EFFECT OF CASSAVA BROWN STREAK DISEASE CONTROL MEASURES ON CASSAVA PRODUCTION IN RUHANGO AND BUGESERA DISTRICTS OF RWANDA

CONCILIE NYIRAHORANA

MASTER OF SCIENCE

(Agriculture and Applied Economics)

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Effect of Cassava Brown Streak Disease Control Measures on Cassava Production in Ruhango and Bugesera Districts of Rwanda

Concilie Nyirahorana

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DECLARATION

This thesis is my original work and has not been submitted for a degree in any other University

Signature……………………………………… Date……………………………..

Concilie Nyirahorana

This thesis has been submitted for examination with our approval as University supervisors.

Signature……………………………………… Date……………………………..

Prof. David Mwehia Mburu, PhD

JKUAT, Kenya

Signature……………………………………… Date……………………………..

Dr. Patrick Mulyungi, PhD

JKUAT, Kenya

DEDICATION

This research thesis is dedicated to my family

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LIST OF ACRONYMS

ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ATT	Average treatment on Treated effect
CBSD	Cassava Brown Streak Disease
CBSV	Cassava Brown Streak Virus
CMD	Cassava Mosaic Disease
CPM	Cassava Planting Materials
DRC	Democratic Republic of Congo
FAO	Food Agriculture Organization
KCP	Kinazi Cassava Plant
KM	Kernel Matching
MINAGRI	Ministry of Agriculture
NARO	National Agriculture Research Organisation
NARS	National Agriculture Research
NGO	Non-Governmental Organisation
NNM	Neighboring Nearest Matching
OR	Odd Ratio

PEU Perceived Ease of Use (PEU),

PSF Private Sector Federation

PSM Propensity Score Matching

PSTA Plan Strategique de la Transformation de l'Agriculture

PU Perceived Usefulness

RAB Rwanda Agriculture Board

RM Radius Matching

SSA Sub-Sahara Africa

UCBSV Uganda Cassava Brown Streak Virus

UK United Kingdom

UNDP United nation's development program

ABSTRACT

Cassava Brown Streak Disease (CBSD) continues to spread and its effect on productivity remains high and yield losses of 50- 100 % have been reported in Sub-Saharan Africa. However, there is little knowledge about the level of adoption of CBSD control measures and its influence on cassava productivity in Rwanda. Thus, this study investigated the influence of CBSD control measures on production of cassava in Bugesera and Ruhango Districts. The sampling unit was the farm household. A total of 152 households were randomly sampled in Bugesera and Ruhango districts where cassava demonstration plots are established. The sampling frame was the list of households in each village. A multi stage sampling technique was used. A structured questionnaire was used for individual interviews. Descriptive data analysis was complemented by logistic regression analysis and propensity score matching. SPSS and STATA softwares were used for the data analysis. The results revealed that 68% among the farmers who adopted control measures were aware of them oppositely to 45% who did not adopt the farmers were aware of Cassava Brown Streak Disease. The key factors that influenced adoption of CBSD control measures was farm size, farmer's experience, access to credit, period of plantation and access to demonstration plot since their level of significance were less that five percent (Pvalue<5%).The results of propensity score matching model showed that the average treatment on treated (ATT) across all three matching logarithms that is nearest neighbor ,kernel and radius matching, the mean difference in yield between adopters compared to their control counter parts was 8935.7,8930.1,8913.2 kgs/ha which was statistically significant at t-stat above 2 at 5% level of significance. In order to increase adoption of CBSD control measures policy makers and implementers in Rwanda should continuously support farmers to understand and apply CBSD control measures in agriculture production systems through sensitization and mobilization of farmers for enhanced cassava production.

Key words: *Cassava brown streak virus, Propensity score matching, Smallholder farmers, Bugesera and Ruhango District, Rwanda*

CHAPTER ONE

INTRODUCTION

1.1. Background to the study

Cassava (Manihot Esculenta Crantz) plays a significant role in people's lives. It is now grown throughout Sub-Saharan Africa and is considered second in importance to maize as a human staple food, accounting for more than 200 calories per day per person (Scott, 1992:297). Estimations show that about 160 million people or 40 per cent of the population of Sub-Saharan Africa consume cassava as a staple food and its demand increases with high population growth rates. Except for South America and Thailand, cassava is increasingly being grown for industrial use.

In Africa it is largely grown for human consumption (Montagnac, Davis, & Tanumihardjo, 2009). Hence, cassava remains one of the dominant starchy staples in the diet of people in Sub-Saharan Africa and is grown in many countries though its cultivation is concentrated in humid tropics. It is now becoming a more important crop for both food and for cash income to the rural areas (Patil, Legg, Kanju, & Fauquet, 2015). Cassava showed relevance in nutrition, income generation, and livestock feeding and raw material in plant processing. The main challenge of cassava production is lack of improved resistant varieties.

Despite the economic and social importance of cassava in both Africa and Rwanda, its productivity is severely constrained to both biotic and abiotic factors. Pests and diseases, lack of disease tolerant varieties and inappropriate agricultural practices among others, are some of the major characteristics that influence the low production and profitability of cassava in East Africa. This has been results from factors like socio-economic that affect the use of agricultural technology packages, the following are some of these factors among many others: age, education level, size of household, size of farm. Apart from environmental factors, pests and diseases are considered to be the main constraints to cassava production. Cassava Mosaic Disease (CMD) and Cassava Brown Streak Disease (CBSD) remains a major cause of losses in cassava production.

As one of the main initiatives to fight against these losses; Rwanda Agriculture Board in 2015 released CMD resistant varieties although (Masiga et al., 2014) found that CBSD resistant varieties still remain fewer. Varieties which are resistant to CMD are susceptible to CBSD. This disease is becoming a bigger challenge in SSA. Now the focus is on worldwide CBSD status as well as its socio-economic and institutional consequences.

Cassava Brown Streak Disease was first reported in 1936 in Tanzania and the disease was observed in several countries of Eastern and Southern Africa in the 1950s (Legg et al., 2015). Following 40 years of tiresome scientific activity and economic interest in brown streak, CBSD was re-discovered in Tanzania, Kenya, and Malawi in the 1990s and was first witnessed in Rwanda in 2009.The rapid spread of CBSD is being linked to the super- abundance of the whiteflies (*Bemisia tabacci*) and use of infected planting materials.

It is estimated that African farmers collectively lose revenue of up to $100 million annually due to the devastating disease (Bigirimana, Barumbanze, Ndayihanzamaso, Shirima, & Legg, 2011). In the late 1990s, the incidence of cassava Brown streak disease reached pandemic proportions in many African countries (Legg et al., 2011). The direct consequences of CBSD is food insecurity due to a severe yellow- brown corky necrosis that makes infected areas inedible especially for moderately or heavily damaged roots. In simplest terms Brown streak results in farmers harvesting a crop that they can only partially cut. In Central America 2.51 million hectares are affected while in Asia/Pacific 3.89 million hectares have also been infected by the virus (Asche, Guttormsen, & Tveteras, 2008). In such places, cassava is vital not only as a food crop, but also as a source of income to people both at community and national levels.

In Africa, 9.6 million hectares of cassava are affected by the disease (Asche, Guttormsen, & Tveteras, 2008). Patil et al. (2015) reported that the high incidence of disease was found in Ruhango (91%) and Bugesera (>60%) of Rwanda while in 2009, the three Districts (Muhanga, Bugesera and Nyagatare) out of the 17 surveyed revealed the existence of CBSD and it rapidly spread in the country and reached epidemic level threatening the livelihood of the small scale farmers who depend on cassava.

The disease has affected all cassava growing regions and threatens the ability of most vulnerable farmers to attain household food security (Birhanu, 2015). Consequently, CBSD has been reported to cause up to 70% yield loss. During harvesting, farmers will cut out the necrotic lesions of affected tubers or they will discard tubers that are severely affected. This has brought about 10 to 30% of rotten roots undergoing moderate infection, decreasing the market value of tubers by 90%. For instance, in some villages where the disease pressure is high, prices of cassava have risen; causing serious trouble to the livelihoods that depends on the cassava. Eventually, the overall effect of CBSD is the reduction of root yield in terms of quantity and quality (Masiga et al., 2014).

Due to the incidence of CBSD, technical strategies to reduce the rate of this disease have to be taken into account. Previous studies have identified a number of control measures which have been developed to reduce CBSD incidence and severity, and maintain cassava productivity. Thus, some practical control measures are acceptable to alleviate or control cassava diseases especially CMD and CBSD. There are for example, the uses of resistant/tolerant varieties, disease-free ('clean') planting material and the roguing or removal of infected plant. Still the use of resistant varieties alone is likely to be insufficient to prevent the spread of multiple cassava viral. practically, a careful selection of clean planting material must be initiated by choosing the appropriate area and field for the collection of propagating material (McQuaid, Sseruwagi, Pariyo, & Bosch, 2016).

Definitely, potential benefits of adopting this approach include better plant establishment and rapid growth, which will greatly enhance productivity. Chemical controls such as the application of insecticides are economically unpopular due to the unacceptable increase in costs for subsistence farming (Bigirimana, Barumbanze, Ndayihanzamaso, Shirima, & Legg, 2011). On the other hand, the most economically viable method for cassava brown streak disease management is rather the use of resistant variety (Munga, 2008). In this regard, good management and implementation of control strategies against the spread of CBSD can bring benefits like increased food security and improved incomes to farmers.

Not only farmers do benefit, but also organizations and institutions that work to ensure disease control will economically benefit from better management of the disease. Therefore, this study investigated the influence of adoption CBSD control measures on cassava production in two districts of Rwanda (Ruhango and Bugesera).

1.2. Statement of the problem

Given the existence of negative effect of CBSD on cassava yield, the national cassava yield in Rwanda significantly decreased from 16,325 kg/ha in 2013 to 1,234 kg/ha in 2014 (Bizoza & Byishimo, 2013). In 2015, the Ministry of Agriculture and Animal Resources (MINAGRI) in collaboration with FAO Rwanda have set up a strategy to import a resistant variety named *NASE14* from Uganda. This was meant for the establishment of mother gardens that would serve as the source of clean planting materials for farmers (Birhanu, 2015).

About 40,000,000 cassava cuttings that are disease-free were brought to cover about 4,000 ha. Further still, disease free planting materials are still insufficient at 13.83% rate (RAB, 2015). Consequently, farmers still exchange cassava cuttings and grow them freely without disease control. Thus, at farmers level, CBSD continues to spread and its effect on productivity remains at high level (50- 100 % of losses). Moreover, some farmers that have received clean planting materials did not isolate their cassava fields. So, they may be infected with virus from neighboring diseased fields (Birhanu, 2015).

