EFFECTS OF INNOVATION APPLICATION ON MANAGEMENT OF PROBLEMATIC SOIL (ACIDIC SOIL) IN NIGER STATE, NIGERIA

BY

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MTech/SAAT/2019/9341

DEPARTMENT OF AGRICULTURAL EXTENSION AND RURAL DEVELOPMENT

FEDERAL UNIVERSITY OF TECHNOLOGY

MINNA

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A THESIS SUBMITTED TO THE POST GRADUATE SCHOOL FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY IN AGRICULTURAL EXTENSION AND RURAL SOCIOLOGY

JULY, 2023

DECLARATION

I hereby declare that the thesis titled: **"Effects of innovation application on management of problematic soil (acidic soil)"** is a collection of my original research work and it has not been presented for any other qualification anywhere. Information from other sources (published or unpublished) has been duly acknowledged.

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SIGNATURE & DATE

CERTIFICATION

The thesis titled: **"Effects of Innovation Application on Management of Problematic Soil (Acidic Soil)"** by: ABUBAKAR, Abdullahi (MTech/SAAT/2019/9341) meets the regulations governing the award of the degree of M.TECH of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation.

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DEDICATION

This project is dedicated to the Almighty Allah for His mercies over my life and academics and to my late parents

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ABSTRACT

The paramount means of sustaining crop management is a "healthy" soil. This implies that a healthy soil will produce healthy crop that have optimum vigour and are less susceptible to pests This necessitated the conduct of this study, which examined the effects of innovation application on management of problematic soil (acidic soil). Specifically the study aimed to describing the socio-economic characteristics of project farmers; examine the sources of innovation available to the project farmers; examine the level of innovation application by the project farmers; determine the effects of innovation application on problematic soil on the project farmers output and identify the constraints associated with innovation application to problematic soil by the project farmers. Three stage sampling procedures were used to select 180 project farmers; primary data were elicited from the respondent with the aid of a semi-structured questionnaire complemented with interview schedule. Data were analyzed using descriptive statistics and OLS regression. The findings indicated that majority (84.7%) of the project farmers were within the age bracket of 30 – 59 years with a mean age of 44 years and average household size of 14 person respectively. Most (97.2%) were married while about 65.0% had non-formal education (Quranic and adult). Majority (60.0%) of the project farmers source their information on innovative means of managing problematic soil from radio, about 64.8% from friends and family and 48.0% from extension agent. Agricultural lime (78.0%), agricultural lime 3WBP (78.3%), agricultural Lime +FYM+ NPK (53%), agricultural lime + NPK and NPK (Special blend (OCP) (40%) were the major type of innovation applied on problematic soil used by the maize project farmers while agric lime (85%), agric lime 3WBP (73.3%), spacing 5by 75 (78%), agric. Lime + SSP+ FYM (55%), FYM+SSP (40%) were the major type of innovations on problematic soil used by the project farmers for their soybean. Agric. lime 3WBP ($\bar{X}$=4.0), agric. Lime +FYM+ NPK ($\bar{X}$=3.9), agric lime + NPK ($\bar{X}$=3.8), agric. Lime ($\bar{X}$=3.8) and FYM+NPK ($\bar{X}$=3.8) were the prevalent innovation adopted by project farmers for maize production while agric. Lime + SSP+ FYM ($\bar{X}$=3.8), FYM+SSP ($\bar{X}$=3.8), spacing 5 cm by 75cm ($\bar{X}$=3.7), agric lime ($\bar{X}$=3.7) and agric 3WBP ($\bar{X}$=3.7) were the major innovative practices adopted by the projected farmers. Farming experience (89.2786), relative advantage (46.0641), compatibility (1110.225) and seed rate (91.9084) had direct relationship with maize output while age (910.7487), Education (54.7708), Relative advantage (31.3439) and seed rate (4.5152) had direct influence on soybean output. Lastly, poor access to credit (.594), low level of income (.739), inadequate technical knowhow (.758), high cost of inputs (635), low level of education (.556) and distance to sources of innovation (.572) were the economic factors influencing innovation application, the political factors include untimely delivery of input (.553), low level of education (.633) and long distance to sources of innovation (.445), that of cultural factor include pest and disease attack (.666), insufficient rainfall (.433), problem of land tenure system (.687), problems of banditry attack (.611) and farmers herders clash (.589) while wrong view of farmers in capable of taking rational decision (.698) and low level of motivation (.624) were the attitudinal factors that influenced innovation application in the study area. The study recommended that Office Chérifien des Phosphates (OCP) Africa should be encouraged by the project coordinators to establish one of their One Stop Shop in the study area to enhance the utilization of this innovation package.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Land is an asset of enormous importance to billions of rural dwellers in the developing world. Right from creation, man depends on land for his basic needs of life. Martin (2010) describes land as a gift of nature to man which remains the most important factor of production. The rural dwellers depend on the environment, especially natural resources such as land, for the satisfaction of their basic needs. Land is essential natural resources, particularly land for agriculture (Umukoro, 2014). It is the fundamental natural resources that provide habitat and means of sustenance for living organisms. Africa is blessed with enough land mass to undertake small and large scale activities to support household security, national development, trans-boundary cooperation and regional integration to transform trade, and create new opportunities for sustainable development that is sensitive to the environment and social economic issues (Umukoro, 2014). The economic development of most developing countries, including Nigeria, however, revolves, largely around the exploitation and use of land resources especially in the agriculture (Titilola and Jeje, 2008). As land deteriorates in quality, the poor become poorer.

Soil is the most crucial resource on which agriculture is based. Proper management of this valuable resource is vital to sustain long-term agricultural productivity. According to Ashokkumar (2019), soils which are characterized uneconomical for the growing and cultivation of crops without adopting proper reclamation measures are known as problematic soils. Akamigbo (2019) opined that soils in Nigerian are found to be within medium to high potentials. There is no class one soil type in Nigeria, class two soils accounted for about 5.5% of the total land area while class three soils is about 46.5% and these are of medium productivity and have a great potentialities for agricultural development. Lastly over 48% fall into classes four and five that are low in productivity. The major soil types in Nigeria, according to Food and Agricultural Organization (FAO) soil taxonomy legends are fluvisols, regosols, gleysols, acrisols, ferrasols, alisols, lixisols, cambisols, luvisols, nitosols, arenosols and vertisols. These soil types vary in their potential for agricultural use. None of these soils was rated as class 1 with high productivity by the FAO (2011). The problematic soil in Nigeria that reduces the yield of crop are soils erosion, salinization, acidity, flooding, declining fertility, desert encroachment, mismanagement and misuse etc (Akamigbo, 2019).

Soil acidity is one of the limiting factors of nitrogen fixation by the legume-rhizobia symbiosis (Van Zwieten *et al*., 2015). Acidic soils are deficient in phosphorus (P), magnesium (Mg), calcium (Ca), molybdenum (Mo), and potassium (K) with a high concentration of iron (Fe), aluminium (Al), hydrogen (H), copper (Cu) and manganese (Mn) ions (Keino *et al.* 2015). Soil acidification largely depends on the nature of soil, agro-ecology and farming systems. It can also occur through natural leaching of CO2 after rainfall and excess application of nitrogenous fertilizer or organic matter (Jérôme *et al.*, 2019).

Application of innovation in the management of problematic soil can produce interesting effects on maize and soybean farmers. Improved agricultural practices have various impacts on the farmer’s production and the economy of the nation. In essence increased agriculture productivity and household food security and nutrition can be achieved through the adoption of improved agricultural technology. Increased technology development and adoption can raise agricultural output, hence improved household food intake which in turn serves to improve the function of the human body and performance of a healthy, normal life required to promote work output (Van Zwieten *et al*., 2015). However, increase technology adoption may result in high labour demands and less time available for other household activities by women (e.g household chores like child care, and fuel wood and water collection) (Weyori *et al.,* 2018).

1.2 Statement of the Research Problem

Throughout human history, our interaction with the soil has affected our ability to cultivate crops and influenced the success of civilizations. This interaction between humans, the earth, and food sources affirms soil as the foundation of agriculture (Parikh and James, 2012). Soil is a natural finite resource base which sustains life on earth.

Nigeria is blessed with arable land and fresh water resources when viewed as a whole with approximately 61 million hectares of the land cultivable while the total renewable water resource is estimated about 280 km3/year (Victor, 2018). Soil condition and water availability if effectively managed will help boost food production and address food crisis in the nation. Despite the vast arable land in Nigeria, food security is still a major challenge in the country. This is mainly due to socio-institutional constraints, types of farming system and nature of soil. Soil acidity which is the major problematic soil in the study area poses serious land degradation reducing the yield of crops especially Maize (Zea mays) and Soybean (Glycine max). The acidification of soil in the study area maybe natural occurrence or aggravated by farmers activities. It pushes soil nutrients out of reach of the cultivated crop, leading to stunting of root system of the crop. As a result, the crop becomes less tolerant to drought (Jérôme *et al.,* 2019).

The paramount means of sustaining crop management is a "healthy" soil. This implies that a healthy soil will produce healthy crop plants that have optimum vigor and are less susceptible to pests. As a result of enormous consequences of acidic soil on maize and soybean in the study area, adoption of improved innovation practices appears to be an appropriate strategy for improving the poor soil fertility (acidic soil) and enhancing farmers' production and improve their livelihood. Much of the adoption studies in soil fertility management that have examined determinants of farmers' decisions to adopt soil fertility enhancing technologies have focused on adoption of a single technology. The identified knowledge gaps in the literature form the bases for this study and there is dearth of knowledge on effects of innovation application on management of problematic soil. It is based on the foregoing the researcher formulates the following research questions:

i. What are the socio-economic characteristics of project farmers?
ii. What are the sources of innovation available to the project farmers?
iii. What is the level of adoption of innovation application by the project farmers?
iv. What are the effects of innovation application on problematic soil on the farmers output?
v. What are the constraints associated with innovation application to problematic soil by the project farmers?

1.3 Aim and Objectives of the Study

The aim of this study is to ascertain the effects of innovation application on management of problematic soil (acidic soil). The specific objectives are to:

i. describe the socio-economic characteristics of project farmers;
ii. examine the sources of innovation available to the project farmers;

iii. determine the level of adoption of innovation application by the project farmers;

iv. determine the effects of innovation application on problematic soil on the project farmers output and

v. identify the constraints associated adoption with innovation application to problematic soil by the project farmers.

1.4 Hypothesis of the Study

H_0: There is no significant relationship between selected socio-economic characteristics (level of education, extension contact), selected production variables (Fertilizer, agrochemical and labour) and the innovation application on problematic soil by the project farmers

1.5 Justification for the Study

Farmers no doubt, are the most valuable asset of any developing nation and anything that affects them directly or indirectly affects the nation as such would constitute a national threat to food security. To this end, the study will generate information on socio-economic characteristics of the project farmers, which will be useful to government and policy makers that will help to identify the felt needs of the farmer. In view of the fact that there are numerous innovations for agriculture which are not been used by farmers due to inadequate awareness. Therefore, it’s germane to examine the sources of innovation. Finding of the study will help in improving the sources of information of the project beneficiaries. The result from the perceived effect of innovation application on problematic soil will provide information to project coordinator

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Concept of Maize and Soybean

Maize (*Zea mays L*.) and Soybean (Glycine max.) are one of the most widely grown crops in the world after rice (Oriza sativa L.) Dadzie (2012). Maize forms the bedrock for food security in some of the world's poorest regions in Africa including Nigeria. It is estimated about 100 million hectares cultivated in 125 developing countries (Tandzi *et al.*, 2018**).** Acidic soils hamper maize production, causing yield losses of up to 69%. Low pH acidic soils can lead to aluminum (Al), manganese (Mn), or iron (Fe) toxicities. Also Soybean requires high nutrients, with P and K being most crucial for optimal production (Sikka *et al.*, 2012). Soybean production in the study area is also low and this could be due to its sensitivity to low soil pH. Soil pH below 5.2 and above 6.5 does not favour soybean growth; hence poor yields are experienced under such conditions (Ribeiro *et al*., 2007). High levels of aluminium and low levels of phosphorus in acidic soils affect the growth of symbiotic nitrogen-fixing bacteria. Soil pH < 5.0 limits soybean nodulation due to toxicity effects of Al and Fe ions causing poor nodules formation and functioning (Nakesa *et al*., 2011). Acidic soils also face reduced organic matter breakdown, nutrient cycling by microorganisms, reduce uptake of nutrients by plant roots and inhibition of root growth (Fageria *et al.*, 2013).

Maize (*Zea mays* L.) is among the most widely grown cereal crops in the world after rice (*Oriza sativa* L.) and wheat (*Triticum aestivum* L.). It forms the basis for food security in some of the world's poorest regions in Africa, Asia, and Latin America and is produced on nearly 100 million hectares in 125 developing countries (Prasanna, 2011).

Soybean is among the major industrial and food crops grown in every continent. The crop can be successfully grown in many States in Nigeria using low agricultural input and cultivation has expanded as a result of its nutritive and economic importance and diverse domestic uses (Fageria *et al.*, 2013). It is also a prime source of vegetable oil in the international market. The seeds contain about 20% oil on a dry matter basis and this is 85% unsaturated and cholesterol-free. Soybean also has an average protein content of 40% and is more protein rich than any of the common vegetable or animal food sources found in Nigeria (Adrian, 2006)

One of the major abiotic constraints of maize and soybean production is the occurrence of acidic soils, caused by a low potential of hydrogen (pH). Considerable grain yield reductions of maize under low soil pH have been reported in numerous studies. Dewi-Hayati *et al*. (2014) reported that grain yield reduction in acid soils varied from 2.8 to 71%, whereas Tandzi *et al.* (2015) found maize yield reduction under acid soils to be up to 69%. The variation in yield reduction under low soil pH is based on the level of acidity of the soil, the agro-climatic conditions of the environment, and the genetic potential of maize genotypes. Improving grain yield under acidic soil conditions is a major objective of maize breeding programs in many regions of the world. An estimated 3950 million ha, or 30% of global arable land, is covered by acidic soils (Dalovic, 2012). The largest amount of potentially arable acid soils exists in the humid tropical zones, and comprises about 60% of the acid soils of the world (Tandzi *et al.*, 2018). The poor fertility of acidic soils is due to a combination of mineral toxicities (Al, Mn, and Fe) and nutrient deficits caused by the leaching or decreased availability of phosphorus (P), calcium (Ca), magnesium (Mg), sodium (Na), and micronutrients such as molybdenum (Mo), zinc (Zn), and boron (B) (Gupta *et al.*, 2013).

