doi:10.14720/aas.2024.120.3.15366 Original research article / izvirni znanstveni članek

Land productivity of root crop farmers amid pesticide application in Southeast Nigeria

Emeka OSUJI [1, 2], Igwe OBASI [3], Christiana IGBERI [1], Ngozi UMEH [1], Roseline NWOSE [1], Eberechi KEY-AGHA [4], Nneka OKOLI [5], Kelechi ANYIAM [6], Chinaekwu COOKEY [4], Glory BEN-CHENDO [6], Maryann OSUJI [6], Christopher ECHEREOBIA [4], Innocent NWAIWU [6], Esther NWACHUKWU [6], Ifedayo OSHAJI [6], Bethel UZOMA [7], Maryrose EZE [8], Ogechukwu UMEH [5]

Received August 3, 2024; accepted August 12, 2024.
Delo je prispelo 3. avgust 2024, sprejeto 12. avgust 2024

Land productivity of root crop farmers amid pesticide application in Southeast Nigeria

Abstract: The study evaluated the land productivity of root crop farmers amid pesticide application in Southeast Nigeria. A sample of 358 root crop producers was chosen using a multistage sampling process. Information on the objectives of the research was obtained using primary instruments. The analysis of the data included the use of mean, frequency, percentage, total factor and partial factor productivity, analysis of variance, multiple regression model, and local average treatment effect (LATE). The results show that root crop growers were mostly women (76.9 %), married(85.1 %), educated (mean=12.0), and in their prime working age (51 years). Estimate of total factor productivity (TFP) and partial factor productivity (PFP) were 7.69 and 177.25, which indicates higher land productivity values across Imo, Abia, and Ebonyi State. Education, access to farm inputs, soil/land improvement practices, size of farm, and extension visits were significant determinants of land productivity at1 % and 5 % levels. Use and application of pesticides according to specified recommendation increased land productivity by (727.07 %) and (880.28 %). Erosion problems (99.7 %), pests and disease (96.9 %), high cost of inputs (99.1 %), climate change (99.4 %) and land fragmentation (93.0 %) constrained land productivity in the states. The study recommends farmers to practice more of soil and land improvement practices and adhere strongly to specified pesticide use and application to increase land productivity.

Key words: land productivity, root crops, household farmers, pesticide application

Produktivnost kmetov pridelovalcev korenovk in gomoljnic ter uporaba pesticidov v jugozahodni Nigeriji.

Izvleček: V raziskavi sta bili ovrednoteni produktivnost kmetov, ki pridelujejo gomoljnice in korenovke ter uporaba pesticidov v jugozahodni Nigerijio. Izbran je bil vzorec 358 pridelovalcev v večstopenjskem procesu vzorčenja. Informacije o predmetih raziskave so bile pridoblljene s primarnimi postopki. Analiza podatkov je vsebovala uporabo poprečij, frekvenčne in odstotkovne analize delne in skupne faktorske produktivnosti, analizo variance, multipli regresijski model in učinek poprečja lokalne pridelave (LATE). Rezultati kažejo, da so pridelovalci teh poljščin pretežno ženske (76,9 %), ki so poročene (85,1 %), izobražene (poprečje = 12,0), z najpogostejšo starostjo 51 let. Izračuna produktivnosti glede na vse (TFP) in posamezne dejavnike (PFP) sta znašala 7,69 in 177,25, kar kaže na večjo produktivnost zemljišč v državah Imo, Abia in Ebonyi. Izobrazba, dostop do pomoči kmetijam, izboljšane tehnike obdelave tal, velikost kmetij in obiski kmetijskih svetovalcev so bili značilni določevalci produktivnosti zemljišč na1 % in 5 % ravni. Uporaba pesticidov glede na priporočila je povečala produktivnost zemljišč za 727,07 % in 880,28 %. Problemi z erozijo(99,7 %), s škodljivci in boleznimi (96,9 %), velikimi stroški pridelave (99, 1 %), s klimatskimi spremembami (99, 4 %) in razdrobljenostjo zemljišč (93,0 %) so omejevali produktivnost v vseh državah. Raziskava priporoča kmetom, da uporabljajo boljše načine obdelave tal in zemljišč in, da se bolj posvetijo k primerni rabi in pripravi pesticidov, kar bo vse povečalo produktivnost.

Ključne besede: produktivnost zemljišč, korenovke in gomoljnice, kmetje, uporaba pesticidov

1 Department of Agriculture, Alex-Ekwueme Federal University Ndufu-Alike Abakaliki, Nigeria
2 Corensponding author: osujiemeka2@yahoo.com
3 Department of Agricultural Economics, Michael Okpara University of Agriculture Umudike, Nigeria
4 Department of Crop Science and Technology, Federal University of Technology, Owerri, Imo State, Nigeria
5 Department of Crop Science and Horticulture, Nnamdi Azikiwe University Awka, Nigeria
6 Department of Agricultural Economics, Federal University of Technology, Owerri, Imo State, Nigeria
7 Department of Arts and Humanities Education, Alex Ekwueme Federal University Ndufu-Alike Abakaliki, Nigeria
8 Department of Vocational and Technical Education, Alex Ekwueme Federal University Ndufu-Alike Abakaliki, Nigeria

