ISSN:
Print - 2277 - 0755
Online - 2315 - 7453

Journal of Agricultural Science and Environment

SOIL CONSERVATION TECHNIQUES AND PRODUCTIVITY OF ARABLE CROP FARMERS IN KOGI STATE, NIGERIA

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ABSTRACT

The study examined soil conservation techniques and its effect on productivity of arable crop farmers in Kogi state, Nigeria. Data were collected from 184 farmers using three stage sampling technique. Data analyses were carried out using descriptive statistics, Total Factor Productivity (TFP) and regression analysis. Result shows that the soil conservation technique prevalent in the area was application of inorganic fertilizer. About 36.4% of the sampled household heads have productivity value above average across all the soil conservation categories (productive). Result also reveals that age (-1.801), household size (-0.310) and access to credit (-0.056) impacted arable crop farmers negatively while alley cropping (0.357), crop rotation (0.380), application of inorganic fertilizer (0.503), mulching (0.560) and organic manure (0.373) positively impacted arable farmers' productivity. The study concludes that soil conservation techniques are productivity enhancer. Promoting sustainable conservation techniques that are farm or farmer specific is recommended.

Keywords: Arable crop farmers, Determinants, Household heads, Soil conservation techniques and Total factor productivity

INTRODUCTION

Soil degradation is one of the most severe global environmental problems of this generation (Antonio, 2016). Even though degradation status is different from place to place, it is touching every corner of the world (Ouyang *et al.*, 2018). This worldwide depletion of soil resources continues to be a serious threat, particularly in the least developing countries, where agriculture is the main pillar of their economy (Zhu, 2014). It is threatening their survival on this planet as well as national prosperity.

In Sub-Sahara Africa (SSA), smallholder farming dominates the agricultural landscape operating on less than 2 hectares in total land holding and supply the food needs of the population as well as contribute to their national economies (FAO, 2014). Yet, smallholder agriculture is constrained by many inter-related factors including low soil fertility, frequent dry spells, drought and unsustainable management practices. Traditional agricultural practices have diminished soil productivity to the extent that many agricultural soils are depleted of nutrients and unable to naturally sustain crop productivity. In the coming decades, a crucial challenge to agriculture in SSA will be meeting food demands without undermining further the environment. Increasing productivity and economic returns to smallholder farming in a sustainable manner is a central challenge to achieving global poverty reduction and environmental management objectives (FAO, 2012). This calls for a rethinking on the current soil conservation practices employed by farmers for agricultural production.

Soil conservation according to Ezeaku (2012) is a set of management strategies for prevention of soil being eroded from the earth's surface or becoming chemically altered by over use, salinization, acidification, or other chemical soil contamination. It comprises the combination of all methods of management and land use to guard against soil depletion or deterioration by natural or man-induced factors. Traditionally, farmers employ several soil conservation practices ranging from simple agronomic practices, soil management and use of mechanical methods of soil management. The earth has about 7.86 billion acres of land potentially suitable for agriculture, half of which has been put into use (Schiller 1980). To boost agricultural production, there are two possibilities of either bringing the rest of the land into cultivation or by increasing the output per acre. If the first option is to be heeded, there is imminent trouble staring at the human populace because a time shall come when there could be no more land to farm. Therefore, the importance of soil conservation in agriculture cannot be over emphasized.

Soil management practices are pivotal to maximizing the production of agricultural commodities and it is also important for controlling the increasing environmental pollution (Powlson 2011; Shah and Wu 2019). Therefore, soil must be protected from activities that can lead to its destruction and permanent damage by adapting practices that avoid soil contamination and degradation. The nexus between soil conservation and agricultural productivity serves as the basis for assessing the economic benefits of improved soil management. Soil quality significantly affects the productivity of resource-use in agricultural production (Wiebe *et al.*; 2001, OECD 2009). Previous studies in developing countries have found that economic benefits are the strongest drivers in farmers' decision about soil conservation practices adoption and hence special attention to soil quality (Van Herzele *et al.,* 2013; Sastre *et al.*, 2016).

Lasway *et al.,* 2020 examined the determinants of Soil Conservation Technologies (SCTs) among small-scale maize farmers in Tanzania. Secondary data from the National Panel Survey were used in their study. A binary probit regression model was employed to analyze the data. The results showed that plot steepness, access to extension services as well as plot value were significant variables determining the adoption of the introduced soil and water conservation practices. On one hand, slope steepness influenced the adoption of soil conservation practices negatively at 1%, while on the other hand, access to extension services and plot value were positive at 1% and 5% level respectively. The study recommends that concerned bodies should consider these influential factors to enhance farmers' adoption of soil conservation practices and promote agricultural productivity and environmental quality.

