

Research Application Summary

Isolation distance as a phytosanitation option for cassava clean seed multiplication in Uganda

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Abstract

Cassava brown streak disease (CBSD) caused by cassava brown streak viruses and cassava mosaic disease (CMD) caused by different species of cassava mosaic geminiviruses (CMGs) are the two major viral diseases constraining cassava production in Uganda. Both diseases are spread through cuttings and are transmitted by whiteflies *Bemisia tabaci*. A number of phytosanitation strategies including isolation distances have been used to control these two cassava viral diseases. However, the minimum isolation distance has not been verified for effective virus control in the major cassava growing agro-ecologies and the quality of cassava seed remains a challenge in Uganda. In order to ensure that seed multipliers produce clean cassava seed in isolated fields to prevent infections before planting materials are provided to farmers, there is need to test different isolation distances in major cassava growing agro-ecological areas in order to establish the effective isolation distance for the management of CBSD and CMD as different areas in Uganda have different whitefly infestations and CBSD and CMD pressure. This review article presents a summary on virus status of cassava planting materials, major cassava viral disease prevalence at varying isolation distances and how phytosanitation strategies such as effective isolation distances can be an alternative option for clean seed multiplication for farmer preferred but susceptible cassava cultivars in Uganda.

Key words: Cassava brown streak disease, cassava mosaic disease, clean seed planting materials, isolation distance, phytosanitation, Uganda

Résumé

La maladie des stries brunes du manioc (CBSD), causée par les virus des stries brunes du manioc, et la maladie de la mosaïque du manioc (CMD), causée par différentes espèces de géminivirus de la mosaïque du manioc (CMG), sont les deux principales maladies virales qui entravent la production de manioc en Ouganda. Les deux maladies sont propagées par les boutures et sont transmises par les aleurodes *Bemisia tabaci*. Un certain nombre de stratégies phytosanitaires, y compris les distances d'isolement, ont été utilisées pour contrôler ces deux maladies virales du manioc. Cependant, la distance minimale d'isolement n'a pas été investiguée pour un contrôle efficace des virus dans les principales agroécologies où la culture du manioc est pratiquée et la qualité des semences de manioc reste un défi en Ouganda. Afin de s'assurer que les multiplicateurs de semences produisent des semences de manioc propres dans des champs isolés pour prévenir les infections avant que le matériel de plantation ne soit fourni aux agriculteurs, il est nécessaire de tester différentes distances d'isolement dans les principales zones agroécologiques de culture du manioc afin d'établir la distance d'isolement efficace pour la gestion de la CBSD et de la CMD, car la pression d'infestation des aleurodes et maladie CBSD et CMD varie d'une zone agroécologique à l'autre. Cet article de synthèse présente

un résumé du statut viral du matériel de plantation de manioc, la prévalence des principales maladies virales du manioc à différentes distances d'isolement et comment les stratégies phytosanitaires telles que les distances d'isolement efficaces peuvent être une option alternative pour la multiplication de semences propres pour les cultivars de manioc préférés des agriculteurs mais sensibles au maladie vegetales en Ouganda.

Mots clés: maladie des stries brunes du manioc, maladie de la mosaïque de manioc, Semences propres, distance d'isolement, phytosanitaire, Ouganda

Introduction

Cassava (*Manihot esculenta* Crantz) is an important staple food crop cultivated in many parts of Africa. The crop is a good source of food energy for majority of the people living in the lowland tropics of sub-Saharan Africa (SSA) where it is also used as an industrial raw material and a substitute in many animal feeds. In Uganda, it is grown all over the country, with the eastern and northern regions being the major producers (FAOSTAT, 2017; UBOS, 2017). Cassava production worldwide is on the decline and greatly constrained by a number of abiotic and biotic factors. However, of the biotic factors, the two major viral diseases i.e., cassava brown streak disease (CBSD) caused by cassava brown streak viruses (CBSVs) and cassava mosaic disease (CMD) caused by different species of cassava mosaic geminiviruses (CMGs) are the major constraints to cassava production leading to severe yield losses of up to 100% (Legg *et al.*, 2011; Legg *et al.*, 2014) thereby resulting into increased food and income insecurity. Both CBSD and CMD are transmitted by whiteflies *Bemisia tabaci* and also spread through cuttings, which is exacerbated by the virtue that cassava is vegetatively propagated (Maruthi *et al.*, 2005). Despite the fact that a number of phytosanitation measures have been developed and adopted to control these major viral diseases, CBSD and CMD are still the most important viral diseases prevailing in farmer cassava fields in Uganda (Legg *et al.*, 2015; Kawuki *et al.*, 2017).

