THE EFFECTS OF CASSAVA STREAK VIRIUS DISEASE ON CASSAVA PRODUCTION

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DECLARATION

I OPIO PATRICK, hereby declare that this research proposal on "The effects of cassava brown streak disease on cassava production in petta sub-county Tororo district is my own, original work and has never been at any point presented for any award of certificate, diploma or degree in any institution of learning

Signature ....

Date 22. 01. 2024.

APPROVAL

This to certify that this research proposal of OPIO PATIRCK entitled the effects of cassava brown streak disease on cassava production in petta sub-county Tororo district has been under my supervision and is now ready for submission with my approval.

SIGNATURE……………………………

DATE 22/10/2024

MR. DRAMADRI GERALD AFAYO

(SUPERVISOR)

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I finally take this chance to thank the Almighty God for the wisdom, good health, provision, care, love and for always protecting me.

Dedication

I dedicate this research report to my beloved father Mr. Ofwono Sam and mother Mrs. Aketch Agnes for their continued support throughout my school and university education and bringing me up morally. I owe them a lot

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

NARO National Agriculture Research Organization

NARS National Agriculture Research

NGO Non-Governmental Organization

UCBSV Uganda Cassava Brown Streak Virus

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ABSTRACT

Brown streak virus disease is the most important biotic constraint to cassava production in the Uganda. Symptoms include foliar chlorosis and sometimes stem lesions. The disease also affects the tuberous roots which develop a yellow/brown, dry, corky necrosis within the starch-bearing tissues, sometimes accompanied by pitting and distortion, that is visible externally. The foliar symptoms of the disease often do not greatly affect plant growth, although the most sensitive cultivars may be stunted and defoliated. The main impact of the disease on the crop is by causing root necrosis. Field experiments were conducted at two sites in Tanzania to determine the effect of the disease on yield and quality of the roots. Cassava brown streak disease (CBSD) decreased root weight and patches of root necrosis made roots unmarketable, although the unaffected parts might still have been suitable for home consumption. The disease therefore has two effects, one on total root yield and one on root quality, which affects marketability. The field trials showed that CBSD can decrease root weight in the most sensitive cultivars by up to 70%. The length of time between the appearance of foliar symptoms and the development of root necrosis is a varietal characteristic. In the most susceptible cultivars, root necrosis may appear within 6 months of planting cuttings derived from symptomatic mother plants. A local cultivar known as cv. Nachinyaya exhibited a form of tolerance to CBSD in which foliar symptoms appeared but the development of root necrosis was delayed allowing the full yield potential to be realized

CHAPTER ONE

1.0 Introduction

Cassava (Manihot esculenta Crantz), is an important staple crop in many African countries which account for 61.1% the of world production (*Niyonzima 2021)*. In sub-Saharan Africa (SSA) there are about 18 major cassava growing countries, each producing from 1 to over 50 million turns. The major cassava producing countries include Nigeria (60 million t), Democratic Republic of the Congo (DRC) (41 million t), Ghana (21.8 million t), Angola (8.8 million t), and Tanzania (7.6 million) where it is grown mostly by resource-poor farmers, many of them women. Further, it is either grown as a sole crop or intercropped with vegetables, cereals (millet, maize, sorghum) or legumes (beans, cowpea) for food security *(Obadina and Olotu 2017*). In recent years, utilization and processing of cassava as a raw material has increased especially in the manufacture of many industrial products such as starch, beer, flour and other bio-based products including medicine, feed, cosmetics and biopolymers. For example, in Mozambique and Nigeria, cassava flour has replaced up to 20 and 10% of wheat flour in bread, respectively Coupled with these developments, its cultivation in many countries is transforming from subsistence to a more commercially-oriented farming enterprise *(Maggidi and Makindara)*. Because of this, the area under cassava production continues to expand in several African countries. Despite the expansion, productivity remains low and continues to be threatened by abiotic and biotic factors. Among the biotic factors contributing to low productivity are diseases particularly those caused by viruses., Cassava is susceptible to over 20 different viruses, of which the most important are viruses causing cassava brown streak virus (CBSD) and CMD (Patil, Legg et al. 2015). Cassava mosaic geminiviruses (CMGs) causal agent of cassava mosaic disease (CMD) comprise several species of circular single strand DNA (ssDNA) viruses belonging to the genus Begomovirus, family Geminiviridae. Contrastingly, cassava brown streak ipomoviruses (CBSIs) causal of CBSD comprises two positive sense single strand RNA (ss RNA) genomes, belonging to the genus Ipomovirus, family Potyviridae. The CMGs and CBSIs, are not seed borne but are transmitted by the polyphagous whitefly complex Bemisia tabaci (Gennadius) (Hemiptera: Aleyrodidae). CMD and CBSD are spread over long distances through planting of infected cuttings originating from diseased plants (Wagaba, Beyene et al. 2013). However, the presence and abundance of infected whiteflies feeding on the plants quickens the spread from plant to plant within or adjacent fields (Jones 1998). Symptoms of CMD and CBSD are characterized by severe mosaic and chlorosis, respectively (Legg, Jeremiah et al. 2011). During the early years when CBSD was first reported, it was confined to areas provides insights in the management of the two diseases as well as future directions. CBSD and the causal viruses (Chikoti and Tembo 2022).

