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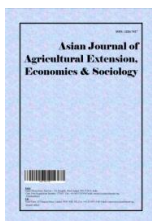
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Determinants of Adoption of New Agricultural Technologies by Cooperative Farmers in Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Globally, advanced technologies are invented or discovered for the improvement of farming activities. In Nigeria, such technologies are gradually being available from research institutes and imported technologies. The low outputs of farms suggest that these technologies seem not to be highly adopted in Nigeria and the factors that determine the adoption of these technologies are yet to be explored. The study examined the socio-economic and institutional determinants of the adoption of new agricultural technologies by cooperative farmers in Nigeria. A descriptive survey research design was adopted. Multistage random sampling technique was used to select three hundred and twenty farmers (160 individual farmers and 160 co-operative farmers), statistically derived using the Taro Yamane formula. The data used for this study were sourced from primary data. Descriptive and inferential statistics were deployed in the analysis of data. Findings revealed that sex, marital status, farm size and annual farm income socio-economic are the socioeconomic factors affecting the adoption of new agricultural technologies while the frequency of contact with extension agents is the key institutional factor affecting the adoption of agricultural technologies. Recommendations made include that extension services should be improved by the Agricultural Development Programme. There should be at least two extension agents to each community who should visit the farms regularly and expose the farmers to the latest agricultural technologies

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through Small Plots Adoption Trials (SPATS) and On-Farm Adaptive Research. The extension service workers in ADP should enjoin individual farmers to form effective groups (Co-operative Societies) for easy diffusion of the agricultural technological innovations.

Keywords: Adoption; agriculture; technology; cooperatives.

1. INTRODUCTION

The population growth, uncertainty in food markets and changing consumption patterns of food commodities and nutrition in Sub-Saharan Africa have created the need for improving agricultural productivity in the region [1,2,3]. The backbone of agricultural production in Sub-Saharan Africa is the population of smallholder farmers who are largely and historically constrained by several product structural and policy issues that have led to slow increases in yields and even stagnation in some parts and for some crops [3]. The absence of technology, limited access to or the use of inappropriate technology is among some of the factors blamed for food deficiency in many parts of the developing world [4].

To achieve a transition from productivity or subsistence agriculture to a high productivity agro-industrial economy, the World Bank [5,6], emphasized the importance of the adoption of new agricultural technology and innovations developed around the world and locally to make countries of the world food secure. As of 2009, Albert and Isife in their work entitled "Issues in Developing a National Policy on Agricultural Extension Services in Nigeria" projected that the supply of food will need to rise by around 70 per cent by the year 2020 if the 6.5 billion people who are expected to be living in developed countries, including Nigeria are going to be food secured [7]. Food production has remained stagnant or declined in most of the Sub-Saharan African countries and Nigeria particularly still depends on other countries for livelihood including food supply.

There has been a surprising imbalance between the food demand and the actual production as Nigeria currently has over 200 million residents scrambling for limited food available. Moreover, the cost of agricultural production is high and continues to rise in Nigeria. The continuous decline in agricultural production was attributed by Odigbo and Onwualu (2005) to the problems of the inadequacy of technologies and adoption by farmers. The World Bank report of 2018 indicated that the population growth rate of

Nigeria is 2.6 per cent while the GDP growth rate of 1.9 per cent. This suggests that sustaining the large population is difficult and with the current coronavirus (COVID-19) pandemic which has thrown the world economy into a recession with many countries running into negative economic growth and Nigeria is not exempted. There may be very limited funding of agricultural research or the importation of new technologies. Therefore the adoption of the existing but new technologies is imperative at this time to boost food production in Nigeria.

It is no longer news that the economy of Nigeria is by no means, self-sufficient in food production owing mostly to the use of crude implements by the farmers. It is interesting to note that several new technologies exist in Nigeria with the Agricultural Development Programme and other agricultural research institutions which are largely not adopted by the final users. Cooperatives are perceived as veritable tools for the adoption of new ideas and stimulating a wider spread however, the role of cooperatives have not been given adequate attention among researchers and policymakers in driving innovation adoption. In this critical moment of economic recession and projected decline in agricultural production and very high rising population of Nigeria, an intensive study on identifying the key determinants of adoption of Agricultural technology is imperative so that there would be policy recommendations that would speed up the rate of adoption of these technologies and improve food production for the consumption of the teeming population of Nigerians and indeed have excess for export to other African Countries.

