Spread of Bacterial Wilt Disease of Potatoes in Kenya: Who is to Blame?

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Abstract Bacterial wilt (caused by Ralstonia solanacearum) has spread to all potato growing areas in Kenya, affecting over 70% of potato farms and causing yield losses of between 50% to 100%; it is followed by late blight affecting 67% and viral diseases (12%).

Introduction

In Kenya, potato is grown mainly by small scale farmers as a cash and food crop and therefore plays an important role in food and nutrition security (MoA, 2005; 2008). Potato is grown by about 800 000 farmers, on 158 000 hectares per season, with an annual production of about 1 million tonnes in two growing seasons (Riungu, 2011). The annual potato crop is valued at USD 6.25 million at farm gate level, and USD 12.5 million at the consumer level (ANN, 2009). Potato farming in Kenya employs 2.5 million people at all levels of the value chain (ANN, 2009).

However, potato production in Kenya has not achieved its potential because of a number of production constraints. These include low soil fertility, inadequate supply of certified seeds, use of low yielding varieties, and diseases (FAO, 2009). The most common diseases include late blight, viral infections and bacterial wilt (Kaguongo et al., 2008).

Bacteria wilt of potato (caused by Ralstonia solanacearum) is tuber borne, and is primarily disseminated through infected seed tubers (French et al., 1975; Nyangeri et al., 1984; Kinyua et al., 1998). The other source of inoculum is the infested soil; the bacterium is native in many tropical soils (Martin and French, 1985). Bacterial wilt is further spread through infected run-off water or soil adhering to tools and shoes (Martin and French, 1985; Pradhanang, 1999; Kabira et al., 2006b). Potato seed tubers carry the bacterium in the vascular tissue, lenticels, and on the surface (Kelman, 1953; Sunaina et al., 1989). Bacterial wilt is widely distributed in tropical, subtropical, and warm temperate climates of the world, and it occurs in about 45 countries in the southern hemisphere; the hardest hit countries being Kenya, China, Uganda, Indonesia, Bangladesh, Bolivia, and...
Peru (Hayward, 1991; EPPO, 2004). In Kenya, the disease is believed to have been introduced with tuber seeds imported from Europe (Todd, 1969). It was first reported in Kenya in 1945 around the Embu area, from where it spread to other parts of the country (Ajanga, 1993; Otipa et al., 2003). Of late, the disease has spread to all potato growing areas of the country (Jane et al., 2013), affecting over 70% of potato farms and causing yield losses of 50 to 100%; it is followed by late blight (67%), and viral diseases (12%) (Kaguongo et al., 2010). Currently, bacterial wilt has spread countrywide (The Organic Farmer, 2013). Limited availability of high quality seed and lack of farmer knowledge on proper agronomic practices for control of the disease are major factors contributing to its spread (Kabira et al., 2006b). This is exacerbated by lack of effective crop rotation possibly due to small sizes of the farms (The Organic Farmer, 2012). This review article looks at factors responsible for the fast spread of bacterial wilt of potatoes in Kenya and provides a way forward in the control of the disease.

**Potato Seed Systems in Kenya**

The formal seed system is characterised by official rules through laws and guidelines from government departments. The guiding principles in the formal system are to produce, distribute and use certified seed, which is a seed of optimum physical, physiological and sanitary quality (GOK, 2012 (1991)). This is the progeny of basic seed and its production is handled so as to maintain specific genetic identity and purity according to the standards prescribed for certified potato seeds. It may also be the progeny of certified seed provided this reproduction does not exceed three generations beyond basic seed stage. Certified seed is obtained by multiplying basic seed under stringent supervision of Kenya Plant Health Inspectorate (KEPHIS). It is the only tradable seed potato under the Kenyan law. Because of the long process of its production and stringent regulation from KEPHIS, certified seed production and use is limited. The formal seed production system can only produce about 1.1% of all the certified seeds required by farmers in the country (The Organic Farmer, 2013). In addition, the seeds are highly priced and beyond the reach of many farmers. Farmer seed system currently dominates the sub-sector, contributing about 96.3% of the total seed used while both ‘clean’ and ‘positively selected’ seed contribute 2.6% (Kaguongo et al., 2010). Because of the limitations of the formal system, the informal seed system is the main option through which most potato farmers in Kenya can obtain potato seeds (Crissman et al., 1993). The informal seed sources include farm-saved (self-supply), local markets, and neighbours. Self-supply forms the major source of seed for most farmers who select the small tubers as seed from the ware potatoes (Kaguongo et al., 2008). From one season to the next, farmers select seed at harvest from their own farms but periodically go outside of their farms to boost their farm-saved seed reserves or to bring in “new” or “fresh” seed (seed renewal) from neighbours or local markets. Neighbours are the major source of information about new varieties, and the community serves as the seed bank for farmers when they run out of their own seeds. This informal system leads to the use of poor quality seeds and often accelerates the spread of seed-borne diseases, especially bacterial wilt (Muthoni et al., 2010). Latently infected seed tubers from bacterial wilt infested areas have mainly contributed to the spread of the disease to many potato producing areas in Kenya; the spread of bacterial wilt is a consequence of the informal potato seed system prevalent in the country (Kaguongo et al., 2008).