2.2 Soil Acidity

Soil acidity is one of the main factors that limit the growth and productivity of many crops, especially in most of tropical and subtropical regions. In this context, it is important to understand its nature in order to perform the correct soil management. It should be considered different forms of acidity: active and potential (Anaglo *et al.*, 2020).

The active acidity related to amount of H+ dissolved in soil solution. The activity of this ion is express by pH, defined as a cologarithm of H+ activity in solution. A correlation is observed between the concentration of H+ in soil solution and its pH, the higher H+ content the lower pH.

Potential acidity is related to soil resilience in having its pH changed when basic compounds are added (Akamigbo.2019). This is divided into exchangeable and non-exchangeable acidity. The exchangeable acidity refers to ions Al3+ and H+ retained on the surface of soil colloids. This amount of exchangeable H+ is small. Therefore, only exchangeable Al3+ is allow. The non-exchangeable acidity is the H+ ion of covalent bond associated to negatively charged colloids and aluminum compounds. The acidity soils show when pH is below 5.5. Above pH 5.5, there is no more exchangeable Al3+. The potential acidity is the sum of exchangeable and non-exchangeable acidity. It limits the roots growth and occupies spaces in colloids, allowing free nutrients in soil solution to be leached (Bissa ni *et al.*, 2008).

2.3 Soil Acidification

2.3.1 Natural causes

Some factors affecting soil pH such as climate, mineral content and soil texture cannot be changed. Soils may naturally have acidity depending on the source material and climatic conditions to which it is exposed. Generally, the acidification started or get emphasis from the removal of basic elements (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) of colloids soil combined with a reduce rate of release by weathering.

The rain water contributes to the input of H^{+} ions, which occurs by the partial dissolution of carbonic gas from atmosphere: $CO_2 + H_2O \Leftrightarrow HCO_3^{-} + H^{+}$, releasing HCO_3 and H^{+}. In turn, H^{+} releases an exchangeable cation in solid phase of soil. This exchangeable cation is leach with HCO_3. This contributes to increasing the acidity of soil, the lower pH of soil the greater concentration of H^{+} ions (Bissani *et al*., 2008; Gliński *et al*., 2011).

The decomposition of organic matter by microorganisms also supports the increase in soil acidity due to organic and inorganic acids formed during the decomposition of soil organic matter, plant residues and soil biota (Bissani *et al.*, 2008; Gliński *et al*., 2011). Another factor that contributes to acidification of soils is the weathering of minerals and the dissociation of organic acids (Van Breemen *et al*., 1983; Faiji *et al*., 2012).

2.3.2 Human causes

In addition to environmental causes, human actions can also contribute to soil acidification. The application of nitrogen fertilizer contributes to soil acidification, since the use of ammoniacal fertilizer and urea requires a process of nitrogen transformation, called nitrification, which is carry out through the action of bacteria (*Nitrosomonas*; *Nitrobacter*). In this process, hydrogen ions are release, which contribute to reducing the soil pH.

Another source of rising soil acidity is the occurrence of acid rain, resulting from anthropic interference. Due to the gases emission, mainly SO2 and NOx from the combustion of fossil fuels, nitric and sulfuric acids are formed that reach the soil through precipitation (Gliński *et al*., 2011).

2.4 Soil Liming

The great demand in food production worldwide demands more and more from soil management to obtain high agricultural productivity in order to ensure food security (Antwi *et al.*, 2020). The growing acidification of soils because of agricultural activity has become a major environmental concern in recent years (Kryzevicius *et al.*, 2019).Nigeria government is faced with the necessity of intensive agricultural production and together with sustainable management it is necessary to build the soil fertility. This construction seeks chemical, physical and biological improvements. In this context, the liming technique is a fundamental tool. It is a technique in which calcium and magnesium are applied, mainly carbonates, oxides, hydroxides or a mixture of these, in addition to silicates that can also be used, but less frequently. The objective of this technique is to reduce the protons concentration in acidic soils (Miller *et al.*, 1995; Bortolanza and Klein, 2016). The liming requirement can be defined as the amount of corrective material necessary to obtain the maximum economic efficiency of a crop, which would mean having defined quantities of Ca2+ and Mg2+ available in soil and adequate pH conditions to have a good availability of nutrients (Dechen *et al*., 2016).

Soils can be naturally acidic due to the poor sources of material in calcium, magnesium, potassium and sodium, which are the exchangeable bases of soil or the intensity of weathering processes resulting in higher levels of hydrogen and aluminum in the soil exchange complex and, consequently, also in the soil solution (Dechen *et al*., 2016). However, the process of agricultural exploitation is also a factor that generates soil acidity, either through exportation, leaching of soil nutrients (exchangeable bases) and intensification of organic matter cycle in soil; in addition, the application of nitrogen fertilizers with an acidifying effect. This form of soil acidification is call anthropic influence (Bortolanza and Klein, 2016).

The liming is an agricultural practice capable of altering chemical, physical and biological soil, providing a number of benefits. It promotes a decrease in soil acidity, insolubilization of toxic elements, mainly aluminum and manganese; increase calcium and magnesium levels and phosphorus and molybdenum availability (Ronquin, 2010). Besides, it favors the development of microorganisms present in soil and enables greater root system development, expanding the plants' capacity to absorb water and nutrients from soil.

However, in addition to changes in the chemical and biological attributes of soil, the practice of liming also results changes in the physical attributes. These effects depend on the interaction of several factor such as climate, soil class and intrinsic characteristics of each soil. Several researches have already studied the physical changes resulting from use of limestone demonstrating its influence on flocculation of soil particles (Spera *et al*., 2008), formation and stability of aggregates (Ferreira *et al*., 2019), density (Spera *et al*., 2008; Auler *et al*., 2017), porosity (Anikwe *et al.*, 2016; Ferreira *et al*., 2010) and penetration resistance. The results of these changes reflects on other factors, presenting indirect effects: root development (Bomfim-Silva *et al*., 2019), microbiological activity (Børja and Nielsen, 2009), nutrients availability (Cahyono *et al*., 2019), crop yield Zandoná *et al*. (2015) and content of organic matter of soil (Passos *et al.*, 2019). Due to the diversified dynamics that liming can present in different edaphoclimatic conditions, this review article aims to contribute with information about the liming effects on physical properties of soil.

2.5 Agricultural Innovation

Agricultural innovations are products or processes for improving production, income generation and quality of life for farmers. The absence of agricultural innovation and low- or non-adoption of recent technologies by farmers are reported to be among the major causes of poor productivity of agriculture in third world nations (Pannell *et al*., 2006; Weyori *et al*., 2018). It is often argued that rural farmers in developing nations cannot improve agriculture in 21st century by relying primarily on indigenous knowledge and linear technology transfer without a functional agricultural innovation system (AIS) (Aerni *et al*., 2015).

AIS is a network of people and organizations determined to develop the novel products, services and processes in agriculture into economic use, alongside the institutions and policies that influence the way various agents relate, exchange and utilize information for the good of agriculture (Mariano *et al*., 2012; Meijer *et al*., 2015; Aerni *et al*., 2015). According to Weyori *et al.* (2018) promoting the usage of farm technologies involves a multi-layered interaction between various stakeholders harnessing the interdependence, networking and social interactions that occur among actors. These stakeholders interlink and communicate in a web-like way to share ideas and develop new technologies to increase productivity for farmers. With increasing number of agricultural innovations targeting improved farming practices, it is expected that farmers integrate certain technologies in agricultural production, processing, distribution, and marketing processes

Effective adoption of agricultural innovations in a functional AIS could potentially address the critical issues in agriculture such as productivity, climate change and resource management to ensure food security, poverty, hunger and malnutrition reduction. However, studies have shown that adoption of new technologies among farmers remains negligible (Weyori *et al*., 2018) in some localities in Africa. There are many factors influencing the adoption of agricultural innovation, one of them being farmers' perception of innovations (Mariano *et al.*, 2012). Farmers' perception of any introduced innovation is influenced by factors such as level of knowledge/education, amount of help available/functionality of AIS, local reports about the technology, gender, social and cultural inclination as well as cost implication in the adoption process (Mwangi *et al.*, 2006).

Adoption, whether individual or aggregate, is often expressed at various levels in any locality and time and is not a permanent behaviour (Malesse, 2018) because a farmer may decide to discontinue the use of an innovation for a variety of reasons relating to personal, economic, structural and social issues with the technology (Feder *et al.*, 1985; Ntshangase *et al.*, 2018). However, three approaches are majorly used to explain the behaviour and forces influencing the adoption of agricultural innovations: the innovation-diffusion model, the economic constraints model and the perception of adoption model (Ntshangase *et al.*, 2018). According to Feder *et al.* (1985) cited by Ntshangase *et al.* (2018) the underlying premise of the "innovation-diffusion model is that the technology is technically and culturally" relevant.

Economic constraints model focuses on the affordability of the technology by the local users, the cost implications in the adoption process and the expected returns. The perception model, explains the understanding of the attributes of the technology that affects farmer's adoption behaviour; which means that even with good intentions for inventing the innovation/technology, farmers will subjectively interpret the technology differently from scientists (Kivlin and Fliegel, 1967; Malesse, 2018). This buttresses the need for functional interlinks (AIS) among farmers, intermediaries/agents and the inventors/researchers. Consequently, understanding the perceptions of farmers about a given agricultural innovation is crucial in resolving adoption issues.

2.6 Concept of Technology

Ikoku (1981) cited by Daudu (2010), defined technology as the embodiment of useful knowledge that has been effectively evolved and adapted to practical use and is available to be applied for the purpose of meeting man's immediate economic and social needs as determine by him. It entails all the new methods that increase agricultural production. Also technology can be defined as the accumulation of scientific knowledge and its adoption to suit conditions of man's environment.

The adoption of improved practices/innovations and transfer of improved modern technologies to the predominantly farming populace of this country is one of the greatest challenges facing agricultural scientist and the extension services in Nigeria (Adekoya and Tologbonse, (2005). Many reached the farmers, few are adopted initially, and while very few are eventually adopted with many discontinued. The reason for this may not be far-fetched

2.7 Management of Acidic Soils

A number of management practices are used to correct low soil pH. Liming is the most commonly recommended management practice (Goulding, 2016). Kisinyo *et al.* (2016) found that the application of both lime and P fertilizer are important for P and N fertilizer recovery efficiencies necessary for healthy maize growth under acid soils. However, the application of lime and/or fertilizer is not always affordable for small-scale farmers and is not environmentally friendly (Tandzi *et al., 2015*). Additionally, liming affects the topsoil and does not remove acidity in the subsoil, where it poses a severe problem to developing r oots.

Mwangi *et al*. (2006) reported that farm yard manure is a better amendment for correcting soil pH because it has a strong buffering capacity that contains both soil acidity and alkalinity. However, the general recommendations are very high (10 tons per hectare) and the manure is not always available. The addition of crop residues to soils can result in an increase in soil pH (Tandzi, *et al.*, 2018). Hoyt and Turner (1978) cited by Tandzi *et al.* (2018) found an increase in soil pH of about 0.5 of a pH unit when lucerne meal was added to acid soil, but observed a decline of pH 20 days after incubation. It has been generally observed that the addition of residues causes an initial rise in soil pH, which is then followed by a decline in pH.

2.8 Innovation and Land-use Management

Technology innovation and diffusion is not a new concept for land use management. In fact, the contemporary leading theory of Diffusion of Innovation DOI can be traced to agricultural innovations, such as hybrid seeds, new equipment, biological/chemical developments and land-use conservation measures, in various parts of the United States in the early years of the last century (Njabulo and Audu, 2018) Not surprisingly in an age when agricultural technology was advancing rapidly, examining how independent farmers adopted new innovations was important to the development of agriculture and home economics. As a critical factor of agricultural production, land-related technology innovations are also important, especially from the perspective of individual farmers, because they can increase agricultural production and crop yields and enhance precision agriculture and conservation measures (Schut *et al.*, 2015).

Land-use management activities are a cooperative process between local governments and land owners. In addition to farmers adopting new land-use ideas and technologies to promote sustainable development, governments need to pursue sustainability goals at the regional and national levels. Land Information Land Information System (LIS), a computerized system that manages land-related data, is a technological innovation for many governmental departments and agencies. With the rapid pervasion of information technology into land administration, researchers have endeavored to develop a general-purpose computer "mapping" LIS to store, collect and analyse data about land usage. From the first geographical information system (GIS), designed for a Canadian land inventory in the 1960s, to 3D simulation and visualization modelling in recent years, advanced geospatial technologies and standards are continuously being developed and introduced into land management (Tandzi *et al.*, 2018).

2.9 Diffusion of Innovation

The diffusion process of choosing to adopt an innovation can be decomposed into a series of five phases which passes from first knowledge of an innovation, to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision (Rogers, 2005). Diffusion researchers believe that a population can be broken down into five different segments, based on their propensity to adopt a specific innovation: innovators, early adopters, early majorities, late majorities and laggards. New innovations adoption process usually begins with a tiny number of innovators (Moore, 2002), the innovation must be accepted by a sufficient number of adopters. Therefore, a deeper understanding on what the adopters' beliefs, attitude and decision about the spatial technology innovation will provide useful information for strategies designed to encourage adoption behaviors for successful diffusion. Individual adoption of innovation on pragmatic soil is a complex process resulting from many factors, which included technological constraints and human factors regarding system use (Davis *et al.*, 2015).

2.9.1 Characteristics of the innovation

The characteristics of natural resource management practices or innovations may pose barriers to their adoption. Characteristics that have been shown to influence or encourage adoption include relative advantage, the associated risk, the complexity, the compatibility, the trialability and the observability of a given practice (Rogers, 2003; Webb, 2004).

Agricultural practices or innovations that are believed to be profitable have an increased likelihood of adoption, while those that are considered to primarily produce public benefits – that is, for society as a whole – are less likely to be adopted (Barr and Cary, 1992; Cary *et al.*, 2002). Many land managers will chose not to adopt sustainability practices if they calculate that it is not in their own best interests; that is, if the relative advantage is low (Pannell, 2001). On the other hand, if a land manager feels that by the nature of the practice design they and their family will benefit, adoption is much more likely (Vanslembrouck *et al.*, 2002). The relative advantage is innovation specific and will vary between individuals.

The degree of risk associated with a new practice is another motivating factor for land manager willingness to adopt changed practices. There is a large degree of variation across individuals regarding their willingness to adopt practices that are perceived as risky (Cary *et al.,* 2002). However, it is reasonable to assume that sustainable practices which are perceived as relatively risky will be less likely to be adopted by land managers. This will likely vary according to differences in income, needs, personal adversity to and perception of risk, and profit motivation.

