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Research Application Summary

The existence and distribution of cassava bacterial blight in East Africa

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Abstract

Cassava bacterial blight is one of the major bacterial diseases in all cassava growing regions in the world. The disease is caused by *Xanthomonas axonopodis PV. Manihotis*, a gram-negative rod shaped and belongs to the Gammaproteobacteria. The disease is only found in plants belonging to the Manihotis family. A lot of studies and advances have been made on the disease and surveys done to show the presence of the disease in the various parts of the world. Various detection method of the pathogen in the plant materials and in the seed is being worked on as a measure to be able to manage the pathogen through clean materials. The review shows how the disease is spread in Kenya Africa and the world and what are the copping strategies for managing the disease. The disease has been there in Kenya for more than 3 decades but less documentation has been done on the losses that the disease has in the country although damages in other countries like Nigeria and D.R.Congo has been done. Many farmers have not been empowered to know the disease and hoe they can manage the disease a factor that is contributing to the recent increase in the prevalence of the disease in cassva growing areas. Research institutions like IITA and CIAT have done a lot of work in cassava and tried to recommend management of the diseases through various scientists. Though no epidemics for the disease has been reported in Kenya but surveys done show there is an increase in the prevalence of the disease a factor that might lead to future epidemics hence the need for awareness and its occurrence in the country.

Key words: AFLP, cassava bacterial blight, East Africa, PCR, Xam, Xac

Résumé

La brûlure bactérienne du manioc est l'une des principales maladies bactériennes dans toutes les régions productrices de manioc du monde. La maladie est causée par Xanthomonas axonopodis PV. Manihotis, une tige gram-négative en forme et appartient aux Gammaproteobacteria. La maladie ne se trouve que dans les plantes appartenant à la famille Manihotis. De nombreuses études et avancées ont été faites sur la maladie et des enquêtes ont été effectuées pour montrer la présence de la maladie dans les différentes parties du monde. Diverses méthodes de détection de l'agent

pathogène dans les matières végétales et dans les semences sont en cours d'élaboration afin de pouvoir gérer l'agent pathogène à l'aide de matières propres. L'examen montre comment la maladie se propage au Kenya, en Afrique et dans le monde et quelles sont les stratégies de réduction pour gérer la maladie. La maladie existe au Kenya depuis plus de 3 décennies, mais moins de documentation a été faite sur les pertes que la maladie a dans le pays, bien que des dommages aient été causés dans d'autres pays comme le Nigéria et la République démocratique du Congo. De nombreux agriculteurs n'ont pas été autorisés à connaître la maladie et ils savent comment gérer la maladie, un facteur qui contribue à l'augmentation récente de la prévalence de la maladie dans les zones de culture du manioc. Des institutions de recherche comme l'IITA et le CIAT ont fait beaucoup de travail sur le manioc et ont essayé de recommander la gestion des maladies par le biais de divers scientifiques. Bien qu'aucune épidémie de la maladie n'ait été signalée au Kenya, les enquêtes réalisées montrent qu'il y a une augmentation de la prévalence de la maladie, un facteur qui pourrait conduire à de futures épidémies, d'où le besoin de sensibilisation et sa présence dans le pays.

Mots clés: AFLP, brûlure bactérienne du manioc, Afrique de l'Est, PCR, Xam, Xac

Introduction

Cassava, *Manihot esculenta,* is a major crop in the tropics and it is grown as a famine reserve crop by small holder farmers. It is a major source of carbohydrates and starch to rural households. The crop withstands low rainfall conditions therefore remaining a reliable source of food during drought and hunger season, when other seasonal crops are not ready. In Africa cassava is grown by millions of resources limited farmers including women and those living on marginal land. Nigeria remains the leader in cassava production in Africa. Cassava has the potential to increase food, farm incomes, reduce rural and urban poverty and help close the food gap. In Kenya the crop is produced by small scale holders with high volumes in western Kenya followed by coastal Kenya.

