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Research Application Summary

Status of potato bacterial wilt and its management options in Kenya

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Abstract

Bacterial wilt disease, caused by *Ralstonia solanacearum*, is an important disease of potato (*Solanum tuberosum* L). In Kenya, bacterial wilt occurs throughout potato growing regions, affecting close to 70% farms under this crop. The disease spread has been accelerated by the use of informal seed sources due to seed unavailability and high cost of certified seeds which are unaffordable to small-scale farmers. Attempts to combat the disease have been difficult because the pathogen has a complex heterogeneous genetic makeup, a wide range of host of more than 200 families, including weeds. The objective of this review is to establish the current status of bacterial wilt and its management in Kenya. Phytosanitary and cultural methods, biological, chemical and physical control have been used to control the disease but with mixed results. Lack of land to practice rotation and lack of resistant varieties has constrained farmers, making the control of bacterial wilt difficult. Integrated disease management using crop rotation, in combination with using tolerant and certified seed potato cultivars is being encouraged so as to leverage from synergistic control mechanisms.

Key words: Disease, Kenya, *Ralstonia solanacearum*, *Solanum tuberosum* L.

Résumé

Le flétrissement bactérien, causé par *Ralstonia solanacearum*, est une maladie importante de la pomme de terre (*Solanum tuberosum* L). Au Kenya, le flétrissement bactérien se produit dans toutes les régions de culture de la pomme de terre, affectant près de 70 % des exploitations pratiquant cette culture. La propagation de la maladie a été accélérée par l'utilisation de sources de semences informelles en raison de l'indisponibilité des semences et du coût élevé des semences certifiées qui sont inabordables pour les petits agriculteurs. Les tentatives de lutte contre la maladie ont été difficiles car l'agent pathogène a une composition génétique hétérogène complexe, un large éventail d'hôtes de plus de 200 familles, y compris des mauvaises herbes. L'objectif de cette revue est d'établir l'état actuel du flétrissement bactérien et de sa gestion au Kenya. Des méthodes phytosanitaires et culturales, un contrôle biologique, chimique et physique ont été utilisés pour contrôler la maladie mais avec des résultats mitigés. Le manque de terres pour pratiquer la rotation et le manque de variétés résistantes ont contraint les agriculteurs, rendant difficile le contrôle du flétrissement bactérien. La gestion intégrée des maladies utilisant la rotation des cultures, en combinaison avec l'utilisation de cultivars de pommes de terre de semence tolérants et certifiés, est encouragée afin de tirer parti des mécanismes de contrôle synergiques.

Mots clés: Kenya, *Ralstonia solanacearum, Solanum tuberosum L.*

Introduction

In Kenya, potato (*Solanum tuberosum* L.) is the second most important crop, after maize. It is a source of employment to about 800,000 farmers and 2.5 million people are involved in the potato value chain (Muthoni, 2017). The potato value chain is however impaired by low yields which are currently averaged at 10 t ha^{-1}, which is quite low compared to the potential yield of 40 t ha^{-1} (KEPHIS, 2016). Potato production has been declining in recent years due to diseases and pest prorilification and low seed quality (KEPHIS, 2014). Bacterial wilt disease, caused by *Ralstonia solanacearum*, is a devastating disease affecting potato production globally (Kumari and Ranjan, 2019). The disease has affected over 1.7 million hectares of potato in 80 countries, causing losses estimated to amount to US$950 million annually (Aljilogba and Babalola, 2013).

Bacterial wilt is the second most important disease in potato production after late blight, and in Kenya, it affects over 70% of potato farms causing tuber yield losses of 50-100% (Kaguongo *et al*., 2010). It is mainly spread through infected run-off water, farm tools, infested seeds and contaminated soil (Jibat *et al*., 2018). It is one of the most destructive pathogens identified to date because it induces rapid and fatal wilting symptoms in the host plants (Yuliar *et al.,* 2015). Currently there are no resistant potato varieties because of the diverse host range of more than 200 plant species in 50 different families (Meng, 2013). On the other hand, certified seeds are limited and costly resulting into farmers in Kenya sourcing informal seed sources, thus making the disease control difficult (Aguk *et al*., 2018).

Integrated disease management has been advocated for reducing the disease spread, although, several attempts to implement it have had limited success (Nyangeri, 2011). Establishment of management strategies to reduce the pathogen population structure, survival and interaction in the ecosystem may be necessary in curbing the disease (Muthoni *et al*., 2020). The objective of this review, therefore, is to establish the status of potato bacterial wilt and its management in Kenya.

