

**EFFECT OF CONNECT POTATO VARIETY ON FARM PRODUCTIVITY IN
PLATEAU STATE, NIGERIA**

BY

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CERTIFICATION

This is to certify that this thesis has been read and approved as meeting the requirement of the Department of Agricultural Economics and Farm Management, University of Ilorin, Ilorin, Nigeria, for the award of Doctor of Philosophy (Ph.D.) degree in Agricultural Economics.

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DEDICATION

This thesis is dedicated to God Almighty and to my Parents who sacrificed all for me.

DECLARATION

I, **OJEDIRAN, EZEKIEL OLAMIDE**, a Ph.D. student in the Department of Agricultural Economics and Farm Management, University of Ilorin, Ilorin hereby declare that this thesis entitled “Effect of Connect Potato Variety on Farm Productivity in Plateau State, Nigeria” submitted by me is based on my actual and original work. Any materials obtained from other sources or work done by any other persons or institutions have been duly acknowledged. In addition, the research has been approved by the University of Ilorin Ethical Review Committee.

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TABLE OF CONTENT

Certification	ii
Dedication	iii
Declaration	iv
Acknowledgement	v
Table of Content	vii
List of Tables	xi
List of Figures	xii
Abstract	xiii
1.0 INTRODUCTION	
1.1 Background to the study	2
1.2 The Connect Potato variety	6
1.3 Statement of the problem	8
1.4 Objectives of the study	10
1.5 Justification of the study	10
1.6 Organization of the study	11
2.0 REVIEW OF LITERATURE	
2.1 Concept of Agricultural Technology Usage/Adoption	12
2.1.1 Factors affecting the usage of Agricultural Technology	13
2.1.2 Measuring Usage of Agricultural technologies	18
2.1.3 The Heckman selection model	20
2.2 impact Evaluation	22
2.2.1 Methods of impact Assessment	23

2.2.1.1 Qualitative approach	23
2.2.1.2 Quantitative approach	23
2.2.2 The Propensity Score Matching (PSM)	25
2.2.3 Counterfactual in Impact analysis	27
2.3 Farm profitability Analysis of small-scale farming	29
2.4 Efficiency in Agricultural production	29
2.4.1 Technical Efficiency	30
2.4.2 Methods of measuring Technical Efficiency	31
2.4.3 The Stochastic Production Frontier	32
2.4.4 Previous empirical studies on efficiency in Agriculture	33
2.5 The Student's t-test	36
2.6 The Likert Scale	37
2.7 Theoretical framework	37
2.7.1 The innovation diffusion theory	38
2.7.2 The theory of social change	40
2.8 Conceptual Framework	41
3.0 METHODOLOGY	
3.1 Study area	44
3.2 Population, sample size and sampling method	46
3.3 Method of data collection	47
3.4 Analytical Techniques	48
3.4.1 Descriptive statistics	48
3.4.2 The Heckman Selection model	48

3.4.3 Productivity measurement	50
3.4.4 Gross margin Analysis	51
3.4.5 Stochastic production frontier	52
3.4.6 Student's t-test of significance	55
3.4.7 Estimating the Effect of the Connect Potato variety	56
3.4.7.1 The Propensity Score Matching	56
3.4.7.2. Identifying the perceived benefits of the Connect potato variety	
3.5. Limitations of the study	58
4.0 RESULTS AND DISCUSSION	
4.1 Potato Farm/Farmer's Characteristics	59
4.1.1 Demographic Characteristics of the Farmers	59
4.1.2 Socio-economic Characteristics of the farmers	63
4.1.3 Potato Farm Input Characteristics	67
4.1.4 Farm Output/Sales Characteristics	74
4.2 Level of Connect potato variety usage	76
4.3 Factors Affecting Level of Usage	77
4.3.1 Decision to use the Connect Potato variety	78
4.3.2 Factors affecting the intensity of usage of the Connect potato variety	79
4.4 Analysis of the Total Factor Productivity of the farmers	81
4.5 Profitability Analysis	82
4.6 Analysis of Efficiency of the Farmer	83
4.6.1 Analysis of the LR-test for the choice of production function	83
4.6.2 Analysis of Levels of Efficiency of the Farmers	84

4.6.3 Determinants of Efficiency of the Farming Households	85
4.6.4 Determinants of production inefficiency	87
4.7 Effect of the Connect Potato Variety on Farm Productivity	89
4.7.1 Parameter estimates of the propensity score matching	89
4.7.2. Perceived Benefits of Using the Connect Potato Variety	91
5.0 SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS	
5.1 Summary of major findings	93
5.2 Conclusion of major findings	98
5.3 Policy recommendations	98
REFERENCES	99
QUESTIONNAIRE	111

LISTS OF TABLES

Table 1: General overview description of the Connect potato variety	7
Table 2: Sampling Design Outlay	47
Table 3: Distribution of respondents by Demographic Characteristics	59
Table 4: Distribution of Respondents by Socio-economic Characteristics	63
Table 5: Distribution of Respondents by credit access, sources and amount	66
Table 6: Distribution of Respondents by potato variety cultivated, quantity, source and cost	68
Table 7: Distribution of Respondents by land size cultivated and tenure system practiced	70
Table 8: Distribution of Respondents by quantity of fertilizer used	71
Table 9: Distribution of respondents by quantity of agrochemicals used	72
Table 10: Distribution of Respondents by labour usage	73
Table 11: Distribution of farmers by farm output, output price and sale outlet	74
Table 12: Distribution of farmers based on intensity of usage of the Connect potato variety	76
Table 13: Factors affecting usage and the intensity of use	77
Table 14: Result of Analysis of the Total Factor Productivity Indices	81
Table 15: Costs and return to potato farming among the Connect users and non-users	82
Table 16: Generalized Likelihood Ratio Test of Hypothesis	83
Table 17: Distribution of the Connect users and non-users by technical efficiency indices	84
Table 18: Maximum Likelihood Estimates of the Stochastic Frontier Function of Farmers	86
Table 19: Determinants of production inefficiency	87
Table 20: Estimated impact parameters using the three different matching algorithm	89
Table 21: Perceived benefits derived from the Connect Variety	91

LIST OF FIGURES

Figure 1: Potato yield statistics	8
Figure 2: The Conceptual Framework	43
Figure 3: Map showing the study area	45

ABSTRACT

In a bid to overcome the challenge of potato blight disease that has greatly lowered potato productivity in Nigeria, the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) project in collaboration with the National Root Crops Research Institute, introduced the Connect potato variety. The Connect potato variety is high yielding, blight resistant with a large tuber size and highly palatable. However, there is dearth of information on whether it has had any impact on potato farming or not. This study therefore examined the effect of the Connect potato variety on farm productivity in Plateau State, Nigeria. The objectives of the study were to: (i) estimate the level of usage of the Connect potato variety; (ii) identify the factors affecting the usage of the variety; (iii) compare the level of farm productivity of the two categories of farmers; (iv) compare the production efficiency of Connect potato variety with the local variety; (v) estimate the costs and return to potato production between the Connect users and non-users; and (vi) determine the effect of the Connect potato usage on farm productivity.

The target population was potato farmers in the state. A two-stage sampling technique was used to draw a sample of 302 respondents from a total population of 10,213 potato farmers in the eight producing Local Government Areas. From the selected 302 respondents, 74 of them were users of the Connect variety while 228 were non-users. Cross-sectional data was used and were collected using a well-structured questionnaire. The statistical tools used for analysis were Heckman selection model, stochastic frontier model, total factor productivity index, gross margin analysis and the propensity score matching.

The findings of the study were that:

- i. the average quantity of Connect potato variety planted by the users was 1485kg/ha which is low when compared to the required 3000kg per hectare;
- ii. the amount of credit (t-value = 3.39; $p < 0.01$), Connect seed price (t-value = 1.69; $p < 0.1$), membership of association (t-value = 1.91; $p < 0.05$), off-farm income (t-value = 1.66; $p < 0.1$), perception of variety's relative importance (t-value = 2.33; $p < 0.05$) and availability (t-value = 8.67; $p < 0.01$) were the factors affecting the usage of Connect potato variety;
- iii. the Connect users had a significantly (t-stat = 2.37; $p < 0.05$) higher total factor productivity index (4.94) than the non-users (3.92);
- iv. the mean technical efficiency of the Connect users (88%) was significantly higher than that of the non-users (77%) (t-stat = 4.516; $p < 0.01$);
- v. the profitability estimates showed that the users and non-users have a gross margin of ₦1,869,122.1 and ₦722,040.79 per hectare, respectively; and
- vi. the users were better off in productivity by 1.09 units (t-stat = 2.00; $p < 0.05$); technical efficiency by 12% (t-stat = 4.16; $p < 0.01$) and returns on capital invested by ₦1.34 (t-stat = 3.86; $p < 0.01$).

The study concluded that the use of Connect potato variety improved the productivity of potato farms and therefore recommended that farmers be encouraged to adopt the variety through effective sensitization programmes by the Ministry of Agriculture and other relevant agencies.

CHAPTER ONE

1.0

INTRODUCTION

1.1 Background to the Study

Solanum tuberosum also known as potato is an important staple in the diet of many. It ranks fourth after rice, maize and wheat in the world's staple consumption and has been reported to play a pivotal role in human diet, food security and livelihood of hundreds of millions of people (WFP, 2013; Ayuba and Kitsche, 2014; Anoma and Thamilini, 2016). These potentials lie in its distinct nutritional content, availability for finished food as well as its agronomic characteristic. The crop's short gestation period of about 3-4 months is well suited to accommodate more than the double cropping cycle in most parts of the world particularly in rain-fed systems. Harvestable tubers are available within 60-120 days which is a significant advantage over most grains, which require four to nine months (Ayuba and Kitsche, 2014). Furthermore, Potato has been found to be an important crop for periods between harvests when people lack enough food to satisfy their hunger and meet their basic calorie and nutritional needs (Scott, Rosegrant, and Ringler 2000; Chuwang, 2014; Ndor, 2016). All these competitive advantages have over the years triggered a rapid increase in its production, especially in the developing world as it is now being cultivated in more than 155 countries and over a billion people consumes it daily (Agriculture and Horticulture Development Board; Anoma and Thamilini, 2016).

At inception, potatoes were mostly cultivated and consumed in the developed world (North America, former Soviet Union countries and Europe) until the early 90s when other places of the world like Asia, Africa and Latin America took on its production on a commercial scale (Bruinsma 2003; Thiele et al. 2010). Since then, output has increased globally from below 30 million tonnes

to over 300 million tonnes over a span of 50 years. It now currently stands at over 388 million tons in 2017 (FAOSTAT, 2018). A greater quantity or percentage of this production came from the developed countries. However, subsequent years after 2005, ushered in a shift in production to the developing worlds with over 180 million tonnes coming from Asia alone (FAOSTAT, 2018). This increase in the developing world's production however, was found to be as a result of the increase in total hectareage farmed as the yield of the developing countries is still below that of the developed world (FAOSTAT, 2018). Average potato yield in developed economies range between 30–40 tonnes per hectare while that of the developing world is within the range 15-20 tonnes per hectare (FAOSTAT, 2018). This yield gap between the developed and developing economies has been reported to represents an opportunity loss of over 400 million tonnes of potato.

According to FAO, (2009), potato in Africa is “cultivated under a wide range of conditions - from commercial farms under irrigation in South Africa and Egypt to intensively farmed tropical highland zones of Central and Eastern Africa, where it is largely a peasant farmer's crop”. Production in Africa has been estimated at about 25 million tonnes in the recent times and found only to contribute less than 10% to the world potato production (FAOSTAT, 2018). About 80% of Africa's potato production is concentrated in the Northern and Eastern Africa with Northern Africa recording the highest production of more than 12 million tonnes in 2016 which accounts for about 52% of Africa production and 3.5% of the world total production (FAOSTAT, 2018). Southern Africa produces an average of 2.2 million tonnes annually. Central Africa and Western Africa records the lowest in production quantity. They are both below the 2 million production mark (FAOSTAT, 2018). Yield in Africa however took another turn as Southern Africa records the highest yield in Africa. It has maintained an almost consistent 30 tonnes per hectare from year 2000 till date (FAOSTAT, 2018). This is followed by the northern Africa and the eastern Africa

having 28 and 13 tonnes per hectare respectively (FAOSTAT, 2018). By implication considering what is observed in Northern and Eastern Africa's production statistics, it can be concluded that increase in hectareage farmed brought about their increased production capability. West Africa records a yield of less than 5 tonnes per hectare which is the lowest as far as yield in Africa and the world is concerned.

The late 19th Century experienced the influx of potatoes into Nigeria through missionary activities (Obigbesan, 1976; National Root Crops Research Institute, 2015). It thrives well in areas with yearly rainfall of 1,000 mm to 1,400 mm and temperature of between 15-25⁰C (Ayuba and Kitsche, 2014). These climatic conditions are well met at Biu Plateau in Borno State, Jos Plateau in Plateau State and at the Mambila Plateau in Taraba State (Lenka *et al* 2008; Dimlong, 2012). However, the majority of Nigeria's production (over 90%) comes from the Jos Plateau (Ayuba and Kitsche, 2014). It has been reported that Plateau state has a sole comparative advantage in the production of Potatoes (Chuwang, 2014; Ayuba and Kitsche, 2014). Potato statistic in Nigeria revealed that its current production only constitutes 4% of Africa's production despite being cultivated on about 300,000ha of land. Also, yield currently stands below 4 tonnes per hectare which is considerably small when equated to the yield of other African countries (Egypt, South Africa, Malawi etc.) or the potential 20 tonnes per hectare that is possible considering the variety cultivated in this part of the world (Ayuba and Kitsche, 2014). The commonly cultivated varieties in Nigeria are Nicola, Diamant, Lady Christyl, Marabel and Caruso (NRCRI, 2017).

Ayuba and Kitsche, (2014) identified the underlying causes of the observed low productivity in the Nigeria's potato sub-sector. These are: disease infestation, lack of clean and certified seeds that are of high vigor, inadequate institutional backing for the sub-sector, small farming scale, limited or poor mechanization, application of poor agronomic practices, inadequate

transport infrastructures, absence of suitable storage facilities and lack of financial resources for investment. However, the key impediment to increasing productivity in the recent times have been identified to be disease infestation (Ugonna, Jolaoso and Onwualu, 2013; Chuwang, 2014; Ayuba and Kitsche, 2014; NRCRI, 2017). The changing climate which now increasingly favours the growth of most diseases, coupled with the poor agronomic practices and the limited availability/use of quality and disease-free potato seed have contributed to the noticeable effect and spread of diseases in Nigeria's potato sub-sector (Ndor, 2016; NRCRI, 2017). The most economically important of all these diseases to potato production in Nigeria is the blight (late and early) disease (Chuwang, 2014; NRCRI, 2014; Ndor, 2016).

The blight disease (late and early) is a fungal disease (Ndor, 2016). The potato blight disease is seed, air and soil borne. Its spread is very rapid and virulent under the right weather conditions thus earning it the name 'community disease' (Johnson, 2010; Ahmed *et al.*, 2015). It has been reported that relative humidity greater than 70% promotes its spread. Its asexual spores are wind borne and travels easily under a cool and moist weather condition. These characteristics gives it a leeway especially in Nigeria where there is no efficient system for development, replication and dissemination of certified seed tubers and where majority of the potato farmers hardly follows the best agronomic practices (Gildemacher, 2009; Demo, et al. 2009; Johnson, 2010; Chuwang, 2014; Ayuba and Kitsche, 2014; Ahmed *et al.*, 2015). The occurrences of blight have always been observed in Nigeria but the rate of recurrence and severity of cases remained in a manageable economic threshold until recently (Chuwang, 2014; Ndor, 2016). The first incidence of this disease that raised the concern of the Nigeria government was in the year 2014 when it was reported to be responsible for the destruction of more than a thousand hectares of cultivated potato farmland (FMARD, 2014; NRCRI, 2014). Increasingly, even areas which previously had no

presence of this disease are now affected and report has made it known that losses associated with the potato late blight (PLB) disease in Plateau State (specifically) is almost a hundred percent in most farms (Ayuba and Kitsche, 2014; Ndor, 2016).

1.2 The Connect potato variety

In light of the fore-going, the “Pro-Poor Growth and Promotion of Employment in Nigeria” (SEDIN) Project in the year 2014, introduced the Connect potato variety which was brought in from Germany as a way of overcoming the late blight disease and increasing productivity. The SEDIN project was implemented by the “German Corporation for International Cooperation” (GmbH) in the year 2011. The “German Corporation for International Cooperation” (GmbH) or “Deutsche Gesellschaft für Internationale Zusammenarbeit” (GIZ) is an enterprise entirely owned and financed by the German Government which also supports it in realizing its goals for sustainable development in its international relations. It started its first phase in Nigeria from April 2011 until July 2014 and the second phase from April 2014 until March 2017 (Sedin-Nigeria, 2017). The target groups of the SEDIN programme are the employees and owners of micro and medium enterprises as well as members of low income households that are economically active. The programme objective was pursued via four units. Among those four units is the promotion of agricultural and non-agricultural value chains which was put in place to diversify the economy and promote productivity. The SEDIN project is interested in three agricultural value chains. These are Sheanut-butter in Niger, Cassava in Ogun and Potato in Plateau State. The SEDIN project considered five objectives with respect to up-scaling the potato value chain in order to achieve the overall project goals and targets. The objectives are to;

- i. increase quality and quantity of potato production in Plateau State;

- ii. strengthen local small-and medium scale potato processing industries;
- iii. improve market linkages along the value chain;
- iv. support an enabling environment for potato cultivation, processing and exports and;
- v. identify new products and markets

In line with these objectives, the Connect potato variety was brought as the first step in achieving the set objectives having observed that the late blight disease is one of the key impediment to increasing productivity (Ayuba, 2012; Ayuba and Kitsche, 2014).

The Connect potato variety is a late blight disease tolerant/resistant potato variety with a light yellowish flesh. It was developed by a potato breeders company in Germany called Solana (Solana, 2017). Connect is high yielding and have a good resistance to a considerable number of diseases. It was brought in into Nigeria in the year 2014 through the SEDIN project. Table 1 shows all necessary information about the Connect potato variety.

Table 1: General overview description of the Connect potato variety.

General description	Connect potato variety
<i>Species</i>	<u>Solanum tuberosum</u> L.
<i>Name of variety</i>	Connect
<i>Origin/Source</i>	Solana, Germany
<i>Type of variety</i>	Hybrid
<i>Pedigree</i>	Proprietary
<i>Releasing organization</i>	NRCRI, Umudike and GIZ
<i>Morphological characteristics</i>	Tall and semi-upright
<i>Adaptation</i>	Mid-altitude (800 – 1500m asl), low temperature condition (max. 15°C night temperature for two months).
<i>Days to maturity</i>	90 – 110
<i>Potential yield</i>	21 tons/ha
<i>Pest and disease reaction</i>	Resistance to late blight, bacterial wilt and viruses
<i>Outstanding characteristics</i>	Large tuber (size:> 50mm in diameter and high tuber yield)

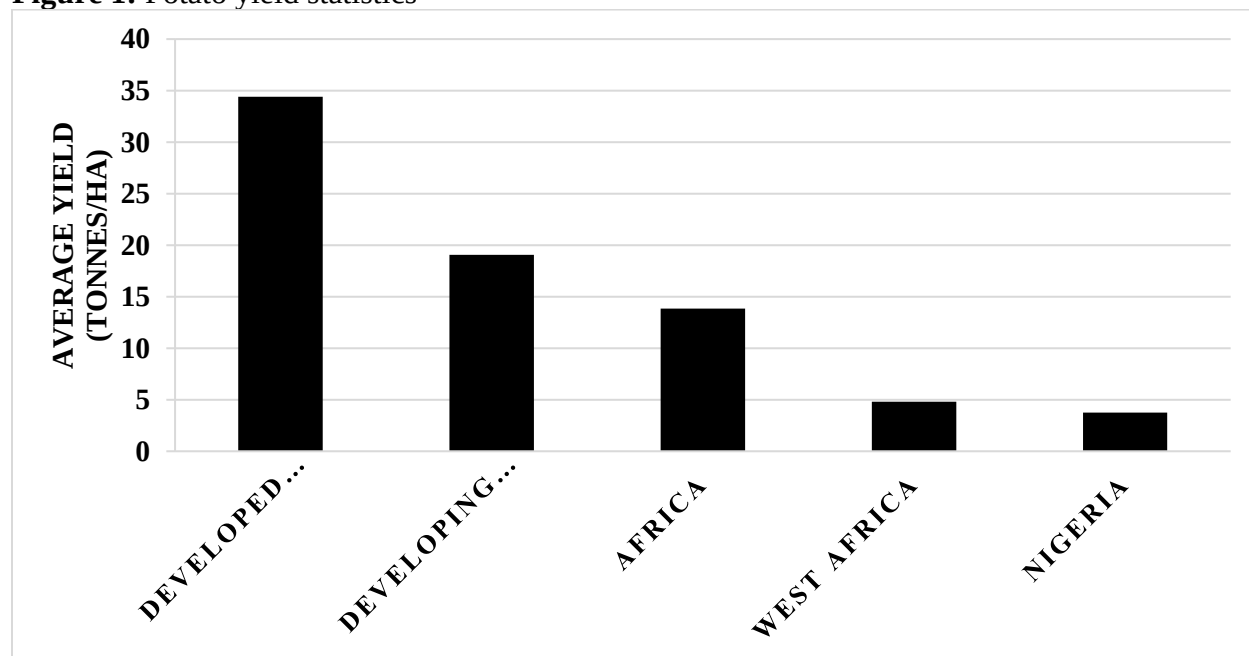
Tuber quality	Dry matter: 17%
	Moisture: 79.2%
	Crude protein: 1.52
	Crude fibre: 1.10
	Ash: 0.8%
	Carbohydrate: 12.4%

Source: NRCRI Farm Trial Report, 2015;
["https://www.solana.de/kartoffelsorten-detail_en/items/connect.html"](https://www.solana.de/kartoffelsorten-detail_en/items/connect.html)

1.3 Statement of the problem

The increasing set-back to development in the Nigeria potato industry has over the years made it impossible to maximize its potentials to attaining self-sufficiency, food/nutritional security and eradication of poverty in Nigeria. This sub-sector is so under-developed that it currently records the lowest yield in Africa and in the world as seen in figure 1.