1.1. Background:

Cassava is one of the most important food staple crops for more than 200 million people in East and Central Africa (Parmar, Sturm et al. 2017). Human population growth rates in this sub-region continue to be one of the highest in the world, and consequently there is an urgent need to match this growth with concomitant increases in food production, using one of the most robust crops in terms of resilience to climate variability The crop was prioritized by the New Partnership for African Development (NEPAD) as one of the crops to combat poverty and food and nutrition insecurity in Africa, and is a high priority commodity in the Uganda national research and development agenda. However, cassava production in the region and in Uganda is restricted by a diverse set of constraints (Herrera Campo, Hyman et al. 2011). The most economically important are the two virus diseases: cassava mosaic disease (CMD) and cassava brown streak disease (CBSD). Both have been recognized in the region since 1930s, but have become increasingly damaging in recent years (Hillocks and Jennings 2003). CMD is caused by viruses of the family Geminiviridae: genus Begomovirus, referred to collectively as cassava mosaic Gemini viruses (CMGs) (Legg, Kumar et al. 2015). Nine species are currently recognized, of which eight have been reported from Africa. CMD occurs wherever cassava is grown in Africa, from Senegal in the north-west to Mozambique in the south-east, as well as on the off-shore islands of Madagascar, Mauritius, Seychelles, Zanzibar and Cape Verde. The biology of the CMGs has been the subject of much study since the early 1990s. Key areas of interest included: molecular characterization, vector transmission, field and regional-level epidemiology, resistance breeding and management. The re-emergency of CBSD after 2002 led to even more devastating consequences. Our recent studies show that CBSD is caused by at least 2 distinct ipomoviruses (*Mukasa)*. The most prevalent virus in the coastal and lowland areas of east Africa retained the name CBSV while the second virus was named UCBSV *(Patil, Legg et al. 2015*). These CBSD associated viruses are gaining in severity, threatening food and livelihood securities for millions of farmers and cassava consumers in region. CBSD causes a dry necrotic rot in the storage roots, leading either to decimating yields and/ or significant reductions in quality (Mukasa). Current estimates show that CBSD causes economic losses in excess of $100 million annually (*Mohammed, Abarshi et al. 2012)*. Recognizing the gravity of the threat, a proactive programme was initiated at Makerere during 2005 under the BIOEARN Programme to bridge the knowledge gaps in order to combat the disease and stabilize production of this important food crop (*Mukasa)*. Activities focused on identification and diversity of CBSV, developing diagnostic tools for the virus, using conventional and genetic transformation methods for developing high-yielding, CBSD-resistant varieties, and developing an array of integrated pest and crop management options suited for small-holder agriculture *(Mukasa*). Tissue culture applications were also sought in the areas of rapid multiplication of new varieties, low cost multiplication protocols, virus elimination and regeneration protocols for genetic engineering.

1.2. Statement of Problem:

Cassava brown streak disease (CBSD) was first described in Tanzania during the 1930s *(Mukasa*). Unlike Cassava mosaic disease (CMD) which is widely distributed wherever cassava is grown in Africa, CBSD was restricted mostly along the East African coastal cassava-growing regions and hence considered for a long time as a low altitude (< 1000 masl) problem. Nicholas (1950) reported that the disease was endemic in all East African coastal cassava growing areas from the north-east border of Kenya to southern Tanzania and Zanzibar and that was widespread at lower altitudes in Malawi. In Uganda, CBSD was first reported in 1945 on materials imported from the then East African Cassava Breeding Station at Amani in Tanzania (*Robson, Hird et al. 2023*). The materials were imported to control the CMD epidemic of the 1930's and 1940's (Kaweesi 2014). The affected crops at Bukalasa were destroyed and the intensive eradication programmes fully controlled the disease. The problem was not noticed until 1994 when symptoms typical of CBSD were observed in a field near Entebbe on the northern shores of Lake Victoria *(Alicai, Omongo et al. 2007).* A decade later symptoms of CBSD were again observed on cassava in some locations in central Uganda; this time in relatively higher incidences, albeit localized, on some of the popular CMD resistant varieties being grown countywide by farmers*(Mukasa*) . This caused serious concern as cassava production in the country had just been restored through use of CMD-resistant varieties following devastation by the severe CMD epidemic in the 1990s. The emergency of CBSD in the high altitude areas led to proposing the possibility of having a new strain(s) of the CBSV or due a general replacement of tolerant varieties with more susceptible ones following deployment of varieties in the fight against CMD. There is therefore need to establish the prevalence of the disease in the country and the reason for increased severity and/or spread in order to institute corresponding mitigation strategies.

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1.3.0. General and Specific Objectives:

1.3.1 General Objective:

To assess the effects of Cassava Brown Streak Disease on cassava production in Petta Sub-County, Tororo District.

1.3.2 Specific Objectives:

a) To assess the impact of CBSD on cassava yield and quality.

b) To assess farmers 'knowledge, attitudes, and practices regarding CBSD management

c) To identify factors influencing the spread and severity of CBSD.

d) To recommend appropriate strategies for mitigating the effects of CBSD on cassava production.

1.4. Research Questions:

a) How does CBSD affect cassava yield and tuber quality?

b) What are farmers 'current knowledge, attitudes, and practices regarding CBSD management?

c) What are the factors contributing to the spread and severity of CBSD?

d) What strategies can be recommended to mitigate the effects of CBSD on cassava production?

1.5.0. Research hypotheses

1.5.1. Null hypotheses

There is no significant difference in the effect of CBSD on cassava yield and tuber quality in petta Sub County.

There is no significant difference on farmer’s current knowledge, altitude and practice regarding CBSD management in petta Sub County.

There is no significant difference on the factors contributing to the spread and severity of CBSD in petta Sub County

1.5.2. Alternative hypotheses

There is significant difference in the effect of CBSD on cassava yield and tuber quality in petta Sub County.

There is significant difference on farmer’s current knowledge, altitude and practice regarding CBSD management in petta Sub County.

There is significant difference on the factors contributing to the spread and severity of CBSD in petta Sub County

CHAPTER TWO: LITERATURE REVIEW

2.0. 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 four main sections after the introduction: section 2.2 contains the impact of CBSD on cassava yield and quality, section 2.3 contains farmers 'knowledge, attitudes, and practices regarding CBSD management 2.4 contains factors contributing to the spread and severity of CBSD while the last section reveals strategies to mitigate the effects of CBSD on cassava production.

2.1. The impacts of cassava brown streak disease on cassava production

To evaluate the threat of CBSD, I will first understand the casual viruses, their spread, and the symptoms they cause. CBSD is caused by two viruses, CBSV, and the UCBSV (Mbanzibwa, Tian et al. 2011). Studies have shown that CBSV occurs widely and is the more aggressive virus, infecting both tolerant and susceptible cultivars as a single or mixed infection with UCBSV (Elegba, Gruissem et al. 2020). Although there are only two species reported, further speciation is suggested within the UCBSV clade. The two viruses are transmitted in a semi-persistent manner by the whitefly vector, from plant to plant Other vectors could transmit CBSVs. reported transmission of CBSV by Aleurodicus disperses albeit at low rate. Other studies have shown a highly conserved motif of three amino acids AspAla-Gly (DAG) within the CBSV, which is associated with aphid transmission Although mostly associated with cassava, CBSV can also infect other host plants, for example, Nicotiana benthamiana Studies by in Mozambique have shown that non-cassava perennial wild plant species: Zanha africana and Trichodesma zeylanicum are alternative hosts to CBSV. The plants are widely distributed in east, central and southern Africa. Manihot carthaginensis subsp. glaziovii, a wild cassava relative native to Brazil is also a host to CBSVs and occurs widely in Mozambique (Amisse 2023). CBSD affects all the plant parts; leaves, seed capsule, stems, and roots (Rwegasira and Rey 2012). The CBSVs causes yellowing of the leaves, brown streaks on the stems, and necrosis of the roots, rendering them unpalatable and unsuitable for the market. In addition, they cause concentric necrotic spots on the fruit. Leaf symptoms predominantly appear as leaf chlorosis in feathery patterns along the margins of tertiary veins. In some varieties, chlorosis manifests as pin spots and may later develop into chlorotic blotches. Infected stems show brown lesions or streaks, resulting in stem dieback in severe infections. In younger stems, the streaks appear purplish. Root symptoms are characterized by formation of radial constrictions and necrotic lesions within the root. The symptom expression depends on the virus strain infecting cassava, cassava variety, and environmental factors (rainfall, temperature, soil nutrient). Within the same variety, the CBSD symptoms can be observed either only on the leaves or on the stems or on the roots. In some cases they can appear on all plant parts or only on two plant parts (leaves and stems or on leaves and on the roots).

