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Research Application Summary

The prevalence and management options for bacterial wilt caused by *Ralstonia solanacearum* in African Nightshades in Kenya

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Abstract

The consistently rising human population in Kenya demands production of healthy food. African Nightshades have good potential in contributing to Kenya's vision 2030 in attaining food and nutrition security. African nightshades form an important component in diets, by providing essential vitamins, micronutrients and fibre. They also possess phytochemicals including antioxidants, which strengthen the body's defense against diseases. However, production of African nightshades is threatened by the devastating bacterial wilt pathogen *Ralstonia solanacearum*. The pathogen causes heavy yield losses of up to 100%, particularly in Sub-Saharan Africa due to prevailing optimal conditions. The pathogen is capable of surviving long periods underground, in crop residues and irrigation water owing to its great metabolic adaptability. A survey was done to determine the prevalence of bacterial wilt on African Nightshade in selected areas in Kenya. *R. solanacearum* was reported in Western, Central and Rift valley regions. Of the farms surveyed, 24% showed symptoms of wilting with the narrow leafed variety, *Solanum villosum,* showing higher severity. Different management strategies were employed by farmers including rotation, uprooting and burning affected plants, biocontrol, use of amendments and use of chemicals. In the current study, we provide insights on the status and available management options for control of bacterial wilt disease in African Nightshades in Kenya. It is hoped that the findings will contribute to improved yields of African nightshades and to new knowledge on the disease management.

Key words: African Indeginous Vegetables, African Nightshades, Kenya, *Ralstonia solanacearum, Solanum spp*.

Résumé

La population humaine en constante augmentation au Kenya exige la production d'aliments sains. Les morelles sont potentielles pour contribuer à la vision 2030 du Kenya pour l'atteinte de la sécurité alimentaire et nutritionnelle. Les morelles constituent un élément important dans les régimes alimentaires, en fournissant des vitamines, des micronutriments et des fibres essentielles. Elles possèdent également des composés phytochimiques, notamment des antioxydants, qui renforcent la défense du corps contre les maladies. Cependant, la production des morelles est menacée par l'agent pathogène qui cause la flétrissure bactérienne *Ralstonia solanacearum*. Ce dernier provoque de lourdes pertes de rendement allant jusqu'à 100%, en particulier en Afrique subsaharienne, en raison des conditions optimales qui y prévalent. Il est capable de survivre pendant de longues périodes sous terre, dans les résidus de culture et l'eau d'irrigation en raison de sa grande adaptabilité métabolique. Une enquête a été menée pour déterminer la prévalence de la flétrissure bactérienne sur les morelles dans quelques régions du Kenya. *R. solanacearum* a été signalé dans les régions de l'ouest, du centre et de la vallée du Rift. Parmi les exploitations parcourues, 24% présentaient des symptômes de flétrissement avec la variété à feuilles étroites, *Solanum villosum*, présentant la sévérité la plus élevée. Divers moyens de lutte ont été employés par les agriculteurs, notamment la rotation, le déracinement et le brûlage des plantes affectées, la lutte biologique, l'utilisation d'amendements et l'utilisation de produits chimiques. Dans la présente étude, nous fournissons des informations sur l'état de prévalence et les moyens de lutte disponibles contre la flétrissure bactérienne chez les morelles au Kenya. On espère que les résultats contribueront à l'amélioration de leurs rendements et à de nouvelles connaissances de gestion de la pathologie.

Mots clés : Légumes indigènes africains, Morelle noire, Kenya, Ralstonia solanacearum, Solanum spp.

Introduction

African indigenous vegetables (AIVs) are important in attaining food security because they are a rich source of essential vitamins (Orech *et al*., 2007; Uusiku *et al*., 2010). The AIVs are particularly important in contributing to Sustainable Development Goal (SDG) number 2 – Zero hunger through reducing micronutrient deficiencies, responsible for "hidden hunger". This is important in maintaining a healthy population necessary for contribution to economic growth (Keatinge *et al*., 2011). Initially, AIVs were considered food for the rural poor but this notion is rapidly changing with consumption increasing in urban areas (Kebede and Bokelmann, 2017). African Nightshades are important AIVs belonging to the Solanacea family that has many diverse genera. The most common African Nightshades in Kenya include *Solanum nigrum L., Solanum villosum, Solanum americanum,* and *Solanum scabrum* (Maundu *et al*., 1999). African Nightshades have increasingly become important for commercial purposes in Kenya over the recent past with many markets and groceries having them for sale (Mwaura *et al*., 2013). In Central Kenya, about 9,000 tonnes of nightshades and other indigenous vegetables were sold in formal and informal markets between 2008 and 2010 (AVRDC, 2010). This gives a good indication of their importance to support rural, peri-urban and urban populations for income generation. Nightshade cultivation attracts many farmers because they do not require heavy capital investments and can be intercropped with other crops (DFID and R4D, 2010). Furthermore, nightshades are important for gender empowerment with women being majorly involved in all aspects of the farm produce supply chains (Weinberger *et al*., 2011).