1.1 Objectives of the Study

The broad objective of this study is to identify the determinants of the adoption of new agricultural technologies to stimulate greater adoption of these technologies for increased food production.

The specific objectives include to:

- i. determine the extent to which socio-economic affects the adoption of new

- technologies by cooperative farmers in Nigeria.
- ii. examine the influence of institutional factors on the adoption of new technologies by cooperative farmers in Nigeria.

1.2 Hypotheses

The following hypotheses were formulated in line with the objectives of the study:

H₁: Socio-economic and institutional factors do not significantly influence the adoption of new technologies in Nigeria by Cooperative farmers.

1.3 Adoption of New Farm Technologies among Agricultural Co-operatives

Technology is the systematic application of scientific or other organized bodies of knowledge to practical purposes [8]. Agricultural technology according to Techane [9] refers to new ideas, methods, practices and techniques which provide means of achieving workers' jobs to encourage farmers to adopt innovations of proven value. According to Jain, Arora and Raju [10], Agricultural technologies include all kinds of improved techniques and practices which affect the growth of agricultural output. Some of the technologies include; high-yielding varieties of seeds, chemical fertilizers, pesticides, Herbicides and the use of machinery. By improved input/output relationships, new technology tends to raise output and reduces the average cost of production, which in turn results in substantial gains in farm income.

Adoption of new Agricultural technologies is perceived to be a necessity for improved farm yield. Agricultural technologies are seen from two clear perspectives. The first one includes physical objects like fertilizers, seeds, equipment and the second one is the farming methods. We can therefore align farm technologies into tangible and intangible farm technologies. What makes a technology new is dependent on the time the technology got to a particular area and the farmers. It is safe to state that an old technology in Germany may be new in Uganda because of the timing of its spread to the area. So long as the technology is still novel to the farmer, it is regarded as new technology. New technology has been defined by Rogers (2003) as an idea, practice or object that is perceived as new by an individual or other unit of adoption. A good look at the definition suggests that new technology may be an idea or practice which are

largely intangible or a tangible object. Rogers further postulated that a farmer always looks at two different things to assess the technology for adoption. The farmers look at the perceived advantage of using the technology and the technology that preceded it as well as the perceived compatibility with the existing values, needs and experiences. Rogers (2003) further noted that new technologies have a good chance of being adopted by the farmers if the technology appears simple (less complex) and the results are visible and observable by other people including farmers.

In simple terms, Akubuilu [8] stated that adoption is a decision made by an individual or group of persons to accept and use innovation in a continuous manner. The concept of social innovation was described by Mulgan, et al. [11] as innovative activities and services which are aimed at meeting a social need that is largely generated (developed) and diffused via organisations whose primary purposes are social. In the case of new agricultural technology, the aim is predominantly economic purpose as the adoption of them is expected to yield better productivity and invariably increased income for the farmers. Technology adoption starts from a mental perception of the usefulness of the new technology by the farmers at the time he heard about it the complete and comprehensive use of the technology to the point where it has not only become sustainable for the user but has become a way pattern of behaviour

Farmers tend to be influenced to adopt new technology when they observe that others are deriving observable benefits from the use of the technology and organisations like agricultural cooperatives have considerable potential to fill this gap between the researcher and the final user of technology (farmers) by championing the test of new agricultural technologies in their communities the moment they are introduced to build the interest of the individual farmers to adopt They can also fill the social vacuum through the provision of services which are needed by the community efficiently and in time and which are based on high principles of management and ethics of the Principles of Cooperation. Cooperatives are member-driven, member-controlled and member-responsive organisations; the design of the cooperatives imparts a high drive level and a cohesive governance structure. Cooperatives establish viable and strong linkages with external research and development/extension agencies in the field

of agriculture and technology. These are appropriate to the needs of cooperatives and their members.