The two viral diseases are prevalent in all the agro-ecological zones in Uganda and most cassava fields usually have both CBSD and CMD on the same cassava plants at the same time (Kawuki *et al.*, 2017; Kasule *et al.*, 2020). Therefore, management strategies require that both of these major viral diseases are simultaneously controlled. Breeding cassava cultivars resistant/tolerant to both diseases has been adopted as the most suitable strategy especially for the resource poor farmers in the Uganda for prevention of both CBSD and CMD (Kawuki *et al.*, 2016). However, these resistant cassava varieties are sometimes not preferred by some farmers as they are deficient in some attributes. This demands that farmers in Uganda grow cassava with a diversifying approach as opposed to directional selection of cassava varieties, which often forces farmers to grow low yielding and disease susceptible varieties but with preferred attributes like sweet taste (Kawuki *et al.*, 2017; Nakabonge *et al.*, 2018).

Phytosanitation strategies like isolation distances can offer a good alternative for the supply of clean planting materials to farmers for preferred but susceptible cassava cultivars. Farmers can obtain clean cassava planting materials from seed multiplication blocks that are established in isolated blocks that are 250 m away from other cassava fields to allow clean seed multiplication (Kasule *et al.*, 2020). Therefore, in this review article, we describe and discuss recent aspects about virus status of cassava planting materials and how phytosanitation strategies such as effective isolation distances can be an alternative option for clean seed multiplication for farmer preferred but susceptible cassava cultivars in Uganda.

Virus status of cassava planting materials. Cassava is mostly cultivated as a root tuber crop and it is propagated vegetatively using stem cuttings which act as good points of entry for diseases especially those caused by viruses (Maruthi *et al.*, 2005). Research has shown that in most of the cassava

fields in eastern and northern Uganda, the major cassava producing areas in Uganda, are severely infected with CBSD and CMD. Yet small holder farmers and large producers growing cassava in Uganda recycle and replant cassava planting materials often obtained from their own seed, friends, non-government organizations (NGOs), while few farmers obtain their cassava seed from National Agricultural Research Organizations (Kawuki *et al.*, 2017; Nakabonge *et al.*, 2018). Since cassava is clonally propagated, the exchange of planting materials among farmers in the different agro-ecologies of the country contributes significantly to increased virus accumulation and dissemination leading to the high viral disease incidences (Legg *et al.*, 2015; Kawuki *et al.*, 2016; Nakabonge *et al.*, 2018).

The situation is further exacerbated by the virtue that most of the cassava planting materials sold by most cassava seed multipliers in Uganda and those shared among Ugandan farmers are not properly checked or certified as virus free clean planting materials. This has led to an increased supply and exchange of diseased cassava planting materials among smallholder farmers growing cassava in the country (Legg *et al.*, 2011; Legg *et al.*, 2014; Nakabonge *et al.*, 2018). The recycling of cassava planting materials by cassava farmers has led to a continued increase virus presence (Maruthi *et al.*, 2005). Therefore, implementation of well experimented effective isolation distances could enable multiplication of virus free clean cassava planting materials by seed multipliers in the different agro-ecologies which can be distributed to small holder cassava farmers in Uganda thus contributing to effective management of CBSD and CMD (Kasule *et al.*, 2020). The effective isolation distance could also be adopted by cassava seed inspectors in the different agro-ecologies of Uganda.

Phytosanitation measures and clean cassava seed production. Phytosanitation often refers to approaches or strategies which aim at preventing spread of plant viruses such as CBSVs and CMGs by eliminating the sources of inoculum from which further spread of major cassava viruses can occur through the activities of the white fly vector (Thresh and Cooter, 2005; Legg *et al.*, 2015). A number of phytosanitation strategies/measures have been developed and adopted in Uganda for the sole purpose of controlling major viral diseases in cassava. Cassava mosaic disease (CMD) has been managed in many severely affected countries like Uganda through the development and dissemination of resistant cassava varieties, however, the management of cassava brown streak disease (CBSD) has been done through the implementation of technologies like treating/spraying cassava stem cuttings with insecticides in order to prevent early viral infections by targeting vectors like whiteflies (Kawuki *et al.*, 2016; Maruthi *et al.*, 2019). However, although such measures have been developed and adopted by farmers, CBSD and CMD have persisted in the pandemic affected areas. Therefore, this has called for the use of resistant/tolerant cassava varieties as the best way to manage and control CBSD.

Ugandan small holder and large cassava producers have adopted improved cassava cultivars like NASE 14, NASE 19, NAROCASS 1, NAROCASS 2, among others, which are the recently released cultivars by the cassava breeding program in the country. These recently released cultivars have excellent resistance to CMD and are tolerant to CBSD (Kawuki *et al.*, 2016; Mukiiibi *et al.*, 2019). However, different farmers prefer different cassava cultivars basing on the different attributes portrayed by such cultivars. This has led to the propagation of cultivars that are susceptible to CBSD and CMD by farmers in Uganda. Therefore, phytosanitation strategies or measures such as those involving the use of virus free cassava planting materials preferably tissue culture derived, coupled with effective isolation distances from the surrounding areas which could be potential sources of infection (Maruthi *et al.*, 2017; Kasule *et al.*, 2020). This will in turn offer an excellent potential for cassava clean seed multiplication and CBSD and CMD control for especially farmer preferred but susceptible cassava cultivars in Uganda.