Despite their great potential as a food source, the production of African nightshades is affected by the soil borne pathogen *Ralstonia solanacearum* (Fig. 1) causing bacterial wilt. The pathogen is gram negative β-proteobacterium with a wide host range affecting over 200 plant species in tropical and subtropical environments (Agrios, 2005). *Ralstonia solanacearum* is distributed globally and in the absence of a susceptible host, alternative hosts or non-host plants enable its survival (Genin and Denny, 2012). It poses a serious threat to food security globally especially where epidemics are reported with heavy crop losses (Ravelomanantsoa *et al*., 2018). *Ralstonia solanacearum* enters the plant through wounded roots or natural openings in the root elongation zone or at the location of developing lateral roots (Kurabachew and Wydra, 2013). The pathogen multiplies rapidly in the xylem vessels thus clogging them resulting to disruption of smooth flow of water and eventual wilting and dying of the plant. *Ralstonia solanacearum* multiplies severely in warm and humid environs (Li *et al*., 2016) with capacity to survive in the soil for lengthy periods even in absence of a susceptible pathogen. Molecular studies have classified the pathogen into phylotypes based on phylogenetic analyses of sequences from the 16S-23S internal transcribed spacer (ITS) region and the the endoglucanase (egl) partial gene. It was taxonomically organized into three species that classified phylotypes I and III as *Ralstonia pseudosolanacearum*, phylotype II as *Ralstonia solanacearum* and phylotype IV as *R. syzygii* (Safni *et al*., 2014; Prior *et al*., 2016).

Ralstonia solanacearum was reported to survive preferentially on African nightshades as a weed (Nyangeri *et al*., 2015). Toukam *et al*. (2009) reported presence of the pathogen specifically Pholotype I in African nightshades. The devastating nature of the pathogens calls for studies to assess presence and impact of the disease in African nightshades production zones in Kenya. The aim of the study was to determine the status of bacterial wilt disease on African Nightshades and the management options employed by Kenya farmers.

Figure 1. Photos of wilted African nightshades *R. solanacearum*

Materials and methods

The survey was done during the short rains season of September to December 2016 in Central, Western and Rift valley regions of Kenya. These areas are major African Nightshade producing areas and also represent different agro-ecologies. The elevation of the study areas is Gitaru 1941 meters, Kerugoya (1548meters), Sabasaba (1386 meters), Kanduyi (1447 meters), Mayanja (1170 meters) and Kipkaren (1859 Meters). The Agricultural Officers in the areas surveyed were consulted to get information on the farmers practicing African nightshade farming. The sample size was calculated according to Yamane (1967) as shown in the formula below.

$$n = \frac{N}{1 + N\left(e^2\right)}$$

N – Population size and e – Confidence level taken as 95%

A structured questionnaire was used to get information on African nightshade production practices, the varieties grown, the production challenges, presence of bacterial wilt and management practices carried out, among others. In the farms surveyed, disease incidence was determined by presence or absence of wilting. An initial diagnostic test described by Goszczynska *et al*. (2000) was done in the farms surveyed. The mid-stem of the wilted plants was cut and suspended in a beaker with clear water. Presence of bacterial streaming indicated presence of *R. solanacearum*. Incidence was calculated by dividing the wilted plants by the total plant population. The farms were checked for symptoms of wilt and soil and tissue samples carried for laboratory isolations to confirm infection.

Results and Discussion

The survey indicated that African nightshades were among the preferred vegetables by more than 80% of the farmers in the surveyed areas particularly because they fetch better prices as compared to exotic vegetables such as kales and spinach. Varieties of African nightshades cultivated in the surveyed areas were classified by the farmers generally as either the broad-leafed/improved or narrow-leafed/local. The broad leafed were more preferred by many farmers though the narrow leafed were reported to realize better prices in the market. African nightshades ranked high in importance among other local and exotic vegetables. Sources of seed varied with use of certified seed very low. The high cost incured by farmers is explained by the high cost of certified seed resulting in farmers preferring to use of seed from the market or their own saved seed.