Fantappiè *et al.,* (2020) found that effective profitability emanated from productivity is the main efficient stimulus to the adoption of soil conservation practices rather than much larger farmers' ecological attitudes, or the presence of subsidies. Based on this, the study estimates effect of soil conservation techniques on total factor productivity among arable crop farmers in Kogi State, Nigeria.

MATERIALS AND METHODS

The study area

The study was carried out in Kogi state, Nigeria. The state was carved out of former Benue and Kwara states of Nigeria. The state lies between latitude 6.33^{0}N and 8.44^{0}N of the equator and longitudes 5.22^{0}E. It thus spans the tropical rain forest on the southern fringes and the woody derived savannah and guinea savannah in the northern extreme. The state has a land mass of 29,833 square kilometers (km^2). According to the 2006 National Population Census (NPC), Kogi state has a population of 3,595,798 million. About 80% of population of the state resides in the rural areas and are predominantly small scale farmers with approximately 228,964 farm families. Annual rainfall pattern fluctuates between 1000mm and 1800mm, and it is generally adequate for most agricultural crop production. Mean daily temperature for all seasons range between 24^{0}C and 27^{0}C. The cultivation of arable crops such as rice, yam, cassava, sorghum, maize, millet, cowpea and groundnut predominate the agricultural practice. Oil palm grows a lot in the wild, while cash crops like cashew, cocoa and coffee are commonly grown especially in the southern and eastern parts of the state.

Sampling procedure

A three stage sampling technique was used in collecting data from arable crop farmers for 2016 production season. The first stage was the random selection of four (4) local government areas (LGAs) from the state. The second stage involved random selection of twelve (12) villages from across the LGA based on probability proportional to the number of villages in each local government. The last stage was the selection of the two hundred (200) farmers for interview and only one hundred and eighty-four (184) copies of questionnaire returned with useful information were used for the analyses.

Analytical technique

This study employed a number of analytical tools for the study. The tools include descriptive statistics, total factor productivity and multiple regression. Descriptive statistics was used to describe the socio-economic characteristics and the soil conservation techniques using minimum, maximum, mean, standard deviation and percentages where applicable. Total factor productivity model as employed by Adepoju and Salman (2013) was used to estimate the productivity value of the farming household heads based on the soil conservation techniques most frequently practiced. Total Factor Productivity (TFP) is a method of calculating agricultural productivity by comparing an index of agricultural inputs to an index of outputs (Jean-Paul, 2009). Total factor productivity is therefore measured as the inverse of unit cost following Key and Mcbride (2003). This is the ratio of outputs in naira value to the Total Variable Cost (TVC) of production. TFP measures that use physical quantities as output measures rather than revenue actually exhibit even more variation than do revenue-based measures as documented in Foster *et al.*, (2008). Hsieh *et al.*, (2009) also find greater productivity dispersion in the TFP measures that use quantity proxies to measure output.

$$TFP = \frac{Y}{TVC} \quad \ldots\ldots 1$$

Where Y = Output in Naira value in line with Mwuese and Okorji, (2014).

TVC = Total Variable Cost

$$TFP = \frac{Y}{\sum P_i X_i} \quad i = 1, 2, \ldots n \ldots\ldots 2$$

Where Y = quantity of output in Naira and TVC = Total Variable Cost

Where P_i = unit price of ith variable input and X_i = quantity of ith variable input

The inputs used in line with Fakayode *et al.*, (2008) are: cost of labour, cost of planting materials, cost of inorganic fertilizer, cost of herbicide and cost of pesticide.

The model is specified as follows;

Model Specification: $Q^* = f(x_1, x_2, x_3, x_4, x_5 \ldots\ldots x_{14}, \mu)$ ……………………………………3

Where

Q^* = TFP estimate

The Cobb-Douglas production function is specified as:

$Q_i = A\ \pi_i\ Z_i^{\ b_i}$; i = 1, 2,... 14 ……………………………………………4

The expanded form is:

$Q_i = A\ Z_1^{\ b1} Z_2^{\ b2} Z_3^{\ b3} Z_4^{\ b4} Z_5^{\ b5} \ldots\ldots Z_{14}^{\ b14} e^{ui}$ ……………………………………5

Following Gujarati (2004), the empirical model to be used for this study can be cast in double-log form as follows:

$\ln Q_i = \ln A + b_1 \ln x_1 + b_2 \ln x_2 + b_3 \ln x_3 + b_4 \ln x_4 + b_5 \ln x_5 \ldots\ldots b_{14} \ln x_{14} + u$ ……………………6

Based on the view of Hussain and Perera, (2004) and as adopted by Akintayo and Rahji, (2011), Adepoju and Salman, (2013) the following factors were hypothesized as the determinants of TFP of arable crop farmers in the study area.

x_1 = Age of household heads (years), x_2 = Number of years of formal education, x_3 = Household size (number), x_4 = Farming Experience (years), x_5 = Access to credit (Dummy Variable; Yes = 1 otherwise = 0), x_6 = Farm Size (ha), x_7 = Extension contact (Dummy Variable; Yes = 1 otherwise = 0), Vector of index of soil conservation techniques (Dummy Variable; Yes = 1 otherwise = 0), x_8 = Alley cropping, x_9 = Bush fallowing, x_{10} = Cover cropping, x_{11} = Crop rotation, x_{12} = Application of inorganic fertilizer, x_{13} = Mulching , x_{14} = Application of organic manure, μ = error term which is assumed to be normally distributed and with mean zero and constant variance.

This study checked for the degree of multicollinearity among the hypothesised explanatory variables before estimating the model using the Variance Inflation Factor (VIF).

RESULTS AND DISCUSSION

The socioeconomic characteristics of the respondents is presented in Table 1. The result shows that farming activities in study area was male dominated (65.8%) compared to their female counterparts (34.2%). The higher level of participation by men in farming activities supports the assumption that men are usually the breadwinners in their respective families. The fact that males were more involved than females in arable crop production could be as a result of their access to land and other production inputs. This agrees with the findings of Ayana (2017) who found out that 98% of his respondents on willingness to pay for soil conservation practices were males. In all the soil conservation techniques, more than half of the farmers were in the age bracket of 31 – 50 years, with the mean age of 41.26±8.82 years. The implication is that arable crop farmers in the study area were still very active to cope with the rigorous farming activities. The result is in tandem with that of Sambo (2015) that the average age of adopters of recommended environmental management practices was 42 years. In the case of marital status, most of the farmers (89.1%) were married while the remaining were either single, widowed or divorced. The result is consistent with that of Tunde *et al.,* (2015) and Balogun (2011) who also opined that cultural practices and the socio-economic environment contribute to making people regard married persons as responsible and so respected in society. The result of household size reveals that more than half (54.9%) of the sampled farmers had household size of 5 -8 members; 21.7% and 20.7% had household sizes of 9-12 members and 1-4 members respectively, while household size greater than 12 constituted 2.7%. The mean household size in the study area was found to be 6.72±2.88 persons per household. The result supports the findings of Sambo (2015) that large family size characterizes most families in developing countries and they can be put into production as family labour. About 15.8% of crop farmers had no formal education, 22.8% completed primary education, 38% completed secondary education while 23.4% had tertiary education. The mean years of education of 9.59±5.39 implies that an average farmer in in the study area has basic education. The level of farmers' education is believed to influence the use of improved technology in agriculture and, hence, farm productivity. The level of education determines the level of opportunities available to improve livelihood strategies, enhance food security, and reduce the level of poverty. It affects the level of exposure to new ideas and managerial capacity in production and the perception of the household members on how to adopt and integrate innovations into the household's survival strategies. This finding is in sharp contrast to the findings of Junge *et al.*, 2009 who found 35% of their respondents on adoption of soil conservation technologies in Osun State had post-secondary education.