Development partners including the International Potato Centre (CIP), German Development Agency (GTZ, now GIZ), and USAID supported the development of informal seeds systems in Kenya. These organisations in collaboration with KARI trained more than 5 000 extension workers employed by the Ministry of Agriculture in potato growing areas so that they may in turn train selected farmers to produce good quality seeds. The seed would then be sold to potato growers who were unable to obtain sufficient certified seeds from the Kenya Agricultural Research Institute (KARI) or Agricultural Development Corporation (ADC), the two public institutions mandated with production of certified potato seeds in Kenya (The Organic Farmer, 2013). The resultant seed (called ‘Clean Seed’) comprises seed multiplied at farm level which originates from
certified or basic seed but has not been inspected by KEPHIS. Most production guidelines used in production of certified seeds are applied in production of clean seeds and only sample testing and supervision by KEPHIS is lacking. The clean seeds produced in this system is equivalent to what in FAO is referred as ‘Quality Declared Seed’ (Fajardo et al., 2010). Although clean seed can go a long way in easing the bottleneck in availability of disease-free potato seeds in Kenya, such seed is not officially recognised by the Kenyan law and such trade is illegal (MoA, 2009). Consequently, clean seed may never get the premium price in the market as deserved. This discourages many potential seed growers from venturing into the business. The potato growers then have no option but to continue planting their diseased potato seeds from informal sources. Positively selected seeds are produced from ordinary or farmers seed through a process of positive selection by farmers trained on seed selection and management by Ministry of Agriculture, KARI, GTZ, CIP or TOT. It involves selecting the best looking plants in a potato field as source of seed for the next season (Gildemacher et al., 2007b). These are selected and pegged when the plants are growing vigorously 6~7 weeks after planting (and before flowering). At harvest, the pegged plants are harvested one by one. The selected healthy looking plants are harvested before the rest of the field, and the seed tubers are handled in clean disinfected containers. These seeds tubers are then used for subsequent seed increase or for ware potato production. Application of positive selection is limited because few farmers can recognise disease symptoms; in addition, the pegging work is quite tedious especially in cases where bacterial wilt incidence is high.

Management of Bacterial Wilt

The common approach in the management of bacterial wilt in potatoes is an integrated combination of measures such as phytosanitation and cultural practices, chemical control, biological control, and host resistance (Martin and French, 1985; Champoiseau et al., 2010). Use of disease-free certified seed tubers is advocated in Kenya (Wakahiu et al., 2007). However, it is not effective because the quantities of disease-free certified tuber seeds produced by the formal seed system are insufficient to meet the farmers’ requirements (Lung’aho et al., 1997; Ayieko and Tschirley, 2006; Kagwango et al., 2008). Because of the insufficient quantities available, the potato seeds are highly priced; one 50 kg bag goes for USD 37.5. Yet a farmer requires 16 such bags to plant one acre; this translates to USD 600. Few farmers can afford such each season. Consequently, farmers use tuber seeds from informal sources, and the health status of such seeds cannot be guaranteed (Muthoni et al., 2010). In addition, quarantine is not possible in Kenya because the movement of potato locally is uncontrolled, and potato seed system is largely informal (Muthoni et al., 2010). Furthermore, the international borders are porous leading to illegal importation of both ware and seed potatoes (Muthoni et al., 2010).

Crop rotation of 5~7 years excluding host plants has been recommended to control the bacteria in the soil (EPPO, 2004). According to Gildemacher et al (2007a), a crop rotation sequence where potatoes are grown once in every four seasons is ideal so long as no other Solanaceous crop is grown. However, in most potato growing areas in Kenya there is not enough land for such a long rotation (Riungu, 2011). In management of bacterial wilt, farmers have been advised on the following in their potato fields: Minimum 1 season of crop rotation if no bacterial wilt is spotted; Minimum 2 seasons of crop rotation if less than 5% of the potato plants are wilting; Minimum 3 season crop rotation if more than 5% of the potato plants are wilting.