Indeed, this shows how control measures in place are not adopted by farmers and also demonstrate that the number of CBSD control measures and their choice are still limited due to different socio-economic factors. All these may result in CBSD persistence and its incidence may continue to spread all over. In the neighboring countries to Rwanda where the CBSD originated, there are few studies that investigate the adoption of CBSD control measures at farmers' level. Among others, we can mention the study of Katinila and Kwikwega (2001) conducted in Tanzania, which highlights that the acceptance of disease control strategies is low, as only 58% practice one or more of these strategies leaving the remaining, and still 42% do not control the disease.

In addition to this, the study of Mago and Toro (2013) also conducted in Tanzania, demonstrate that many farmers (93%) were aware of the control measures but only 31% were practicing them. From this study, the authors show that roguing was the most widely practiced method (46%) whereas selection of clean planting materials was practiced by 5% of farmers and use of tolerant cultivars was owned by 3% of the farmers. Unfortunately, such studies have never been carried out in Rwanda. Currently there is very little knowledge about socio –economic impact of the CBSD in Rwanda and even there is little documentation about the relationship between socio-economic and institutional factors on adoption of CBSD control measures. Thus, to fill these gaps, the study attempts to assess the influence of CBSD control measures on cassava production by using quantitative methods.

1.3. Objectives of the study

The overall objective of this study was to investigate the influence of CBSD control measures on cassava production in Bugesera and Ruhango districts of Rwanda.

1.3.1. Specific objectives

1. To establish the current status of farmers' awareness on cassava brown streak diseases and it's control measures in Bugesera and Ruhango districts of Rwanda.

2. To determine the factors influencing the adoption of CBSD control measures in Bugesera and Ruhango districts of Rwanda.

3. To assess effect of adoption CBSD control measures on cassava production in Bugesera and Ruhango districts of Rwanda.

1.3.2. Research hypotheses

H01. There is no significant correlation between farmers' awareness about cassava brown streak diseases and its control measures.

H02. There are no significant correlation between factors influencing the adoption of CBSD control measures and adoption status among Cassava farmers.

H03. There is no significant difference in cassava production level between adopters and non-adopters of CBSD control measures.

1.4. Justification of the study

This study is important since it would benefits farmers to know the effectiveness of adopting CBSD control measures on cassava production. On the side of society, the information provided will help policy makers to get feedback information on adopted interventions to fight against CBSD. In the same perspective, community in would benefits while learning from the side effects results through adopting control measures. Finally, there would be an increase of national gross domestic product (GDP).

1.5. Scope of the study

The study was designed to determine the factors influencing the adoption of CBSD control measures in Rwanda. This study target cassava farmers of the two districts of Rwanda Ruhango district in southern province and Bugesera District in eastern province. These are representative areas where different pressure zones for the CBSD epidemics have also been reported. The study will be covered in the period 2015-2016.

1.6. Organization of the study

This research thesis is arranged in five chapters. Chapter one describes the background to the study, statement of the problem and objectives of the study. It also presents research hypothesis, scope and significance of the study. Chapter two contains a review of the existing literatures. Chapter three presents a discussion of the methodology that was used in the study; it includes the study design, justification of the area of study, sample size and selection, data collection methods and tools, data processing. Chapters four presents the summary of key findings, and finally Chapter five tackles the conclusions and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1. Introduction

This chapter contains a review of the existing literatures in relation to CBSD and its Control Measures on cassava production. It is made up of three main sections after the introduction: section 2.2 Provides theoretical framework for adoption, section 2.3 contains the empirical literature while the last section reveals the conceptual framework for the undertaken study.

2.2. Theoretical framework for adoption

This study took into consideration the following theories as the pillar; Theory of Reasoned Action which put emphasis on the value of knowledge resulted from the information available in adoption of any decision, and Adoption-Diffusion Theory which has been widely used to identify factors that influence an individual's decision to adopt or reject an innovation. As far as theoretical framework provides a starting point to structure ideas during research and writing. It is this regard each of the following theories starting from the theory of reasoned action permitted the researcher to understand to recognize that human beings usually behave in a sensible manner, while technology acceptance model permitted the researcher to understand how people make a choice of new technology in the daily life.

2.2.1. Theory of Reasoned Action

Theory of Reason Action is essentially a series of linked concepts and hypotheses postulated and developed by social psychologists to understand and to predict human behavior (Lopes, Antunes, & Martins, 2012). The theory is one of the "expectancy-value" models of human behavior , its terminology is not very different from that of the well-established subjective expected utility model used by economists (Quiggin, 2012).

As the name of the theory implies, it is based on the assumption that human beings usually behave in a sensible manner. They take account of available information and implicitly or explicitly consider the implications of their actions. The theory postulates that a person's intention to perform (or not perform) a behavior is the immediate determinant of that action; barring unforeseen events, people are expected to act in accordance with their intentions".

This theory is directly linked to the knowledge which has the focal point on information. "Human beings are usually quite rational and make systematic use of information available to them.

2.2.2. Technology Acceptance Model

The acceptance of CBSD control measures has been done through the acceptance of technological influence in Cassava farming (looking for resistant varieties by applying the process of making hybrids). Knijnenburg, Willemsen, Gantner, Soncu, and Newell (2012), introduced Technology Acceptance model derived from extension of their study puts forth two beliefs: Perceived Usefulness (PU) and Perceived Ease of Use (PEU), which determine attitude towards the adoption of new technology. PU is defined as the degree to which a person believes that using a particular system would enhance his or her job performance. On the other hand, PEU is defined as the degree to which a person believes that using a particular system would be free of effort.

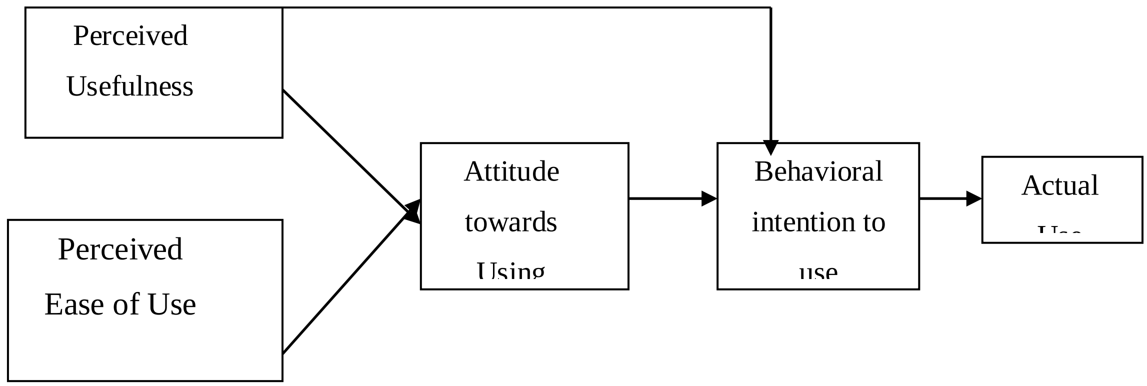

Figure 2.1: TAM Model

Source: Perceived usefulness, perceived ease of use and user acceptance of information technology. MIS Quarterly**,** Davis, (1989: 319-340)

2.2.3. Adoption-Diffusion Theory

Adoption and diffusion of innovations theory has been widely used to identify factors that influence an individual's decision to adopt or reject an innovation (Rogers Everett, 1995). An innovation, according to Rogers, is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption." Rogers identifies five characteristics of an innovation that affect an individual's adoption decision.

These are (1) relative advantage, which is the degree to which an innovation is perceived as being better than the idea it supersedes; (2) compatibility, or the degree to which an innovation is perceived as consistent with the existing values and beliefs, past experiences, and the needs of potential adopters; (3) complexity, which is the degree to which an innovation is perceived as relatively difficult to understand and use; (4) trialability, or the degree to which an innovation may be used experimentally on a limited basis; and (5) observability, which is the degree to which the results of an innovation are visible to others (Clancy, Breen, Moran, Thorne, & Wallace, 2011).

Classical adoption-diffusion theory has been criticized for pro-innovation bias, individual-blame bias, and issues of equality. In the beginning, adoption-diffusion researchers identified characteristics of adopters, such as socio-economic status, personality, communication behavior, and risk tolerance that determine the likelihood of adoption. More recently, the focus of adoption-diffusion research has been on attributes of innovations and rates of adoption.

Such attributes include relative advantage (economic factors, status aspects, effects of incentives); compatibility (with needs, values and beliefs, previously introduced ideas, and technology clusters); complexity; trial ability; observability; diffusion affect; and, over adoption (Clancy, Breen, Moran, Thorne, & Wallace, 2011).The relative advantage and observability of an innovation describes the immediate and long term economic benefits (i.e. profits) from using it, whereas compatibility, complexity, and trialability indicate the ease with which a potential adopter can learn about and use an innovation (Clancy et al., 2011).

2.2.4. Adoption model

There are five steps in the adoption process as conceptualized as follows in different model forms: Knowledge, persuasion, decision, implementation, and confirmation (Garnevska, Gray, & Baete, 2013).

Table 2.1: Componential models of adoption process

Adoption process models	Meaning
Knowledge model	Individual become aware of new existing information
Persuasion model	Individual may change his or her attitude towards new technology or knowledge
Decision model	Individual engages in the activities that will consequently lead to the adoption
Implementation	Individual seeks to apply the new knowledge acquired

Confirmation	Individual seeks more information reinforcing the decision he or she made.

Source: Rogers (2003) recited by Baete (2013)

2.3. Empirical literature

2.3.1. Farmers' awareness on cassava brown streak diseases and its control measures

Cassava Brown Streak Disease is a major biotic production constraint of cassava (Hillocks et al., 2001). It is in this regard, different researches/studies have been done in order with the aim of evaluating cassava farmers 'awareness on CBSD. Kwikwega (2005) conducted a study about Evaluation of farmer knowledge on Cassava Brown Streak Disease (CBSD) in the Roman Catholic Church Diocese of Tunduru-Masasi in south eastern Tanzania.

In his study, A total sample o f 80 households (8 0 farmers) were interviewed in 4 villages which have been participating in CBSD project (On-Farm Research trials) through Farmer Research Group (FRGs), other 4 villages were those villages which were not involved in on-farm agricultural research.

It was found that, the majority (98%) o f respondents was aware of CBSD and was able to recognize the disease's symptoms. Those are root necrosis, roots rot, yellowing of leaves, stem die back and stem lesion. In general about 80 % of respondents reported to use some control strategies. It was found that, about 44% use d tolerant varieties, 54 % were uprooting diseased plants, 70% were using disease free planting materials an d 36 % were burning diseased plants.

