Journal of Agricultural Sciences
Vol. 60, No. 3, 2015
Pages 301-314

DOI: 10.2298/JAS1503301L
UDC: 635-295(676.2)
Original scientific paper

POTENTIAL OF INTERCROPPING FOR MANAGEMENT OF SOME ARTHROPOD AND NEMATODE PESTS OF LEAFY VEGETABLES IN KENYA

Kimaru S. Linguya[1*], Onyango C. Moraa[2], Kimenju J. Wangai[2] and Kilalo D. Chao[2]

[1]Ministry of Education, P.O box 281-10201, Murang'a, Kenya.
[2]Department of Plant Science and Crop Protection, University of Nairobi, Kenya, P.O box 30197, Nairobi

Abstract: African leafy vegetables (ALVs) play an important role as income and food security crops in many households in Kenya. However, their potential in alleviating poverty and ensuring household food and nutrition security has not been fully exploited. The objectives of this study were to identify some arthropod and nematode pests that infest ALVs and to evaluate the effectiveness of intercropping of susceptible and resistant plants for the management purposes. Three vegetable types: African nightshade, sunn hemp and spider plant were used in determining the efficacy of an intercrop of susceptible and non-susceptible types in reducing arthropod and nematode pest effect. The treatments in the field experiment consisted of different intercrop designs and a sole crop design as control while data was taken based on five different variables. Crops in the field were infested with arthropod pests and eight different species were enumerated. The same row and hill intercropping designs were the most effective in reducing the effect of arthropod and nematode pests compared to the control plots. Spider plant and African nightshade intercrops recorded the least arthropod pest damage, higher fresh and dry shoot yields and differed significantly ($P \leq 0.05$) to African nightshade planted as a sole crop. A similar trend was observed when the experiment was repeated with a sunn hemp and African nightshade intercrop. It is concluded from this study that intercropping of different crops can be integrated with other methods to provide an easily adaptable technology to apply for effective management of arthropod and nematode pests with low external inputs.

Key words: leafy vegetables, juveniles, efficacy, susceptibility, nematodes.

[*]Corresponding author: e-mail: samuelklinguya@gmail.com

Introduction

There is rekindled interest in and increased demand for African leafy vegetables (ALVs) by rural and urban dwellers of all socio-economic classes in Kenya. This has stimulated the production of these vegetables but the supply is lower than the demand, leading to low consumption levels (Gotor and Irungu, 2010). The most widely cultivated ALVs in Kenya include spider plant (*Cleome gynandra* [L.] Thunb), amaranth (*Amaranth hybridus* [L.] Thell), African nightshade (*Solanum scabrum* [L.] Mill.), cowpea (*Vigna unguiculata* [L.] Walp.), jute mallow (*Corchorus olitorius* [L.] Guillaumin) and sunn hemp (*Crotalaria juncea* [L.] Duke.) (AVRDC, 2003). Traditionally, these ALVs are used as food. They are rich in mineral nutrients and have medicinal value (Abukutsa-Onyango, 2007). For example, amaranth and African nightshade can be used to feed those people with human immune deficiency virus (HIV/AIDS) since they are both nutritive and therapeutic (Abukutsa-Onyango, 2007). According to Adebooye and Opabode (2004), the vegetables can be used to eliminate malnutrition and promote healthy diets in Africa, through the increased production and consumption. The leaves and seeds provide vitamins A and C, calcium, iron, protein, carbohydrates and lipids (IPGRI, 2003).

ALVs like sunn hemp (*Crotalaria juncea*) and spider plant (*Cleome gynandra)* produce strong odour and farmers report little incidence of arthropod and nematode pests on them compared to exotic ones (Nchore et al., 2010). The above observation suggests that these vegetables possess inherent pest repellent effects and antagonistic properties. According to Wang et al. (2003), these vegetables also suppress non-edible weeds in fertile soils. African nightshade, sunn hemp and spider plants were used as intercrops for arthropod and nematode pest management in the current study. Sunn hemp reduces egg oviposition in nematodes and as a legume has an added advantage of increasing yields through nitrogen fixing capacities (IPGRI, 2003).

Sunn hemp suppresses nematode pests by producing toxic allelochemicals and also encourages the production of nematode-antagonistic fungi. The combination of the above factors reduces the population densities of *Meloidogyne* species, Goeldi, 1887 (*Meloidogyne javanica* [Treub, 1885], *M. arenaria* [Neal, 1889], *M. incognita* [Kofoid and White, 1919] and *M. hapla* [Chitwood, 1949]) by interfering with their feeding and reproduction (Keller, 2004; Wang et al., 2003). Intercropping with a non-host plant such as spider plant has a disruptive effect on feeding by arthropod pests through physical or chemical perplexity (Schippers, 2000). The objectives of this study were to identify arthropod and nematode pests that infest ALVs and to evaluate the effectiveness of intercropping of susceptible and resistant plants for the management purposes.