2.2 Farmers 'knowledge, attitudes, and practices regarding CBSD management

Cassava Brown Streak Disease is a major biotic production constraint of cassava. 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 (80 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, 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 13 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. Factors contributing to the spread and severity of CBSD

Recent surveys in Uganda indicate re-emergency of CBSD with worrying food security and economic consequences (Mukasa). An important feature of CBSD in Uganda is that incidence is highest and severity greatest in CMD-resistant varieties that are being promoted for the management of the CMD pandemic (Nyirakanani 2023). This is most prominent for the two varieties TME 14 and TME 204 that have proved to be highly popular with farmers, and have therefore spread very rapidly within and between farming communities. Importantly, CBSD symptoms can also now be seen in diverse local cultivars, although in this case symptoms appear to be less severe. It also seems likely this ‘new’ spread of the virus causing CBSD is being enhanced by the superabundance of the whitefly vector, Bemisia tabaci, a phenomenon that was also associated with the CMD pandemic (Legg, Jeremiah et al. 2011). This suggests that all parts of Uganda already affected by the CMD pandemic with concomitant super-abundant whitefly populations are vulnerable to CBSD spread. In view of the present importance of CBSD in Uganda, it is timely to develop a strategy to manage this devastating disease of cassava(Ntawuruhunga and Legg 2007). In several countries, however, where CBSD is prevalent, it is apparent that much use of CBSD infected planting material is an effective means of perpetuating and disseminating the disease also demonstrated that CDSD was graft-transmissible and that, cuttings from affected plants invariably gave rise to plants showing CBSD symptoms. Mechanical transmission by use of sap is also possible but this is easier from cassava to a number of herbaceous hosts than between cassava plants (Ogwok, Patil et al. 2010). Epidemiology of CBSD Settumba Mukasa 1472 There is evidence, however, of natural spread between plants as clones introduced from West Africa or other areas that are free from CBSD have become infected when grown at sites in Mozambique, Malawi, Kenya and Tanzania .Plants raised from seed introduced from West Africa have also become infected at these sites. Speculated that this natural spread was most likely to be mediated by the whitefly (Bemisia species). Although, however, until recent there were only a few transmission experiments that were conducted, transmission of CBSD was unsuccessful with the whitefly Bemisia tabaci and with six species of aphids in an experiment conducted in Kenya. Also from experiments conducted by Hillocks et al. (2001) in Tanzania with diseased and disease free planting stocks of a range of local CBSD susceptible varieties and locations, it was revealed that the peak of the disease corresponded with the period of peak whitefly numbers. All this circumstantial evidence seems to suggest that B. tabaci and B. afer may indeed be the vectors, but that conditions used so far in transmission studies have not been appropriate to demonstrate this (Maruthi et al., 2005). In some transmission experiments conducted in Tanzania, transmissions were achieved using B. tabaci, but symptoms appeared in only one test plant on each of two repeated experiments. More recent transmission studies show that like CMGs, CBSV is transmitted by B tabaci and via the stem cuttings that are often used for replanting without any quality check. Recent cage transmission experiments and field surveys show that transmission of CBSV is sporadic However, rate of transmission was low (maximum 22%) even when using high whitefly numbers of up to 120 per target plant. Spread of CBSD in the field coincided with increases in whitefly numbers; further supporting the evidence that B. tabaci is a vector of CBSV (Mohammed 2012). CBSV is sporadically spread by B. tabaci at a seemingly low rate and given the incidence and prevalence level of CBSV in low and high altitude areas, suggests planting material as key vehicle in the spread of the virus. Prior to 2004, CBSD had never been recorded at high incidence above 1000 masl., and was primarily known as a disease of the lowland cassava-growing areas of East Africa, including the shores of Lake Malawi. However, from late 2004 onwards it became apparent that CBSD was becoming more and more widespread in parts of south central Uganda IITA and Uganda's National Agricultural Research Organization 1473 Third RUFORUM Biennial Meeting 24 - 28 September 2012, Entebbe, Uganda

Economic Importance of CBSD conducted a survey of cassava pests and diseases in January 2007 which incorporated an assessment of CBSD leaf symptoms for all of the 493 fields sampled through 26 of the most important cassava-growing districts in the country. CBSD was recorded from 40 of the fields, distributed virtually throughout the country, but with greatest incidence in south, central areas, corresponding to the area in which cultivation of TME and TME-like varieties is most widespread. The national cassava program work indicated that more than 30 districts are attacked