Figure 1: Potato yield statistics



Source: FAOSTAT, 2018

Despite been cultivated on over 300,000Ha of land, harvest volume of potato barely represents 1.5% of the total output of all staple crops in Nigeria annually making its contribution of marginal relevance for the overall food safety. Exacerbating this low productivity issue is the pressure put on supply by the increasing population, changing consumption pattern and demand for finished food so much that Nigerians now have to pay more than necessary for potatoes relative to other staple crops.

The growing demand for potatoes combined with the observed low productivity potentials and the ever increasing climate change impacts is a clear call for strategies that are directed towards improving yield. To this end, the “Pro-Poor Growth and Promotion of Employment in Nigeria” (SEDIN) Project in 2014, introduced the Connect potato variety. It is of the claim that this new variety is not only resistant to the late blight disease but also of a higher yield creating a pathway to bridging the observed demand-supply gap and by extension maximizing its potentials to ending poverty and hunger. However, these claims have not been empirically established making this study particularly imperative to filling the existing gap in knowledge on the effect this new variety has and can potentially have on the performance of potato farming in Plateau State. The above discussion therefore raises the following research questions:

- i. What is the intensity of usage of the Connect potato variety?
- ii. What are the factors affecting the usage of the Connect potato variety?
- iii. What is the level of farm productivity of the Connect variety users and the non-users?
- iv. Do Connect potato production differ from the local variety in terms of technical efficiency?
- v. Is the returns to investment of Connect potato users better-off than those of the non-users?
- vi. What is the effect of the Connect potato variety usage on farm productivity?

1.4 Objectives of the study

The general objective is to examine the effect of the Connect potato variety on farm productivity in Plateau State.

The specific objectives are to:

- i. estimate the intensity of usage of the Connect potato variety;
- ii. identify the factors affecting the usage of the Connect potato variety;
- iii. compare the level of farm productivity of the Connect variety users and the non-users;
- iv. compare the efficiency of production of the Connect potato users and non-users;
- v. compare the costs and returns to production among the Connect users and non-users; and
- vi. assess the effect of the Connect potato variety on farm productivity.

1.5 Justification of the study

The development of a cost-effective, vibrant and viable potato subsector in Nigeria, hinge on ways to surmount a number of tenacious limitations. These measures include developments of quality planting materials that are resilient in the face of climate changes, better access to credit, production inputs and markets, and farming systems that improves sustainable use of natural resources. As disease infestation is among the prominent problems currently facing the production of potato in Nigeria, the result of this study has brought to light empirically if and just how far the newly introduced variety in question has solved this prevailing problem in the sub-sector. This is particularly crucial as getting rid of this problem will contribute immensely to reconnoitering its potentials.

This study is also relevant as it recommends strategies needed to enhance the diffusion and usage of this particular variety among the potato farmers which would eventually improve livelihood. This is more so as agriculture still remains the mainstay of most rural households in the State. This is necessary for reducing income poverty and food insecurity in Nigeria.

Finally, this study is a blue-print for policy makers to design effective policies, intervention and technological innovations in this sub-sector *vis-a-vis* the Agricultural sector in general. If Nigeria will overcome the present economic down-turn, it is important to ensure proper resource allocation and management that would fosters growth and development especially in the Agricultural sector.

1.6 Organization of the study

“ This thesis is divided into five (5) chapters. The contents of the remaining chapters are as follows.

Chapter two (2) is on the review of literature where the empirical, theoretical and reviews on impact assessments studies were presented. This chapter also includes the analytical reviews of the tools that were used in this study. This chapter ends with the conceptual framework used for the study.

Chapter three (3) presents the methodology for this study. This includes the description of the study area, the process of data gathering, survey and sampling procedures and the analytical techniques adopted for this study.

Chapter four (4) presents the results and relevant discussions of the study.

Finally, chapter five (5) presents the summary of the study, inference and recommendations for improvement and policy making”.

CHAPTER TWO

2.0

REVIEW OF LITERATURE

2.1 Concept of Agricultural Technology Usage/Adoption

Agricultural technologies embraces all manners of enhanced techniques, inventions or practices which when applied, improves Agricultural productivity as well as get things done easily, faster and in a cost-effective manner. This includes machineries, implements, improved agronomic practices or the usage of improved farm inputs (Jain *et al.*, 2009). The most prominent areas of technological growth in crop production includes new/improved crop varieties; management practices in soil fertility; control of pest, disease and weeds and water usage and irrigation practices (Loevinsohn *et al.*, 2013). According to Challa, (2013), the use of Agricultural technologies have a higher tendency to increase productivity as well as increase farmer's income.

Adoption has been defined by various authors. Loevinsohn *et al.*, (2013) defined it as the incorporation of a new and improved way of doing things (technology) into a current practice. He explained further that this process in most cases, is customarily preceded by a “trying” period and some form of alteration and adaptation. Feder, Just and Zilberman (1985) described adoption as a lucid process that an individual passes through when he is first informed about an invention to the ultimate stage when he uses it.

Understanding adoption has been categorized into two parts for the sake of understanding. These are: rate of adoption and the intensity of adoption. Rate of adoption talks about the speed with which an innovation is adapted and applied. This considers “time” as a factor i.e how fast or slow an innovation is used. The intensity of adoption on the other hand talks about the level at which a given innovation is used at any time period (Bonabana-Wabbi 2002). Adoption of improved Agricultural innovations has been linked with food security, reduced poverty, stable

socio-economic stand, increased productivity, better farm returns, lowered food prices, increased and sustained nutritional status and source of employment for landless laborers (Loevinsohn *et al.*, 2013). It should be noted that for the purpose of this study, the rate of adoption which is based on the element of time was not considered but rather in terms of use and disuse of the variety in question. As a result, the use of the term “level of use or usage” or “adoption” interchangeably should be understood as having the same meaning for the purpose of this study.

2.1.1 Factors affecting the usage of Agricultural Technology

According to Loevinsohn *et al.*, (2013), “farmers judgment on if and what level to use a new invention or an innovation are habituated by the dynamic relations between features of the invention or innovation itself and the range of circumstances. Diffusion itself comes from a succession of individual choices to initiate using the new technology, choices which are often the outcome of appraisal of the ambiguous benefits of the new invention with the unknown costs of using it (Hall and Khan, 2002). An understanding of the dynamics manipulating this choice is vital both for economists revising the elements of growth and for the creators and disseminators of such technologies” (Hall and Khan, 2002). “Conventionally, economic analysis of technology usage has hunted to elucidate actions relative to individual characteristics and endowments, flawed facts, threats, ambiguities, institutional restraints, input availability, and infrastructure” (Uaiene, 2009; Rogers, 2003; Kohli & Singh 1997; Foster & Rosenzweig 1996; Koppel 1994 and Feder *et al.* 1985). Although, some studies classified these factors into diverse groupings (Lavison 2013; Akudugu *et al.* 2012; Wu and Babcock, 1998; McNamara, Wetzstein and Douce 1991 & Nowak, 1987), there is no obvious distinctive characteristic amongst variables in each group. “Groupings is done to ensemble the technology being investigated, the location, and the researcher’s preference” (Bonabana- Wabbi 2002). This study did not review the factors determining usage of

agricultural technology by categorizing them but rather individually. This will enable an in-depth review of the potential effect of each factor. From literature, these factors are:

i. Association or cooperative societies membership

Social groups like farmer's associations and cooperatives societies are one of the major platforms for information exchange among farmers. This is because knowledge about the existence of a technology, the work-how and its benefits are easily conveyed amongst farmers in a social group. (Uaiene *et al.* 2009; Mignouna *et al.*, 2011). According to the findings of Bandiera and Rasul, (2002); Katungi and Akankwasa, (2010), adoption is faster among farmers in a social group than those that are not. So also, joining a social group can discourage adoption at some point. A group that do not accept an innovation will eventually influence all new and existing members to reject also. It may even be a personal decision of the adopters to discontinue use so as not to be what is termed "a social prier"

Technology awareness

The availability of information about the existence of a new technology/innovation elucidates it and makes it accessible and useful to farmers. Information brings to minimum the vagueness about the performance of an innovation/technology which will enable individual to understand a technology not just from their personal view points but also from the view point of others (Caswell *et al.*, 2001). Farmer's decision are principally molded by the availability of information. They come to a stage of consideration whether to adopt or reject an innovation (Feder & Slade, 1984). However, adoption may also be deterred with increase in information if the experience from usage of others about an innovation is limited. This may be because increased information about an innovation that has been less adopted may all present it as been very risky and unprofitable to adopt.

ii. *Frequency of extension contact*

How frequent farmers are visited by extension workers has also been observed and reported to contribute immensely to the adoption of innovation. Awareness, benefits and technical know-how on technological operation are all the package made available to farmers through extension contacts. They (extension agents) serve to connect the innovators to the final consumer in the most cost-effective manner (Genius *et al.*, 2010). To do this, extensionists usually have and target their information at a focal person (one that all other farmers can approach to seek direction and information) who would probably be an early adopter and a direct or indirect knowledge bank for other farmers in an area (Genius *et al.*, 2010; Akudugu *et al.* 2012; Mignouna *et al.* 2011; Uaiene *et al.*, 2009; Serunkuuma, 2005; Nkonya *et al.*, 2004). In the same vein, studies have also shown that frequency of extension contact has made obsolete new innovations and not triggering adoption at all (Mkandawire, 1993). This can be as a result of many reasons ranging from the inability of the extension agent to appraise well what they bring to the farmers to the ideology of the farmers which can be a barrier to the type of innovation brought.

iii. *Access to credit*

“Adoption has also been reported to change as a result of change in farmer’s credit status (Mohammed & Temu, 2008). By relaxing the liquidity constraints faced by farmers, access to credit has been seen to promote the adoption of innovation which may have been considered otherwise risky. Credit availability increases the risk bearing attitude of farmers (Simtowe & Zeller, 2006). This is because the option of credit opens the farmers to better and efficient farming enterprise options which are more productive to them”. On the other hand, adoption has been

discouraged in some places that are gender biased to making credit available. Female headed households finds it difficult to get credit and as a result, lessen their possibility of adoption (Muzari *et al.*, 2013).

iv. Level of Education

Farmer's level of education has been found to increase the likelihood of adoption. This is because education improves farmer's capability to seek, acquire, process and utilize information as it pertains to a particular innovation (Lavison, 2013; Namara *et al.*, 2013; Mignouna *et al.*, 2011; Okunlola *et al.* 2011; Ajewole 2010). Attitudes and thought patterns are changed by education. They become more analytical, rational which will eventually lead them to making informed decisions (Waller *et al.*, 1998). Education has been found to ease both the introduction and implementation of an innovation (Adebiyi & Okunlola, 2010). In the same vein, studies have also shown that education can be a hindrance to adoption (Ishak and Afrizon, 2011; Uematsu and Mishra 2010; Samiee *et al.*, 2009; Banerjee, *et al.*, 2008; Khanna, 2001 & Grieshop *et al.*, 1988).

v. Age

Age is also considered one of the prime movers of adoption. The experience gained by older farmers gives them a better chance and ability to appraise an innovation rightly than the younger ones (Mignouna *et al.*, 2011; Kariyasa and Dewi 2011). In the same vein, the negative contribution of age to adoption of innovation has also been made clear by some studies (Mauceri *et al.*, 2005; Adesina & Zinnah, 1993). It was also explained that risk aversion increases with age making older farmers forgo innovation (Alexander and Van Mellor, 2005).

vi. Sex

“Gender issues in adoption has been a point of controversy since time immemorial (Bonabana-Wabbi, 2002). Morris and Doss, (1999) in their study reported that there is no relationship between gender and the probability of adoption of Agricultural technology. Some studies has also showed that men as household head due to the fact that they are in control of the household resources are more likely to adopt agricultural innovation” (Tesfaye *et al.*, 2001; Mesfin, 2005; Mignouna *et al.*, 2011; Obisesan 2014).

vii. Household size

“Considering household size as a factor that affect adoption is a two way ride according to Mignouna *et al.*, (2011) and Bonabana- Wabbi, (2002). It is believed that the higher the household size, the more available labour will be to reduce the constraints accrued to adoption of a new technology. It is also believed that a large household size can be a motivating factor to adopt an innovation when farmers seek to increase his production capacity so as to meet family needs. On the other hand, adoption may also be discouraged as the farmer will not want to risk the little capital base he possess to feed his large family”.

viii. Farm size

Farmsize has also been found to affect technological adoption. Some studies, Omotosho, (2016); Kasenge, (1998) reported a positive relationship between them. Some has also observed a negative influence (Yaron, Dinar and Voet, 1992). Still some reported no significance whatsoever (Mugisa-Mutetikka *et al.*, 2000). Farmsize has been known to affect the cost of adoption, human capital, risk perception, labour, credits etc. The higher cost required to use a technology in a larger farm size, most times discourages farmers from usage (Abara and Singh, 1993).

ix. Cost accrued to adoption

Most innovations comes at a cost and this accrued cost has also been reported to influence adoption. Farmers with large capital base have the ability to go for innovations that are capital intensive while those that have a small capital base, goes for the cheap ones (El Oster and Morehart, 1999; Khanna, 2001).

x. Non-farm Income

Non-farm income also affects adoption. Farmers having other source of income often have the capital base to adopt new technology while those without don't (Mwania *et al.*, 1989). It is also possible that as a result of this non-farm income, farmers might be satisfied with their income potentials and never bother to go for a new innovation in farming.

2.1.2 Measuring Usage of Agricultural technologies

The expectation of maximum utility and profitability are the major factors assumed to influence farmer's decision to adopt a technology at a given time period. As a result, the usage of Agricultural technology/innovation is first subject to farmer's choice and then the level of resources at his disposal (Feder *et al.*, 1985). Over the years, static models of estimations have been adopted to provide answers as to if a particular innovation/technology would be used and also the level or intensity at which it is used. This is because static models takes into account the decision of farmers to use an innovation or not, factors that affects usage and the determinants of usage pattern at a given time period (Ghadim and Pannell, 1999). Therefore, given that this study used a cross-sectional survey data, the best static model approach was considered and used.

The Logit and probit models has since time past been the static binary settings used in adoption studies (Polson and Spencer, 1991; Jansen, 1992). These, merely uses a dichotomous

decision style that captures whether a farmer uses a technology or not. “This involves a functional relationship between a group of potential determining regressors and the likelihood of usage of the technology which is econometrically estimated utilizing the logistic distribution for Logit and the normal distribution for the probit”. The Probit/Logit procedure checks if there are significant relationships between a group of explanatory variables and the choice to use a technology or not. However, this does not take into account or measure the level/intensity of usage of the technology. It basically categorizes a farmer that utilized a technology once in a season as the same to a farmer that utilizes the technology more than once in the same farming season. To explain further and clearer, if a Logit model is utilized to analyse data on Agrochemical usage, a farmer who made use of the required level of chemical is treated equal as one who applied less than required (Ghosh, 1992). There are other static methods of analyzing such data. This is the Tobit model analysis (Tobin, 1958). It is used to analyse quantifiable decisions to use an innovation or technology when information on usage level is accessible (e.g amount of input used or percentage of land area cultivated etc). Using a continuous dependent variable like in the above example gives room for zero values for some of the data point which signifies those that did not use the technology at all. When this happens, there is need for censoring which the Tobit model catered for in its estimation. However, “the short-fall to using the Tobit model for this study is that the Tobit model enacts limitations that the variables and coefficients determining whether and how much to use decisions are identical which is not so in reality” (Dong and Saha, 1998). This was refuted by the studies of Craig, (1971) and Coady, (1995) who explained in their findings that such decisions are not closely interrelated. As a result, other alternatives was looked into which cater for this weakness because it is paramount to be careful in selecting the model of estimation to be used as it influences the type of result we get (i.e a biased result if data are misappropriated) (Amemiya, 1984). This is

in the use of the Double-Hurdle model (DHM) of estimations (Cragg, 1971; Heckman, 1976). The Heckman two-step selection model is the most restrictive of the DHM. This is because it assumes that none of the zeros for the non-users are caused by the adoption decision (i.e first hurdle dominance) such that a typical Tobit censoring is irrelevant (Jones, 1989). Therefore, the Heckman two-step model was adopted for this study to determine the factors affecting farmer's decisions to use and also the level of usage of the Connect potato variety.

2.1.3 The Heckman selection model

The Heckman selection model was originally formulated by Heckman (1979) and it allows dealing with the censoring problem and by modelling the decision process in two steps. “The first step normally involves running a Probit or Logit regression which measures the household's choice whether to use a technology or not while the next step involves the Ordinary Least Square regression which then determine what influences the optimal adoption level decisions of the farmers in the study area (Blundell and Meghir, 1987). The problem of non-usage/adoption of the Connect potato variety can be viewed as a subject of sample selection bias (Heckman, 1979). “The decision to use or dis-use represents sub-samples of the total households. Sampling centered on the categorization of respondents into users and non-users/adopters can yield a non-random sample. For example, a farmer that do not use this variety as a result of unavailability and those that are unwilling to use can result in sample selection bias. This means that farmers who could access the Connect variety can be differentiated from those that have no access. Heckman developed a two-stage assessment technique that gives results that have a consistent parameter estimates (Heckman, 1979)”. The Heckman's two-step analysis also correct for specification error (censored sample problem) by estimating the omitted variable λ_i . It is always presented as the

inverse mill ratio (IMR) and is estimated using the Probit analysis. Thus the stage one of the Heckman estimation gives the estimates parameters of the IMR as well as the regressors. This is done by the log-likelihood function of the Probit model being maximized. In the stage two of the Heckman estimation, λ_i is added to the regressors of the ordinary least squares (OLS) estimation of level of usage for respondents that used the Connect variety ($Z > 0$). The parameters gotten from the stage two of estimation are asymptotically normal and consistent. If the IMR is significant, it implies the presence of selection bias. A significant inverse Mill's ratio shows that selection bias is present. The decision by a household to use the Connect variety has been shown to be influenced by a number of household characteristics" and can be represented by the following equation:

$$Z_i^* = \gamma'X_i + U_i \quad (1)$$

"Where Z_i^* is a dummy variable representing the household access to the Connect potato variety. Therefore Equation (1) estimates the probability that the i th household uses the variety. X_i is a vector of exogenous household variables affecting Z_i^* . Z_i^* is unobservable, but we can observe if a uses the Connect variety or not. X denotes parameters to be estimated. Household features have also been shown to sway the intensity of usage. Hence in the second stage of estimation, quantity per hectare of the Connect variety is regressed on various household characteristics". Given that $Z_i = 1$, we have the following:

$$Y_i = \beta'w_i + v_i \quad (2)$$

"Where Y_i represents the intensity of use by each household, w_i is the vector of variables which determine intensity of use, and β refers to the parameters to be estimated. In Equations (1) and (2), u_i and v_i have bivariate normal distributions with zero means, standard deviation δ_u and δ_v , and they are associated with correlation coefficient ρ (Nguyen, 2011). It is assumed that Z_i and X_i are both observable for a random sample of individual households". However, Y_i is observed only

when the household uses the Connect variety ($Z_i = 1$). From Heckman (1979), the expected intensity of use equation may be expressed as follows:

$$E(Y_i|Z_i = 1) = E(Y_i|Z_i^* > 0) = E(Y_i|U_i > \gamma'X_i) = \beta'w_i + E(v_i|u_i > \gamma'X_i) = \beta'w_i + \beta\sigma_v\lambda_i(\alpha_u) \quad (3)$$

Where

$$\lambda_i(\alpha_u) = \frac{\varphi(\alpha_u)}{1 - \phi(\alpha_u)} = \frac{\varphi(-\alpha_u)}{\phi(\alpha_u)} = \frac{\varphi(\gamma'X_i/\alpha_u)}{\phi(\gamma'X_i/\alpha_u)} \quad (4)$$

The function $\lambda_i(\alpha_u)$ is referred to as the inverse Mill's ratio. When this is absent from an Ordinary Least Square estimation of Y_i on w_i , the resulting β estimators will be inconsistent. Another way to rid this problem is by including the error term. However, since it cannot be estimated in the Heckman model, the IMR must be calculated and incorporated in the equation as shown by equation 2. The density and distribution function are given as φ and ϕ respectively.

2.2 Impact Evaluation

There is a growing realization among governments and non-governmental organizations in the recent times that critical appraisals of social interventions must have a place in the processes of decision making in social policies. Given the increasing financial constraints on developing countries of which Nigeria is one, it is becoming all the time more imperative to justify public spending and certify that the already implemented and financed interventions are realizing their envisioned goals. It is imperative to know if and how far an intervention is advantageous to its target population and how cost-effective it is in its implementation and sustainability. This is actually the sole most critical policy question that needs to be answered if and if the limited resources that are available will not be wasted. This and possibly other related questions is what makes up impact evaluation. Other questions that is usually answered during impact evaluation studies are also to shed light on the prime movers responsible for its effectiveness and if not

effective, the factors that are responsible for this too. It basically provide necessary information to policy makers on what to do, why it should be done and how to do as it relates to public policies. Impact is a degree of modifications made and impact assessment seeks out to institute an underlying link between inputs and changes in relations to magnitude (IFRC, 2011). “Impact evaluation evaluates the changes that can be ascribed to a specific intervention, such as a project, programme or policy, both the intended ones, as well as the unintended ones” (World bank, 2008; Organization for Economic Co-operation and Development, 2014; White, 2006; Gertler, 2011).

2.2.1 Methods of impact Assessment

The approaches used to assess impact of an intervention has been categorized into two. These are:

- Qualitative approach and
- Quantitative approach.