Materials and Methods

Experimental site

The experiments were established at Kahatia location of Murang’a County from June to October 2012. Kahatia is located at latitude 0^0 43’30’’ South and longitude 37^0 9’ 28’’ East at an altitude of 1,700m above sea level (Kenya-data@maps, 2012). The site receives mean annual rainfall of 1,800mm while the soils are volcanic in origin, extremely deep and dark reddish brown to dusky red clay (Nitosols) (Gachene and Kimaru, 2003). The temperature ranges between a minimum of 14^{o}C and a maximum of 28^{0}C with a mean average of 24 ^{0}C (Gachene and Kimaru, 2003).

Experimental material

African nightshade (susceptible to arthropod and nematode pests) was intercropped with sunn hemp and spider plant (both resistant to arthropod and nematode pests). African nightshade, sunn hemp and spider plant were categorized into different groupings after evaluation for resistance to root knot nematode in 2012 under greenhouse conditions. The selected vegetables were first raised in the nursery except spider plant. The nursery was raised 15cm above the ground surface; soil was loosened and enriched with decomposed manure. Seeds of the selected vegetables were sowed singly in drills 10cm apart. The seedbed was initially mulched but the mulch was removed when the seeds started germinating. The nursery bed was watered daily and seedlings were transplanted to the seedbed. Those with six true leaves, vigorously growing and healthy were selected. Farm yard manure was applied at 20 kg per 9 m^2 for proper seedling establishment in the field.

Experimental Design

The seedbed was subdivided into thirty-six plots each measuring 3 m x 3 m. The treatments were: the same row intercropping of resistant and susceptible African leafy vegetables (ALVs), the same hill intercropping of resistant and susceptible ALVs, border intercropping of resistant and susceptible ALVs, one row intercropping of resistant and two susceptible ALVs, alternate row intercropping of resistant and susceptible ALVs and the control plots which were planted with monocrops. African nightshade was intercropped with spider plant in block one under six treatments replicated thrice. In the second block, African nightshade was intercropped with sunn hemp under six treatments replicated thrice. Both experiments were laid out in a randomized complete block design. Inter and intra row spacing was 40cm x 20cm with one plant per hill. The crops were watered regularly and weeding was done when necessary. The experiment was repeated for the second season following the same procedure.

Sampling, estimation and identification of arthropod pests

Identification and estimation of populations were done through monitoring of arthropod pests infesting the different crop species by visual leaf inspection. Oviposition, feeding damage and mines were used to identify leaf miners while aphids were observed on the underside of the leaves and at the growing terminals. Thrips and whiteflies were monitored by gently tapping the plants and recording the numbers of thrips on a white paper as well as counting them. A hand lens was used to help identify adults and immature thrips and whiteflies on the leaves. A visual inspection of diamondback moth was done to detect larvae, oviposition, damage occasioned by small circular holes in leaves from the undersides giving the leaves a shot-hole appearance.

Red, green and yellow specks of red spider mite damage symptoms were monitored. Scale insects were recorded as present or absent without estimating their numbers. The population of flea beetles was obtained by gently tapping the plant leaves and stems on a white paper with insect counting squares and manual counting for small pests and large pests respectively. Shoot damage due to arthropod pests was scored using a scale 0–3, where 0 = no pest visible; 1 = ≤ 50 individual pests/feeding/oviposition holes per plant; 2 = 50–100 individual pests/feeding/oviposition holes per plant; 3 = >100 individual pest /feeding/oviposition holes per plant. The arthropod pests were preserved and transported for identification and classification at the University of Nairobi, Kabete entomology laboratories.

Sampling, extraction and counting of nematodes

At the beginning of the experiment, ten soil samples were taken from each of the thirty-six plots. In each plot, the samples were mixed thoroughly and ¼ of the soil was placed in a labeled zip-lock plastic bag and temporary stored in an insulated cooler. At the end of the experiment, sampling was done again in a zigzag manner in all plots taking into account the patchy distribution of nematodes where ten samples were taken from each plot and representative samples were placed in zip-lock plastic bag and stored in a cooler. Extraction and counting of nematode pests were carried out at Kabete plant pathology laboratories at the Department of Plant Science and Crop Protection. The eggs and second-stage juveniles (J2) were extracted from the nematode infested plant roots (rhizosphere) and moist soil obtained from experimental plots (Perry et al., 2009). The root maceration method described by Coyne et al. (2007) was used to extract nematode eggs and the juveniles. Briefly, roots were gently washed with tap water and cut into 1-cm long pieces and a ratio of 1g of root to 20ml of water and 0.5% sodium hypochlorite (NaOCl) was added to form root water mix. The mixture was loaded into a domestic blender and blended for 20 seconds at high speed. The suspension was passed through a 250-µm sieve then nested over a 25-µm sieve to collect the eggs while the root material was retained at a 250-µm sieve (Hooper et al., 2005). The above process was repeated to extract all the nematodes from the infected plant roots.