Cassava production is largely reduced by biotic constrains (Hahn *et al.,* 1989) among which diseases are of high importance. Major cassava diseases in Africa include cassava mosaic diseases, cassava bacterial blight cassava rots and stem rots, anthracnose disease and Cercospora leaf disease. Yield loses due to Cassava bacterial blight was estimated at 75 tones (CIAT, 1996). The disease can result to 100% yield loss if no management practices are put in place and the favorable conditions prevail. Death of leaves and stems is encountered when epidemics occur. It leads to lose in steam cuttings, leafy vegetables and the roots.

This paper gives an overview of the disease distribution in East Africa and other parts of the world, including the occurrence of the pathogen in Kenya; the farmers involved, the cassava crop farming, prevalence of the disease in recent times and some work done in other countries across Africa. Institutional support to farmers in managing the disease is also discussed. Advances in detection techniques and any genetic variability in the pathogen strains as reported in previous studies is also presented.

Cassava bacterial blight

Cassava bacterial blight is caused by the pathogen *Xanthomonas axonopodis* pv. *manihotis* and it is the most wide spread bacterial disease of cassava (ref).The disease was first reported in Brazil in 1912 and from that time it has spread to all cassava growing regions in Asia, Africa and Latin America (Lozano,1986). In Africa the disease was first reported in Madagascar in 1946 .The pathogen only affects members of the genus *Manihotis* (Lozano, 1986). Currently, the disease is extensively distributed in Asia, Africa and South America. The disease spreads from one area to another through the infected planting stakes, tools, insects and rain splash.

Colony description. The bacterium grows on sucrose containing media where it produces non pigmented colonies, and it is a gram negative rod shaped bacterium with a single polar flagellum. It measures 0.5 x 1.0 mm. Most of its physiological and biochemical characteristics are similar to those of Xanthomonads (Kreig and Hold, 1984; Ongujobi *et al*., 2010).

Epidemiology.The entry points of the bacteria into the plants are normally stomatal openings and epidermal wounds. Artificial inoculation experiments have shown that establishment of the bacteria requires at least 12 hours at 90-100% relative humidity with an optimum temperature of 22-26^{0}C (Lozano, 1986) Infection is common in young plant tissues and in most susceptible cultivars, the pathogen causes extensive break down of parenchymatous tissues (Lozano, 1986).

Etiology. Infection begins with the multiplication of the pathogen as an epiphyte, occurring usually near the stomata. Leaves are penetrated through stomata openings or wounds. Twelve hours of high relative humidity is sufficient for bacterial establishment. The most appropriate temperature for infection is approximately 23^{o}C. The pathogen establishes itself inside the vessel after a preliminary phase of intercellular development in the mesophyll. If the pathogen invades lignified stems, it remains within the vascular tissues where it can survive for up to 30 months (Lozano, 1986).

Symptoms . *Xanthomonas axonopodis* pv *manihotis* am is a systematic pathogen and an epiphyte. The pathogen induces a combination of a wide range of symptoms which makes the pathogen unique among other plant pathogenic bacteria. Symptoms are expressed on the leaves, on the stem, on fruits and petioles as follows: appearance of the water soaked lesions on leaves of infected plants which often start along the veins, margin and tips of leaf blades. As the disease develops neighboring spots join together to form large brown patches or blights killing the leaf blade as it expands. The leaf dries or wilts and finally falls. Creamish or yellowish gummy exudates are discharged on leaves or stems but often distinctively on leaf petioles of infected plants. Petioles of blighted leaves are often horizontally orientated to the main stem axis. In advanced stages of the disease, dieback of stems is common and new shoots are often seen developing from dead ends of stems of severely infected plants.

Cassava bacterial blight pathogen is related to Cassava bacterial angular leaf spot

pathogen since they come from one genus and they have almost similar symptoms on the plants which are confusing and need a clear eye observation to differentiate. The disease is characterized by presence of water soaked, angular spots on leaf lobes where small gummy drops of exudate may be observed While these characteristics are similar to those of bacterial blight, the bacterial angular spots are generally restricted to the foliar system. The pathogen sometimes invades stem buds and young branches via the phloem. Infected leaves show initially lesions surrounded by yellowish halos which coalesce inducing yellowing of the whole leaf. Leaves fall prematurely causing plant defoliation.