2.2.1.1 Qualitative approach:

According to Khandler, Koolwal & Samad, (2010), the qualitative approach involves understanding the socio-cultural and institutional context, as well as intervention and beneficiaries’ details. It can help in the identification of mechanisms through which interventions might be having an impact and also identify personnel who would be important in determining the course of how programmes are implemented, thereby aiding operational evaluation. Nevertheless, a qualitative assessment used independently cannot assess outcomes against counterfactual outcome.

2.2.1.2 Quantitative approach:

This involves the use of numerical analyses to determine the aggregate change in outcomes of a specific group of individuals that can be ascribed to a specific intervention via a realistic and

fitting methodology to appraise enquiries (Khandler *et al*, 2010). The quantitative method approach is divided into two based on the time frame in an intervention programme. These are:

- a. ***Ex ante impact analysis (before and after)***: It comprises doing a probable investigation of what the effect of an intervention may be if it has been done, so as to enlighten policymaking on if and how to go about implementation (OECD, 2014). In other words, it endeavors to estimate the projected impacts of programmes and policies to be carried out in the future given the present condition of the target population. It begins in the design stage of an intervention and involves the assemblage of baseline, mid and endline data from both participants and non-participants of the intervention
- b. ***Ex post impact assessment (with or without)***: “This part involves the appraisal and management activities of the policy cycle. Largely, evaluation aims to comprehend to what degree and how a policy intervention improves the problem it was envisioned to address which is the focus of this study (OECD, 2014)”. This study took this path of impact assessment as it brought to bare the extent to which the prevailing productivity problem have been solved as a result of the introduced potato variety.

The choice of a particular ex-post impact assessment tool is dependent on the assumption about the kind of possible selection bias in intervention targeting and participation. Various tools have been adopted based on this assumption like the Double difference, Chow test, Instrumental Variable estimation, Regression, Regression Discontinuity, Pipeline comparisons and the Propensity Score Matching. However, the propensity score matching was adopted for this study as it is the most suitable considering the nature of potential selection bias.

2.2.2 The Propensity Score Matching (PSM)

“The PSM is an econometric technique that is used to analyse and access the effect a particular treatment has on a target population (treated). This becomes possible when the covariates that forecasts receiving the treatment is accounted for. It constructs a counterfactual on the conjecture that the statistical spread of the basic features of programme participants and non-participants overlaps. This means that the beneficiaries and the non-beneficiaries are not from two distinctly different population. In a general sense, PSM endeavors to lessen the prejudice that arise from confounding variables that could be observed in an estimate of the treatment effect gotten from merely relating outcomes among components that received the treatment as opposed to those that did not. This method of analysis was first developed and used by Rosenbaum and Rubin in the year 1983, and it executes the Rubin causal model for studies that are observation based (Rosenbaum *et al*, 1983). The likelihood of bias rises because the superficial variance in outcome between these two groups or sets that are compared may hinge on features that affects whether or not a group received the treatment and not due to the effect of the treatment per se. In randomized experiments, the randomization permits balanced estimation of the effects of treatment; for each covariate, randomization infers that treatment-groups will be balanced on average, by the law of large numbers. Regrettably, for observational studies, the allotment of treatments to a target population is typically not random. PSM endeavors to simulate randomization by generating a sample of units that received the treatment which is alike on all observed covariates to those that did not receive the treatment”. The steps involved in implementing PSM are as follows:

- i. Propensity score estimation: The samples of users and non-users are pooled. Then the propensity score is estimated.
- ii. Checking overlap and common support: At this stage, the subcategory of the contrast group that is akin to the treated group is analyzed.

- iii. Choosing a matching technique: “This step involves matching treated and control groups that have identical propensity scores using a suitable algorithm. These PSM algorithms varies in their measure the gradation of similarity between the treated and control groups and also the weight they allot to the matched groups. The common algorithms are: Nearest-neighbor Matching (NNM), Calliper or Radius matching (RM), Stratification matching (SM) and the Kernel matching (KM). They all have their strength and weaknesses. Using farmers with the closest propensity scores, the NNM matches farmer from the user and non-user group which makes the NNM unfavorable in situations where the closest neighbor is far away hence facing the peril of bad matches. However, the Radius algorithm is an improvement over the NNM as it reduces this risk by using caliper matching. The RM enacts a range of acceptable difference in the matched propensity score which is dynamic in its operation. Finally, kernel matching builds counterfactuals by using the weighted averages of all respondents in the users group. This is advantageous in the sense that it produces ATE estimates which have lesser variance as a result of its use of large sample sizes. The present paper uses all three approaches to estimate the effect of the Connect potato variety on farmer’s productivity”.
- iv. Evaluating matching quality: The quality of the matching method is assessed based on its ability to harmonize the user and the non-user groups with the covariates utilized in the estimation of the propensity scores. Rosenbaum and Rubin (1983) “suggested that a good matching technique should lessen the standardized prejudice for each of the covariates used in estimating the propensity scores”.
- v. Effect Estimation: “After the matching has been adjudged a satisfactory quality, the effect is then computed. This may involve calculating the average of the effect of the variance

between the outcome variable in the user and non-user groups. The standard error is also computed before using a t-test analysis to check the statistical significance”.

2.2.3 Counterfactual in Impact analysis

According to Loi and Rodrigues, (2012), counterfactual refers to what the state of beneficiaries/participants would have been if the intervention has not been in existence. Estimating counterfactuals in impact studies can be problematic as it can be an over-estimation or under-estimation of the programme’s effect using the ex-post (with-and-without) or the ex-ante (before-and-after) method approaches. For instance, in using the ex-post method, the observed difference might be as a result of some underlying differences rather than the intervention itself. If decisions are made based on these observations without correcting for these inconsistencies, the result will be biased (Khandler et al, 2010). Therefore, to ensure that the problem of counterfactuals is corrected for in this study, the five principles as propounded by the International Initiative for Impact Evaluation was well considered so as to validate the result of this study. These principles are:

- **Confounding:** “It arises where socio-economic related factors, are correlated with exposure to the intervention and independent of exposure are causally linked to the outcome of interest”.
- **Selection bias:** “It is a case of confounding. It occurs when the outcome of non-participant is taken as a ballpark figure to the outcome the users would have had minus the treatment. This is only acceptable in situations where there are no observable elements which are linked with access or beneficiaries in the intervention”.
- **Spillover:** “It occurs when members of the control group are affected by the intervention. It is referred to as contagion in impact evaluations”.

- **Contamination:** This occurs when beneficiaries and/or non-beneficiaries are involved in other intervention programme.
- **Impact Heterogeneity:** “This denotes the difference in impact due to beneficiary type and context. This principle centers on the degree to which different group, such as the deprived benefit from an intervention and potential effect of the context on impact”.

2.3 Farm profitability Analysis of small-scale farming

Cost-return analysis habitually forms the foundation for farm profitability study. This embroils itemizing the costs and returns of production and utilizing them to work out estimates as the returns to a unit of the resource used, the gross margin, as well as net returns.

Basically, gross margin estimation is commonly used to work out the profitability of small-scale farming. Gross margin also means the gross income (i.e. production value) less variable costs, which are the inputs used. This is because the cost of production of any small-scale farming depends largely on the variable costs while the fixed capital constitutes just an overlooked portion of their farming enterprise (Olukosi & Erhabor, 1998; Olukosi, Isitor & Ode, 2006). Gross income or value of production is production articulated in monetary terms. This comprise of the product was sold, estimated value of that given away, value of those stored and the value of by-products if they are in any way valuable. The variable costs include labour, seed and their planting materials, fertilizer, sprays and sundry farm expenses. The sundry farms expenses cover any other miscellaneous costs incurred by the farmers.

Other profitability ratios that can be derived from cost-returns analysis of small-scale farming are the operating ratio and return on capital investment (Ojo *et al.*, 2011; Usman & Bakari, 2013). “Operating ratio (OR) is obtained by dividing the total operating cost (total variable costs)

by gross income. It shows the proportion of the gross income that goes to pay for the operating costs. The lower the ratio, the higher the profitability of farm business (Ojo *et al.*, 2011; Usman & Bakari, 2013)”. Returns on capital invested is obtained by dividing the gross margin by the total variable cost. The higher the ratio, the higher the profitability of the farm business.

2.4 Efficiency in Agricultural production

The quantity of output gotten per hectare has always been the adopted measure for efficiency. However, in reality, it is known that output is not a function of a single input in farming process but multiple inputs therefore, making this method of measurement rudimentary in its use as it only consider on input factor. The optional way of measuring efficiency is through the use of the traditional econometric analysis, which is of the overall assumption that production processes are always optimized by producers. It should however be noted that there are incongruities between the amount produced and the value of what was produced even if the enterprises have an equal technological limitations which hinges on the diverse productive skills and mis-use of resources by some enterprises (Burhan, Ceylan & Hatice, 2009). Generally, the reason why it is important to transcend the traditional techniques of viewing efficiency to a more detailed method like the frontier is because the traditional techniques of estimations (like the Ordinary Least Square) sees all deviations from optimality as those that arises from random statistical noise. It is however, known that some of this deviations can be as a result of the farmer’s inefficiencies which will not be made obvious when the traditional method of estimation is adopted. Farmers do not always succeed in optimizing their production. As a result, it is appropriate to drive efficiency analysis towards the frontiers method of estimation (Kumbhakar and Lovell, 2000). Thus, production

frontier typifies the least bundles of inputs that is essential to bring about a defined level of output commonly called technical efficiency (Palmer and Torgerson, 1999).

2.4.1 Technical Efficiency

“Technical efficiency can be explained as the marginal fraction by which a vector of input can be readjusted while outputs are still being produced. Supplementary, technical efficiency is the measure of how resourceful a firm utilizes its existing inputs to manufacture a given level of output”.

“A farm is said to be technically efficient if its output plan is a direct function of its combinations of input (i.e $Y^o = f(X^o)$) and inefficient (also technically) if its output plan is less than the combinations of the input used (i.e $Y^o < f(X^o)$). Consequently, the TE can be measured using the ratio $0 \leq Y^o/f(X^o) \leq 1$. This technique of efficiency measurement is of the assumption that the production function of the most efficient unit/farmer is somewhat identifiable. But since in practice, the definite production function is never identifiable, Farrell, (1958) proposed that it can be assessed from the sample data by utilizing either a non-parametric technology or by a parametric function presented in the Cobb-Douglas form”.

“Aigner and Chu (1968) charted the latter technique and assessed a deterministic parametric frontier using a homogeneous Cobb-Douglas production function. Later, Timmer (1971) transformed the deterministic frontier into a frontier technique that is based on probability. However, this method has some confines. All farms share a mutual frontier and any deviations in farm efficiency are accessed in relation to this frontier. This method disregards any random features that can affect the efficiency of a farm (such as climatic related factors). Besides, the outcomes of this method are extremely delicate to flexible selection and data errors”.

Later, “Aigner *et al.* (1977) and Meeusen and Broeck (1977), individually came up with a method called the *stochastic frontier* so as to measure the rate of output change to a unit of input or the TE. This method presents TE as a neutral shift variable inside a production function outline. This implies that the input coefficients of the conventional production function and that of the frontier function are the same and only the intercept term varies”. In practice, the TE term must be indicated - as half-normal, truncated normal, or otherwise. As proposed individually by Jondrow, Lovell, Materov and Schmidt. (1982), one can compute individual-specific TE values by utilizing this process. “This specific method has been drawn-out in various ways, such as the measurement of more general distributions for the residual term (exponential and gamma), the use of panel data for investigation, and the measurement of TE using cost/profit functions”.

2.4.2 Methods of measuring Technical Efficiency

There are two basic econometric methods that has been adopted in measuring efficiency with an assumption that factors that causes inefficiency are present in the production system. These are:

- Data Envelopment Analysis (DEA) and
- The Stochastic Frontier Analysis.

These two procedures adopts dissimilar approaches to analyse data, and as a result, permits different allowance for random noise as well as in the make-up of production technology. The advantages of stochastic over the DEA approach boils down to the fact that it is stochastic in its method and it tries to tell apart the noise effects from the inefficiency effects while the DEA which utilizes the approach of linear programming cancels out random noise and actual inefficiency

effects. It is also known as a deterministic approach of measuring efficiency. For this reason, this study utilized the stochastic method of efficiency estimation.

2.4.3 The Stochastic Production Frontier

“Stochastic frontier analysis is a technique of economic modeling that was introduced by Aigner et al, (1977) and Meeusen and Van den Broeck (1977). Without the random component, the frontier model can be expressed as:

$$Y_i = f(x_i; \beta) \cdot TE_i \quad (5)$$

Y_i is the observed scalar output of the i th producer,

$i=1...I$, x_i is a vector of N inputs utilized by the producer i ,

$f(x_i; \beta)$ is the production frontier, and

β is a vector of parameters to be estimated”.

“ TE_i indicates the technical efficiency defined as the ratio of observed output to maximum feasible output. $TE_i = 1$ shows that the i -th firm obtains the maximum feasible output, while $TE_i < 1$ provides a measure of the shortfall of the observed output from maximum feasible output. A stochastic component that defines random shocks affecting the production process is added. These shocks are not directly attributable to the producer or the causal technology. These shocks may come from weather vicissitudes, economic difficulties or plain luck. We symbolize these effects with $\exp\{v_i\}$. Each producer is fronting a dissimilar shock, but we assume the shocks are random and they are defined by a mutual distribution”. The stochastic production frontier will become:

$$Y_i = f(x_i; \beta) \cdot TE_i \cdot \exp\{v_i\} \quad (6)$$

“We are of the assumption that “ TE_i is also a stochastic variable, with a definite distribution function which is common to all producers. We can also express it as an exponential $TE_i = \exp \{-u_i\}$, where $u_i \geq 0$, since we required $TE_i \leq 1$ ”. Thus, we obtain the following equation:

$$Y_i = f(x_i; \beta) \cdot \exp \{-u_i\} \cdot \exp\{v_i\} \quad (7)$$

Now, if we also assume that $f(x_i, \beta)$ takes the log-linear Cobb-Douglas form, the model can be written as:

$$\ln Y_i = \beta_0 + \sum_n \beta_n \ln x_{ni} + v_i - u_i \quad (8)$$

Where, v_i is the noise component, which we will almost constantly consider as a two-sided normally distributed variable, and u_i is the non-negative technical inefficiency component. Together they create a compound error term, with a definite distribution to be determined, hence the name of composite error model as is often referred”.

2.4.4 Previous empirical studies on efficiency in Agriculture

Omotosho, (2016) in the study “Economic analysis of urea deep placement technology usage in rice production in Kano and Niger state, Nigeria used the Cobb Douglas production function, to estimate how efficient the farmers were and also the rate of change of output to a change in input usage”. The result explained that the efficiency level of the technology users is 89% while those of the non-user is 73%. The coefficient of farm size, seed quality, fertilizer quantity, herbicides, family labour and hired labour were significant for the technology users to affect efficiency. All was also significant for the non-users except hired labour. The study also

reported that year of schooling, household size, age, extension contact, farmers association and amount of credit contributed to inefficiency of the rice producers in the study area.

A study done by Falola, (2015) on “the effect of Agricultural programmes on small-scale crop farming: The case of Growth Enhancement Scheme in Kwara state, Nigeria used stochastic frontier production function which incorporates a model of inefficiency effects. He used farm level data collected from a sample of 250 participating farmers in the four Agricultural zones in Kwara State. According to his study, the beneficiaries (80%) of the GES programmes were more efficient than the non-beneficiaries (71%). He reported that fertilizer and seed/seedlings were significant in determining the output of beneficiaries while fertilizer, farm size, herbicides and family labour affected those of the non-beneficiaries. He further explained that farming experience and educational level were the factors contributing to beneficiaries’ inefficiency while age, farming experience, educational level and extension contact contributed to inefficiency of the non-beneficiaries”. In this study, it was recommended the government should help by improving access of farmers to basic inputs at subsidized cost and farmers training.

A study carried out in Plateau State on “the production of rain-fed Irish potato by Jwanya, Dawang, Mashat and Gojing, (2014) also used the stochastic approach to estimate farm efficiencies. They reported an efficiency range of 2.37% to 95.6% with a mean of 74%. The determinants reported were education, farming experience, the type of variety planted and the off-farm income”. The study recommended that policies that is geared towards the enhancement of the observed influencing factors should be put in place.

Geta et al., (2013) in his study, used the translog function of stochastic estimation followed by the Tobit regression to determine the TE level of Southern Ethiopian farmers. He reported a

low efficiency level of 40% and the factors responsible for this were labour, fertilizer usage, oxen power, farm size, seed variety and agro-ecology.

A study carried out in Kwara State by Adewumi, Ayodele & Omotesho, (2013), on the Presence of Large Scale Zimbabwean Farming and its implication on Small Scale Farmers also adopted the latent class stochastic production frontier as a tool of analysis in the efficiency of adopters and non-adopters. They reported an increase in the productivity of the small scale farmers which can be attributed to the presence of the Zimbabwean farmers in the study area. However, there were some observed dissatisfaction displayed by the local farmers.

A study in Vietnam by Huynh and Mitsuyasu (2011) established further on the effectiveness of “the stochastic frontier production function in the measuring of efficiency. They measured the technical efficiency in rice farming using the Cobb-Douglas production function. They reported a high level of efficiency among the farmers in the study area and the prime movers of this efficiency value were labour, irrigation and education”.

Sekhon, Amrit, Manjeet and Sidhu, (2010) in their study on adoption, used the stochastic frontier production function analysis to estimate the efficiency of respondents in the region of India. They reported a varied technical efficiencies across the observed sub-regions which was basically influenced by farmer’s experience and age. As a result, they recommended that policies be developed more at the local levels to ensure maximum benefits.

“The literature review above prevails that Cobb Douglas production function has wider application in analysis of efficiency. Hence this study contributed to literature, by analyzing efficiency of both the users and non-users of the potato improved variety and determinants using the stochastic production frontier”.

2.5 The Student's t-test

The t-test is an econometric tool that is used to check if the calculated mean of two sample group are statistically different from each other. This analysis is suitable whenever you want to relate the sample average of two groups. It is used in comparing a group, who performs a task in a usual way with an experimental group who perform the same task under the same condition with an exception known as experimental manipulation control (Hinton, McMurray, & Brownlow, 2004). If the two groups perform differently, then one can attribute the difference to the effect of the manipulation. In applying the t-test, there is need to make sure that the groups are selected so that the only difference between them is the experimental manipulation and there are no other cofounding variables. Mathematically, it is given as:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}} \quad (9)$$

The numerator of equation 9 represents the mean difference of the sample that is been compared while the denominator accounts for the dispersion measurement of the scores. It is known as the standard error of the difference. “It is computed by calculating the variance of the sample and dividing by the sample size. The square root of the sum of the two values is then taken. The assumptions underlying the use of the student's t-test are as follows:

- i. The population in question being compared must follow a normal distribution.
- ii. They must have the same variance.
- iii. The data utilized in carrying out the test must be sampled independently from the two populations being compared for if the data are known to be dependently sampled (i.e., if

they were sampled in clusters), then the classical *t*-tests discussed here may give misleading results”.

2.6 The Likert Scale

The Likert scale method of analysis was introduced by Rensis Likert in the year 1932. It is also referred to as “frequency scales” and they use choice response layouts which are prepared to quantify opinions, attitudes or perceptions (Bowling, 1997; Burns & Grove, 1997). It is an ordinal scale which has been used on a large scale and in numerous studies to measure levels of agreements/disagreements. In its final form, the Likert scale is essentially the sum of responses to several Likert items, which are statements that the respondents is asked to evaluate. Thus, it range captures the strength of the feelings of respondents for a given item or matter in question (Burns & Burns, 2008).

A likert scale is of the fundamental assumption that the forte of experience assumes a linear that is on a scale from strongly agree to strongly disagree. It is also based on the assumption that attitudes can be measured. The sampled farmers are offered a variants of pre-determined questions to choose within a scale of strongly agree to strongly disagree with an “indifference” response so as to create a less prejudiced measurement. The real and numeric scale may however differ (Likert, 1932)

2.6 Theoretical framework

This research is anchored on the Innovation diffusion theory and the theory of Social Change.

2.6.1 The innovation diffusion theory

The innovation diffusion theory talks about how innovations or inventions or technology becomes known, acknowledged and spread through society (Rogers, 2003). It seeks to elucidate on why, how and at what rate innovation diffuse. From the definition, it should be understood that the four key elements of the diffusion theory are time, social systems, communication channels and the innovation itself. Diffusion research has five focuses:

- i. The features of an innovation which may impact its adoption.
- ii. The process (decision making process) that ensues when an individual considers adopting an innovation.
- iii. Individual characteristics that may likely affect the adoption of an innovation
- iv. The impact of the adopted innovation on individuals and society at large.
- v. The network of communication utilized in the adoption process.

In IDT, the concept of innovation-decision process simply speaks about the process taken by an individual in choosing to use an innovation or technology. Through this process, individuals makes decision whether to accept or reject an innovation after he has formed an attitude about it through gaining sufficient knowledge (Demir, 2006). They then go on to implement and confirm their decision after they have chosen to adopt. The entire process occurs in five stages. These are explained below:

The knowledge phase:

This is the phase/stage of exposure to a new innovation or technology. It is also the phase where the individual explores how the purpose of the innovation/technology. Three forms of knowledge are identified in this stage:

- i. Awareness knowledge (knowing that the technology or innovation exists).

- ii. Knowledge on how the innovation/technology works and
- iii. Knowledge on the usage of the technology.

It is important to know that knowledge on how an innovation works is not necessary for acceptance and use however, it may cause the discontinuation of usage if not acquired (Rogers, 2003). Awareness knowledge can come through mass media while knowledge on technology/innovation usage comes from change agents and early adopters of the innovation/technology (Rogers, 2003).