Similarly, Chipeta et al. (2016) conducted a study about Farmers' knowledge of cassava brown streak disease and its management in Malawi.The objective of this study was to assess farmers' knowledge of CBSD diagnosis and management. The study was conducted in three districts of Malawi by administering semi-structured interviews in combination with disease incidence and severity surveys. Farmers' knowledge of disease diagnosis and management was associated with CBSD incidence and severity. High levels of knowledge about CBSD were observed in areas with high disease incidence. Only 10.1% of the farmers were capable of identifying the foliar symptoms of the disease. On average, 75.0% and 71.7% of the farms had leaf and storage root incidences, respectively.

At harvest, 88.3% of the farmers' fields exhibited storage root necrosis. CBSD leaf and storage root severities differed significantly ($P < 0.001$) from one district to the other and between varieties. Most farmers were found to lack a source of clean planting material. High needs for extension services on cassava cultivation methods and pest management were identified, but few farmers received such services. The lack of new improved varieties was reported as the most important constraint of cassava production, beyond CBSD. Education of farmers on the efficient management of this viral disease through selection of clean planting material should be provided. Additionally, the development of early root bulking cultivars as a long-term solution in avoiding CBSD impact should be supported.

2.3.2. Factors influencing technology adoption

Salum (2016) carried out a study regarding Factors influencing adoption of improved cassava varieties in increasing farm yield: a case of Magharibi District, Zanzibar. A cross sectional survey method was employed for the study.

A total of 120 respondents were involved. In this study descriptive statistics tools and binary regression were employed to analyze the data using the Statistical Package for Social Science (SPSS). The study findings indicated that smallholder farmers had negative attitude towards ICV. The major challenges observed were unavailability of inputs, scarcity of land and lack of training. Socio-economic factors such as age, household size, income, farm size and unreliable extension services significantly influenced the adoption of ICV. The study, therefore, concludes that poor adoption towards ICV had reduced cassava production.

Clancyet al. (2011) examine the socio-economic factors affecting willingness to adopt bioenergy crops .The study identified the socio-economic characteristics of the farmers and determined the level of adoption of cassava varieties. Also the study determined the specific benefits derived from the varieties in use and finally investigated the constraints encountered by farmers in production of the improved varieties. By using the Pearson Product Moment Correlation analysis, the study revealed that a significant and positive relationship exist between age, level of education and the adoption impact.

Also a significant difference was found in the material life style and production level of the farmers before and after the adoption of improved varieties in cassava production. Poor access to credit was ranked as the most serious constraint to cassava production .Ojo and Ogunyemi (2014), conducted a study about the Analysis of factors influencing the adoption of improved cassava production technology in Ekiti state, Nigeria. The result of the probit model showed that age, marital status, household size, membership of cooperative society, ownership status, major occupation, contact with extension agent and feedback from the extension personnel were the significant determinants of adoption of improved cassava production technology in the study area. Their study tended by recommending that effort must be made to motivate farmers through extension agents to embrace improved cassava varieties which will increase cassava production and income to the farmer.

2.3.3. Effect CBSD control measures on Cassava production

Gondwe,(2011) assessed the economic losses experienced by small-scale famers in Malawi due to cassava brown streak virus disease. He found Cassava brown streak disease decreases root weight and patches of root necrosis , which makes roots unmarketable ,although the unaffected parts might still have been suitable for consumption .The disease therefore has two effects ,one on total root yield and then on root quality, which affects marketability. The adoption of CBSD control measures has a positive impact on cassava production. The use of disease free planting materials and tolerant varieties lead to the increase of cassava yield

2.4. Critique of relevant literature and Research gaps

The literature shows that there is a significant level of awareness of CBSD among cassava farmers. The literatures also showed that among cassava farmers, they are able to detect its symptoms and they have ability to apply at least one of the existing controls. Except the availability of CBSD control measures. Among the consulted literatures, there is no specified reason of high incidence of CBSD despite the effort being in place to control it. Therefore, this study intended to investigate the adoption of CBSD control measures at the level of small cassava farmers.

2.5. Conceptual frame work

In the model shown in Figure 2.2; the three factors have been identified to be playing a big role in the adoption CBSD control measures. Those factors are the following: famers' demographic characteristics, knowledge based factors and economic based factors affect the adoption CBSD control measures. If they have positive effect, there would be an increase in output or cassava production, increase in farmer income and then improvement in the quality of life. The intermediate variables are constituted by the adoption of different CBSD control measure while the dependent variable is the cassava production.

The three factors are there to influence the adoption of CBSD control measures. Among many others, those measures are made up of the following behaviors confirming the adoption; resistant variety use, free-disease planting material (PM) use, quarantine or field isolation, early planting and early harvesting, field hygiene and rotation.

Farmers 'demographic factors include sex, age, marital status, size of households, household's headship and relation to the head of household. Knowledge based factors include education level, experience in cassava farming and access to training while economic based factors include land size, land ownership, livestock ownership, access to inputs, main source of income and Labor availability.

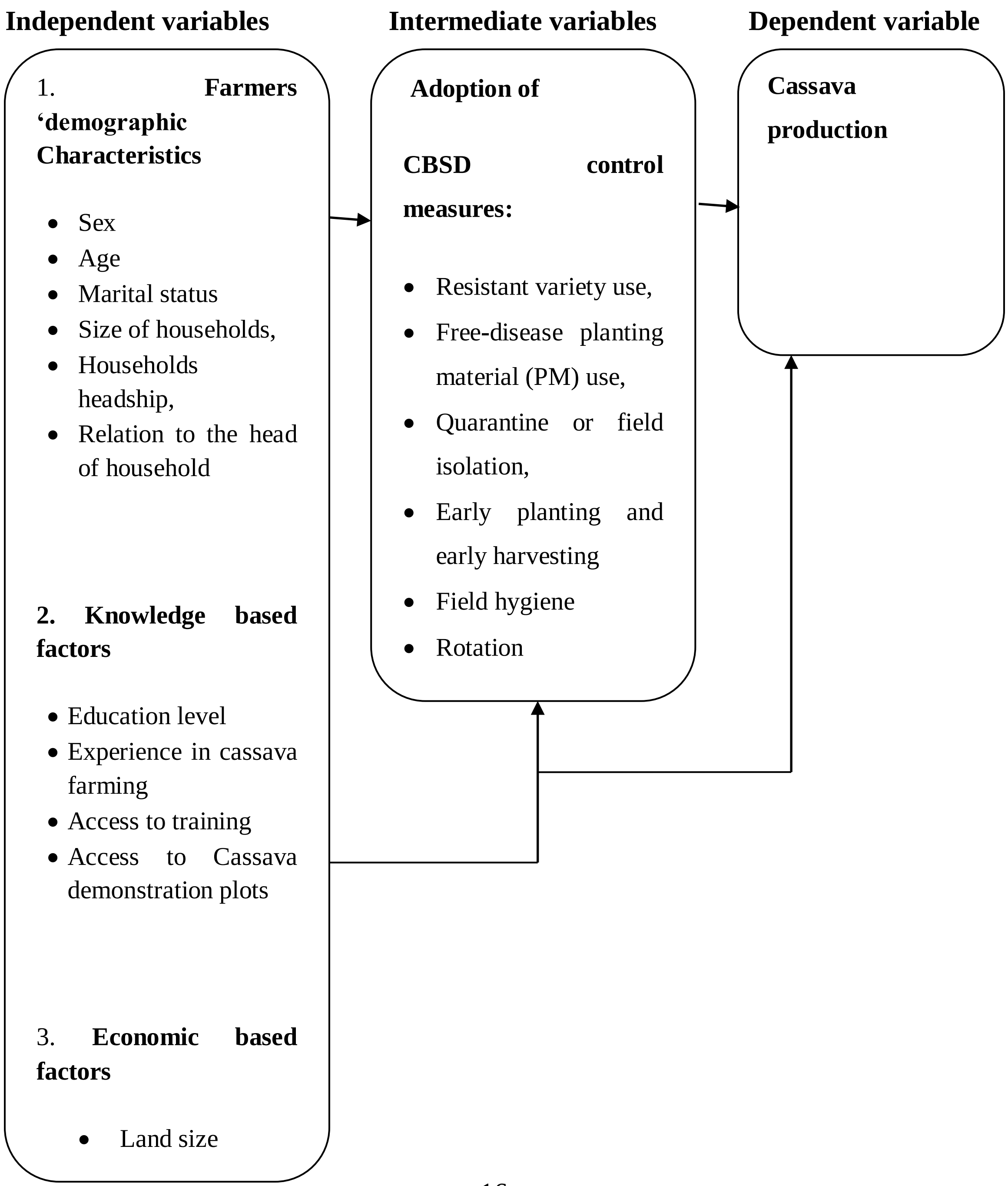

Figure 2. 2: Conceptual Framework

CHAPTER THREE

METHODOLOGY

3.1. Introduction

This chapter presents research design, population, study area, target population, sample and sampling technique, research instruments, data collection procedure, pilot test-depends on the instrument being used as well as data Processing and analysis.

3.2. Research design

This study adopted cross section survey and descriptive research design. It is cross sectional since the researcher did not intend to do a follow up of a cohort of cassava farmers. This research is descriptive due to the fact that it had intention of describing the awareness of cassava farmers with regard to CBSD and its control measures.

3.3. Study area

Two districts Ruhango and Bugesera were chosen based on the fact that they are the ones where cassava is widely grown and there is high incidence of Cassava brown streak disease. The study has to consider the boundaries of Ruhango District at the Southern Province and Bugesera at the Eastern Province. Ruhango district has Nine (9) Sectors. From these sectors the whole district has fifty -nine (59) cells and five hundred thirty-three 533 villages. It covers an area of 626.8 square kilometers. Its relief, alternate seasons, vegetation give a smooth climate for its population. On the other hand, Bugesera District, it is one of seven Districts of the Eastern Province in Rwanda. It covers a total surface area of 1337 Km^2. The district is composed of 15 Sectors, 72 Cells and 581 Villages with a total Population of 363,339 people, where 177,404 are males and 185,935 are females (Urimubenshi et al., 2015).

