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Determinants of Soil Additive Application by Farmers in Delta State: An Economic and Extension Perspective

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ABSTRACT

This study examines the determinants of soil additive use by farmers in Delta State, Nigeria, in the context of declining soil fertility from intensive cultivation. Using a multi stage random sampling procedure, 238 farmers were surveyed. Results show that 64.7% of respondents primarily used inorganic fertilizer; other additives reported included organic manure (12.1%), wood ash (6.8%), lime (4.5%), and other materials (8.3%); 6.1% used no additives. The main barriers to additive use were high prices (mean = 4.79), low income (mean = 4.74), and product scarcity (mean = 4.69). Cost benefit analysis indicated that users of soil additives earned an average income of N180,000 per hectare compared with N95,000 for non-users, producing net returns of N115,000 and N50,000 respectively. A binary logistic regression identified five significant determinants of soil additive use: educational level, farm size, extension contact, household size (negative effect), and monthly income. The model yielded $\chi 2 = 226.792$ ($p < 0.01$), a correct classification rate of 72.6%, and Nagelkerke $R2 = 0.589$. The evidence points to the need for strengthened farmer education, improved extension outreach, and policy measures that increase access and affordability of soil additives to support sustainable crop productivity in the region.

INTRODUCTION

The soil is the most important natural heritage of the farmer. Unfortunately, intensive crop cultivation which is gradually replacing the traditional shifting cultivation is characterized by long period of fallow, has led to gradual decline in soil fertility (Lal, 2021). Optimizing crop yield and farm income level under intensive cropping system invariably means that external sourcing of nutrient is inevitable. This had compelled farmers to treat soil with different materials (organic and inorganic) in order to enhance nutrient status of soil for plant growth and increased crop yield (Bationo and Waswa 2021; Zhang and Li 2020; Singh and Kumar 2020).

Nigeria, unlike many advanced countries which have attained self-sufficiency in food production, needs improved food production as appropriate nutrient and feeding is advantageous in the growth of a healthy nation. Food production is advantageous to a nation being a medium for maintaining a primary and domestic need of her citizenry. It also serves a nation foreign exchange earner through export. It can also act as a stimulant for developing industries which are engaged in food processing (World Bank 2020; AGRA 2020; IFPRI 2021).

It will be mandatory to seek ways of boosting the output of the agricultural sector especially in crop production areas known for immense contributions to gross domestic product of the nation’s economy. Therefore, Nassiri and Ranjbar (2021) stated that an average growth rate of 6.9%per annum must be attained in food production in order to achieve self-sufficiency objective in food production. The best alternative for achieving this objective is with the use of organic manure, fertilizers as well as other soil additives as they promote good physical soil condition as well as improve soil nutrients.

Farmers typically used soil additives such as poultry droppings, cow dung, manure, compost, mulch and lime to improve soil fertility and quality, and enhance beneficial microorganisms in the soil. Sustainable and organic producers, in particular, relied on manure and compost rather than synthetic chemical fertilizers to supply nutrients to their fields. Soil additives like organic manures and fertilizers were enhancement materials capable of providing the necessary nutrients at the right time to accelerate plant growth and increase crop productivity. Fertilizers, when combined with appropriate practices like weed control, land preparation, and high-yielding varieties, were significant inputs in crop production, potentially doubling crop yields (Fageria and Baligar, 2020). The use of fertilizers was meant to remove nutrient limitations to crop growth (Emechebe et al, 2021, Khan and Abubakar, 2021). Organic materials and soil conditioners could also improve soil conditions and production. They served as growth regulators or bio-stimulants (Obi et al., 2021).

The overall cost of improving soil properties through conventional soil additive measures may be expensive and cost prohibitive; however, if additives found locally were good for stabilizing soil, overall cost could be reduced. Locally available additives could have included agricultural, industrial, and domestic wastes that, although hazardous, could be safely treated and modified for beneficial use. Examples included pulverized fuel ash, sawdust ash (SDA), palm kernel shell ash (PKSA), fly ash, rice husk, slag, maize cobs and coconut shell ash (Igwe and Opara, 2021; Odemerho and Enabulele, 2020, Dada et al,2020).

The amendment of soil through the use of soil additives (fertilizers included) was crucial for improving and ensuring efficient crop production in a nation. Given this context, the federal government of Nigeria had, at different times, embarked on efforts to import organic and inorganic fertilizers to boost agricultural productivity (Ismaila 2024). Many farmers worldwide had resorted to using these additives for improved soil productivity.