CBSD and CMD prevalence at varying isolation distances. Recent research aiming at enhancing sustainable production, processing and marketing of cassava by employing phytosanitation measures has led to the establishment of an effective isolation distance for the management of CBSV and CMG

infections. Both screen house and open field experiments run in coastal Tanzania and at the Makerere University Agriculture Research Institute, Kabanyolo (MUARIK) in Uganda showed that CBSD and CMD symptoms appear on cassava plants in plots closer to spreader plants and viral disease gradient decline as the isolation distance is increased away from the CBSD and CMD spreader plants (Maruthi *et al.*, 2017; Kasule *et al.*, 2020). This explained the higher incidences and severities for both CBSD and CMD on cassava plants at the 50 m compared to at 100 m isolation distances (Kasule *et al.*, 2020). Shorter isolation distances favor whitefly semi persistent transmission mechanism for cassava brown streak viruses. Therefore, these short distances combined with high whitefly infestations in Central Uganda (MUARIK) and coastal Tanzania led to high CBSD and CMD prevalence observed (Abaca *et al.*, 2012; Kaweesi *et al.*, 2014; Maruthi *et al.*, 2017; Kasule *et al.*, 2020).

Kasule *et al.* (2020) suggested that for cassava multiplication areas that have natural barriers or those far away from other cassava fields can block the spread of CBSD and CMD if there is a 250 m isolation distance from the other cassava fields. This would simultaneously manage the spread of both CBSD and CMD. The 250 m isolation is long enough to limit a big number of CBSV- and CMG-carrying whiteflies from infecting the healthy cassava plants, thus the observed no CBSD and CMD severity and incidence at the 250 m isolation distance (Kasule *et al.*, 2020).

Clean cassava seed multiplication at effective isolation distances. Cassava seed multipliers and inspectors in Uganda are advised to promote the 250 m isolation distance which is instrumental in clean seed multiplication and production of cassava planting materials that are free from CBSV and CMG infections. Generally, CBSD and CMD prevalence is higher among field sourced (FS) than tissue culture (TC) derived cassava planting materials confirming the superiority of using TC planting materials especially for the farmer preferred but susceptible cassava cultivars in the management of major viral diseases in cassava compared to using FS planting materials (Legg *et al.*, 2017; Tumwegamire *et al.*, 2018; Kasule *et al.*, 2020). Therefore, the technology of tissue culture if set up and employed in many areas of Uganda can be an important strategy in setting up a clean cassava seed production system. The majority of small holder farmers and large scale producers of cassava in Uganda use FS cassava planting materials in a cyclic propagation fashion and this has led to a continued virus presence and build up in the environment (Maruthi *et al.*, 2005; Nakabonge *et al.*, 2018). Therefore, for clean cassava multiplication, isolated multiplication blocks should start with clean TC materials whose virus free status is known and can be maintained by employing phytosanitary measures coupled with effective isolation distances from the surrounding potential sources of infections. This would offer an excellent potential for clean cassava seed multiplication and viral disease control (Maruthi *et al.*, 2017; Kasule *et al.*, 2020). Cassava plants planted at the 250 m isolation distance away from potential infections can provide good and clean stem cuttings that can be provided to small holder farmers in Uganda to boost cassava production. This would provide hope for multiplication of farmer preferred but susceptible cassava cultivars thereby enhancing CBSD and CMD management (Kasule *et al.*, 2020). Therefore, for a clean seed system in Uganda, cassava seed multipliers and inspectors should adopt and implement the 250 m isolation distance for production and multiplication of clean planting materials.

Way forward

Both CBSD and CMD are prevalent in the different agro-ecologies of Uganda and cause significant yield losses in cassava production in the country. Managing one of these disease in isolation will not help as cassava fields are often simultaneously infected by the two viral diseases. Therefore, simultaneous management of both CBSD and CMD is the most sustainable way since both viral diseases are spread by the same vector, the whitefly. Research should focus on clean cassava seed multiplication in isolated multiplication blocks that are 250 m away from other possible sources of cassava infections. Since limited experimental research has been carried out in Uganda in the different

agro-ecologies to establish the effective isolation distance for management of major cassava viral diseases more research is needed to verify the recommendations in different parts of the country. This will strengthen the understanding of genotype by environment interactions for farmer preferred cassava cultivars (both susceptible and tolerant to major viral diseases) at varying isolation distances. Furthermore, an effective isolation distance for CMD and CBSD is necessary for countries that do not have both viral diseases occurring simultaneously in farmer fields. This will enhance CBSD and CMD management in farmer preferred yet susceptible cultivars. Therefore, cassava seed multipliers and inspectors worldwide can adopt these effective isolation distances for the production and multiplication of clean planting material. At the moment, Makerere University, International Institute of Tropical Agriculture (IITA), National Resources Institute (NRI), National Crops Resources Research Institute (NaCRRI) and other research institutions are currently undertaking research to this effect. In this respect, a study focusing on establishing an independent effective isolation distance for CMD and CBSD for both susceptible local and improved cassava cultivars, taking into account genotype by environment interactions is needed to further improve management of CBSD and CMD.

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