Persuasion phase:

At this stage/phase, individuals seek out information regarding the innovation so as to be well informed before making any kind of commitment. They also try to appraise reliable sources of information and also peer reaction towards the same innovation/technology. At this stage, a negative or promising reaction about an innovation does not always lead to approval or refutation of the innovation. When this happens it is known as the knowledge-attitudes-practice gap (Rogers, 2003).

Decision phase:

An individual is said to be in the decision phase if they involve themselves in processes that end up in the rejection or acceptance of an innovation or technology. They always seek out to start small in the usage of such innovation before fully committing themselves and their resources. They do this to be sure that the introduced innovation has an advantage over their current practice or technology. If it does, it quickens acceptance but if not, a speedy rejection of the

innovation (Rogers, 2003). Overall rejection of an innovation generally happens at this stage however, it can also happen at any stage of the IDT (Rogers, 2003).

Implementation phase:

Implementation is what comes after an individual has decided to adopt an innovation. Implementation is the stage of usage and it is also characterized by events that can lead to discontinued usage which can arise from not knowing how to fully implement the innovation. This is one of the key stages where the involvement of a change agent is essential as he would help in charting ways for effective implementation. Added incentives are also made available for the adopters by those who find enhanced use of an innovation (Rogers, 2003).

Confirmation:

This marks the concluding phase of the innovation diffusion process. At this phase, those that have newly adopted an innovation seek out support to augment their decision to use the technology. They do not want to find themselves in a position where they have come to realize they have been hasty in their decision and made a wrong move. As a result, they seek corroboration for their choices. However, if their plight for information to corroborate their decisions are not in tandem with what they imagined, they may discontinue usage of such innovation or technology. At this stage, the adopter either replaces the innovation or become totally indifferent about everything. “This is known as disenchantment discontinuance which happens when the benefits of an innovation is not in tandem with the imaginations of the new adopter”.

2.6.2 The theory of social change:

Marxian theory of social change is predicated on the fundamental assumption that the observed social change in a setting are as a result of changes in forces and relations of production which he termed “economic infra-structures”. He explained that societies is made up of two

distinct structures- infra-structures and super-structures. Branches of social systems like legal, religious, ideological and political institutions are what he termed the “super-structure” which serves to maintain the infra-structures. Max further explained that productive forces which comprised the infra-structure is of two categories- “means of production” and “mode of production”. Means of production according to him includes land, raw materials, labour, natural resources, implements and machineries while the mode of production are the techniques employed in production and various human ideology which affects their pattern of decisions. Thus he concluded that the state of productive forces is the determinant of the socio-economic structure of the society. “For Max, the contradiction between the constantly changing and developing ‘productive forces’ and the stable ‘production relations’ is the demiurge of all social development or social change”. The fulcrum of all social changes is the production system which must be dynamic because it is the necessities of man that underlies his productive efforts. Social change may be unplanned or planned. It is planned because of the intentional human involvement in driving change towards some specified goals while unplanned change is that which occurs suddenly usually through the act of nature thereby affording man the no chance to plan before it happens.

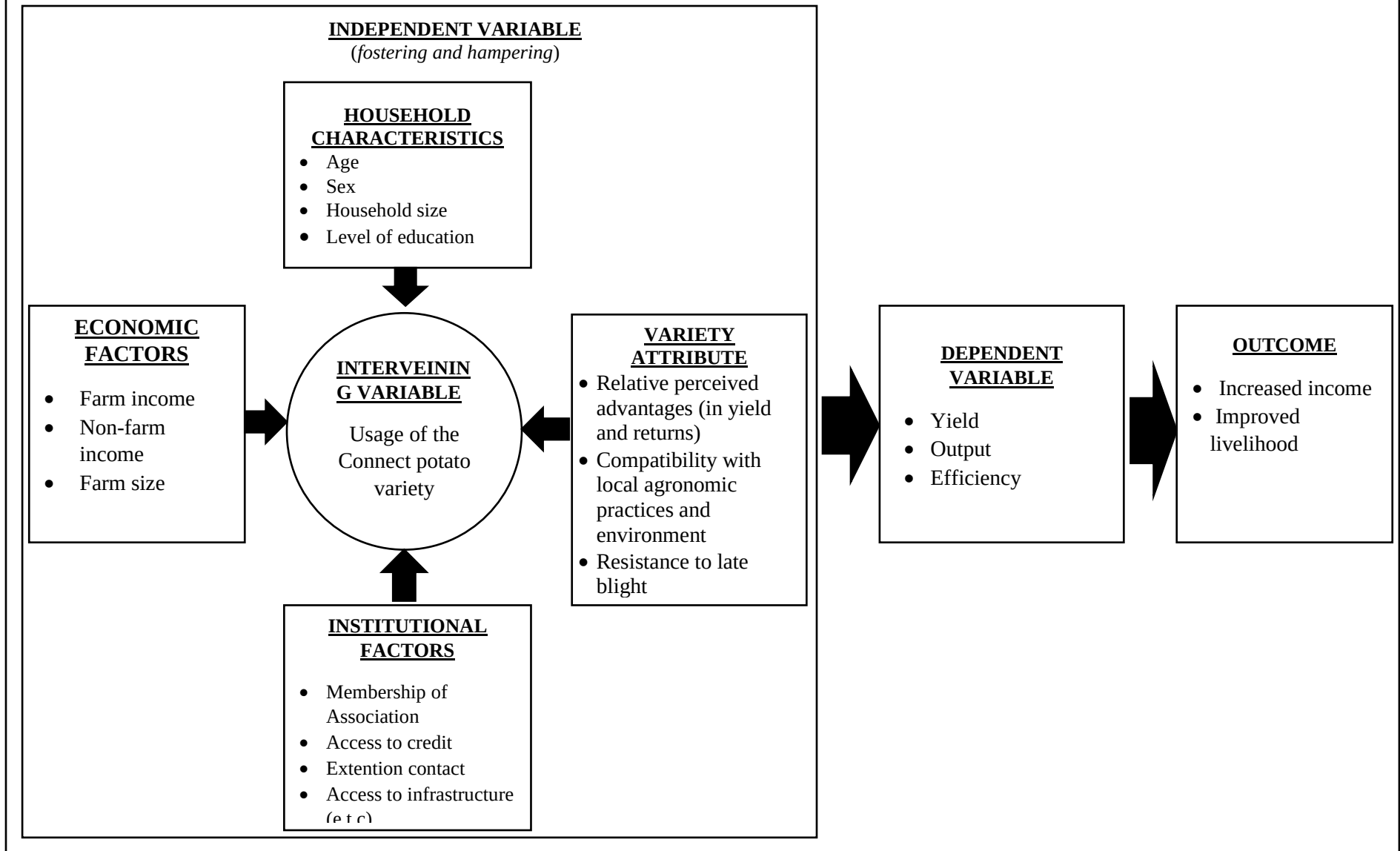
These theories (innovation diffusion and social change) will help in creating a framework on which the changes in the productivity of potato farmers as a result of the use of the Connect potato variety will be understood.

2.7 Conceptual Framework

Figure 2 shows the conceptual framework for this study. The decision to adopt an invention according to Mwangi & Kariuki, (2015) was categorized into four main parts. These are – the

Variety attributes (which talks on the characteristics of the variety in question); the economic factors (e.g off-farm income, cost accrued to adoption e.t.c); institutional factors (basically the social capital base of the farmers which can be associations, extension contacts, access to credit e.t.c) and the Household factors (e.g. Age, household size, farming experience, sex e.t.c). All these can result into a positive or a negative adoption of the intervening factor (Connect potato variety). All these affects their output and productivity which can either increase or decrease income, cost of production, efficiency and yield.

Figure 2: The Conceptual Framework



Source: Author's design, 2018

CHAPTER THREE

3.0

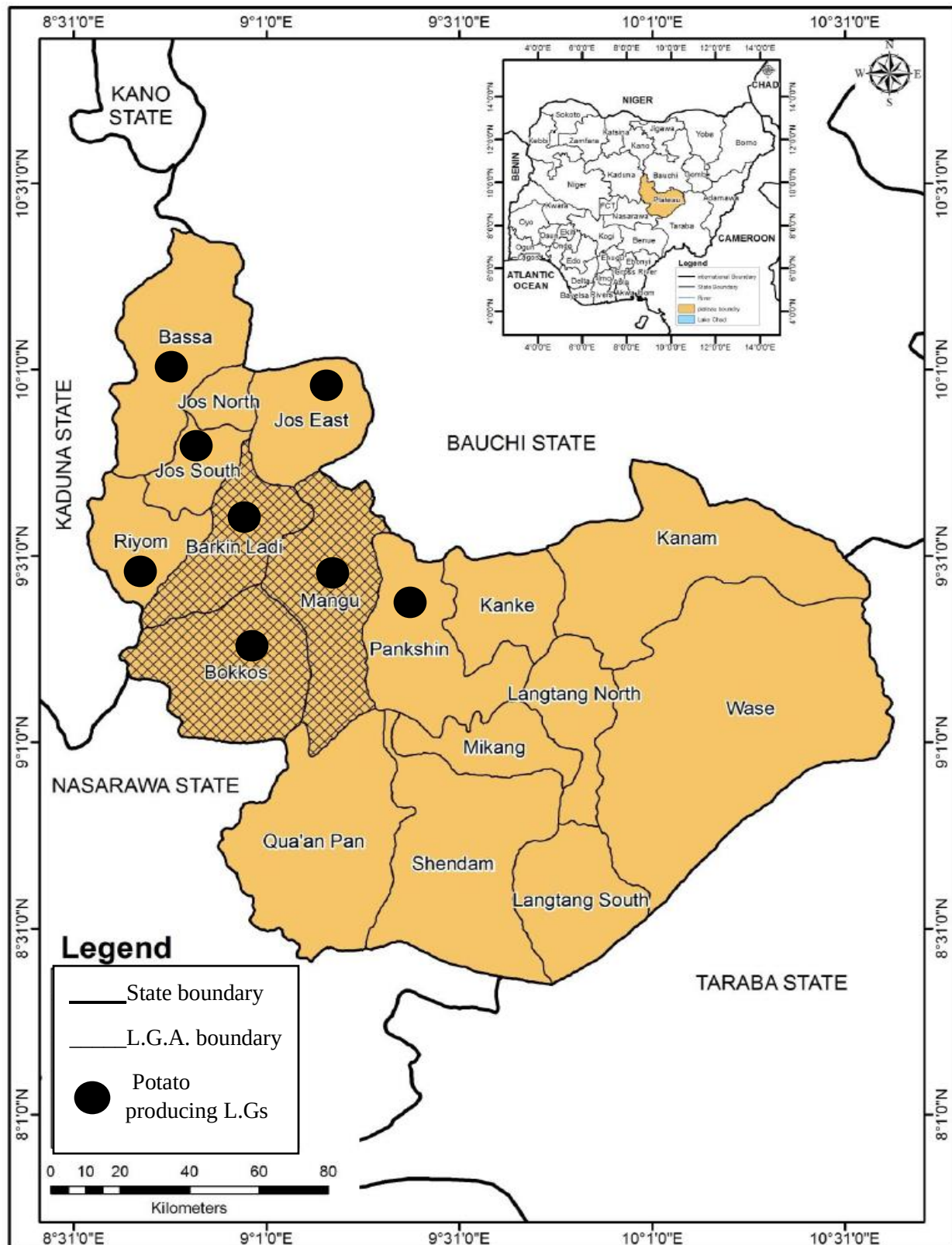
METHODOLOGY

3.1 Study area

The study was carried out in Plateau State, Nigeria. “Plateau is located in the northern middle belt area of Nigeria. The State contains within its fetters of hills and several fascinating rock formations. It is situated 1,200-1,829 meters above sea level thus birthing the name ‘Plateau State’. It shares boundary with Kaduna State, Bauchi State, Benue State, Taraba and Nasarawa States. It lies between the latitude $08^{\circ}24'N$ and longitude of $008^{\circ}32'$ and $010^{\circ}38'$ East of the Greenwich Meridian and land area is about 53,585 square kilometers (FOS, 2006). “Plateau State has a total of seventeen (17) Local Government Areas with Jos town being the capital city. It has a population of 3,178,712 with a growing rate of 2.7% per annum (NPC, 2006). The state is divided into (3) agro-ecological zones namely: northern zone, southern zone and central zone”. Potato, which is the focus crop for this study is majorly cultivated in the northern and central zone of the state”.

Plateau state is characterized by two separate seasons. The rainy and the dry season. The rainy season spans from April to October while the dry season, between November and March. The state is relatively cold when compared to other states in Nigeria. Maximum temperature of about $25.5-28.5^{\circ}C$ is usually recorded in the months of March and April while its lowest of about $15-20^{\circ}C$ in December and February and rainfall ranges from 800mm-1700mm. Agriculture which is the mainstay of the people of plateau state is mostly at the subsistence level (Ayuba and Kitsche, 2014). Diversities of crops cultivated are potatoes, cabbage, beniseed, bambara nut, groundnut, sorghum, millet, cocoyam, maize, sweet potatoes, tomato, soybean and vegetables.

Figure 3: Map showing the study area.



Source: NRCRI, (2015)

3.2 Population, sample size and sampling method

“The sample population are the potato farmers in Plateau State. This embraced the users and non-users of the Connect potato variety. A two stage stratified random sampling technique was used to select the samples for the study. The first stage involves purposive selection of the eight potato producing Local Government Areas in Plateau State”. These are Bokkos, Mangu, Pankshin, Jos East, Jos South, Barkin Ladi, Riyom and Bassa. Using the potato farmer’s population frame provided by each Local Government Areas, 320 potato farmers (comprising the users and non-users of the Connect potato variety) were randomly selected using the proportional allocation technique. The formula for this is given as:

$$n_h = \frac{n.N_h}{N} \quad (10)$$

Where

n_h = Number of respondents to be selected in stratum/zone h

n = Total number of farming household

N_h = Number of farming household population in stratum/zone h

N = Total number of farming household population

Accordingly, a random sample of 67 respondents was chosen from Bokkos, 50 from Mangu, 24 from Pankshin, 27 from Jos East, 18 from Jos South, 81 from Barkin Ladi, 13 from Riyom and 22 from Bassa based on the proportion of the farming household population in each Local Government Areas (Table 2)

Table 2: Sampling Design Outlay

Zones	Local government	Population N	Sample n	Users	Non-users
Central	Bokkos	2266	67	14	53
	Mangu	1691	50	17	33
	Pankshin	811	24	11	13
Northern	Jos East	913	27	6	21
	Jos South	609	18	6	12
	Barkin Ladi	2739	81	18	63
	Riyom	440	13	-	13
	Bassa	744	22	2	20
Total		10,213	302	74	228

Source: *Author's design, 2018*

3.3 Method of data collection

Primary data were used for the study. Primary data were collected through the administration of a well-structured questionnaire to the heads of the selected households. This captured the necessary information for the 2018 production year. The questionnaire was pre-tested to ensure it captures all necessary information needed to achieve all stated objectives. “Data collected were socio-economic background of respondents; farm input-output data; farming practices; labour used; costs of inputs and price of output; constraints, to mention a few”. Face-to-face interviews and focus group discussion with the assistance of field agents was also used to establish the view of respondents in general so as to elucidate possible areas of misrepresentation or discrepancies.

3.4 Analytical Techniques

3.4.1 Descriptive statistics

To get some insight about the socio-economic and demographic characteristics, “descriptive statistical analysis was employed. This involves the use of measures of dispersion such as percentage, frequency and measures of central tendency such as mean, variance, and standard deviation. Socio-economic data relating to the farmer that was collected includes age, gender, level of education, and marital status”.

So also, to gain insight into the level of usage of the Connect potato variety, descriptive statistics was also employed. Conventionally, at the specified plant spacing of 75cm by 30cm, 3000kg of potato is needed to cultivate a hectare of land (NRCRI, 2014). Using this knowledge, the Connect users has been divided into three main groups according to their level of use. These were; low level users (those that used less than 1000kg to cultivate a hectare of land), medium level users (those that used between the ranges of 1000kg – 2000kg to cultivate a hectare) and the high level users (those that use above 2000kg to cultivate a hectare of land).

3.4.2 The Heckman Selection model

The level of use of the Connect potato variety can be divided into two. “The first stage is the decision making stage, when the farmers decides to use the variety or not. Farmers who do not choose to use this variety are dismissed from this stage of the study and the farmers who have the willingness to use the variety enter the second stage. The second stage is the level of the decision-making stage, which measures farmer’s intensity of usage. Hence, this study used Heckman’s two-stage model to analyze the level of usage of the Connect potato variety”. The models are expressed as follows:

Model 1 observes the factors that determines the decision to use this variety. It is a probit model. The specification is as shown below:

$$\mathbf{Z}_i^* = \gamma' \mathbf{x}_i + u_i \quad (11)$$

Model 2 observes the influencing factors of the farmer's intensity of use of the Connect variety. It is a multiple linear regression. The model is specified as:

$$\mathbf{Y}_i = \beta' \mathbf{w}_i + v_i \quad (12)$$

Where

“ $\mathbf{Z}_i^*$ is the observed dependent variable (farmer's decision to use): A dichotomous variable depicting the farmer's usage of the variety and will take 1 if the farmer is a user of the variety and 0, if otherwise”.

$\mathbf{Y}_i$ is the latent variable describing farmer intensity of use of the Connect potato variety. This is the quantity per hectare of the Connect variety used by each farmer.

$\mathbf{x}_i$ is the vector of variables explaining the decision to use

$\mathbf{w}_i$ is the vector of variables explaining the intensity of use

β and γ are the regression coefficients

v_i and u_i are the respective error terms assumed to be independent and distributed as $v_i \sim N(0,1)$ and $u_i \sim N(0, \sigma^2)$

“On the basis of reference literature and combined with the precise situation of the study area, twelve indicators/variables are designed to evaluate the changes in the farmers decision and the intensity of use of the Connect potato variety”. This are explained below:

The hypothesized independent variables are:

$w_1; x_1$ = Farming experience (Years)

$w_2; x_2$ = Years of education (Year)

$w_3; x_3$ = Non-farm income (Naira)

$w_4; x_4$ = Cost of the Connect seed variety (Naira)

$w_5; x_5$ = Household size

$w_6; x_6$ = Amount of credit obtained (Naira)

$w_7; x_7$ = Extension contacts

$w_8; x_8$ = Membership of association (1 =Yes; 0 = No)

$w_9; x_9$ = Availability of Connect variety seed (1 =Yes; 0 = No)

$w_{10}; x_{10}$ = Sex (Male = 1; female = 0)

$w_{11};$ = Perception of relative importance

3.4.3 Productivity measurement

“To know the level of output obtained per unit input, the Total Factor Productivity (TFP) was used. Total factor productivity (TFP) of respondents according to Key and McBride, (2005)” “is measured as the inverse of unit cost. This is so since TFP is the ratio of the output to the total variable cost (TVC)”. It is given as:

$$TFP = \frac{A}{TVC} \quad (13)$$

Where A = Value of output (₦)

TVC = Total Variable Cost (₦)

This variable costs includes the cost of seed, labour, fertilizer, herbicides, pesticides, fungicides and short-term credit. The value of output is the quantity of potato produced multiplied by the market price.

3.4.4 Gross margin Analysis.

“The gross margin analysis was used to determine the profitability of both the users and non-users of the Connect potato variety. This was done by estimating the cost, revenue and gross

margin of the production process on the basis of a hectare. Other profitability indices such as operating ratio, returns on capital invested was also be estimated. The potato farmer's revenue was computed as the monetary value of all farm output while the variable costs are those incurred on seeds, labour, chemicals, fertilizers, trainings, rental, short-term credits and hiring fees. In situations where fixed capital is just a negligible portion of the farming enterprise, gross-margin analysis is adopted (Olukosi *et al.*, 2006; Adewumi *et al.*, 2012). It is given as:

$$GM = TR - TVC \quad (14)$$

Where

GM = Gross margin (Naira)

TR = Total revenue from the sales of potatoes measured in Naira

TVC = Total variable cost (Naira)

According to Ojo *et al.*, (2011), the operating ratio is directly related to the farm variable input usage. The lower the ratio, the higher the profitability. The operating ratio is given as:

$$\text{Operating Ratio} = \frac{TVC}{GI} \quad (15)$$

Where

TVC = Total variable cost incurred in Naira

GI = Gross income

The returns on capital invested was also estimated. It is given as:

$$RCI = \frac{GM}{TVC} \quad (16)$$

Where

RCI = Returns on capital invested

GM = Gross margin

TVC = Total variable cost”

3.4.5 Stochastic production frontier

Translog and Cobb-Douglas functional forms are the two types of models generally used in stochastic frontier analysis (SFA). For the purpose of this study, it is essential to find which of this functional form is best suited for analysis. To do this, the generalized Likelihood Ratio (LR) test statistics was used to conduct a hypothesis test as used by Farnsworth, (2015). The general formula is given by:

$$\lambda = -2\ln \left[\frac{L(H_0)}{L(H_1)} \right] \quad (17)$$

“Where, $L(H_1)$ and $L(H_0)$ are the log-likelihood function values for the model under the null and alternative hypotheses i.e $L(H_0)$ is the likelihood function value of the Cobb-Douglas production frontier model where the coefficients of the outcome parameters (squared and interaction) assumes a zero value $H_0 = \beta_{ji} = 0$; $L(H_1)$ is the likelihood function values for the translog production frontier model where the coefficients of the outcome parameters (squared and interaction) do not assume a zero value. A series of formal hypotheses were obtained using the generalized likelihood ratio test. This test statistic is assumed to be asymptotically distributed as a mixture of chi-square distribution with degree of freedom equal to the number of restrictions involved (Taymaz and Saatci, 1997)”. The rejection or acceptance of the null hypotheses was done using Likelihood ratio value compared to critical chi-square values. Meaning, if the test statistic (λ) exceeds the critical value as used by Constantin, Martin, Rivera & De, (2009), we reject the Null hypothesis but if not, we accept.

