =2, Tailoring =3)

X_4= Household size (numbers)

X_5= Farming experience (years)

X_6= Farm size (Hectares)

X_7= Contact with extension agents (Yes =1, No =0)

X_8= Land ownership (Borrowing =1, Rented =2, Inherited =3)

X_9= Source of inputs (Agro dealer =1, GOV =2, NGOS =3)

X_{10}= Cooperative membership (Yes =1, No =0)

4. Results and Discussion

4.1 Socioeconomic Characteristics of the Respondents

The results of the farmers socioeconomic characteristics presented in table 2a and 2b show that most of the respondents are married (91%) and own land majorly (78.3%) through inheritance. The majority (77.5%) of the farmers do not belong to cooperative groups and only few (15.8%) of them have contact with extension agents. The result further indicates that a substantial proportion (52%) of the farmers in the study area have formal education ranging from primary (21.7%), secondary (20.8%), and tertiary (9%) levels. The findings also revealed that farmers have some level of formal education, which may hinder their incorporation of new knowledge and technologies in their production activities. Salihu et al. obtains a similar result, where 19% of respondents are found to hold a Primary, 51.2% a secondary school, and 29.0% a tertiary degree [15]. Result for major occupation of the farmers findings indicate that a respectable percentage of the respondents (49.2%) were farmers, while 44% were dealers and 3.3% were vegetable and fruit vendors. This suggests that the major occupation in the study area is farming. The result further shows that most (81.7%) of the farmers source their production inputs through family and relatives.

Variable	Frequency	Percentage (%)
Education		
Primary	26	21.7
Secondary	25	20.8
Tertiary	11	9.2
Non-formal education	58	48.3
Major occupation		
Trading	44	36.7
Farming	59	49.2
Tailoring	13	10.8
vegetable and fruits sellers 4	4	3.3
Marital status		
Married	110	91.7
Single	6	5
Divorced	3	2.5
Widowed	1	0.8
Form of land ownership		

Borrowed	1	0.8
Rented	3	2.5
Inherited	94	78.3
Purchased	22	18.3
Source of inputs		
Agro dealer	9	7.5
GOS	3	2.5
NGOS	10	8.3
Family	98	81.7
Cooperative membership		
Member	27	22.5
None Member	98	77.5
Contact with extension agents		
Contact	21	17.5
No Contact	99	82.5
Total	120	100

Table 2a: Qualitative Socioeconomic Characteristics of the Respondents

Result for quantitative socioeconomic characteristics was shown in table 2b, the result revealed farmers to have average age of 48 years which means the farmers are in their active age of production similar to the average number of farmers reported by Abdulkadir et al, [11]. The farmers were also found to have average household of 12 members implying the availability of family labor in the farming household. Moreover, the result shows that most of the respondents (91.7%) have 17-64 years of farming experience with the average of 35.36 years of farming experience. Regarding Farm size of the farmers table 2b shows the result for the respondent's farm size in which most of the respondents (46.7%) have 3.5-4.4 hectares of land allocated for cereal crop production, with an average of 3.29ha. This is in line with the study carried out by Bwambale et al, who reported that variations in land ownership greatly influenced adoption of soil fertility management practices [16]. Farmers with more land (above 3 acres) adopted most of the reported soil fertility management practices compared to farmers with three acres or less.

Variables	Frequency	Percentage (%)
Age		
22-31	13	10.8
32-41	24	20
42-51	32	27
52-61	28	23
62-71	23	19.2
Mean	48.21	
Standard deviation	12.88	
Household size		
1-6	30	25
7-12	31	25.8
13-18	39	32.5
19-24	20	16.7
Mean	12.12	
Standard deviation	5.85	
Years of farming experience		