In addition to this crop rotation scheme, removal of volunteers is extremely important (Kabira et al., 2006b; Gildemacher et al., 2007a; The Organic Farmer, 2012). Rotating potatoes with cabbage has been shown to reduce bacterial wilt incidences (The Organic Farmer, 2012). For better results, potatoes should be rotated with cucumber, lettuce, carrot, radish, beetroot, turnip, onion, parsley, strawberry cabbages, beans, peas, onions, carrots, maize, oat, sorghum, barley, pasture grass or pasture legumes (Kabira et al., 2006b; The Organic Farmer, 2012). In Kenya with two growing seasons in a year, farmers
are advised to avoid host crops for four consecutive seasons (two years). Crop rotation as a control measure for bacterial wilt may not be effective in Kenya because of the small farm sizes, often less than one hectare (Lemaga, 1997; Otipa et al., 2003; Kaguongo et al., 2008; Kaguongo et al., 2010). For a rotation programme to be effective, volunteer crops need to be rogued out of the field. Removal of volunteers is the last thing a farmer will do because it gives him valuable food; this renders the rotation impractical. In addition, the small scale farmers do not have sufficient land to plant anything but essential food crops. Potato farming in the Kenyan highlands is a business; few farmers will be willing to be out of potato production for a long time. Furthermore, the pathogen has a very wide host range and it may be difficult to avoid all these crops during crop rotation period on small holder farms.

Soil fumigation using chemicals to control bacterial wilt is not feasible due to environmental considerations. In addition, search for a biological control agent for bacterial wilt from the local bacterial antagonists in Kenya was initiated in 1992; however, the biological control agents were largely ineffective (Smith et al., 1998). As for host resistance, nothing much has been achieved and research is going on.

When infection has already occurred, then measures are needed to contain the disease. To this end, local farmers are advised to use clean seed or tubers of tolerant varieties bought from reliable sources such as KARI-Tigoni or from Agricultural development Corporation (ADC). Unfortunately, there are no tolerant varieties (Kabira et al., 2006b). In addition, the farmers are advised to disinfect all farm tools with sodium hypochlorite (household bleach) before and after use, to rotate with crops that are not related to potatoes such as maize or beans, to plant potatoes in disease-free fields that have not been used for growing potato or tomato for at least 3 years and to avoid planting potatoes in low-lying or water-logged areas. They are also advised to stop run-off water from flowing into potato fields, not to pass through infected fields, to plant only whole, undamaged tubers, to weed regularly and earth up taking care not to damage roots and stems, to remove any volunteer potato plant from the previous season while weeding because it may be carrying the disease, to ensure that farmyard manure and compost are fully decomposed to avoid spreading disease and to check fields regularly for wilt and other diseases; if more than 1 out of 100 plants are infected with bacterial wilt, farmers should not to use the crop for seed production but for home consumption. Any diseased plants should be uprooted and dispose of (they should not be put on the compost heap). Farmers should keep the seed store clean and check regularly for rotten tubers (Kabira et al., 2006b; Gildemacher et al., 2007a; Gildemacher et al., 2007b; The Organic Farmer, 2010; 2008). After uprooting the diseased plants and removing the soil (from where the wilting plant has been uprooted), the material should be thrown in a 2-feet deep pit outside the field and covered with clean soil, or burnt. Subsequently two handfuls of ash or one handful of lime should be put in the hole (where the diseased plant has been uprooted) and mixed well with the soil (Gildemacher et al., 2007b).

In a previous study, it was found that farmers manage bacterial wilt of potatoes by uprooting (41%), crop rotation (36%) and spraying with fungicides (21%) (Kaguongo et al., 2010).

However, in spite of all these plausible recommendations, most small scale potato farmers in the Kenyan highlands just do nothing to contain the disease (Jane et al., 2013). This could be due to the fact that most of the farmers do not understand the disease, how it is spread and how to control it (The Organic Farmer, 2012). Most farmers have stopped growing potatoes altogether because the soils are already contaminated; when they open up new fields in an attempt to control the disease, they end up spreading the disease even further because the seeds they use are already contaminated.

Conclusions and Recommendations
Government policy regarding control of bacterial wilt in small holder potato farms (less than one hectare) in the Kenyan highlands (1500~3000 meters above sea level) is required to enable the crop maintain its status as the second most important crop after maize. Measures which could be considered include 1)
increasing the supply of certified seed potatoes at prices small farmers can afford 2) Improving the quality of farmers’ seed through legalizing Quality Declared Seed, and 3) promote potato production as a business so as to encourage farmers to control bacterial wilt on their farms.

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