The complexity of an innovation may also influence the likelihood of its uptake (Cary *et al.,* 2002). Complexity refers to the degree of knowledge or information needed to implement an innovation, the level of change required for adoption, and the ease of use, speed and reliability of an innovation (Webb, 2004). The more complex an innovation, the less likely it is to be adopted, as complexity increases the risk of failure as well as the knowledge investment needed to adopt changed practices (Cary *et al.,* 2002). Compatibility refers to the extent to which an innovation is compatible with existing agricultural practices, knowledge systems and social practices – if an innovation 'fits' with the needs and values of a land manager it is more likely to be adopted (Cary *et al.,* 2002; Rogers, 2003; Webb, 2004)

The trialability and observability of a natural resource management innovation are also important as a lack of confidence in recommended practices is identified as an important constraint affecting adoption (Curtis and Robertson, 2003). First, if innovations can be trialed on a small scale and shown to be successful, the perceived risk of failure will decrease. Similarly, if others can observe changes as a result of innovative practices, they are also more likely to be adopted (Cary *et al.,* 2002; Rogers, 2003). Alternatively, if a trial does not produce observable results in the short-term it may prevent the adoption of good practices with long-term outcomes (Webb, 2004).

2.9.2 Delineating and characterizing adoption decision-making

According to Meijer *et al*. (2015) Adoption decision-making is characterized by non-linearity and complexity, this is due to the non-linear interactions of extrinsic (e.g., innovation attributes) and intrinsic variables (e.g., knowledge of the innovation), which inform adoption decisions, and the difficulty in teasing out the interdependencies of the mediating variables. To disentangle the complexity, their study proposed a comprehensive framework that captured the interactions between the extrinsic and intrinsic variables and the adoption decisions. Nazziwa-Nviiri *et al.* (2017) attributed the complexity to the interactions of several push and pull factors associated with adoption decision-making. These include institutional and access-related variables, agro-ecological factors, and farm household characteristics. To Fisher *et al.* (2000) cited by Dinh *et al.* (2015), the complexity exists partly because the livelihood impacts of a technology cannot be determined a priori, and sometimes not even after its adoption. Framing adoption from a behavioral change viewpoint, Straub argued that it is a complex decision-making process, because it is mediated by cognitive, effective (emotional), and contextual factors, which no one theory can account for (Straub, 2009). Others ascribed the complexity to the embedding and intersection of an adoption decision environment with gendered norms and culture, differentiated access to and control over resources, and heterogeneous intra-household decision-making dynamics (van, 2015). Adding new insight, Olabisi *et al*. (2015) contended that adoption decision contexts are not only complex, but are also inherently dynamic, as farmers' choices and the decisional criteria informing their choices are not static; they may change from year to year.

2.10 Empirical Review

2.10.1 Effects of innovation application

Oladeeboand Olarinde (2019) examined the effects of land management practices on food insecurity in Osun State, Nigeria. The results of the findings reveals that the use of land management practices have a positive relationship with food security, and the more farmers engaged in the practices, the more food secured they were. It is therefore recommended that there should be increased awareness about land management practices and since majority of the farmers rely on the use of fertilizer for production, government should subsidize the price of fertilizer and ensure it gets to the users at the right time.

In the study of Mmom *et al.* (2017) who examined the land management practices and the yield of cassava (*Manihot esculenta* Crantz) in the humid Deltaic tropical environment of Nigeria reported that the ridge land management system had the highest yield accounting for 156 tubers of cassava which in turn amounts to 35.8t/ha as against the other two land management systems. The study therefore recommended that the ridge land management system should be adopted as a land management practice to increase cassava production which in recent time a foreign earner and for increased production. Similarly, Ladeebo *et al.* (2017) who examined poverty level and land management practices among maize-based food crop farmers in Oyo State, Nigeria**.** The study revealed that majority of maize-based crop farmers were males**,** married with low level of education. The estimated coefficient of farmers being poor was negatively correlated with the probability of adoption of farmland management practices and statistically significant at ($p<0.05$) based on the first-hurdle estimates. The study concluded that poverty reduces the likelihood of land management practices adoption in the study area. It was suggested that poverty alleviation strategies should be formulated in order to address the adverse effect of poverty on the adoption of land conservation technologies in the study area.

Asuming-Brempong (2010) examined the land management practices and their effects on food crop yields in Ghana. The study reveals that different land management practices affect crop yields differently in the different ecological zones. Also, the types of land management practices farmers use differ across the different ecological zones. The policy implication is that agricultural interventions should be developed on the basis of agro-ecological zones, and blanket crop improvement packages should be avoided. The study recommended that food crop farmers should be helped to improve the management of their agricultural lands by ecological zones at two levels. First, the practices that is common and promotes agricultural production in each zone should be targeted for improvement. Such a policy will re-orient farmers towards the adoption of more sustainable farm practices. Second, land management practices that are not currently being used by farmers in each zone but have potential to improve crop production should be identified and promoted in the respective agro-ecological zones. A pro-active policy of this kind will provide farmers better land use alternatives in each ecological zone.

Oluwaseun and Sibongile (2015**)** investigated the impact of Sustainable Land Management Practices (SLMP) on the smallholder maize farmer's welfare in the Gert Sibande District in the Mpumalanga Province of South Africa. The finding reveals that household socio-economic characteristics and institutional factors statistically influenced the choice of SLMP. Subsequently, the pair-wise correlation matrix of the MVP model revealed complementarities among all SLMP implemented by the farmers. Similarly, the ESRM treatment effect indicated that the average net farm income of farmers who adopted SLMP were significantly higher than that of the group who did not. Consequently, the study recommended support policies on farmers' demography, farm-based characteristics, and institutional factors to improve the welfare of the farmers and promote rural vitalisation.

2.10.2 Sources of information

The study of Anaglo *et al.* (2020) revealed that the sources of agricultural information to the cassava farmers were ranked as fellow farmers, radio, agricultural extension agent, input dealers with the least source used being newspapers/agricultural bulletins. It was also noted that, although majority of the farmers sourced for agronomic, market and credit information, it was only agronomic information which was found to have a significant influence on the farm practices undertaken by the farmers. A statistically significant relationship was observed between the farmer's agricultural practice and level of income, increased incomes and well-being and increased incomes and food security. It was recommended that extension officers in the district should extend credit information to the farmers and assist them to access credit. This may ensure that agricultural information obtained by the cassava farmers can be put into practice to improve their livelihood outcomes.

Daudu *et al.* (2010) examined the sources of agricultural information utilized by farmers in Gboko and Makurdi Local Government Areas of Benue State, Nigeria. The result of the finding reveals that most of the farmers preferred extension agents as their source of information. The major constraint indicated by farmers in sourcing information was financial problem. The recommended that credit facilities or subsidies should be provided to farmers to purchase radio receivers to enhance information sourcing

2.10.3 Constraints to adoption of recommended environmental management practices

Insecurity of land tenure particularly leasing arrangements, absentee ownership, small operating units and higher property taxes have been hypothesized to be institutionalized obstacles to adoption of recommended environmental management practices (Mwangi and Kariuki, 2015; Capstaff and Miller, 2018). Emeka *et al.* (2015), stated that the perceived cost and compatibility of innovations are key determinant in the adoption decision process model.. He further reported that when farmers find recommended farm innovations not to be technically feasible, economically viable and culturally compatible, they often reject such innovation. Mohamed and Temu (2008) in a similar vein stated that farmers often reject innovation when innovations are inappropriate or unrelated to their needs and problems. Emeka *et al.* (2015), identifies other constraints to adoption are fear of risk and uncertainties, fear of the consequences, desire to preserve traditional ways and general unwillingness to change. FAO (2011), went further to add some constraints to adoption as, absence of the problem, inappropriate innovations, incorrect identification of adoption domain, local practices better and poor extension

2.10.4 Staged adoption modelling approach

Most adoption conceptual models in agriculture define adoption as information driven staged process (Rogers, 1962; Zeweld, 2017). Since Rogers (1962) defined adoption as "the mental process an individual passes from first hearing about an innovation to final adoption (of the technology), it is commonly accepted that an innovation's final adoption is only reached after going through a process of learning and experimentation. Rogers' Information-Decision

Process Model (Rogers, 2003; Nazziwa-Nviri *et al.*, 2017) proposed a five-staged model: knowledge, persuasion, decision, implementation, and confirmation. Adrian (2006) identified and used an earlier model to analyze the adoption of precision agriculture: the Transtheoretical Model. This model also consists of five stages to explain how an individual considers a change, prepares for change, makes the change, and maintains the changed behavior. The stages are pre-contemplation, contemplation, preparation, action, and maintenance. Pannell *et al.* (2006) outlined a staged process of adoption at a farm level consisting of the following stages: awareness, non-trial evaluation, trial evaluation, adoption, review and modification, and dis-adoption.

All of these conceptual models explain, in different ways, "the process people go through when becoming aware of the possibility of a change, the decision to adopt, the implementation of the change, and the maintenance of the change".

Conceptualizing adoption as a staged process is potentially more useful to design interventions than an aggregated approach because it could help target parameters affecting specific adoption stages (e.g., where extension efforts would be more effective, where the policy would influence the most). In process models, transitions between stages are driven by information the decision-maker transitions from one stage to the next depending on the accumulation of information and the speed to process it (Pannell *et al.*, 2006; Kayode *et al.*, 2017).

Some authors use a step-hazard approach to represent the different stages of the adoption process as a way to better understand the transitions between them.

2.11 Theoretical Framework

2.11.1 Adoption and diffusion of innovation theory

Adoption, according to Rogers (2003) is a mental process, which an individual passes through in deciding to use an innovation. Also Stockdill and Morehouse (1992) noted that adoption is synonymous to transfer of technology. He defines transfer of technology as that which embraces all efforts to make sure that the farmers adopts new technology. He emphasized that for transfer of technology to take place, it must embraces input support, advice and other essential so that farmers will have no reasons for rejecting the technology. Before any technology is adopted according to Malesse (2018) it must pass through a process of adoption, which involves, awareness, interest trials, evaluation and adoption. The success of the adoption process depends very much on effective instructor, by extension agents, which is determined by methods and techniques of instruction used.

Diffusion, according to Rogers (2003) is the process by which an innovation is adopted or gain acceptance by members of a community. Rogers (1995) defines diffusion as the process by which an innovation is communicated through certain channels over time among members of a social system. According to him a number of factors interact to influence the diffusion of innovation. These are the innovation itself, communication channels, time and the nature of the social system in which the innovation is being introduced; Adekoya and Tologborse (2005) stated the process of diffusion is a precursor to adoption, although this does not necessarily always end in the latter. However, Mariano *et al.* (2012) reported that adoption and diffusion are the process governing the utilization of innovation. In another study, Mohamed and Temu (2008) demonstrated that farmers followed an ordered, sequential process over time, and were likely to adopt practices in sets if they offered a means of arresting declining returns per production unit. Farmers made a rational decision not to adopt practices which do not have a socio-economic advantage to them. Traditional studies of innovation adoption behavior have asserted a modernity continuum from traditional to modern poles (Rogers, 2003), described reactive and pro-active forms of resources management.

2.12 Conceptual Framework

Explanation of the conceptual framework: The conceptual frame work was based on the premise that, adoption of innovation of problematic soil (dependent variables) will improve the respondent food security status. Through the influence of socio economic variables and institutional factors (independent variables) assess the sources of innovation, stages of innovation and factors hindering the innovation application of farmers in the study area. The result of the interaction is expected to bring an improved level of output for the maize and soybean crop farmers. The conceptual framework highlights the interactions in the process with regard to relationship between the categories of independent variables and their components.

The more educated and exposed a farmer is, the better he/she utilized innovation. This is because an enlightened individual has a good understanding of the strategies to improving their output. The intervening variables such as government policy, availability of credit facilities and inputs, private sector participation, individual knowledge and understanding of ecological concepts to problematic soil influence the adoption decision directly or indirectly.

Conceptual Framework

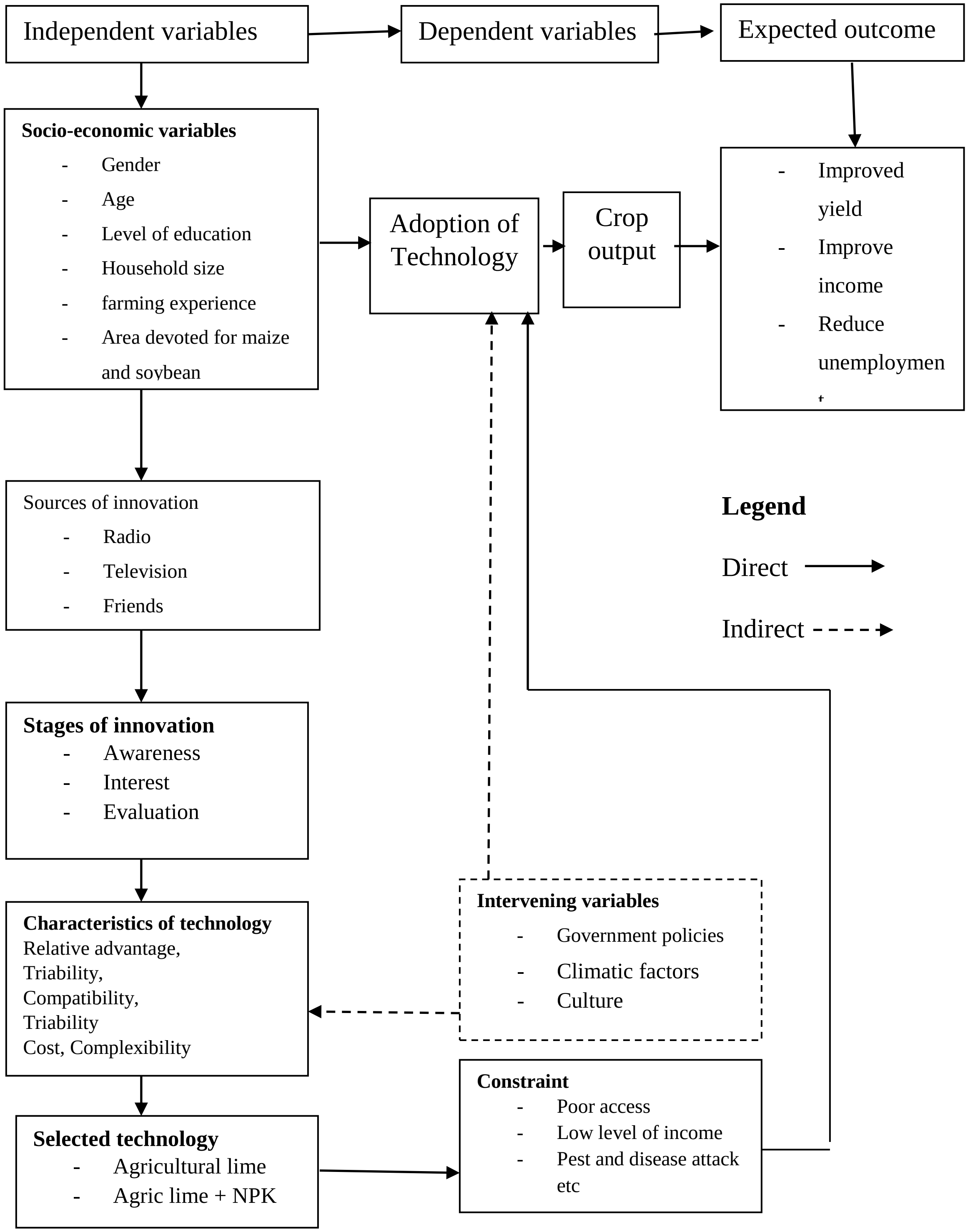

Figure 2.3: Conceptual framework on the adoption of innovation of problematic soil.