Table 1. Socio-economic characteristics of the respondents

Variables	Organic manure	Bush fallow	Crop rotation	Inorganic fertilizer	Alley cropping	Cover cropping	Mulching	Pooled
Sex	%	%	%	%	%	%	%	%
Male	56.0	52.2	51.6	77.8	63.0	65.0	95.4	65.8
Female	44.0	47.8	48.4	22.2	37.0	35.0	4.6	34.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Age								
≤30	4.0	34.8	16.3	8.3	7.4	20.0	4.5	13.0
31-40	52.0	52.2	32.2	27.8	44.4	35.0	27.3	38.0
41-50	20.0	13.0	35.4	41.7	37.1	35.0	50.0	33.7
51-60	24.0	0.0	16.1	11.1	7.4	10.0	18.2	12.5
>60	0.0	0.0	0.0	11.1	3.7	0.0	0.0	2.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mean	41.52	32.78	41.65	46.19	7.71	39.05	6.95	41.26
SD	7.87	7.39	8.18	8.56	30.00	9.11	29.00	8.82
Min	28.00	22.00	25.00	32.00	62.00	20.00	55.00	20.00
Max	57.00	50.00	54.00	65.00	7.71	55.00	6.95	65.00
Marital status								
Married	100.0	87.0	93.5	88.9	100.0	75.0	72.7	89.1
Single	0.0	0.0	0.0	0.00	0.0	20.0	18.1	6.0
Widow	0.0	8.7	6.5	8.3	0.0	5.0	4.6	3.3
Divorced	0.0	4.3	0.0	2.8	0.0	0.0	4.6	1.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Household size								
1-4	12.0	86.96	12.9	11.1	0.0	5.0	27.3	20.7
5-8	68.0	8.69	61.3	61.1	63.0	75.0	40.9	54.9
9-12	20.0	4.35	22.6	27.8	33.3	20.0	18.2	21.7
>12	0.0	0.00	3.2	0.0	3.7	0.00	13.6	2.7
Total	100. 0	100.00	100.00	100. 0	100.0	100.0	100.0	100.0
Mean	6.76	3.26	7.00	6.94	7.96	7.00	7.36	6.72
SD	2.37	2.05	2.63	2.18	2.36	2.41	3.98	2.88
Min	2.00	1.00	4.00	4.00	5.00	1.00	2.00	1.00
Max	12.00	10.00	15.00	11.00	14.00	24.00	16.00	16.00
Educational level								
No formal	4.0	4.4	22.6	16.7	18.5	15.0	27.3	15.8
Primary	32.0	13.0	22.6	13.9	33.3	30.0	18.2	22.8
Secondary	8.0	56.5	29.0	47.2	37.1	40.0	50.0	38.0
Tertiary	56.0	26.1	25.8	22.2	11.1	15.0	4.5	23.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mean	12.04	11.61	8.71	9.97	8.26	8.80	7.64	9.59
SD	5.46	3.95	5.78	5.41	5.27	4.95	5.47	5.39
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	.00
Max	18.00	17.00	5.78	20.00	17.00	15.00	15.00	20.00

Source: Field Survey, 2017

Households soil conservation techniques

Household soil conservation techniques used in the study area is presented in Table 2. The result shows that inorganic fertilizer ranked highest as 19.6% of the sampled household heads used it, this could be attributed to its ability to sustain crop yield and retain soil fertility; next to this is crop rotation (16.8%) which became popular because it has no residual effect on crops; it is also a biological method of pest and disease control. After this is alley cropping (14.7%) which has no residual effect on crops, some 13.6% of the sampled household heads made use of organic manure which farmers obtained from cow and other animal dungs, this helps in soil fertility retention and sustains crop yield. Bush fallowing accounted for 12.5%, this practice is becoming unpopular due to population pressure on land. Close to this is mulching which accounted for 11.9% as it helps in soil water retention. Last and the least is cover cropping which accounted for 10.9%. Although multiple responses were given, farmers were classified based on the type of soil conservation techniques most frequently used. Classification under a particular soil conservation technique does not imply that farmers are exclusively looking for a single practice to use but rather a combination of practices with various degree of preference for one over the other.

Table 2: Households soil conservation techniques used in the study area

Land management practices	%
Organic manure	13.6
Bush fallowing	12.5
Crop rotation	16.8
Inorganic fertilizer	19.6
Alley farming	14.7
Cover cropping	10.9
Mulching	11.9
Total	100.00

Source: Field Survey, 2017

Households productivity estimate in the study area

Across all the soil conservation techniques, the minimum value was 0.19, the maximum value was 8.78 while the modal group in most cases being 1.00 to 1.99 with the exception of bush fallowing and crop rotation which have their modal group as 2.00 to 2.99. On the average, mulching has the highest mean of 3.48 with a standard deviation of 1.25, this was followed by inorganic fertilizer application with a mean productivity value of 2.8±1.13, next to this was crop rotation having a mean of 2.47±1.43, after this was application of organic manure which has a mean of 2.36±1.02, bush fallowing has a mean of 2.16±0.93, alley cropping with a mean of 1.97±1.25, cover cropping has the least (1.79±0.84), while the pooled data has a mean of (2.41±1.2). This is close to the findings of (Mwuese and Okorji 2014) who found a mean productivity of 2.66 among women cassava farmers in Benue State. The highest mean value in respect of mulching could be attributed to their lowest cost of conserving the soil as the mulching material could be obtained at the least cost possible if it will attract any cost at all. Though a labour intensive practice, but the households with an average family size of 6.7 implies availability of family labour poses no threat. Also, mulching apart from being a soil conservation technique helps to conserve soil water which makes water available during the dry season to the crop. The fact that inorganic fertilizer does not top the group could be attributed to high cost/ non-availability in the required quantity as an average farmer that cultivated 1.79ha made use of 201.09kg of inorganic fertilizer as against the recommended rate of 200 to 300kg per hectare. Result of the pooled data indicates that 36.4% of the famers were productive as they contributed more than the average productivity value of 2.41.

