



**DOES AGRICULTURAL TRAINING TRANSLATE TO ECONOMIC GAINS? EVIDENCE FROM INTEGRATED SOIL FERTILITY MANAGEMENT (ISFM) INTERVENTION AMONG SMALLHOLDER MAIZE FARMERS IN BENUE STATE, NIGERIA**

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**ABSTRACT**

This study was designed to evaluate the effectiveness of ISFM training in improving maize productivity and income of smallholder farmers. Specifically, the study sought to evaluate changes in ISFM technology adoption before and after the training intervention; and compare productivity and income between farmers in the treatment and control groups. The study employed randomized controlled trials (RCT) approach to randomly assigned 39 of the farmers to the treatment group that received structured ISFM training and the remaining 39 farmers to the control group that did not receive the training. Data were collected using structured questionnaire and analyzed using descriptive statistics, double difference estimator, independent sample-t-test, and paired sample t-test. The results revealed there were no statistically significant differences between the treatment and control groups across all observed socio-economic variables. Inorganic fertilizer dominated the ISFM technologies utilized by farmers in the treatment group before and after the training program. The independent sample t-test result on changes in ISFM technology adopted by the farmers in the treatment group before and after the training program revealed 37.3% increase in the number of ISFM technologies used by the farmers after the training. The results of the estimated average treatment effect and t-test analysis of variables used to determine the effects of ISFM training revealed that farmers trained in ISFM technologies achieved productivity that was 788.72kg/ha higher and significantly different at 1% ( $t = 3.517, P < 0.01$ ) compared to their untrained counterparts. The result also revealed that farmers trained in ISFM technologies earned income that was ₦239715.64/ha higher and significantly different at 5% ( $t = 2.180, P < 0.05$ ) compared to their untrained counterparts. The study concludes that training on ISFM technologies is a viable and impactful intervention for improving the productivity and income of smallholder maize farmers in Benue State. It was recommended that ISFM training should be expanded to reach more smallholder maize farmers across the States, and that practical ISFM training should be promoted through demonstration farms to reinforce training outcomes.

**Keywords:** ISFM, Training, Maize, Productivity, Farm, Income

**INTRODUCTION**

The International Institute of Tropical Agriculture (IITA) in 2017 put the value of Nigeria's maize industry at \$6 billion (₦2.5 trillion) annually. In recent years however, Nigeria has witnessed its maize output decline. According to Okojie (2021), Nigeria is currently producing about 10.5 million metric tons per annum with a domestic demand of 15million metric tons, leaving a supply-demand gap of 4.5 million tons per annum. In an effort to bridge the supply short-fall, the country has resorted to importation which has also affected her foreign exchange. According to a 2021 report by PricewaterhouseCoopers, maize import into Nigeria doubled from 0.5 million metric tons to about 1 million metric tons between October 2019 and October 2020. The report by PricewaterhouseCoopers (2021) also revealed that in the third-quarter of 2020, Nigeria imported about ₦26.6billion worth of maize from Argentina, China, the United States, and Brazil. This short-fall in supply has continued to persist. This has caused prices of maize to increase, posing a major threat to poultry, food and beverage industries and the country's food security. Hence, there is urgent need to address the decline in maize output in the country which has continued to threaten the poultry, food, and beverage industries as well as the food security and foreign exchange of the country.

Studies such as Alabuja *et al.* (2022), and Makama *et al.* (2022), targeted at guiding policies that will boost maize production in the country, focus mainly on resource use efficiency in maize



production, and how socio-economic variables influence output of maize farmers. Presently, no study has adopted randomized controlled trial approach to examine the effectiveness of training on ISFM technologies on the productivity and income of smallholder maize farmers in the country. Thus, this study was designed to bridge this research gap. The broad objective of the study was to evaluate the impact of integrated soil fertility management technologies training on the productivity and income of smallholder maize farmers in Benue State, Nigeria using randomized controlled trials (RCTs) approach. Specifically, the study sought to:

- i. evaluate changes in ISFM technology adoption before and after the training intervention; and
- ii. compare productivity and income between farmers in the treatment and control groups.

Rigorous empirical evidence is essential for informing evidence-based policy and practice in agricultural development. By applying a Randomized Controlled Trial (RCT) approach, this study generates robust evidence on the causal impact of ISFM technologies training on maize farmers' productivity and income. Such evidence is invaluable for policymakers, extension agencies, and development practitioners seeking to design and implement effective interventions to support smallholder farmers.