1.4 Theoretical Framework

This study is based on the diffusion of innovation theory. The theory was developed by E.M. Rogers in 1995. This is the most popular. It explains how, over time, an idea or product gains momentum and diffuses (or spreads) through a specific population or social system. The result of this diffusion is that people, as part of a social system, adopt a new idea, behaviour or product. Technically defined, the adoption of a new idea or practice is a stage in the innovation-decision process which is the mental process through which an individual or group passes from first knowledge of an innovation to a decision to adopt or reject and the confirmation of this decision. Adoption means that a person does something different than what they had previously (i.e., purchase or use a new product, acquire and perform a new behaviour, etc.). The key to adoption is that the person must perceive the idea, behaviour, or product as new or innovative. It is through this that diffusion is possible.

The process of adoption of innovation has been studied by scholars in several disciplines however in rural sociology and agricultural co-operatives, the main focus has been the impact of socio-cultural factors on communication and adoption behaviour over time and space within society. The studies have shown that the adoption process follows the same general

pattern regardless of the means of communication and the cultural setting.

The adoption process is often slow and it follows the following stages as Onunamadu (2006) puts it: Awareness, Interest, Evaluation, Trial and Adoption

Fig. 1 refers to the five established adopter categories. While the out-grower majority of the general population tends to fall in the middle categories, it is still necessary to understand the target population's characteristics. When promoting an innovation, there are different strategies used to appeal to the different adopter categories which are Innovators, Early Adopters, Early Majority, Late Majority and Laggards.

Diffusion of Innovation theory is apt for this study because of the peer networks that exist in agricultural co-operatives. The peer network creates the influence of innovators and early adopters on the farmers who serve as opinion leaders that sparks the initial "take-off" point in the innovation adoption process. These opinion leaders who could be members of agricultural cooperatives serve as valuable integral change agents who influence their peers through peer to peer communication, role modelling, and networking to adopt new agricultural technologies in their farms. This process works well within an organization or in society at large. A prime example is the use of social media networking to influence people through opinion leader tactics. Agricultural co-operative societies could serve as the agents of change (early adopters) by creating awareness and developing the interest of other farmers who form the early majority.

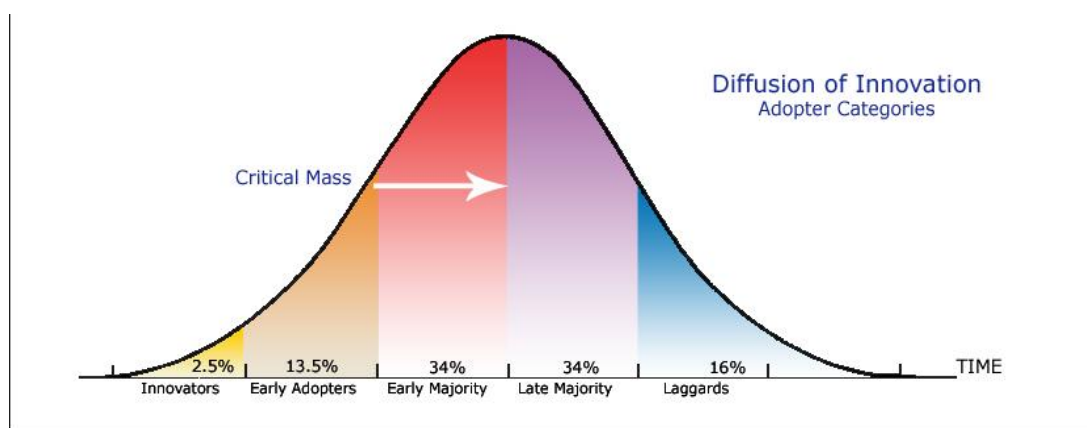


Fig. 1. Adopted from Diffusion of Innovation theory (Rogers, 2003)

Authors who used adoption theory in their different works have awareness, interest, evaluation, trial and adoption as the adoption process but in different methods that suit their works, but no group of farmers in mind or co-operative farmers. However, this study made use of the five-step theory of adoption in investigating ten selected agricultural technologies from agricultural co-operative farmers in Nigeria, using a co-operative approach.

Rogers contends that for new technology to be adopted the five factors of relative advantage, compatibility, complexity, trialability and observability must play out. The technology must be perceived by the users to have a better advantage and more relevance compared to the already existing ones. It has to be perceived by the user to be somewhat consistent with already existing technologies. Any new technology must also not appear to be very difficult to use or learning as it would discourage the user from trying it out, let alone adopt it. It is also very pertinent that new technology should be easily tried or experiment with on a limited basis without necessarily creating waste. Users of new technology are always interested in being able to observe the new technology used by others and see the extent of its usefulness before they want to try it, therefore, observability is a key factor in the adoption of new technology.