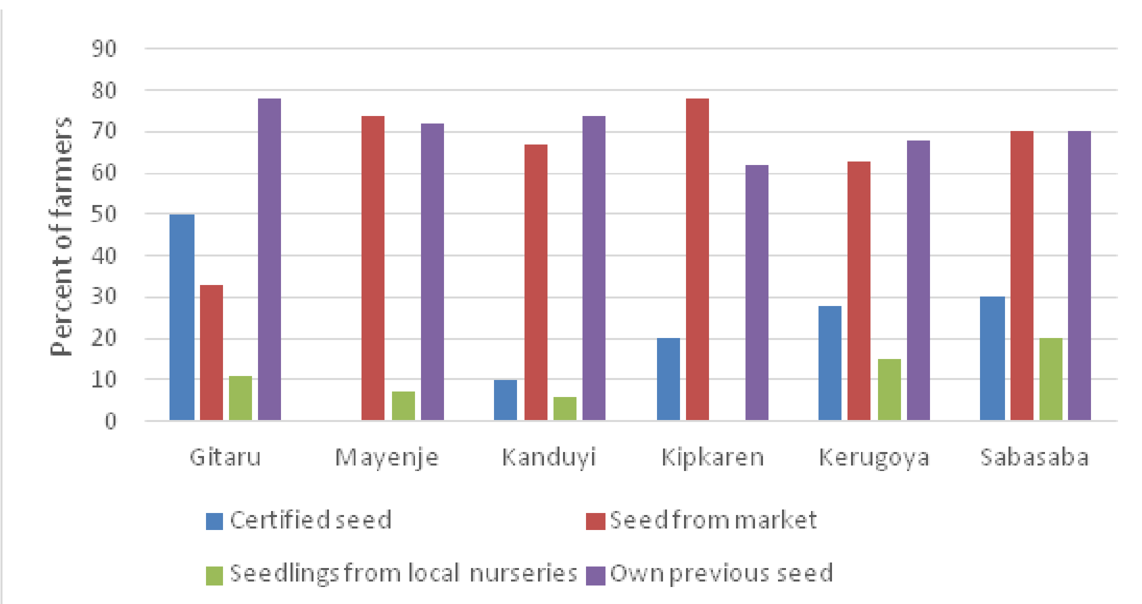

Figure 1. Sources of African nightshade seeds in Kenya

Among the challenges encountered in growing African nightshades, pests and diseases were considered as the most challenging (Fig. 3). Other challenges included theft, high transport cost to markets and scarcity of land.

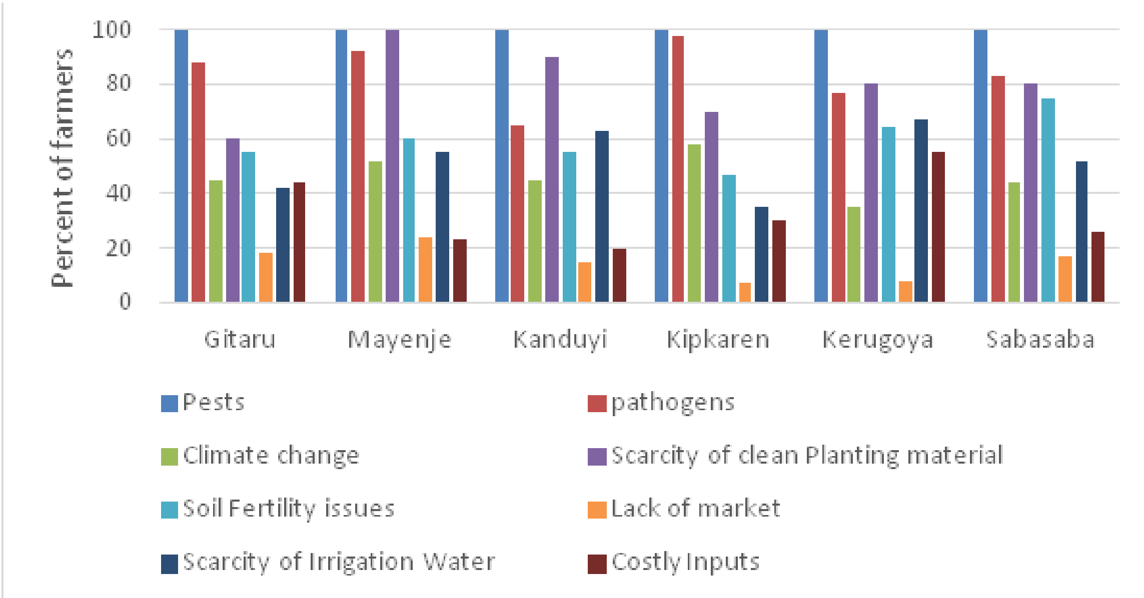

Figure 3. Major constraints affecting African nightshade production in the surveyed areas.

Bacterial wilt was observed in 24% of the farms surveyed growing African nightshade (Table 1).

Table 1. Mean occurrence of Bacterial Wilt in Africa Nightshade fields

Survey Area	Nightshade	Potato	Tomato	Other
Gitaru	0.10±0.19a	0.70±0.19b	0.30±0.19a	0.20±0.19a
Mayenje	0.40±0.19b	-	0.20±0.19a	-
Kanduyi	0.30±0.19ab	-	0.10±0.19a	-
Kipkaren	0.50±0.19b	-	0.20±0.19a	-
Kerugoya	0.10±0.19a	0.50±0.19ab	0.80±0.19b	0.30±0.19a
Sabasaba	0.10±0.19a	0.40±0.19a	0.20±0.19a	-
P	0.144	0.703	0.006	0.409

Data are the mean ± standard error (SE). Means separated using LSD test, means within the column followed by the same letter are not significantly different at P<0.05. (-) indicates the crop is not grown in the farms surveyed.