Source: Authors construct, 2021

CHAPTER THREE

3.0 METHODOLOGY

3.1 The Study Area

The study was carried out in Niger State. Niger State is located in the North Central region of Nigeria and it has largest land mass in the country. It borders to the south by the Niger River, It is also bounded by the states of Kebbi and Zamfara to the north, Kaduna to the north and northeast, Kogi to the southeast, and Kwara to the south. The Abuja Federal Capital Territory (FCT) borders Niger State to the East, and the Republic of Benin to the West. The landscape consists mostly of woody savannah and includes the floodplains of the Kaduna River. Niger State lies between the latitude 10°00′N and Longitude 6°00′E with an average annual rainfall varying from 1300mm in the North to 1600mm in the south. They have land mass of 29,484 square miles (76,363 square km) with a population of 3,950,249 according to 2006 Population Census (NPC, 2006)

Niger State is populated mainly by the Nupe people in the South, the Gwari in the east, the Busa in the west, and Kamberi (Kambari), Hausa, Fulani, Kamuku, and Dakarki (Dakarawa) in the North. Islam is the predominant religion. Most of the inhabitants are engaged in farming shea nuts, yams, and peanuts (groundnuts) are cultivated both for export and for domestic consumption. Sorghum, millet, cowpeas, corn (maize), sugarcane, and fish are also important in local trade. Paddy rice is widely grown as food crop in the flood plains of the Niger and Kaduna rivers, especially around Bida. Cattle, goats, sheep, ch ickens, and guinea fowl are raised for self and marketing.

Minna and Bida are the major towns in the Statte and also the main education centres, with teacher-training colleges, a polytechnic institute in Bida, and a Federal University of Technology in Minna.

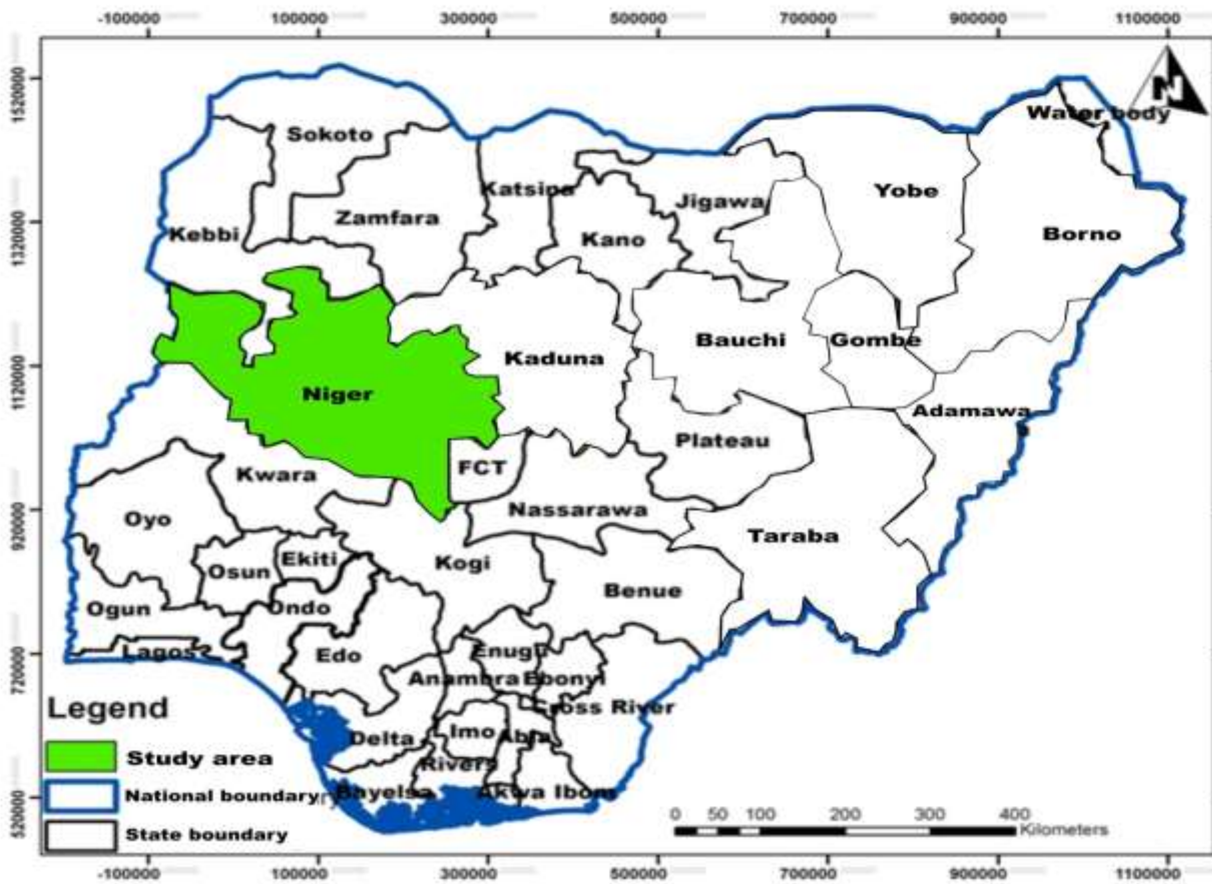

Figure 3.1: Map of Nigeria Showing Niger State

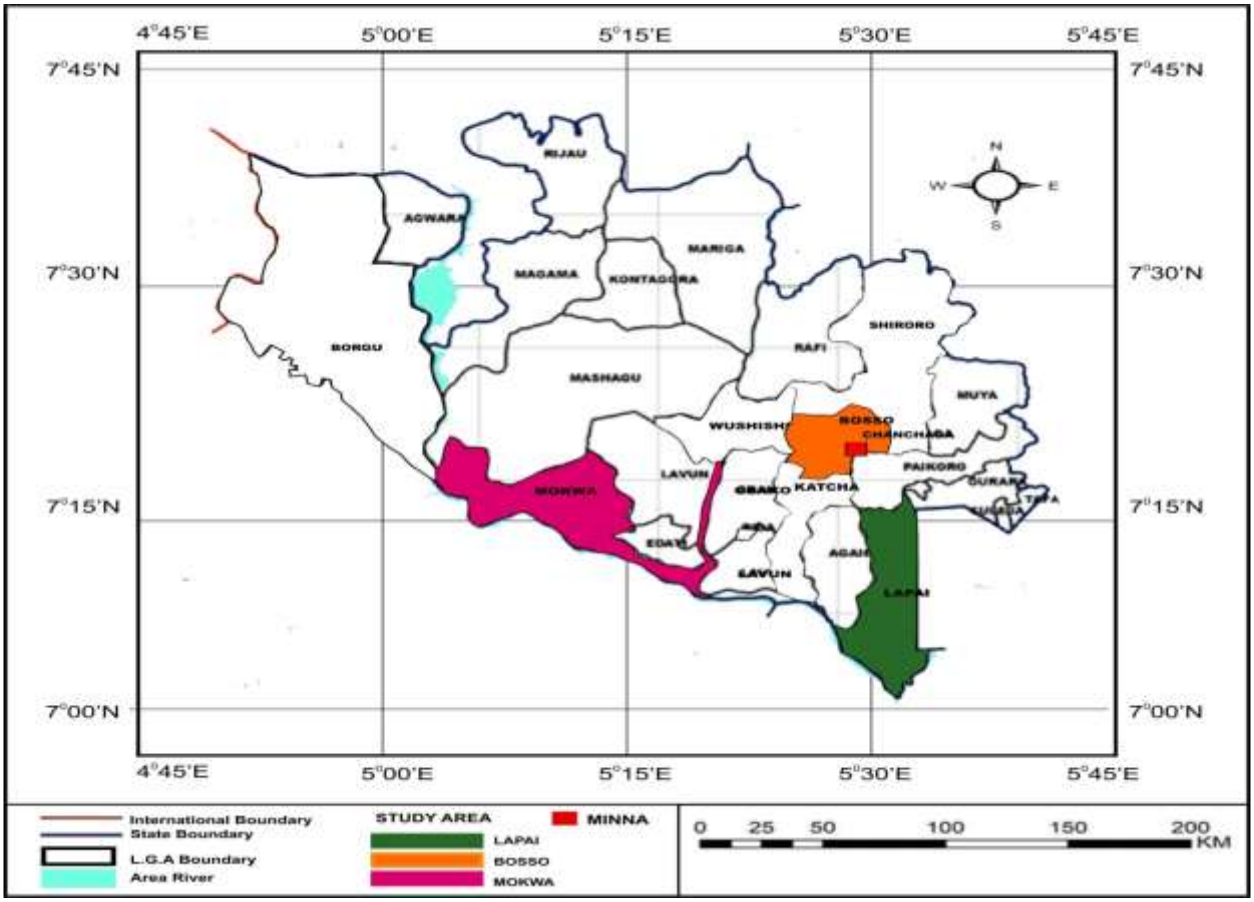

Figure 3.2: Map of Niger State showing the selected Local Government Areas

3.2 Sampling Procedure and Sample Size

Three stage sampling procedure was employed to select the project farmers for the study. At the first stage, 3 Local Government Areas (LGAs) were purposively selected (Bosso, Lapai and Mokwa) this was due to their prevalence to acidic soil. In the second stage one village was selected from each of the selected LGAs making 3 villages. At the third stage, 60 respondents were randomly selected from each village based on National Institute of Soil Scientist (NISS) directive.

Table 3.1: Sampling procedure and Sample Size

State	LGAs	Villages	Sample frame	%	Sample size
Niger	Bosso	Gidan mangoro	600	10	60
	Lapai	Nassarawa	401	15	60
	Mokwa	Raba	300	20	60
	Total	3			180

Source: NPFFS (2021) and NISS (2021)

3.3 Methods of Data Collection

Primary data were used for the study. Data were obtained from the respondents with the aid of semi-structured questionnaire complemented with interview schedule to elicit information from farmers who cannot read and write with the help of trained enumerators. The Data obtained include the general information on the socio-economic characteristics such as age, gender, marital status. Similarly, data were also collected on sources of innovation and constraints. Also data on effects of innovation application on problematic soil were obtained.

3.4.1 Validity of data collection instrument

To establish the validity of the research instrument, face validity was adopted. The research instrument (questionnaire) was subjected to the scrutiny of my supervisors and three other professionals in the field of agricultural extension and rural development to ascertain the validity of the instrument. The experts are expected to rate each item on a scale of 1–10.

Their recommendations were used to finally modify the questionnaire as a formal tool that has the ability to elicit the expected information for the data.

3.4.2 Reliability of data collection instrument

In this study, the instrument used for data collection underwent the test-retest method to assess its reliability. The process involved randomly selecting a subset of respondents from the study area. The selected respondents were then administered the instrument, and the same respondents were retested after a three-week interval. To evaluate the instrument's reliability, scores were assigned to the specific objectives being measured. The scores obtained from each administration of the instrument (test and retest) were summed up for each respondent. These total scores were then subjected to a statistical analysis called Pearson's Product Moment Correlation (PPMC). A reliability coefficient, represented by the correlation coefficient (r), was calculated. A reliability coefficient of 0.75 and above was considered reliable, indicating a strong and consistent relationship between the two administrations of the instrument.

3.5 Measurement of Variables

The variables to be measured in this study include the following:

3.5.1 Dependent variable

The dependent variable for this study was the output of the project beneficiaries in the study area. This was measured in kilogram (kg).

3.5.2 Independent variables:

(I) The independent variables for this study include the following:

i. Age was measured in years

ii. Sex was measure by male 1, female 0

iii. Educational status was measured by the number of years spent in formal schooling

iv. Farming experience was measured in years

v. Farm size was measures in hectares (ha).

vi. Extension contact was measured by the number of extension visit per year

vii. Labour usage was measured in man days

viii. Agro-chemicals was measured in litres(L)

ix. Seeds was measured in kilogramme (Kg)

x. Increase in market price was measured as dummy. (If Yes=1, if otherwise 0)

xi. Increase in farm land was measured as dummy. (If Yes=1, if otherwise 0)

(II). Source of innovation

Respondents in the study area were asked to indicate their sources of innovation as provided in the questionnaire.

(III) Types of innovation

Respondents were asked to indicate the type innovation on problematic soil used as provided in the questionnaire

(IV). Level of innovation application adopted

The stages of innovation application on soybean and maize were measured with 5-point Likert-type rating scale of Aware 1, Interest 2, Evaluation 3, Trial 4, Adoption 5. This is used to generate the perception score. However, reference mean for the scale was obtained as 5 + 4 + 3 + 2 + 1 = 15/5 to get 3.0. Thus, mean score value of ≥ 3.0 was adjourned high adoption while < 3.0 was adjourned low adoption.

(V). Constraints

The constraints associated with the adoption of innovation application of project farmers was measured using economic related, policy related, cultural related, attitude related factors as provided in the questionnaire

3.6 Methods of Data Analysis

Data were analyzed using descriptive statistics and inferential statistics such as multiple regression and Factor analysis. Descriptive Statistics such as mean, frequency distribution tables and percentages were used to achieve objectives i, ii, and iii, objective iv was achieved using multiple regression while objective v was achieved using factors analysis

3.6.1 Model specification

3.6.2 Ordinary least square regression model

This model was used to determine the effect of innovation application on problematic soil by project farmer's output, objective iv. The algebraic specification of the model is given as:

$$Y = (\beta_1 X_1) + e, \quad (3.1)$$

Where;

Y = Output of the project beneficiaries measured in kilogram (ha)

β_1 = Vector of the parameter estimated hypothesized to influence the depending variables

X_1= The victor of explanatory variables.

