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Original scientific paper

POTATO PRODUCTION PRACTICES AND LATE BLIGHT MANAGEMENT IN NYANDARUA COUNTY, KENYA

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ABSTRACT

Potato is the second most important crop after maize for food and nutrition security in Kenya. Late blight is a major threat to potato production causing losses of up to 100% if not controlled. Poor production and disease management practices enhance the development and occurrence of potato late blight. A survey was conducted in Nyandarua County to assess potato production and disease management practices on the development and occurrence of late blight. Solvin's formula was used to determine the sample of 105 farmers. Data on socio-demographic aspects, prevalent potato diseases, management options, and agronomic practices were collected and analyzed using SPSS version 25. Major findings reflected a positive correlation ($r = 0.57$, n = 105, p = 0.001) between the size of farms owned and the area under potato. Awareness of biological control practices and integrated disease management was 33.3% and 28.6%, respectively. Practices largely influencing disease prevalence included the use of single variety (86.7%) and farm-saved seeds (74.3%), providing a medium for inoculum incubation. Averagely, 48.6% of farmers practice mono-cropping, and 13.3% leave plant debris in the field which enhances inoculum build-up and recurrence. An average of 65.8% use fungicides in a single class, leading to the pathogen developing resistance. It is therefore recommended that potato farmers adhere to good agricultural practices including crop rotation, intercropping, alternation of fungicide classes, use of biological control products, use of clean certified seeds, proper field sanitation, and primarily Integrated Disease Management to minimize the prevalence of late blight and the associated heavy use of chemical pesticides.

Key words: Inoculum, *Phytophthora infestans*, biological control, pesticides, yield loss, farmer practices.

INTRODUCTION

In Kenya, potato *Solanum tuberosum* (L.) is second after maize concerning food and nutrition security and contributes up to 50 billion Kenya shillings annually (Muthoni *et al.*, 2013, 2017; Mumia *et al.,* 2018). Kenya is the fifth-largest potato producer in Africa realizing on average 8 to 15 t/ha (Taiy *et al.,* 2017). This production is about three times lower than the 30 to 40 t/ha potential (Muthoni *et al.*, 2013; Gitari *et al.*, 2018a, b). Potato is also of great importance since it has a rich nutritious value and short maturity period (FAO, 2013). About 90% of potato producers in Kenya are small scale farmers owning less than 1 hectare (Gitari *et al.,* 2016; Muthoni *et al.,* 2017). Potato is the leading food crop in Nyandarua County presenting a market value of 8.12 billion Kenyan shillings (Nyandarua CIDP, 2018).

In Nyandarua County, small-scale farmers face several challenges in potato production. These include, production practices, most notably decision making on disease management practices which has a significant effect on the development and occurrence of potato late blight (Pacilly *et al.,* 2016, 2019). Additionally, lack of disease-free certified seeds (Okello *et al.*, 2016; Thomas-Sharma *et al.,* 2016), attack by pest and diseases (Riungu, 2011), poor plant

debris management, high cost of inputs such as fertilizers and certified seeds, and marketing constraints where middlemen dominate (Machangi *et al.,* 2016).

Late blight, caused by the polycyclic pathogen *Phytophthora infestans* (Mont.) de Bary, is a major threat to potato production globally (de Vries *et al.,* 2018). The disease causes severe losses of about 30 to 60% in Kenya, and can lead to up to 100% yield loss if not controlled (Mariita *et al.*, 2016). Under favourable environmental conditions for such as, high relative humidity of >90% and low temperatures of 7.2 to 26.6℃ (Lal *et al.,* 2018), a potato crop can be infected by *P. infestans* at any stage of growth from emergence until post-harvesting stage, often leading to total crop failure. The attack by *P. infestans* is exacerbated by high rainfall, over 95% humidity, and temperatures below 15℃ (Lal *et al.,* 2018). *Phytophthora infestans* can survive in living host tissue, such as seed tubers, cull piles, and volunteer potatoes left in the field post-harvest, on alternate host crops, and around the root zone in the soil (Lal *et al.,* 2018).