The Cobb-Douglas functional form

“The stochastic frontier production model of Cobb-Douglas functional form was employed to estimate the farm level technical efficiency of both the users and non-users of the Connect potato variety and its determinants. Cobb-Douglas functional form have been used in many studies, particularly in those relating to developing agriculture. It meets the requirement of being self-dual, allowing an examination of economic efficiency (Battese & Coelli 1988)”. It is specified as:

$$Y_i = f(X_i; \beta) \exp(v_i - \mu_i) \quad (18)$$

“The technical efficiency of individual farmers is defined in terms of the ratio of observed output to the corresponding frontier output conditioned on the level of input used by the potato farmers”.

It is expressed as:

$$TE_i = \frac{Q_i}{Q_i^*} = f(X_i; \beta) \exp(v_i - \mu_i) / f(X_i; \beta) \exp V = \exp(-\mu_i) \quad (19)$$

Where

Q_i = Observed output

Q_i^* = Frontier output

Technical efficiency has value that ranges from 0 and 1.

The production efficiency of the potato farmers is specified as:

$$\text{Log} Y_i = \beta_0 + \beta_1 \log X_{1i} + \beta_2 \log X_{2i} + \beta_3 \log X_{3i} + \beta_4 \log X_{4i} + \beta_5 \log X_{5i} + \beta_6 \log X_{6i} + v_i + \mu_i \quad (20)$$

Where:

Y_i = Potato output of the i th farmer

β = Regression coefficients

X_1 = Farm size (Ha)

X_2 = Quantity of seed used (Kg)

X_3 = Quantity of fertilizer (kg)

X_4 = Quantity of Fungicides used (litres)

X₅ = Quantity of Herbicides used (litres)

X₆ = Labour (Man days).

v_i = disturbance not in control of the farmer. “It assumes an independent and identically distributed random errors having normal $N \sim (0, \delta v^2)$ distribution and independent of μ ”.

μ_i = “Deviation from output maximization that can be attributed to technical inefficiency. The μ_i assumes a non-negative truncation of the half-normal distribution $N \sim (\mu, \delta \mu^2)$ ”.

According to Coelli *et al.*, (2005), the factors responsible for technical inefficiency are a function of the socio-economic factors. These factors are expressed in the inefficiency model given below:

$$\mu_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7i} \quad (21)$$

Where:

μ_i = Inefficiency effect

Z_{1i} = Years of formal education

Z_{2i} = Farming experience (Years)

Z_{3i} = Extension visit (Numbers of contact within the cropping season)

Z_{4i} = Household size

Z_{5i} = Sex of household head (Male = 1; Female = 0)

Z_{6i} = Non-farm occupation (1 = Yes; 0 = No)

Z_{7i} = Access to credit (1 = Yes; 0 = Otherwise)

“The values of unknown coefficients in the equations, (i.e β and the δ) can be obtained jointly using the maximum likelihood method (ML). An estimated value of technical efficiency for each farmer will then be calculated in $TE_{1i} = \exp (-\mu_i)$. The maximum likelihood estimates (MLE) of

the parameters in the Cob-Douglas stochastic frontier production function model and the technical inefficiency effects would be obtained using FRONTIER 4. 2 (Coelli, 1996)”.

3.4.6 Student's t-test of significance

T-test analysis was carried out to know if the observed differences in the socio-economic characteristics, profitability and efficiency of the variety's users and non-users are statistically significant. It is mathematically given as:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{N_1} + \frac{s_2^2}{N_2}}} \quad (22)$$

Where

$\bar{x}_1$ = Mean of x_1 (Connect potato variety users)

$\bar{x}_2$ = Mean of x_2 (Connect potato variety non-users)

N_1 = Number of users

N_2 = Number of non-users

S_1^2 = Variance of x_1 variable (users)

S_2^2 = Variance of x_2 variable (Non-user)

3.4.7 Estimating the Effect of the Connect Potato variety

The effect of the Connect potato variety was analyzed from two perspective. First, the effect of the variety on potato farm performance was examined. In this case, the concepts considered were: technical efficiency of the farmer, total farm productivity and profitability

estimates. Second, the users were requested to identify the benefits that they perceived to have been derived from the use of the variety.

3.4.7.1 The Propensity Score Matching

The Propensity Score Matching (PSM) was used to measure the effect of the Connect potato variety on farmer's performance. According to Khandler, Koolwal and Samad, (2010); Asante *et al.*, (2014) "it is a statistical matching technique that attempts to estimate the effect of a treatment, policy, or other intervention by accounting for the covariates that predicts receiving the treatment. PSM attempt to reduce the bias due to confronting variables that could be found in an estimate of the treatment effect obtained by comparing outcomes among units that received the treatment versus those that did not".

"In a randomly selected potato farmer in the sample population, it is expected that he would either be a user or non-user of the Connect potato variety. Assuming the potential outcome for using this technology is represented as y_1 and that for not using as y_0 , then the average treatment effect which represents the expected population impact of usage can be derived" as follows:

$$TE_i = y_{i1} - y_{i0} \quad (23)$$

$$ATE = E(y_1 - y_0) \quad (24)$$

Where TE_i denotes 'treatment effect' and represent the effect of usage on farmer i .

y_{i1} is the potential impact for the Connect variety users

y_{i0} is the potential impact for the Connect variety non-users.

$y_1 - y_0$ "is undefined for farmer i because in reality, an outcome and its counterfactual cannot be observed. But since using the variety usage is a necessary condition for impact, the $y_0 = 0$ for a

randomly sampled farmer. This implies that the impact on farmer i is y_i and the average usage impact $ATE = E(y_i)$. This however in reality underestimates the true population impact because y_1 is observed only for usage, a situation that could result into selection bias. If $NA = 1$ denotes users and $NA = 0$ denotes non-users, then the average impact on the using sub-population (ATT) will be more relevant for this study”. It is derived as:

$$ATT = E(Y_1 \mid NA = 1)$$

Where Y_i is the outcome variables – technical efficiency of the farmer, total farm productivity and profitability estimates”.

3.4.7.2. Identifying the perceived benefits of the Connect potato variety (Likert Scale)

The users were asked to state whether there has been any advantage in using the variety or not. “And if they have, they were asked to indicate the perceived benefits they have derived from the use over the years using a five point Likert-type scale. The scale was ranged from

Strongly agree = 5

Agree = 4

Indifferent = 3

Disagree = 2

Strongly disagree = 1.

Mean scores was then calculated for each responses so as to know the perceived benefits of the Connect potato variety”.

3.5. Limitations of the study

The limitations of this study are listed as follows:

- i. Getting access to the correct list of potato farmers in the study area proved difficult. The list used were those gotten from each local government potato associations which may not be comprehensive. The study was therefore based on the assumption that the sampled farmers were a fair representation of the users and non-users of the variety.
- ii. Most farmers relied on mental recall as none of them kept records of their production activities in the study area therefore some variation that would be the outliers have been taken care of by a priori information and survey into the study area.
- iii. The prevailing unrest around the period of data collection was a major constraint for this study. As a result, the services of extension agents was employed in retrieving data from places that could not be reached. Although trained, it's possible some may still result into data manipulation. However to control for this, existing data served as a template to check what was submitted by the agents.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

“This chapter comprises the presentation of results and discussion of this study. This includes socioeconomic and demographic characteristics of the potato farmers, potato farm characteristics, level of the Connect potato variety usage, factors influencing the usage of this variety, the gross margin analysis of both the users and non-users, efficiency estimation of both groups and the effect of Connect potato variety usage on potato farmer’s productivity in the study area”.

4.1 Potato Farm/Farmer’s Characteristics

4.1.1 Demographic Characteristics of the Farmers

Tables 3 shows the demographic characteristics of Connect users, non-users and the pooled data. The indicators measured comprise of age, gender, marital status, the household size, and the level of education of farmers in the study area.

Table 3: Distribution of respondents by Demographic Characteristics

Household Characteristics	Pooled n = 302	Connect variety users n ₁ = 74	Connect variety Non-users n ₂ = 228
Age (years)			
≤ 30	29 (9.6)	6 (7.4)	23 (10.0)
31-40	95 (31.5)	29 (39.5)	66 (29.0)
41-50	109 (36.1)	24 (33.3)	85 (37.1)
51-60	50 (16.6)	13 (17.3)	37 (16.3)
>60	19 (6.3)	2 (2.5)	17 (7.7)
Mean	43.0	42.7	43.6

Standard deviation	9.64	8.90	10.38
(t-stat = 1.15; p = 0.87)			
Sex			
Male	240 (79.4)	61 (82.7)	179 (78.7)
Female	62 (20.5)	13 (17.3)	49 (21.3)
Marital Status			
Single	10 (3.3)	3 (3.7)	7 (3.2)
Married	286 (94.7)	70 (95.1)	215 (94.6)
Widowed	6 (2.0)	1 (1.2)	5 (2.3)
Household size			
1-5	150 (49.7)	49 (66.7)	101 (44.3)
6-10	116 (38.4)	16 (22.2)	100 (43.9)
11-15	27 (8.9)	5 (7.4)	22 (9.5)
>15	8 (2.6)	3 (3.7)	5 (2.3)
Mean	5.97	5.53	6.51
Standard deviation	3.58	3.66	3.50
(t-stat = 0.5862; p = 0.2797)			
Education status			
Primary	48 (15.9)	8 (11.1)	40 (17.7)
Secondary	115 (37.1)	20 (27.2)	95 (41.6)
Tertiary	64 (21.2)	37 (46.9)	27 (11.8)
No formal Education	76 (25.2)	10 (14.8)	66 (29.0)

Figures in parenthesis are percentages.

Source: Field survey, 2018

The result revealed that the mean age of the sampled Connect potato variety users was 43 years while those of the non-users is 44 years. The modal age range for the users was found to be 31-40 years while for the non-users is 41-50 years. The minimum and maximum age for both groups was also observed to be 25 and 70 years respectively. Also, the result of the inferential statistics (t-stat = 1.15; p = 0.8736) shows that there is no noteworthy difference between the ages

of the two groups of farmers. Meaning that it cannot be conclusively said that the non-users are older than the users. Age has been conjectured to assume a quadratic function in farming activities. In some cases, farmers that are young are more liable to adopt modernizations than the older farmers who might have gone past their economically active age. Without making any definitive assertions, it is clear that based on the age distribution obtained in this study, it can be inferred that the potato farming population is economically active and agriculturally viable. This result validates the findings of Jwanya *et al*, (2014) & Oppong-Yeboah, (2015).

The distribution of the respondents by sex revealed that 82.7% of the Connect variety users were male while 17.3% were female. Also for the non-users, 78.7% were male while 21.3% were female. Generally, the low involvement of women (20.2%) in the potato farming business suggests that the potato farming enterprise may be labour intensive which corroborates the findings of Sani, Abdullahi & Zekeri (2015) who reported more male involvement in potato farming. However, other factors like the culture of the people can also affect female involvement in potato farming.

The distribution of the respondents by household size showed that the majority (49.7%) of the respondents have household sizes ranging between 1-5 persons. About 38.4% of the respondents have 6-10 family members; 8.9% of the farmers had 10 - 15 members while just 2.6% had more than 15 members. The mean household size of both the Connect users and non-users were also found to be 6 and 7 members respectively. The mean difference between this two groups was also statistically insignificant as shown by the inferential statistic ($t\text{-stat} = 0.5862$; $p = 0.2797$) implying no noteworthy difference between the household sizes of the two groups. Families with larger household sizes are likely to adopt an innovation as they have greater responsibilities of meeting the family needs. Also, a larger household size can also be an advantage as it contributes to farm labour. This finding showed that, the household of both users and non-users are relatively

large but no significant difference. The results corroborate the findings of Oppong-Yeboah, (2015), who observed that potato farmers in Plateau state had an average household size of 7.

Table 3 also showed that 94.7% of the respondents were married, 3.3% single while just 2% were in the widower group. Majority of the Connect potato variety users (95.1%) and non-users (94.6%) were married. The population of unmarried household consists of the single, the divorced and the widowed. Marital status as a household indicator is used to determine stability as it is normally believed that married household heads tend to be more stable in farming and opened to innovations than the unmarried ones (Oppong-Yeboah, 2015). Also, this enhances the availability of family labour for their production activities. This result agrees with the findings of Obisesan, (2014) who reported that marital status plays an important role in the usage of innovations.

Finally, Table 3 showed the result of the educational status of the respondents. Findings of this study shows that, majority (58.3%) of the respondents have post-primary education while 25.2% has no form of education whatsoever. It was observed that the greater percentage (46.9%) of the Connect potato variety users have up to tertiary education and a smaller percentage of them (14.8%) had no formal education. This however differs from those of the non-users. The majority of the non-users (41.6%) have at least a secondary education while 29.0% of the non-users have no form of formal education. This suggests that most of the farmers (especially among the users) are literate enough to make informed decisions to use or dis-use an innovation. This aligns with the study of Abdullahi & Abdullahi (2011), who posited that education facilitates the usage of modern technologies.

4.1.2 Socio-economic Characteristics of the farmers

The socio-economic characteristics of the farmers are discussed in this section. These includes farming experience, membership of association, extension contacts, type of business enterprise, primary source of income, non-farm income and credit. These results are presented in Tables 4 and 5.

Table 4: Distribution of Respondents by Socio-economic Characteristics

Household Characteristics	Pooled n = 302	Connect variety users n₁ = 74	Connect variety Non-users n₂ = 228
Potato farming experience (Years)			
1 – 10	60 (19.9)	6 (8.1)	54 (23.7)
11 – 20	73 (24.1)	47 (63.5)	26 (11.4)
21 – 30	156 (51.6)	16 (21.6)	140 (61.4)
>30	14 (4.6)	5 (6.8)	9 (3.9)
Mean	18.87	17.83	19.91
Standard deviation	10.16	10.49	8.83
(t-stat = 0.5763; p = 0.7170)			
Membership of association			
Yes	154 (50.9)	47 (63.0)	107 (47.1)
No	148 (49.1)	27 (37.0)	121 (52.9)
Extension contacts per year			
No contact	141 (46.7)	32 (43.2)	109 (48.0)
Once	66 (21.8)	17 (24.7)	49 (21.7)
Twice	73 (24.1)	16 (21.0)	57 (24.9)
Thrice	12 (4.0)	4 (4.9)	8 (3.6)
More	9 (3.0)	5 (6.2)	4 (1.8)
Type of business enterprise			
Farming only	128 (42.4)	25 (33.7)	103 (45.2)
Farming + Artisan	14 (7.8)	5 (6.8)	9 (3.9)
Farming + Civil servant	81 (26.8)	29 (39.2)	52 (22.8)
Farming + Trading	67 (22.1)	14 (18.9)	53 (23.2)

Farming + Others (student)	12 (4.0)	1 (1.3)	11 (4.8)
Primary source of income			
Farming	148 (49.0)	34 (45.7)	114 (50.2)
Non-farming	154 (50.9)	40 (54.3)	114 (49.8)
Non-farm income (₦/month)			
None	136 (45.0)	31 (42.0)	105 (46.2)
≤ 10,000	13 (4.3)	3 (3.7)	10 (4.5)
10,001 – 50,000	115 (38.1)	31 (42.0)	84 (36.7)
50,001 – 100,000	29 (9.6)	6 (8.6)	23 (10.0)
>100,000	5 (1.7)	2 (2.5)	3 (1.4)
Mean	21,703.22	22,545.46	20,860.97
Standard dev.	27,368.94	26,918.47	27,819.41
(t-stat = 0.8594; p = 0.1964)			

Figures in parenthesis are percentages.

Source: Field survey, 2018

Table 4 shows the result of years of experience in potato farming. The average potato farming experience recorded from pooled data is 19 years with a minimum of 3 years and a maximum of 43 years. About 8.1% of the Connect users and 23.7% of the non-users have an experience range of 1-10 years. Also, 63.5% and 11.4% of the users and non-users respectively fell within the experience range of 11-20 years. The majority of the non-users (61.4%) were in the experience range of 21 – 30 years. A wide standard deviation of 10.49 and 8.83 for both the users and the non-users respectively suggests that there is a wide disparity between the years of experience of the respondents which hence begat the low average. The mean years of experience in potato farming was approximately 18 years and 20 years for the users and non-users respectively. The inferential test on mean difference shows there is no difference between the two groups of farmers. Finally, about 6.8% and 3.9 % of the users and non-users respectively had more than 30 years of experience in the study area.

The result of membership of association as reported in Table 4 also revealed that 50.9% of the sampled respondents were in a form of Agricultural association while 49.1% were not. It was observed that about 63.0% of the Connect potato variety users were a member of an association which is considerably higher when compared to their non-using counterpart where only 47.06% are members. About 37.0% and 52.9% of the users and non-users respectively were not in any form of association. Some of the advantages of being in a form of a social group is that there is availability of information for informed and better decision making as well as ideas and other form of social capitals. Farmers are able to learn and gain experiences from each other as it pertains to the use of a new innovation in a social system. This findings corroborates the result of Mignouna et al., (2011) where he reported a strong positive correlation between belonging to a social group and the usage of innovation.

Furthermore, the result in Table 4 on frequency of extension contact, a maximum of four extension contacts was recorded per year in the study area. In all, the Connect users (56.8%) had at least a contact with extension agent in the last production season. This is higher than their non-using counterpart whom just (52.0%) having at least a contact. Frequency of extension contact has also been found to be a key aspect in innovation/technology usage (Akudugu *et al*, 2012). The knowledge that an innovation exists as well as the know-how in its usage and benefits are what is usually brought by the extension agents.

Finally, the result of business enterprise as engaged by the respondents revealed that 45.7% of the Connect potato users has potato farming as their primary source of income while 50.2% representing the majority of the non-users reported potato farming as their primary source of income. The various non-farm occupation of the farmers were also measured. It ranges from artisans, traders, and civil servants. About 6.8, 39.2, 18.9 and 1.3 percent of the Connect users

combined Artisan, civil servant, trading and studying respectively with their farming activity. Also, 3.9, 22.8, 23.2 and 4.8 percent of the non-users combined their farming activity with Artisan, civil servant, trading and studying respectively. “The average monthly non-farm income of the Connect users and Non-users were found to be ₦22,545 and ₦20,860 respectively which suggests that there may be an availability of capital to increase farm investment. The difference in mean value of the two group was however not significant (t-stat = 0.8594; p = 0.1964) implying that there is no difference between the non-farm income of the users and non-users in the study area. It is believed that credit lowers the constraints placed on capital and improves households risk bearing ability (Abate, Rashid, Borzag & Getnet 2016)”.

Table 5: Distribution of Respondents by credit access, sources and amount.

Household Characteristics	Pooled n = 302	Connect variety users n₁ = 74	Connect variety Non-users n₂ = 228
Access to credit			
No	189 (63.2)	33 (44.4)	158 (69.2)
Yes	111 (36.7)	41 (55.6)	70 (30.8)
Source of credit			
Informal money lenders	14 (4.6)	4 (4.9)	10 (4.5)
Bank	22 (7.3)	5 (6.2)	17 (7.2)
Informal groups	28 (9.3)	13 (17.3)	15 (6.8)
Family & friends	30 (9.9)	10 (14.8)	20 (8.6)
Government	17 (5.6)	9 (12.3)	8 (3.6)
Amount of credit by farmers (₦/year)			
≤ 10,000	211 (69.6)	37 (50.0)	174 (76.2)
10,001 – 50,000	29 (9.6)	8 (10.8)	21 (9.2)
50,001 - 100,000	20 (6.6)	5 (6.8)	15 (6.6)
100,001 – 150,000	22 (7.3)	5 (6.8)	16 (7.0)
150,001 – 200,000	5 (1.7)	2 (2.7)	2 (0.9)
>200,000	18 (6.0)	17 (23.0)	0 (0.0)
Mean	53,116.64	87,961.11	18,272.17
Standard deviation	80,353.1	92,102.20	38,604
(t-stat = 5.92; p = 0.000)			

Figures in parenthesis are percentages.

Source: Field survey, 2018

The result in table 5 shows that 55.6% of the Connect variety users had access to credit while 44.4% had none. So also, only 30.8% of the non-users had access while 69.2% had none. Majority (17.3%) of those that had access among the users got it mostly through informal groups (cooperatives, thrifts or credit unions) while the non-users from families and friends. In all, a lower percentage of the farmers (6.95%) borrowed from the bank. This may be attributed to the high interest rate attached to borrowing. It was also observed that the Connect users has a mean annual credit usage amount of ₦87,961.11 while the non-users, ₦18,272.17. The result of the inferential statistics (t-stat = 5.92; p = 1.000) shows that there is a significant difference between the amount of credit between the two groups of farmers. This suggests that the Connect users opt for more and larger amount of credit which may be attributed to some implicit cost as it relates to the use of the Connect variety. The maximum credit amounts among the users and non-users are ₦210,000 and ₦165,000 respectively.

4.1.3 Potato Farm Input Characteristics

This section of the study, shows the overall situation of the farm input characteristics of both the Connect users, non-users and also for the pooled data. The indicators measured were the quantity of potato seed planted, potato seed price per kilogram, the source of the seed used, potato varieties cultivated, the farm size, land tenure system, the quantity of labour used, the quantity of fertilizer and chemical used.