Management of the disease was predominantly through cultural practices. The farmers practiced crop rotation between planting seasons where African nightshades were not planted where Solanacea crops were previously planted. Janvier (2007) reported that crop rotation helps in managing crop diseases through reducing pathogen population especially of soil borne pathogens. Uprooting and burning affected plants and practicing field hygiene was also done by 70% of the farmers. Sanitation was also employed through eliminating undesirable crops that were thought to act as alternate hosts. The measures were usually economically feasible. However, control achieved via cultural practices was often inadequate and needed to be supplemented with other methods.

Thirty five percent of the farmers in the areas surveyed practiced chemical control against pests and diseases associated with African nightshades. Globally, antibiotics have been used to protect crops against pathogenic bacteria such as *Xanthomonas, Pseudomonas* and *Erwinia* (McManus *et al.*, 2001). However, extensive use of antibiotics over the years has been reported to cause resistance (Sundin *et al.*, 2016). Additionally, use of chemical bactericides is one of the traditional methods of disease control but this method is not popular due to the environmental pollution and other adverse effects (Fujiwara *et al*. 2011; Tan *et al.*, 2015).

Seventy eight percent of the farmers in the survey areas plant the broad-leafed/improved varieties which are more tolerant to bacterial wilt. Host resistance is considered a useful option for managing bacterial wilt since it is the most environment friendly and effective method. However, resistance is strongly influenced by environmental conditions such as soil temperature, pH, and moisture. Also, breeding for resistance is a complex process dictated by factors such as the availability and diversity of resistance sources, agronomic qualities, variability of the pathogenic strains and plant-pathogen interactions (Boshou, 2005; Elphinstone, 2005). Resistance is typically strain specific, and the diversity of pathogenic strains of *R. solanacearum* has led to the development of resistant lines that are not durable over diverse geographic regions. Another issue that has been problematic for breeders is undesirable yield characteristics linked to resistant varieties. Resistant plants according to Prior *et al.* (1996) showed heavy infestation by *R. solanacearum* but without visible symptoms. Additionally, Nakaho *et al.* (2004) indicated suppressed multiplication of bacteria as a result of restricted pathogen movement within the xylem tissues. However, more effort in breeding is necessary because resistance to bacterial wilt in many crops has generally been negatively correlated with yield and quality. Induced systemic resistance is not being employed to manage bacterial wilt but has good potential. Recently, Silicon was determined to enhance resistance of crops thus aids in managing several pests and diseases in various plant species. Additionally, silicon assists in tolerance to various abiotic stresses including salt stress, nutrient imbalance, high temperature, freezing among others (Ma, 2004). Silicon and chitosan have also been confirmed to induce resistance in tomato against bacterial wilt (Kiirika *et al.*, 2013). Induced resistance focuses on increasing capacity of the cell wall to impart resistance against pathogens.

Hundred percent of the farmers in the areas surveyed used either organic or inorganic fertilizers during cultivation. This is mostly done to improve soil fertility and improve yields. These practices have been known to suppress activity of the bacterial wilt pathogen. Calcium (Ca) fertilizer was found to effectively reduce bacterial wilt incidence and severity. Increased concentration of Ca in the stems of tomato plants significantly reduced the population of *R. solanacearum* (Yamazaki *et al.,* 2000). Further, He *et al.* (2014) showed increase in concentration of Ca_2+ significantly decreased pectinase activity of *R. solanacearum* thus making it difficult for the pathogen to degrade the cell wall and gain entry into the plant.

Eight percent of the farmers reported use of commercial biocontrol agents. However, majority of the farmers reported lack of knowledge on biocontrol agents and those familiar with them reported they were not using them because of the high costs. Use of Biological control agents (BCAs) and organic matter is on the increase due to the issues associated with use of chemicals. The modes of action of BCAs are characterized by various interactions, such as the competition for nutrients and space, antibiosis, parasitism, and induced systemic resistance (Yuliar *et al.,* 2015). Plants are efficient producers of different biologically active compounds (Dubey *et al.*, 2011) which include pyrethrum, rotenone, neem, and essential oils. Thus they can be exploited to develop new biopesticides (Gurjar *et al.,* 2012; Bhagat *et al.*, 2014).

Conclusion

Bacterial wilt was found to be present in the surveyed areas. Farmers employed different management measures. However, more studies are needed to identify the best options for better African Nightshade yields and to prevent bacterial wilt disease spread.

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