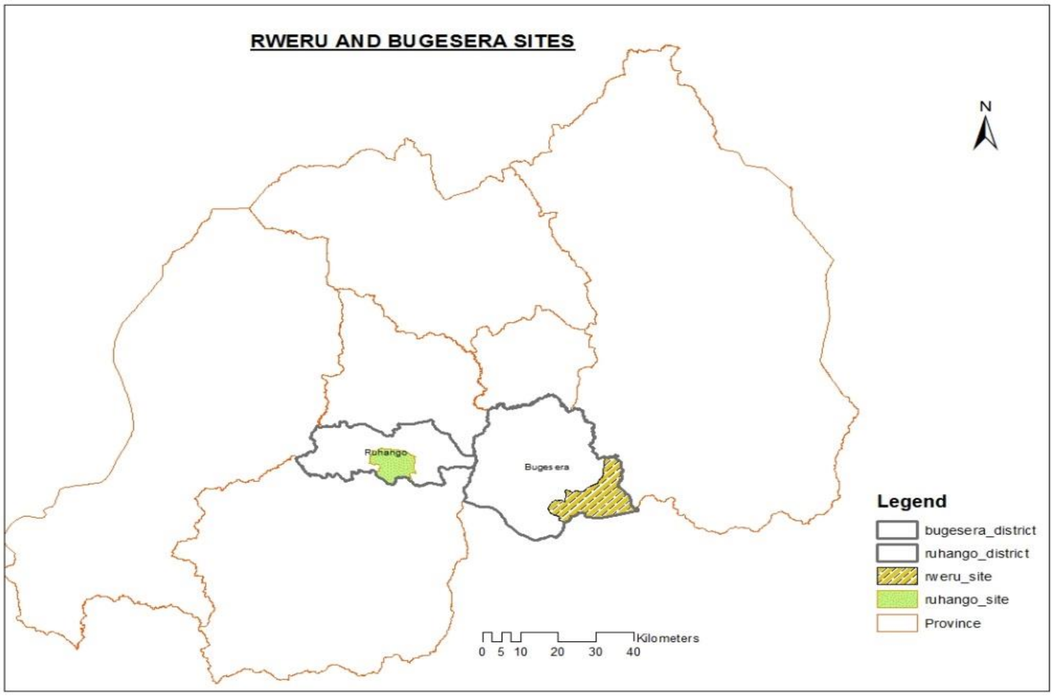

Figure 3.1: Map of Bugesera and Ruhango

3.4. Target Population

The available list of cassava farmers in the two villages of the two districts has 224 farmers. Through the use of simplified formula provided by Slovin; only 152 cassava farmers were selected research focuses on influence of cassava brown streak disease control measures on cassava production in Ruhango and Bugesera Districts of Rwanda**.** Target population comprised of adopters and non-adopters.

Table 3.1: Sampling frame

Sectors	Villages	Total number of cassava farmers	Number of sample selected		Total sample
			Adopters	Non-adopters	
Bugesera	Nemba	65	35	30	65
Ruhango	Musamu	87	52	35	87
Total		152	87	65	152

Source: **Authors 'Compilation,** 2018

3.5. Sampling techniques

A simple purposive sampling technique was used in the sampling of the districts due to availability of many cassava farmers. Two districts (Ruhango and Bugesera) with high incidence of cassava brown streak disease were selected. A two-stage cluster sampling was used to sample the cells in each sampled sector. The first sampling stage involves the selection of a predetermined number of clusters (cells) per sector. A simple random sampling technique was used in the sampling of the farmers. Farmers will be having equal chances of selection. The list of total household heads in the selected sectors will be obtained from the sector offices.

3.6. Sample size determination

Using the Yamane (1967:886) formula, the sample was obtained as follows:

$$n = \frac{N}{1+Ne^2} \qquad (1)$$

Where n =sample size, N=Population size e=margin of error.

In our case population size was 244 with the intention of gathering data at least 5% margin of error, sample size would be 152.

$$n = \frac{244}{1 + 244 * 0.05^2}$$

$$n = 152$$

3.7. Research Instruments

Quantitative methods were used by the researcher using survey questionnaire. The questionnaire contained three sections first section contain contents related to level of awareness of CSBD. The second section includes factors influencing adoption and third section contains information related effect of CSBD measures on production.

3.8. Data collection techniques

The use of administered questionnaire, the researcher used face to face interviews with sample of the selected cassava farmers. Before starting the process of interviewing, the researcher started by introducing herself and explaining the intention of the research to farmers (academic research).

3.9. Data Description

Age:

Age is a continuous variable measured in years, old age can be an indicator of better experience, greater resources, and enhanced authority that may influence adoption of new varieties positively Sarkis et al., 2010).

Education:

This is a continuous variable measured in number of years spent in school, findings in technology adoption studies, indicate that education improves the analytical ability of the decision makers, hence positively influencing participation (Sarkis et al., 2010).It is hypothesized that education has a positive influence on adoption of CBSD control measures.

Gender:

This is a dummy may have a significant influence on some technologies and not on others. For instance, a study on adoption of technology found that, gender had a significant and positive influence on adoption of improved cassava production in Nigeria. It is perceived that male- headed households are more likely to participate in adoption of new agriculture technologies than the female- headed households (Sarkis et al., 2010).

Household size:

This was measured on number of house members the family owns. The effect of on technology adoption could be positive or negative. Adoption of technology depends on whether the household has a higher ratio of members who contribute to farm work (implying more labor, hence more time for participation) or the household has a higher consumer-worker ratio (raising the need for more labor for production, hence reducing time available for participation (Sarkis et al., 2010).

Farm size:

Farm size was simple measured in land owned (Mignouna, Manyong, Rusike, Mutabazi, & Senkondo, 2011). It was hypothesized to influence adoption positivelyUaiene, Arndt, and Masters (2009), suggests that social network effects are important for individual decisions, and that, in the particular context of agricultural innovations, farmers share information and learn from each other. It was dummy variable hypothesized to influence adoption positively.

Institutional factors:

Include farmers' access to extension services, credit, market, farmers' organization and mass media (Kaguongo, Ortmann, Wale, Darroch, & Low, 2012).Extension services are reflected by the number of extension contacts either through farm visits made or training sessions received prior to and during production season influence crop productivity (Anyiro & Oriaku, 2011).

Access to credit:

This has been stated to motivate technology adoption. It also stimulates the adoption of risky technologies through relaxation of the liquidity constraint as well as through the boosting of household's-risk bearing ability. This is because with an option of borrowing, a household can do away with risk reducing but inefficient income diversification strategies and concentrate on more risky but efficient investments (Anyiro & Oriaku, 2011)**.**

Farmers' organization:

Helps them to participate in group activities, as they may tend to share ideas on profitable enterprises and adopt them as well as engage in market activities of inputs acquisition or selling of produce and thereby improve their profits. Consequently, organized farmer groups are promoted as useful avenues for increasing farmer productivity and for the implementation of food security and other development projects (Masunga, 2014).

Use of resistant or tolerant varieties:

This was measured on whether a famer uses the variety or not, (Mc Quaid et al, 2016)**.**This could influence adoption positively.

Use of disease free planting materials:

This was measured on whether a famer knows about the planting material or not (Birhanu, 2015). This could influence adoption positively.

Early planting and early harvesting:

This was measured on whether a farmer knows about the harvesting periods or not (Tennant, 2015). This could influence adoption positively

Field hygiene:

This was measured on whether a farmer knows about the field hygiene or not (Legg et al., 2011).This was hypothesized to influence adoption positively.

3.10. Validity and reliability

The questionnaire to be used in this study was pre-tested among small holder farmers in the same study. Piloting on 10% equivalent to 15 cassava farmers' members was conducted to test for validity and reliability of the data prior to the actual study in order to ensure validity,

3.11. Data analysis

After data collection, the next step was data entry which was done in Ms Excel and then after they were exported into SPSS version 20 and STATA version 13, for analysis. The data analysis incorporated both descriptive and econometric analysis.

Objective one:

Descriptive analysis was used to describe the percentages on current status of awareness on adoption of CBSD.

Objective two:

Logit regression analysis was used to estimate factors that are independently associated with adoption of CSBD. This was for independent variables that have p -values of less than 0.05 in their relationship with the dependent variable in Bivariate analysis. Logit regression is the appropriate regression analysis to conduct when the dependent variable is dichotomous (binary)

Objective three:

Propensity score matching was used to estimate effect of CBSD on cassava production. Like other matching procedures, PSM estimates an average treatment effect from observational data. The key advantages of PSM were, at the time of its introduction, that by using a linear combination of covariates for a single score, it balances treatment and control groups on a large number of covariates without losing a large number of observations. If units in the treatment and control were balanced on a large number of covariates one at a time, large numbers of observations would be needed to overcome the "dimensionality problem" whereby the introduction of a new balancing covariate increases the minimum necessary number of observations in the sample geometrically.

3.12. Model Specifications

3.12.1. Logit model

In this study, a farmer was defined as an adopter if he or she was found to adopt at least one of the CBSD control measures for the current agricultural season of 2015-2016. Thus, a farmer could be classified as an adopter and still have grown some traditional varieties. The adoption variable was therefore defined as 1 if a farmer is an adopter of CBSD control measures and zero otherwise. This study adopted the logistic regression to assess the factors that determine the farmers' decision to adopt improved cassava varieties.

The logistic regression model or the logit model as it is often referred to, is a special case of a generalized linear model and analyzes models where the outcome is a nominal variable. Analysis for the logistic regression model assumes the outcome variable is a categorical variable. It is common practice to assume that the outcome variable, denoted as Y, is a dichotomous variable having either a success or failure as the outcome. Let Y_i represent response variable, x_i represent covariates that mainly factors affecting farmers to adopt CBSD control measures grouped into the Socio-economic and institutional factors (Farmer experience, Education, Ages ,Gender ,Land size, Extension services ,Training, Technology transfer), we get :

$$P(y_{i=1}) = \pi_i = \frac{\exp(\beta_0 + \beta_i \chi i}{1+\exp^{-}(\beta_0 + \beta_i \chi_i)} \qquad (2)$$

The goal of logistic regression is to find the best fitting model to describe the relationship between the dichotomous characteristic of interest (dependent variable = response or outcome variable) and a set of independent (predictor or explanatory) variables. Logistic regression generates the coefficients (and its standard errors and significance levels) of a formula to predict a *logit transformation* of the probability of presence of the characteristic of interest: The probability that a farmer will adopt at least one CBSD control measure was postulated as a function of some socioeconomic and institutional factors. Following Pindyck and Rubinfeld (1998), the cumulative logistic probability model which is estimated is econometrically specified as:

$$Pi = F(Zi) = F(Y) = \sum_i \beta_i \chi_i = \frac{1}{1+e^{-Z_i}} \qquad (3)$$

Where Pi is the observed response for the ith observation of the response variable P. It is the probability that a farmer will adopt at least one CBSD control measure or not. Given Xi; Pi =1 for an adopter (i.e. farmers who adopt at least one CBSD control measure) and Pi = 0 for a non-adopter (i.e. farmers who do not adopt CBSD control measure); e denotes the base of natural logarithms, which is approximately equal to 2.718; Xi represents the explanatory/ independent variables, associated with the ith individual, which determine the probability of adoption (P);λi and γ are parameters to be estimated. The function, F may take the form of a normal, logistic or probability function. Zi is the Cumulative density function of Pi (probability that a farmer will adopt at least one CBSD control measure)

$$1 - pi = \frac{1}{1+e^{-Z_i}} \qquad (4)$$

Logit model could be written in terms of the odds and log of odds, which enables one to understand the interpretation of the coefficients. The odds ratio implies the ratio of the probability (Pi) that a farmer adopts, to the probability (1-Pi) that the farmer is a non-adopter.

$$Zi = \sum_{i=1}^{n} \beta_i \chi_i + \mu_i \qquad (4)$$

This procedure does not require assumptions of normality or homoskedasticity of errors in predictor variables (Alexopoulos, 2010). The analysis will be carried out using IBM statistics version 20.The analysis of this study shall be also concerned about the determination of factors influencing the decision to CBSD control measures. The analysis of this objective is also subjected to the use frequency table and percentage in terms of description.