Distribution in other countries

The pathogen *Xanthomonas axonopodis* pv *manihotis* is widely distributed and is found in all cassava growing areas. The pathogen has been known in Latin America since 1912 when it was reported in Brazil. In the 1970s the disease spread to Africa and Asia (Boher and Verdier, 1994). The pathogen is widspread in Africa, Asia and Latin America according to CABI mapping of the presence of the disease. In Africa it causes severe epidemics (Hillocks and Waydra, 2002). In Nigeria the disease was reported by Williams *et al*. (1973), in DR. Congo by Daniel *et al*. (1980) and in Sudan by Kwaje (1984).

In Africa it is more prevalent in the Savannah and the forest Savannah transitions zones than in the forest zones. The pathogen strains also vary with ecological zones. The pathogen is found in Oceania, South America, Central America, Caribbean, North America and Asia. In Africa the pathogen has been reported in 24 countries (CABI map). In Kenya it was documented by Mukunya in 1982.

There is increased attention from the government and non-governmental organizations on cassava as a staple food crop which has led to a lot of work being done on the disease affecting cassava. Reports show that the disease is already widely established. Surveys have been conducted to ascertain the presence and prevalence of the disease in various African countries and worldwide. In some areas the spread is rapid and this is attributed to exchange of planting materials among farmers. The pathogen has not been reported from the countries in the Southern Pacific.

Why it is becoming more prevalent?. Cassava is being advocated for as a climate smart crop and a crop that can be used to industrialize the economy of Kenya and the world at large. Many institutions, NGOs and County governments in Kenya are supporting farmers to access the materials and increase the crop production volumes. But most of these materials are not certified and tested for the purity from the pathogen *Xanthomonas axonopodis* pv *manihotis*. Most of the materials being shared are infected with the pathogen and the origin sources of the materials have not been confirmed to be free from the pathogen.

Farmers have not accessed resistant varieties to the pathogen and most of them lack knowledge on the disease. As such they continue sharing unkowingly infected materials among themselves as the interest for growing cassava increases, especially in Kenya where cassava is being promoted to curb food insecurity in the zones declared as food

insecure by the government.

Detection techniques. For better management of the disease detection is critical. Detection deals with establishing the presence of particular target organisms within a sample with special emphasis on symptomless individuals. The pathogen *Xanthomonas axonopodis* pv *manihotis* can survive in plant tissues without causing the symptoms hence requiring better detection methods. Plant pathogenic bacterial remain latent in the planting material and in very low numbers, and as such methods of high sensitivity, specificity and reliability are required. Proper and rapid diagnostic methods for detection are necessary in planting material propagation units or nurseries. There are a number of techniques involved in detection of plant pathogenic bacteria. For cassava diseases there is still development of techniques being done and some protocols have been documented for detection of the pathogen *Xanthomonas axonopodis* pv *manihotis*. *Xanthomonas axonopodis* pv *manihotis* is closely related to *Xanthomonas axonopodis* pv *cassavae* causing bacterial angular leaf spot in cassava and this makes it difficult to distinguish them, requiring separate detection for each.

Detection can be done in plant materials and in vectors. The grass hopper *Zonocerus variegatus* that has been found to transmit the pathogen (Waydra, 2006). It is only through better detection methods of the pathogen in materials that will enhance sustainable farming of cassva. Detection techniques have evolved significantly in the last few years to achieve rapid and reliable detection of the pathogens. Serological and molecular techniques are currently used in the analysis of many plant samples. In molecular techniques purification of nucleic acid from the pathogen is being adopted. The various PCR techniques, that are simple and multiplex PCR, nested PCR in a single closed tube, co-operative PCR and real time monitoring of the amplicons are being refined. The latest advancements in the use of microarray technology which requires DNA and RNA extraction are being adopted.

Detection methods of the day involve: Serological detection techniques that entails use of specific monoclonal and recombinant antibodies, Enrichment ELISA protocols, on site testing tissue sprint ELISA and lateral flow devices, and Flow cytometry. Techniques reported to have been applied include: AFLP Finger printing which has been used in detecting genetic variation of Xam in Colombia; detection using PCR has been used in Columbia to detect various strains of the pathogen on cassava leaves and stem lesions.