Nematodes were also extracted from the soil samples using Baermann filtration technique as described by Coyne et al. (2007); in each 200cm^3 of soil a filter paper was placed onto the collection plate and the soil sample was placed inside the filter paper. Water was then poured until the collection tray was submerged and the sample was left for 48 hours. The sieve was removed from the collection tray, soil discarded and the extraction from the collection tray was poured into the beaker and the plate was rinsed. The mixture was sieved and using a dissecting microscope, the eggs and the second-stage juveniles (J2) were counted to estimate the concentration per milliliter of the fluid from the sieving. Nematode eggs and second-stage juveniles in 200cm^3 soil and roots were estimated from samples obtained in all the plots at the start and end of the experiment. Percentage changes in nematode counts were compared for the different treatments at the beginning and termination of the experiment.

Determination of pest damage and shoot weight

Ten plants were sampled per plot to estimate the damage due to arthropod and nematode pests and the percentages were recorded. At the flowering stage, ten plants in each plot were sampled and weighed using a weighing balance (Scout Pro-sp.6000, Ohaus Corporation, N J. USA) to determine fresh shoot weight. The sampled fresh shoots per plot were then oven dried at 60^{0}C for two days to determine dry shoot weight.

Statistical analysis

All data collected was subjected to analysis of variance (ANOVA) using Genstat statistical software (Payne and Lane, 2007). Treatment means were compared using the Fisher's protected LSD test at a 5% probability level.

Results and Discussion

Insect pests infesting the indigenous leafy vegetables

Black aphids (*Aphis fabae* [Scopoli, 1763]), flea beetles (*Phyllotreta cruciferae* [Chevrolat in Dejean,1936]), tomato leaf miners (*Liriomyza trifolii* [Burgess,1880]) and vegetable leaf miners (*Liriomyza sativae* [Blanchard,1938]), red spider mites or two spotted red spider mites (*Tetranychus urticae,* C.L Koch,1836), turnip moth (*Agrotis segetum* [Denis and Schiftermuller,1775]), diamondback moth (*Plutella xylostella* [Linnaeus,1758]), thrips (*Thrips tabaci* (Lindeman) and whiteflies (*Bemisa* species [Gennadius,1889]) were observed at the experimental plots. Root knot nematodes (*Meloidogyne* spp) and beneficial insects which included ants and lady bird beetles were also recorded. More than fifty thrips, aphids, whiteflies and red spider mites were sampled per plant. Leaf miners, flea beetles and scale insects rated low (1-2) (Table 1).

Table 1. Mean scores of various arthropod pests on African nightshade with prevailing temperatures for the two seasons.

Arthropod pests		Week after transplanting	4		5		6		7		8		9	
		Temp ^{0}C	25	14	24	18	26	14	22	20	21	21	24	22
		Season	S1	S2	S1	S2	S1	S2	S1	S2	SI	S2	S1	S2
1	Leafminers (*Liriomyza trifolii)*		0	0	1	1	1	0	1	2	1	2	2	2
2	Thrips (*Thrips tabaci*)		2	1	2	1	3	1	2	2	3	2	3	2
3	Aphids *(Aphis fabae)*		3	1	3	2	3	1	3	2	3	2	3	3
4	White fly *(Bemisa tabaci*)		3	1	3	1	3	1	2	2	2	2	2	2
5	Diamondback moth *(Plutella xylostella*)		1	0	1	1	0	0	1	1	0	1	2	2
6	Red spider mites *(Tetranychus urticae)*		2	0	2	1	3	0	2	1	2	1	2	2
7	Turnip moth (*Agrotis segetum)*		1	1	1	1	2	0	1	0	0	0	0	0

Arthropod pest index score. 0 = no pest visible/pest oviposition holes per plant; 1 = ≤ 50 individual pests/pest oviposition holes per plant; 2 = 50–100 individual pests/pest oviposition holes per plant; 3 = > 100 individual pests/ pest oviposition holes per plant S1–Season one and S2–Season two.

Black aphids, thrips, diamondback moth, whiteflies and red spider mites scored 3 (more than 100 individuals per plant) in season one and scored 1 (less than 50 individuals per plant). Temperature had an effect on arthropod pest numbers. Season one which experienced higher temperatures recorded an increase in pest incidence compared to the lower temperatures recorded in season two (Figures 1 and 2).