1 INTRODUCTION

Despite the strategic significance of the petroleum industry, agriculture remains a substantial sector of the Nigerian economy (FAO, 2020a). In addition to fostering economic growth, it has the capacity to lessen hunger and poverty. The industry employs a sizable labor force and contributes more than 30 % of Gross Domestic Product in Nigeria (FAO, 2021, World Bank, 2022). Agricultural cultivation in Nigeria is still domiciled at the subsistence level with the cultivation of root/tuber crops, legumes, cereals and vegetables. Root crops are majorly grown because they are excellent source of carbohydrates and includescassava (Manihot esculenta Crantz), yam (Dioscorea spp.), cocoyam (Colocassia spp.), and sweet potato (Ipomoea batatas Lam.) are categorized as primary root crops in Africa (FAO, 2020b). These crops are categorized as the primary root crops in Africa. They are important source of income for rural household farmers who make a living from it. They are mostly used in the production of grain, alcohol, fermented drinks, and contain nutrients for humans and animals (Ukeje et al., 2022).

The land productivity of root crops is an indicator of production efficiency. According to Muhammad et al. (2022), it is a measurement of the relationship between output and inputs during the process of production. Umar et al. (2021) define productivity as the total output divided by the total input. It deals with the conversion of specific inputs into outputs. Land productivity can be calculated using both partial and total factor productivity. Partial factor productivity, or PFP, is the ratio of output to each individual input used in the manufacturing process, while total factor productivity TFP, is the ratio of a farm's total output to its entire input used in production (Fuente et al., 2020). Thus, farm output and land productivity could be improved through the application of high yielding inputs. However, root crop production has recently being under attack from pests and diseases, lowering its yield and productivity and thus necessitating pesticide use and application (Đokić et al., 2022). Consequently, to prevent the damaging impact of insects and other pests' attacks on crops, household farmers employ pesticide as a damage control input. Its use is considered a cost-effective, labor-saving, and effective method for controlling insects and other pests (Ladapo et al., 2020). Despite its detrimental effects on both human health and the environment, pesticides provide competitive advantage in agriculture. This is because the usage of pesticides is necessary for maintaining the current levels of production yield and crop quality (Prihandiani et al., 2021). It is on record that pest can reduce yield and productivity of arable land due to its excessive application, and can equally increase crop yield and land productivity of farmers when applied correctly (FAO, 2021).

In Nigeria, several researches have been conducted on crop production, agricultural growth and productivity (Alemu et al., 2017, Montfort et al., 2020, Kurdyś-Kujawska et al., 2021, Đokić et al., 2022, and Hemathilake and Gunathilake, 2022), while other studies have looked at pesticide application on crop production (Yadav et al., 2015, Lozowicka et al., 2015, Al-Wabel et al., 2016, and Tudi et al., 2021). The above studies examined the generality of farmers' land productivity and pesticide application without consideration on the principal root crop or crops; hence, this creates a lacuna that is a wide gap in knowledge and literature.

A priori, the study hypothesized that the land productivity of root crop farmers performed well amid the application of pesticides. This study differs from previous studies in that it is the first study in Sub-Saharan Africa to examine the land productivity of three major root crops (cassava, yam and sweet potatoes) amid pesticide application. Again, the complexity of induced alterations of pesticide use and application on root crop production at the farm level have not been explored in previous studies but was empirically and objectively analyzed in this study, thereby contributing to new knowledge in science and literature. Thus, the study accessed the land productivity of root crop farmers amid pesticide application in Southeast Nigeria.

2 MATERIALS AND METHODS

The study was conducted in southeast Nigeria. The states of Abia, Anambra, Ebonyi, Enugu, and Imo make up this region. The region has an estimated population of 22 million residents, representing 10 % of the entire nation's population (NPC, 2022). Its land area is approximately 41,440 square kilometers. The location of the region lies between latitudes 4 and 7 degrees north and longitudes 7 and 9 degrees east of the equator. The region's native vegetation is that of the tropical rainforest, with sandy-loamy soil predominating. This study employed a multi-stage sampling technique. First, three of the five states that make up the region were chosen at random. In the subsequent phase, two local government areas (LGAs) were chosen from the states, totaling six LGAs. Two communities were chosen at random in the third stage, to make 12 communities. From these communities, two villages were chosen bringing the total to 24 villages. In the last stage, 16 farmers who grow root crops were randomly chosen, creating a sample size of 384 persons that participated in the study. The sample frame was created using a list of registered growers of root crops that was obtained from the State Agricultural Development Program. The study made use of primary data collected using the survey tool (questionnaire). Only 358 of the questionnaires were considered useful for data analysis based on its verified contents. Descriptive statistics, total factor and partial factor productivity, analysis of variance, multiple regression model, and local average treatment effect (LATE) were used to analyze the data. Analysis of the land productivity of the principal root crops grown throughout the states was conducted using total factor and partial factor productivity models and was expressed as follows;

TFP = TO/TI ------------------- eqn. 1

PFP = TO/ IthIPU……………….. eqn. 2

Where;
TFP = Total factor productivity
PFP = Partial factor productivity
TO = Total output
TI = Total input
Ith IPU = Individual inputs used by ith farmer