The model in its implicit form is specified as:

$Y = f$ (FM, LU, AC, SE, FE, AG, ED, FM, IF,EC, RA, CX, OB, TR, CP, AL, NPK, SR, S, FM, SSP, UR and CT) (3.2)

The explicit functional forms of the OLS regression model were expressed as:

$$Y = \beta_o + \beta_1 FM + \beta_2 LU + \beta_3 AC + \beta_4 SE + \beta_5 FE + \beta_6 AG + \beta_7 ED + \beta_8 FM + \beta_9 MC + \beta_{10} AC + \beta_{12} IF + \beta_{12} IN + \beta_{13} EC + U_i \quad (3.3)$$

Where;

Y = Output (Kg)

FM= Farm size (hectare)

LU= Labour usage (mandays)

AC= Agro-chemicals (Liters)

SE= Seeds (kg)

AG= Age (years)

ED= Education (years)

FM= Farming experience (years)

EC = Extension contact (Numbers of contact)

AL = Agric Lime (Kg)

NPK = Nitrogen phosphorus potassium (Kg)

SR = seed rate (kg)

S = spacing (cm)

FM = Farm yard manure (Kg)

SSP = Single Supper Phosphate (kg)

UR = Urea (Kg)

RA = Relative advantage(Dummy 1 if yes and 0 if otherwise)

CX = Complexibility (Dummy 1 if yes and 0 if otherwise)

OB = Observability (Dummy 1 if yes and 0 if otherwise)

TR = Triability (Dummy 1 if yes and 0 if otherwise)

CP = Compatibility (Dummy 1 if yes and 0 if otherwise)

CT = Cost ₦

β_o = constant

$\beta_1 \ldots \beta_{16}$ = coefficients of the independent variables

U_i = Error term

ln = Natural log

3.6.3 Likert rating type scale

The objective four (4) which is to ascertain the level of innovation application on Soybean and Maize which include Agricultural Lime, NPK Fertilizer (Special Blend by OCP), Application of Urea (46%N), Application of Farm Yard Manure, Farmers Practice (NPK only) etc.

To determine the level of adoption of innovation application on soybean and maize, 5-point Likert-type rating scale of Aware 1,Interest 2, Evaluation 3, Trial 4,Adoption 5 was used. The corresponding values of 5, 4, 3, 2 and 1were added together to obtain an aggregate score of 15, which was then divided by 5 to obtain a mean score of 3.0 as the cut-off mean. Thus, mean score value of ≥ 3.0 implied that high adoption while < 3.0 implied low adoption.

$$XS = \sum \frac{F}{n}$$

Where

XS = mean score

$\sum$ = summation

F = Frequency

n = Likert nominal value

3.6.4 Factors analysis

Factor analysis was employed with varimax rotation. The constraints were grouped using principal component analysis with iteration and varimax rotation method. The cutoff point constraints will be within the range of 0.3 – 0.5 were added together to obtain an aggregate score of 0.8, which was then divided by 2 to obtain a mean score of 0.4 as the cut-off mean. Any variables that loaded above the mean eigen value is set to be significant while variable that load below the mean eigen value is not significant as used by Akinnagbe (2013) and Ibrahim 2016.

$$Y_1 = a_{11}X_1 + a_{12}X_2 + \text{**********************} + a_{1n}X_n \quad (3.4)$$

$$Y_2 = a_{21}X_1 + a_{22}X_2 + \text{**********************} + a_{2n}X_n \quad (3.5)$$

$$Y_3 = a_{31}X_1 + a_{32}X_2 + \text{**********************} + a_{3n}X_n \quad (3.6)$$

*

*

*

$$Y_n = a_{n1}X_1 + a_{n2}X_2 + \text{**********************} + a_{nm}X_n \quad (3.7)$$

Where

Y_1, Y_2............... Y_n= Observe variables/ constraints to linkage/practice

a_1, a_n = constraints to correlation coefficients;

X_1, X_2 ....X_n = Observed underlying factors constraining linkage practice

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents and discuss the results obtained from the analyses carried out to achieve the objectives of the research.

4.1 Socio-economic Characteristics of Project Farmer

This section presents the results of the study on socio-economic characteristics of the project farmers in the study area which comprises of the age, marital status, secondary education and level of education.

4.1.1 Age of the project farmer

The result in Table 4.1 reveals that majority (84.7%), (83.3%) and (79.6%) of Bosso, Lapai and Mokwa project farmers respectively were within the age bracket of 30 – 59 years with the mean age of 43, 44 and 46 years respectively. Meanwhile, the mean age of the pooled sample was 44 years. This implies that the farmers were still relatively active and energetic to cope with the daily challenges and demands of farm production activities. This is an indication that there is availability of able-bodied labour force for project farmers to engage in farming that could enhance their adoption of sustainable problematic soil techniques in the study area. Also, young farmers are expected to be flexible in their decisions to adopt new ideas that can improve their productivity especially those that are sustainable.

The findings is similar to the study of Mariano *et al*. (2012), who reported higher adoption of improved farming practice among mid-age in the study area..

4.1.2 Marital status of project farmer

Table 4.1 revealed that majority (97.2%) of pooled were married. Meanwhile majority (96.6%), (96.7%) and (98.3%) of Bosso, Lapai and Mokwa project farmers respectively were married. This implies that majority of the project farmers were married individual. This is because the study area is mostly agrarian societies where members marry in order to have more hands that could be used as a cheap labour source for farm operations, which can go a long way in boosting farm income and improving the livelihoods of rural farmers in the study areas. Although, high household size increase the physiological needs of family members thereby incurring more cost in meeting those needs.

4.1.3 Sex of the project farmers

The result in Table 4.1 shows that majority (89.4%) of pooled were male. Similarly, majority (88.3%), (99.0%) and (89.9%) of the project farmers in Bosso, Lapai and Mokwa respectively were Male. This implies that majority of project farmers in the study area were male. The dominance of male over female could be attributed to drudgery and physical strength associated with agriculture. This is in line with Chukwuone *et al***.** (2006) who posits that majority of rice farmers in Ogun State were male.

Table 4.1: Distribution of respondent according to socio-economic characteristics of project farmers

	Bosso			Lapai			Mokwa			Pool		
Variable	**F**	**%**	**Av**	**F**	**%**	**A**	**F**	**%**	**A**	**F**	**%**	**A**
Age												
<30	5	8.3		15	8.4		6	10.0		4	6.8	
30 – 39	22	36.7		51	28.5		15	25.0		14	23.7	
40 – 49	17	28.0	43	61	34.1	44	24	40.0	44	20	33.9	46
50 – 59	12	20.0		36	20.1		11	18.3		13	22.0	
60 and above	4	6.7		16	8.9		4	6.7		8	13.6	
Marital status												
Married	58	96.6		174	97.2		58	96.7		58	98.3	
Single	1	1.7		4	2.3		2	3.3		1	1.7	
Divorced	1	1.7		1	0.5		0	0.0		0	0.0	
Gender												
Female	53	88.3		19	10.6		6	10.0		6	10.1	
Male	7	11.7		160	89.4		54	90.0		53	89.9	
Household size												
<5	4	6.7		15	8.4		7	11.9		4	6.8	
5 – 9	19	31.7		54	30.2		19	31.7		16	27.1	
10 – 14	14	23.3	13	39	21.8	14	13	21.7	13	12	20.3	15
15 – 19	9	15.0		27	15.1		9	15.0		9	13.3	
20 and above	14	23.3		44	24.6		12	20.0		18	30.5	
Area devoted												
1 – 10	20	33.3		44	24.6		14	23.3		10	16.9	
11 - 20	23	38.3	16	73	40.8	18	24	40.0	16	26	44.1	20
21 – 30	10	16.7		36	20.1		14	23.0		12	20.3	
31 and above	7	11.7		26	14.5		8	13.3		11	18.6	
Level of education												
No formal	13	21.7		39	21.8		12	20.0		14	23.7	
Primary	5	8.3		17	9.5		8	13.3		4	6.8	
Secondary	15	25.0		43	24.0		15	25.0		13	22.0	
Tertiary	3	5.0		13	7.3		7	11.7		3	5.1	
Adult	5	8.3		19	10.6		8	13.3		6	10.2	
Quranic	19	31.7		48	26.8		10	16.7		19	32.2	

Sources: Field survey, 2021

4.1.4 Household size of the project farmers

Household is an important factor in determining the extent to which labour force is available in practicing agricultural activities. It was expected that the larger the household size the higher the number of hands available for labour.

The result in Table 4.1 also indicated that majority (70.0%), (68.4%) and (60.7%) of the project farmers in Bosso, Lapai and Mokwa had household size of 5 – 19 respectively with mean household size of 13, 13 and 15 persons respectively. This implies that majority of the respondents had large household size which is expected to increase the use of family labour in carrying out farming operations. The finding is agrees with Cooksey (2013) and Davis *et al.* (2015) who reported that, household size is related to the adoption of new innovation. Large household size is proportional to labour availability and reduce the cost of hired labour. Also, larger households diversify their means of livelihoods, which enable them to earn more income. This may likely increase their food security and adoption of improved soil conservation practice. Although, large household size also is a reflection of a high level of dependency which may likely increase the household expenditure.

4.1.5 Level of education of the project farmers

The result in Table 4.1 revealed that 26.8% of the pooled sample had quranic education, 24.0% had secondary education, 21.8% no formal education, 10.6% had adult education and only 7.3% had tertiary education. Meanwhile, the result of Bosso revealed that 31.7% of the project farmers had quranic education, 25% had secondary education, 21.7% no formal education, 8.3% had adult and primary education, and only 5% had tertiary education. In the same vain the result of Lapai indicated that 25.0% had secondary education, 20.0% had no formal education, 16.7% had quranic education, 13.3% had adult and primary education and only 11.7% had tertiary education, while, the result of Mokwa showed that 32.2% of the project farmers had quranic education, 23.7% no formal education, 22.0% had secondary education, 10.2% had adult education, and only 5.1% had tertiary education.

The implication of this result is that educational status of the project farmers in the study area is low with most having attained quranic and secondary education. The study contradicts with the findings of Alderman and Linnemayr (2009), who found a positive relationship between education and use of new farming practices. Similarly, Simon *et al.* (2010) found education to be related to level of use of improved agricultural practices. The low educational status in the study area could be attributed to family involvement in farming activities. The majority of respondents started farming as children, leaving little time for post-secondary education this is expected to have inverse relationship on the adoption of innovative practice on problematic soil.

Table 4.2: Distribution of respondent according socioeconomic continued

	Bosso			Lapai			Mokwa			Pool		
Variable	**F**	**%**	**Av**	**F**	**%**	**A**	**F**	**%**	**A**	**F**	**%**	**A**
Secondary occupation												
Livestock	14	23.3		52	29.1		21	35.0		17	28.8	
Fishing	1	1.7		3	1.7		2	3.3		0	0.0	
Rice farming	11	18.3		38	21.2		13	21.7		14	23.4	
Petty trading	5	8.3		10	5.6		3	5.0		2	3.4	
Processing farm produce	6	10.0		12	6.7		3	5.0		3	5.1	
civil servant	8	13.3		26	14.5		9	15		9	15.3	
Handicraft	4	6.7		12	6.7		3	5.0		5	8.5	
Transport	11	18.3		26	14.5		6	10.0		9	15.3	
Membership of cooperative												
Yes	23	38.3		68	38.0		21	35.0		19	32.2	
No	37	61.7		111	62.0		39	65.0		40	67.8	

Sources: Field survey, 2021

4.1.6 Secondary occupation of the project farmers

The result of secondary occupation in Table 4.2 revealed that 29.1% of the pooled sample engages in livestock production as a secondary occupation, 21.2% engages in rice farming while 14.5% engages were transporters. Meanwhile, the result of Bosso revealed that 23.3% of the project farmers were livestock farmers, 18.3% were rice farmers and transporter while 13.3% were civil servant. Also, the result of Lapai indicated that 35.0% of the project farmers were livestock farmers, 21.7% were rice farmers, 15.0% were civil servant while 10.0% were transporter. Lastly, the result of Mokwa showed that 28.8% of the project farmers were livestock farmers, 23.4% were rice farmers, 15.3% were civil servant and transporter respectively. This implies that the project farmers in the areas diversify their sources of income to help them overcome the unforeseeable circumstances that are always associated with farming.

4.1.7 Membership of cooperative

The result in Table 4.2 revealed that 61.7% of project farmers in Bosso were members of cooperative societies, 65.0% of project farmers in Lapai were members of cooperative while 67.8% of project farmers in Mokwa were members of cooperative societies and 62.0% were members of cooperative in the pooled sample. This implies that majority of the project farmers in the study area were members of cooperative this is because of several interventions by governmental and nongovernmental organizations which mandate farmers of similar commodities to form clusters in order to participate in their interventions. Ogunbameru *et al.* (2008) posits that participation in cooperative have the potential of creating confidence between farmers and financial institutions thus allowing farmers to have access to farm credit from such institutions using their collective grains in a community warehouse as collateral.

4.1.8 Area devoted for farming

The result in Table 4.2 reveals that 33.3% of project farmer in Bosso had a farm size within the range of 1 – 10, 38.3% had farm size within the range of 11 – 20 hectares with mean farm size of 16 hectares per project farmer**.** Also, about 40.0% of project farmers in Lapai had farm size within the range of 11 – 20, 23.3% and 20.0% had farm size within the range of 1 – 10 and 21 -30 respectively with mean of 16 hectares per project farmer. While 41.1% of Mokwa project farmer had farm size within the range of 11 – 20, 20.3% and 18.6% had farm size within the range of 21 – 30 and 31 and above respectively with mean of 20 hectares per project farmer for maize and soybean production. In addition, the mean farm size of pooled sample was 18. This implies that project farmers in the study area devoted large expand of land for maize and soybean production. The reason for this finding could be attributed to the fact that majority of project farmers obtained their land through family inheritance.

4.2 Sources of Innovation for the Project Farmers

The result presented in Table 4.3 revealed the sources of innovation for project framers. It shows that majority (60.0%) of pooled sample source their information on innovative means of managing problematic soil from radio. This is followed by friend and family where about 64.8% of the pooled sample obtained their information from friends and family. About 48.0% of the pooled samples source their information on improved agricultural practices from extension agent while only 5.0% of the pooled sample obtained their information from television. The result further shows that majority (63.3%) of project farmer from Bosso obtained their information from friends and family, 53.3% source their information from radio, half (50.0%) of the project farmers from Bosso opined that they source their information from extension agent while 3.3% source their information from television. Meanwhile, majority (71.7%) of project farmers from Lapai source their information on improved problematic soil management from radio, 65.0% source their information from friends and family, 50.0% from extension agent while only 6.7% of the project farmers from Lapai source their information from television. Lastly, about 64.0% of project farmers from Mokwa posits that they source their information on improved problematic soil management from friends and family, about 63% source their information from radio, more than half (55.9%) source their information from extension agent while only 5.0% source their information from television. This follows Anaglo *et al.* (2020) who reported that the sources of agricultural information to small scale farmers were fellow farmers, radio, agricultural extension agent, input dealers with the least source used being newspapers/agricultural bulletins.

