

Incidence and Occurrence of Root-Knot Nematode (*Meloidogyne species*) in African Leafy Vegetables in Western Kenya

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Abstract

There is a rekindled interest and increased demand for African Leafy Vegetables (ALVs) by urban dwellers of all socio-economic classes in Kenya. The current supply of ALVs does not meet the domestic demand due to production constraints which include pests and diseases. Root knot nematodes (RKNs) are economically important pests in a wide range of cultivated vegetables in tropical and subtropical countries where they cause losses of up to 80% in heavily infested fields. However, there is little information on their incidence and occurrence on ALVs in Kenya. The study was conducted in Busia, Bungoma and Kakamega Counties in ALVs farms to determine the types of ALVs grown and the occurrence and prevalence of RKNs in Western Kenya. Structured questionnaires were administered to 120 purposively sampled respondents, 40 from each county. Soil samples from the farms and four most grown ALVs were sampled for RKNs presence and data analysed using SPSS. The study revealed that nine ALV types were grown in the three counties and the four most grown were Solanum nigrum (56%), Cleome gynandra (52%), Crotalaria spp. (46%) and Amaranthus spp. (45%). The frequency of RKN in the three counties ranged from 60-83% with Busia recording the lowest and Bungoma the highest. The incidence of RKN was highest in Solanum spp. (79.3%) as compared to Cleome spp. (10.7%), Crotalaria spp. (0.3%) and Amaranthus spp. (1%). The plant damage or root gall/root system of the plants differed significantly at $P < 0.05$ for the four different ALVs; Solanum spp. (mean of 4.8), Cleome spp. (3.7), Crotalaria spp. (1.0) and Amaranthus spp. (2.5). Mixed cropping system was practiced by over 60% of the farmers with 48.3% of the farmers growing all their vegetables in the main farm, 80% in home gardens and 28.3% growing both in the main farm and in home gardens. RKNs prevalence was found to be high in the three counties at 73%. There was no significant difference in nematode levels both in mixed and mono cropping systems. Solanum was found to be very susceptible to RKNs while Crotalaria was a non-host.

Key Words: African Leafy Vegetables, Cropping Systems, Root Knot Nematodes

Introduction

African Leafy Vegetables (ALVs) are an important commodity in the diet of many African communities because they are affordable to many people in rural, peri-urban and urban areas. They are accessible to low-income communities and they play a crucial role in food security of poor families (Gotor & Irungu, 2010). ALVs play a very important role as source of nutrients to the human body and their consumption ensures intake of various essential mineral elements and vitamins hence avoiding the problem of malnutrition (Oladele, 2011). In Western Kenya, ALVs are valued for their taste, nutritional qualities, medicinal and culinary properties. These vegetables are easily adapted to the environmental conditions they are being grown and are easy to grow and manage (Abukutsa-Onyango, 2007a).

There is an increasing interest in indigenous vegetables and fruits throughout the world, reflecting a growing trend within agriculture to identify and develop new crops for export and domestic markets which are often referred to as neglected and underutilized species (Oladele *et al.*, 2011). In Kenya, there is a rekindled interest and therefore increased demand for these vegetables by urban dwellers of all socio-economic classes. The increase in demand has stimulated many entrepreneurs especially women to grow and trade these vegetables on small scale. Hence, opportunities exist in Kenya to use ALVs to expand the local food base, improve the health of the population, enhance food security and generate income (Onyango *et al.*, 2009).

However, the demand for ALVs in Kenya outstrips the market supply (Ngugi *et al.*, 2007) due to low production. The low production of ALVs is due to various reasons which include; poor seed quality, drought, poor marketing channels, lack of agronomic techniques (Abukutsa-Onyango, 2007a), flooding and root knot nematode (RKN). It has been reported that RKN is among the greatest threat to vegetable production in Kenya (Nchore *et al.*, 2012).

Vegetable crops in tropical and subtropical countries are among the most susceptible and worst affected by these nematodes (Anwar *et al.*, 2011), they cause losses of up to 80% in heavily infested fields and lead to global agricultural losses amounting to an estimated \$157 billion annually (Abad *et al.*, 2008). They reduce crop productivity by their direct parasitism that induces extensive galling and root damage which reduce the absorptive capacity for water and nutrients, by their association in the pathogenic disease complexes (Anwar & McKenry, 2012) and by their effect on

legume biological N-fixation. The occurrence of RKNs in indigenous vegetables in Kenya has not been reported unlike in other countries therefore there is little information on their incidence and prevalence on ALVs.