3.12.2. Propensity Score Matching

The study targeted how the adopted CBSD control measures impact the cassava productivity. For this case, the study preferred to use the concept of Propensity Score Matching (PSM) in the analysis of how there is a difference in variation between the cassava productions among the people who adopt the use of those measures compared to those who do not. By definition Propensity Score Matching is a statistical method which deals with the analysis of observational data, it attempts to estimate the effect of a treatment, policy, or other intervention by accounting the covariates that predict receiving treatment (Domingue & Briggs, 2009).

Therefore, for a farmer i, (where i=1…I, and I denotes the population of farmers), the major task of impact evaluation studies is to separate the impact of CBSD control measures adopters (Di=1) on a certain outcome Yi(Di) from what would have happened anyway to the CBSD control measures non- adopters (Di=0), the so called counterfactual scenario. As shown in equation (1), this is done by differentiating the observed outcome for adopter i and the counterfactual potential outcome without adoption.

$$\prod_i = \gamma_i (1) - \gamma_i (0) \tag{5}$$

The impact $\prod_i$ cannot be observed, since in an ex post setting, a farmer is either a adopter or non-adopter, but not both. This situation shifts researchers' attention to the average population effect. This consists of estimating the average treatment effect on the treated (ATT) defined as follows:

$$\prod_{ATT} = E[\prod|D=1] = E[\gamma(1)\ |D=1] - E[\gamma(0)|D=1] \tag{6}$$

Since E[γ (0)|D=1] is unobservable, the technique consists of subtracting the unobserved effect of adoption (E[γ (0) |D=0]) had they not adopted CBSD control measures.

$$E[\gamma\ (1)|D=1]-E[\gamma\ (0)|D=0]=\prod_{ATT}+ E[\gamma(0)|D=1]-E[\gamma\ (0)|D=0] \tag{7}$$

The right-hand side of the equation represents the impact under investigation, while the two last terms on the right-hand side stand for the selection bias. Hence, the identification of the true impact $\prod_{ATT}$ can only be done if:

$$E[\gamma(0)|D=1]-E[\gamma\ (0)|D=0]=0 \tag{8}$$

To solve the selection bias, the identification problem assumes that farmers with identical characteristics (X) that are not adopters will observe similar outcomes without adopting CBSD control measures.

Such an assumption is commonly referred to as conditional independence assumption (CIA) (Rosenbaum & Rubin, 1983). Within the two groups, few adopters could be comparable to non-adopters, but selecting this subset is technically difficult because it is based on high-dimensional set of pre-treatment characteristics to be considered (Dehejia & Wahba, 2002). The PSM method allows this matching problem to be reduced to a single dimension: the propensity score Pr(X) = A (D_i=1|X). There are three assumptions underlie the PSM method (Rosenbaum & Rubin, 1983).

First, the balancing assumption in equation (5) ensures that farmers with similar propensity score will share similar unobservable characteristics, irrespective of their adoption outcome.

$$D \perp X \mid Pr(X) \qquad (9)$$

Second, assuming that adoption of CBSD control measure is not confounded, the conditional independence assumption (CIA) in equation (6) implies that after controlling farmers' characteristics (X), adoption is as good as random.

$$\gamma\ (1), \gamma\ (0) \perp D \mid X, \text{ for all } X \qquad (10)$$

Third, the common support assumption in equation (7) ensures that the probability of adopting CBSD control measures for each value of vector X is strictly within the unit interval so that there is sufficient overlap in the characteristics of adopters and non-adopters to find adequate matches.

$$0 < [Pr(X) = Pr\ (D=1 \mid X] < 1 \qquad (11)$$

With the CIA assumption, the resulting PSM estimator for ATT can be generalized as follows:

$$\prod_{ATT}^{PSM} = E_{\ Pr(X)}\ |_{D=1}\{E\ [\gamma(1)\ |D=1,\ Pr(X)]-E[\gamma(0)\ |D=0,\ Pr(X)]\} \qquad (12)$$

Pr(X) = Pr (D_i=1|X) for assessing the impact, the study adopted a logit model (Guo & Fraser, 2014). This model estimates the probability that a farmer i with particular characteristics X_i will fall under a group of adopters as follows:

$$Pr\ (D_i=1|X) = \Phi\ (X_i^{'}\beta), \qquad (13)$$

Where Φ denotes the cumulative distribution function of the standard normal distribution.

PSM technique is a two-step procedure: firstly, a probability (logit or probit) model for adoption of CBSD control measures were estimated to calculate the propensity score for each observation; secondly, each adopter is matched to a non-adopter with similar propensity score values, in order to estimate the ATT.

Despite the fact that PSM tries to compare the difference between the outcome variables of adopters and non-adopters with similar characteristics in terms of quantity (Adopters and non-adopters can have same average education but this does not necessarily mean education has the same return ‘coefficient’ on outcome variable for both groups of farmers as the quality of education may vary across the group). It cannot correct unobservable bias because it only controls for observed variables (to the extent that they are perfectly measured).We estimated PSM using *teffects psmatch* command in Stata 12 which implements nearest-neighbor matching (NNM) in the estimation process. The standard errors implemented in *teffects psmatch* were derived by (Abadie & Imbens, 2012).

Nearest Neighbor Matching which is an algorithm used most often. NNM method is the most straight forward matching method. It involves finding, for each individual in the treatment sample, the observation in the non-participant sample that has the closest propensity score, as measured by the absolute difference in scores (Abadie & Imbens, 2012). To match adopter and non-adopter based on the propensity scores, the study used different algorithms and compares their results. For a user farmer *I* and non-user farmer *j*, the nearest neighbor matching algorithm calculates the absolute difference between propensity scores as follows.

$$\left|\Pr_i - \Pr_j\right| = \min_{K\varepsilon L=0}\left\{\Pr_i - \Pr_k\right\} \tag{14}$$

The Kernel Based matching (KBM) method is also a non-parametric matching method that uses the weighted average of the outcome variable for all individuals in the group of non-users to construct the counterfactual outcome, giving more importance to those observations that provide a better match. This weighted average is then compared with the outcome for the group of participants. The difference between the two terms provides an estimate of the treatment effect for the treated case, placing higher weights to non-users with propensity scores closer to that of the user. Under this technique, for a user farmer *i*, the associated matching outcome is given by (Deschamps-Laporte, 2013).

3.13. Ethical considerations

All respondents were assured that the data collected would only be used for academic purposes and handled with confidentiality.

3.14. Limitations of the study

The research has been carried out in the rural area where some respondents did not know know how to read and write, therefore the researcher took initiative to use face to face interviews.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1. Introduction

This chapter covers the results of the study, it started by describing the profile of the respondents and the findings of the research with respect to the following specific objectives: to establish the current status of farmers' awareness on cassava brown streak diseases and it's control measures in Bugesera and Ruhango districts, to determine the factors influencing the adoption of CBSD control measures in Bugesera and Ruhango districts and to assess effect of adoption CBSD control measures on cassava production in Bugesera and Ruhango districts of Rwanda.

4.2. Profile of the respondents

This study categorized factors influencing adoption of CBSD control measures into three main categories based on farmers 'profile, those factors are the following : Faermers'demographic characteristics, knowledge based characteristics and economic based characteristics. Each category was assessed independently during the description of demographic associated variables. The results of the study indicated that in the category of the farmer's demographic characteristics specifically on age category between 50 to 60 was observed to many farmers 21.1% for the category adopters and 9.9% for non adopters, this age category is followed by 40 to 50.

In terms of comparing districts, Ruhango districts had many adopters 34.2% compared to 23% representing those who adopted CBSD control measures in Bugesera district. Concerning the prevalence among non adopters, the two districts seems to have the same prevalence since Ruhango district had 21.7% compared to 21.1% of the farmers who did not adopt any measure. The observation shows that there is a slight difference within the two districts. In the section of marital status, for both adopters and non adopters the majority were married while in the section of size of households the majority for both categories had between 4 and 8 persons in their respective households. This case is similar to the case of gender of households' heads where male heading households represent the majority.

With regard to knowledge based characteristics; the results of the study showed that for the section of education level, the majority for both categories attended primary education as the following consecutive prevalence indicates 31.3% among the adopters and 28.7% of non adopters. The assessment about the section of the cassava farming experience, the majority of the surveyed cassava farmers were observed in the category between 20 years and 40 years, the descriptive frequency showed that among adopters 28.3% while 19.7% among non adopters. On the side of taking a look at access to training the majority among the surveyed farmers for both categories did not got a chance of getting access to training. The study results also in the assessment of farmers' knowledge based factors showed that the majority among the adopters of CBSD control measures got access to cassava demonstration plot in their area, this is confirmed by 32.9% out of the sampled cassava farmers and this is greater prevalence compared to 8.6% among non adopters.

The assessment of the study results with regards to farmers 'economic based factors showed that in terms of source of income 26.3% among adopters and 10.5% among non adopters had to make sale of their crop ,sale of livestock product and casual employment as the main source of income. 53.6% of the adopters and 36.4% of non adopters agreed that they had access to animal manure as cassava farming inputs, the study also confirmed the higher prevalence in terms of accessibility for livestock drugs , certified seed ,post-harvest insect control, fungicides and insecticide, fertilizer usage.

The observation of the results of the findings as depicted by the table 4.1 showed that the majority of the cassava farmers for both categories adopters and non adopters owned the land of the size between 0 and 5 ha as the following consecutive prevalence indicate 52.6% for adopters and 38.8% for non adopters. The assessment of the findings of the study with regard to livestock ownership also showed that cattle, goats, pigs, chicken and rabbits were grown types of livestock and the results indicate high prevalence among adopters than non adopters. The majority of adopters had had access to credit compared to non adopters.