Analysis of variance (ANOVA) was used test the significant difference in land productivity of major root crops cultivated across the states and was expressed as follows;

$$F = \frac{MSSB}{MSSW} = \frac{SSB/(n-k)}{SSW/(k-1)} \text{-----------} \quad \text{eqn. 3}$$

$$SSB = \sum_{j=1}^{k} nj\ (x\text{-}x)^2$$

$$SSW = \sum_{i=1}^{nj} \sum_{j=1}^{k} (Xij - \ddot{X})$$

$$SST = SSB + SSW$$

Where:
F = the number that will be used to determine the statistical significance of the mean difference.
SSB = Sum of square variations between the principal root crops grown throughout the states
SSW = Sum of squares variations from the mean land productivity of the main root crops grown in the states.
SST = Sum total of squares of the land productivity of major root crops cultivated across the states.
Xi = Mean level of land productivity of major root crops cultivated
 = Mean level grand of land productivity of major root crops cultivated across the states.
Xij = ith level of land productivity of major root crops cultivated
nj = Size of the farmers
n = Nominal observances in the 3 states.
k^{-1} = Freedom of degree between samples.
n-k = Freedom of degree within samples.
k = No. of state.
x = Land productivity of major root crops cultivated across the states.

Multiple regression technique isolated the land productivity determinants of the root crop growers and was specified;
$Y = f\,(b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + b_9X_9 + b_{10}X_{10}) + e$

Where
Y = Land productivity (Naira)
X_1 = Education (schooled years)
X_2 = Age (no. of years)
X_3 = Access to subsidized farm inputs (Accessed = 1, Otherwise = 0)
X_4 = Soil/land improvement practices (Practiced = 1, Otherwise = 0)
X_5 = Farm size (ha)
X_6 = Farming experience (Years)
X_7 = Access to credit (Accessed =1, Otherwise = 0)
X_8 = Labour supply (manday)
X_9 = Land tenure patterns (Inheritance = 1, Otherwise = 0)
X_{10} = Extension contacts (No of visits)

To examine the impact of pesticide use and application on the land productivity of growers of root crops, the LATE model was utilized:

$$E\left(y_1 - \frac{y_0}{d_1} = 1\right) = LATE = \frac{cov(y,z)}{cov(d,z)} \text{ --- --- --} \qquad \text{eqn. 4}$$

$$= \frac{E\left(\frac{y}{z}=1\right) - E\left(\frac{y}{z}=0\right)}{E\left(\frac{d}{z}=1\right) - E\left(\frac{d}{z}=0\right)}$$

$$= \frac{E(y_i * (z - E(z_i))}{E(d_i * (z - E(z_i))}$$

$$= \left(\frac{\sum_{i=1}^{n} y_i z_i}{\sum_{i=1}^{n} z_i} - \frac{\sum_{i=1}^{n} y_i(1-z_i)}{\sum_{i=1}^{n}(1-z_i)}\right) X \left(\frac{\sum_{i=1}^{n} d_i z_i}{\sum_{i=1}^{n} z_i} - \frac{\sum_{i=1}^{n} d_i(1-z_i)}{\sum_{i=1}^{n}(1-z_i)}\right) \text{-----} \qquad \text{eqn. 5}$$

Specifying LATE model components,

$$ATE = \frac{1}{n}\sum_{i=1}^{n} i\, \frac{(d_i - p(X_i)y_i}{p\,(X_i)(1-p(X_i)}$$

$$ATE1 = \frac{1}{n1}\sum_{i=1}^{n} i\, \frac{(d_i - p(X_i)y_i}{(1-p)(X_i)}$$

$$ATE0 = \frac{1}{1-n1}\sum_{i=1}^{n} i\, \frac{(d_i - p(X_i)y_i}{p(X_i)}$$

Let z (yi) be a binary outcome variable with the value 1 when a farmer uses pesticides and 0 otherwise. We have d0 = 0 for all farmers and the observed outcome is given by d = zd1. As a result, the sub-populations of Eyi* and Edi* are described by the condition d1 = 1 and d = 1 (which is equivalent to the condition z = 1 and d1 = 1), respectively. We suppose that the possible outcomes d1, y1, and y0 are unrelated to z. ATE = ni = (I = 1) and i is the total number of farmers employing pesticides, where n is the sample size. ATE1 represents the typical treatment outcome for farmers who use pesticides in accordance with suggested specifications, while ATE0 represents the typical treatment outcome for farmers who do not use pesticides in accordance with recommended specifications. Propensity score matching (PSM) and inverse propensity score weighing (IPSW) are represented as P(Xi)