2.4. How to mitigate the effects of CBSD on cassava production.

The intensive monoculture of crop plants today invites the epidemic spread of many diseases and pests, among the most important of which are viruses (Hollings 1965). Rapid vegetative propagation and a flourishing movement of planting material have made matters worse. There are at present no practical treatments to cure virus-infected plants once they are set out in the field. The production and distribution of virus-free propagating material has proved highly successful in controlling virus diseases in many crops, and can be of wider application in management of cassava viral diseases, including CBSD (Tumwegamire, Kanju et al. 2018). The strategy of control through virus-free stock aims to dilute the amount of virus infection by the supply of large quantities of healthy planting material. Inevitably, this material will sooner or later become infected and is regarded as expendable; to be replaced as soon as noticeable deterioration occurs. The key lies in maintaining the foundation mother stock isolated, or otherwise fully protected against re-infection, so that only the progeny propagated from it are exposed to the hazards of ordinary cultivation (Mukasa). Phytosanitary programmes require (i) proper diagnosis of CBSD, (ii) reliable and affordable virus indexing methods, (ii) appropriate techniques for virus elimination that can be employed whether no healthy material is found for farmer preferred cultivars, and (iv) establishment of virus indexed foundation stocks for distribution to farmers. The benefits of selecting of CBSD-free stems when replanting were clearly demonstrated and recommended although advocating a phytosanitation programme to farmers has some drawbacks including the need for major educational and training input For experimental purposes, planting material free of CMD were obtained from infected plants using heat treatment. A combination of meristem tip culture and heat treatment together with appropriate virus indexing techniques can effectively result into cassava planting material free of CBSD (Mwangangi 2015). Farmers can also been introduced to the control of CBSD through phytosanitation e.g. it may be worthwhile rouging the infected individual (Alvarez, Llano et al. 2012). Roguing was used Management of CBSD Settumba Mukasa 1478 in Uganda and effectively worked to rid the country of CBSD when it had been introduced in planting material from Tanzania (Jameson, 1964). The method was also successful in Tanzania when producing symptomless breeding stocks from populations that were originally showing symptoms of CBSD. Also, a key facet of CBSD management, given its apparently restricted distribution, will be the prevention of movement between countries and region through the implementation of strict quarantine procedures. It is therefore critical that movements of germplasm in vegetative form should be strictly controlled (through meristem tip culture and thermotherapy) and that virus indexing laboratories that test tissue culture material prior to export are fully equipped for CBSV diagnosis (Mukasa). Another attempt for CBSD management is the use of resistant varieties. Selection for resistance to CBSD began at Amani in northern Tanzania as far as 1937, where resistance was transferred from cassava related species, such as, Manihot glaziovii Muell-Arg, M. dichotoma Ule, M. catingae Ule and ‘tree’ cassava, believed to be a natural hybrid between M. esculenta Crantz and M. glaziovii Muell-Arg. Also, a few cassava cultivars, such as, cv. Macaxiera Aipin are also resistant to CBSD. Other two shrublike species M. saxicola and M. melanobasis are also highly resident to CBSD but their roots contain high concentration of hydrocyanic acid. Also conventional breeding for resistance to CBSD requires too much time, with each generation taking not less than 3 years and a series of backcrosses are needed to remove the undesirable characteristics, such as, tree like characteristics and high cyanide level, while retaining resistance to CBSD. Nonetheless, varieties have been identified in southern Tanzania and Malawi which are either resistant to infection by CBSV or express very mild symptoms which do not have an effect on yield. No information is currently available on mechanisms of resistance, and there has as yet been no major effort to use conventional breeding approaches to develop CBSV-resistant germplasm. However, preliminary screening by NARO raises hope of identifying resistant varieties. The only hope lies in the fact that some few varieties such as NASE 3 and two pre-release varieties; 2961 and 0067 commonly called "Akena" seem to be tolerant or escape the disease. Therefore with more research a suitable resistant cultivar may be developed. 1479 Third RUFORUM Biennial Meeting 24 - 28 September 2012, Entebbe, Uganda Therefore, the relative merits of any approach compared to others need to be evaluated. It seems that resistant and tolerant varieties together with field sanitation and use of disease free planting material may all have an important role to play in managing CBSD, but considerable research remains to be done on the conditions under which each is most appropriate and on how best to combine them into an integrated strategy.

CHAPTER THREE: MATERIALS AND METHODOLOGIES

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.

3.2. Research design

This study consisted of 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

I conducted my research in three parishes pakoi, mbula and petta in petta sub-county due to the fact that they are the ones where cassava is widely grown and there is high incidence of Cassava brown streak disease. The study considered two villages and five farmer were randomly selected in each village to represent the whole farmers in petta sub-county where i draw my conclusion about my research.

3.4. Target Population

The study considered two villages and five farmer were randomly selected in each village and one extension worker making a total of 31 people to represent the whole farmers in petta sub-county where i draw my conclusion about my research. Target population comprised of adopters and non-adopters

3.5. Sampling techniques

I employed simple purposive sampling technique in the sampling of the parishes due to availability of many cassava farmers. Three (pakoi, mbula and petta) with high incidence of cassava brown streak disease was selected. A two-stage cluster sampling was used to sample the cells in each sample sector. The first sampling stage involved the selection of a predetermined number of clusters (cells) per sector. A simple random sampling technique was also be used in the sampling of the farmers. Farmers had equal chances of selection. The list of total household heads in the selected sectors was obtained from the sector offices.

3.6. Data collection techniques

Using a close ended questionnaire, I used face to face interviews with sample of the selected cassava farmers. Before starting the process of interviewing, I started by introducing myself and explaining the intention of the research to farmers (academic research).

3.7. Data Processing and Analysis

Data from the respondents was verified, compiled, coded and summarized before being analyzed using the Statistical Package for Social Sciences (SPSS) Windows Software Version 16.0. Both quantitative and qualitative methods of data analysis was be used. For quantitative data, descriptive and inferential statistics was applied. In descriptive statistics, frequencies percentages, mean, standard deviation, standard error and range will be calculated.

4.0. CHAPTER FOUR: RESULTS.

4.1. The demographic information

The demographic information included the gender, region of respondents, level of education, age range of respondents and marital status of the respondents as summarized in the table below.

Table 1: demographic information of the respondents

Demographic information of respondents		**Frequency**	**Percentage (%)**
Region (parishes)	Pakoi	10	32
	mbula	10	32
	Petta	15	35
Gender	Male	18	59
	Female	13	41
Education level	Illiterate	12	39
	Primary	8	26
	Secondary	7	23
	Tertiary	4	13
Marital status	Single	5	16
	Married	22	71
	Widowed	4	13
Age range (years)	18-23	8	26
	24-28	11	35
	29-35	12	39

According to the table above, out of the 31 cassava farmers who participated in this study, 18 were male and 13 were female. All these farmers came from different regions of Petta subcounty. Of these, 25 cassava farmers were from Pakoi parish which constituted 32%, 11 were from petta parish (35%) and 10 farmers were from Mbula parish, accounting for only (32%). This result indicated that more farmers who grew cassava are from Pakoi parish, followed by Mbula parish and the least number of cassava farmers came from Peta parish.

I also investigated the marital status of farmers and according to the table 2 above, out of 31 farmers who participated in this study, 22 farmers (71%) were married, 5farmers (16%) were single and the widowed were found to be 4(13%). This indicated that most people who participate in cassava production are individuals with families (those who are married) since they tend to have more labor force to help work in the cassava plantation.

Among the 31 cassava farmers who were investigated, 8 farmers were aged between 18-23 years, 11 were aged between 24-28 years followed by only 12 farmers who were aged between 29-35 years. On the side of education of the farmers, 12 farmers were found to be illiterate (39%), 8 farmers attained a primary level of education (26%), and could read and write, 7 farmers attained secondary education and 4 other farmers also attained tertiary education which constituted to 23% and 13% respectively. This indicated that most of the farmers in Petta sub county are illiterate and cannot read and write.