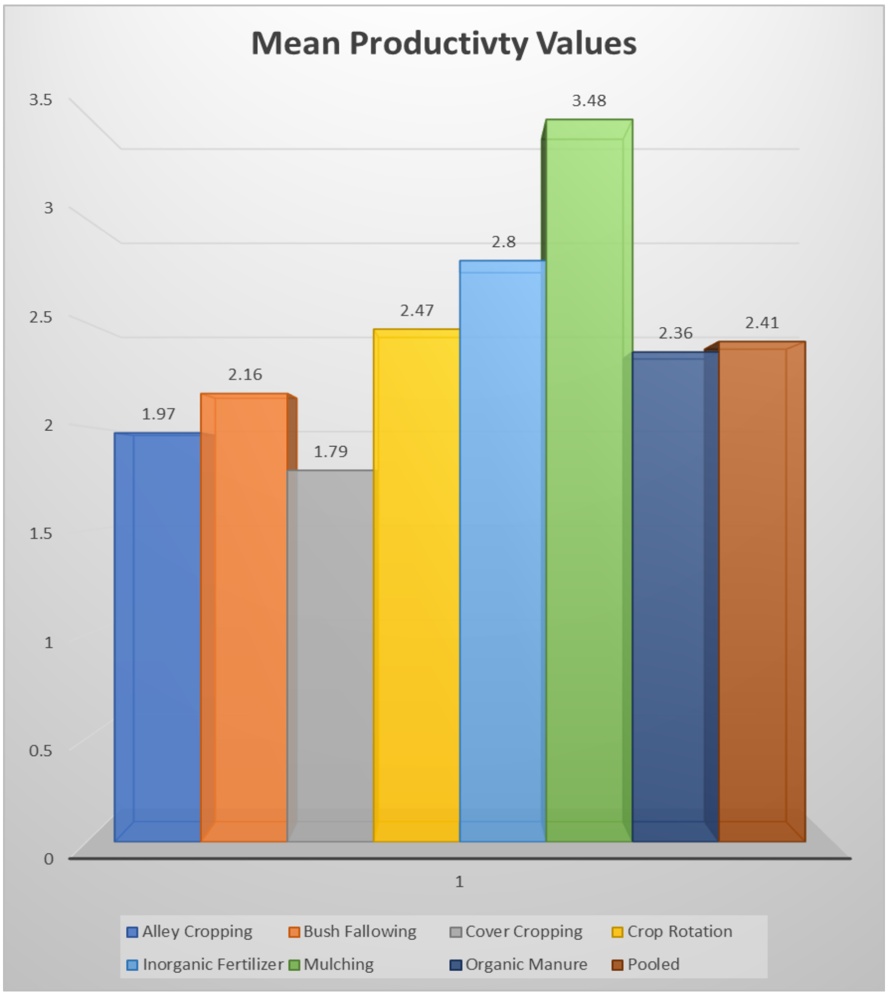

Fig 1: Bar chart showing the mean productivity values across the soil conservation techniques in the study area

Factors affecting Total Factor Productivity (TFP)

Test of multicollinearity among the variables affecting TFP is shown in Table 3. The result of multicollinearity test indicated that VIF is less than 10 and 1/VIF is above 0.1, an indication that there is no correlation among the hypothesized independent variables

Table 3: Test of multicollinearity among the independent variables for the factors affecting TFP

Variables	VIF	$1/_{VIF}$
$\mathbf{X_1}$	1.83	0.545713
$\mathbf{Z_1}$	1.22	0.820560
$\mathbf{X_5}$	2.00	0.498811
$\mathbf{X_6}$	1.65	0.605263
$\mathbf{X_9}$	1.09	0.913680
$\mathbf{X_{12}}$	1.55	0.643102
$\mathbf{X_{14}}$	1.16	0.864684
$\mathbf{Z_2}$	2.29	0.436929
$\mathbf{Z_4}$	1.88	0.530529
$\mathbf{Z_5}$	2.28	0.438492
$\mathbf{Z_6}$	2.88	0.347599
$\mathbf{Z_7}$	2.06	0.485245
$\mathbf{Z_8}$	2.18	0.459449
Mean VIF	1.85	