Table 4.1: Farmers'demographic and Knowledge based Characteristics

Variables under consideration			Adopters	Non adopters	Pvalue
Faermers'demographic Characteristics	Age Category	20-30	3.90%	7.20%	
		30-40	6.60%	8.60%	
		40-50	12.50%	8.60%	
		50-60	21.10%	9.90%	0.102
		60-70	8.60%	5.30%	
		70-80	2.60%	2.00%	
		80-90	2.00%	1.30%	
	Districts	Ruhango	34.20%	21.70%	0.024
		Bugesera	23.00%	21.10%	
	Marital Status	Single	1.30%	4.60%	
		Married	42.80%	25.70%	0.917
		Widowed	11.20%	10.50%	
		Separated/Divorced	2.00%	2.00%	
	Size of households	1-4	22.40%	21.70%	
		4-8	27.60%	17.80%	0.047*
		8-12	7.20%	3.30%	
	Gender Households head	Male	42.80%	27.00%	0.124
		Female	14.50%	15.80%	
Knowledge Based Characteristics	Education level	No formal education	14.70%	12.70%	
		Adult education	2.70%	0.70%	
		Primary education	31.30%	28.70%	0.316
		Secondary education	6.70%	1.30%	
		University education	1.30%	0.00%	
	Farming Experience	1-20	17.80%	16.40%	
		20-40	28.30%	19.70%	0.194
		40-60	9.20%	5.90%	
		60-80	2.00%	0.70%	
	Access to training	Yes	19.10%	2.00%	
		No	38.20%	40.80%	0.000*
	Access to Cassava demonstration plot	Yes	32.90%	8.60%	
		No	24.30%	34.20%	0.000*

Table 4.2: Economic based factors

Variables under consideration			Adopters (n=87)	Non adopters (n=65)	Pvalue
Economic based factors	Source of income	Sale of crops and sale of livestock products	23.70%	20.40%	
		Sale of crop ,Sale of livestock product and casual employment	26.30%	10.50%	
		Casual labor	5.90%	11.20%	0.546
		Off farm activities	1.30%	0.70%	
	Access to inputs	Fertilizer Usage	16.40%	3.90%	
		Fungicides and Insecticide	13.20%	2.00%	
		Animal Manure	53.60%	36.40%	
		Certified seed	22.80%	5.40%	
		Post-harvest insect control	22.50%	8.60%	
		Livestock drugs	32.70%	10.00%	0.000*
	Owned land Size	0-5 ha	52.60%	38.80%	0.978
		5-10 ha	4.60%	3.90%	
	Livestock Ownership	Cattle	35.5%	18.4%	
		Goats	36.2%	23.7%	
		Pigs	3.9%	1.3%	
		Chicken	21.7%	11.8%	
		Rabbits	1.3%	0.7%	0.194
	Access to credit	Yes	28.10%	24.00%	
		No	21.90%	26.00%	0.419

* Significant at 5% standard level of significance

4.3. T-test for socio-demographic profile of the respondents

The point differentiation has also been observed on the side of quantitative variables by the use of t- test for independence so as to compare these variables between adopters and non-adopters. Apart from the mean age which has been talked about in the previous paragraph, the study revealed significant difference under the following points: household size, farm size (in hectares), area under cassava cultivation and amount of production (P-values <5%). The findings proved the insignificancy of the difference on the side of farm experience in farming cassava although the mean difference is about 4 years and more (McKay, 2015).

Table 4.3: Mean Comparison for quantitative variables

Variables	Adopters N=87	Non-Adopters N=65	Difference (P-value)
Mean age (years)	52.49	48.42	3.815(0.107)
Household size (number of household members)	5.47	4.83	0.810(0.047) **
Farm size (in hectares)	2.8218	1.8600	0.96176(0.023) **
Farm experience (Years)	29.76	25.57	4.189(0. 106)
Area under cassava cultivation	0.4411	0.3149	12.20(0.037) **
Amount of production (Kg)	82478.56	159.95	2009.071(0.000) **

** Represent 5% level of significance

4.4. Objectives of the Study

4.4.1. Current status of farmers' awareness on cassava brown streak diseases and it's control measures

The figure 4.1 provides the summary of the farmers' awareness on cassava brown streak diseases and control measures. The observation indicates that there is a considerable lag on the side of farmers who did not adopt in terms of knowing the CBSD control measures.

The results of the study as depicted by the figure 4.1 shows that 68% among the farmers who adopted control measures were aware of them oppositely to 45% who did not adopt. The findings among non adopters the majority about 55% did not manage to be aware of control measures. The findings of the study through showcasing the pictures of the disease showed that farmers proved their level of awareness by describing and naming the observed pictures. The following are the results of their observations: root necrosis, roots rot, yellowing of leaves, stem die back and stem lesion.

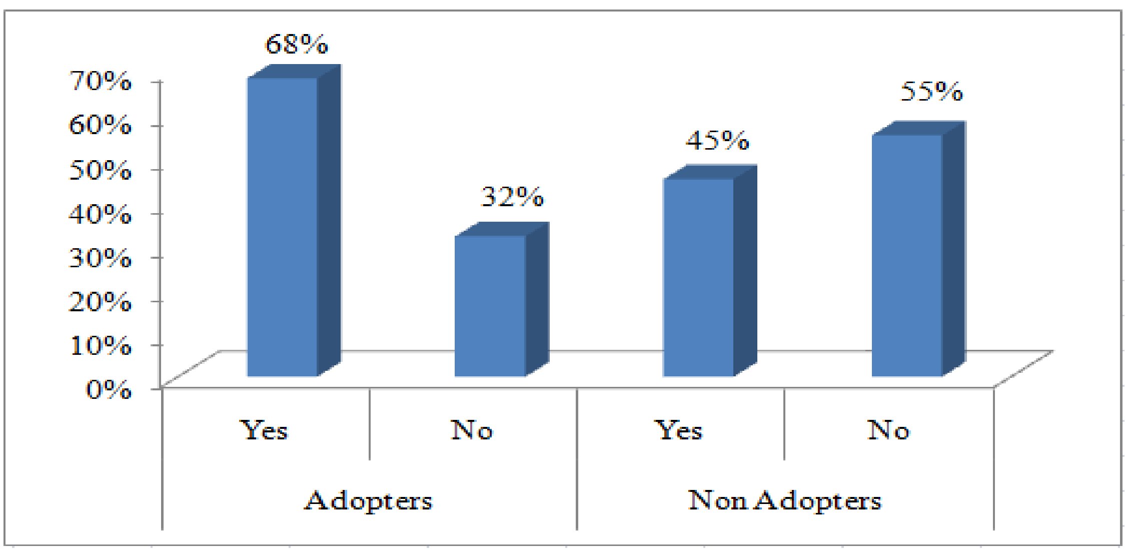

Figure 4.1: Farmers' awareness on cassava brown streak diseases

The study showed that the majority of adopted the control measures in the following respective order, resistant/tolerant varieties (83%), rotation practice (70%), Roguing and burning the infected cassava in the field (68%), early planting and early harvesting (63%), field isolation (58%) and use clean planting materials (49%).The results of the study in Rwandan context indicates serious gap to be covered by extension agents and a lot of effort to be put in mobilizing and sensitizing farmers to adopt CBSD control measures. The findings of the study tally with (Afolami et al., 2015).

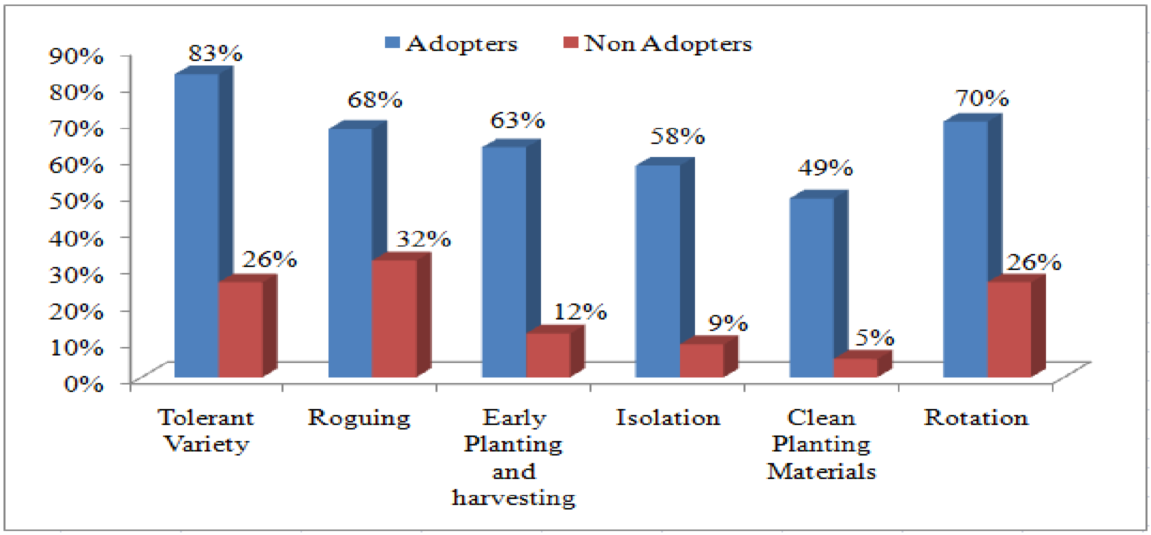

Figure 4.2: Awareness of CBSD control measures

The results of the study as depicted by the table 6 about the results of multinomial logistic regression model which was used to determine the level of likeliness of each measure to adopted for adopters. The results showed that 55.3% adopted resistant variety as control measure and it is 6.6 fold likely for adopters to adopt this measure, this is followed by 46.7% preferred to use clean planting materials and it is 4.9 more likely to be used among adopters of CBSD control measures, 52.6% preferred to use Roguing and burning infected cassava plants and this has 2.75 level of chance of being used among adopters, 36.8% preferred to use field isolation which was also 1.4 more likely to be used. The study also identified that the early planting and early harvesting and rotation consecutively were less likely to be used by the farmers among adopters.

Table 4.4: Likeliness of Adopting CBSD Control measures

		Adoption Status		Total	B	OR [95%CI]
		Yes	No			
		(%)	(%)	(%)		
Constant					-1.683	
Resistant variety	Yes	55.3	3.3	58.6	1.889	**6.613**[2.284-19.143]
	No	15.1	26.3	41.4		
Roguing and burning infected cassava plants	Yes	52.6	4.6	59.2	1.013	**2.754**[.877-8.646]
	No	13.8	27.0	40.8		
Early planting and early harvesting	Yes	40.8	0.7	41.4	-0.09	.914[.204-4.098]
	No	29.6	28.9	58.6		
Field isolation	Yes	36.8	0.0	36.8	0.36	**1.434**[.271-7.577]
	No	33.6	29.6	63.2		
Using clean planting materials	Yes	46.7	4.6	51.3	1.591	**4.909**[.254-2.231]
	No	23.7	25.0	48.7		
Rotation	Yes	64.5	5.3	69.7	1.3	.753[.377-3.443]
	No	5.9	24.3	30.3		

4.3.2. Factors influencing the adoption of CBSD control measures

As it is one the specific objectives, the study also considered evaluated the effect of factors influencing the adoption of CBSD control measures as they are detailed in the tables 3 and 4 about respondents' profiles. The general assessment of the results presented in the table 7 showed that each category of the three factors has a positive contribution to the adoption of CBSD control measures except age category of household head, area of Cassava plantation and education level of household head.