Materials and Methods

Study Sites

The study was conducted in Busia, Bungoma and Kakamega counties, located between an latitude of 0.25° S and longitude 33.5° E. The altitude ranges from 1000-1500 metres above sea level, annual rainfall ranges from 1000-2000 mm and annual average temperature fluctuates between $15-30^{\circ}$ C with a mean annual temperature of 21° C.

From these counties respondents were purposively sampled on the basis of their growing the ALVs. 120 structured questionnaires were administered to respondents in the three study sites (40 for each site). Information captured in the questionnaires included crops grown, the list of ALVs cultivated, section of land allocated to the vegetables, and the cropping system used by the respondents.

Soil and Roots Sampling

Soil and root sample were taken from the 120 farms of the respondents. Four most grown ALVs types in the three counties were randomly selected in a zigzag pattern per farm and three plants of each type gently dug out together with the adhering rhizosphere soil using a hand trowel. Soil was shaken off gently from the roots and then placed in a labelled polythene samples bag. Soil samples were taken up to a depth of 30 cm around the rhizosphere of the sampled plants and thoroughly but gently mixed and a 1 kg sub-sample taken. Both roots and soil samples were placed in a cool box and the procedure repeated for the other farms. The samples were transported to the University of Eldoret laboratory for extraction.

Nematode Extraction from Soil

Extraction of nematodes from the soil was done using the modified extraction-tray technique as described by Thomas (1959). Soil samples were mixed and passed through coarse sieve to remove rocks and a sub sample of 100 g measured. The

recovered nematodes were quantified using an electronic microscope and the density expressed as the number of nematodes in 100 g of soil.

Assessment of Root-knot Nematode Gall-indices

This was done on the four most grown ALVs types in the region. The plant roots were washed with water and stained with cold yellow eosin solution (0.1 g/L) for 30 min (García & Sánchez-Puerta, 2012). Stained root galls on the root system were assessed on a 0–5 scale: 0 = 0 galls per plant, 1 = 1-2, 2 = 3-10, 3 = 11-30, 4 = 31-100 and 5 = more than 100 (Taylor & Sasser, 1978).

The frequency of occurrence (prevalence) and incidence of the RKNs in each county was calculated by the formula of Esfahani (2009):

$$\text{Frequency of occurrence} = \frac{\text{Number of fields with RKN infection}}{\text{Total number of fields surveyed}} \times 100$$

$$\text{Incidence} = \frac{\text{Number of plants galled}}{\text{Total number of plants sampled}} \times 100$$

Data Analysis

Data was subjected to analysis of variance (ANOVA) and analyzed using Statistical Package for Social Scientists (SPSS). The differences were accepted as significant at $P < 0.05$. Descriptive statistics was used to explain the quantitative part where percentages of the various responses were used and presented in form of tables and graphs.

Results and Discussion

Nine ALVs types were found to be grown in the three regions; these include Amaranth (*Amaranthus* spp.), Night shade (*Solanum* spp.), Spider plant (*Cleome gynandra*), Pumpkin leaves (*Cucurbita moschata*), African eggplant (*Solanum aethiopicum*), Cowpea (*Vigna unguiculata*), Jute mallow (*Corchorus olitorius*), Sweet potato leaves (*Ipomoea batatas*) and Slender leaf (*Crotalaria* spp.) (Figure 1). The four most grown in the three counties were *Solanum* spp. (56%), *Cleome gynandra* (52%), *Crotalaria* spp. (46%) and *Amaranthus* spp. (45%).