The implication of this result is that radio, friends and family and extension agents were the major sources of information to project farmer on improved problematic soil management in the study area. The low utilization of television as a source of information in the study area could be attributed to epileptic power supply by Power Holding Company of Nigeria (PHCN). It could also be attributed to high cost of TV set. Radio is the most prevalent sources of information in the study area. The reason for this result could be attributed to the fact that at least one member of the household had access to mobile phones with radios installed on them and popular MP3 radio sets, which is common in most households. This allows farmers to listen to their favorite radio programs during their leisure time, where most of these improved practices can be advertised.

Friend and family is the second common source of information on improved problematic soil management for project farmers across the study areas. The reason for this result could be attributed to the fact that the study area is a homogeneous society with a primary group, which makes the diffusion of new innovations faster among the inhabitants. Lastly, the extension agent was also utilized as a source of information on improved problematic soil management. This is because Niger state attracts several interventions from the World Bank (APPEALS, IFAD, and FADAMA, among others) and other non-governmental organizations due to their high involvement in agriculture. Thus, several innovative practices are disseminated through extension agents to the farming population.

Table 4.3: Distribution of respondent according to sources of innovation

	Bosso		Lapai		Mokwa		Pool	
Sources	Freq.	%	Freq.	Freq.	%	%	Freq.	%
Radio								
Yes	32	53.3	43	108	60.3	71.7	37	62.7
No	28	42.7	17	71	39.7	29.3	22	37.3
Television								
Yes	2	3.3	4	9	5.0	6.7	3	5.0
No	58	96.7	56	170	95.0	93.3	56	95.0
Friends and family								
Yes	38	63.3	39	116	64.8	65.0	39	64.1
No	22	36.7	21	63	35.2	35.0	20	33.9
Extension agent								
Yes	30	50	30	93	48.0	50.0	33	55.9
No	30	50	30	86	52.0	50.0	26	44.1

Source: Field survey, 2021

4.3.1 Type of innovation used

The result in Table 4.4 presents the results of the type of innovation on improve problematic soil management used by project farmers for maize and soybean production.

Maize

The result in Table 4.4 revealed that agric lime (78.0%), agric lime 3WBP (78.3%), agric. lime +FYM+ NPK (53.0%), agric lime + NPK and NPK (Spec. blend (OCP) (40.0%) were the major type of innovation on problematic soil used by Bosso project farmers. Also, agric lime (80.0%), agric lime 3WBP (78.3%), Spacing 25 by 75cm (70.0%), agric. lime +FYM+ NPK (53.0%), agric lime + NPK (50%) and NPK (Spec. blend (OCP) (38.0%) were the major type innovation on problematic soil used by Lapai project farmers. While that of Mokwa project farmers reveals that agric lime (80.0%), agric lime 3WBP (78.3%), Spacing 25 by 75cm (88.0%), agric. lime +FYM+ NPK (60.0%), agric lime + NPK (53.0%) and NPK (Spec. blend (OCP) (35%) were the major innovation used to improve their soil. Lastly, the result of the pooled sample as presented in Table 4.3 shows that agric lime (80.0%), agric lime 3WBP (79.0%), spacing 25 by 75cm (72.0%), agric. lime +FYM+ NPK (53%), agric lime + NPK (56.0%) and NPK (Spec. blend (OCP) (38.0%) were the major type of innovation on problematic soil used in the study area.

Soybean

The result in Table 4.3 revealed that agric lime (85.0%), agric lime 3WBP (73.3%), spacing 5by 75 (78.0%), agric. lime + SSP+ FYM (55.0%), FYM+SSP (40.0%) were the major type of innovation on problematic soil used by Bosso project farmers for their soybean. Also, agric lime (83.0%), agric lime 3WBP (75.0%), spacing 5 by 75 (71.0%), agric. Lime + SSP+ FYM (53%.0), agric. lime + SSP only (38.0%) were the major type of innovation on problematic soil used by Lapai project farmers for their soybean. While that of Mokwa project farmers revealed that agric lime (82.0%), agric lime 3WBP (73.0%), spacing 5 by 75cm (73.0%), agric. lime + SSP+ FYM (53.0%), agric. lime + SSP only (45.0%) were the major innovation used to improve their problematic soil. Lastly, the result of the pooled sample as presented in Table 4.4 shows that agric lime (83.0%), agric lime 3WBP (74.0%), spacing 5 by 75cm (75.0%), agric. lime + SSP+ FYM (53.0%), FYM+SSP (43.0%) were the major type of innovation on problematic soil used in the study area on soybean.

Fertilizer usage helps to improve the fertility of the soil, but improper application of this fertilizer usually leads to acidification of the soil. Leaching and volatilization of nitrate fertilizer from the soil may also contribute to acidification of the soil. In addition, bush burning, which is a common practice of land clearing among farmers in the study areas, may likely contribute to the acidification of soil. This necessitates the use of agricultural lime to control the acidity of the soil, especially on maize farms, which do not thrive well on soil pH below 5.0 (Vitalis, 2021). This could be the reason for the high level of agricultural lime and nitrogen fertilizer usage among the project farmers across the study areas. Also, the Small Plot Adoption Techniques adopted for the project have revealed to the project farmers the importance of proper spacing of crops, which tends to influence crop growth, makes it easier for weed control, and reduces the spread of pests and diseases. This could be the reason for the higher adoption of spacing by project farmers.

Table 4.4: Distribution of respondent base on the type of innovation used

Innovations	Bosso F(%)	Lapai F(%)	Mokwa F(%)	Pooled F(%)
Maize				
Agric. Lime	47(78.3)	48(80.0)	48(80.0)	143(79.9)
Agric. lime 3WBP	47(78.3)	47(78.3)	47(78.3)	141(78.8)
NPK(Spec. blend (OCP)	24(40.0)	23(38.3)	21(35.0)	68(38.0)
Urea 46% N	14(23.3)	7(11.7)	8(13.3)	29(16.2)
farmyard manure	15(25.0)	9(15.0)	15(25.0)	39(21.8)
Farmer practice (NPK only)	15(25.0)	7(11.7)	12(20.0)	34(19.0)
Agric lime + NPK	25(41.7)	30(50.0)	32(53.3)	87(48.6)
Agric. Lime +FYM+ NPK	32(53.3)	32(53.3)	36(60.0)	100(55.9)
FYM+NPK	17(28.3)	8(13.3)	14(23.3)	39(21.8)
Seed rate 290kg per ha	15(25.0)	16(26.7)	14(23.3)	45(25.1)
Spacing 25by 75cm	43(71.7)	42(70.0)	44(88.0)	129(72.1)
Soybean				
Agric lime	51(85.0)	50(83.3)	49(81.7)	150(83.8)
Agric 3WBP	44(73.3)	45(75.0)	44(73.3)	133(74.3)
NPK(Spec. blend (OCP)	27(45.0)	28(46.7)	26(43.3)	81(45.3)
FYM	11(18.3)	9(15.0)	9(15.0)	29(16.2)
Farmer practice(SSP)	13(21.7)	10(16.7)	10(16.7)	33(18.4)
Agric. Lime + SSP only	29(48.3)	23(38.3)	27(45.0)	79(44.1)
Agric. Lime + SSP+ FYM	33(55.0)	32(53.3)	30(50.0)	95(53.1)
FYM+SSP	24(40.0)	22(36.7)	30(50.0)	76(42.5)
Seed rate (40kg)	19(31.7)	13(21.7)	15(25.0)	47(26.3)
spacin5cmby 75cm	47(78.3)	43(71.7)	44(73.3)	134(74.9)

Source: Field survey, 2021

4.3.2 Level of innovation application adoption by the project farmers

This section present the results of Likert type rating scale on the level of innovation application by the project farmers on both maize and soybean.

Maize

The result of the Likert type rating scale on the level of innovation application on maize and soybean by the project farmers as presented in Table 4.5 revealed that Agric. lime 3WBP ($\bar{X}$=4.0), Agric. Lime +FYM+ NPK ($\bar{X}$=3.9), Agric lime + NPK ($\bar{X}$=3.8), Agric. Lime ($\bar{X}$=3.8) and FYM+NPK ($\bar{X}$=3.8) were ranked first, second and third respectively as the major innovation adopted by project farmers in Bosso LGA on their maize farm. Others include Spacing 25cm x 75cm ($\bar{X}$=3.7), Urea 46% N ($\bar{X}$=3.5), Seed rate 290kg per ha ($\bar{X}$=3.5), farmyard manure ($\bar{X}$=3.4) and Farmer practice ($\bar{X}$=3.4) which were ranked sixth, seventh and ninth among the innovation adopted by maize farmers in Bosso.

Meanwhile, in Lapai LGA Agric lime + NPK ($\bar{X}$=4.1), Agric. Lime +FYM+ NPK ($\bar{X}$=4.0), Agric. lime 3WBP ($\bar{X}$=3.8), Spacing 25cm x 75cm ($\bar{X}$=3.8) were ranked first, second and third innovative practice on problematic soil adopted in their maize production. Others include, Agric. Lime, Farmer practice (NPK only) and Seed rate 290kg per ha ($\bar{X}$=3.7) which were ranked fifth respective. In addition, Urea 46% N and farmyard manure ($\bar{X}$=3.4) ranked seventh respectively. In the case of Mokwa LGA, Agric lime + NPK ($\bar{X}$=4.1), Agric. lime 3WBP ($\bar{X}$=3.9), Agric. Lime ($\bar{X}$=3.8), Agric. Lime +FYM+ NPK ($\bar{X}$=3.8) and Spacing 25cm x 75cm ($\bar{X}$=3.8) were ranked first, second and third adopted innovative practice on problematic soil management in their maize farm. Seed rate 290kg per ha ($\bar{X}$=3.6) and Farmer practice (NPK only) ($\bar{X}$=3.6) ranked sixth while Urea 46% N and farmyard manure ($\bar{X}$=3.4) ranked seventh innovative practices adopted by the project farmers.

Lastly, the pool sample revealed that the most prevalent innovative practices on problematic soil adopted across the study areas for maize production were Agric lime + NPK ($\bar{X}$=4.0), Agric. Lime +FYM+ NPK ($\bar{X}$=3.9), Agric. lime 3WBP ($\bar{X}$=3.9) ranked first and second respectively. Agric. Lime ($\bar{X}$=3.8), Spacing 25by 75cm ($\bar{X}$=3.8), Seed rate 290kg per ha ($\bar{X}$=3.6), Farmer practice (NPK only) ($\bar{X}$=3.6) ranked fourth and sixth respectively while FYM+NPK ($\bar{X}$=3.5), Urea 46% N ($\bar{X}$=3.4), farmyard manure ($\bar{X}$=3.4) and NPK (Spec. blend (OCP) ($\bar{X}$=3.0) were eighth, ninth and eleventh respectively.

Soybean

As regards innovative practice adopted to manage problematic soil (acidic soil) for soybean production which are presented in Table 4.4 portray that Agric. Lime + SSP+ FYM ($\bar{X}$=3.8), FYM+SSP ($\bar{X}$=3.8), spacin5cmby 75cm ($\bar{X}$=3.7), Agric lime ($\bar{X}$=3.7) and Agric 3WBP ($\bar{X}$=3.7) were first and second respectively were the major innovative practices adopted by Bosso projected farmers. Agric. Lime + SSP only ($\bar{X}$=3.5), FYM ($\bar{X}$=3.5), Farmer practice (SSP) ($\bar{X}$=3.5) and Seed rate (40kg) ($\bar{X}$=3.4) were ranked sixth and eighth respectively. The result of Lapai depicts that spacin5cmby ($\bar{X}$=3.9), Agric lime ($\bar{X}$=3.6), Agric 3WBP ($\bar{X}$=3.6), Agric. Lime + SSP+ FYM ($\bar{X}$=3.6) and FYM+SSP ($\bar{X}$=3.6) were ranked first and second innovative practices on improved problematic soil (acidic soil) management adopted in the study area while, Farmer practice (SSP) ($\bar{X}$=3.4), Agric. Lime + SSP only ($\bar{X}$=3.3) and FYM ($\bar{X}$=3.2) were ranked sixth, seventh and eighth respectively.

The result in Table 4.5 further revealed that Mokwa project farmers adopted Seed rate (40kg) ($\bar{X}$=3.9), Agric. Lime + SSP+ FYM ($\bar{X}$=3.8), Agric lime ($\bar{X}$=3.7), spacing 5cm x 75cm ($\bar{X}$=3.7) in managing the menace of problematic soil (acidic soil) on their soybean farm. FYM ($\bar{X}$=3.6), NPK (Special blend (OCP) ($\bar{X}$=3.4), Farmer practice (SSP) ($\bar{X}$=3.3) and FYM+SSP ($\bar{X}$=3.3) were the other innovative practices adopted by project farmers in the study areas. Lastly, the result of the pool sample revealed that spacing 5cm x 75cm ($\bar{X}$=3.9), Agric lime ($\bar{X}$=3.7), FYM+SSP ($\bar{X}$=3.7) and Agric. Lime + SSP+ FYM ($\bar{X}$=3.6) were the major innovative problematic soil (acidic soil) strategies adopted across the study areas. While FYM ($\bar{X}$=3.5), Farmer practice (SSP) ($\bar{X}$=3.5), NPK (Spec. blend (OCP) ($\bar{X}$=3.4), Agric. Lime + SSP only ($\bar{X}$=3.4), Seed rate (40kg) ($\bar{X}$=3.3).

Problematic soil (acidic soil) has caused lots of havoc in the productivity of agricultural commodity especially those crops that are acid sensitive. Maize and soybean are not immune to these effects in the study area. The major recourse to reduce or manage the problematic soil (acidic soil) was to adopt sustainable cultural and soil conservation practices that will enhance the productivity and food security status of project farmer in the study area.