Table 6: Distribution of Respondents by potato variety cultivated, quantity, source and cost

Characteristics	Pooled n = 302	Connect seed users n₁ = 74	Connect Seed Non-users n₂ = 228
Quantity of potato seed planted (Kg)			

≤500	67 (22.2)	55 (74.1)	12 (5.43)
501 – 1000	45 (14.9)	8 (12.3)	37 (16.3)
1001- 1500	95 (31.5)	4 (4.9)	91 (39.8)
1501 – 2000	8 (2.65)	2 (2.5)	6 (2.7)
2001 – 2500	4 (1.3)	1 (1.23)	2 (0.9)
2501 – 3000	39 (12.9)	4 (5.41)	36 (15.8)
>3000	43 (14.2)	-	43 (19.0)
Mean	1220.13	719.35	1720.9
Standard deviation	254.61	208.52	300.69
(t-stat = 2.30; p = 0.0112)			
Potato seed purchase price (₦/Kg)			
≤ 100	94 (31.1)	13 (17.3)	81 (35.3)
101 – 200	74 (24.5)	1 (1.23)	73 (32.1)
201 – 300	64 (21.2)	18 (24.7)	46 (20.3)
301 – 400	39 (12.9)	23 (30.9)	16 (7.23)
401 – 500	14 (4.6)	14 (18.5)	0 (0.00)
>500	15 (5.0)	5 (7.4)	10 (4.5)
Mean	317.5	396.7	238.2
Standard deviation	111.12	100.96	121.28
(t-stat = 7,83; p = 0.000)			
Other potato varieties cultivated by non-users			
Nicola	-	-	105 (46.2)
Caruso	-	-	7 (3.2)
Marabel	-	-	74 (32.6)
Diamant	-	-	4 (1.8)
Lady christyl	-	-	32 (14.0)
Jelly	-	-	2 (0.9)
Batita	-	-	5 (2.3)
Source of potato seed			
Personal storage	78 (25.8)	13 (17.3)	65 (28.5)
Fellow farmer	64 (21.2)	41 (55.6)	23 (10.0)
Market	132 (43.7)	2 (2.5)	130 (57.0)
Association	28 (9.3)	18 (24.7)	10 (4.1)

Figures in parenthesis are percentages.

Source: Field survey, 2018

Table 6 shows the distribution of respondents by the quantity of potato planted in the last production season, price per kilogram of the potato seed used, the source of the potato seed and

the varieties cultivated by the non-users in the study area. The t-test result ($t\text{-stat} = 2.30$; $p = 0.0112$) shows that there is a significant difference between the mean values of the potato quantity planted by the two groups and was significant at 5%. This means that the non-users planted more than the users per year. The average quantity of potato planted by the Connect users and non-users were 719.23kg and 1720.90kg respectively. The modal quantity range planted by the Connect users was less than 500kg while those of the non-users was between 1001 – 1500 kilogram of potato. Still among the users, 12.3% planted between the 501 – 1000kg while 5.41% planted in the kilogram range of 2501 – 3000 kg. Given all this, it can be implied that there is a low usage of the Connect potato variety in the study area. The reason for this as explained by many farmers from the focus group discussion conducted was that the variety was scarce to come by.

Therefore, to further gain insight into the state of usage, the price per kilogram was also examined as shown in Table 6. The Connect potato variety was found to be costlier than the other variety. It was observed that an average price per kilogram of ₦396.70 and ₦238.20 was observed for the users and non-users respectively. The t-test analysis which was statistically significant at 1% (7.83) showed that there is a significant difference between these values. Meaning that more is spent on the Connect variety than other varieties. This high price per kilogram of the Connect variety suggests it may also be a reason for its low usage in the study area. This was also corroborated in the discussion had with the farmers collectively. However, some of the interviewed farmers tied this high price to its ability to resist or tolerate the late blight disease.

Furthermore, the result of the distribution of respondents by the source of their potato seed as presented in Table 6 showed that the majority of the Connect users (55.6%) get theirs from their fellow farmers. 24.7% of the users also reported that they sourced theirs from their association which was plausible as the introducing body (GIZ-SEDIN) distributed these variety through

associations. 17.3% claimed theirs was from storage and a small percentage of 2.5 claimed they got theirs from the market. It was also observed that the majority of the non-users got their own seed from the market.

Finally, Table 6 also shows the distribution of the non-users by the varieties they cultivate. It was observed that Nicola potato variety (46.2%) was mostly cultivated by the non-users in the study area. This is followed by Marabel (32.6%), Lady Christyl (14.0%), Caruso (3.2%), Batita (2.3%), Diamant (1.8%) and finally Jelly (0.9%).

Table 7: Distribution of Respondents by land size cultivated and tenure system practiced

Characteristics	Pooled n = 302	Connect seed users n ₁ = 74	Connect Seed Non-users n ₂ = 228
Mode of land acquisition			
Inherited	251 (83.1)	64 (86.4)	187 (81.9)
Rental	22 (7.3)	4 (4.9)	18 (7.7)
Communal	2 (0.7)	0 (0.0)	2 (0.9)
Bought	13 (4.3)	4 (4.9)	9 (4.0)
Lease	12 (4.0)	2 (3.7)	10 (4.5)
Farm size (Hectares)			
<0.5	36 (11.9)	15 (19.8)	21 (9.0)
0.5 – 1.0	75 (24.8)	52 (70.4)	23 (10.0)
1.1 – 1.5	13 (4.3)	5 (6.2)	8 (3.6)
1.6 – 2.0	173 (57.3)	3 (3.7)	170 (74.7)
2.1 – 2.5	2 (0.7)	0 (0.0)	2 (0.9)
2.6 – 3.0	2 (0.7)	0 (0.0)	2 (0.9)
3.0	2 (0.7)	0 (0.0)	2 (0.9)
Mean	1.75	0.78	2.73
Standard deviation	2.58	0.37	4.78
(t-stat = 3.104; p = 0.0013)			

Figures in parenthesis are percentages.

Source: Field survey, 2018

Table 7 shows the distribution of respondents by the land size cultivated and the tenure system practiced. The Connect potato user cultivates on an average 0.78 hectare of land while on

average, non-users cultivates 2.73 hectares of land. The result of the inferential statistics (t-stat = 3.104; p = 0.0013) shows a significant difference in the land size cultivated of the two groups. This suggests that the non-users cultivates more land than the users. The standard deviation of 0.37 among the Connect users explains that there is a low disparity among the variables. However, the standard deviation of 4.78 reveals that there is a wide disparity among the non-users. From the results, it can be observed that the Connect users cultivated less land. This probably, may be because of the low level of Connect they had access to or could purchase. Table 7 also showed that 86.41% of the users and 81.9% of the non-users inherited their land therefore do not incur any cost as it relates to land acquisition. 7.3% of the respondents rented the land they used. 4.3% and 4.0% bought and lease theirs respectively while just 0.7% of the respondents practiced the communal tenure system.

Table 8: Distribution of Respondents by quantity of fertilizer used

Quantity of fertilizer used (Kg)	Pooled n = 302	Connect seed users n ₁ = 74	Connect Seed Non-users n ₂ = 228
≤ 100	94 (31.1)	25 (33.8)	69 (30.3)
101 – 200	80 (26.5)	34 (46.0)	46 (20.2)
201 – 300	110 (36.4)	10 (13.5)	100 (43.9)
301 – 400	14 (4.6)	4 (5.4)	10 (4.4)
>400	5 (1.7)	1 (1.2)	4 (1.8)
Mean	207.08	170.55	243.61
Standard deviation	104.88	91.91	117.85
(t-stat = 1.075; p = 0.857)			

Figures in parenthesis are percentages.

Source: Field survey, 2018

“Table 8 shows the distribution of respondents by quantity of fertilizer used in the 2018 farming season. The Connect users used on the average 170.55kg of fertilizer with a minimum of 40kg and a maximum of 400kg while the non-users used 243.61kg with a minimum of 40kg and a maximum of 650kg. A standard deviation of 91.9 and 117.9 was observed among the users and non-users respectively”. This implies that there is a wide disparity within the variables. The modal

fertilizer quantity range for the Connect users was 100 – 200 kilogram while those of the non-users was 201 – 300 kilogram. The inferential statistics (t-stat = 1.075; p = 0.857) shows that there is no difference between there mean values of the users and non-users which therefore leaves no bases for comparism between the two groups.

Table 9: Distribution of respondents by quantity of agrochemicals used

Quantities of Agrochemicals used	Pooled	Connect seed users	Connect Seed Non-users
Quantity of Herbicide used (litres)			
≤5	71 (23.5)	66 (89.5)	5 (2.1)
6 – 10	225 (74.5)	8 (10.5)	217 (95.1)
>10	6 (1.99)	0 (0.0)	6 (2.8)
Total	302	74	228
Mean	6.65	5.32	7.99
Standard deviation	2.03	2.09	1.96
(tstat = 1.28; p = 0.1004)			
Quantity of fungicide used (litres)			
≤5	145 (77.5)	0	145 (77.5)
6 – 10	42 (22.5)	0	42 (22.5)
Total	187	0	187
Mean	5.67	0	5.67
Standard deviation	1.53	0	1.53
Quantity of insecticide used (litres)			
≤5	81 (98.8)	16 (100)	65 (98.5)
6 – 10	1 (1.2)	0	1 (1.5)
Total	82	16	66
Mean	5.03	5.0	5.05
Standard deviation	2.36	2.65	2.07
(tstat = 0.294; p=0.392)			

Figures in parenthesis are percentages.

Source: Field survey, 2018

Table 9 shows the distribution of farmers by the quantity of agrochemical used in the 2018 farming season. It was observed that the connect users used on the average 5.32 litres of herbicides while the non-users, 7.99 litres. However, the t-test analysis carried out ($t_{stat} = 1.28$; $p=0.1004$) suggest that there is no significant difference between the two group of farmers as it relates to the use of herbicides. The modal litre quantity used by the users was less than 5 litres while that of the non-users was 6 – 10 litre range.

Table 9 also revealed that the users did not use fungicide at all as the variety they cultivate (Connect) do not require its use since it is not susceptible to the prevailing disease of potato in the study area (Late blight disease). However, the non-users, on the average, used about 5.67 litres of fungicide. The modal quantity used was less than 5 litres. The table also showed that the average insecticide litre used for both the users and non-users were 5 litre and 5.05 litre respectively. The t-test analysis also showed that there was no significant difference between the two groups.

Table 10: Distribution of Respondents by labour usage

Labour (Man-day)	All n = 302	Connect seed users n ₁ = 74	Connect Seed Non-users n ₂ = 228	t-value
Land preparation	40.4	26.7	54.1	4.35***
Planting	11.3	8.9	13.7	0.97
Fertilizer application	17.3	12.4	22.1	5.26***
Fungicide application	12.9	0.0	25.7	-
Herbicide application	11.1	11.8	10.3	3.54***
Harvesting	15.0	12.9	17.1	1.77**

*Figures in parenthesis are percentages; key: *** 1%; **5%; *10%*

Source: Field survey, 2018

Pertaining to labour usage, the result according to Table 10 showed that the Connect users used less labour (26.7 man-day) than the non-users (54.1 man-day) for land preparation. The statistical test which was significant at 1% suggests that there is a significant difference between the two groups as it pertains to labour usage on land preparation. This was also the same for labour

usage in fertilizer application and harvesting which were significant at 1% and 5% respectively. This suggest that the non-users utilized more labour than the users. Also, the users and non-users used 8.9 man-day/hectare and 13.7 man-day labour per hectare for planting. However, the result of the statistical test which was not significant suggest there is no significant different between the two groups as it pertains to labour usage for planting. There was no labour use for fungicide application among the users but 25.7 man-day/hectare was recorded for the non-users in the study area. Finally, the Connect users used more labour in applying herbicide than the non-users and the result of the statistical test shows that there was a significant difference between the two groups of farmers as it pertains to labour usage of herbicide application.

4.1.4 Farm Output/Sales Characteristics

Table 11 shows the distribution of farmers by farm output, sales price of output by farmers and the sales outlet. It was measured in tonnes per hectare.

Table 11: Distribution of farmers by farm output, output price and sale outlet

Farm output/sales characteristics	Pooled N = 302	Connect users n₁ = 74	Connect non- users n₂ = 228
Potato output (Tonnes/Ha)			
<1.0	46 (15.2)	1 (1.4)	45 (19.7)
1.0 – 4.9	162 (53.6)	26 (35.2)	133 (58.3)
5.0 – 9.9	48 (15.9)	29 (39.2)	22 (9.6)
≥ 10	47 (15.6)	18 (24.3)	29 (12.7)
Mean	7.73	11.23	4.23
Standard deviation	9.50	5.49	13.52
(tstat = 8.39; p=0.00)			
Potato sales price (₦/Kg)			
≤100	29 (9.6)	0 (0.0)	29 (12.7)
101 – 200	77 (25.5)	1 (1.2)	76 (33.5)

201 – 300	82 (27.2)	35 (46.9)	47 (20.4)
301 – 400	95 (31.5)	37 (49.4)	58 (25.3)
>400	18 (5.9)	2 (2.4)	16 (7.2)
Mean	297.4	331.4	263.4
Standard deviation	89.6	57.13	122.08
(tstat = 5.99; p=0.000)			

Figures in parenthesis are percentages.

Source: Field survey, 2018

According to the result presented in Table 11, the mean farm output for both the connect users and non-users was calculated as 11.23 tonnes/hectare and 4.23 tonnes/hectare respectively. The t-test analysis result (tstat = 8.39; p=0.00), revealed that there is a significant difference between the two groups as it relates to output. Implying that the connect users have more output than the non-users. The modal output range for the connect user is the range 5.0 – 9.9 while that of the non-user is 1.0 – 4.9 tonnes per hectare. Only 1.4% of the users have an output less than 1 tonne while about 19.7% of the non-users obtained below the 1 tonne mark. 35.2% and 58.3% of the users and non-users respectively have output of 1.0 – 4.9 tonnes per hectare while 24.3% and 12.7% of the users and non-users respectively got more than 10 tonnes per hectare of land cultivated. The disparity in output quantity among the non-users was found to be wider than those of the users as shown by their respective standard deviation values.

Also from Table 11, the average sales price for both the users and non-users was calculated as ₦331.36 per kilogram and ₦263.42 per kilogram respectively. The t-test analysis showed that there was a significant difference between the two groups as it pertains to sales price. This implies that the price that the Connect users sold their product was higher than the non-users in the study area. The modal range price for the users and non-users was calculated as ₦301 - ₦400 per kilogram and ₦100 – ₦200 per kilogram respectively. It was also observed that the standard

deviation of the non-users were higher than the users implying that there is a wider disparity among the variable of the non-users than the users in the study area.

4.2 Level of Connect potato variety usage

Table 12 shows that the level of Connect potato variety usage in the study area. It was observed that majority of the Connect users (55.4%) can be categorized as a low level user because they used less than 1000kg. In this group, the average quantity planted was calculated at 301kg/ha. About 37.8% of the users were categorized under the mid-level users because they used between the range values 1000 – 2000kg of the Connect variety.

Table 12: Distribution of farmers based on intensity of usage of the Connect potato variety

Classes	Quantity used (Kg/ha)	Frequency (percentage)	Average quantity planted (Kg/ha)
Low level users	<1000	41 (55.4)	301
Medium level users	1000 – 2000	28 (37.8)	1516
High level users	2001 - 3000	5 (6.8)	2640

Source: Field survey, 2018

This group planted on average 1516 kg/ha of the Connect variety. The high-level users includes farmers that planted above 2000 kg of the variety. About 6.8% of the sampled farmers fell in this group. On the average, they planted about 2640kg/ha. In general, there is a low usage of the Connect variety in the study area.

4.3 Factors Affecting Level of Usage

“Table 13 presents the result of the selection (probit) and outcome equations of the Heckman model of the factors influencing both the decision to use the connect variety and the intensity of usage. The inverse Mill’s ratio (λ) was found to be significant at the 5% level implying

that there is no selection bias in the model which therefore strengthens the requisite of using the Heckman's two-step model. In other words, sample selectivity bias would have occurred if the level of participation had been estimated without taking into account the decision to use. Thus the coefficients of the explanatory variables represents consistent estimates of the intensity of usage. The inverse Mill's ratio carries a negative sign which infers that there would have been a downward bias in the estimated coefficients if selection bias had not been revised in the model. The value of Wald was found to be 6503.83 and the P value, 0.00. This implies that the null hypothesis that there is no relationship between the dependent and independent variables was rejected and hence the model is effective".

Table 13: Factors affecting usage and the intensity of use

Variables	<u>Decision to use</u>		<u>Intensity of use</u>	
	Coefficient	P> z	Coefficient	P> z
Household size	- 0.14	0.351	15.22**	0.010
Credit amount (Naira)	0.03***	0.001	2.14**	0.036
Seed price (Naira)	- 0.09*	0.080	-0.61***	0.000
Sex of household head	- 0.19	0.685	-8.28	0.758
Years of education	- 0.14	0.486	10.94	0.393
Membership of association	0.71**	0.036	-31.73	0.143
Farm experience (Years)	- 0.01	0.462	2.42**	0.010
Off-farm income (Naira)	0.01*	0.098	-0.03	0.352
Extension contacts	- 0.02	0.641	0.64	0.846
Availability of Connect seed	8.51***	0.000	7.89**	0.030
Perception of relative importance	76.24**	0.021	-	-
Inverse mill ratio			-83.96**	0.040
Wald's chi2	6503.83			
Sigma	81.39			
Prob chi2	0.00			
Rho	-1.03			

Source: Field survey, 2018 **key: *** 1%; **5%; *10%**

4.3.1 Decision to use the Connect Potato variety

The empirical results indicated in Table 13 revealed that the amount of credit, potato seed price, membership of association, off-farm income, perception of relative importance and availability of the Connect seed were factors found to influence the farmer's decision to use the variety.

The amount of credit has a positive and highly significant (at 1% level) relationship to the decision to use the Connect potato variety. This means that farmers that have access to credit are more likely to use the Connect potato variety.

The seed price was significant at 10% level but negatively. This implies that the likelihood of using the Connect variety increases as its price falls. This result is probable as the Connect variety records a higher price than all other varieties in the study area as a result of its relative scarcity.

Furthermore, the membership of association was also found to be significant at 5% level and positively implying that farmers in one form of association are more likely to opt for the usage of this variety. This also applies for off-farm income which was also positively significant at 10%.

The perception of each farmers that knows about the existence of this variety was also measured and was found to be positively significant at 5% level. This implies that farmers that knows about the advantage of this variety over the others are more likely to opt for its usage. Then finally, the availability of this variety which was significant at 1% also increase the likelihood of been used in the study

4.3.2 Factors affecting the intensity of usage of the Connect potato variety

The empirical results on the factors affecting the intensity of use as indicated in Table 13 revealed that the amount of credit, potato seed price, household size, potato farming experience and availability of the potato seed were the significant factors that influences the intensity of use of the Connect potato variety in the study area.

Household size was also found to be positively significant at 5% level and with a coefficient of 15.22. This implies that a unit increase in the size of household of the Connect users will lead to 15.22 kilogram per hectare increase in the intensity of usage of this variety. In simple terms, it can be said, that household of larger members tends to use more of the Connect variety. This may be because a large household members places an increasing demand on meeting the household livelihood. This can also mean that the farmer (household head) with larger household sizes may decide to go more of this variety because of the availability of family labour at his disposal. This result goes in line with the findings of Umar *et al*, (2014) who reported a positive influence of household size on new maize variety usage.

Just as in the decision to use, the amount of credit was also positively significant but at 5% level and with a coefficient of 2.14. This implies that a unit increase in the credit amount that a farmer has access to, there is a 2.14 kilogram increase in the quantity of Connect variety used per hectare. In simpler terms, increased credit intensifies the usage of the Connect variety. Credit has been reported to increase capital base which in turn opens them to new and improved innovations possibilities. This result corroborates the work of Udimal, Jincai, Mensah & Caesar, (2017) who reported a positive relationship between adoption and credit in their work on factors influencing Nerica Rice adoption in Ghana.

The price of the Connect seed was negatively significant at 1% level with a coefficient of 0.61. This implies that the possibilities of intensifying the use of the Connect potato variety falls

as its price increases. And a unit increase in the price of the Connect seed variety will lead to 0.61 reduction in the kilogram planted by the users in the study area. The cost of a technology has been reported to play a pivotal role in its adoption and usage. There is a more likelihood of intensifying the usage of an innovation that is affordable than those that are expensive irrespective of the farmer's level of interest (Oppong-yeboah, 2015). This is because farmers with a low capital base may find it difficult to go for the variety considering its cost. The result of this study agrees with the study of Howley & Donoghue, (2012) who also reported a negative relationship between the adoption of artificial insemination technology and expenditure accrued to adopting the technology. Udimal, Jincai, Mensah & Caesar., (2017) also corroborates the result of this study.

The potato farming experience was also a driver of the intensity of usage. It was found to be positively significant at 5% level with a coefficient of 2.42. This means that the intensification of use of this variety increases with experience and a unit increase in the years in potato farming will result into a 2.42 kilogram increase in the use of the Connect potato variety. In other words, farmers that are more experience are more likely to intensify their use of the variety than farmers that are not. The result of this study corroborates the result of Komolafe *et al*, (2014) who reported a positive relationship between farming experience and adoption of improved crop practices.

Finally, availability of the Connect potato seed was also positively significant at 5% level with a coefficient of 7.89. This implies that there is a 7.89 kilogram increase in usage of this variety as more of it becomes available for use. This is still relatively scarce as explained by the farmers in the focus group discussion had with them. Many of them explained that it is still hard to come by and even when they do, it comes at a high price.

4.4 Profitability Analysis

Table 14 presents the comparative analysis of costs and the return to farmer' labour and management for the Connect users and non-users.