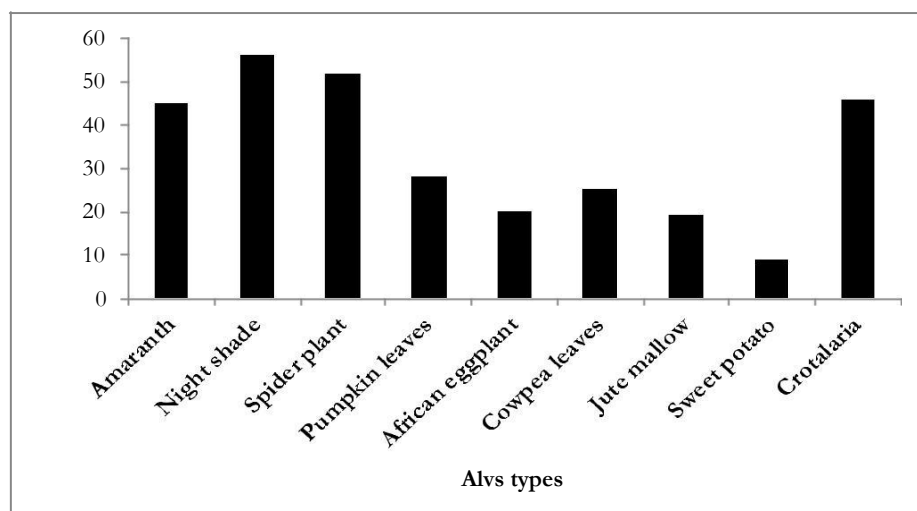


Figure 1. ALVs Grown in Western Kenya

In Kakamega County the four most grown ALVs were found to be *Amaranthus* spp., *Cleome* spp., *Corchorus olitorius* and *Ipomoea batatas* leaves (Figure 2). In Bungoma, *Solanum* spp., *Amaranthus* spp., *Cleome* spp. and *Solanum aethiopicum* were found to be the four most grown while in Busia it was *Amaranthus* spp., *Vigna unguiculata*, *Corchorus olitorius* and *Crotalaria* spp.

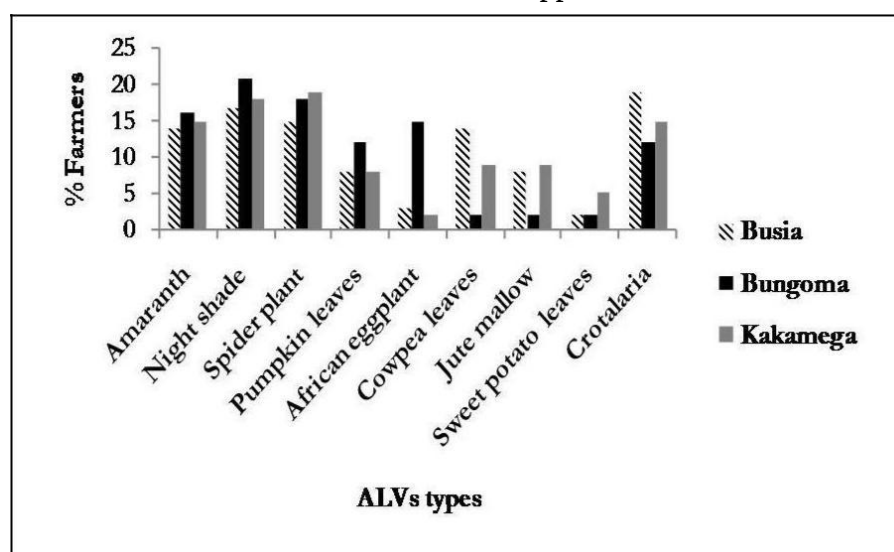


Figure 2. ALVs Grown in Western Kenya (Busia, Bungoma and Kakamega)

The incidence of RKN was highest in *Solanum* spp. (79.3%) in the three counties as compared to *Cleome* spp. (10.7%) *Crotalaria* spp. (0.3%) and *Amaranthus* spp. (1%) (Table 1).

Table 1. Incidence of Root-Knot Nematodes in Western Kenya

Common ALVs types	No. of plants sampled	No. of plants galled	Incidence (%)
<i>Solanum</i> spp.	360	286	79.3
<i>Cleome</i> spp.	360	39	10.7
<i>Crotalaria</i> spp.	360	2	0.3
<i>Amaranthus</i> spp.	360	4	1