Bacterial wilt disease in Kenya

The disease was first introduced in Kenya in 1945 through potato seeds, which were imported from Europe to Embu (Muthoni *et al*., 2014). The disease has since then spread to all potato growing regions in the country (Kaguongo *et al*., 2010). The distribution of the disease is as a result of dynamic processes involving multiple host availability, susceptibility, abundance and suitability of climatic conditions and farmers' practices (Mamphogoro *et al*., 2020).

The disease has spread to over 70% of potato farms in the country with yield losses of 50-100% (Kaguongo *et al*., 2010). Major counties affected include: Uasin Gishu, Nakuru, Narok, West Pokot, Keiyo, Bomet, Nyandarua, Nyeri and Kiambu (GOK, 2013). Shortage of certified seed potato and inadequate land to practice crop rotation has accelerated the disease occurrence (Muthoni *et al*., 2014). The use of informal seed systems dominates potato farming in Kenya with the unregulated movement of seeds through the international boundaries which fuels disease spread (Muthoni *et al*., 2010). The disease occurrence is reportedly high in the Kenyan highlands (75%) and lower (25%) in lowlands (Kariko *et al*., 2016). This is attributed to high soil moisture and wet weather conditions which are predisposing factors accelerating the disease incidences (Kaguongo *et al*., 2010).

Management and control of Bacterial wilt

Bacterial wilt is difficult to control and no management strategy has proven 100% effective (Muthoni *et al*., 2014). Methods used in the disease management include: Phyto-sanitation and cultural practices, chemical control, physical control and biological control. These are articulated in the following sections:

Phyto-sanitation and cultural practices. These entails farming techniques which improve the quality and quantity of crop yields, while decreasing the disease influence (Aljilogba and Babalola, 2013). These methods include:

*Crop rotation***.** Continuous cropping with the same susceptible host crop accelerates the development of *R. solanacearum* (Yuliar *et al*., 2015). Muthoni *et al*. (2014) reported that farmers in Kenya control bacterial wilt mainly through crop rotation (26%), uprooting (41%) and chemical control (21%). Potato crop rotation with maize and wheat was reported to reduce the disease incidence to 6.3%, compared to potato mono-cropping, which was reported to have 80% disease incidence (Kirigo, 2019). One season crop rotation with tomato-maize- potato reduced the disease incidence from 46.7% to 7% in bacterial wilt infected soils. In two season rotation, tomato-bean-potato reduced disease incidence from 46.7% to 1% and cabbage-potato to 2% (Nyangeri, 2011). Farmers are advised to plant potato for one season then practice crop rotation if there is no disease incidence, minimum two season of crop rotation if < 5% of the potato have bacterial wilt symptoms and minimum three season crop rotation if >5% of the potatoes have disease incidence (Muthoni *et al*., 2014). However, this method is impracticable due lack of adequate land to practice crop rotation by smallholder farmers who often own less than one hectare per household (Riungu, 2011).

Soil amendments. In a study done by He *et al*. (2014) on the influence of soil pH on bacterial wilt, raising pH through the application of calcium oxide and calcium carbonate inhibited *R. solanacearum* survival in the soil. On the other hand incorporating lemon grass in solarized soil decreased bacterial wilt incidence by 38.3% over the control in ginger (Jibat *et al*., 2018). Andama, (2015) reported that bio-fumigation in potato by incorporating crop residues (*Brassica* spp), which release isothiocyanates which are toxic to soil-borne pests and diseases can enhance biodiversity antagonistic to bacterial wilt. Decomposing plant residues such as chilies and lemon grass have antimicrobial activity, through the release of inhibitory substances, which leads to pathogen suppression (Yuliar *et al*., 2015). About 63% of farmers in Kenya reportedly use both organic and inorganic amendments as an integrated disease management practice in potato production (Kago *et al*., 2017). It is however ineffective due to high cost of fertilisers, inaccessibility to smallholder farmers and environmental concerns (Nakhro and Dkhar, 2010; Kago *et al*., 2017). Fertiliser and soil amendments improve and increase microbial activity and enrich populations of beneficial microorganisms, which are antagonistic towards pathogens (Liu *et al*., 2015).

Certified seeds. The use of certified seed has been advocated for since it contributes to the reduction in disease spread (Kaguongo *et al*., 2010). Certified seeds are of high quality, disease-free and result in high yield (Beata *et al*., 2020). However, these seeds reportedly contributes only 1% of the total seed potato produced in the country rendering them ineffective (Kaguongo *et al*., 2010). This has led to farmers using informal seed sources which are often of poor quality and have accelerated high disease prevalence (Muthoni *et al*., 2014).