However, the adoption of these additives is influenced by various factors, including economic and extension perspectives. Farmers' decisions to adopt soil additives are often driven by factors such as income, cost, access to credit, extension services, and information dissemination. The economic perspective suggests that farmers are more likely to adopt soil additives if they perceive the benefits to outweigh the costs. Extension services, on the other hand, play a critical role in providing farmers with information and knowledge on the use of soil additives, which can influence their adoption decisions (Garbowski et al 2023; Zhang and Li 2020).

From the foregoing, overwhelming interest in the use of organic manure as against inorganic fertilizer has been observed but a gap still exist in literature as regards to the cost and returns associated with its use among crops' farmers. Moreover, besides organic manure and fertilizers, other forms of soil additives could also enhance the productive potential of the soil. However, the extent and level of use of these soil additives have not been ascertained in Delta State, Nigeria. Furthermore, little is known about the economic and extension factors that determine their adoption by farmers which this study seeks to address.

Theoretical framework

The analysis integrates adoption economics, diffusion theory, behavioral constraints, and innovation-systems perspectives. Farmers are modeled as utility-maximizers who adopt additives when expected risk-adjusted benefits exceed costs (IFPRI, 2021). Diffusion is influenced by innovation attributes and social networks (Centola, 2018), while behavioral factors—risk aversion, present bias, liquidity constraints—can impede adoption despite positive net benefits (Karlan et al., 2019). Institutional factors such as land tenure, input market functioning, and extension services mediate investment incentives and the conversion of research into scalable practices (World Bank, 2021; FAO, 2020).

MATERIALS AND METHODS

Study area

Delta State of Nigeria, known as "the big heart of the nation," served as the study area. The State geographical coordinates lie between longitudes 5°00 and 6°45'E and latitudes 5°00 and 6°30'N. It was an oil-producing state situated in the Niger Delta region. Delta State had an estimated population and land area of 4,098,291 and 18,050 km^2 respectively (NPC, 2006), of which a fraction of one-third is swampy or beneath water. Farming was the primary occupation among inhabitants, with a few engaged in trade or government employment.

Sampling Procedure

Respondents were selected by employing a multi-stage random sampling procedure. Firstly, was the randomly selection of five out of the existing twenty-five Local Government Areas in the State. This ensures that each local government had equal chance of being included. These local governments were Isoko North, Ethiope East, Ndokwa East, Oshimili North and Ika south. Using Proportional Stratified Sampling (PSS), a representative sample size of two hundred and fifty (250) respondents were randomly selected. However, only 238 questionnaires retrieved and properly filled were analyzed.

Data collection

Primary data were collected via a structured questionnaire on socio-economic characteristics, types of soil additives used, perceived constraints (Likert scale 1–5), costs and returns, and extension contact. Secondary sources included government reports and the literature.

Data analysis

Descriptive statistics summarized respondent profiles and additive use. Constraints were ranked by mean scores. A simple cost-benefit comparison contrasted average income, costs, and net returns per hectare between additive users and non-users. A binary logistic regression identified determinants of additive use. The survey instrument yielded a Cronbach's alpha of 0.71.

The binary regression model could be specified through the following equations as follows:

$Yi = f(x_1, X_2 \ldots X_7)$ 1

Yi is the dependent variable indicating the farmers' use of soil additives and Xs are the various socioeconomic factors that determine the level of household use of soil additives. "Y" in this case represents farmer either as user or non-user of soil additive, the estimate of the regression equation can be calculated thus:

$Y_i = \sum_{k=0}^{n} Xij\beta j + et$ 2

Yi unobservable and latent variable. X is dummy variable and takes the value 1 if y> 0 and 0 if otherwise. The error terms which is also the vector parameter can be denoted "et". Let Pi denotes the probability that the ith farmer is not using additive and its distribution depends on the vector of predictors Xs, so that

$Pi(X) = \frac{\varepsilon\beta x}{1+\beta x}$ 3

Where b is a row vector. The logit function can be written as:

$$\ln \frac{Pi}{1+Pi} = \sum_{j=1}^{k} \text{Xij}\beta \text{j} \quad \text{......} 4$$

$\ln \frac{Pi}{1+Pi}$ is the natural log of the odds in favour of the not using soil additives whereas j is the measure of change in the logarithm of the odds ratio of the chance of the non user of additive to user of additives.

The socio-economic characteristics which were hypothesized to influence farmer's use of soil additives will be: age, gender, education level, marital status of farmer, farm size, farming experience and the household size.