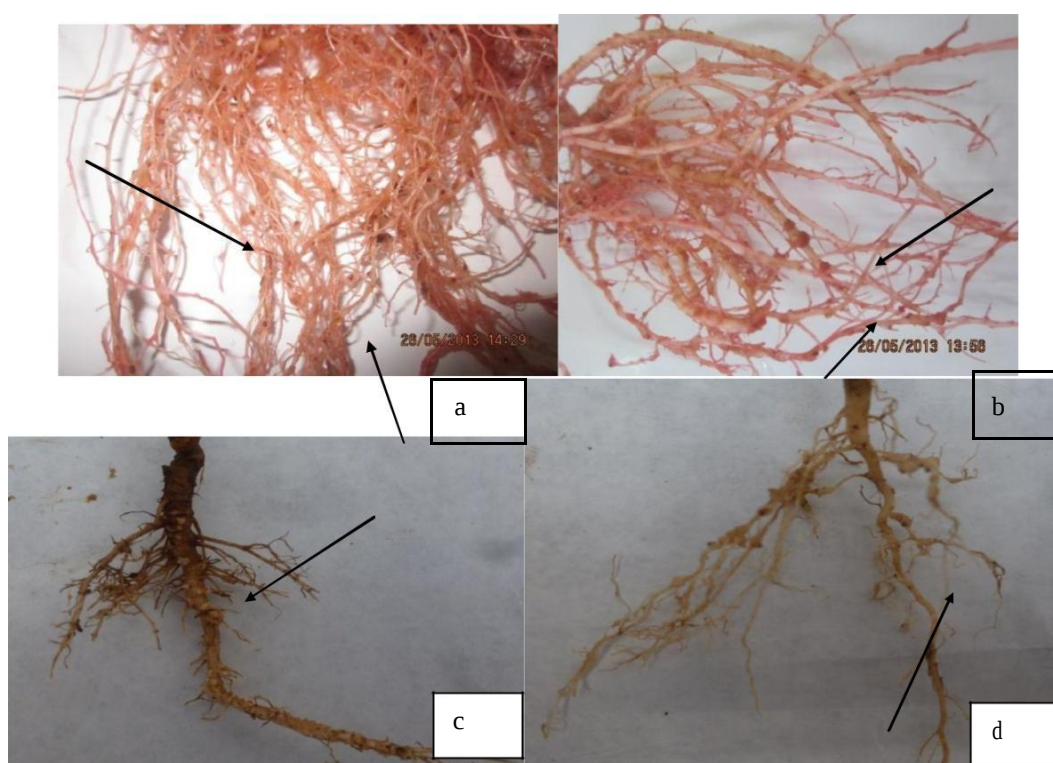


Plate 1. Root-knot Galls on *Solanum* spp. (a), *Cleome* spp. (b), *Crotalaria* spp. (c) and *Amaranthus* spp. (d)

The plant damage or root gall/root system of the plants differed significantly at $P < 0.05$ for the four different ALVs; *Solanum* spp. (mean of 4.8), *Cleome* spp. (3.7), *Crotalaria* spp. (1.0) and *Amaranthus* spp. (2.5).

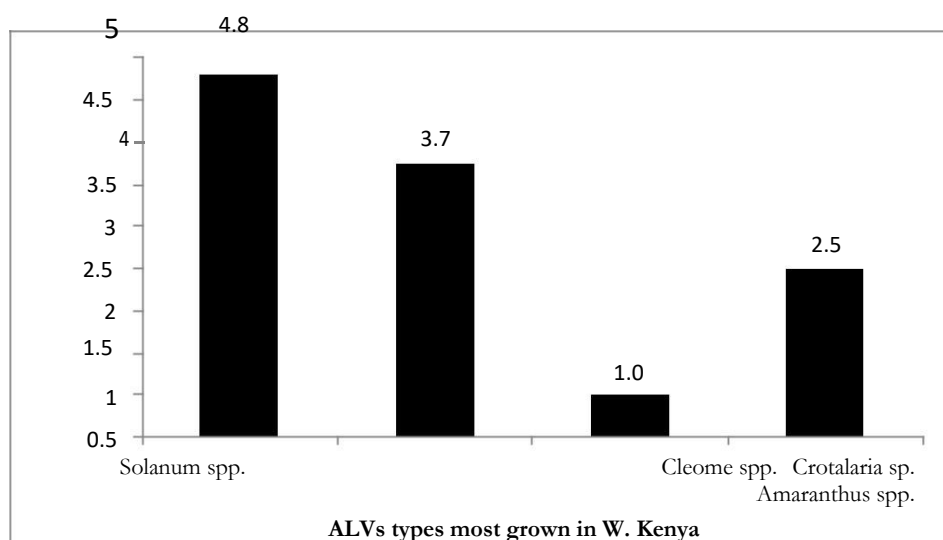


Figure 3. Mean Gall Index (GI) of the Four most Grown ALVs in W. Kenya

Root knot nematodes were present in the three counties in the soil samples collected (Table 2). The frequency in the three counties ranged from 60-83% with Busia recording the lowest and Bungoma the highest. The frequency of occurrence in the three regions of Western Kenya was found to be 73%.