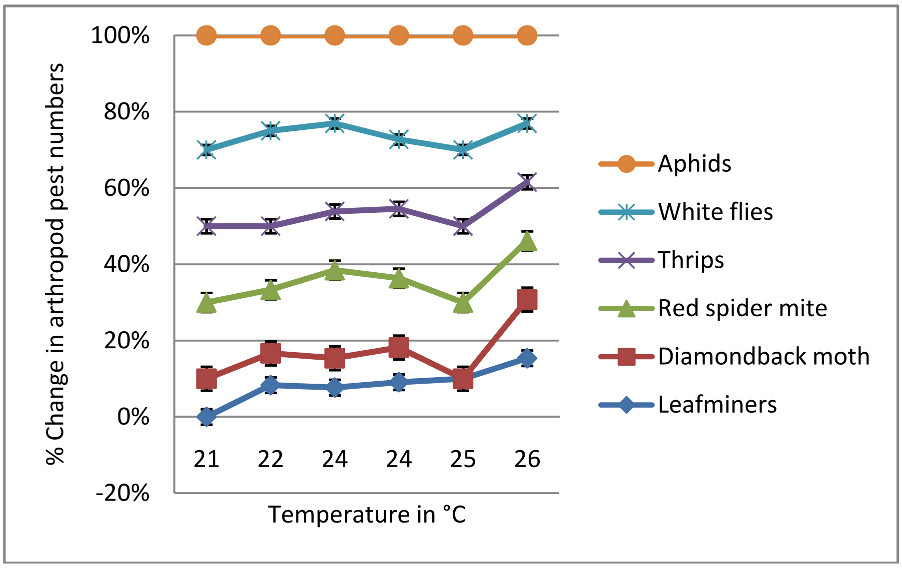

Figure 1. The effect of temperature on major athropod pests infesting African leafy vegetables for season one.

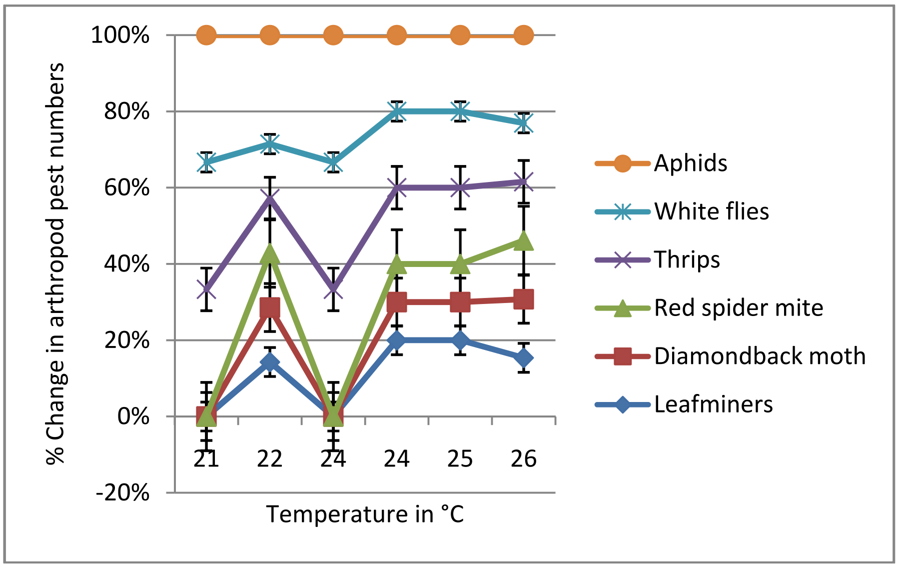

Figure 2. The effect of temperature on major athropod pests infesting African leafy vegetables in season two.

Effect of intercropping selected indigenous leafy vegetables on arthropod and nematodes pests

The same row and hill intercropping designs varied significantly ($P \leq 0.05$) with other intercropping designs in all the evaluated parameters (Tables 2 and 3). Spider plant and African nightshade intercrops recorded the least arthropod pest damage, for example on the same hill intercrops 19.5% and 21.4% were recorded for arthropod pest damage in season one and season two respectively (Tables 2 and 3). The other intercrop designs also recorded arthropod damage; the same row (29.4%), one row and two rows (38.2%), border (40.2%) and alternate rows (36.6%) were recorded in season one and a similar trend was observed when the experiment was repeated (Tables 2 and 3). The control plots where African nightshade alone was grown 47.5% and 38.2% of arthropod pest damage were recorded for the two seasons respectively (Tables 2 and 3). Therefore, the control plots recorded the highest damage due to arthropod pest damage compared to all the other intercrop designs.

Table 2. The effect of arthropod and nematode pest infestation on different intercrops under field conditions for season one.