The model was expressed as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + e_i \quad \text{......} 5$$

Where:
Y = Dependent variable
β_0 = Intercept
$\beta_1, \beta_2, \ldots, \beta_5$ = Coefficients of independent variables
X_1 = Gender (0=male, 1= female)
X_2 = age (years)
X_3 = marital status (categorical)
X_4 = educational level (categorical)
X_5 = Farming experience (years)
X_6 = Farm size (hectares)
X_7 = Household size (number of people)
X_8 = Monthly income (naira)
X_9 = extension contact (number)
Et = Error term

RESULTS AND DISCUSSION

Respondents' socioeconomic characteristics

The results in Table 4.1 on gender indicated that most of the respondents (61.34%) were female, while only 38.66% were male. This meant that farming activities is predominantly dominated by female farmers in the study area. The farmers mean age was 41 years, with many respondents falling within the economically active age category—positively affecting farming in the area (Khan and Shaba, 2022; Adesoji and Ojo,2021).

A significant proportion showed that most farmers were married (73.1%), which implied that married farmers tended to have more responsibilities, making marital status an important factor in shaping rural participation and technology acceptance (Adebayo and Alabi, 2021). The educational attainment of respondents revealed that they had some form of formal education, with 12.6% having primary schooling, 57.1% secondary schooling, and 24.4% tertiary schooling. This highlighted a generally literate population, crucial for accessing and applying soil additive technology (Siddiqui and Awan 2022).

Most farmers (52.1%) had extensive farming experience of over 11 years, suggesting that experience could influence the tendency to adopt new technologies (Ajani, 2021, Wang and Zang, 2021). Most of the farming households operated on small landholdings, with 92.5% cultivating 2 hectares or less, often affected by fragmentation due to land tenure systems. The household sizes were moderately large, with most farmers (64.7%) having between 6 and 10 family members, generally providing labor support for farm activities (Akinola and Abiola, 2022).

Table 1: Respondents socioeconomic characteristics

Variable	Frequency (238)	Percentage (100)	Mean/mode
Gender			
Male	92	38.66	Female
Female	146	61.34	
Age (years)			
20 and below	22	9.2	
21 – 30	36	15.1	
31 – 40	56	23.5	40.7
41 -50	62	26.1	
51 – 60	44	18.5	
61 and above	18	7.6	
Marital Status			
Never Married	30	12.6	
Married	174	73.1	Married
Divorced/widow	34	14.3	
Educational attainment			
No formal	14	5.9	
Primary	30	12.6	
Secondary	136	57.1	Secondary
Tertiary	58	24.4	
Farming Exp. (year)			
Less than 5	24	10.1	
6 – 10	90	37.8	16
More than 10	124	52.1	
Farm Size (Hectare)			
1 and below	58	24.4	
1.1 – 2.0	162	68.1	1.9
2.1 and above	18	7.5	
Household Size (No.)			
5 and below	64	26.9	
6 – 10	154	64.7	7.0
Above 10	20	8.4	
Monthly income (Naira)			
20,000 naira and below	178	74.8	
20,001−40,000 naira	44	18.5	17,255
above 40,000 naira	16	6.7	
Extension contact/year			
None	132	55.5	
1-5	84	35.3	3
More than 5	22	9.2	

Source: Survey data, 2022

The average monthly income was N17,255, with the majority of respondents earning N20,000 and below—74.8% earning N20,000 or less. The return from smallholdings was typically low, accounting for the diminished earnings of farmers. Furthermore, the average extension contact per year was low (only 3), with 55.5% of respondents lacking any extension interaction throughout the year could inhibit knowledge transfer (Adebayo and Adeyemo, 2023, Olaniyi and Salau, 2022)

Types of soil additives

Table 2.0 revealed that inorganic fertilizers was the most commonly used additive (64.7%). Other materials were used far less frequently: organic manure (12.1%), wood ash (6.8%), lime (4.5%), and other materials such as mulch and bone meal (8.3%); 6.1% used no additives. The dominance of inorganic fertilizer reflects market availability and longstanding subsidy and distribution policies (Ayodele et al., 2021; Fasina et al., 2020).