1.5 Empirical review on Determinants of Adoption of New Technologies

Cafer and Rickoon [12] utilized a mix of methods to survey smallholder farmers in examining the adoption of new technologies by smallholder farmers: the contributions of extension, research institutes, cooperatives, and access to cash for improving the production in the South Wollo zone

of the Amhara region in Ethiopia. They found out that cash (resources) which mitigate market inefficiency and for the purchase of expensive inputs and capital were key and most significant influencers or predictors of the decision to adopt row planting input packages. They also found out that cooperative involvement was a significant predictor of adoption.

A study by Uaiene, et al. [13], in Mozambique examined the determinants of agricultural technology adoption. Their findings show that households with access to credit and extension advisory services as well as members of agricultural associations are more likely to adopt new agricultural technologies. The study also revealed that level of education is an important determinant of the level of adoption of new technologies as households with higher levels of education were more likely to adopt the technologies because of their level of education and exposure and that out-grower scheme by providing credit to farms can help stimulate agricultural technology adoption.

Sulo, et al. [14], examined the socioeconomic factors affecting the adoption of improved agricultural technologies among women in Marakwet county Kenya. Stratified random sampling was used to conduct the survey. The survey obtained 160 women from two targeted groups by the Women in Agricultural projects (WIA) under the Catholic Diocese of Eldoret. They used both quantitative and qualitative data analysis methods to analyze explanatory variables which are the factors affecting adoption. The results revealed that primary occupation, annual income, household size and membership of women's groups had a positive and very significant relationship with the women's adoption of agricultural technologies.



Fig. 2. Factors affecting Innovation Adoption

Another study on the factors influencing the adoption of new technologies in the Kwali area council of the Federal Capital Territory Abuja which concentrated on a particular technology (agro-chemical technology) by Bello, Ibrahim, Salau, Kaura & Age [15] adopted a structured interview schedule as the method of data collection for the study. The researchers chose Ten respondents who were randomly selected from each of the eight districts making the area council giving a total of eighty respondents. Statistical tools involving means, frequency and percentage were used to analyze the data. Ordinary least square linear regression was used to determine factors influencing the adoption of agrochemicals technology in the study area. The results of the study revealed that gender, age, farm income, marital status and years of farming experience have a positive influence on the adoption of agrochemicals in the study area.

Belay, et al. [16] examined the challenges facing agricultural extension agents in South-Western Ethiopia who collected data from 85 extension workers revealed that the quantity and quality of extension workers in the study area were very low in number and qualification. The communication skills of the extension workers were really poor because of their poor qualification which impacted the level of adoption of new agricultural technologies because they are the ones that are responsible for choosing the farmers to engage in the on-farm demonstration and the involvement in extension activities among other factors.

2. MATERIALS AND METHODOLOGY

The research design used in this study is the descriptive survey. Nigeria was used as the area of the study. The population of the study is made up of 45 Agricultural Co-operative Societies that collaborate with the Agricultural Development Programme with a total member population of 912 and all the 688 individual farmers which formed a total population of 1600. The multistage random sampling technique was adopted for this study. Firstly, 4 states from each of the geopolitical zones of Nigeria were selected except South-South and North East largely because of the insurgency in the two zones. In each zone, two Local Government Areas (LGAs) were randomly selected. In each selected LGA, 4 communities were randomly selected. Lastly, 5 individual farmers and 5 co-operative farmers who relate to the Agricultural Development Programme were selected from each of the

communities. In all, 4 states, 8 local government areas, 32 communities, and 320 farmers were used for the survey. This brought the sample size of the study to three hundred and twenty farmers (160 individual farmers and 160 cooperative farmers). The sample size was statistically derived as 320 using the Taro Yamane formula with a population size of 1600. The data used for this study were sourced from primary data.

The research instrument (questionnaire) was validated to ensure face and content validity. To ensure the reliability of the instrument, the test-retest technique was adopted. To achieve this, selected respondents were administered the questionnaire twice at an interval of 12 days. The correlation of the two sets of scores was determined using the Pearson Product Moment Correlation as 0.87. The high coefficient indicated good consistency of the questionnaire. Descriptive and inferential statistics were deployed in the analysis of data collected from respondents. The descriptive statistics involved the mean and standard deviation. Multiple Regression, T-test and Pearson Product Moment Correlation were used to test hypotheses 1, 2 and 3 respectively.