	Type of intercrop	Mean number of plants damaged	Mean fresh shoot weight (kg/plot area) 9cm^3	Mean dry shoot weight (kg/plot area) 9cm^3
1	The same row intercrop (African night shade and spider plant)	29.4a	3.62a	1.08a
2	The same hill intercrop (African night shade and spider plant)	19.5a	3.96a	1.11a
3	One row and two rows (African night shade and spider plant)		2.75b	0.95b
4	Border intercrop (African night shade and spider plant)	40.9b	2.61b	0.9b
5	Alternate row intercrop (African night shade and spider plant)	36.6ab	2.21b	0.81b
6	African night shade only	47.5c	2.05c	0.79b
	Grand mean	35.4	3.19	1.05
	[1]LSD ($p \leq 0.05$)	12.2	0.56	0.14
	[2]Cv%	46.3	9.7	7.4

[1]Least significance difference, [2]Coefficient of variance. Means followed by the same letter(s) within columns are not significantly different ($p \leq 0.05$) while those followed by the different letter(s) within columns are significantly different; Means are separated by LSD ($p \leq 0.05$).

The yields of African nightshade and spider plant in the same hill and same row intercrop design were significantly ($P \leq 0.05$) different from the other intercrops tested. The fresh shoot weight recorded in season one in kg/plot area was as follows: the same hill (3.96), the same row (3.62), one row and two rows (2.75), border (2.61) and alternate rows (2.21) (Table 2). Where African nightshade was planted singly with no intercropping, it recorded the lowest yield of 2.05 kg/plot area (Table 2). A similar trend was observed when the experiments were repeated (Table 3). The dry shoot weight yields for season one followed a similar trend as that of fresh shoot weight with the following being recorded in kg/plot area: the same hill (1.11), the same row (1.08), one row and two rows (0.95), border intercrop (0.9), alternate rows (0.81) and the control plots with African nightshade only recording the lowest yield weight of 0.79 (Table 2). A similar trend was observed when the experiment was repeated.

Table 3. The effect of arthropod and nematode pest infestation on different intercrops under field conditions for season two.

	Intercrop pattern/design	Mean number of plants damaged	Mean fresh shoot weight (kg/plot area)	Mean dry shoot weight (kg/plot area)
1	The same row intercrop (African night shade and spider plant)	22.8a	4.23a	1.31a
2	The same hill intercrop (African night shade and spider plant)	21.4a	4.59a	1.37a
3	One row and two rows (African night shade and spider plant)	30.3b	3.24b	1.09bc
4	Border intercrop (African night shade and spider plant)	33.8b	3.24b	1.15b
5	Alternate row intercrop (African night shade and spider plant)	25.2ab	2.61c	1.01c
6	African night shade only	38.2c	2.34c	0.89c
	Grand mean	28.6	3.8	1.26
	[1]LSD ($p \leq 0.05$)	3.5	0.24	0.07
	[2]Cv%	36.7	7.8	6.5

[1]Least significance difference, [2]Coefficient of variance. Means followed by the same letter(s) within columns are not significantly different ($p \leq 0.05$) while those followed by the different letter(s) within columns are significantly different; Means are separated by LSD ($p \leq 0.05$).

In plots where sunn hemp was intercropped with African nightshade in the same hill and row, a slight increase in the percentage of second-stage juveniles was recorded (Table 4). The increase for the same hill was 14.4% and 13.2% for season one and season two respectively. The same row recorded an increase of 14.6% and 11.9% for seasons one and two respectively. The same row and hill intercrops differed significantly with other intercrop designs (Table 4). The highest number of second-stage juveniles were recorded where African nightshade was used as a monocrop with 31.9% and 17.6% recorded for season one and season two respectively. However, there were no significant ($P \leq 0.05$) differences among the other intercrop designs compared with the control plots (Table 4).

Arthropod and nematode pests were abundant during the experiment period and were a major constraint during field production of the selected African leafy vegetable. A number of arthropod pests were identified. They included black aphids (*Aphis fabae*), flea beetles (*Phyllotreta cruciferae*), tomato leaf miners (*Liriomyza trifolii*) and vegetable leaf miners *(Liriomyza sativae)*, red spider mites/two spotted red spider mites (*Tetranychus urticae*), turnip moth (*Agrotis segetum*), diamondback moth (*Plutella xylostella*), thrips (*Thrips tabaci*) and whiteflies (*Bemisa* species) were observed at the experimental plots. Nematode pests also infested the ALVs while growing. Similar findings were reported by Olubayo et al. (2011), in the study of insect pest species associated with African leafy vegetables in Taita district, Kenya.

Table 4. The effect of intercropping African night shade with sunn hemp on numbers of second-stage (J2) juveniles of root knot nematodes in the soil and % of increase in numbers of J2.