## **METHODOLOGY**

### **Study Area**

The study was conducted in Benue State, Nigeria. Benue State is located in the North Central region of Nigeria. The State lies between latitudes 6°25'N and 8°8'N and longitudes 7°47'E and 10°E' and has a total land-area of about 33, 955 square kilometers (Okeke *et al.*, 2024) with a projected population of 6,573,600 people at 2.3% annual increase (Nathan *et al.*, 2025). The State has population density of approximately 200 persons per square kilometer (Brinkhoff, 2022). Benue State is situated in the Southern Guinea Savannah agro-ecological zone of Nigeria, an area characterized by extreme grassland interspersed with scattered trees and shrubs (Adedibu *et al.*, 2022; Agro-Climatic Resilience in Semi-Arid Landscapes [ACReSAL], 2026). The vegetation type provides fertile soils suitable for the cultivation of a wide range of crops, particularly cereals such as maize. The State is endowed with arable land and relatively low incidence of dense forest cover, making large-scale crop production feasible. The climate of Benue State is tropical, with two distinct seasons: the rainy season, which typically extends from April to October, and the dry season, which lasts from November to March (Idoko *et al.*, 2023; Damsa *et al.*, 2025). Annual rainfall ranges from approximately 1200mm to 1500mm, while mean annual temperatures vary between 21°C and 35°C (Idoko *et al.*, 2023). Relative humidity in the State is generally high during the rainy season and lower during the dry season. These climatic conditions are highly conducive to maize production. In addition, the combination of fertile soils, favourable rainfall distribution, and suitable temperature regimes has made Benue State one of Nigeria's major maize-producing areas.

### **Research Design**

The study employed randomized controlled trial (RCT) which was carried out over a period of three months. RCT is widely recognized as a rigorous methodological approach for evaluating the impact of interventions in agricultural development. According to Deaton and Cartwright (2018), RCT involves randomly assigning participants to treatment and control groups to evaluate the causal effect of an intervention. Duflo (2020) highlight the strengths of RCTs in establishing causal relationships between interventions and outcomes, thereby providing robust evidence for policymaking and program implementation.

This approach was used in this study because of its strengths to establish causal relationships between training on ISFM technologies, productivity, and income of smallholder maize farmers. In applying this approach in this study, the participating maize farmers were randomly assigned to either a treatment group (received the training on ISFM technologies) or a control group (did not receive training on ISFM technologies). The participating maize farmers were not told which group they would fall into. The purpose of the randomization was to minimize selection bias and ensure that the two groups were comparable in characteristics.



Before randomization was done, baseline data were collected from the participating maize farmers. These data included their socio-economic characteristics, current agricultural practices, productivity and income levels, ISFM technologies awareness and adoption. The RCT procedure together with the training lasted for three months.

### **Participants**

The participants were smallholder maize farmers in Benue State. The exclusion criteria were: maize farmers with farm size greater than or equal to six hectares, and undergoing any form of productivity enhancing training were excluded from the study's sample. The farmers were formally invited to participate in the training. The participants were invited through radio advertorial concerning the training program. Also, the services of Divisional Agricultural Officers (DAOs) working at the Benue State Ministry of Agriculture and Rural Development were employed in inviting the farmers for the training. Structured questionnaire was used in collecting baseline data from the participating farmers.

### **Sample Size and Sampling Technique**

The target population for this study were smallholder maize farmers in Benue State. The study made use of a sample size of 78 participants consisting of 39 farmers for the intervention group and 39 farmers for the control group. Multi-stage sampling technique was used to select the study participants. In the first stage, Guma and Gwer-West Local Government Areas (LGAs) of Benue State were purposively selected due to their high level of maize production. In the second stage, the services of Divisional Agricultural Officers from the Benue State Ministry of Agriculture and Rural Development were utilized to mobilize maize farmers within the selected LGAs. Farmers willing to participate in the Integrated Soil Fertility Management (ISFM) technologies training program were invited to indicate their interest through a structured participation interest form design for the study. A total of 82 maize farmers expressed interest and submitted completed forms. Thereafter, an eligibility screening exercise was conducted based on farm size and whether the farmer was undergoing another productivity enhancing program. Farmers cultivating more than six hectares of maize farmland were excluded from the study in order to maintain homogeneity among smallholder farmers and ensure consistency with the study target population.

Following the screening exercise, 78 eligible smallholder maize farmers remained and constituted the study sample. The eligible farmers were randomly assigned into two groups using simple random assignment technique. Thirty-nine (39) farmers were assigned to the treatment group that received ISFM technologies training, while the remaining thirty-nine (39) farmers were assigned to the control group that did not receive the training. The random assignment of participants into treatment and control groups was done to minimize selection bias and ensure comparability between the groups for impact evaluation.