4.2. Time spent in cassava farming.

All the farmers who participated in this study were found to be year-round cassava growers. I found out that they had taken more than three years growing cassava and had more than three acres of land of which at least one acre was allocated for cassava production

4.3. Cassava species cultivated in Petta Sub County.

I was also able to obtain the cassava species grown in different regions of the sub county, their local names, English names, source of the planting materials, purpose for planting and number of farmers who were involved in their production. This information was summarized in the table 3, as shown below.

Table 2: cassava cultivar planted in Petta sub county.

Cassava cultivar planted (English name)	**Local name**	**Source of planting material (RESEARCH CENTERS)**	**Purpose for planting**	**Number of farmers involved.**	**Percentage (%)**
NAROCAS1	Narocas	NARO	Food and for sale	20	65
MAGANA	Magana	NARO	Food and for sale	09	29
NAIGERIA	Nigeria	NARO	Food and for sale	02	6

Basing on the table above, NAROCAS1 has the highest frequency 20(65%) of being grown by the farmers. Most farmers said that it is NAROCAS1 which gives highest yield compared to other cassava species, and on addition to the yield it is also resistant to some extent to the diseases including Cassava Brown Streak Diseases. This was followed by MAGANA with a frequency of 9(29%) and lastly, NAIGERIA with a frequency of only 2(6%).

4.4. Awareness of farmers about CBSD.

It was also found that 20 farmers out of the 31 farmers who participated in this study were aware of the Cassava Brown Streak Disease and this constituted 65% and only 11 were not aware of the cassava brown streak disease which constituted35%. This information was summarized on a pie-chart in figure 1below. This implied that most farmers had pre-requisite knowledge concerning the cassava brown streak disease.

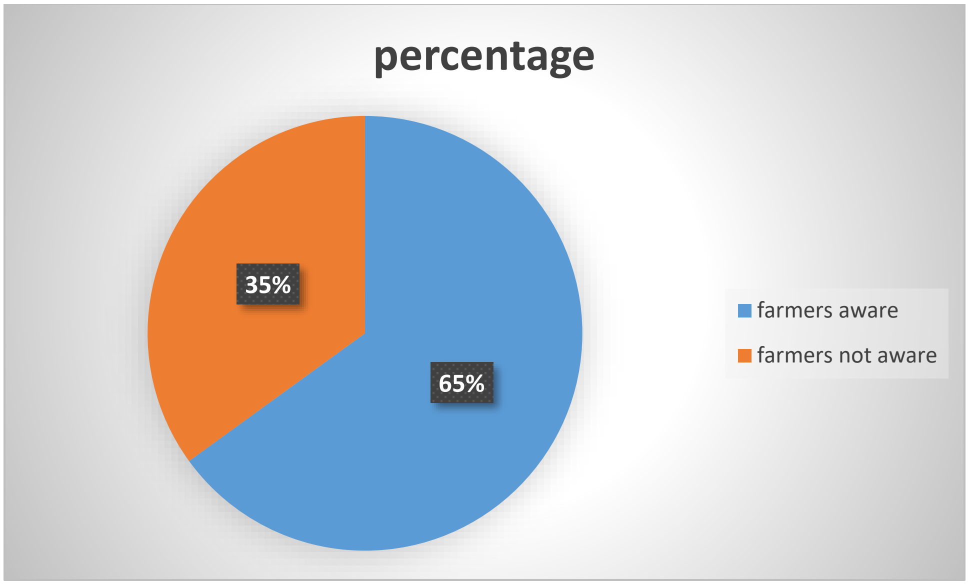

Figure 1: A pie-chart showing the percentage of farmers who are aware and those who are not aware of CBSD.

4.5. Prevalence of disease signs and symptoms.

Signs and the symptoms of the cassava brown streak disease were also investigated and among the farmers who were consulted, I found out that those who were aware of the disease also had some knowledge about the signs and the symptoms of the cassava brown streak disease. The following information concerning the signs and symptoms were presented in the table 4 below

.Table 3: Signs and symptoms of CBSD.

Signs and symptoms	**Frequency**	**Percentage (%)**
Brown streaks on leaves	16	52
Yellowing of leaves	22	71
Stem lesion	12	39
Root necrosis	12	39
Internal tuber necrosis	9	29
Leaf mosaic	20	65

From the table above, yellowing of leaves were found to be the most frequently observed signs and symptoms on the infected cassava plant with a frequency of 22, which constituted 71%, followed by leaf mosaic, with a frequency of 20 which constituted to 65%, the brown streaks on leaves with a frequency of 16(52%), leave lesion and root necrosis with the same frequency of 12(39%), and lastly internal tuber necrosis with frequencies 9(29%).

4.6. The extent of damage caused by the cassava brown streak disease.

Affected parts of the cassava plant was identified per Parish and presented on the table below. The parts investigated included the leaf, stems and the tubers as shown in the table below.

Table 4: The extent of damage of different parts of the cassava plant.

Parishes	Parts of plant	Severity (extent of damage)	Scores	Frequency(average)	Percentage (%)	Average percentage
Petta	Leaves	Severe	3	2	50	33.3
	Stems	Mild	1		17	
	Tubers	Moderate	2		33	
Pakoi	Leaves	Moderate	2	1.7	33	27.7
	Stems	Mild	1		17	
	Tubers	Moderate	2		33	
Mbula	Leaves	Moderate	2	1.3	33	22.3
	Stems	Mild	1		17	
	Tubers	Mild	1		17	

According to the table above, leaves were the most affected part with a score of 3, 2 and 2 with a percentage of 50%, 335 and 33% in Petta, Pakoi and Mbula parishes respectively, followed by the tubers which were moderately affected with a score of 2(33%) in Petta and Pakoi parishes, and 1(17%) in mbula parish. The least affected plant part was the stem which had a score of only 1(17%) in all the studied areas. This result indicated that leaves are more vulnerable to CBSD virus

Since leaves are the plant part concerned majorly with photosynthesis, poor yield of the tubers is directly related to its infection.

4.7. Control strategies used by the farmers for controlling cassava mosaic disease.

The control strategies of cassava brown streak disease were also examined and the result compared per parish. The results showed that farmers who had some knowledge on the CBSD also had knowledge on how to control. They were able to mention some of the control measures employed to control the disease and among the strategies mentioned are; **use of resistant varieties, uprooting the infected plants (Rogueing) and burning them, use of clean planting materials a4nd cultural practices like intercropping.** Use of insecticides and pesticides were mentioned by only two farmers. All the strategies mentioned were presented in the table in table as shown below.

Table 5: frequency of the control strategies used for controlling CBSD in Petta Sub County.