Table 14: Costs and return to potato farming among the Connect users and non-users

Variables	USERS (₦/hectare)	NON-USERS (₦/hectare)
Gross revenue	2,520,305.16	1,049,290.55
Less variable costs	<u>651,183.05</u>	<u>325,250.64</u>
<i>Cost of seed</i>	415,024.34	181,981.51
<i>Cost of fertilizer</i>	52,791.71	47,201.39
<i>Cost of fungicides</i>	-	6,705.96
<i>Cost of herbicides</i>	6,686.13	7,705.97
<i>Cost of insecticide</i>	1,215.98	935.41
<i>Less depreciation of farm tools</i>	12,837.50	14,002.41
<i>Less labour cost</i>	62,201.12	57,579.97
<i>Less transport cost</i>	17,925.00	5,010.81
<i>Less storage cost</i>	4,547.33	104.23
<i>Less imputed cost of land</i>	27,160.49	6,256.91
<i>Less cost of credit (interest)</i>	50,793.42	18,272.17
Equals Gross margin (GM)	1,869,122.10	722,040.79
Operating Ratio (OR)	0.26	0.31
Returns to capital invested	2.87	2.32

Source: Field survey, 2018

The result of Table 7 showed that the connect users were more profitable in their production than the non-users. The users, on average harvests about 11 tonnes per hectare while the non-users 4 tonnes per hectare. The gross revenue of the users and non-users were ₦2,520,305.16 and ₦1,049,290.55 per hectare respectively. That of the users was higher because of their higher yield and sales price per kilogram of the Connect variety. The gross margin of the users and non-users was calculated as ₦1,869,122.1 per hectare and ₦722,040.79 per hectare respectively. The total variable cost of the Connect users was found to be higher than those non-users. This was so because the cost incurred on seed purchase to cultivate a hectare by the users is very high which is also due to its scarcity. The rate of return to investment for the Connect users (2.87) is higher than that of

the non-users (2.32). This depicts that for every naira invested, the Connect users earn ₦2.87 and non-users earn ₦2.32 as returns to input, labour and management. “Also, the operating ratio is directly related to the farm variable input usage. It shows the proportion of the gross income that goes to pay for the operating cost. The lower the ratio, the higher the profitability. The operating ratio of the Connect users is 0.26 while that of the non-users is 0.310. This implies that only 26% of the gross income goes to pay for the operating cost among the users while about 31% of the gross income goes to pay for the operating cost of the non-users in the study area”. Therefore, it can be said that potato farming business is more profitable among the Connect variety users than the non-users in the study area.

Analysis of the Total Factor Productivity of the farmers

Table ... shows the distribution of the farmers (users and non-users) by their level of Total factor Productivity (TFP). As indicated by the table, the TFP indices of the users ranged from 0.145 to 10.67, with an average of 4.94. The productivity score of the non-users ranged from 0 to 12.44 with an average of 3.92.

Table: Result of Analysis of the Total Factor Productivity Indices

Total factor productivity indices	Users	Non-users
≤ 1.00	9	31
1.01– 3.00	13	83
3.01 – 5.00	16	58
5.01 – 7.00	21	27
> 7.00	15	29
Minimum	0.145	0
Maximum	10.67	12.44
Mean	4.94	3.92
Standard deviation	3.77	3.48
Coefficient of variation	0.76	0.88
t - value	2.37**	

Source: Field survey, 2018

Note: numbers in parenthesis are percentage;

***, ** and *** represents significance at 10%, 5% and 1% respectively.**

“The result of the test-statistic showed that the mean TFP of the users was significantly higher than the non-users at 5 percent ($p < 0.05$). This suggest that the cost incurred per unit of output produced is different for the two categories of farmers. It also implies that the Connect potato variety plays a significant role in terms of increasing output of the using farmers”. Finally, the result of the coefficient of variation indicates a more consistency in the level of TFP among the non-users than the users.

Analysis of Partial Productivity of the Farmers

Table ...: Result of Analysis of the Partial Factor Productivity

Partial factor productivity	Users	Non-users	t-value
Seed input productivity (Kg/Kg)	15.07	4.21	5.43***
Fertilizer inputs productivity (Kg/Kg)	22.3	11.29	4.36***
Agro-chemicals inputs productivity (Kg/Litres)	1575.25	634.36	5.23***
Labour productivity (Kg/manday)	234.02	100.43	3.87***
Land productivity (Tonnes/Ha)	11.23	4.23	8.39***

4.5 Analysis of Efficiency of the Farmer

“The LR statistics was utilized to proper tests of hypotheses so as to decide the functional form appropriate in this stochastic frontier analysis (Cobb-Douglas or Translog) and the results are presented in Table 15. The first hypothesis $H_0: \gamma = 0$ was rejected, which specified the presence of technical inefficiency effects in the model. This is to say that the technical inefficiency effects concomitant with potato farming were significant”.

Table 15: Generalized Likelihood Ratio Test of Hypothesis

Hypothesis	Value of λ	Critical value	Decision
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$H_0: \gamma = 0$	23.55	0.000	Reject
$H_0: \mu = 0$	17.92	0.012	Reject
$H_0 : \psi = 0$	5.95	0.312	Accept

Source: Author's presentation, 2018

“The second hypothesis $H_0: \mu = 0$ was also rejected, which brought to bare the suitability of the truncated-normal distribution over the half-normal distribution for the explanation of the inefficiency effects. The third hypothesis $H_0 : \psi = 0$ was accepted, which also indicates the suitability of the Cobb-Douglas over the Translog production function”.

4.5.2 Analysis of Levels of Efficiency of the Farmers

“The distribution of farmer's (users and non-users) by their level of efficiency is presented in Table 17. The frequency distribution of technical efficiency of the connect variety users ranges from 0.52 to 0.99 with a mean of 0.88. Also, the technical efficiency of the non-users ranged from 0.11 to 0.94 with an average of 0.77. This implies that on the average, the Connect users and the non-users were able to obtain 88% and 77% output respectively from a given combination of production inputs. The result of the test shows that there is a significant different in the level of technical efficiency of the connect users and non-users at 1% significant level (t stat = 4.516). This implies that the Connect users are more technically efficient than the non-users. It was also observed that a greater percentage of the Connect users (53.1%) operated between the efficiency ranges of 90 - 99 percent while a greater percentage of the non-user (37.5%) operated in the efficiency range of 80 to 89 percent”.

Table 17: Distribution of the Connect users and non-users by technical efficiency indices

LEVEL OF EFFICIENCY ($\times 100$)	ALL FARMERS $n = 302$	CONNECT USERS $n = 74$	CONNECT NON-USERS $n = 228$
10-19	5 (1.7)	0 (0.0)	5 (2.3)
20-29	6 (2.0)	0 (0.0)	6 (2.7)
30-39	7 (2.3)	0 (0.0)	7 (3.2)
40-49	10 (3.3)	0 (0.0)	10 (4.5)
50-59	10 (3.3)	1 (1.2)	9 (4.1)
60-69	21 (7.0)	5 (6.2)	16 (7.2)
70-79	38 (12.6)	14 (17.3)	24 (10.9)
80-89	101 (33.4)	18 (22.2)	83 (37.5)
90-99	104 (34.4)	43 (53.1)	61 (27.6)
Min	0.1192	0.5230	0.1192
Max	0.9932	0.9932	0.9425
Mean	0.8265	0.8800	0.7740
Standard deviation (t-stat = 4.516; p=0.000)	0.1567	0.1983	0.1152

Note: numbers in parenthesis are percentages.

Source: Field survey, 2018

The mean value of 88% for the users indicates that if a Connect users was to operate in the production frontier, the efficiency of input usage need to be increased by 12%. i.e. the average Connect potato farmer requires 12% cost saving to attain the status of the most efficient potato farmer while the least performing Connect users would need 48% cost saving to become the most efficient farmer. In the same way, if the non-users were to operate in the production frontier given their mean value of 77%, the efficiency of input usage must be increased by 23%. The connect users can also be said to be better in the use of farm inputs than their non-using counterpart.

4.5.1 Determinants of Efficiency of the Farming Households

“The maximum likelihood estimate of the stochastic production frontier function of the potato farmers is summarized in Table 16. The estimated variance (δ^2) was statistically significant at 1% for both the Connect users and non-users. This indicates the goodness of fit and the correctness of the specified distributional assumption of the composite error term. The maximum

likelihood of gamma (γ) is 0.55 and 0.74 among the Connect users and non-user respectively”. “These values are consistent with the theory that the true γ - value should be greater than zero and less than one. Also, since the value of the γ -estimate is significantly different from one, it means that random shocks are also playing a role in the variation observed in the yield of the users and non-users”.

Table 16: Maximum Likelihood Estimates of the Stochastic Frontier Function of Farmers

VARIABLE	PARAMETER	USERS	NON-USER
Constant	β_0	3.99*** (4.38)	2.93*** (11.62)
Farm Size (Ha)	β_1	0.08 (-0.35)	0.055 * (1.69)
Quantity of Seed (Kg)	β_2	0.055*** (4.88)	0.26*** (16.9)
Quantity of Fertilizer (Kg)	β_3	0.08*** (2.73)	0.18** (2.52)
Quantity of Chemicals used (Litres).	β_4	0.066*** (2.70)	0.15*** (6.21)
Labour (Man-day)	β_5	0.11** (2.23)	0.01 (0.35)
Sigma square	δ^2	0.22 (5.19)	0.41 (8.78)
Gamma	γ	0.55	0.74
Number of observation		74	228

Source: Field survey, 2018

Note: numbers in parenthesis are t-stat; *, ** and *** represents significance at 10%, 5% and 1% respectively.

“With an estimated γ of 0.55, the study showed that about 55% of the variation in output of the Connect users from the frontier was due to their technical inefficiency. This indicates that a significant portion of the error variation among the users is due to inefficiency error u_i and not due to random error v_i (which are factors that cannot be influenced by the farmers) implying that the random component of the inefficiency effect makes a significant contribution in the stochastic analysis of the connect users. In a simple term, it means factors that are controllable by the Connect variety users are likely to affect output than the uncontrollable factors as related to potato production. In the same way, the estimated γ value of 0.74 among the non-users indicates that 74% of the variation in output of the non-users was due to the technical inefficiency. This implies that the random component of the inefficiency effects makes a significant contribution to the stochastic analysis of the Connect non-users”.

The mean likelihood estimates showed that the variables that significantly influenced the output of the Connect users were seed quantity ($p < 0.01$), fertilizer quantity ($p < 0.01$), quantity of chemical used ($p < 0.01$) and labour ($p < 0.05$). The coefficients of these variables were all positive. This result implies that a unit increment in inputs such as seed quantity, fertilizer quantity, quantity of chemical used and labour will result to an increase in output by 5.5 percent, 8 percent, 6.6 percent and 11 percent respectively. The positive value in other words implies that the present input used were not optimal and yield would have increased from the additional use of the inputs. This result corroborate the results of Gatemberezi, (2011), Assa *et al*, (2012) and Jwanya et al., (2014) who all reported a positive relationship between output and seed quantity, fertilizer quantity and labour.

“The mean likelihood coefficient for the Connect non-users showed that each of the inputs quantity of seed ($p < 0.01$), quantity of fertilizer ($p < 0.05$), quantity of chemicals ($p < 0.01$) and farm size ($p < 0.1$) were significant and had positive values of 0.26, 0.18, 0.15 and 0.055 respectively. This implies that a unit increment in the inputs such as seed quantity, fertilizer quantity, chemical quantity and land size among the non-users will lead to an increase in output by 26 percent, 18 percent, 15 percent and 5.5 percent respectively. The positive values also mean that the present inputs used were not optimal and yield would have increased from the additional use of the inputs”.

4.5.3 Determinants of production inefficiency

Farmers’ socio-economic characteristics may influence farmers’ production decisions as well as the overall technical efficiency in production. “This section reports on sources of

inefficiency estimated in the model. A negative sign on parameter inefficiencies implies that the variable reduces technical inefficiency while a positive sign increases technical inefficiency”.

Table 18: Determinants of production inefficiency

VARIABLE	PARAMETER	USERS	NON-USER
Constant	Z ₀	-0.81 (-0.15)	0.46 (1.06)
Years of Education	Z ₁	0.04 (0.12)	-0.92*** (-3.51)
Farm Experience (years)	Z ₂	-0.06*** (3.31)	-0.54*** (3.65)
Extension contacts	Z ₃	0.08 (0.54)	-0.86 (-1.46)
Household size	Z ₄	-0.73* (-1.68)	-0.69*** (-3.65)
Sex	Z ₅	-0.16*** (4.79)	0.22 (1.042)
Non-farm occupation	Z ₆	-0.08 (-0.09)	1.18** (2.479)
Access to Credit	Z ₇	-0.09 (-0.32)	0.60 (1.48)

Source: Field survey, 2018

Note: numbers in parenthesis are t-stat; *, ** and *** represents significance at 10%, 5% and 1% respectively.

Table 18 shows the result of the technical inefficiency for the Connect users in the study area. “It revealed that farm experience, household size and sex were significant and negatively. Farm experience was significant at 1% level and with a coefficient of 0.06. This implies that a unit increase in farm experience results in 0.06 unit reduction in inefficiency. In other words, efficiency increase as farm experience increase among the Connect users. The household size was also significant at 10% level with a coefficient of 0.73. This implies that an increase in household size results in an increase in efficiency of the users. In other words, inefficiency falls as household size increases. This may be attributed to the fact that these households consumes more food and therefore strive to achieve higher output. In addition, these households have more labor available, which may influence the supply of household labor for non-farm work. Finally, the result also shows that men increases efficiency but it falls with female”.

“Furthermore, the result of the technical inefficiency as shown in Table 18 revealed that years of education, farming experience and household size were negatively significant while non-

farm income was found to be positively significant. The coefficient of education was 0.92 and was found to be significant at 1% level. This implies that the efficiency of the non-users increase by 0.92 at a unit increase in the years of education. In other words, inefficiency falls as year of experience increases. So also, years of experience was negatively significant at 1% level and a coefficient of 0.54. This implies that efficiency increase by 0.54 unit at a unit increase in the farmer's experience in potato farming. In other words, inefficiency falls as the years of experience increases. Education and farming experience plays a significant role in skill acquisition and technology transfer and farmers with higher levels of education were likely to be more efficient in the use of inputs than their counterparts with little or no education (Okoruwa et al, 2006; Gatemberezi, 2011). Household size was also significant at 1% level with a coefficient of 0.69. This implies that efficiency increases by 0.69 unit at a unit increase in household size. Household size has been hypothesized to increase efficiency as households with larger numbers have more labour to supply to farm work (Gatemberezi, 2011). Finally, going against apriori expectation, non-farm income was found to be positively significant at 5% level and with a coefficient of 1.18. This implies that as non-farm income increases, inefficiency increases also. In simple terms, as farmers non-farm income increase by one unit, their efficiency falls by 1.18 units. This might be ascribed to the fact that most farmers might start getting comfortable with their non-farm income to the extent that less efforts are now directed towards farming activities”.

4.6 Effect of the Connect Potato Variety on Potato Farmer's Productivity, Profitability and Efficiency.

Table 19 shows the result of the effect of the Connect potato variety on the farmer's productivity, profitability and efficiency. This estimated impact was done using three different matching algorithms. These are radius, kernel and the nearest neighbor matching algorithms.

Table 19: Estimated impact parameters using the three different matching algorithm.

Algorithms	Variable	Treated	Control	ATT	t-test
Radius (caliper 0.10)	Gross margin	1,869,122.10	730303.8	1138818.3****	4.88
	Technical efficiency	0.88	0.78	0.12****	4.16
	Returns on investment	2.87	1.53	1.34****	3.86
	Operating ratio	0.10	0.63	-0.53*	-1.69
	Total factor productivity	4.93	3.84	1.09**	2.00
Kernel	Gross margin	1,869,122.10	864947.10	1004175.00****	4.64
	Technical efficiency	0.88	0.78	0.10****	5.21
	Returns on investment	2.87	1.40	1.47****	3.13
	Operating ratio	0.10	-0.35	0.45	0.46
	Total factor productivity	4.93	4.14	0.79	1.59
Nearest neighbor (NNM)	Gross margin	1,869,122.10	749283.7	1119838.40****	4.80
	Technical efficiency	0.88	0.78	0.11****	3.95
	Returns on investment	2.87	2.12	0.75****	3.20
	Operating ratio	0.10	0.45	-0.35	0.17
	Total factor productivity	4.93	4.19	0.74	1.33

Source: Field survey, 2018.

Note: *, ** and *** represents significance at 10%, 5% and 1% respectively.

“Since the NNM matches each farmer from the user group with the farmer from the non-users group having the closest propensity score, it faces the risk of bad matches if the closest neighbor is far away”. For this reason, although valid, the NNM algorithm will not be used to explain the effect of the Connect potato variety. The Radius algorithm however, reduces this risk “by using caliper matching, which imposes a maximum tolerance on the difference in propensity scores”. Also since the Radius matching algorithm (caliper 0.10) gave the highest number of significance on outcome variable, it was adopted to explain the estimated effect of the Connect potato variety on the farmer’s productivity, profitability and efficiency.

As shown in Table 19, the variable considered were the gross margin, technical efficiency, returns on investment and operating ratio. The average treatment effect on the treated (effect parameter) for the gross margin variable was estimated at ₦1,138,818.3. The t-test result (4.88) showed that there is a clear difference between the control and the treated. This implies that the Connect users were better-off in returns as a result of using the variety as the effect parameter indicates a ₦1,138,818.3 increase in gross margin among the users as a result of their usage.

The result of the radius matching in Table 19 also showed the effect parameter (ATT) of technical efficiency. According to the result, it was observed that using the Connect potato variety increased the efficiency of the users by 12% and the result of the statistical test (4.16) revealed that there is a difference between the control and the treated group. This implies that the users of the Connect variety are operating on the frontier 12% better than the non-users as a result of using the variety.

Similarly, the result of the returns on investment showed that every user gains 1.34 units more than the non-users for every unit invested in potato farming. The result of the t-test analysis showed this to be statistically significant at 1% level.

The result on the total factor productivity shows that the usage of the Connect potato variety increased the increased the output attained per unit inputs of the users by 1.09 at 5% significant level. This implies that the users are doing better in their input to output conversion rate as a result of the usage of the Connect potato variety.

Finally, the result also shows that the proportion of the gross income that goes to pay for the operating cost amongst the users is 0.54 less than those of the non-users in the study area.

4.6.2. Perceived Benefits of Using the Connect Potato Variety

Table 20 shows the result of the benefits derived from using the Connect potato variety as opined by the using farmers in the study area. “About 86% of the users reported an increase in their yield size as a result of using the Connect potato variety. Higher yield size has a mean score of 4.03”.

Table 20: Perceived benefits derived from the Connect Variety

Benefits	SA	A	I	D	SD	WS	MS
Higher yield	42 (57.5)	21 (28.8)	6 (7.5)	5 (6.25)	0 (0.00)	322	4.03
Disease resistance	44 (60.0)	12 (16.3)	5 (6.25)	8 (11.25)	5 (6.25)	304	3.8
Higher profit	15 (20.0)	38 (52.5)	9 (12.5)	7 (8.75)	5 (6.25)	273	3.4
LPPHL*	37 (46.8)	28 (37.1)	6 (7.5)	3 (3.75)	0 (0.00)	312	3.9
Palatability	8 (10.8)	12 (16.2)	37 (50.0)	17 (22.9)	1 (1.35)	234	2.9

Source: Field survey, 2018. (*Low pre&post-harvest loss)

About 76% of the users were of the opinion that the reason why it gave a higher yield than other varieties cultivated in the study area was because the variety was resistance to disease especially the prevailing late blight disease which has been found to be a major problem to potato production. it is noted that the 17.5% that disagreed to the fact that the variety was resistant to the late blight disease gave reasons that they had rather prefer to say that the variety was “blight tolerant” rather than being resistant. This is because, the presence of the disease was still sited on their farm. However, they still had higher yield than all other local varieties they have used. They also pointed out that this also saved them the expenses on fungicide to control the disease.

Furthermore, 72% of the users opined that they have made higher profits in the production activities ever since they have been using the Connect variety. They also explained that it valued more than the local varieties and as a result, more profitable. Finally, 83.9% of the users reported that there has been a low level of pre and post-harvest since they have been using the Connect

variety. They did not lose their farm product to disease and after harvesting, they found it much easier to sell off their output faster than other varieties because of the favourable characteristic of the variety and its size.

4.7. Challenges faced by the Connect users

Table 20 shows the challenges faced by the Connect users in the study area. The scarcity of the Connect variety ranked the highest with a mean value of 4.3. They did complained more on this in the group discussion had with the farmers in the study area.

Table 20: Constraints to Connect usage in the study area

Constraints	VS	S	MS	LS	NS	WS	Mean
Scarcity of the Connect seed	145	112	25	11	3	1273	4.3
Low yield	24	24	52	145	51	713	2.4
Disease susceptibility	26	93	47	79	51	852	2.5
Low tuber quality	9	41	42	155	49	694	1.9
Long gestation period	18	67	63	124	24	819	2.8
Small tuber size	19	36	38	142	61	698	2.7
High cost of the seed	85	137	60	14	0	1181	3.9
Short shelf life	27	50	76	113	30	819	2.7

Source: Field survey, 2018.

KEY: VS-very serious; S-serious; MS-moderately serious; LS-least serious; NS-not serious; WS-weighted score.

The majority of those that used this Connect variety procured their seed from their fellow farmers who happened to have them. Those that did, complained that it is usually sold at a high price which made high cost of seed ranked the second constraint to usage of the variety. It has a mean of 3.9. The least constraints to usage was low yield of the variety and low tuber quality.

CHAPTER FIVE

5.0. SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of major findings

This study examines the effect of the Connect potato variety on farmer's productivity in Plateau State. The study was carried out in the eight potato producing local government in plateau state. These were Barkin-Ladi, Bassa, Mangu, Bokkos, Jos East, Jos South, Pankshin and Riyom. Production and household data was collected from 302 potato farmers (comprised of 74 Connect potato variety users and 228 non-users) with the aid of a well-structured questionnaire and interview by trained enumerators. Seven major tools were employed for this study. These are: Descriptive and inferential statistics, Heckman selection model, Stochastic Production Frontier Model, Gross Margin Analysis, t-test analysis and the propensity score matching.

“The result of the demographic characteristic revealed that the mean age of the sampled Connect potato variety users and non-users was 43 and 44 years respectively. The distribution of the respondents based on gender revealed that majority of the Connect variety users (82.7%) and non-users (78.7%) were male and mean household size of both the Connect users and non-users was found to be 6 and 7 members respectively. Majority of the Connect potato variety users (46.9%) have up to a form of tertiary education while the majority of the non-users (41.6%) have at least a secondary education”.