Potato late blight has put a lot of pressure on farmers forcing them to rely heavily on synthetic pesticides to mitigate the effects of the disease (Rani *et al.*, 2017). About 93 to 100% of potato farmers in Kenya solely rely on synthetic pesticides to control late blight (Gianessi & Williams, 2011). The sole overreliance on synthetic chemicals very often lead to short and the long-term effect on human and environmental health as well as resistance development by the pathogen (Zaker, 2016). The study aimed to assess the impact of potato production and disease management practices on the development and occurrence of late blight disease in Nyandarua County, Kenya.

MATERIALS AND METHODS

Study site and design

A survey was carried out in May 2018 in Kinangop sub-County, Nayandarua County to assess potato production and disease management practices on the development and occurrences of late blight. Kinangop sub-County lies in the Upper Highland sub-zone 3 (UH3) Agro-ecological zone (Jaetzold *et al.*, 2007, 2010; MoALF, 2016), between 0°8’ North and 0°50’ South and between 0°43’0’’ South and 36°39’0’’ East. The area experiences bimodal rainfall, with the long rains occurring from March to May and short rains from September to December, averaging 1500mm annually (Nyandarua CIDP, 2018).

Nyandarua County has a total of 143,879 households (Nyandarua CIDP, 2018). A sample of 105 farmers was identified from the estimated 70,000 small scale potato farmers in Nyandarua (NCPK, 2021). The desired sample size was determined using Solvin’s formula with an 8% margin of error at a 95% confidence level (Subianto *et al*., 2013).

$$\boldsymbol{n = \frac{N}{1 + Ne^2}}$$

Where: ***n*** is the required sample size; ***e*** is the margin of error and ***N*** is the total population.

The 105 respondents were distributed in the eight wards of Kinangop sub-County proportionate to population size.

Households were randomly sampled at least 1 kilometer apart and administered with a semi-structured questionnaire. The interviews were conducted at the respondents’ farms to capture and confirm the information on the size of the farm, the area allocated to potato farming, farming history, cropping systems practiced, and late blight disease occurrence and management strategies. Photo cards were used to enable respondents to easily identify the symptoms of various diseases/pests observed in the farms (Schneider *et al.,* 2013).

Data analysis

Data on level of education, sources of seed tubers, and varieties of potatoes cultivated, farming practices and potato disease management practices were analyzed using IBM Statistical Package for Social Sciences (SPSS) software version 25.

RESULTS

A total of 47.6% of the respondents allocated less than 1 acre to potato farming, closely followed by 1-3 acres (43.8%) and 4-6 acres (8.6%). About 67.6% of respondents planted potatoes for three seasons in a single year, 29.5% cultivated for two seasons, while very few (2.9%) planted potatoes for only a single season in a year. Potato cultivation experience among the respondents varied with 34.3% having over five years while 12.4% had up to a year.

The relationship between the size of a farm owned and the area under potato reflected a medium positive correlation (Linear Pearson's $r = 0.57$, N = 105, p = 0.001) as shown in figure 1. This trend implies that a significant (p=0.001) change in farm size moderately influences a significant (p = 0.001) change in the area allocated to potato production and vice versa.