Tolerant cultivars. No potato variety has proven fully resistant against bacterial wilt in Kenya (Kirigo, 2019). Moderate tolerance has been achieved against the disease in some cultivars such as Jelly (NPCK, 2019). However, these tolerant cultivars, present abnormal agronomic traits which are unacceptable to potato farmers and consumers (Champoiseau *et al*., 2010). These abnormalities include inability to show resistance to climatic conditions such as high temperatures and very cold temperatures (Muthoni *et al*., 2020). Breeding for resistance using bacterial wilt resistant wild potato has been done without much success, due to complexity of the host-pathogen-environment interaction (Muthoni *et al*., 2014; Karim and Hossain, 2018).

Positive and negative selection. These methods are mostly used by seed multiplies and farmers, who intend to save seeds for the next season (Sharma *et al*., 2018). Positive selection entails the selection of healthy-looking plants as mother plants, to obtain seeds to be used in the next generation (Gildemacher *et al*., 2012). On the other hand, negative selection involves removal of plants with bacterial wilt symptoms, poor growing habits and those with disorders that can cause contaminations in clean seed production (Sharma *et al*., 2018). A study done by Gildemacher *et al*. (2011) in Kenya reported that positive selection reduced bacterial wilt from an average of 7.6 to 2.6% as compared to plots which did not carry out selection, and yields increased by 29%. These methods are tedious and may be ineffective in large scale production (Kaguongo *et al*., 2010).

Use of chemicals. Chemical control is effective, but increasingly discouraged due to chemical persistence in the environment, which leads to environmental contamination and pollution, both in the soil thus in underground water (Kirigo, 2019). Continuous use of chemicals can also result in induced resistance preventing disease control (Champoiseau *et al*., 2010). Soil fumigation has been reported to decrease disease incidence in sweet pepper by 72-100% (Mamphogoro *et al*., 2020); however, this method is expensive to small-scale farmers in Kenya (Kirigo, 2019). Verma *et al*. (2014) reported that antibiotics (Gentamicin) showed antibacterial efficacy against bacterial wilt which inhibited 100% colony formation at 1ppm concentration. However, it has been unsuccessful when tested in the greenhouse and field conditions (Karim and Hossain, 2018).

Physical methods. Solarization and hot water treatments have proven to be effective in the control of bacterial wilt pathogen (Kirigo, 2019).

Soil solarization. Transparent plastic mulch was reported to reduce bacterial wilt by 38.3 % and 42.05% after 2-4 hours of solarization in ginger done at different locations. This was attributed to climatic variations (Jibat *et al*., 2018). This is due to the ability of the plastic mulch to trap soil radiation that warm the top layer of soil leading to death of weeds, pests, nematodes and pathogens (Yuliar *et al*, 2015). However, it has a negative impact on beneficial soil microbes by reducing their activity and require re-inoculation (Mamphogoro *et al*., 2020).

Cold and heat treatment. R. solanacearum does not survive in high temperatures (35^{o}C) and low temperatures (<20^{o}C) (Kariko *et al*., 2016). Tajul *et al*. (2011) reported that tomato irrigated with cold water (4^{o}C) reduced bacterial wilt incidence as compared to irrigation water at 30^{o}C due to the poor survival ability of the pathogen in low temperatures. On the other hand, heat treatment as a disease control measure efficacy varies depending on soil moisture content, temperature and heating duration. Heat treatment is used to disinfect seed potato by subjecting them to hot air 44^{o}C and disinfecting soil by subjecting it to hot water (70°C-90°C). This kills most spores forming bacteria, lethal weed seeds, pests and pathogens thus controlling the disease (Mamphogoro *et al*., 2020). These methods require knowledge and skills which are lacking amongst smallholder farmers in Kenya.

Biological control

Biological control has proven to be more sustainable as an alternative to chemical control. This is due to interactions such as parasitism, antibiosis and induced systemic resistance (Yuliar, Nion and Toyota, 2015). Inoculating tomato plant with *Glomus versiforme* reduced bacterial wilt incidence by 81.7% (Yuliar *et al*, 2015). According to Aguk *et al*. (2018), the use of Arbuscular mycorrhiza in combination with organic amendments reduced bacterial wilt incidences and no symptoms were observed in Tigoni and CIP clones. Bacillus isolate CB64 proved effective in reducing bacterial wilt incidence and severity; it reduced *R. solanacearum* in the soil by more than 90% and it also promoted the growth and yields of tomato plants (Kariuki *et al*., 2020).

Conclusion and recommendation

Bacterial wilt is a major threat in potato production in Kenya and has proven difficult to control using existing technologies. With lack of resistant varieties, the use of integrated disease management can be used to alleviate the disease spread with cultural methods such as crop rotation, soil fertilisation integrated with the use of certified seeds and tolerant varieties can be a promising method in bacterial wilt control. The avoidance of crop losses due to the pathogen significantly contributes to increased crop production. Increasing the multiplication capacity of certified seeds and training farmers on the production can help in reduction of the disease spread.

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