3 RESULTS AND DISCUSSION

3.1 SOCIO-DEMOGRAPHIC FEATURES OF ROOT CROP PRODUCERS

The socio-demographic features of root crop producers are presented in Table 1. The average length of education for growers of root crops was 12 years, which suggests that the farmers at least finished their secondary education. Crop productivity increases with increase in educational attainment. This is because education increases farmers' knowledge and comprehension of agricultural production principles (Ayi, 2022).The root crop farmers were 51 years old, which suggests that they are actively engaged in root crop production. Age of farmers is a symbol of extensive farming expertise, which aid crop productivity. The household size was 6, indicating that the farmers had a sizable household to deal with root crop production. Large household size guarantees large-scale farm cultivation. Gender of the root crop farmers' shows that more females, 77 %, were involved in root crop cultivation relative to the male folk. Typically, studies have reported engagement of more female root crop farmers than their male counterparts (Fanelli, 2022). The percentage of married root crop farmers is 85.1; this shows that the married farmers dominated the states. Marriage contributes immensely to family labour utilized in crop cultivation. The mean extension contact of the root crop farmers was 3.6, this shows that the farmers had up to 4 visits within the cropping season. Extension visits impact positively on the knowledge of the farmers and inculcate practical experiences required for improved farm production (Issa, 2021). The root crop farmers were experienced in agricultural practices with 22 years of farming experience. Farming experience enhances farmers' skills and helps in overcoming inherent farm production challenges (Ladapo et al., 2019). The percentage of credit access was 21.0, indicating that just a small portion of root crop farmers used agricultural loans. This could be due to collateral demands of financial institutions. Membership of farmer group indicated a percentage of 56.6; implying that about 57 % of the root crop farmers belongs to farmer groups. Cooperative association support crop farmers and provides farm incen-

Table 1: Socio-demographic features of root crop producers

Variable	Mean / %	Std. Deviation
Education (schooled years)	12.01	8.01
Age (no. of years)	50.6	0.82
Household size (people living together)	6.02	0.08
Gender (% of female)	76.9	12.4
Marital status (percentage married)	85.1	11.2
Extension contact (no. of extension visits)	3.6	9.50
Years of experience	22.3	12.8
Credit access (% of access)	21.0	7.01
Membership of farmer groups (% of members)	56.6	8.10
Farm size (hectare cultivated)	3.70	0.49
Income from off farm activity	72,345.8	4.06

Source: Field survey data, 2022

Table 2: Land productivity of major root crops cultivated in the State

State	Mean output of cassava	Mean inputs used	Mean output of yam	Mean inputs used	Mean output of sweet potatoes	Mean inputs used	Total mean outputs	Total mean inputs	TFP	PFP
Abia	91673.27	42178.02	88363.46	37732.83	69935.36	19832.52	249972.09	99743.37	2.51	67.80
Ebonyi	87055.35	38982.49	93452.93	45832.04	59546.56	18834.50	240054.84	103649.03	2.32	58.04
Imo	94936.53	33982.83	90336.63	31834.73	62634.56	20935.45	247907.72	86753.01	2.86	51.41
Total	273665.15	115143.34	272153.02	115399.60	192116.48	59602.47	737934.65	290145.41	7.69	177.25

Field survey data, 2022. TFP = Total factor productivity; PFP = Partial factor productivity

tives. Farm size cultivated was 3.70 hectares; this is synonymous with rural lands and implies small-scale land cultivation which affects land productivity. Income from off farm activity gave ₦72, 345.8; this could support the root crop farmers in their cultivation in terms of inputs accessibility.

3.2 PRODUCTIVITY OF LAND OF PRINCIPAL ROOT CROPS CULTIVATED ACROSS STATES

The land productivity of principal root crops cropped in the state is presented in Table 2. The land productivity of the farmers was isolated into mean outputs, mean inputs and total factor and partial factor productivity across the states. The result shows that Imo state had an estimated mean cassava output, (94936.53 kg) which is higher than that of Abia and Ebonyi state. This connotes a 104 % and 109 % increase above Abia and Ebonyi states respectively. This could imply optimal efficiency in cassava production in the state (Esiobu, 2019). The mean inputs used in cassava production across the states shows that Abia state seemingly had about 108 percentage increases in mean inputs over Ebonyi and 124 percentage increases over Imo state. This could imply high usage of inputs in cassava production in Abia state relative to Ebonyi and Imo state. The low input usage from other states could result in high costs of inputs in southeast states (Okorie et al., 2021). Again, mean outputs in yam cultivation across the states shows that Ebonyi state had an estimated value of 93452.93 kg, which implies about 106 percentage increases in mean output over Abia and 1.03 percent increase over Imo. This could result from efficient utilization of inputs in Ebonyi state as depicted in the mean inputs used, which was relatively higher compared to Abia and Imo state. (See Table 2). Consequently, Abia state recorded a higher estimate of 69935.36 kg in sweet potato production, implying about 1.2 percentage increases over Ebonyi state and a whopping 112 percent increase over Imo state. The mean inputs in sweet potato production indicate that Ebonyi state had the least input relative to other two states. Furthermore, TFP estimate shows higher value in Imo state relative to Abia and Ebonyi state. This implies that Imo state had the highest TFP compared to other two states. More so, the PFP estimates across the states indicate that Abia state had the highest PFP in comparison with other two states. It is important to note that the differences in estimates of land productivity across the three states may be related to both internal and external production factors (Vibeke et al., 2020; Wang et al., 2021). However, the principal root crops produced total TFP and PFP values of 7.69 and 177.25indicating a high land productivity of the crops across the three states.Source:

3.3 TEST OF SUBSTANTIAL DIFFERENCES IN LAND PRODUCTIVITY OF THREE MAIN ROOT CROPS GROWN IN THE STATES USING ANALYSIS OF VARIANCE