Model Specification

The multiple regression model is implicitly specified thus:

$$Adp = f(\text{Age, Edu, Fas, Inc, Cre, Hsz, Mkt, Mda, Cop, Ext, } e)$$

Where;

Adp= Level of Adoption of new Agricultural Technology (Index of Adoption)
 Age= Age of Farmer (Years)
 Edu= Farmers Educational level (years)
 Fas = Farm Size of Farmers (Hectares)
 Inc = Farmers Income (Naira)
 Cre = Credit Availability (Naira)
 Hsz = Household Size of Farmers (Number of Persons)
 Mkt = Availability of Market (Number of Market)
 Mda = Mass Media Exposure (Dummy variable, Yes =1, No = 0)
 Cop = Membership of Co-operative Society (Dummy variable, Yes =1, No = 0)
 Ext = Farmers Contact with Extension Agents (Monthly).
 e = Error Term

The explicit model of the regression is as follows:

Adoption = $\alpha + \beta_1 \text{Age} + \beta_2 \text{Education} + \beta_3 \text{Farm Size} + \beta_4 \text{Income} + \beta_5 \text{Credit} + \beta_6 \text{Household Size} + \beta_7 \text{Market} + \beta_8 \text{Media Exposure} + \beta_9 \text{Co-operative Membership} + \beta_{10} \text{Extension services} + \epsilon$

The α s are the intercepts and the β s are the regression coefficients to be estimated while the ϵ s are the error terms designed to capture other variables not included in the models.

F and t statistics were employed to test the significance of estimates of the multiple regression models.

Table 1 above shows that the majority of the respondents were male, mostly married and fairly old people with low literacy levels. It also revealed the most respondents have 2-3

hectares of land and above with annual farm income ranging from less than #100,000 to above #200,000.

Table 2 shows that there is a high frequency of contact of extension officers with the respondents mainly once in two months. The farmers mostly have 2 or more markets available for the purchase of their farm proceeds. 67.5% of the respondents agree that they are sufficiently sensitized through the mass media.

2.1 Test of Hypothesis (H₁)

H₁: Co-operative farmers' adoption of new technologies in Nigeria is affected by socio-economic and institutional variables

Table 1. Distribution of respondents on the socio-economic profile of members

Variable	Frequency	Percentage
Sex	N=160	(%)
Female	67	41.9
Male	93	58.1
Marital Status		
Single	38	23.8
Married	122	76.2
Age		
Under 18	8	5.0
18-30	52	32.5
31-50	49	30.6
51 and above	51	31.9
Educational Qualification		
FSLC	84	52.5
WASSC	50	31.3
NCE/OND	23	14.3
HND/First Degree and above	3	1.9
Farm Size		
1 Hectare	42	26.2
2-3 Hectares	80	50.0
4 Hectares and above	38	23.8
Annual Farm Income		
Less than 100,000	54	33.8
100,000-200,000	47	29.4
Above 200,000	59	36.9

Source: Field Survey, 2019

a. Dependent Variable: Level of Adoption by Co-operative Members

Predictors: (Constant), Sensitization on New Technologies through the Mass Media, Age, Marital Status, Markets Available for the Purchase of Farm Proceeds, Frequency of Contact with Extension Agents Agricultural Development Programme, Family Size, Educational Qualification, Sex, Farm Size, Annual Farm Income

Table 2. Distribution of respondents on institutional factors of adoption

Variables	Frequency	Percentage
Contact with Extension Officers	N=160	(%)
Once or Twice in a Year	14	8.8
Once in Two Months	50	31.3
Once a Month	38	23.8
Twice a month	58	36.3
Number of Markets		
One	14	8.8
Two	80	50.0
Three	66	41.3
Sensitization through Mass Media		
No	45	28.1
Yes	108	67.5

Source: Field Survey, 2019

Table 3. ANOVAa

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	56.574	10	5.657	100.342	.000 ^b
	Residual	7.837	139	.056		
	Total	64.411	149			