Table 2. Frequency Occurrence of Root-Knot Nematodes in Western Kenya

Counties	No. of fields surveyed	No. of Fields with Infection	Frequency (%)
Busia	40	24	60
Kakamega	40	30	75
Bungoma	40	33	83
Total	120	87	73

Over 60% of the farmers in the three Counties practiced mixed cropping systems in their farms while only 34% of the farmers practiced mono cropping system (Figure 4). The vegetables were mostly grown with other vegetables or cereals like sorghum, millet or maize.

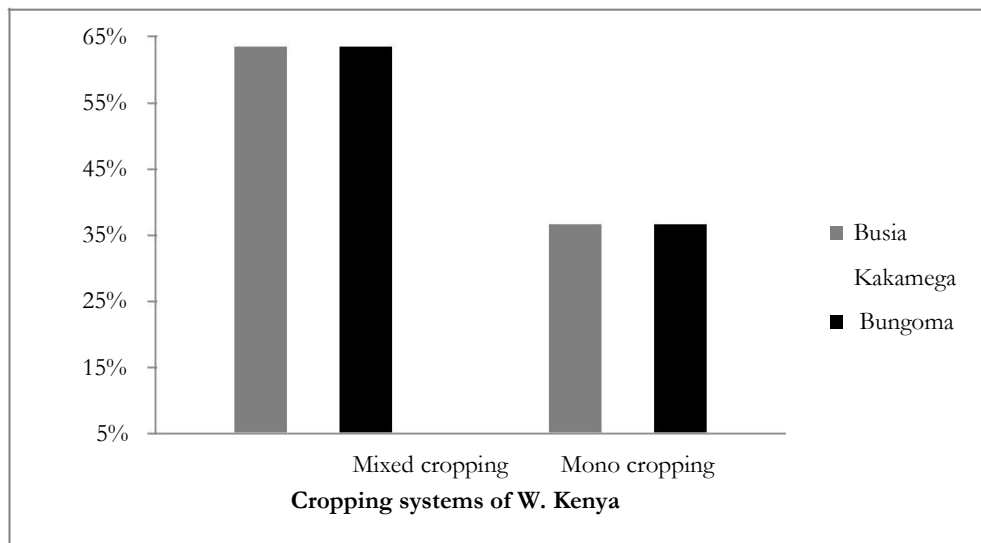


Figure 4. Cropping Systems of Western Kenya

The study showed that 48.3% of the farmers grow all their vegetables in the main farm while most of the ALVs farmers, 80% grow all their vegetables in home gardens. 28.3% grew some of the vegetables in the main farm and others in home gardens (Figure 5). The ALVs grown in the main farm included *Crotalaria* spp. and *Vigna unguiculata* as they are hardy and do not require frequent watering in case of drought while ALVs like *Solanum* spp., *Cleome* spp. and other drought susceptible vegetables are grown in the home gardens.