In Table 3, the test of considerable variation in land productivity of key root crops grown in the states is shown. The outcome demonstrates that the ANOVA

Table 3: Test of substantial differences in land productivity of main root crops grown in the states using analysis of variance

Sources of variation	Sum of squares	Degrees of freedom	Mean squares	Fcal	Ftab
Between groups	899330712	2	61760210	4.09	2.17
Within groups	659608143	355	54075137		
Total		357			

Source: Field survey data, 2022 Fcal; Significant at 1 % level model generated an F-cal. value of 4.09, which was higher than the F-tab. value of 2.17 and significant at the 1 % level. This suggests that there are large regional variations in the productivity of the main root crops grown in the three states. One could add that there are statistical differences and inequalities in the land productivity of the main root crops grown in the states. Table 2 above further supported the conclusion.

3.4 DETERMINANTS OF LAND PRODUCTIVITY OF ROOT CROP PRODUCERS

Table 4 discussed the factors affecting the land productivity of the root crop growers. The four functional forms of the multiple regression model were fitted to produce the lead function. Judging from the results the Double-Log function's have high F-value, high number of significant variables, and high coefficient of multiple determinations (R^2), and was chosen as the lead model. The variance in the dependent variable was explained by the analyzed independent variables, while the model's fitness was indicated by the F-value. Positive and significant results for education imply that land productivity among root crop farmers rises with higher educational

Table 4: Determinants of land productivity of root crop producers

Variable	Linear	Semi-log	Double-log	Exponential
Constant	403.172 (0.514)	0.3315 (4.502)***	2.6608 (4.071)***	15.9022 (3.902)***
Education (X_1)	8.8951 (0.134)	3.1043 (2.701)**	8809.61 (4.117)***	0.7758 (1.305)
Age (X_2)	-902.433 (-4.302)***	-12.0409 (-1.401)	-948.118 (-1.050)	-10.6155 (-4.402)***
Access to farm inputs (X_3)	45.9040 (2.103)**	1.5566 (0.711)	4405.15 (3.100)***	7.1943 (2.007)**
Soil & land improvement practices (X_4)	4112.90 (0.219)	13.1950 (3.010)***	7.2478 (4.000)***	0.9095 (1.021)
Farm size (X_5)	880.051 (3.311)***	4.0121 (1.401)	2854.19 (1.591)*	21.7701 (3.712)***
Farming experience (X_6)	5667.89 (0.942)	6892.01 (1.589)*	0.5467 (4.735)***	8921.34 (0.951)
Access to credit (X_7)	7.9642 (0.735)	6389.03 (0.839)	19.6371 (2.834)**	0.7488 (2.835)**
Labour supply (X_8)	0.7448 (0.563)	0.7346 (0.982)	18.8456 (0.747)	0.9454 (0.943)
Land tenure patterns (X_9)	0.5467 (0.734)	0.6488 (2.834)**	9.0001 (0.456)	0.7457 (0.745)
Extension contact (X_{10})	1789.603 (4.913)***	0.0203 (1.306)	18901.7 (2.661)**	0.7735 (1.041)
R2	0.7814	0.7751	0.8991	0.8182
F- ratio	17.109***	12.001***	21.642***	8.482***

Source: Field survey data, 2022. Significant at ***1 %, **5% and *10 %

attainment. Education enhances knowledge acquisition of the farmers and helps them adopt soil management practices targeted at increasing land productivity (Ukeje et al., 2022). Access to farm inputs was significant and positive; indicating that access to farm inputs increases the productivity of the land. Accessibility of farm inputs such as improved seedlings, fertilizers, pesticides, etc. improves crop yield and aid the productivity of the land (Ullah et al., 2020). Soil and land improvement practices became positively significant; this implies that a 1 % increase in soil and land improvement practices will cause a corresponding increase in land productivity by 725 %. Soil management and land improvement practices such as erosion control, weeding, crop rotation, mulching, organic manure, irrigation and good drainage systems enhance crop yield and thus the productivity of farmlands (Gizaw et al., 2021). The impact of farm size was significant and favorable, which suggests that any increment in farm size will result in a comparable rise in farmers' land productivity. Large hectares of land aid large-scale cultivation and allow the practice of sustainable soil management and improvement practices, which aid productivity of the land (Dereje et al., 2021). Farming experience was substantial and favorable. This suggests that a 1 % improvement in the root crop farmers' farming experience will result in a commensurate increase in land productivity of 54.5 %. Farming experience helps farmers in evaluating, understanding and adoption of land management measures targeted at improving crop yield and land productivity of the farmers. Access to credit was significant and positive; this indicates that increase in credit access increases the productivity of the land. Credit is a veritable tool in farm production in that it enables farmers to acquire essential and enhanced agricultural inputs like improved seeds, agro-fertilizer, agro-pesticides, labor, and lease land rent (Amanullah et al., 2020), this improves crop yield and land productivity at large. However, requirement and demand for collaterals in most cases limits credit accessibility of the farmers. Positive and meaningful extension contact suggests that an increase in the number of extension visits to farmers will result in a proportionate rise in the farmers' land productivity. Extension contacts impact positively on the crop farmers in terms of on-hand practical knowledge and encourage adoption of land management and soil sustainability techniques (Osuji et al., 2023). These techniques improve crop yield, income and productivity of the land.