Source: Analysis of Empirical Data, 2019

Table 4. Model Summary

Model	R	R Square	Adjusted R Square	Std. An error of the Estimate
1	.937 ^a	.878	.870	.23745

Source: Analysis of Empirical Data, 2019

a. Predictors: (Constant), Sensitization on New Technologies through the Mass Media, Age, Marital Status, Markets Available for the Purchase of Farm Proceeds, Frequency of Contact with Extension Agents from Agricultural Development Programme, Family Size, Educational Qualification, Sex, Farm Size, Annual Farm Income

Table 5. Regression coefficients^a

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	1.793	.254		7.047	.000
Sex	.409	.073	.308	5.634	.000
Marital Status	.300	.059	.189	5.073	.000
Age	.027	.036	.038	.761	.448
Educational Qualification	.061	.042	.076	1.446	.151
Family Size	-.024	.062	-.028	-.389	.698
Farm Size	.209	.048	.227	4.344	.000
Annual Farm Income	.324	.060	.416	5.371	.000
Frequency of Contact with Extension Agents from Markets Available for the Purchase of Farm Proceeds	.058	.028	.090	2.064	.041
Sensitization on New Technologies through the Mass Media	-.030	.042	-.028	-.718	.474
	.052	.053	.036	.972	.333

Source: Analysis of Empirical Data, 2019

a. Dependent Variable: Level of Adoption by Co-operative Members

Table 4 showed that the R square is 0.937, adjusted R square is 0.878 and adjusted R square is 0.870 which implies that the adoption of new agricultural technologies is explained by the independent variables.

3. DISCUSSIONS

The regression result revealed that sex, marital status, age, educational qualification, farm Size, annual farm income, frequency of contact with extension agents and sensitization on New technologies through the mass media have a positive influence on the adoption of new agricultural technologies. The positive coefficient of sex and marital status shows that married males have a higher tendency of adopting the new agricultural technologies. The positive coefficient on age shows that the older an individual is, the higher his reception of new technology. The table also reveals that the higher the educational qualifications of farmers, the higher the chances of adopting new agricultural technology which reflects a positive influence. Family size has a negative coefficient which implies that the higher the family size of a farmer, the lower his chances of adopting new agricultural technologies. Similarly, the annual farm income, frequency of extension contacts and sensitization through the mass media have a positive influence on the adoption of new agricultural technologies. Availability of markets has a negative influence on technology adoption. However, not all the variables are significant. Sex, marital status, farm size and annual farm income are significant socio-economic factors. This is in consonance with the findings of Bello, et al. (2012), Orisakwe and Agomuo (2011) and Uaiene, et al. [13]. The significant institutional factor as revealed by table 4 is the frequency of contact with extension agents. This is also in consonance with the findings of Orisakwe and Agomuo (2011).

4. CONCLUSION

The study revealed that the core socio-economic factors that affect the adoption of new agricultural technologies are sex, marital status, farm size and annual farm income while the frequency of contact of extension workers with co-operative farmers is a major institutional factor that affects the adoption of new agricultural technologies. This conforms with the findings of Sulo, Koech, Chumo and Chepng'eno [14], Adedjeji, Nosiru, Akinsulu, Ewebiyi, Abiona and Jimoh [17] and Orisakwe and Agomuo (2011). All hands

therefore should be on deck to encourage the adoption of agricultural technologies since such a step is aligning the right direction to promote food security.

5. RECOMMENDATIONS

Based on the findings of the study, the following findings were made;

1. Extension services should be improved by the Agricultural Development Programme. There should be at least two extension agents to each community who should visit the farms regularly and expose the farmers to the latest agricultural technologies through Small Plots Adoption Trials (SPATS) and On-Farm Adaptive Research.
2. The extension service workers in ADP should enjoin individual farmers to form effective groups (Co-operative Societies) for easy diffusion of the agricultural technological innovations.
3. Farmers should be persuaded by the extension workers in ADP to attend agricultural exhibitions where the farm outputs of the new technologies are displayed together with the outputs of the old technologies so that they can see the obvious difference and adopt the new technologies especially those who are retrogressive to changes (the late majority and Laggards).
4. Seminars, workshops and symposia should be organized by ADP and secondary co-operative societies to make the farmers understand the importance and correct usage of new agricultural technologies.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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