In complementarily, the results of the study showed that the category of farmers 'characteristics which has no variables with significant positive contribution to the adoption level. Again it is important to note that in the category of knowledge bad characteristics; the following variables: Farmer's experience in cassava farming and access to cassava demonstration plots had positive and significant contribution to the adoption of CBSD control measures, this is associated to the possession of standard level of significance which is less that the normal standard level of significance (p value<5%).

In Rwandan context and agriculture production experience means ability to increase production and if a farmer is less experienced production can decrease, the results of the study are consistent with findings (Masunga, 2014).In addition to the effect of knowledge bad characteristics through the mentioned two important variables, the study results also showed that economic based factors contribute to the adoption of CBSD control measures through the following variables: farm size, access to credit and period of plantation (p value<5%). The farmers confirmed the contribution of these three factors since they feared a huge burden of loss.

Table 4.5: Factors influencing the adoption of CBSD control measures

Adoption Status	Coefficients	SE.	Z	P>|z|
Faermers'demographic Characteristics				
Age of household head	-0.025800	0.020957	-1.23	0.218
Gender of Household head	0.696091	0.403023	1.73	0.084
Marital Status	0.117140	0.267912	0.44	0.662
Household size	0.043723	0.057680	0.76	0.448
Households headship	0.215721	0.024531	0.87	0.034
Knowledge Bad Characteristics				
Education level	-0.108760	0.146078	-0.74	0.457
Farmer's experience	0.040429	0.019714	2.05	0.040*
Access to training	0.788460	0.529205	1.49	0.136
Demonstration Plots	0.627040	0.316887	1.98	0.048*
Economic based factors				
Membership in Groups	0.941248	0.630609	1.49	0.136
Agricultural extension	0.444253	0.336276	1.32	0.186
Farm size	0.487786	0.076341	2.89	0.013*
Access to credit	0.857057	0.301305	2.84	0.004*
Period of Plantation	0.412364	0.128126	3.22	0.001*
Area of Cassava plantation	-0.044760	0.086677	-0.52	0.606
Constant	-2.494790	1.021677	-2.44	0.015

*Represent 10% level of significance

4.3.4. Effect of CBSD control measures on cassava production

The effect of CBSD control measures on cassava production across all production seasons was also computed using the three matching algorithms namely, nearest neighbor matching (NNM), kernel based matching (KBM) and radius matching (RM) are shown below in table 4.5. The outcome variable was the amount of cassava in kgs produced in across all agriculture seasons.

The results from nearest neighbor, kernel, and radius matching methods showed the mean difference was 8935.7, 8930.1 and 8913.2 Kgs produced and estimates were statistically significantly at (7.9**) at t-stat above 2 at 5% level of significance The null hypothesis that adoption of CBSD control measures does not increase production is rejected.

Table 4.6: Control measures on cassava production ATT matching estimates

Matching estimator	Sample	Adopter	Non-adopter	Difference	S.E	T.stat
NNN*	ATT	9639.5	703.7	8935.7	1118.5	7.9**
	Un matched	9639.5	730.0	8909.5	1287.9	6.9
KM*	ATT	9721.3	791.2	8930.1	1132.8	7.9**
	Un matched	9721.3	707.2	9014.1	1301.9	6.9
RM*	ATT	9721.3	808.1	8913.2	1129.7	7.9**
	Un matched	9721.3	707.2	9014.1	1301.9	6.9

****** Represent 5% level of significance

*NNN: Nearest Neighbor Matching

*KM: Kernel Matching

*RM: Radius Matching

The graph of the adoption assessment shows that the histograms of estimated propensity scores densities for adaptors and non-adaptors in CBSD control measures do not overlap. Adoption of control measures indicates the individuals in the adaptors' group found a suitable match. From the graphs, all adopters and non adopters individuals were within the region of common support indicating that adopters had corresponding non adopters. Hence the assumption of common support was attained.

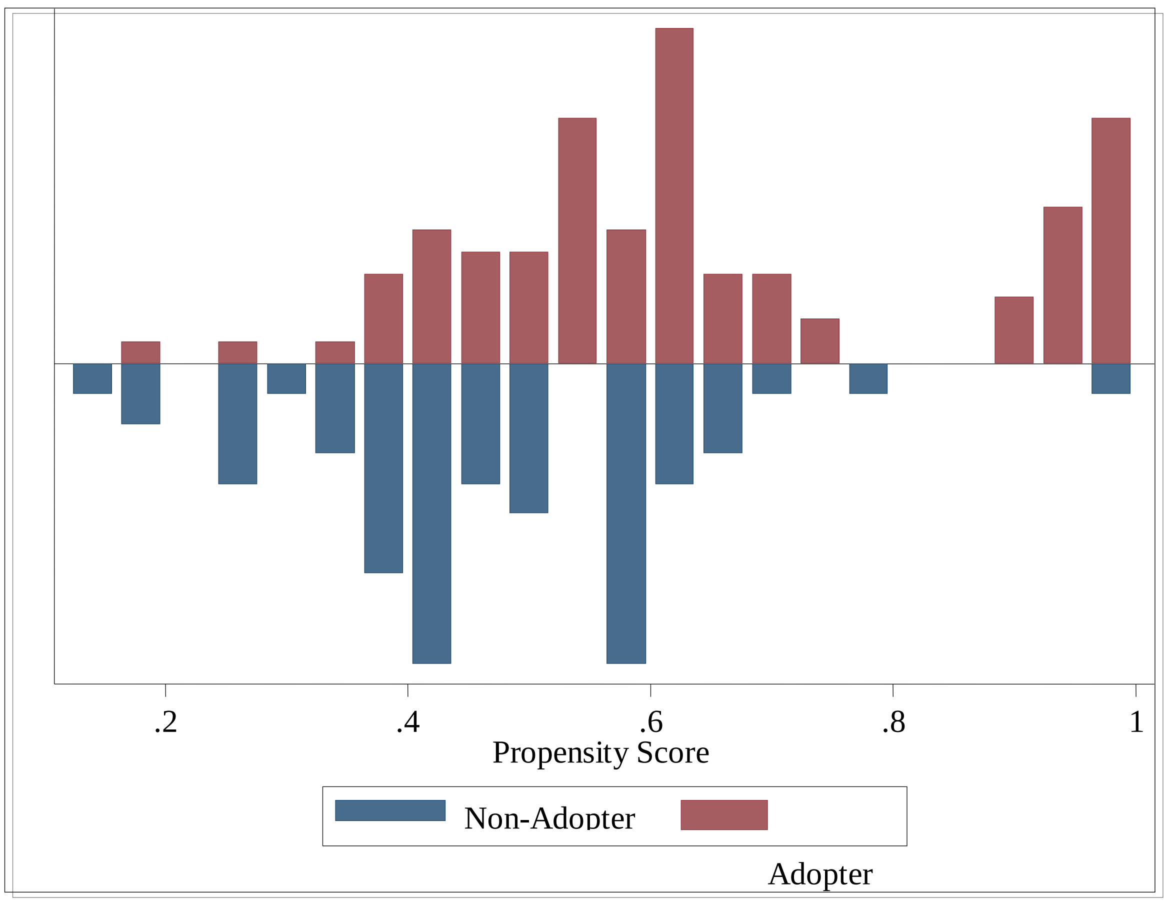

Figure4.3: Histograms of estimated propensity scores adaptors and non-adaptors

CHAPTER FIVE

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATION

5.1. Introduction

The study has concerned with the effect of Cassava Brown Streak Disease Control Measures on Cassava production in Ruhango and Bugesera Districts of Rwanda. This chapter presents general discussion of the study findings; it also presents the conclusions and subsequent recommendations.

5.2. General Discussion

This study has the target of investigating the influence of CBSD control measures on cassava production in Bugesera and Ruhango districts of Rwanda. In order to find out relevant information regarding the study. It was important to split it into three main specific objectives as follows: to assess the current status of farmers' awareness on cassava brown streak diseases and it's control measures, to determine the factors influencing the adoption of CBSD control measures and to assess effect of adoption CBSD control measures on cassava production in Bugesera and Ruhango districts of Rwanda.

As far as this study took into consideration the issue of CBSD and its control measures, the main target population would be cassava farmers in the districts where cassava is planted in abundance in Rwanda. The study considered the farmers regardless of any criteria so to deliver unbiased findings. In line with the assessment of specific objectives starting from farmer's awareness of CBSD and its control measures, the results found that 68% among the farmers who adopted control measures were aware of them oppositely to 45% who did not adopt. This high prevalence of awareness among adopters does not contradict to what has been found by Kwikwega (2005) where he found that the majority (98%) of respondents (cassava farmers) was aware of CBSD and was able to recognize the disease's symptoms. Within this study, the results of analysis indicated that farmers were able to recognize CBSD through observation of the pictures and the recognized symptoms were the following: root necrosis, roots rot, yellowing of leaves, stem die back and stem lesion.

The awareness of CBSD among the surveyed cassava farmers also goes with the awareness of control measures. This is the reason why among the surveyed cassava farmers, the control measures were highlighted at the following proportions :resistant/tolerant varieties (83%), rotation practice (70%), Roguing and burning the infected cassava in the field (68%), early planting and early harvesting (63%), field isolation (58%) and use clean planting materials (49%). In the same perspective, the awareness and use of CBSD control measures are not particularity of the surveyed cassava farmers of Ruhango and Bugesera district since Hillocks et. al (2001)generally about 80 % of respondents reported to use some control strategies while they remarked that about 44% use d tolerant varieties, 54 % were uprooting diseased plants, 70% were using disease free planting materials an d 36 % were burning diseased plants. Hence, the study at this objective conclude the accuracy of what the surveyed cassava farmers revealed and it is possible to eradicate CBSD yet the measures exist and known.

Although CBSD and its control measures are available and known at certain level, the study also identified factors influencing the adoption. It is in this regard, the three factors related to farmers'socio-econominc aspects but classified into the following categories have been identified: farmers 'demographic characteristics, knowledge based characteristics and economic based characteristics. Despite the diversification that were found with the level of influence in each category, all these factors had positive contribution and the significance were found within the following determinants: Farmer's experience in cassava farming and access to cassava demonstration plots had positive and significant contribution to the adoption of CBSD control measures in the category of farmers 'demographic characteristics.

In Rwandan context and agriculture production experience means ability to increase production and if a farmer is less experienced production can decrease, the results of the study are consistent with findings (Masunga, 2014).In addition to the effect of knowledge bad characteristics through the mentioned two important variables, the study results also showed that economic based factors contribute to the adoption of CBSD control measures through the following variables: farm size, access to credit and period of plantation (p value<5%). The farmers confirmed the contribution of these three factors since they feared a huge burden of loss.