3.5 IMPACT OF PESTICIDE APPLICATION ON LAND PRODUCTIVITY OF ROOT CROP GROWERS

Table 5 shows how pesticide use and application affect root crop growers' land productivity. The table shows that the estimates using propensity score matching (PSM) and inverse propensity score weighing (IPSW) were 62.5501 and 42.0177. These estimation falls short of identifying the true incidental impact of pesticide use and application on farmers' land productivity. As a result, they are deemed insufficient to paint a complete picture of the impact of pesticides on land productivity. This suggests that non-compliance may be present or at the very least taken into account when dealing with impact of pesticide use and application on root crops. The lack of compliance in this case indicates that some farmers will never follow the instruction for applying and use of pesticides as indicated in the instruction manual. Furthermore, the lack of compliance effectively explains the hidden bias in pesticide application and usage problems, which can only be eradicated through an impact parameter known as the local average treatment effect (LATE) (Choi, 2021). The LATE (WALD) and LATE (IV) estimation, which were highly significant, produced results of 7.2707 and 8.8028 respectively. In the event of non-compliance, LATE assessed either way indicates the genuine causal impact of pesticide use and application on farmers' land outputs (Choi, 2021). This suggests that the use and application

Table 5: Impact of pesticide application on land productivity of root crop growers

PARAMETER	LATE (WALD)	LATE (IV)	ATE (IPSW)	PSM
ATE	7.2707	8.8028	42.0177	62.5501
	(45.02)***	(26.40)***	(19.06)***	
ATE 1			7.9094	
			(4.17)***	
ATE 0			-3.0250	
			(-2.75)**	

Source: Field survey data, 2021. Significant at ***1 %, **5 % and *10 %

of pesticides in accordance with the stipulated recommendations enhanced the productivity of the land by 72.7 % and 88.0 %, respectively. This further implies that the higher the use and application of pesticides as recommended, the higher the land productivity of the growers of root crops, meaning that a unit increase in the use and application of recommended pesticides would result in a unit increase in yield and land productivity of the growers of root crops (Prihandiani et al., 2021). Again, the ATE 1, estimate was positive and significant, implying that the use and application of pesticides according to stated usage and specification yielded a positive increase of 79.0 % in land productivity. While the ATE 0 was negative though significant, implying the wrong use and application of pesticides on planted root crops. This further indicates that some of the farmers did not adhere strictly to pesticide manual instruction as recommended and this caused a decrease in land productivity of about 30.2 % (Anthony et al., 2021). The adherence and non-adherence to pesticides manual instruction could be associated with the farmers' literacy levels, exposures and other related socio-economic variants. This is to say that pesticides is targeted at controlling root crop insects, diseases and pest attacks in a bid to improve crop output and land productivity; however its usage and application most times could be detrimental as it could either increase or mar yield and land productivity per cropping season.

3.6 PERCEIVED CONSTRAINTS TO LAND PRODUCTIVITY OF ROOT CROP GROWERS

Table 6 discussed the root crop growers' perceived barriers to land productivity. The result shows that erosion problems constituted about 99.7 %. Erosion destroys arable farm lands causing land denudation and disintegration which seriously affects crop yield and productivity of the land (Joseph et al., 2020). Poor drainage menace was indicated by 86.3 % of the farmers. Poor drainage causes flooding and water percolation on farmlands suffocating crop yield and in turn reducing land productivity. About 84.4 % of the farmers attested to a high cost and a limited quantity of workers, this severely impedes land productivity owing to the increasing labour wages which is in short supply (Umar et al., 2021). Ignorance on soil/land improvement practices was observed by 77.9 % of the growers suggesting no knowledge on soil and land improvement practices. This poses serious constraints to land productivity. Limited farming lands were reported by 81.3 % of the farmers. No doubt inadequate and/ or shortage of farm land are great disadvantage to land productivity. Large farmlands support large scale production and vice versa (Dokic et al., 2022). Poor extension access and services was attested by 80.7 % of the farmers. Extension service and access increases land productivity by exposing farmers to new ideas and practices, whereas lack of access or restricted access limits land productivity (FAO, 2021). About 93.0 % of the farmers indicated land fragmentation. Land fragmentation refers to small land holdings or fragment which may not be sustainable for improved crop yield and land productivity. Climate change issues were reported by 99.4 % of the crop growers. Nowadays, issue of climate change has altered cropping calendars and cropping systems causing havoc to

Table 6: Perceived constraints to land productivity of root crop farmers

Perceived Constraints	*Frequency	Percentage
Erosion problems	357	99.7
Poor drainage menace	309	86.3
High cost and limited supply of labor	302	84.4
Ignorance on soil/land improvement practices	279	77.9
Limited farming lands	291	81.3
Poor extension access and services	289	80.7
Land fragmentation	333	93.0
Climate change issues	356	99.4
Inadequate capital	350	97.8
Low access to credit facilities	299	83.5
Pests and disease attacks	347	96.9
High cost of input materials	355	99.1

Source: Field survey data, 2022.

crop production and productivity of the land (Osuji et al., 2023). Issues of high temperatures, unpredictable rainfall patterns, high humidity, etc. worsen land productivity at large. Inadequate capital was indicated by 97.8 % of the farmers. Capital is a major incentive and necessary tool for crop production, because it is essentially needed to purchase farm inputs. Its inadequacy demoralizes farmers and impedes their cultivation plans thereby affecting productivity of the land (Anthony, 2021). Pests and disease attacks was reported by 96.9 % of the farmers. The attack planted root crops reducing their yield and land productivity. High cost of input materials was attested by 99.1 % of crop growers. Inability of the growers to access farm inputs could limit the productivity of the land.

