

Research Application Summary

Plant resistance as a bacterial blight management strategy for cassava: A Review

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Abstract

Cassava (*Manihot esculenta* Crantz) is a major food crop and raw material to the manufacture industry in the tropics. However, the full production potential of this crop has not been realised owing to numerous challenges that plague its production. The objective of this review was to perform a systematic review of the achievements and shortfalls of research for development (R4D) in plant resistance as a strategy for managing bacterial blight disease of cassava in Sub-Saharan region.. The study found scarce information on host pathogen relationship of both causal agents and cassava. At present there is not a variety available to farmers with sufficient resistance to CBB and that any work on resistance ought to be done to suit prevailing local agroecological conditions

Key words: Africa, Bacterial blight, cassava host resistance

Résumé

Le manioc (*Manihot Esculenta* Crantz) est une culture alimentaire majeure et une matière première pour l'industrie de la fabrication dans les tropiques. Cependant, le potentiel total de production de cette spéculacion agricole n'a pas été réalisé en raison de nombreux défis qui endiguent sa production. L'objectif de cette étude était de procéder à un examen systématique des réalisations et des déficits de recherche de développement (R4D) sur la résistance des plantes en tant que stratégie de gestion des rouilles bactériennes du manioc dans la région subsaharienne. L'étude a trouvé des informations rares sur la relation entre des agents pathogènes et leur hôte, le manioc. Actuellement, il n'y a pas à la disposition des agriculteurs une variété avec une résistance suffisante à la CBB. Il est recommandé d'entreprendre des travaux de recherche sur la résistance pour répondre aux conditions agroécologiques qui dominent les contextes locaux.

Mots-clés: Afrique, brûlure bactérien, résistance intrinsèque du manioc

Introduction

Cassava (*Manihot esculenta* Crantz) plays a crucial role in the lives of more than 800 million people in the tropics, as a food security crop and as an industrial raw material (Adeyemo *et al.*,

2017). Despite its high potential, cassava production is yet to reach its optimum yields particularly in sub-Saharan Africa owing to surging constraints especially by bacterial blight which interferes with tuber quality, productivity, and the integrity of plant materials (Hong *et al.*, 2021). The objective of this paper was to undertake a systematic review of the achievements and shortfalls of research for development (R4D) in plant resistance as a strategy for managing bacterial blight disease of cassava in Sub-Saharan region.

Cassava bacterial blight (CBB) is caused by two gram negative bacterial causal agents *Xanthomonas phaseoli* pv *manihotis* (XAP) (Syn. *Xanthomonas axonopodis* pv *manihotis*) and *Xanthomonas axonopodis* pv *cassavae* (XAC) (Livoi *et al.*, 2021). Both start epiphytically and instigate infections in conducive weather (Fanou *et al.*, 2017). Nonetheless they differ in terms of virulence and colony characteristics with the former being whitish and the latter yellow. In terms of virulence, XAP is more aggressive on cassava compared to XAC (Huy *et al.*, 2019). Additionally, XAP is capable of systemic infection; while XAC is mostly limited to foliar infection. In as much as XAC seems to be inferior to XAP, it can incite serious disease in certain conditions yet to be elucidated, thus requiring special attention (Azorji *et al.*, 2016; Montenegro Benavides *et al.*, 2021). Furthermore, at present there is no variety that has been identified that shows sufficient levels of resistance to both causal agents. Most of the varieties present within farmers' fields are suspected to be extremely vulnerable to the disease in case an epidemic erupts. Whereas both causal agents have been known to exist within Sub-Saharan Africa, information on host pathogen interactions remains inadequate for both causal agents. This has greatly contributed to limited deployment of formidable cultivars.

Spread of CBB. Cassava bacterial blight continues to expand its boundaries and isolations are being made in new areas of the world previously considered safe; examples are in Mali and Burkina Faso (Kante *et al.*, 2020). Both causal agents are widely spread in eastern and central African countries. However, *Xanthomonas axonopodis* pv *cassavae* has recently been isolated for the first time in Nigeria, most probably introduced via germplasm exchange (Ogunjobi *et al.*, 2007). In south America, the disease incidence continues to increase alarmingly (López and Bernal, 2012). The pathogen exhibits diversity globally with those from some regions being more aggressive compared to others. This has been noted among the African and South American strains, which are more virulent compared to the Asian strains (Fanou *et al.*, 2017). Nevertheless, other areas like Kenya have been reported to have a monoclonal population (Chege *et al.*, 2017), implying that identification of a cultivar that is resistant to both causal agents might be sufficient in managing the pathogen in such areas (Chege *et al.*, 2017). Nonetheless, robust monitoring has been advocated for as key in early detection of pathogens. Weak surveillance systems have been faulted for the continued introduction of the causal agents in new areas. This if not addressed poses a threat to any resistance cultivar introduced due to unresponsiveness to newly introduced variants of the causal agents (Odongo *et al.*, 2019).