	Intercrop pattern/design	Mean number of J2/200cm^3 season one			Mean number of J2/200cm^3 season two		
		J2 initial count (Log_2x)	J2 final count (Log_2x)	% of increase in J2	J2 initial count (log_2X)	J2 final count (log_2x)	% of increase in J2
1	The same row intercrop (African night shade and sunn hemp)	7.2a	8.25a	14.6	7.33a	8.2a	11.9
2	The same hill intercrop (African night shade and sunn hemp)	7.19a	8.23a	14.4	7.35a	8.32a	13.2
3	One row and two rows (African night shade and sunn hemp)	6.9b	8.49b	23.04	8.24b	9.52b	15.5
4	Border intercrop (African night shade and sunn hemp)	6.46b	8.69b	34.5	8.18b	9.55b	16.8
5	Alternate row intercrop (African night shade and sunn hemp)	6.64b	8.69b	30.8	8.13b	9.46b	16.4
6	Control with African night shade only	6.61b	8.72b	31.9	8.16b	9.6b	17.6
	[1]LSD value($p \leq 0.05$)	0.25	0.23		0.33	0.42	
	Significance level	*	*		*	*	

[1]Least significance difference, Means followed by the same letter(s) within columns are not significantly different ($p \leq 0.05$) while those followed by the different letter(s) within columns are significantly different; Means are separated by LSD ($p \leq 0.05$).

There was a high incidence of arthropod and nematode pests during the first season because of the warm temperatures that prevailed with the minimum temperature of 21^{0}C recorded in season one. The low incidence of pests was recorded during the second season whose first weeks were extremely cold recording the lowest temperature of 14^{0}C. These findings conform with those by Mohammed et al. (2009), who reported that besides host-plant resistance, fluctuations in the populations of pests depend upon variations in weather factors, especially those of temperature and relative humidity. In plots where African nightshade was planted as a monocrop the shoot damage due to pests was high indicating high susceptibility of the crop to infestation by a wide range of pests.

The same hill design of intercropping where spider plant and black nightshade were intercropped and the same row design of intercropping had a reduced number of plants with shoot damage caused by pests hence high yields. This implies that the closer the interaction between the plants, for example in the same hill and same row intercrop, the more effective the intercrop is in repelling the arthropod pest away from the susceptible plants. Palada and Chang (2003) reported that spider plant oil and hairy surface deter arthropod pests from infesting it and other plants around it. Spider plant is a useful intercrop and companion crop in reducing diamondback moth in cruciferous crops (Schippers, 2000).

The same hill and same row intercrops reduced nematode infestation in the plots where sunn hemp and African nightshade were intercropped suggesting that the closer the plants were the better the interaction was in reducing nematode pest infestation. According to Vargas et al. (2000), sunn hemp is known to inhibit the formation of galls, production of egg masses and release of root exudates toxic to nematodes. This, therefore, explains the reason for less infestation where sunn hemp was used as an intercrop. In intercropping, the compounds produced from root exudates have a greater allelopathic effect than when sunn hemp is planted with no intercrop (Seamen et al., 2004).

Furthermore, in the same hill and same row intercropping there was closer interaction between the roots of ANS and sunn hemp hence ANS benefited from the sunn hemp good attributes. In addition, the same hill and row intercrop African nightshade benefited from nitrogen fixed by sunn hemp (*Crotalaria juncea*) which is leguminous hence the high yields obtained from these two intercrops. This compares with earlier studies by Nchore et al. (2010), who showed that an intercrop with sunn hemp led to increased yields presumably by the transfer of biologically fixed nitrogen from the roots of the legumes to the root zone of the companion crop. The results also compare with those reported by Vargas et al. (2000) that sunn hemp (*Crotalaria juncea*) is a poor host to many plant-parasitic nematodes especially the *Meloidogyne* species. It is also a poor host or non-host to a large group of other pests and pathogens (Grubben and Denton, 2004). Moreover, sunn hemp is known to enhance multiplication of natural enemies of phytopathogenic nematodes, such as fungi that directly feed on nematodes eggs (Atkins et al., 2004). They aid in fixing nitrogen and promote the accumulation of decomposers such as free-living nematodes. This increases nutrient availability for plant uptake leading to healthy plants that are resistant to nematode damage (Wang et al., 2003).

Sunn hemp (*Crotalaria juncea*) and spider plant (*Cleome gynandra*) performed well as intercrops due to their inherent genetic characteristics that they are not preferred by the pests (Keding et al., 2007). According to Otipa et al. (2009), the challenge to research is, therefore, to identify suppressive crops that satisfy the economic considerations in cropping systems. The choice of intercrop and design/distance should be based on the knowledge that has been tested considering the economics, genetics, proximity and spatial orientation of the intercrops to avoid plant-plant competition for sunlight, space and nutrients, hence reducing yields. Cultural methods such as intercropping are better than the use of chemicals in pest management because they are friendly to the environment, leave no pesticide residue on the produce for consumption and utilise fewer resources/external inputs.