4 CONCLUSION AND RECOMMENDATION

Land productivity of root crop farmers has been a source of concern due to variant internal and external factors associated with crop production. Findings show that Imo state had an estimated mean cassava output, 94936.53 kg, which is higher than that of Abia and Ebonyi states. Mean outputs in yam cultivation across the states shows that Ebonyi state produced a high value of 93452.93 kg, which is higher than the values obtained in Abia and Imo states. Again, Abia state produced a higher, value 69935.36 kg in sweet potato production over Ebonyi and Imo states. Furthermore, TFP estimate shows higher value in Imo state relative to Abia and Ebonyi state. More so, the PFP estimates across the states indicate that Abia state had the highest PFP in comparison with other two states. Education, access to farm inputs, soil and land improvement practices, size of farms, and extension contacts were important determinants of land productivity across the states. LATE estimates show that use of pesticides increased land productivity by 72.7 % and 88.0 %. Inadequate capital, pests and disease attacks, climate change issues, and erosion problems were perceived as land productivity constraints. Farmers were recommended to embrace land and soil improved practices and adhere strictly to recommended pesticide use and application for increased crop yield and land productivity.

5 REFERENCES

Alemu, G.T., Ayele, Z.B., & Berhanu, A.A. (2017). Effects of land fragmentation on productivity in Northwestern Ethopia. *Advances in Agriculture*, 4509605, 1-9. https://doi.org/10.1155/201//4509605

Al-Wabel, M.I., El-Saeid, M.H., El-Naggar, A.H., Alromian, F., Osman, K., Elnazi, K., & Sallam, A.S. (2016). Spatial distribution of pesticide residues in the groundwater of a condensed agricultural area. *Arab Journal of Geosciences,* 9, 1–10. doi: 10.1007/s12517-015-2122-y.

Amanullah, G.R.L., Siraj, A.C., Habibullah, M., Mansoor, A.K., Jing, W., & Naseer, A.C. (2020). Credit constraints and rural farmers' welfare in an agrarian economy. *Heliyon*, *6*(10), e05252.

Anthony, L., Alabi, O.O., Ebukiba, E.S. & Gamba, V. (2021). Factors influencing output of rice produced and choice of marketing outlets among smallholder farming households in Abuja, Nigeria. *Sarhad Journal of Agriculture*, *37*(1), 262-277.

Ayi, N. A. (2022). Farmers field school extension approach: A knowledge booster in Calabar agricultural zone, Cross River State, Nigeria. *Journal of Agricultural Extension and Rural Development*, *14*(2), 52-60.

Choi, B.Y. (2021). Instrumental variable estimation of truncated local average treatment effects. *PLoS One*, *16*(4), e0249642.

Dereje, K..,Girmay, T., & Bezabih, E. (2021). Impact of land acquisition for large-scale agricultural investments on income and asset possession of displaced households in Ethiopia. *Heliyon*, *7*(12), e08557.

Đokić, D., Matkovski, B., Jeremic, M., and Đurić, I. (2022). Land productivity and agri-environmental indicators: A case study of Western Balkans. *Land*, *11*(12), 2216. https://doi.org/10.3390/land11122216.

Esiobu, N.S. (2019). Understanding the allocative efficiency of cassava farms in Imo State, Nigeria. *Journal of Economics and Sustainable Development*, *10*(19), 82-88.

Fanelli, R.M. (2022). Bridging the gender gap in the agricultural sector: Evidence from European Union Countries. *Social Sciences*, *11*(3), 105-111.

Food and Agriculture Organisation (2020a). *Agriculture in Nigeria*. Food and Agriculture Organisation of the United Nations, Rome Italy.

Food and Agriculture Organisation (2020b). *Tracking progress on food and agriculture-related SDG*. Food and Agriculture Organisation of the United Nations, Rome Italy.

Food and Agriculture Organisation (2021). *Nigeria agriculture at a glance*. Food and Agriculture Organisation of the United Nations, Rome Italy.

Fuente, B., Weynants, M., Bertzky, B., Delli, G., Mandrici, A., & Garcia, B.E. (2020). Land productivity dynamics in and around protected areas; globally from 1999 to 2013. *PLoS ONE*, *15*(8), e0224958.

Gizaw, D., Lulseged, T., Wuletawu, A., Tilahun, A., & Anthony, W. (2021). Effects of land management practices and land cover types on soil loss and crop productivity in Ethiopia: A review. *International Soil and Water Conservation Research*, *9*(4), 544-554.