Soil and environmental conditions. The severity of the disease depends on the soil fertility, environmental conditions and the varieties within that geographical area (Toure *et al.*, 2020). The disease is mostly severe during wet conditions and reduces when the dry season sets in. Cassava bacterial blight has demonstrated different severity levels in different Agroecological zones. In some areas it is severe while in others it is repressed. Furthermore, some compounds like silica have been shown to contribute positively to CBB resistance (Njenga *et al.*, 2017). The

latter implies that cassava impoverished soils are more likely to be severely affected by CBB compared to those in good nutritional conditions. Hence, environmental conditions and nutritional conditions of regions ought to be considered when exploring resistance as a management strategy (Zárate-Chaves *et al.*, 2021).

Disease symptoms. The CBB disease symptoms range from angular leafspot, blighting, wilting, dieback and defoliation (Zárate-Chaves *et al.*, 2021). The symptom is usually bacterial oozing, with *Xanthomonas phaseoli* pv *manihotis* generally produces more ooze compared to *Xanthomonas axonopodis* pv *cassavae*. Wilting of young plants is usually associated with infection of planting materials. Tuber yield losses can be up to 100% (Fonseca, 2018). Furthermore, even at incidences of 10 – 20% losses of up to 25% can be experienced by farmers (Fanou *et al.*, 2017). Additionally, symptom development and severity is more devastating in susceptible plants compared to in resistant cultivars. Bacterial colonization is faster in susceptible plants with some completely dying when infected with the pathogen. This is due to the slow immune response from such plants which is partly favored by some molecules produced during infection which suppress the immunity (Mbaringong *et al.*, 2017). However, some resistant plants though displaying symptoms have been shown to recover from the attacks of the pathogen. Since some of the most vulnerable varieties are preferred by farmers understanding the mechanism involved in resistance and susceptibility is key in the generation of improved varieties (Harris *et al.*, 2015).

Cassava bacterial blight: Resistance. Resistance has been advocated for as the most viable method towards the control of cassava bacterial blight within a composite management system (Fanou *et al.*, 2017). Its benefits have been witnessed, especially in areas, such as South America where the disease has been reduced to a state of minor importance (Mbayi, 2014). The prospects of this approach is further enhanced by the fact that cassava is a highly diverse crop and shows adaptability to the various geographical locations within which it is grown. Furthermore, potential sources of resistance have already been identified from various regions across the globe (Mbaringong *et al.*, 2017). It is, however, important to note that these sources represent only a fraction of the varieties available within those regions. Nonetheless, farmers are yet to reap benefits from such varieties as at present there is no variety with sufficient levels of resistance against both causal agents (Veley *et al.*, 2021). Hence, more needs to be done to identify and deploy such varieties, particularly in Sub-Saharan Africa where cassava plays an important role in the lives of many households (Bart and Taylor, 2017).

Mechanisms of resistance to CBB. The resistance against CBB has been suggested to be polygenic in nature, controlled by multiple genetic loci (Zárate-Chaves *et al.*, 2021). Numerous factors come into play to curtail the progression of the disease within the cassava plants. These include generation of tyloses, phenolic compounds, lignin and callose depositions as well generation of suberin, which are rapidly formed in resistant plants compared to in susceptible ones (Soto Sedano *et al.*, 2017). Of interest is the fact that strain specific interaction has been observed whereby some varieties have been documented to be severely affected by some strains compared to others. An environment-genotype interaction has also been noted as some varieties are more affected by the disease in one environments conditions compared to in another (Fanou *et al.*, 2017). This underscores the need for recommendations specifically targeted for a given location environmental conditions.

It has also been established that some transcription activation factors present within cassava may play an important role in resistance and susceptibility. For example, it has been established that Me sweet10 gene contributes to disease success probably by suppressing resistance against the pathogen (Cohn *et al.*, 2014). It has also been suggested that two resistance regimes may be present within the cassava plants, leaf level resistance as well as stem resistance. This is due to the fact that variances have been observed in the manner in which the disease progresses within the stem and leaves of various cassava varieties (Wydra *et al.*, 2007). Hence, understanding how various cassava varieties respond to the causal agents will give an opportunity to decipher the underlying resistance mechanisms opening ways for further crop improvement.

Various loci have been identified which contribute to resistance against the pathogen within various cassava varieties (Soto Sedano *et al.*, 2017). Furthermore, some trait loci have been found to be expressed in certain environments; but not in other environments. Nonetheless, stable loci have identified across different environments and seasons. These could have been due to different detection methods used to identify them in the experiments.

Challenges of resistance as a management option. Challenges facing deployment of resistant varieties include long breeding cycle of cassava, lack of a resistant variety having farmer preferred traits, and difference in performance of varieties across different environments. Nonetheless, newer breeding methods are being explored to aid with shorten the period within which new varieties can be released. Also in depth understanding of host pathogen relationship is currently being explored at the genetic level to understand which genes are expressed during pathogen infection in a bid to develop resilient plants.

Conclusion

Cassava bacterial blight induced by two causal agents *X. phaseoli* pv *manihotis* and *X. axonopodis* pv *cassavae* continues to be a major problem within the various cassava growing regions of the world. This withstanding there is still lack of varieties that have sufficient levels of resistance to CBB, farmers preferred qualities and suitable to the various agroecological characteristics across that cassava cultivation belt. Furthermore, strengthening of phytosanitary surveillance for both causal agents ought to go hand in with research for development of resistance variety. This is important to avoid introduction of variants of the causal agents which may overcome resistance in the developed varieties.

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