### **Randomization**

After baseline data collection, participants were randomly assigned to the intervention group or control group. The treatment group received training on ISFM technologies while the control group did not receive the training

### **Study Procedure**

The study lasted for 12 months. After randomization, meetings were held with specialists in ISFM technologies to describe the specific program to be carried out for the treatment group and to set the dates and sessions and evaluation procedures.

### **Intervention Design**

Following the baseline data collection and randomization, the intervention/treatment group started receiving training lessons on ISFM technologies two days every month. The intervention group received 18 sessions of two hours training together with 60 hours practical session over three months from specialists. The control group did not receive any training on ISFM practices. This training and practical sessions were conducted by subject matter specialist from Joseph Sarwuan Tarka University, Makurdi and Agricultural Extension Units of the Benue State Ministry of Agriculture and Rural Development.



**Data Collection**

Date were collected at baseline (pre-intervention) and endline (post-intervention) stages. Trained enumerators were used for data collection. Structured questionnaire was used for data collection. Baseline data were collected from both treatment and control groups prior to the intervention. Primary data were collected on the farmers' socio-economic characteristics, farm characteristic, current farming practices, input use, productivity, household and farm income details. Follow-up data were collected at regular intervals (using cost-route method) after the intervention to evaluate changes in farmers' knowledge, attitudes, and practices related to soil management practices, maize productivity, and income levels.

**Data Analysis**

Descriptive statistics such as frequency distribution table, mean, and percentage were used to describe baseline characteristics of intervention and control group to assure comparability between groups, while independent sample t-test was used to account for any baseline difference between the treatment and control groups. Changes in the use of ISFM technologies before and after the training was evaluated using paired sample t-test (Objective I); and Double Difference (DD) estimator or Difference-in-Difference (DID) analysis together with independent sample t-test were used to compare the productivity and income of the treatment and control groups.

**Model Specification**

The Double Difference (DD) estimator was specified as follows:

$$D = (P_2 - P_0) - (P_3 - P_1) \quad \dots (1)$$

Where,

$P_2$  = productivity (kg/ha) of treatment group after the training on Integrated Soil Fertility Management (ISFM)

$P_0$  = productivity (kg/ha) of treatment group before the training on ISFM

$P_3$  = productivity (kg/ha) of control group after the training on ISFM

$P_1$  = productivity (kg/ha) of control group before the training on ISFM

$$D = (Y_2 - Y_0) - (Y_3 - Y_1) \quad \dots (2)$$

Where,

$Y_2$  = income (₦/ha) of treatment group after the training on ISFM

$Y_0$  = income (₦/ha) of treatment group before the training on ISFM

$Y_3$  = income (₦/ha) of control group after the training on ISFM

$Y_1$  = income (₦/ha) of control group before the training on ISFM

**RESULTS AND DISCUSSION**

**Comparison of the Socio-economic Characteristics of Farmers in the Treatment and Control Groups**

The baseline analysis of the socio-economic characteristics of treatment and control groups is presented in Table 1. The result of the analysis in Table 1 showed that there were no statistically significant differences between the treatment and control groups across all observed socio-economic variables ( $P > 0.05$ ), thus confirming the effectiveness of the randomization process. According to Abu-Alsoud *et al.* (2025), a lack of significant differences signifies effective randomization.

**Table 1:** Baseline Socio-economic Characteristics of Treatment and Control Groups

Socio-economic characteristics	Mean of treatment	Mean of control	t-value	p-value
Household size (person)	8.95	8.38	0.902	0.370 <sup>NS</sup>
Level of formal education (years)	12.13	12.67	-0.648	0.519 <sup>NS</sup>
Age (years)	38.18	37.03	0.604	0.548 <sup>NS</sup>
Farming experience (years)	9.59	9.62	-0.022	0.982 <sup>NS</sup>
Farm size (ha)	3.62	4.18	-1.481	0.143 <sup>NS</sup>
Annual farm income (₦)	857,948.72	851,454.10	0.030	0.976 <sup>NS</sup>

**Source:** Field survey data, 2025

NS = not significant



This also implies that the two groups were having similar socioeconomic characteristics before the training intervention, suggesting that any post-intervention differences in the outcomes of interest can reasonably be attributed to the ISFM training program rather than on pre-existing disparities. This result is in line with standard RCT practice which requires balance in observable covariates to ensure unbiased impact estimates (Ivers *et al.*, 2012; Babaei *et al.*, 2023). Also, this result is similar to previous impact evaluation studies on farmers such as Olowogbon *et al.* (2019) and Dhehibi *et al.* (2022) in which the treatment and control groups were statistically comparable at baseline across key socio-economic variables.