Hemathilake, D.M.K.S, & Gunathilake, D.M.C.C. (2022). Agricultural productivity and food supply to meet increased demands. *Future Foods*, 539-553. https://doi.org/10.1016/B978-0-323-91001-9.00016-5.

Issa, F.O. (2021). Agricultural extension services amidst covid-19 pandemic in Nigeria: Policy options. *Proceedings of the*

Annual Conference of the Agricultural Extension Society of Nigeria. 26-29, April 2021, 99-107.

Joseph, A.D., Edward, M., Joseph, M., Vernon, G., Isaac, K.A., & Samuel, K.O. (2020). Farmers' perception on drought constraints and mitigation strategies in cassava cultivation in northern Ghana: Implications for cassava breeding. *Sustainable Futures*, *2*, 100041.

Kurdyś-Kujawska, A., Sompolska-Rzechuła, A., Pawłowska-Tyszko, J., & Soliwoda, M. (2021). Crop insurance, land productivity and the environment: A way forward to a better understanding. *Agriculture*, *11*, 1108.

Ladapo, H. L., Aminu, F.O., Selesi, O. S. & Adelokun, I. A. (2019). Determinants of the effects of pesticide use on the health of rice farmers in Kwara state, Nigeria. *Journal of Research in Forestry, Wildlife and Environment*. *12*(3), 2141–1778.

Lozowicka, B., Abzeitova, E., Sagitov, A., Kaczyński, P., Toleubayev, K., & Li, A. (2015). Studies of pesticide residues in tomatoes and cucumbers from Kazakhstan and the associated health risks. *Environment Monitoring Assessement, 187*, 609. doi: 10.1007/s10661-015-4818-6.

Muhammad, A.Y., Hussein, S., Baloua, N., Chris, O. O., & Gideon, D.A. (2022). Sorghum production in Nigeria: opportunities, constraints, and recommendations. *Acta Agriculturae Scandinavica*, *72*(1), 660-672.

Montfort, F., Bégué, A., Leroux,L., Blanc, L., Gond, V., Cambule, A.H., Remane,I.A.D., & Grinand, C. (2020). From land productivity trends to land degradation assessment in Mozambique: Effects of climate, human activities and stakeholder definitions. *Land Degradation & Development*, *32*(1), 49-65. https://doi.org/10.1002/ldr.3704.

NPC, (2022). *Data reports of national population commission*, Abuja, Nigeria

Okorie, O.J., Okon, U.E., & Enete, A. (2021). Profit efficiency analysis of cassava production in Enugu State, Nigeria. *Journal for the Advancement of Developing Economies*, *10*(1), 37-45.

Osuji, E.E., Igberi, C.O., & Ehirim, N.C. (2023). Climate change impacts and adaptation strategies of cassava farmers in Ebonyi state, Nigeria. *Journal of Agricultural Extension*, *27*(1), 35-48.

Prihandiani, A., Bella, D.R., Chairani, N.R., Winarto, Y., & Fox, J. (2021). The tsunami of pesticide use for rice production on Java and its consequences. *The Asia Pacific Journal of Anthropology*, *22*(4), 276-297.

Tudi, M., Daniel, R.H., Wang, L., Lyu, J., Sadler, R., Connell, D., Chu, C., & Phung, D.T. (2021). Agriculture development, pesticide application and its impact on the environment. *International Journal of Environmental Resource and Public Health*, *18*(3), 1112. doi: 10.3390/ijerph18031112.

Ukeje, B.A, Njoku, M.E. & Onyemma, J.O. (2022). Market orientation strategies for root and tuber crop production among smallholder farmers in Southeast, Nigeria. *Nigerian Agricultural Journal*, *53*(1), 303-308.

Ullah, A., Mahmood, N., Zeb, A., & Kächele, H. (2020). Factors determining farmers' access to and sources of credit: Evidence from the Rain-Fed Zone of Pakistan. *Agriculture, 10,* 586. https://doi.org/10.3390/agriculture10120586.

Umar, M.B., Yarima, M.M., Yusuf, O.E., Adetayo, A. & Salihu, M. (2021). Tractor use and agricultural productivity in Nigeria: prospects and challenges. *Journal of Tropical Agriculture, Food, Environment and Extension*, *20*(2), 1–8.

Vibeke, B., Henning, B., Andre, F., & Van, R. (2020). Why agricultural production in sub-Saharan Africa remains low compared to the rest of the world – a historical perspective. *International Journal of Water Resources Development*, *36*(1), 20-27.

Wang, H., Zhong, S., Guo, J. & Fu, Y. (2021). Factors affecting green agricultural production financing behavior in Heilongjiang family farms: A structural equation modeling approach. *Frontier Psychology*, 12, 692140.

World Bank, (2022). *Nigeria agriculture sector development policy operation*. The World Bank Group, USA.

Yadav, I.C., Devi, N.L., Syed, J.H., Cheng, Z., Li, J., Zhang, G., & Jones, K.C. (2015). Current status of persistent organic pesticides residues in air, water, and soil, and their possible effect on neighboring countries: A comprehensive review of India. *Science of the Total Environment*, *511*, 123–137. doi: 10.1016/j.scitotenv.2014.12.041.