The use of agricultural lime was generally adopted across the study areas to reduce the acidity of the soil. Majority of farmer’s cultural practices which include bush burning, method of fertilizer application, clean clearing and crop removal among others leads to acidification of soil. Also, natural occurrences like leaching may also cause acidification of soil. Thus the agricultural liming introduced by the project met the felt needs of project beneficiaries which accounted for it general acceptance and adoption in the study area. Agric lime + NPK was the second mostly adopted innovative practice in the study area for maize production. Generally maize is a cereal crop which requires high Nitrogen for it growth and development. Thus proper combination of lime and nitrogen as exemplified by the project leads to their higher adoption across the study areas. NPK (Special blend (OCP) were also highly adopted in the study area. The reason for this result could be attributed to the fact that NPK special blended OCP was specially formulated to enhance the productivity of nitrogen demanding crops like maize. The result demonstration as shown by the project might likely be the reason for it adoption. Spacing 25 x 75cm was highly adopted in the study area. Adoptions of recommended spacing help to reduce the competition for soil nutrient, enhance proper growth and facilitate weed control. It was revealed that in the study area farmers planted using legs this tends to reduce the planting density and invariably reduce the yield and productivity of farmers. This may likely be the reason for the adoption of proper spacing in the study area. This is in line with the study of Simon and Lieberman (2010) who reported that liming help to reduce the acidity of soil.

Table 4.5: Distribution of respondent according to Innovation application

	Bosso (N=60)							Lapai (N=60)							Mokwa (N=60)							Pooled(N=180)						
													Maize															
Variable	A	I	E	T	A	WS	WM	A	I	E	T	A	WS	WM	A	I	E	T	A	WS	WM	A	I	E	T	A	WS	WM
Agric.	8	1	1	7	3	23	3.8	9	0	1	4	2	22	3.7	7	0	1	9	2	22	3.8	2	1	5	2	8	67	3.8
Lime			4		0	0	*			8		9	4	*			8		5	2	*	4		0	0	4	6	*
Agric. lime	5	0	1	1	3	24	4.0	6	0	2	8	2	22	3.8	4	0	2	7	2	23	3.9	1	0	5	2	8	70	3.9
3WBP			4	0	1	2	*			0		6	8	*			1		7	0	*	5		5	5	4	0	*
NPK(Spec.	2	6	1	1	5	15	2.5	2	8	1	7	6	13	2.3	3	5	1	6	4	12	2.1	8	1	3	2	8	75	3.0
blend	3		4	2		0		7		2			7		1		3			4		4	6	9	5	4	3	*
(OCP)																												
Urea 46%	4	4	2	1	1	21	3.5	5	6	2	8	1	20	3.4	3	7	3	4	1	19	3.4	1	1	7	2	4	61	3.4
N			3	6	3	0	*			6		5	2	*			0		5	8	*	2	7	9	8	3	0	*
farmyard	4	6	2	1	1	20	3.4	8	4	2	7	1	20	3.4	7	5	2	4	2	20	3.4	1	1	7	2	5	60	3.4
manure			4	2	4	6	*			4		7	1	*			3		0	2	*	9	5	1	3	1	9	*
Farmer	5	6	2	1	1	20	3.4	5	3	2	1	2	22	3.7	4	2	2	7	2	21	3.6	1	1	7	2	5	63	3.6
practice			4	1	4	3	*			0	1	1	0	*			6		0	4	*	4	1	0	9	5	7	*
(NPK																												
only)																												
Agric lime	4	4	1	1	2	22	3.8	4	2	1	1	3	24	4.1	3	2	1	1	3	24	4.1	1	8	3	4	8	71	4.0
+ NPK			4	6	2	8	*|			1	2	1	4	*			1	2	1	3	*	1		6	0	4	5	*
Agric.	5	2	1	1	2	23	3.9	4	1	1	1	2	24	4.0	3	5	1	1	2	22	3.8	1	8	4	3	8	69	3.9
Lime			5	0	8	4	*			5	1	9	0	*			6	1	4	5	*	2		6	2	1	9	*
+FYM+																												
NPK																												
FYM+NP	3	2	2	1	2	22	3.8	9	0	1	4	2	22	3.7	7	6	2	8	1	19	3.3	1	9	6	3	5	63	3.5
K			2	3	0	5	*			8		9	4	*			2		6	7	*	8		6	3	3	1	*
Seed rate	9	4	1	1	1	21	3.5	6	6	1	1	1	21	3.7	5	8	1	1	1	21	3.6	2	1	3	5	5	64	3.6
290kg per			3	5	9	1	*			0	9	9	9	*			1	7	8	2	*	0	8	4	1	6	2	*
ha																												
Spacing 25	7	5	1	1	2	22	3.7	5	5	1	1	2	22	3.8	4	4	1	1	2	22	3.8	1	1	3	4	6	67	3.8
by 75cm			1	3	4	2	*			3	4	3	5	*			3	6	2	5	*	6	4	7	3	9	2	*
													Soybean															
Agric lime	8	9	8	6	2	21	3.7	6	1	1	7	2	21	3.6	5	7	1	1	2	22	3.7	1	2	3	2	7	65	3.7
					9	9	*		0	2		5	5	*			1	1	5	1	*	9	6	1	4	9	5	*
Agric	8	6	1	3	3	22	3.7	7	7	1	4	2	21	3.6	2	9	9	5	1	14	2.5	6	3	2	1	3	44	2.5
3WBP			3		0	1	*			6		6	5	*	4				2	9		9	4	9	7	0	2	
NPK(Spec.	2	1	9	6	7	13	2.3	2	1	1	6	1	15	2.6	6	7	1	1	1	20	3.4	1	2	5	3	4	60	3.4

blend (OCP)	4	4				8		1	1	1		1	5				8	4	4	0	*	5	8	8	5	3	0	*
FYM	3	10	19	10	18	210	3.5*	6	11	21	11	11	190	3.2*	2	7	22	12	16	210	3.6*	9	27	61	37	45	619	3.5*
Farmer practice(SSP)	3	11	18	12	16	207	3.5*	4	9	21	13	13	202	3.4*	2	14	20	8	15	197	3.3*	9	20	68	37	45	626	3.5*
Agric. Lime + SSP only	2	11	20	9	18	210	3.5*	3	14	21	8	14	196	3.3*	8	7	16	1	27	209	3.5*	7	39	61	25	47	603	3.4*
Agric. Lime + SSP+ FYM	4	9	13	3	31	228	3.8*	9	6	14	3	28	215	3.6*	2	5	19	9	24	225	3.8*	21	22	43	7	86	652	3.6*
FYM+SSP	3	6	17	6	28	230	3.8*	5	8	17	7	23	215	3.6*	3	11	20	14	11	196	3.3*	10	19	53	22	75	670	3.7*
Seed rate (40kg)	2	12	22	8	16	204	3.4*	5	14	21	11	9	185	3.1*	1	8	13	9	28	232	3.9*	10	37	63	33	36	585	3.3*
spacin5cm by 75cm	1	8	12	8	31	219	3.7*	2	9	13	8	28	231	3.9*	3	5	20	12	19	216	3.7*	4	25	38	25	87	703	3.9*

Source: Field survey, 2021

Note: A= Awareness, I= Interest, E=Evaluation, T=Trial, A=Adoption and *= significant.

4.4 Effects of Innovation Application on Problematic Soil by Project Farmers Output

From the OLS analysis result presented in Table 4.6 revealed that the coefficient of determination (R^2) value was 0.8750 and 0.7439 for maize and soybean respectively. This implies that approximately about 87% and 74% variation in output of maize and soybean of project farmers were explained by the independent variables included in the model, the remaining 13% and 26% unaccounted for could be due to error or other variables not captured in the model. The F – ratio is statistically significant at 0.01 probability level implying the perfect fit of the model and good at predicting the observed data.

Maize

The result revealed that out of sixteen (16) variables included in the model, six (6) variables were statistically significant at 0.01, 0.05 and 0.10 probability levels respectively. Four (4) variables, such as farming experience (89.2786), relative advantage (46.0641), compatibility (1110.225), seed rate (91.9084) were found to be positive and statistically significant, thus directly influencing the output of project farmers, while two (2) variables such as complexibility (-353.614) and cost (-337.2121) were negative and statistically significant and inversely influencing the output of maize

The coefficient of farming experience (89.2786) was positive and statistically significant at 0.05 probability level. This implies that a unit increase in farming experience may likely leads to 87.27% increases in the maize output of project farmers. This agrees with the study of Ladeebo *et al.* (2017) who found farming experience to have positive correlation with output in Oyo state. This has the expected *a priori* because farming experiences is expected to improve farmers' wealth of knowledge over time to manage and adjust to challenges of farming overtime. The reason for this result could be attributed to the fact that majority of project farmers in the study area were experienced farmers. Therefore, the new innovations on managing problematic soil (acidic soil) were highly adopted which is expected to enhance their productivity.

The coefficient of relative advantage (46.0641) was positive and statistically significant at 0.01 probability level. This implies that a unit increase in relative advantage may leads to 46.06 increases in the maize output of project farmers. This has the expected *a priori* because innovation that is more advantageous than the practices that the farmers are used to may likely influence the adoption of such innovation and invariably leads to increase in the productivity of the farmers. The reason for this result could be attributed to the fact that the result demonstration of the packages introduced were found to be superior to their previous practices which leads to high adoption rate in the study area which is expected to increase the productivity of the farmers.

The coefficient of compatibility (1110.225) was positive and statistically significant at 0.05 probability level. This implies that a unit increase in compatibility may leads to 1110 increases in the maize output of project farmers. The reason for this result could be attributed to the fact that the introduced packages not in conflict with norms and value of the study areas.

The coefficient of seed rate (91.9084) was positive and statistically significant at 0.01 probability level. This implies that a unit increase in seed rate will leads to 91.9% increases in the maize output of project farmers. However, in order to ascertain the projected tons per hectare of maize, the planting density with all the required cultural practices most be followed. Thus, adopting the recommended seed rate of maize is expected to increase the productivity of maize farmers.

The coefficient of complexibility (-353.614) and cost (-337.2121) were negative and statistically significant at 0.05 and 0.10 probability levels. This implies that a unit increase in complexibility and cost of innovation will leads to 353 and 337 decreases in the maize output of project farmers. This has the expected *a priori* because the more complex and expensive the technology, the slower their adoption. This may likely leads to project farmers continued with their old cultural practices.

Soybean

Table 4.5 also revealed that out of sixteen variables included in the model five (5) variables were statistically significant at 0.01 and 0.05 respectively. Four (4) variables such as age (910.7487), education (54.7708), relative advantage (31.3439) and seed rate (4.5152) were found to be positive and statistically significant, invariably influencing the soybean output of project farmers directly, while one (1) variable such as cost (-60.1118) was negative and statistically significant thereby inversely influencing the output of soybean of the project farmers.

The coefficient of age (910.7487) was positive and statistically significant at 0.01 probability level. This implies that a unit increase in age may leads to 910 increases in the soybean output of project farmers. This result is similar to the study of Kayode *et al.* (2017) who reported that farmer's age to have inverse relationship with output. This negate the *a priori* expectation, although older farmers may have more experience and resources that enable them to try a technology but they may be too weak to undertake difficult farm operations without the help of labour saving devices. In addition, some are too conservative to try out new innovation. The reason for this result could be attributed to the fact that majority of project farmers are mid-age who were willing to try out new innovation to enhance their productivity.

The coefficient of education (54.7708) was positive and statistically significant at 0.01 probability level. This implies that a unit increase in education will leads to 54.77% increases in the soybean output of project farmers. This meets the *a priori* expectation because education is believed to enhance farmers' exposure to new ideas and innovation, and thus have better knowledge to efficiently analyse and use available information to make rational decision for adoption of the new innovation. This finding corroborates that of Simon and Lieberman (2010) who found that education positively influence the adoption of improved agricultural practices. n.

The coefficient of relative advantage (31.3439) is positive and statistically significant at 0.01 probability level. This implies that a unit increase in relative advantage may leads to 54.77 increases in the soybean output of project farmers. The coefficient for seed rate (4.5152) was positive and statistically significant at 0.01 probability level. This implies that a unit increase in seed rate may leads to 4.51 increases in the soybean output of project farmers. The coefficient of cost (-60.1118) is negative and statistically significant at 0.05 probability level. This implies that a unit increase in cost may leads to 60.1 decreases in the soybean output of project farmers.

Table 4.6: Regression result on effects of innovation application on problematic soil by project farmers on Mize and Soybean output

	Maize		Soybean	
Variables	**Coefficient**	**t-value**	**Coefficient**	**t-value**
Farm size	-606.5399	-1.47	- 112.9207	-0.24
Labour usage	282.8499	0.96	-41.6909	-0.81
Agro-chemicals	4.1506	0.35	-24.9267	-1.87
Seeds	3.5124	0.17	14.0270	0.64
Age	79.8519	0.71	910.7487***	2.86
Education	-4.9218	-0.44	54.7708***	4.43
Farming experience	89.2786**	2.36	51.1853	1.28
Extension contact	-21.4512	-0.11	- 103.1463	-0.47
Relative advantage	46.0641***	3.94	31.3439**	2.38
Complexibility	-353.614***	-2.50	313.7693	1.35
Observability	123.9014	0.58	218.4586	0.94
Triability	437.5892	0.44	-181.2466	-0.30
Compatibility	1110.225**	2.15	128.7814	0.67
Cost	-337.2121*	-1.93	-60.1118**	-2.28
seed rate	91.9084***	4.03	14.5152***	3.16
Spacing	.3240	0.06	53.1521	4.40
Constant	-1254.841	-1.15	-396.883	-0.44
R-squared	0.8750		0.7439	
Adjusted R-squared	0.8301		0.6890	
F-ratio	0.0000		0.0000	

Source: Field survey, 2021

*Note figures in parenthesis are the T-values *** significant 1% probability level, ** significant 5% probability level and * significant 10% probability level

4.5 Constraints Associated with innovation application to problematic soils by the project farmers

Principal component analysis using the varimax rotated factors with Kaiser Normalization was used to analyze the constraints associated with innovation application to problematic soils by the project farmers. The factorability of the constraint variables was examined. The result presented in Table 4.7 shows that the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0. 838 which is adequate and acceptable based on the KMO classification. The Bartlett's test (2769.570) also was significant at 0.01 probability level which shows that the matrix is significantly different from zero (0), that is, the matrix is significantly different from identity matrix. This implied that there were sufficient inter-correlations to conduct the factor analysis. More so, variables with factor loadings of less than 0.40 were not used.

The outcome of factor loadings from principal component analysis after varimax rotation of the project farmer's responses to questions on constraints associated with innovation application to problematic soils by the project farmers is presented. These constraints were listed according to the proportion of variance associated with them and were classified under four major factors. These are economic, policy, cultural and attitude factors.

Factor 1 (economic): The constraints that load high in factor one comprised of poor access to credit (.594), Low level of income (.739), inadequate technical knowhow (.758), high cost of input (.635), Low level of education (.556) and Long distance to sources of innovation (.572). The reason for this result could be attributed to low education status in the study area. This makes it difficult for project farmers to comprehend the technology until it is interpreted into their local dialect. Also, majority of projects farmers were low income earner this is because majority of them still produce agricultural commodity at subsistence level with several household cater for. Although, the project coordinators took the technological on the problematic soil (acidic soil) to the door steps of the beneficiaries but such technology is not available within the community of beneficiaries thus the need to pay more on transportation to use such technology.