Finally, this study ended by remarking the effect of adopting CBSD control measures on cassava production. The outcome variable was the amount of cassava in kgs produced in across all agriculture seasons. The results from nearest neighbor, kernel, and radius matching methods showed the mean difference was 8935.7, 8930.1 and 8913.2 Kgs produced and estimates were statistically significantly at (7.9**) at t-stat above 2 at 5% level of significance. Therefore, the study conclude that the adoption of CBSD control measures increase production

5.3. Conclusion

Least but not last, the results of analysis revealed that among the surveyed cassava farmers were aware of CBSD and its control measures. The study also identified that cassava farmers are more likely to adopt the following measures: resistant variety, use clean planting materials, Roguing and burning infected cassava plants and field isolation among many others. Regarding the factors influencing the adoption it was highlighted that socio-economic factors have significant contribution to adoption of any control measures and finally the study concludes that the adoption of CBSD control measures increase cassava production.

5.4. Recommendations of the study

Based on the findings of the study, this study recommends firstly concluded that CBSD if adopted would significantly increase production of cassava in Rwanda, therefore the study recommended that policy makers and implementers in Rwanda need to support

CBSD control measures in agriculture production systems through sensitization and mobilization of farmers for enhanced cassava production. Secondly, the study recommends that the government and other relevant stakeholders help in the improvement of farmers' such as extension services, trainings and land ownership amongst others so as to enhance adoption of CBSD control measures. Finally, given the difference of yield between adopters and non-adopters and as long as the study proved that the cassava farmers who preferred to apply the control measures in combination gave them the higher level of production, the farmers should be sensitized on the importance of CBSD control measures.

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APPENDICES

Appendice I. Questionnaire for household survey

Mode of responding: Use indicated number where appropriate to respond to the questions.

A. General information

1. Demographic characteristics of Respondent

1.Date of interview	
2. Sector	
3.Village	
4. Name of head of household	
5. Name of Respondent	
6. Is respondent household head?1=Yes 0=No	

2. General household information (How will objective 1 be achieved??) Ensure the questions cover the proposed objectives

Variable	Response	Codes
Demographic data		
1. Gender of Household head		1=Male 0=Female
2. Age of Household head in years		
3. Marriage status		1=Single, 2=Married, 3=Widowed, 4=Separated 6=Other (Specify)
4. If married age of spouse		

5. Education level of household head		1=no formal education, 2=Adult education 3= primary education, 4= secondary education 5=University education
6. Education level of Spouse		
7. Highest level of education attained by any family member		
8.How many members of this family are living away who regularly send remittances?		
9. Household size		
10. How long has the household head been farming as an independent household head?		Number of years

3. Land ownership

How much land does this household own now (in hectares)?

Row	Holdings	(a) Homestead land	(b) Upland away from home	(c) Wetland (if applicable)	(d) Other	(e) Total
1	Owned					
2	Borrowed					
3	Rented out					

4. Livestock ownership

How many livestock does this **household** own now?

Row	Livestock	a)Does your HH own?1=Yes 0=No	(b) If yes, number owned	(d) Jointly owned	(e) Male Spouse	(f) Female spouse	(g) Other HH member	What was the source?[1]
1	Cattle							
2	Goats							
3	Sheep							
4	Pigs							
5	Chicken							
6	Other							

[1] **Source of livestock acquisition:** 1=Government livestock program, 2=NGO/FBO, 3=Bought from market, 4=given by friend/relative, 5=other

5. General access to inputs

1. How would you rate your access to the following inputs?

Row	Type of inputs	(a) Do you use the following inputs 1=Yes, 0=No (→ f)	(b) Common source[1]	(c) Distance from house to regular source (km)	(d) Time taken in hours to get to regular source	(e) Percep-tion of cost[2]	(f) Constraints to access [3]
1	Fertilizer (NPK,Urea,DAP, Others)						
2	Fungicide						

Row	Type of inputs	(a) Do you use the following inputs 1=Yes, 0=No (→ f)	(b) Common source[1]	(c) Distance from house to regular source (km)	(d) Time taken in hours to get to regular source	(e) Percep-tion of cost[2]	(f) Constraints to access [3]
	s and Insecticide						
3	Animal Manure						
5	Certified seed						
6	Post-harvest insect control						
7	Livestock drugs						

[1] **Common source of inputs:** 1=purchased from market; 2=purchased from stockists; 3=purchased from other farmers; 4=received from government; 5=received from NGOs;6= 99=others (specify)…

[2] **Perception of cost:** 1=Very affordable, 2=Affordable 3=Not affordable

[3] **Other constraints to access**: 1=Too far from household, 2=Unsuitable packaging (large) 3=No knowledge of how to use 4=No transport, 5= Not enough money 99=Other(specify)

6. Crop Production in specific fields

R.	Parcel name	Crop grown/plot	1. Plot area	4. Used in season B of 2015? 1=Yes 0=No	5. Used in season A of 2016? 1=Yes, 0=No	6. Tenure type[3]
1						
2						
3						
4						
5						

List all the plots and crops for all parcels cultivated by the household. Please list all crops grown on each plot, with each

7. Fertiliser use in cassava plots

NB: If several fertilizers are applied, use several rows

Plots	Variety[3]	Cropping system [2]	1 Used chemical fertilizer? 1=Yes 0=No If No→5	2 Type of fertilizer used [1]	3 Amount used (Kg/lts)	4 Used organic fertilizer? 1=Yes 0=No	5 Amount used (Kg)
1							
2							
3							
4							

[1]**Chemical fertilizers:** 1 = NPK; 10 = Other (Specify)

[2] **Cropping system**: 1 = Pure stand (mono cropping); 2 = Intercropping (two crops); 3 = Mixed cropping (more than two crops); 99 = other (specify)

[3]Varieties: 1. NASE 14, 2. Kizere, 3. Mavoka, 4. Ndamirana, 5. Others (Specify)

8. Cassava production constraints

1. What are the priority constraints to cassava production?

Row 1	a) Constraints to crop Production	(b) Rank the top three constraints (1 being the top most constraint)
1	Low soil fertility	
2	Pests and Diseases	
3	Lack of improved varieties	
4	Low access to inputs	
5	High cost of inputs	
6	Insecure land tenure	
7	Small land holding	
8	Lack of labour during peak season	
9	Lack of /expensive agricultural equipment	
other	specify:	

9. ACCESS TO CREDIT SERVICES, INFORMATION, EXTENSION, AND TRAINING

(1): Access to credit

Do you have access to any of the following sources of credit?

NB: amount (b) is to be given in one currency, please indicate here which currency you used _____

Row	Source of borrowed money	(a) Have you ever borrowed? 1=Yes 0=No	(b)Amount borrowed in the last 12 months	(c)Purpose of borrowing [1]
1	Relative and friends			
2	Informal savings and credit group			
3	Money lender			
5	Government credit schemes			
6	NGO/Church			
7	Bank or micro-finance institution			
8	Input and output dealers			

[1]**Purpose for borrowing:** 1=Purchase of food 2=Purchase of household assets 3=Payment of fees 4=Cover medical costs 5=Agricultural production 6=Cover educational costs 99=Other (specify)

(2) Access to and use of agricultural extension services

1. Did anyone in your household visit or receive an agricultural extension agent or an agricultural extension center during the last 12 months to seek advice or assistance on growing crops or livestock management? ______

Yes =1 No=0

2. If yes, how many times during the last 12 months did members of your household do this? ______

3. What kinds of assistance or information were requested? Tick where appropriate

Row1	(a) Crop production	(b) Did you request 1=Yes 0=No
A	Use of fertilizer	
B	Use of improved varieties	
C	Pest and disease management	
D	Soil management	
E	Agricultures practices	
F	Credit	
G	General crop production advice	
H	Other	

During the past 12 months, did any agricultural extension agent visit your household? Yes=1 No=0 ______

5. How many times did any agricultural extension agent visit your household during the last 12 months? ______

(3): Access to trainings

Do you have access to any of the following trainings?

NB: amount (b) is to be given in one currency, please indicate here which currency you used _____

Row	Trainings	1=Yes 0=No	Period (Seasons)[1]
1	Cassava agronomy		
2	Cassava Pests and Diseases management		
3	Improved agricultural technologies		
5	Use of fertilisers and FYM		
6	Soil management		
7	Seasons management		

[1]**Seasons:** 1=2015B 2=2016A 3=2016B

(4): Access to cassava demonstration plots

Have you already visited cassava demonstration plots in your area?_____

Row	Seasons	1=Yes 0=No	# of visit	Purpose of visit[1]
1	2015A			
2	2015B			
3	2016A			
5	2016B			

[1]Visits: 1.Training 2. Study tour, 3.others (specify)

11. Welfare indicators

(1) Household income

1. What are your priority sources of income and what is the income estimate from these sources for the last 12 months? 1. Sale of crops .2 Sale of livestock 3. Sale of other products e.g. firewood, trees 4.Casual employment 5. Permanent employment 6.Other business

[2]**Importance of source**: 1=Not important, 2=Moderate importance 3=High Importance 4=Very High Importance

2. At any time last year (last 12 months), did you or anyone in the household do any day labor for income?

1=Yes; 0=No ______

3. Do you have savings? 1=Yes, 0=No.

______

4. If yes, how often do you save money? 1=occasionally; 2=regularly; 4=Always

______

12. Household assets

Row	Equipment	a) Does your HH own Yes=1 No=0 (If no go to next asset)	If yes…. b) Total Number
1	Hoes,		
2	Machetes		
2	Farm equipment		
3	Sprayer		
4	Sewing machine		
5	Bicycle		
6	Motorcycle		
7	Radio		
8	Television		
9	Mobile Phone		

12. Use of CBSD control measures (CM)

Are you aware of CBSD? 1=Yes 0=No

NB: CM refers to any agricultural practices to control or prevent cassava disease

	CBSD control measures	(a) Do you know this? 1=Yes 0=No	(b)Most important source of information [1]	(c) Did you proactively ask for information? 1=Yes 0=No	(d) Have you ever used this CM in your main fields 1=Yes 0=No	(e)When did you first use this technology	(f) Did you use this technology during the 2015/2016 seasons? 1=Yes 0=No
1	Resistant/Tolerant variety						
2	Roguing and burning infected cassava plants						

3	Early planting and early harvesting						
4	Field isolation						
5	Rotation						
6	Combination						

13. Cassava production

Plots	Variety	Period of plantation[2]	Area	Adopt CM 1=Yes 0=No	If Yes CM used[1]	Amount of production	Yield
1							
2							
3							
4							

[1]CM used: 1: Tolerant variety 2: Roguing and burning 3: Early planting 5. Isolation 6: Combination

[2] 1: Season A2015 2: Season B2015, 3: Season A 2016, 4: Season B 2016

Appendix II: Symptoms of CBSD on different parts of cassava

On leaves and stemes

On Roots and tubera