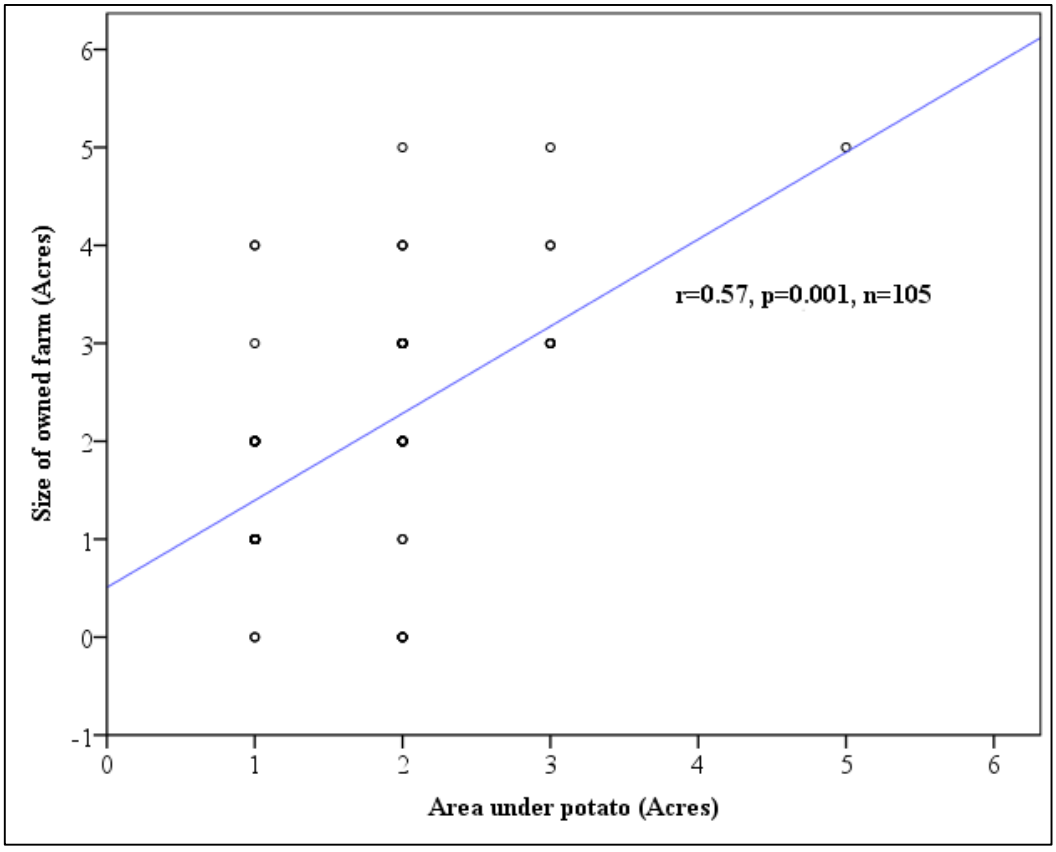

Figure 1. Relationship between area under potato and size of farms owned by small scale potato farmers in Nyandarua County. Linear Pearson's $r = 0.57$, n = 105, p = 0.001.

According to all the respondents (n = 105), potato is the most widely cultivated food and cash crop in Nyandarua County. Farmers intercrop or rotate potato with other crops including, cabbages, beans, peas, maize, groundnuts, carrots, and spinach. The most practiced system is crop rotation by 56.2% of the farmers closely followed by mono-cropping by 48.6%. Intercropping is practiced by 33.3% of the farmers while the least practised is relay cropping constituting only 1%. A combination of cropping systems is done by 30.5% of the farmers.

The majority of farmers in Nyandarua County (86.7%) prefer Shangi as compared to other varieties such as Asante (2.9%) due to its ready market, high yield, readily available seeds, and early maturity.

The main source of potato seeds for the majority of the respondents (74.3%) is tubers saved from the previous harvest. Some source seeds from neighbouring farms (23.8%) while others (14.3%) source seeds from certified dealers such as KALRO, Agricultural Development Corporation (ADC) and Midlands Co. Ltd.

According to 100 and 84.8% of respondents, respectively, potato late blight and early blight are the most devastating potato diseases in Nyandarua County. Other diseases include viruses (43.8%), dry rot (13.3%) and potato wart (6.7%).