Management of the disease

The pathogen has been reported to cause yield losses of up to 100% when no measures are put in place and in conducive environment. Losses estimated from the disease infection on cassava annually in Africa is 7.5 million tons (CIAT, 1996). Losses of up to 75% and 90 -100% have been reported in Nigeria (Otime Nape, 1980). Cuttings obtained from infected fields are likely to be lost upto 80% by the third season of production (Rastrepo and Verdier, 1997). Therefore there is need for integrated management practices in order to reduce losses. Management involves cultural

practices, varietal resistance, biological control, and sanitation measures.

Cultural practices. Crop rotation to disrupt the lifecycle of the pathogen and burning of infected crop residues are important disease management practices (Lozano,1986). Weeding to control bush fallow around the crop and control the vectors (Fanoul *et al*., 1998), and eliminates weeds that grow naturally in cassava plantations also reduce the disease occurence (Lozano, 1986). Adjustment of planting time is done to avoid the peak time of the epidemic by shifting planting date towards the end of the rainy season (IITA, 1998). This also gives a plant an opportunity to accumulate pectin and cellulose that help plants develop resistance to Cassava bacterial blight (Lozano, 1986). In already infected plants pruning can be done to remove the infected portion so as to minimize the spread of the disease to the healthy part of the plant (Lozano, 1986). The pruning part should be well handled not to spread the pathogen and well-disposed or burnt.

Sanitation. The exchange of infected cassava cuttings is the major means of disseminating cassava pathogens and pests (Lozano, 1986). Therefore sanitation measures are important in the exchange of materials and this can be achieved through quarantine regulations to ensure that the risk of disseminating the pathogen through propagative material is eliminated. Use of healthy certified materials can be adopted. Growing clean material in controlled environments can help in producing the pathogen free crops.

Early detection using PCR based diagnostic test which is sensitive to the level of 10x 22 cfu ml^{-1} in stems and leaf tissues (Verdier *et al*., 1998) will help in disseminating clean materials free from the pathogen. Planting can be done in fields proved to be free from the pathogen. One should also control any movement of humans, tools and animals in the field after rain (Lozano, 1986) as this will help in controlling spread of the pathogen.

FAO IBPGR technical guidelines for safe movement of cassava germplasm can be followed during exchange of germplasm (Frison and Feliu, 1991). This is helpful in exchange of materials from one region to another. Farmers should be assisted in selection of healthy stems when making cuttings (Thresh *et al*., 1994); the nurseries to supply cuttings should be cited in areas far from farms pathogenic pressure. Production and distribution of high quality disease-free cuttings (Lozano and Wholey, 1974) has been succeessful in South America.

The use of resistant varieties. Use of resistant varieties is the best control measure (Lozano and Sequeira, 1974) and also the cheapest and most convenient to farmers, but needs to be done in continuation with other management practices. IITA has developed some resistant varieties although resistance is lost over time and requires periodic selection after testing with virulent strain. Farmers can be engaged in production and distribution of landrace varieties known to be resistant to the blight.

Modification of cultural practices. Improvement of crop nutrition through addition of organic matter to soil and rotation with legumes is also recommended. Phosphorus fertilizers have been shown to increases resistance to *Xanthomonas axonopodis* pv

manihotis (Boher and Verdier, 1994).

Physical treatment. Treating stakes by immersing them for 10 minutes in a solution of cupric fungicide such as copper oxychloride or orthocide captan at 3 to 6 gram per liter is recommended. Another physical method used is heat treatment of stakes (CIAT, 2007) using hot water at 49 ^{0}C for 49 minutes.

Biological control. Spraying with suspensions of *Pseudomonas putida* has been used to reduce severity of damage and the cassava yields increased significantly (CIAT, 1985).

Conclusions

Cassava bacterial blight is of great economic importance especially in Kenya where cassava is ranked the third most important food crop after maize and rice. The stakeholders both in the Government and research institutions should pay attention to understanding and managing the disease to avoid future epidemics that might occur in areas where the crop has been widely adopted. Awareness raising should be done and mapping of the areas affected done and the areas not affected used to propagate the varieties that show resistance to the disease. This review shows that there is much still to be done to detect the disease including production of clean planting materials which farmers can access. Sustainable cassava farming will depend on capacity building for farmers and support for healthy seed production systems in Kenya.

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