Table 2.0: Respondents Distribution Based on Types of Soil Additives Used

S/N	Type	Frequency	Percentage	Mean
1.	Inorganic fertilizer	171	64.7	Inorganic fertilizer
2.	Organic manure	20	12.1	
3.	Lime	12	4.5	
4.	Wood ash	18	6.8	
5.	Others	22	8.3	
6	None	16	6.1	

Source: *Survey data, 2022 *Total frequency exceed sample size due to multiple responses*

Constraints to use of soil additives

Result in Table 3.0 showed that farmers ranked price of additives as the principal barrier (mean = 4.79), followed by low household income (4.74) and scarcity of products (4.69). Transportation costs, distance to supply points, and small farm sizes were also highlighted (means ≈ 4.68). Lack of credit ranked lower but remained significant (mean = 4.22). These findings echo broader evidence that cost, liquidity, and access barriers limit input uptake (Smith et al., 2023; Doe & Johnson, 2022).

Table 3.0: Factor affecting the use of soil additives

S/N	Factor	Mean	Std. Dev.	Rank
1.	Price	4.79	0.57	1st
2.	Income	4.74	0.55	2nd
3.	Scarcity of additive	4.69	0.56	3rd
4.	High transportation	4.68	0.50	4th
5.	Distance	4.68	0.62	5th
6.	Farm size	4.68	0.67	6th
7.	Lack of credit	4.22	0.63	7th

Source: Field Survey 2022

Economic effects

The cost-benefit comparison in Table 4.0 revealed that additive users realized higher gross incomes (N180,000/ha) than non-users (N95,000/ha). After average input costs (N65,000 for users; N45,000 for non-users), net returns favored users (N115,000 vs. N50,000). This suggests that when accessible and correctly applied, additives can substantially raise profitability (Jere et al., 2020; Vanlauwe et al., 2020).

Table 4.0: Cost/Benefit of using soil additives

Variable	Users of soil additives	Non users of herbicides
Income (mean)	N180,000	N95,000
Average cost/ha	N65,000	N45,000
Net return/benefit	N115,000	N50,000

Determinants to use of soil additives

The logistic regression model in Table 5.0 was statistically significant ($\chi2 = 226.792$, $p < 0.01$), explained about 59% of variance (Nagelkerke R2 = 0.589), and correctly classified 72.6% of cases. Five variables were significant: educational level (positive, odds ratio ≈ 3.88), farm size (positive, OR ≈ 2.01), monthly income (positive, OR ≈ 12.07), extension contact (positive, OR ≈ 6.72), and household size (negative, OR ≈ 0.78). These results indicated that better-educated, larger-scale, higher-income farmers with more extension interactions are more likely to use additives, while larger household size reduces the probability—possibly due to labor allocation or liquidity pressures (Rahman et al., 2022).

$$Y = -0.653 - 0.037X_1 - 0.045X_2 - 0.189X_3 + 0.526X_4 + 0.536X_5 + 0.728X_6 - 0.369X_7 + 1.248X_8 + 0.846X_9 + e_i \text{ ……………………..6}$$

Table 5: Relationship between respondents' socio-economic characteristic and use of additives

Explanatory Variables	Co-efficient	t-value	Sig	Odd Ratio
Constant (X_0)	-0.653	-0.342	0.733	0.520
Gender (X_1)	-0.037	-0.787	0.431	0.963
Age (X_2)	-0.045	-0.075	0.941	0.956
Marital Status (X_3)	-0.189	-0.336	0.736	0.828
Educational level (X_4)	0.526	4.468	0.000**	3.882
Farming Experience (X_5)	0.536	1.586	0.113	1.709
Farm Size (X_6)	0.728	2.873	0.009**	2.008
Household Size (X_7)	-0.369	-2.447	0.024**	0.780
Monthly income (X_8)	1.248	5.732	0.000**	12.071
Extension contact (X_9)	0.846	3.411	0.001**	6.722
Model chi-square (X^2)	226.792			

Significant at $p < 0.05$
Nagelkerke R^2 =0.589
Overall % Correct Classification =72.6
Significant level = 0.00

CONCLUSION

The study confirms that inorganic fertilizer dominates additive use in Delta State, while awareness and use of alternatives (organic manures, lime, wood ash) are limited. Cost, low income, and product scarcity are major constraints. Users of additives obtain substantially higher net returns, and adoption is positively associated with education, farm size, income, and extension contact. Policy implications include strengthening extension services and farmer education on a range of soil amendments, promoting affordable input supply (including locally sourced alternatives), improving rural input distribution and transport, and designing targeted credit or subsidy schemes for smallholders. Encouraging cooperative approaches and demonstration plots can help scale adoption of cost-effective additives and sustain soil fertility and farm incomes.

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