Table 1. Fungicides used by small scale farmers in management of potato late blight in Nyandarua County

Trade name	Active ingredients	Respondents
Mistress® 72WP	Cymoxanil 8% + Mancozeb 64%	40.0%
Ridomil Gold® MZ 68WG	Mancozeb 64% + Matalaxyl 8%	15.2%
Tata Master® 72WP	Mancozeb 64% + Metalaxyl 4%	32.4%
Agromax® MZ 720WP	Mancozeb 64% + Cymoxanil 8%	13.3%
Sphinx Extra® 713 WDG	Folpet 600g/kg + Dimethomorph 113g/kg	3.8%
Vanguard® 525WDG	Cymoxanil 300 g/kg + Famoxadone 225 g/kg	2.9%
Fortress Gold® 72WP	Mancozeb 640g/Kg + Cymoxanil 80g/Kg	2.9%
Tajiri® 72WP	Mancozeb 64% + Cymoxanil 8%	2.9%
Twigalaxyl® 72WP	Mancozeb 640g/Kg+ Metalaxyl 80g/Kg	2.9%

Farmers solely rely on synthetic fungicides for potato late blight control. Most farmers (65.8%) apply a single type of pesticide while 34.2% alternate different types of fungicides. Cymoxanil, Mancozeb, and Metalaxyl are the major active ingredients contained in the most widely used fungicides reported by the respondents to manage potato late blight. A substantial number of farmers are aware of biological management and integrated disease management strategies, 33.3 and 28.6% of respondents, respectively. However, no respondent reported having used any biological product to manage potato late blight.

Fungicide application frequency against potato late blight is higher during the wet season when the disease is more prevalent and lower during the dry season. During the wet season, 42.9% of potato farmers apply fungicides once a week, 21% apply twice a week, whereas 3.8% apply thrice a week. During the dry season, 26.7% of farmers apply fungicides twice a month, whereas 5.7% apply thrice a month.

After harvesting, 82.9% of farmers use potato plant debris for animal feed, 29.5% burry to decompose, while 13.3% leave the debris to dry in the open field.

DISCUSSION

Potato immensely contributes to food and nutrition security besides being a major source of livelihoods for millions of Kenyans. Potato late blight's occurrence and development is influenced by various factors such as recycling of seeds from the previous harvest, intensive mono-cropping, all year-round potato cultivation, excessive reliance on synthetic chemicals and poor plant debris management.

More men than women in Nyandarua County were literate and actively involved in potato production as per the current study. Men predominantly being the household heads largely influence decision making (such as seed variety and source, pesticide type, etc.) at the household level which can either directly or indirectly influence the prevalence of potato late

blight finally affecting production (Kaguongo *et al.,* 2008). Nyamwamu *et al.* (2014) and Okpachu *et al.* (2014) associated to gender and level of education to technological adoption. Mburu *et al.* (2014) equally reported that gender and level of education impact economic efficiency, perception, and interpretation of useful information regarding plant disease management hence affecting productivity.

The observed significant positive correlation (r=0.57, N=105, p=0.001) between farm size owned and the area under potato production corresponds to the findings of Muthoni *et al.* (2013) of r=0.66 in Kenya. This implies that the more the size of the farm, the more the area allocated for potato production whilst the smaller piece left for other food crops. This supports the report of Nyandarua CIDP (2018) that potato is the leading food crop cultivated by most small-scale farmers in Nyandarua County.

Due to the importance of potato as a source of food and income in Kinangop, the majority of farmers from Nyandarua County cultivate it all year round for up to three consecutive seasons as reported previously by Wakahiu *et al.* (2007). According to the findings of Muthoni *et al.* (2013), potatoes are generally grown in the two rainy seasons in Kenya. Intensive mono-cropping of potato, however, sustains inoculum build-up and spread of late blight (Xie *et al.*, 2016).