Despite the enormous benefits associated with this innovation on managing problematic soil, it is very expensive this may likely reduce the rate of adoption as most project farmers across the study areas were low income earners.

Factor 2 (policy related factor): This was dominated by problem of untimely delivery of input (.553), low level of education (.633) and long distance to sources of innovation (.445). Agricultural production is time bound, little variation in any of cultural practice may likely mar the productivity. It was revealed that the technologies were not readily available. In addition, distance and cost of the technology will also cause delay in delivery of the technology.

Factor 3 (Cultural related factor): The cultural factors that loaded above the cut off eargen value were pest and disease attack (.666), insufficient rainfall (.433), problem of land tenure system (.687), problems of banditry attack (.611) and Farmers herders clash (.589). Prevalence of pest and diseases limit the adoption of sustainable problematic soil management in the study area, this is because farmers may likely discontinue the use of particular technology if such technology is susceptible to diseases. This is in line with the report of FAO (2011) who reported that challenge of pests and diseases, and weak cooperatives were the key constraints faced by the farmers in Nigeria. Variation in weather condition caused by green house emission may alter the rainfall pattern of particular area. This particular scenario may likely leads to reduction in adoption of technology as farmers may not be willing to continue with a particular technology after the first trial was not successful due to weather variation.

The high rate of insecurity in the country has posed threat to our food security and poverty status of Nigerian because farmers cannot freely go to their farm without the fear of been kidnapped or killed by bandits while others fear herders grazing on their farm land. The study area is not exempted to this threat, thus, the rate of adoption of innovation may likely reduce as the project farmers may not want to invest on a technology where his security and that of crops are not guarantee.

Factor 4 (Attitude related factors): This was dominated by problem of wrong view of farmers in capable of taking rational decision (.698) and low level of motivation (.624). To ensure high adoption of agricultural innovation farmers needs to be motivated, the project farmers complaint about low motivation from the project coordinators as they were only given little incentive during flag off of the project. This is similar with the study of Umukoro (2014) who reported that inadequate support and motivation from government affect the adoption of improved agricultural practices by farmers. After the factor analysis, the combination of variables in the first factor explained 30.0% of the variance, the second factor component explained 15.0% of the variance, the third factor explained 25% of the variance and the fourth factor explained 10% of the variance in the 20 variables scale. The true factors that were retained explained 55.0% of the variance in the 20 constraining factor or variable components.

Table 4.7: Distribution of respondent according to constraining factors hindering the innovation application

Variables	Factor 1 (Economic related factors)	Factor 2 (Policy related factor)	Factor 3 (Cultural related factor)	Factor 4 (Attitude related factors)
Inadequate extension contact	.115	.284	.146	-.153
Poor access to credit	.594 *	.347	-.219	-.076
Low level of income	.739*	-.049	-.237	-.136
Inadequate technical know how	.758*	.092	-.138	.029
Pest and disease attack	-.347	.252	.666*	.049
Insufficient rainfall	.284	.107	.433	-.073
Low germination rate	-.395	.129	.256	-.056
Wrong view of farmers in capable of taking rational decision	.096	-.168	-.060	.698*
Untimely delivery of input	-.306	.553*	-.042	-.497*
High cost of input	.635*	-.318	.207	.244
Problem of land tenure system	-.017	-.138	.687*	.384
Inadequate storage facilities	.292	-.321	-.015	.301
Problems of banditry attack	.141	-.297	.611	-.098
Farmers herders clash	.229	.287	.589*	.121
Contradict the norms and values of the society	.285	-.104	.397	.271
Low level of education	.556*	.633*	.079	.180
Low level of motivation	-.336	.116	.232	.624*
Against the felt needs of the farmers	.373	.270	.304	-.138
Inappropriate technology	.280	.212	.251	-.017
Long distance to sources of innovation	.572*	.445*	.375	.169
Kaiser-Meyer-Olkin (KMO)			0.838	
Bartlett' test			2769.570	

Source: Field survey, 2021

4.6 Hypothesis of the study

The hypothesis, which stated that there is no significant relationship between selected socio-economic characteristics (level of education, extension contact), selected production variables (Fertilizer, agrochemical and labour) and the innovation application on problematic soil by the project farmer was tested using the t-value from OLS regression. However, as revealed in Table 4.8, Education (54.7708), have significant influence on the output of soybean project farmers. Therefore, the hypothesis is rejected. This implies that education has a significant influence on the output of the soybean project farmers, while others (labour, agrochemicals, seeds and extension contact) do not have a significant influence on output of maize and soybean.

Table 4.8: Hypothesis testing

	Maize		Soybean	
Variables	Coefficient	t-value	Coefficient	t-value
Labour usage	282.8499 DNR	0.96	-41.6909 DNR	-0.81
Agro-chemicals	4.1506 DNR	0.35	-24.9267 DNR	-1.87
Seeds	3.5124 DNR	0.17	14.0270 DNR	0.64
Education	-4.9218 DNR	-0.44 DNR	54.7708*** R	4.43
Extension contact	-21.4512 DNR	-0.11	- 103.1463 DNR	-0.47

Source: Field survey, 2022

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the findings of the study, it was concluded that project farmers across the study areas were within their active age, married with large family size as well as low level of education and experienced farmers. It was also concluded that Agric lime, Agric lime 3WBP, Agric. Lime +FYM+ NPK, Agric lime + NPK and NPK (Spec. blend (OCP) were the major type of innovation on problematic soil used by maze project farmers while Agric lime, Agric lime 3WBP, Spacing 5 by 75, Agric. Lime + SSP+ FYM, and FYM+SSP were the major type of innovation on problematic soil used by soybean farmers. It can also be concluded that Agric. lime 3WBP, Agric. Lime +FYM+ NPK, Agric lime + NPK, Agric. Lime and FYM+NPK were the prevalent innovation adopted by project farmers for maize production while Agric. Lime + SSP+ FYM, FYM+SSP, spacing 5cm by 75cm, Agric lime and Agric 3WBP were the major innovative practices adopted by projected farmers. Furthermore, farming experience, relative advantage, compatibility, seed rate influence the maize output of project farmers positively, while complexibility and cost had inverse influence on maize output meanwhile, age, education, relative advantage and seed rate had direct influence on the soybean output of project farmers. Lastly, poor access to credit, low level of income, inadequate technical knowhow, high cost of input, low level of education and long distance to sources of innovation were the economic factors hindering innovation application, the political factors include untimely delivery of input, low level of education and long distance to sources of innovation, that of cultural factor include pest and disease attack, insufficient rainfall, problem of land tenure system, problems of banditry attack and farmers herders clash while wrong view of farmers in capable of taking rational decision and low level of motivation were the attitudinal factors hindering innovation application across the study areas.

5.2 Recommendations

From the findings of the study, the following recommendations were drawn:

i. The level of education across the study areas were found to be generally low, it was therefore recommended that state ministry of education and other relevant stakeholders should prioritize adult education across the study areas to broaden their understanding and knowledge of new innovation

ii. The cost of acquiring the innovation was found to be one of the factors hindering the adoption of the technology. Therefore, it was recommended that project beneficiaries should buy the innovation in bulk through their various farmers' groups. Also, the technology should be subsidized by the state government and other relevant stakeholders and ensure it gets to the users at the right time to facilitate its adoption and usage.

iii. Policies should be formulated to support farmers' demography, farm-based characteristics, and institutional factors in order to improve their welfare and promote rural vitalization which will enhance their adoption capabilities

iv. Liming was found to be limiting across the study areas, therefore, it was recommended that project coordinators should try to make necessary contact to ensure that liming is made is available across the study areas.

v. OCP Africa should be encouraged by the project coordinators to establish one of their One Stop Shop across the study areas to enhance the utilization of this technological package

Contribution to Knowledge

1. The study identifies the use of different types of agricultural lime, farm yard manure, and NPK fertilizers as innovations for improving problematic soils in maize and soybean cultivation. These findings can help farmers and agricultural researchers better understand the effectiveness of these methods for improving soil conditions and increasing crop yields.
2. The study on effects of problematic soil on output of project beneficiaries revealed information that can be useful for farmers, agricultural researchers, and policy makers to understand the factors that are most important for improving crop yields and can be used to develop strategies to help farmers increase their crop yields. Additionally, the study could also help researchers to identify ways to reduce the complexity and cost of farming, as well as to develop interventions that can help older or less educated farmers to improve their soybean and maize output.

Suggestion for further studies

1. Investigating the relationship between education and innovation adoption, and identifying opportunities for increasing smallholder farmers' access to education and improving their ability to adopt and implement innovations.
2. Examining the impact of distance to sources of innovation on smallholder farmers' ability to adopt and implement innovations.
3. Investigating the role of government in addressing the economic factors that hinder innovation adoption in rural area

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APENDIX 1

DEPARTMENT OF AGRICULTURAL EXTENSION AND RURAL DEVELOPMENT,
SCHOOL OF AGRICULTURE AND AGRICULTURAL TECHNOLOGY,
FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA,
NIGER STATE, NIGERIA

RESEARCH QUESTIONNAIRE

Dear respondent,

I am a Postgraduate student of the above stated Department and University. I am conducting a research to determine **"Effects of Innovation Application on Management of Problematic Soil in Niger State, Nigeria"**. This questionnaire aims at gathering relevant information that would assist the researcher to effectively carry out the study. All the information supplied here shall be solely for research purposes and will be treated as confidential. You are therefore required to fill in the answers to the following questions and mark or tick as appropriate.

Yours Faithfully,

ABUBAKAR, Abdullahi
(Mtech/SAAT/2019/9341)

SECTION A: SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENT

1. Name of village/town -------------------
2. Marital status (a) Married ( ) (b) Single ( ) (c) Divorced ( ) (d) Widowed
3. Gender (a) Male ( ) (b) Female ( )
4. Age of the respondent -- years
5. Family composition of respondent household (a) Male adult------ (b) Female Adult------ (c) Male children----- (d) Female children-----
6. How many wives do you have? -----------------
7. What is your highest level of education (a) No formal Education ( ) (b) Primary Education ( ) (c) Secondary Education ( ) (d) Tertiary Education ( ) (e) Adult Education ( ) (f) Quranic education ()
8. Numbers of years in farming business-----------
9. Which of the following secondary occupation do you undertake? (a) Livestock ( ) (b) Fishing (c) Rice farming (d) Petty trading (e) Processing farm produce ( ) (f) Civil service ( ) (g) Handicraft/Artisan ( ) (h) Transport bus ( ) (i) Others-------------------------------------
10. Membership of cooperative society (a) Yes ( ) (b) no ( )
11. Area of land devoted for maize and soybean farming ----------------------------
12. What are the types of agro-chemical used for maize and soybean farming? ----------
13. what is the quantity of agro-chemicals used for maize and soybean?------------
14. What is the quantity of seeds used for maize and soybean planting? --------------------
15. What is the numbers of seeds planted per hole? -----------------
16. What is the plant spacing adopted for maize and soybean farming ---------------------
17. Do you have contact with extension agent? (a) Yems [ ] (b) No [ ]
18. If yes, indicate frequency of contact with the extension agent(s). (a) Weekly [ ] (b) Fortnightly [ ] (c) Monthly [ ] (d) Quarterly [ ] (e) Annually [ ]
19. Please tick appropriate the quantity of following used for the last cropping season

Inputs	Quantity in kilogram
Agric-lime	
NPK	
Farmyard manure	
SSP	
Urea	

20. Kindly fill in the table provided below on your output realized from maize and soybean

Crop Produce	**Tick**	**Quantity harvested (kg)**	**Quantity sold (kg)**	**Price (₦)**	**Amount (₦)**
Maize	( )				
Soybean	( )				

21. What are the sources of innovation available in the study area?

Section B: Sources of Innovation

Please tick appropriately

Source	Yes	No
Radio		
Television		
Friends		
Extension agents		

21. Please tick appropriate the innovation type innovation used in your maize and soybean farm.

Innovation	Yes	No
Maize		
Agricultural lime		
Application of agricultural lime 3WBP		
NPK fertilizer (Special blended by (OCP)		
Application of Urea 46% N		
Application farmyard manure		
Farmer practice (NPK only)		
Agric lime + NPK		
Agric. Lime +FYM+ NPK		
FYM+NPK		
Seed rate 290kg per ha		
Planting spacing 25 by 75cm		

Soybean		
Agric lime		
Agric 3WBP		
NPK fertilizer (Special blended by (OCP)		
FYM		
Farmers practice (SSP only)		
Agric. Lime + SSP only		
Agric. Lime + SSP only + FYM		
FYM+SSP		
Seed rate (40kg)		
Planting spacing 5cm by 75cm		

23. What are level of application of the following technologies on maize and soybean

Innovation	Aware	Interest	Evaluation	Trial	Adoption
Maize					
Agricultural lime					
Application of agricultural lime 3WBP					
NPK fertilizer (Special blended by (OCP)					
Application of Urea 46% N					
Application farmyard manure					
Farmer practice (NPK only)					
Agric lime + NPK					
Agric. Lime +FYM+ NPK					
FYM+NPK					
Seed rate 290kg per ha					
Planting spacing 25 by 75cm					

Soybean					
Agric lime					
Agric 3WBP					
NPK fertilizer (Special blended by (OCP)					
FYM					
Farmers practice (SSP only)					
Agric. Lime + SSP only					
Agric. Lime + SSP only + FYM					
FYM+SSP					
Seed rate (40kg)					
Planting spacing 5cm by 75cm					

24. Please tick appropriate the characteristics of the technology compared to your old practices

Characteristics	**Yes**	**No**
Is the technology Complex to understand		
Is the result of technology visible		
Can the technology be tried on a small scale		
Is the technology compactable with your culture		
Is the technology cost efficient		

25. What are the constraints of the innovation application?

Variables	**Factor 1** **(Economic**	**Factor 2** **(Policy**	**Factor 3** **(Cultural**	**Factor 4** **(Attitude**

	related factors)	related factor)	related factor)	related fctors)
Inadequate extension contact				
Poor access to credit				
Low level of income				
Inadequate technical know how				
Pest and disease attack				
Insufficient rainfall				
Low germination rate				
Wrong view of farmers in capable of taking rational decision				
Untimely delivery of input				
High cost of input				
Problem of land tenure system				
Inadequate storage facilities				
Problems of banditry attack				
Farmers herders clash				
Contradict the norms and values of the society				
Low level of education				
Low level of motivation				
Against the felt needs of the farmers				
Inappropriate technology				

Long distance to sources of innovation				