“The average potato farming experience recorded from all observed farmers is 19 years with a minimum of 3 years and a maximum of 43 years. It was also observed that 63.0% and 47.06% of the Connect potato variety users and non-users belongs to a form of social group (farmers association/co-operatives). 56.8% and 52.0% of the Connect users and non- users had contact with extension agent respectively and only 45.7% of this users has potato farming as their

primary source of income. However, 50.2% representing the majority of the non-users reported potato farming as their primary source of income. Finally, the result showed that 52.7% of the Connect variety users had access to credit while just 30.8% of the non-users had access”.

It was observed that the average quantity of potato planted by the Connect users and non-users were 719.23kg and 1720kg respectively. The modal quantity range planted by the Connect users was less than 500kg while those of the non-users was between 1001 – 1500 kilogram of potato. The price per kilogram of Connect potato and other varieties were ₦396.7 and ₦238.20 respectively. The potato varieties cultivated by the non-users were Nicola, Marabel, Lady christyl, Caruso, Batita, Diamant and jelly. The most cultivated was Nicola. The most land tenure used by the farmers was by inheritance. The Connect users cultivates on an average 0.78 hectares of land while on average, non-users cultivates 2.73 hectares of land. The Connect users used on the average 170.55kg of fertilizer with a minimum of 40kg and a maximum of 400kg while the non-users used 243.61kg with a minimum of 40kg and a maximum of 650kg per one planting season. The connect users and non-users used 5.32 litres and 7.99 litre respectively. The Connect users used no fungicides, however, the non-users on the average used 5.67 litres. The average quantity of insecticide used by the users and non-users was 5 litres and 5.05 litres respectively. Furthermore, pertaining to input usage, the result showed that the quantity of labour used in all production process by the Connect users and non-users were 72.63 man-day and 142.35 man-day per hectare respectively. The mean output of the Connect users was calculated as 11.24 tonnes/ha while that of the non-users is 4.23 tonnes/ha. The average selling price for the Connect users and non-users are ₦331.4 and ₦263.4 respectively.

It was observed that majority of the Connect users (55.4%) can be categorized as a low level user because they used less than 100kg of the variety. In this group, the average quantity

planted was calculated to be 301kg/ha. About 37.8% of the users were categorized under the mid-level users because they used between the 1000 – 2000kg of the variety. This group planted an average 1516 kg/ha of the Connect variety. The high level users includes farmers that planted above the 2000kg of the variety. About 6.8% of the sampled farmers fell in this group. On the average, they planted about 2640kg/ha. In general, there is a low usage of the Connect variety.

“The result of the selection (probit) and outcome equations of the Heckman model of the factors influencing both the decision to use the connect variety and the intensity of use showed that amount of credit, potato seed price, membership of association, off-farm income and availability were factors found to influence the farmer’s decision to use the variety in the study area. The seed price was negatively significant which mean that increase in the Connect seed price will reduce the chances of usage of this variety. Amount of credit, membership of association, off-farm income and availability were positively significant which implies that an increase in these factors will likely increase the likelihood of usage of the Connect variety in the study area. So also, the empirical results revealed that the amount of credit, potato seed price, household size, potato farming experience, farm size and farm output were the significant factors that determines the intensity of use of the Connect potato variety in the study area. All but the Connect seed price were found to be positively significant”.

The profitability result showed that the gross revenue of the users and non-users were ₦2,520,305.16 and 1,049,290.55 per hectare respectively. This was so because the cost incurred on seed purchase to cultivate a hectare by the users is very high which is also due to its scarcity. The rate of return to investment for the Connect users (2.87) was also higher than that of the non-users (2.32). This depicts that for every naira invested, the Connect users earn ₦2.87 and non-users earn ₦2.32 as returns to labour and management. Also, the proportion of the gross income that

goes to pay for the operating cost (operating ratio) for the Connect users is 0.26 while that of the non-users is 0.310. The lower this ratio, the better. Therefore, potato farming business is more profitable among the Connect variety users than the non-users in the study area.

“The result of the stochastic frontier showed that technical efficiency of the Connect variety users and non-users is 0.88 and 0.77 respectively. This implies that on the average, the Connect users and the non-users were able to obtain 0.88 and 0.77 potential output respectively from a given combination of production inputs. In simpler terms, it can be said that if the users and non-users were to operate in the production frontier given their mean value, the efficiency of input usage must be increased by 12% and 23% respectively. However, the result of the test shows that there is a significant different in the level of technical efficiency of the connect users and non-users at 1% significant level (t stat = 4.516). This implies that the Connect users are more technically efficient than the non-users”.

“The maximum likelihood estimate of the stochastic production frontier function shows the factors that drives efficiency and inefficiency of potato farming among the users and non-users. The estimated variance (δ^2) was statistically significant at 1% for both the Connect users and non-users indicating the goodness of fit and the correctness of the specified distributional assumption of the composite error term. The maximum likelihood of gamma (γ) is 0.50 and 0.74 among the Connect users and non-user respectively. Since these values of the γ -estimate is significantly different from one, it means that random shocks are also playing a role in the variation observed in the yield of the users and non-users. The mean likelihood coefficient for the Connect users showed that each of the inputs of seed quantity, fertilizer quantity and hired labour had positive values of 0.56, 0.08 and 0.11 respectively depicting an increase in technical efficiency if there is a unit increase in inputs such as the seed quantity, fertilizer quantity and hired labour. The result of

the technical inefficiency for the Connect users showed that farming experience, sex and household size was found to be significant and negatively. This implies that technical inefficiency will reduce as this variables increases. Similarly, the mean likelihood coefficient for the Connect non-users showed that each of the inputs quantity of seed, quantity of fertilizer, quantity of fungicides, quantity of herbicides and farm size had positive values of 0.76, 0.18, 0.51 0.02 and 0.55 respectively implying that a unit increment in these inputs among the non-users, output will increase by their corresponding coefficients. The result of the technical inefficiency showed that years of education, farming experience and household size were negatively significant while non-farm income was found to be positively significant. This result implies that as education, experience and household size increases, inefficiency reduces. Contrariwise, as farmers non-farm income increase, their efficiency falls. This might be ascribed to the fact that most farmers might start getting comfortable with their non-farm income to the extent that less efforts are now directed towards farming activities”.

Nearest Neighbour, Radius and Kernel were the three algorithm considered in explaining the effect of the Connect potato variety usage on farmer’s returns (gross margin, technical efficiency, returns to investment and operating ratio). However, the Radius algorithm of the propensity score matching was found to explain the effect of the connect potato variety on these outcomes better. This algorithm adopted a Calliper of 0.10 as a maximum tolerance in differences of the propensity scores which was done to do away with the problem of bad matches. The result showed that there was a significant improvement in the outcome parameters of the Connect users in the study area. Finally, the result of the constraints to usage showed that high seed cost of the variety was the most prominent in the study area.

5.2 Conclusion of major findings

Based on the findings of this work, it can be concluded that the Connect users are better-off in potato farming which can be attributed to their use of the variety.

5.3 Policy recommendations

Based on the findings of this study, the following are recommended.

- Since credit access is a determining factor for the decision to use and the intensity of Connect variety usage, credit facilities should be provided for the local farmers as this would increase their investing ability for better output and income level.
- Government should be well involved in the importation and multiplication of the Connect potato seed so as to increase its availability and in effect reduce its selling price
- As membership in association encourages usage, farmers should be encouraged to join and form associations as this improves access and information to/about innovations.
- Basic amenities such as farm inputs (agro-chemicals and fertilizer) should be made available to the farmers as these has been found to increase productivity.
- Minimum of secondary school education should be encouraged among the farming households as this will increase their openness to using new farm innovations (specific to this study, Connect potato variety).

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QUESTIONNAIRE
UNIVERSITY OF ILORIN
POSTGRADUATE SCHOOL
DEPARTMENT OF AGRICULTURAL ECONOMICS AND FARM MANAGEMENT.

Informed consent:

Dear respondent,

The researcher is a Ph.D. student of the University of Ilorin, Nigeria. His research work is on the **“Effect of the Connect Potato Variety on Farmer’s Productivity in Plateau State, Nigeria”**. This is part of the requirements for the award of Ph.D. degree.

To this end, this questionnaire has been formulated to retrieve information on the research in question. All information sought here is purely for academic purposes and will be treated with utmost confidentiality. The result gotten will not be used in any discriminatory manner against your personality. Your consent to proceed with this survey is needed and I kindly implore you to respond to all the questions.

However, should you find yourself disinterested at any stage of answering this questionnaire, you can opt out of the interview and your decision will be highly respected. Thanks for your cooperation.

Yours Sincerely
Ojediran Ezekiel Olamide
(08136487341)

Please tick (✓) as appropriate

- I wish to participate in this survey ()
- I am not interested in this survey ()

Local Government:.....

Village:.....

Date of interview:.....

SECTION A: HOUSEHOLD SOCIO-ECONOMIC DATA

Names of household members	Sex 1=Male 0=Fem	Relationship with the household 1=Husband 2=wife 2=child 3=others	Age	Marital status 1= Single 2= Married 3= Divorced 4= Widowed	Educational attainment. 1=Primary 2=Secondary 3=Post-secondary 4= No Formal education	Does he or she help in farm work? 1= Yes 0= No

- (1) Are you a member of any farmer's Association or Cooperative societies? Yes () No ()
- (2) If yes, specify:.....
- (3) What position do you hold in this Association or Cooperative?.....
- (4) What are your entitlements for holding this position?
-
-
- (5) Are these entitlements the same for being an ordinary member? Yes () No ()
- (6) If no, please specify what you gain for being a member
-
- (7) For how long have you been into potato farming?.....
- (8) Is farming your primary occupation () or secondary occupation ()
- (9) Please specify your other occupation (if any) and monthly income

Any other occupation? Please specify by filling in the monthly income you make.	Monthly income (Naira)
Artisan	
Civil service	
Trading	
Others (specify)	

- (10) Did you have access to credit in the last production season? Yes () No ().
- (11) If yes, please specify the source, amount, interest rate (if applicable) and the repayment time

Source	Amount (Naira)	Interest rate	Repayment duration
Informal group			
Bank			
Informal money lenders			
Friend/Relatives			
Government			

- (12) Frequency of extension contact (please specify)..... per month () per year ()

SECTION B: AWARENESS AND USAGE OF THE CONNECT VARIETY

- (13) Are you aware of the Connect potato variety?
Yes () No ()
- (14) If yes, since when?.....Month(s)/Year(s)
- (15) Specify how you became aware of this variety?
TV & Radio () Colleagues () Family & friends () Community leaders () Associations ()
Religious groups () Internet () Others (specify).....
- (16) Do you currently use this Connect potato variety? Yes () No ()
- (17) If yes, for how long?.....(months/years as it applies)
- (18) If no, have you ever used it? Yes () No ()
- (19) If your answer to question (18) is yes, why then did you stop using it? Give reason below.
.....
- (20) If you do not use the connect variety, what is the name of the variety you currently use?.....
- (21) If you use this variety or have ever used it, what is your perception about this variety?

Perceptions	Strongly agree	Agree	Indifference	Disagree	Strongly disagree
Blight tolerant					
Blight resistant					
Higher yield					
Short gestation period					
Large tuber size					
Palatability					

- (22) Did you receive any training as related to the use of this Connect variety? Yes () No ()
- (23) If yes, please specify what the training involves.....
.....

SECTION C: FARM CHARACTERISTICS AND INPUTS

- (24) Year of experience in potato farming?
- (25) Please specify (quantity, year of purchase and cost) the farm tools you own and use in your potato farming

Farm tools/machineries	Quantity	Year purchased	Cost
Hoe			
Cutlass			
Shovel			
Sack			
Wheelbarrow			
Knapsack Sprayer			
Rake			
Head pan			

Knife			
Tractor			
Others (specify).....			
Others (specify).....			
Others (specify).....			

(26) Please specify how many plots of land you cultivate potato on and their various sizes

Potato plots	Size (Ha)	*Tenure system	Cost/year
Plot 1			
Plot 2			
Plot 3			
Plot 4			

* *Whether Rental, Leasehold, Inherited, Communal or Purchased*

Please complete the tables and the subsequent tables as appropriate. Fill the table according to the number of plots (land) you cultivate potato on. If you have just a plot, fill the PLOT 1 table alone. If you have two plots, fill the tables for PLOT 1 and PLOT 2 and if you cultivate potato on three, fill for the three plots. Also note, Fill out the portion for Connect variety if that's what you use. Fill out the other variety portion if you do not use the Connect variety.

PLOT 1

PRACTICES	CONNECT VARIETY	OTHER VARIETY
What quantity of this potato variety did you plant on this plot in the last production season? (kg)		
What was the source of this potato? (<i>please tick</i>)	Bought () Personal storage () Neighbor ()	Bought () Personal storage () Neighbor ()
If bought, how much did a Kg of this variety cost? (<i>Naira</i>)		
What is the distance of this plot to the purchase centre? (<i>Km</i>)		
If from storage, did you incur any cost in storing them? If yes, please specify. (<i>Naira/year</i>)		
Which month of the year did you plant on this plot in this last production season?		
What cropping pattern did you adopt for this plot?	*Monocropping () *Intercropping ()	*Monocropping () *Intercropping ()
If intercropped, specify the crops you planted with your potato		

Forms in which potato tuber are planted for this plot.	Whole () Dissected ()	Whole () Dissected ()
Plant spacing adopted on this plot (cm)	Between row.....(cm) Within rows.....(cm)	Between row.....(cm) Within rows.....(cm)
Planting depth (cm)		
Please specify the quantity of fertilizer used on this plot and the cost of purchase.	Quantity	Cost/Kg
Please specify the quantity and cost of Agro-chemicals used on this plot in the last production season	Chemicals	Qty
	Herbicide	
	Insecticide	
	Fungicide	
Please specify the output from this plot (in Kg) and the price you sold per unit in the last production season.	Quantity	Price sold/kg
Was this sold at the farm-gate or you took it to the market?	Farm-gate () In the Market ()	Farm-gate () In the Market ()
If in the market, what did it cost you to transport the output of this plot to the market?		

Note: **Monocropping means raising potato alone on this plot*

**Intercropping means raising potato with other crops*

PLOT 2

PRACTICES	CONNECT VARIETY	OTHER VARIETY
What quantity of this potato variety did you plant on this plot in the last production season? (kg)		
What was the source of this potato? (please tick)	Bought () Personal storage () Neighbor ()	Bought () Personal storage () Neighbor ()
If bought, how much did a Kg of this variety cost? (Naira)		
What is the distance of this plot to the purchase centre? (Km)		
If from storage, did you incur any cost in storing them? If yes, please specify. (Naira/year)		
Which month of the year did you plant on this plot in this last production season?		
What cropping pattern did you adopt for this plot?	*Monocropping () *Intercropping ()	*Monocropping () *Intercropping ()
If intercropped, specify the crops you planted with your potato		

Forms in which potato tuber are planted for this plot.	Whole () Dissected ()	Whole () Dissected ()
Plant spacing adopted on this plot (cm)	Between row.....(cm) Within rows.....(cm)	Between row.....(cm) Within rows.....(cm)
Planting depth (cm)		
Please specify the quantity of fertilizer used on this plot and the cost of purchase.	Quantity	Cost/Kg
Please specify the quantity and cost of Agro-chemicals used on this plot in the last production season	Chemicals	Qty
	Herbicide	
	Insecticide	
	Fungicide	
Please specify the output from this plot (in Kg) and the price you sold per unit in the last production season.	Quantity	Price sold/kg
Was this sold at the farm-gate or you took it to the market?	Farm-gate () In the Market ()	Farm-gate () In the Market ()
If in the market, what did it cost you to transport the output of this plot to the market?		

Note: *Monocropping means raising potato alone on this plot

***Intercropping means raising potato with other crops**

PLOT 3

PRACTICES	CONNECT VARIETY	OTHER VARIETY
What quantity of this potato variety did you plant on this plot in the last production season? (kg)		
What was the source of this potato? (<i>please tick</i>)	Bought () Personal storage () Neighbor ()	Bought () Personal storage () Neighbor ()
If bought, how much did a Kg of this variety cost? (<i>Naira</i>)		
What is the distance of this plot to the purchase centre? (<i>Km</i>)		
If from storage, did you incur any cost in storing them? If yes, please specify. (<i>Naira/year</i>)		
Which month of the year did you plant on this plot in this last production season?		

What cropping pattern did you adopt for this plot?	*Monocropping () *Intercropping ()		*Monocropping () *Intercropping ()			
If intercropped, specify the crops you planted with your potato						
Forms in which potato tuber are planted for this plot.	Whole () Dissected ()		Whole () Dissected ()			
Plant spacing adopted on this plot (cm)	Between row.....(cm) Within rows.....(cm)		Between row.....(cm) Within rows.....(cm)			
Planting depth (cm)						
Please specify the quantity of fertilizer used on this plot and the cost of purchase.	Quantity	Cost/Kg	Quantity	Cost/Kg		
Please specify the quantity and cost of Agro-chemicals used on this plot in the last production season	Chemicals	Qty	Cost	Chemicals	Qty	Cost
	Herbicide			Herbicide		
	Insecticide			Insecticide		
	Fungicide			Fungicide		
Please specify the output from this plot (in Kg) and the price you sold per unit in the last production season.	Quantity	Price sold/kg	Quantity	Price sold/kg		
Was this sold at the farm-gate or you took it to the market?	Farm-gate () In the Market ()		Farm-gate () In the Market ()			
If in the market, what did it cost you to transport the output of this plot to the market?						

Note: *Monocropping means raising potato alone on this plot

*Intercropping means raising potato with other crops

PLOT 4

PRACTICES	CONNECT VARIETY	OTHER VARIETY
What quantity of this potato variety did you plant on this plot in the last production season? (kg)		
What was the source of this potato? (please tick)	Bought () Personal storage () Neighbor ()	Bought () Personal storage () Neighbor ()
If bought, how much did a Kg of this variety cost? (Naira)		
What is the distance of this plot to the purchase centre? (Km)		
If from storage, did you incur any cost in storing them? If yes, please specify. (Naira/year)		
Which month of the year did you plant on this plot in this last production season?		

What cropping pattern did you adopt for this plot?	*Monocropping () *Intercropping ()		*Monocropping () *Intercropping ()			
If intercropped, specify the crops you planted with your potato						
Forms in which potato tuber are planted for this plot.	Whole () Dissected ()		Whole () Dissected ()			
Plant spacing adopted on this plot (cm)	Between row.....(cm) Within rows.....(cm)		Between row.....(cm) Within rows.....(cm)			
Planting depth (cm)						
Please specify the quantity of fertilizer used on this plot and the cost of purchase.	Quantity	Cost/Kg	Quantity	Cost/Kg		
Please specify the quantity and cost of Agro-chemicals used on this plot in the last production season	Chemicals	Qty	Cost	Chemicals	Qty	Cost
	Herbicide			Herbicide		
	Insecticide			Insecticide		
	Fungicide			Fungicide		
Please specify the output from this plot (in Kg) and the price you sold per unit in the last production season.	Quantity	Price sold/kg	Quantity	Price sold/kg		
Was this sold at the farm-gate or you took it to the market?	Farm-gate () In the Market ()		Farm-gate () In the Market ()			
If in the market, what did it cost you to transport the output of this plot to the market?						

Note: *Monocropping means raising potato alone on this plot

*Intercropping means raising potato with other crops

INFORMATION ON LABOUR AND CONSTRAINT TO USAGE

(27) Please fill out the table below on labour type and cost. Fill according to the plot tables filled out in the farm characteristic section.

PLOT 1

Operations	Family labour				Hired labour				Number of days employed	Wage rate per day
	Adult		Child		Adult		Child			
	AM	AF	MC	FC	AM	AF	MC	FC		
Land preparation										
Planting										
Fertilizer Application										
1 st										

2 nd										
Herbicide Application/weeding										
Fungicide Application										
1 st										
2 nd										
3 rd										
4 th										
Harvesting										
Loading										
Offloading										
NOTE: AM= Adult male; AF= Adult female; MC= Male child; FC= Female child										

PLOT 2

Operations	Family labour				Hired labour				Number of days employed	Wage rate per day
	Adult		Child		Adult		Child			
	AM	AF	MC	FC	AM	AF	MC	FC		
Land preparation										
Planting										
Fertilizer Application										
1 st										
2 nd										
Herbicide Application/weeding										
Fungicide Application										
1 st										
2 nd										
3 rd										
4 th										
Harvesting										
Loading										
Offloading										
NOTE: AM= Adult male; AF= Adult female; MC= Male child; FC= Female child										

PLOT 3

Operations	Family labour				Hired labour				Number of days employed	Wage rate per day
	Adult		Child		Adult		Child			
	AM	AF	MC	FC	AM	AF	MC	FC		
Land preparation										
Planting										
Fertilizer Application										
1 st										
2 nd										
Herbicide Application/ weeding										
Fungicide Application										
1 st										
2 nd										
3 rd										
4 th										
Harvesting										
Loading										
Offloading										
NOTE: AM= Adult male; AF= Adult female; MC= Male child; FC= Female child										

PLOT 4

Operations	Family labour				Hired labour				Number of days employed	Wage rate per day
	Adult		Child		Adult		Child			
	AM	AF	MC	FC	AM	AF	MC	FC		
Land preparation										
Planting										
Fertilizer Application										
1 st										

2 nd										
Herbicide Application/weeding										
Fungicide Application										
1 st										
2 nd										
3 rd										
4 th										
Harvesting										
Loading										
Offloading										
NOTE: AM= Adult male; AF= Adult female; MC= Male child; FC= Female child										

(27) Please specify the constraint faced as it relates to the usage of this variety.

Constraints	Strongly agree	Agree	Indifference	Disagree	Strongly disagree
Expensive					
Low yield					
Low palatability					
High disease susceptibility					
Long gestation period					
Short shelf-life					
Small tubers					
Inaccessible					