**ISFM Technology Adopted by Trained Farmers before and after the Training**

The ISFM technologies utilized by the treatment group before the training programme are presented in Table 2. Analysis of Table 2 showed that inorganic fertilizer dominates the ISFM technologies utilized as 87.2% of the respondents reported to have applied this technology. This is followed by crop rotation (61.5%), organic manure (43.6%), mulching (17.9%), legume intercropping (12.8%), and cover cropping (7.7%).

**Table 2:** Distribution of Respondents Based on ISFM Technology Adopted by Treatment Group at Baseline

S/N	ISFM Technology	Frequency	Percentage*	Rank
1	Inorganic fertilizer	34	87.2	1 <sup>st</sup>
2	Crop rotation	24	61.5	2 <sup>nd</sup>
3	Organic manure	17	43.6	3 <sup>rd</sup>
4	Mulching	7	17.9	4 <sup>th</sup>
5	Legume intercropping	5	12.8	5 <sup>th</sup>
6	Cover cropping	3	7.7	6 <sup>th</sup>

**Source:** Field survey data, 2025 \* Multiple response existed, hence percentage >100

The ISFM technologies utilized by the treatment group after the training intervention are presented in Table 3. The result in Table 3 revealed that inorganic fertilizer accounted for the most utilized ISFM technologies with 89.7% of the respondents attributed to have employed it. This is followed by organic manure (84.6%), crop rotation (66.7%), mulching (59.0%), legume intercropping (53.8%), cover cropping (38.5%), green manure (25.6%), zero/minimum tillage (15.4%), and agroforestry (15.4%).

**Table 3:** Distribution of Respondents Based on ISFM Technology Adopted by Treatment Group at Endline

S/N	ISFM Technology	Frequency	Percentage*	Rank
1	Inorganic fertilizer	35	89.7	1 <sup>st</sup>
2	Organic manure	33	84.6	2 <sup>nd</sup>
3	Crop rotation	26	66.7	3 <sup>rd</sup>
4	Mulching	23	59.0	4 <sup>th</sup>
5	Legume intercropping	21	53.8	5 <sup>th</sup>
6	Cover cropping	15	38.5	6 <sup>th</sup>
7	Green manure	10	25.6	7 <sup>th</sup>
8	Zero/minimum tillage	6	15.4	8 <sup>th</sup>
9	Agroforestry	6	15.4	8 <sup>th</sup>

**Source:** Field survey data, 2025 \* Multiple response existed, hence percentage >100

The dominance of inorganic fertilizers among ISFM technologies utilized by smallholder maize farmers in the study area can be attributed to the immediate release of nutrient, ease of application, and relatively lower labour requirements of inorganic fertilizers. In contrast, organic soil fertility practices are constrained by limited availability of organic materials, labour intensity, and delayed yield response. This finding is consistent with the report of Olorunniyi *et al.* (2026) who found that chemical fertilizer use dominated ISFM practices among maize farmers in Nasarawa State, Nigeria with 89% of these



farmers relying on NPK, urea, and other inorganic fertilizers, and further attributed this dominance of chemical fertilizers to their immediate yield effects and government-supported distribution programs.

**Changes in ISFM Technology Adopted by Trained Farmers Before and After the Training Intervention**

The changes in ISFM technologies adopted by the treatment group before and after the training program are presented in Table 4. Analysis of the results in Table 4 indicated that the farmers in the treatment group utilized an average of 2.41 ISFM technologies before the training program. Also, the results in Table 4 showed that the farmers employed an average of 3.31 ISFM technologies after the training program. The mean difference between the number of ISFM technologies adopted by the farmers in the treatment group after and before the training program was 0.90 ( $t = 2.375$ ,  $p = 0.023$ ) which was positive and significant at 5% probability level.

**Table 4:** Independent Sample T-test Result on Changes in ISFM Technology Adopted by Treatment Group Before and After Training Intervention

Period	Mean number of ISFM technology adopted	Mean difference	t-value	p-value
After training intervention	3.31	0.90	2.375	0.023**
Before training intervention	2.41			

**Source:** Field survey data, 2025 \*\* = Sig@5%

The mean difference of 0.9 represents 37.3% increase in the number of ISFM technologies used after training. The improvement in adoption of ISFM technologies by farmers in the treatment group can be attributed to increased awareness, technical knowledge, and practical demonstrations provided during the training sessions. Also, training on soil fertility management improves farmer’s knowledge and technical capacity, which reduces uncertainty and promotes both initial and sustained adoption of ISFM technologies. This result is in congruence to previous studies on soil fertility management training such as Kansanga *et al.* (2021) and Kiprotich *et al.* (2023) who reported that capacity-building initiatives significantly enhance farmers’ adoption of improved soil management practices.