Control strategies mentioned	**Pakoi parish**		**Petta parish**		**Mbula parish**	
	Frequency	**Percentage (%)**	**frequency**	**Percentage (%)**	**frequency**	**Percentage**
Resistant varieties	20	65	17	55	24	77
Uprooting infected plants	11	35	8	26	9	29
Clean planting materials	16	51	9	29	13	43
Cultural practices	05	16	3	10	9	29

Use of pesticides and insecticides	2	6	04	13	06	19
Little idea about the control measures	14	45	18	58	9	29

According to the results on table above, the use of resistant cassava varieties was found to be the most employed strategy for preventing and controlling CBSD in petta sub county with a frequency of 20(65%), 17(55%), and 24(77%) in Pakoi, Petta and Mbula parishes respectively. The least employed control strategy was the application of pesticides which had the lowest frequencies as shown in the table 6 above.

4.7.1. Effectiveness of the control strategies used.

I also collected and analyzed data about the effectiveness of the most used strategies employed to control CBSD and the following results were obtained and presented as shown in the graph below.

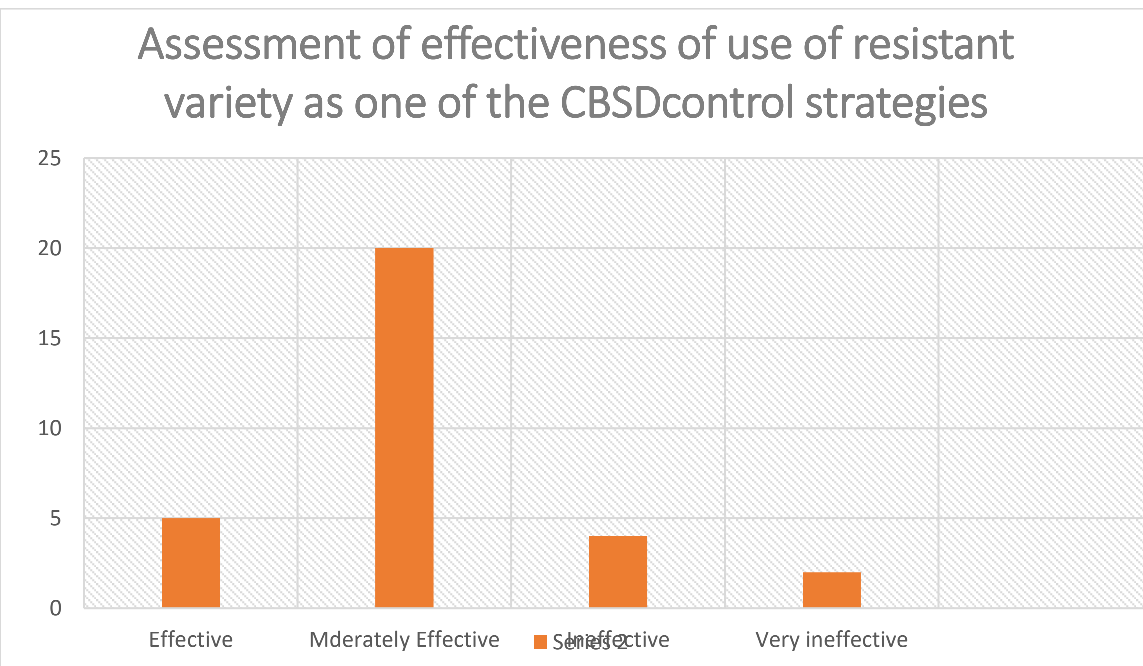

Figure 2: assessment of the effectiveness of the use of resistant varieties of cassava as a strategy of control.

According to the graph above, there were 5 respondents (16%) who said that the method works effectively, 20 farmers (65%) said that the method is moderately effective because the method would be used but they could still find some signs and symptoms of CBSD on the new cassava variety which they thought was resistant. 4 farmers (13%) said that the method employed is ineffective and only 2 farmer (6%) said that the method is very ineffective.

4.8. Challenges faced by cassava farmers in Petta Sub County.

The effectiveness of different CBSD control strategies was moderate including the use of resistant cassava varieties due to various challenges faced by the farmers while implementing these strategies. The challenges mentioned during this research study were presented in the table 7 as below.

Table 6: challenges faced by cassava farmers in Petta subcounty.

Type of challenge	**Frequency**	**Percentage (%)**
Lack of access to resistant cassava variety	10	32
Little knowledge of the disease signs and symptoms	14	45
Poor garden management	15	48
Lack of training on how to control the disease	21	68

This revealed that lack of training of farmers on how to deal with cassava CBSD was the major challenge faced by the cassava farmers of Petta sub county with a frequency of 21(68%). This was due to a very big gap given between the local farmers and the agriculture training organizations like NARO. The new resistant cassava species was given to farmers in 2016, but farmers were not trained on how to manage the cassava plantation and deal with any unexpected threat that would contribute to poor yield.

15 farmers (48%) said that poor garden management was another challenge faced. This was due to laziness and little time given to the cassava plantation in the cassava fields. They also said that it is very hard to uproot all the infected plants in the garden since this can lead to food shortage per the growing population. Therefore, their hopes were that the plants though infected, can provide them some food to sustain the large population. 14 farmers (45%) also said that the challenges they face was the little knowledge of the CBSD signs and symptoms. They said that since they could not identify the infected plants, they were unable to separate them from the normal plants in the garden and this could have led to the increased spread of the disease in the area.

Only 10 farmers (32%) talked of lack of access to the resistant cassava varieties "since this was given to only known individuals in the sub county" said one of the farmers in Petta Pakoi Parish.

4.9. Suggested solutions to the challenges mentioned.

Despite the challenges mentioned above, farmers also suggested some solutions to the challenges they are facing in Petta Sub County. The suggested solutions to the problems faced were presented in the table below.

Table 7: suggested solutions to the challenges.

SOLUTIONS SUGGESTED	**FREQUENCY**	**PERCENTAGE (%)**
Provision of free resistant cassava varieties to all farmers without selecting	28	90
Training of farmers on how to handle cassava mosaic disease (education and awareness)	19	61

Provision of pesticides and insecticides that can work on cassava	9	29
Demonstration services by the National Agriculture Research Organization. (NARO)	11	35

Most farmers 28(90%) said that the government through NARO should provide them with free resistant cassava species randomly, as this will eliminate the discrimination nature of the leaders during provision of the available planting materials. 19 farmers (61%) suggested that the government should put more emphasis on training young and incompetent farmers about the control of CBSD.