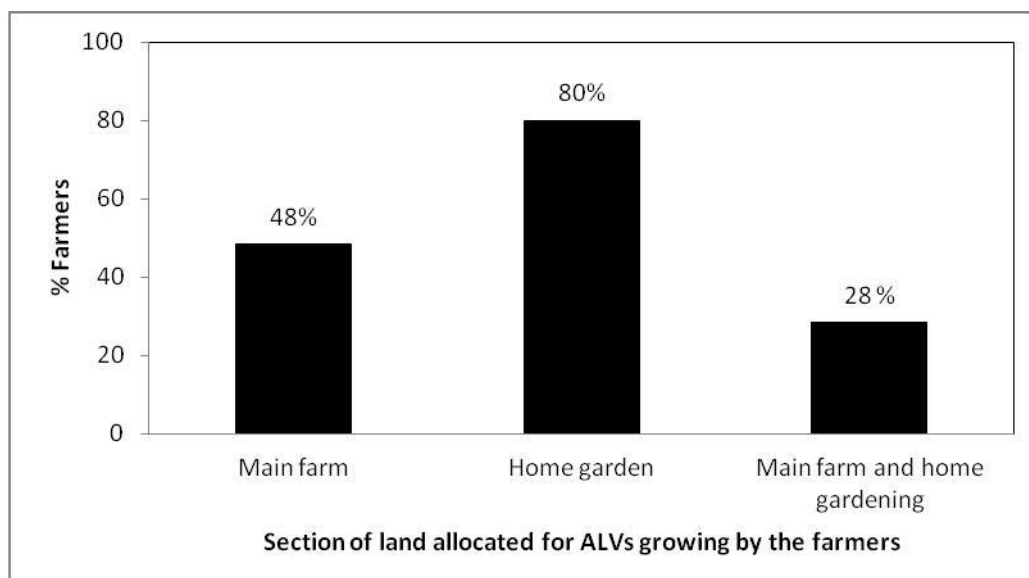


Figure 5. Section of Land Allocated For ALVs Growing by the Farmers

The nematode levels in the soils obtained from both the mixed and mono cropping systems fields showed no significant difference in Busia and Kakamega Counties (Figure 6). However in Bungoma where there was a high nematode occurrence, there was a significant difference in RKN levels with the mono cropping system having higher nematode levels of 93% and mixed cropping system at a level of 83%.

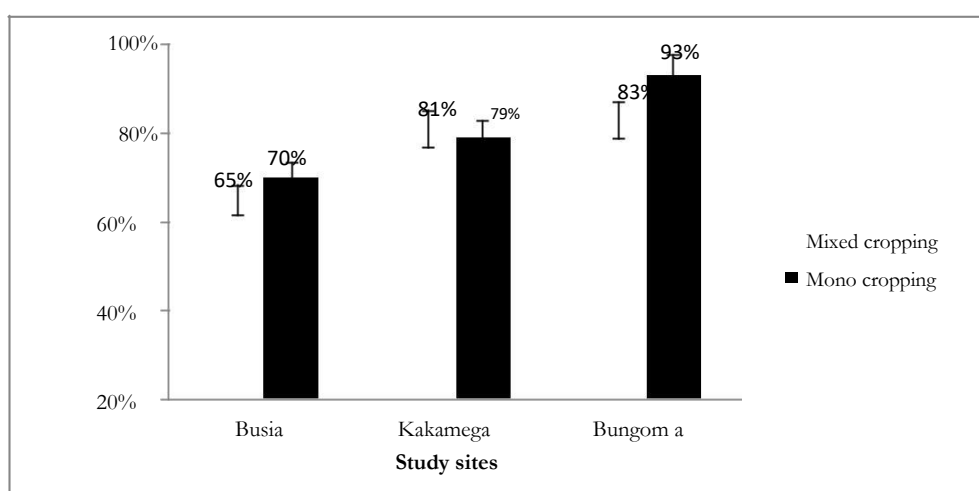


Figure 6. RKNs Levels in Cropping Systems of W. Kenya

Discussions

The findings of the study revealed the existence of many types of indigenous vegetables in Western Kenya as reported by Nchore *et al.* (2012). In Kenya, the traditional leafy vegetables commonly utilized include Spider plant (*Cleome gynandra* L.), Night shades (*Solanum* spp.), Amaranthus (*Amaranthus hybridus*), Cowpea (*Vigna unguiculata*), Crotalaria (*Crotalaria* spp.) and Jute mallow (*Corchorus olitorius*) (Ng'etich *et al.*, 2012). These ALVs represent six botanic families which include Amaranthaceae, Capparaceae, Cucurbitaceae, Fabaceae, Solanaceae and Tiliaceae.

Solanum spp. was found to be the most grown ALVs in the regions; this is supported by the findings of Ondieki (2011) who observes that African nightshades are among the many ALVs that continue to be cultivated by many Kenyan communities. A market survey carried out in Kakamega municipal market revealed that among the ALVs nightshades was among the top ten important vegetables and ranked third in terms of quantities traded (Abukutsa-Onyango, 2000). A study carried out in Western

Kenya communities of Luo, Luhya and Kisii regions by Abukutsa-Onyango, (2007b) found that *Cleome gynandra*, *Crotalaria* spp., *Vigna unguiculata*, *Corchorus olitorius*, *Solanum* spp. and *Amaranthus* spp. were the most profitable ALVs grown in the regions.