**Productivity and Income Comparison between Treatment and Control Groups after Training Intervention**

The estimated Average Treatment Effect (ATE) and t-test analysis of variables used to determine the effects of training in ISFM are presented in Table 5. The findings in Table 5 indicates that maize farmers’ productivity improved more for the treatment group (1546.15kg/ha) than for farmers in the control group (757.44kg/ha). The estimated average treatment effect (ATE) was positive (788.72kg/ha) indicating increase. This represents 104.13% increase in the productivity of trained farmers. The t-test analysis reveals that there was significant difference in the productivity of farmers in the treatment and control groups ( $t = 3.517$ ,  $P < 0.01$ )

**Table 5:** Estimated ATE and T-test Analysis of Variables Used to Determine Effects of Training on ISFM

Variable	Treatment group	Control group	ATE	t-test	p-value
Productivity (kg/ha)	1546.15	757.44	788.72	3.517	0.001***
Farm income (₦/ha)	632023.33	392307.69	239715.64	2.180	0.032**

**Source:** Field survey data, 2025 \*\*\* = sig@1%; \*\* = sig@5%

The results in Table 5 showed that maize farmers’ income improved more for the treatment group (₦632,023.33/ha) than for farmers in the control group (₦392,307.69/ha). The estimated ATE was positive (₦239,715.64/ha) indicating increase. This represents 61.1% increase in the farm income of trained farmers. The t-test analysis indicates that there was significant difference in the farm income of farmers in the treatment and control groups ( $t = 2.180$ ,  $P < 0.05$ ).



The higher maize yield and income observed among ISFM trained maize farmer can be attributed to improved technical knowledge, increased adoption of integrated soil fertility practices, enhanced fertilizer use efficiency, and the synergistic effects between inorganic and organic nutrient sources. These mechanisms collectively improve soil health, leading to higher productivity and, through increased marketable surplus and reduced unit costs, higher farm income is obtained. These results agree with the findings of Nyongesa (2015) who in a study on the effects of training farmers on integrated soil fertility management technologies on crop yield and income in Mbale Division, Kenya, reported that trained farmers achieved an average yield of 3.6tons/ha compared to non-trained farmers who achieved an average yield of 3tons/ha. The report by Nyongesa (2015) also revealed that the trained farmers registered an annual mean household income of \$3,587 compared to the non-trained farmers who had \$2.957. Similarly, a report by Sasakawa Africa Association (2023) revealed that training on Integrated Soil Fertility Management (ISFM) and Conservation Agriculture (CA) provided by Sasakawa Africa Association, helped maize farmers to boost crop yield by 50% and attributed this yield increase to the enhanced soil health and moisture retention resulting from the sustainable agricultural practices recommended in the training.

## CONCLUSION AND RECOMMENDATIONS

The study concludes that training intervention had a positive and statistically significant impact on both maize productivity and farm income as indicated by the average treatment effect and independent sample t-test analysis. Maize farmers who participated in the training recorded higher yields and increased income levels compared to the non-trained farmers, indicating that ISFM practices are effective in enhancing agricultural performance when properly understood and applied.

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

- i. The Benue State Ministry of Agriculture should expand ISFM training to reach more smallholder maize farmers across the State by integrating modules into routine extension packages delivered through the Agricultural Development Program (ADP); recruiting and training more extension agents specifically on ISFM practices; and using the train-the-trainer model, where trained farmers serve as community facilitators.
- ii. The Benue State government should promote practical ISFM learning through demonstration farms to reinforce training outcomes. The State government can achieve this by collaborating with the local governments to establish at least one ISFM demonstration plot per ward; providing subsidized inputs (such as fertilizer, improved seeds, organic manure) for demonstration purposes; organizing periodic field days where farmers observe yield differences first hand; and engaging farmer cooperatives to manage and sustain these plots.
- iii. The Benue State Ministry of Agriculture should encourage collective action among smallholder farmers to enhance adoption and benefits of ISFM by supporting the formation and registration farmer groups at community level, using cooperatives as channels for training, input distribution, and credit access; offering incentives (such as priority access to subsidies) to organized farmer groups.

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