Conclusions

Sunn hemp and spider plant were found to be effective candidates for intercropping to reduce the severity of arthropod pests and plant parasitic nematodes. The intercrop plots showed fewer incidences of arthropod and nematode pests compared to those where the sole crops were planted. The closer the distance between the resistant and susceptible plants the lesser the damage on the crops caused by arthropod and nematode pests thus the same hill intercrop and same row intercrop designs were the best option in the management of arthropod and nematode pests. Therefore, this study establishes that intercropping using resistant plants can be integrated to provide an easily adaptable technology to apply to the effective management of arthropod and nematode pests with low external inputs.

Acknowledgements

The University of Nairobi is acknowledged for providing the facilities and partly funding this research through the University of Nairobi, Deans' Committee Grant Vote No. 500-655-659.

References

Abukutsa - Onyango, M.O. (2007): The diversity of cultivated African leafy vegetables in three communities in western Kenya. African Journal of Food, Agriculture, Nutrition and Development 7(3):1-15.

Adebooye, O., Opabode, J. (2004): Status of conservation of the indigenous leafy vegetables and fruits of Africa. African Journal of Biotechnology (online) 3(12):700-705.

Atkins, S.D., Hirsch P.R., Kerry, B.R., Peteira, B. (2004): Plant parasitic nematodes in sub tropical and tropical Agriculture. Journal of Nematology 36:305-307.

AVRDC (2003): International Co-operators Guide. Narrow - leaved nightshade. Bioversity international website. www.avrdc.org.

Coyne, D., Nicol, J., Claudius-Cole, A. (2007). Practical plant nematology: *a field and laboratory guide*. IITA, Ibadan, Nigeria.

Gachene, C.K., Kimaru, G. (2003): Soil Fertility and Land Productivity - A guide for extension workers in the eastern Africa region. Technical Handbook No.30. Regional Land Management Unit (RELMA)/ Swedish International Development Cooperation Agency (Sida).

Gotor, E., Irungu, C. (2010): The impact of biodiversity international's African leafy vegetables programme in Kenya. Impact Assessment and Project Appraisal, 28(1):41:55.

Gruben, G.J.H., Denton, O.A. (2004): Plant resource of tropical Africa Volume 2. Vegetables. PROTO Foundation, Wageningen, Netherlands/backhuys publishing, Heiden, Netherland/CTA, Wageningen, Netherlands.

Hooper, D.J., Hallmann, J., Subbotin, S.A. (2005): Methods for extraction, processing and detection of plant and soil nematodes. In: Plant and soil nematodes in subtropical and subtropical Agriculture. CAB International, Walingford, UK. pp 53-86.

IPGRI (2003): Rediscovering a forgotten treasure. [Internet] IPGRI public awareness. Rome, Italy. http:// ipgr.pa.grinfo.net/index.php. Hemiol. 101.

Keding, G., Weinberger, K., Swai, I., Mndiga, H. (2007): Diversity, traits and use of traditionl vegetables in Tanzania. Special technical bulletin, Ho.Shanhua, Taiwan: AVRDC - The world vegetable center.

Keller, G.B. (2004): African nightshade, eggplant, spider plant flower production and consumption traditional vegetable in Tanzania from farmers point of view. Master thesis. www.underutilised -species.org.Kenya. Maseno University.

Kenya-data@maps. (2012): National geographical data.mapdata@2012 Afrigis (pty) ltd, Google.9th Edition.

Mohammed, A.A., Dixon, A.F.G., Honex, A., Keil, P., Alois, H. (2009): Relationship between the minimum and maximum temperature thresholds for development of insects. Journal of Functional Ecology 23:1365-2435.

Nchore, S. B., Waceke, W. J.,Kariuki, G. M. (2010): Incidence and prevalence of root-knot nematodes *Meloidogyne* spp. in selected indigenous leafy vegetables in Kisii and Trans-Mara District of Kenya. 12th KARI Biennial Scientific Conference, 8-12 November 2010. KARI Headquarters Complex, Kaptagat Road, Nairobi pp. 100

Olubayo, F., Mnyambo, J., Shibairo, S., Mwangombe, A., Lenihan, E. (2011): Insect species associated with African Leafy vegetables in Taita District, Kenya. Ist Biennial Faculty of Agriculture conference, University of Nairobi. (AGRO 2011).