The incidence of RKN was highest in *Solanum* spp. compared to *Cleome* spp., *Crotalaria* spp. and *Amaranthus* spp. This is supported by Nchore *et al.* (2012) who say that Kisii and Trans-mara counties the incidence of RKN was highest in *Solanum* spp. (64.5%) as compared to *Cleome* spp. (8.5%) and *Amaranthus* spp. (1%). *S. nigrum* is a good RKNs host (Dorman & Nelson, 2012) and is very susceptible for having root galling of > 3. Nightshades were found to have the highest galling index because the vegetables support fast development of nematodes (Lamondia, 1996) in their roots.

The presence of few galls on the roots of *Amaranthus* spp. and *Cleome* spp. is not an indication that they are immune to these nematodes but poor hosts with some level of resistance resulting to reduced incidence and prevalence of RKN (Nchore *et al.*, 2012). These plants therefore show that they support reproduction and development of RKN but at a slower rate. Similar findings were reported by Ateeq-ur-Rehman (2009). However, this does not apply for *Crotalaria* spp. which was found to have the lowest incidence and the least no of galls. This is because these species have been known to effectively suppress populations of RKNs (Costa *et al.*, 2012) and reduce or even eliminate plant parasitic nematodes. The vegetables inhibit egg masses formation and production of root-knot galls (Mbogoh *et al.*, 2012).

The frequency of Root-Knot nematodes in the region was above 50% an indication that it was high. This is supported by reports that have indicated RKNs of the genus *Meloidogyne* spp. are prevalent in most vegetable production areas especially in Western Kenya (Arim *et al.*, 2006). Previous studies on different crops have also shown that root-knot and lesion nematodes are widespread and occur in large numbers in western Kenya (Desaeger & Rao, 2001). In a study conducted in tobacco growing fields in Busia and Bungoma, it was found that RKNs were present in all the 238 sites sampled and the nematodes contributed up to about 85% of the total population count of parasitic nematodes in the tobacco fields (Jogallo, 1984). The high frequency of occurrence of nematodes in the regions could be due to the warm and wet conditions prevailing in the area coupled with high cropping intensity of susceptible plants ideal

for nematode population build up (Kimenju *et al.*, 1999). The lower nematode frequency in Busia could be attributed to the presence of *Crotalaria* spp. in the sampled farms which has been reported to be a non-host of RKN (Mbogoh *et al.*, 2012) and was found to be the most grown vegetable in the region.

Mixed cropping system was reported to be widely practiced in the three counties with most of the farmers growing ALVs in home gardens for ease of management and to protect them from animal damage and thieves. Abukutsa-Onyango (2007a) reports that intercropping is practiced by ALVs farmers in W. Kenya as it offers several advantages that include having diversity of crops in a given season, optimal utilization of resources like nutrients, water and light especially if the intercrops have different growth patterns. She also notes that all the farmers grow their ALVs in home gardens which differed from the results of this study as some farmers grew their vegetables in the main farm while others grew them both in the main farm and in vegetable gardens. Agronomic studies have also revealed that most indigenous fruits and vegetables are grown as intercrops in home gardens (Abukutsa-Onyango, 2011). It has also been reported that ALVs are normally grown in home gardens (Musotsi, 2005) and are usually intercropped with other vegetables or cereals like maize, sorghum or millet (Obuoyo, 2005).

The nematode levels in both the soil and root samples was high in both the mixed and mono cropping systems yet mixed cropping systems is expected to have lower levels. This could be because the vegetables incorporated in the mixed cropping are susceptible to RKNs and therefore lead to multiplication rather than suppression of these pests. These findings are supported by the fact that vegetable crops in tropical and subtropical countries are very susceptible and worst affected by nematodes (Anwar *et al.*, 2011).

Conclusions

The study showed that the three study sites have a high diversity of cultivated African Leafy Vegetables covering six botanic families. *Solanum* spp. is the most grown vegetable and yet very susceptible to nematode attack as it had highest incidence of RKN infection and highest galling index. However, *Crotalaria* spp. is a non-host of RKNs. Respondents in the regions cultivate ALVs in mixed cropping systems both in

home gardens and in the main farm. The RKNs prevalence in the region in all the cropping systems was high indicating that nematodes are widespread in vegetable growing areas of Western Kenya.

Recommendations

The farmers are advised to grow *Crotalaria* spp. in rotational and mixed cropping systems to reduce nematode populations for subsequent and companion susceptible crops.

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