The provision of demonstration centers and services to the village farmers who are illiterate so that they learn by seeing. Provision of pesticides and insecticides were also mentioned by only 9 farmers (29%) who said that it would be Beter to apply insecticides and pesticides to ensure plant health.

4.9.1.0 Data analysis.

4.9.1.1. Checking for Hypothesis one

In order to analyze the hypothesis that there is no significant difference in the effects of CBSD on cassava production in Petta sub-county and that There is significant difference in the effects of CBSD on cassava production in Petta sub-county, a one-way ANOVA Excel Add-ins were used and the data obtained were tableted as below.

Table 8: ANOVA analysis of the extent of damage caused by CBSD in Pakoi, Petta and Mbula parishes.

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
pakoi	10	23	2.3	0.455556
petta	10	23	2.3	0.233333
mbula	10	22	2.2	0.4

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.066667	2	0.033333	0.091837	0.912538	3.354131
Within Groups	9.8	27	0.362963			
Total	9.866667	29				

4.9.1.2. Checking for Hypothesis two

In order to analyze that there is no significant difference on farmer's current knowledge, altitude and practice regarding CBSD management in petta Sub County and that there is significant difference on farmer's current knowledge, altitude and practice regarding CBSD management in petta Sub County, a one-way ANOVA Excel Add-ins were used and the data obtained were tableted as below.

Table 9: ANOVA analysis* on farmer's current knowledge, altitude and practice regarding CBSD management *in Pakoi, Petta and Mbula parishes in petta sub-county

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
pakoi	10	23	2.3	1.566667
petta	10	22	2.2	3.066667
mbula	10	21	2.1	1.433333

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.2	2	0.1	0.049451	0.951838	3.354131

Within Groups	54.6	27	2.022222
Total	54.8	29	

4.9.1.3. Checking for Hypothesis three

In order to analyze that there is no significant difference on the factors contributing to the spread and severity of CBSD in petta Sub County and that there is significant difference on the factors contributing to the spread and severity of CBSD in petta Sub County, a one-way ANOVA Excel Add-ins were used and the data obtained were tableted as below.

Table 10: ANOVA analysis on the factors contributing to the spread and severity of CBSD ***in Pakoi, Petta and Mbula parishes in petta sub-county***

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
pakoi	10	16	1.6	0.266667
petta	10	16	1.6	0.488889
mbula	10	13	1.3	0.233333

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.6	2	0.3	0.910112	0.414473	3.354131
Within Groups	8.9	27	0.32963			
Total	9.5	29				

5.0. CHAPTER FIVE: DISCUTION, CONCLUTION AND RECOMMENDATIO

5.1. DISCUSSION

5.1.1. General characteristics of the respondents.

The number of cassava farmers varied from parish to parish with Pakoi parish having 32%, Petta Ayago parish 35% and Mbula parish 32%. The majority of farmers are aged between 29-35 years (table 2). This means that cassava farming in the area is dominated by the young farmers possibly due to reduced rural-urban migration. The farmers were found to have had experience in cassava farming since all the respondents interviewed had spent more than three years in cassava production. About 62% had spent 15 years and 38% of the farmers had spent more than 30 years in cassava production. This shows that interest in cassava production was gradually increasing over the years. This was probably because people had realized that cassava is one of the major sources of food for the majority in the area.

The majority (59%) of the respondents were males reflecting that male farmer dominates in cassava production. This is possibly because cassava is a stable food crop too many families and men being the head of the households, concentrates on its production as a major food source. According to the results above, 39% of the respondents were illiterates, 26% ended in primary. Secondary education level were 23% and tertiary education levels had only 13% of the farmers interviewed. The low level of education in the study area could also have contributed to the unlimited youth’s participation in agriculture. This shows that cassava farming is mainly undertaken by the less educated.

The majority of the respondents (71%) were married, 13%widowed and only 16% were found to be single. This indicated that most of the respondents were people with families and has mush need for food supply in order to fight food insecurity in families as well as in the country. This is in line with study by (Baguma, 1994) which stated that production of cassava can help prevent food insecurity in a country.

5.1.2. Cassava species grown.

Majority of the respondents grow NAROCAS 1 species (65%). The purpose was mainly for food and to a small extent, for money. Another species grown was MAGANA and NIGERIA species that had 29% and 6% of the species grown. It was also found out that NAROCAS1 dominates in the area. Many farmers explained that it is because of its high yielding capacity and resistance to diseases including the CBSD to a small extent.

5.1.3. Signs and symptoms of CBSD

Yellowing of cassava leaves was the most observed disease sign encountered on an infected cassava plant (71%), followed by leaf mosaic on the leaves (65%), brown streaks on leaves (520, stem lesion and root necrosis (39%), and internal tuber necrosis (29)%. This implied that leaves and stems are more vulnerable to cassava mosaic disease.

Figure 2: showing signs of CBSD on cassava leaves.

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figure 3: showing the signs of CBSD on cassava stem

Figure 4: showing signs of CBSD on cassava tubers.

5.1.4. Extent of damage caused by CBSD on cassava plants in the study area.

A scoring tool was employed to estimate the extent of damage caused by the disease on different parts of the cassava plant and the parts examined were the leaves, stems and the tubers.

Leaves had the highest extent of damage with a frequency of (50%), followed by the tuber with a frequency of (33%) and the least affected plant part was the stems which was found to be mildly damaged (17%) in all the parishes visited. The analyzed data showed that the Alternative hypothesis stands since the p-value (0.442284) is greater than the significant level (0.05), which proved that there is no significant difference in the damages caused by the CBSD on the cassava plant in farmers' garden in Petta sub-county.

5.1.5 Control strategies.

Most of the farmers had knowledge about some of the control strategies while some farmers were found to have no idea about the CBSD control strategies.

Use of resistant cassava varieties was the most used strategy for controlling CBSD in the study area which constituted 33%. This was followed by uprooting of the infected cassava plant also known as rogueing 18%, use of clean planting materials was also mentioned with 13% and cultural practices like intercropping with only 3%. Other suggested measures were timely planting to avoid whitefly vector infestations, growing more than one variety on the same field to minimize the risk of total crop loss and application of insecticides in attempt to control the disease and close spacing. The analyzed data gave a p-value of (0.912538), which is greater than the significant level (0.05). This shows that the alternative hypothesis cannot be rejected and proved that there is significant difference in the effects of CBSD on cassava production in petta Sub County

5.1.6. Challenges faced by farmers in cassava production.

The main constraints to cassava production in the study area were lack of access to resistant cassava varieties, little knowledge of the disease signs and symptoms, poor garden management and lack of training on how to control the disease. This study revealed that lack of training of farmers on how to deal with CBSD was the major challenge faced by the cassava farmers of Petta sub county with a frequency of 21(68%). This could be due to a very big gap given between the local farmers and the agriculture training organizations (Okello, 2020). The new resistant cassava species was given to farmers in 2016, but farmers were not trained on how to manage the cassava plantation and deal with any unexpected threat that would contribute to poor yield.