5-16	10	8.3
17-28	33	27.5
29-40	29	24.2
41-52	25	20.8
53-64	23	19.2
Mean	35.36	
Standard deviation	14.48	
Farm size (hectares)		
<1-1.4	8	6.7
1.5-2.4	24	20
2.5-3.4	22	18.3
3.5-4.4	56	46.7
4.5-5.4	10	8.3
Mean	3.29	
Standard deviation	1.11	
Extension Visit		
None	99	82.5
2-3	12	10
4-5	9	7.5
Mean	3.43	
Standard deviation	1.03	
Total	120	100

Table 2b: Quantitative Socioeconomic Characteristics of the Respondents

4.2 Farmers Awareness on Soil Fertility

Farmer's awareness on soil fertility result is presented in table 3. Findings revealed that most (62.5%) of the respondents are not aware of soil fertility while just few (37.5%) of them are aware about soil fertility. This result indicates that majority of the respondent lack awareness on soil fertility. According Bwambale, and Pulido & Bocco (2014) farmers' awareness of soil fertility degradation is the first step in influencing their decisions about improved soil fertility management practices [16]. As such, farmers become motivated to seek alternative ways to avert current problems based various perceived constraints, including the characteristics of technologies available to them.

Variables	Frequency (f)	Percentage (%)
Yes	45	37.5
No	75	62.5
Total	120	100

Table 3: Farmers Awareness on Soil Fertility

4.3 Physical Attributes of Soil Fertility Known by the Farmers

The physical attributes of soil fertility known by the farmers is presented in table 4 which reveals that a significant proportion of respondents 39.2% and 34.2% believe that changes in the color and texture of the soil respectively are the primary factors that can depict fertility of soil in their various farms, while 20.8% and 5.8% believe that water holding capacity and temperature respectively are the major attribute that signifies soil fertility in their farms. Results implies that most of the farmers in the study area recognize their soil fertility by mere observation of color and texture of the soil. Burek et al. similarly reported that farmers describe soils using physical attribute mostly by the color and water holding capacity [17].

Variables	Frequency	Percentage (%)
Texture	41	34.2
Color	47	39.2
Water holding capacity	25	20.8
Temperature	7	5.8
Total	**120**	**100**

Table 4: Physical Attributes of Soil Fertility Known by the Farmers

4.4 Soil Management Practices by Farmers in the study Area

The distribution of respondents' beliefs regarding potential solutions to the issue of declining soil fertility presented in table 5 revealed most respondents (27.5%) expressed the belief that implementing Fallow farming practices can effectively address the problem. Additionally, (16.5%) of respondents suggested that the application of manure can serve as viable solutions. Furthermore, 12.5% and 13.3% of respondents agreed that the utilization of chemical fertilizers and practicing crop rotation are important management practices they use to improve fertility of their soils, while 8.3% of the respondents believes that tillage, Growing of cover crop and application of green manure can tackle the problem of fertility decrease. This implies that farmers hold the belief that implementing practices such as crop rotation, fallow farming, and the application of manure can effectively address the issue of declining soil fertility in the study area. According to Abdulkadir et al., their survey found that a majority of participants (68.4%) held the belief that fertility levels were not static, but rather subject to variation as shown by fertility indicators [11]. They also found that a significant majority of the respondents in theirs study (83.3%) expressed the belief that the issue of soil fertility could be effectively addressed by implementing technique of bush fallowing and regular application of manure.

Variables	Frequency	Percentage	Rank
Application of fertilizer	15	12.5	4th
Application of manure	20	16.7	2nd
Practicing crop rotation	16	13.3	3rd
Practicing fallowing	33	27.5	1st
Tillage	10	8.3	5th
Intercropping	6	5	6th
Growing cover crops	10	8.3	5th
Green manure	10	8.3	5th
Total	120	100	

Table 5: Soil Management Used by the Farmers in the Study Area

4.5 Socioeconomics Factors Influencing Farmers Awareness on Soil Fertility

Socioeconomic factors influencing farmers, awareness on soil fertility result is presented in table 6. A significant ($p<0.01$) value of Log likelihood and Cox & snell R2 show the overall fitness of the model. The result revealed level of education ($p<0.01$), farming experience ($p<0.1$), source of input ($p<0.1$), and extension visit ($p<0.01$) to be the statistically significant factors influencing farmers awareness on soil fertility in the study area.