Source: Field Survey, 2017

The result of adjusted coefficient of determination (R^{-2}) for arable crop farmers was 0.91 indicating the presence of a high degree of association between productivity (dependent variable) and all independent variables (Table 4). This implies that 90.79% of the variation in the farmers' productivity is explained by the variations in the independent variables. The F-statistics of the farmers (F-test= 139.82., $P<0.001$) was found to be highly significant, implying that the independent variables were collectively important in explaining the variation in the dependent one.

Of the fourteen explanatory variables specified, eight were statistically significant. These were age, household size, access to credit, alley cropping, crop rotation, inorganic fertilizer application, mulching and organic manure application. The negative coefficient ($p<0.01$) on age suggests that farmers were less productive as they age. Older farmers are not physically able to produce as much as younger household heads because farm experience is countered by declining physical strength and perhaps, by negative attitudes toward innovation. The negative coefficient, which implies that a unit increase in farmers' age decreased productivity by 1.801, agrees with the findings of Ahmed and Elrasheed (2016). The coefficient of household size was negative and significant (p<0.01), implying that household size made a negative but significant contribution to productivity. This implies that a unit increase in household size will tend to reduce productivity by 0.31. The possible explanation could be that money and other resources which could be used to expand the farm and produce more are being used to meet the needs of the large family. It could also mean that the families have a high proportion of young children and aged people who consume family resources without contributing to family output. The negative relationship is consistent with the findings of Fawole and Rahji (2016).

The coefficient of access to credit was negative but significant at (p<0.05) level, implying that a unit increase in the use of credit tends to reduce the productivity of respondents by 0.056. This is contrary to a priori expectation of a positive relationship between access to credit and output. The reason for the negative result could be due to the diversion of agricultural credit to non-agricultural uses. A negative coefficient is consistent with the findings of Mwuese and Okorji (2015). Though not significant, the positive coefficient in respect of education implies that a unit increase in the variable increased productivity by .077% while a negative coefficient in respect of farming experience, farm size and access to extension implies that a unit increase in these variables leads to .228, .027 and .016% reduction in productivity. In addition, all the soil conservation techniques were positively related to TFP, implying that increased use of any of the techniques lead to increased productivity. Although bush fallowing and crop rotation were not significant, cover cropping, inorganic fertilizer application, mulching and organic manure application were significant.

Table 4: Factors affecting productivity of arable crop farming household heads in the study area

Variables	Coefficients	Standard error	T	P> | t |
Age	-1.801	.305	-5.90 ***	0.000
Education	.077	.055	1.40	0.165
Household size	-.310	.102	-3.02***	0.003
Farming experience	-.228	.156	-1.46	0.148
Access to credit	-.056	.023	-2.40**	0.018
Farm size	-.027	.025	-1.07	0.285
Access to extension	-.016	.024	-0.69	0.493
Alley cropping	.357	.199	1.79*	0.076
Bush fallowing	. .044	.198	0.22	0.824
Cover cropping				
Crop rotation	.380	.193	1.97**	0.051
Inorganic fertilizer	.503	.213	2.36**	0.020
Mulching	.560	.189	2.96***	0.004
Organic manure	.373	.195	1.91**	0.058
Constant	1.055	.937	1.13	0.262
R^2	0.914			
R^{-2}	0.9079			
Prob>F	0.0000			
F(13 147)	139.82			
N	184			

*** 1% significance level; ** 5% significance level, *10% significance level

CONCLUSION AND POLICY RECOMMENDATIONS

The result of Total Factor Productivity estimate indicates that arable crop farmers practicing mulching were the most productive while those practicing cover cropping were least productive. Practicing alley cropping, crop rotation, mulching and application of organic manure enhanced arable crop farmers' productivity in Kogi State, Nigeria. Age of farmers was negatively related to productivity; it is therefore recommended that young farmers should be encourage to go into arable crop production. Education enhances adoption of soil conservation techniques and production output by farmers hence the study recommends basic education or adult literacy for farmers to enabling them constantly upgrading their knowledge. Soil conservation techniques are productivity enhancer; the need to promote sustainable soil conservation techniques that are farm or farmers specific is hereby recommended.

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(Manuscript received: 2nd November, 2020; accepted: 1st April, 2021).