15 farmers (48%) said that poor garden management was another challenge faced. This could be due to laziness and little time given to the cassava plantation in the cassava fields. They also said that it is very hard to uproot all the infected plants in the garden since this can lead to food shortage per the growing population. Therefore, their hopes were that the plants though infected, can provide them some food to sustain the large population. 14 farmers (45%) also said that the challenges they face was the little knowledge of CBSD signs and symptoms. They said that since they could not identify the infected plants, they were unable to separate them from the normal plants in the garden and this could have led to the increased spread of the disease in the area.

5.1.7 Solutions to the challenges.

Some of the suggested solutions to the prevailing problems facing cassava production in Petta Sub County as presented by this study results were, provision of free resistant and clean planting materials to all farmers randomly. This was also mentioned in the study by ((Baguma, 1994)).

Farmers also suggested training on how to handle CBSD, and demonstration services to be provided to the local farmers as this can give a direct skill since most of the farmers are illiterate who cannot read and write. Provision of pesticides and insecticides were also mentioned by only farmers who said that it would be better to apply insecticides and pesticides to ensure plant health other than rogueing.

5.2. Conclusion.

Based on the findings of this study, cassava production provides for most of the livelihood of farmers of Petta Sub County since all farmers were found to be a year-round cassava producer. It was found to be the major source of food and money to illiterate farmers of the area. This study however revealed that there is a high extent of damage caused by the CBSD on the cassava plants in this area since the analyzed data showed significant difference on the extent of damage between the three compared data sets from different parishes. The p-value obtained (0.912538) was greater than the significant level (0.05) which supports the hypothesis of the study.

Leaves were the severely damaged plant part (50%), followed by tubers (33%) and the least affected plant part were the stem with only (17%). This information indicated that the leaves and the tubers are the most vulnerable parts of the plant to cassava mosaic disease.

In order to curb the damage caused by CBSD, 90% of the farmers suggested the use of resistant varieties of cassava. 19 farmers (61%) suggested that the government should put more emphasis on training young and incompetent farmers about the control of CBSD. 11 other farmers (35%) also suggested the provision of demonstration centers and services to the village farmers who are illiterate so that they learn by seeing. Provision of pesticides and insecticides were also mentioned by only 9 farmers (29%) who said that it would be better to apply insecticides and pesticides to ensure plant health. (15%)of the farmers were found to have no idea concerning the cassava mosaic disease control measures though the analyzed data agreed with the null hypothesis that there exist control strategies for CBSD in Petta sub county with a p-value of (0.090334) when compared to the significance level of 0.05

The effectiveness of the control strategies was found to be moderate since the disease persistence is high in the area and this calls for more improvement in the methods and technologies for controlling and eliminating the disease in the area.

5.3. Recommendation.

Based on this study result, I recommend the following;

There is a need to improve on the control strategies used by the cassava farmers.

There is a need for thorough training of the local farmers on how to identify signs and symptoms, and to manage their cassava plantations to ensure awareness of the disease and its management.

Farmers needs to be sensitized on the modern strategies of controlling CBSD.

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APPENDICES

Appendix 1: questionnaire.

BUSITEMA UNIVERSITY

FACULTY OF SCINCE AND EDUCATION

AGRICULTURE DEPARTMENT

Am Opio Patrick a student of Busitema University, as per requirement of the university we are supposed to carry out Research and now am carrying out research on the topic "The effects of cassava Brown Streak Disease on cassava production which am seeing as a threat in our sub-+county? I promise after my research, it will help the extension worker in this sub-county to manage the effect of this serious cassava disease.

The information which I will get will only be used for research purpose and will be treated with confidentiality.

INTRUCTION FOR THE PARTICIPANTS

You tick in the box where you belong

Section 1: Bio-data

1. What is your age?

a) 18-23 ☐ c) 29-35 ☐

b) 24-28 ☐ d) 36-60 ☐

2. What is your gender?

a) male ☐

b) Female ☐

3. What is your level of education?

a) Primary ☐ b) secondary ☐

c) Higher institutions ☐

4. How many years have you been involved in cassava farming?

a) 1- 5 ☐ c) 5-10 ☐

b) 10-15 ☐ d) 15 and ☐ove

Section 2: Impacts of Cassava Brown Streaks Disease on Cassava Production

1. Have you experienced a decrease in cassava yield due to Cassava Brown Streaks Disease?

a) Yes ☐

b) No ☐

2. How has the quality of cassava tubers been affected by the disease?

a) Good ☐

b) Bad ☐

3. Have you faced economic losses as a result of Cassava Brown Streaks Disease?

a) Yes ☐

b) No ☐

4. Has the disease affected the availability of planting materials for cassava?

a) No ☐

b) Yes ☐

Section 3: Farmers' Knowledge and Practice Regarding Cassava Brown Streaks Disease Management

1. Are you aware of the symptoms of Cassava Brown Streaks Disease?

a) Yes ☐

b No ☐

2. What methods do you currently use to manage Cassava Brown Streaks Disease?

a) Cultural method ☐

b) Integrated pest management ☐

c) Biological method ☐

d) Chemical method ☐

3. Have you received any training or extension services on disease management?

a) Yes ☐

b) No ☐

4. Do you regularly monitor your cassava plants for signs of the disease?

a) Yes ☐

b) No ☐

Section 4: Factors Contributing to Spread and Severity of Cassava Brown Streaks Disease

1. Do you rotate your cassava crops with other plants?

a) Yes ☐

b) No ☐

2. Do neighboring farmers also experience Cassava Brown Streaks Disease?

a) Yes ☐

b) No ☐

3. Do you use certified disease-free planting materials for cassava cultivation?

a) Yes ☐

b) No ☐

4. Are there any wild cassava plants near your farm that could harbor the disease?

a) Yes ☐

b) No ☐

Section 5: Mitigating the Effects of Cassava Brown Streaks Disease on Cassava Production

1. Have you adopted any resistant or tolerant cassava varieties?

a) YES ☐

b) No ☐

2. Do you practice proper sanitation and removal of infected plant material?

a) Yes ☐

☐

b) No

3. Have you sought advice from agricultural experts on disease management strategies?

a) Yes ☐

b) No ☐

4. Are you willing to adopt new practices to mitigate the effects of the disease on cassava production?

a) Yes ☐

b) No ☐

Thank you so much for your time and participating in my research work