The coefficient of level of education, which is positive and significance, implies that farmers with higher level of education of farmers tend to be more aware of soil fertility. This implies that the higher the educational level of farmers, the more the level of awareness on soil fertility. This may be due to the fact that educated farmers have more contact with extension agents. Literate farmers also tend to adopt new technologies than less educated individuals. The coefficient of farming experience that is negative and significant at 10% level of confidence implies that less experienced farmers are more aware of soil fertility which may be due to the fact that less experienced farmers are younger than more experienced farmers and started farming activities when most of the farms soil nutrients are depleted by the older farmers that have been cultivating it for years. Farmers with many years of farming experience may not be willing to change their farming behaviour, including the inputs they use [18]. This may justify the negative awareness about soil fertility among older farmers. Source of input (Government) coefficient that is also positive and significant revealed that farmer that obtained production inputs from government are more aware of soil fertility. This implies that government sources of inputs received with packages of extension of information go a long way to creating awareness about soil fertility.

Variables	Coefficient	Standard error	P-Value
Education(Primary)	-0.385	0.866	0.656
Education(secondary)	0.493	0.816	0.546
Education(Tertiary)	1.839*	1.106	0.096
Age	0.083	0.061	0.175
Major occupation(trading)	-22.226	13649.700	0.999
Major occupation(farming)	-23.110	13649.700	0.999
Major occupation(tailoring)	22.291	13649.700	0.999
Household size	0.081	0.083	0.332
Farming experience	-0.086*	0.046	0.064
Farm size	0.076	0.322	0.815
Landownership(borrowed)	-18.275	40192.970	1.000
Landownership(rented)	1.770	1.501	0.238
Landownership(inherited)	-0.169	0.723	0.815
Source of input(agro dealer)	1.065	1.256	0.396
Source of input(GOV)	1.764*	0.914	0.053
Source of input(NGOS)	-44.680	23659.821	0.998
Cooperative membership	-0.683	0.738	0.355
-2 Log likelihood	95.557		0.000
Cox & Snell R Square	0.410		0.000
Nagelkerke R Square	0.558		0.000

Table 6: Socioeconomics Factors Influencing Farmers Awareness on Soil Fertility

4.6 Constraints Faced by the Farmers in Soil Management Practices

The constraints faced by the farmers in soil management practices is presented in table 7. The result indicated that a significant proportion of the participants (100%) reported encountering difficulties related to insufficient financial resources and the high cost of fertilizer. Additionally, 39.2% of the respondents indicated challenges related to soil degradation, 22.5% reported difficulties with drought and flooding as major challenges affecting soil management practices in their farms.

Variable	Frequency	Percentage	Rank
Soil Degradation	120	100	1
Lack Of Financial Resources	120	100	2
Drought and Flooding	47	39.2	3
High Cost Of Fertilizer	27	22.5	4
TOTAL	**120**	**100**	

Table 7: Constraints Faced by the Farmers in Soil Management Practices

5. Conclusion and Recommendation

The findings of the study indicate that most farmers acquire their agricultural land through inheritance, and they do not actively participate in cooperative groups. Additionally, it was observed that only a small proportion of farmers have regular contact with extension agents. Furthermore, it is worth noting that a limited number of farmers possess knowledge on soil fertility, a factor that is influenced by their level of education, farming experience, and reliance on government-provided agricultural inputs. The farmers in the study area were observed employing agricultural techniques such as crop rotation, fallow farming, and manuring as means of mitigating the reduction in soil fertility. To address the limited awareness and enhance the management practices pertaining to soil fertility, it is imperative to introduce novel approaches for educating farmers in the designated region about soil fertility and its associated management practices.

Declarations

• Availability of data and material: the data used for the manuscript will be provided upon request.

• Competing interests: there are no any competing interests with regard to the study.

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