Otipa, M.J., Kimenju, J.W., Murithi, J.G., Kyalo, G. (2009): Potential of rotation crops in managing root knot nematodes (*Meloidogyne spp.)* in tomato. African Journal of Horticultural Sciences 2:111-123.

Palada, M.C., Chang, L.C. (2003): AVRDC, International co-operator's guide of suggested cultural practices for vegetable amaranths www.JKUAT and JICA, Kenya pp.33-39.

Payne, R.W., Lane, P.W. (2007): VSN International Genstat Release 7.2, Lawes Agricultural Trust (Rothamsted experimental station, version 9), UK. www .VSN .CO.UK.

Perry, R., Moens, M., Starr, J. (2009). Root-knot Nematodes. CAB International, UK.

Schippers, R. R. (2000): African Indigenous Vegetables. An overview of the Cultivated Species. Special report, Natural Resources Institute/ACP-EU Technical Centre for Agricultural and Rural Cooperation, Chatham, UK pp 214.

Seamen, K.A., Gallaher, R.N., Mcsorley, R. (2004): Maintaining clipping height to enhance yield and nitrogen content for sun hemp. Journal of Soil and Crop Science Society of Florida 63:115-116.

Vargas, A.R., Rodriguez, K.R., Morgan, J.G., Kloepper, J.W. (2000): Microbial shifts in soils and rhizosphere induced by velvet bean in cropping systems to control root-knot nematodes. Biological Control. Journal of Nematology 17:11-22.

Wang, K.H., McSorley, R., Gallaher, R.N. (2003): Effects of Sun hemp (*Crotalaria juncea*) amendment on nematode communities in soil with different agricultural histories. Journal of Nematology 35:294-300.

Received: September 30, 2014
Accepted: February 13, 2015

POTENCIJAL ZA GAJENJE ZDRUŽENIH USEVA RADI KONTROLE ŠTETNIH ARTROPODA I NEMATODA LISNATOG POVRĆA U KENIJI

Kimaru S. Linguya[1*], Onyango C. Moraa[2], Kimenju J. Wangai[2] i Kilalo D. Chao[2]

[1]Ministarstvo prosvete, P.O box 281-10201, Murang'a, Kenija
[2]Odsek za proizvodnju i zaštitu bilja, Univerzitet u Najrobiju, Kenija, P.O box 30197, Najrobi

R e z i m e

Neke vrste afričkog lisnatog povrća (ALP) igraju važnu ulogu kao usevi koji obezbeđuju prihod i sigurnost hrane u mnogim domaćinstvima u Keniji. Ipak, njihov potencijal za ublaživanje siromaštva i obezbeđivanje hrane za domaćinstvo i bezbednost ishrane nije u potpunosti iskorišćen. Ciljevi ovog istraživanja su bili da se identifikuju neke štetne artropode i nematode, koje napadaju afričko lisnato povrće, kao i da se proceni efikasnost združivanja osetljivih i otpornih useva radi bolje kontrole ovih štetočina. Za određivanje učinka združivanja osetljivih i neosetljivih useva u smanjivanju uticaja štetnih artropoda i nematoda korišćene su tri vrste povrća: afrička pomoćnica (*Solanum scabrum),* sitasta krotalarija (*Crotalaria juncea)* i afrički kupus (*Cleome gynandra)*. Tretmani u poljskom ogledu su se sastojali od različitih kombinacija združenih useva i kontrolnih parcela čistih useva, dok su podaci uzeti na osnovu pet različitih varijanti. Usevi u polju su bili izloženi napadu štetočina i evidentirano je osam različitih vrsta. Varijante združenih useva u istom redu i u istim kućicama su bili najefikasniji u smanjivanju štetnog uticaja artropoda i nematoda u poređenju sa kontrolnim parcelama. Kod varijante združenog useva afričkog kupusa i afričke pomoćnice je zabeležena najmanja šteta od artropoda, i viši prinosi sveže i suve nadzemne biomase, a razlike su u poređenju sa čistim usevom afričke pomoćnice bile značajne ($P \leq 0,05$). Na parcelama gde je sitasta krotalarija bila gajena kao združeni usev sa afričkom pomoćnicom u istoj kućici ili redu, zabeleženo je blago povećanje drugog larvenog stadijuma nematoda u poređenju sa drugim varijantama združenih useva. Imajući u vidu ovo istraživanje zaključuje se da se gajenje različitih biljaka kao združenih useva može iskoristiti, zajedno sa drugim metodama, za efikasnu kontrolu štetnih artropoda i nematoda u sistemu gajenja sa niskim ulaganjima.

Ključne reči: lisnato povrće, mlade biljke, efikasnost, osetljivost, nematode.

Primljeno: 30. septembra 2014.
Odobreno: 13. februara 2015.

[*]Corresponding author: e-mail: samuelklinguya@gmail.com