Potato late blight is a polycyclic disease completing many disease cycles in a single year (Forbes *et al.,* 2007), this makes it very aggressive developing explosively under favourable environmental conditions (low temperatures and high relative humidity) (Lal *et al.,* 2018). Potato late blight also has the ability to survive in the soil and alternate hosts through spores (Binyam, 2014), thus all year-round cultivation extends spore exposure of potato plants to late blight (Pacilly *et al.*, 2016), making it difficult to manage.

Compared to other food crops such as maize, potatoes generate income more quickly (Muthoni *et al.,* 2013). Shangi's preference in Nyandarua County is attributed to its ready market, high yields, readily available seeds, and early maturity as compared with the other varieties such as Asante as noted from the current finding. Despite Shangi's preference, it is classified as a moderately susceptible variety to potato late blight by the National Potato Council of Kenya (NPCK).

The findings of this study confirm that potato seeds/tubers are mainly sourced from famers' previous harvests as formerly reported by Muthoni *et al.* (2013). A small number of farmers purchase seeds from certified dealers due to the cost implications (Mburu *et al.,* 2014; Nyamwamu *et al.,* 2014). Successive cycles of seed recycling over seasons are one of the major reasons for low yield in potato production (Gaur, 2010) due to potential genetic degeneration (Thomas-Sharma *et al.,* 2016). This is because most seed-borne pathogens, including potato late blight, are most likely to survive and build up in the seeds offseason over time and could be carried on to the subsequent planting season (Gaur, 2010, 2013; Nyamwamu *et al.,* 2014; Thomas-Sharma *et al.,* 2016; Okello *et al.,* 2016). Poor quality seeds or infected seed can cost farmers up to 50% of the total production costs (Gaur, 2010; Okello *et al.,* 2016). The use of certified seeds lowers the chances of occurrence of primary inoculum (Thomas-Sharma *et al.,* 2016).

There is inadequate awareness of biological management and integrated management strategies for late blight among the small-scale potato farmers in Nyandarua County. The fungicide application regime is dependent on the weather condition which foretells disease incidence levels, with late blight well known to thrive well in cooler conditions (Jackson-Ziems *et al.*, 2016). Wet season enables favourable environmental conditions, for instance, high relative humidity (>90%) and low temperatures (7.2 to 26.6℃) (Lal *et al.,* 2018) for late blight's rapid establishment and development (Fry *et al.,* 2013). Results from the current study indicate that during the rainy season, the majority of farmers apply fungicides on a seven-day regime whereas during the dry season it's applied on a twice a month regime. The current

study's findings confirmed those reported by Namanda *et al.* (2004) that in Uganda, pesticides were being applied more than ten times in a single growing season. Overuse of fungicides is not economically viable to small scale farmers as it increases the cost of production (Schreinemachers *et al.,* 2020).

Additionally, synthetic fungicides are toxic and harmful to human health; excessive and long-time exposure can lead to chronic illnesses such as breathing complications and cancers (Hashmi & Khan, 2011; Li *et al.,* 2014). In addition, the fact that the synthetic fungicides are not easily biodegradable and lack target specificity brings about environmental pollution adversely affecting biodiversity (Mahmood *et al.,* 2016). Consistent application of such fungicides from a single class and/or those with the same active ingredients over time has been associated with resistance development by *P. infestans* (Mekonen & Tedesse, 2018).

CONCLUSIONS

Most practices carried out by farmers such as recycling of seeds from the previous harvest, intensive mono-cropping, all year-round potato cultivation, excessive use of synthetic chemicals and poor plant debris management were found to exacerbate the occurrence and development of potato late blight in Nyandarua County. Poor farmer practices influence the development and occurrence of late blight by introducing and spreading inoculum into uninfected areas and into subsequent seasons, sustaining continuity of pathogen's cycles and resistance development by the pathogen. The potential development of resistance by the pathogen could be induced by the excessive pressure to control the disease using synthetic chemicals. Primarily, adoption and integration of various disease management options (IDM) to minimize excessive use of synthetic chemicals should be advocated for, the use of good agricultural practices (GAPs) in plant disease management should as well be encouraged.

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