academicJournals

Vol. 12(21), pp. 1793-1800, 25 May, 2017
DOI: 10.5897/AJAR2017.12275
Article Number: 3A19AB564415
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Understanding the need for transfer of biologically-based crop protection technology for soil pest control in vegetable production in Rwanda

Musebe R.[1]*, Dusenge L.[2], Agwanda C.[1], Kajuga J.[2], Waweru B.[2], Karanja D.[1], Hongmei L.[3] and Day R.[1]

[1]CABI Africa, P. O. Box 633-00621, Nairobi, Kenya.
[2]Rwanda Agriculture Board, P. O. Box 5016 Kigali, Rwanda.
[3]CABI East Asia, C/o MoA-CABI Joint Lab for Biosafety, Beijing 100193, China.

Received 1 March, 2017; Accepted 20 April, 2017

Despite growth in Rwanda's agricultural production ability, with food crops representing 33% of the National GDP and 80% of the population reliant on agriculture, food supply remains fragile. A factor which has significant impact on productivity is soil pests, whose effects filter through the whole value chain. Poor yields result in demand that exceeds supply, leading to higher food prices and reduced affordability by the poor. Poor quality products result in lower consumer acceptability and short shelf life. Rwandan farmers have limited access to plant protection products. A survey of farmers conducted in 2008 revealed that only 16% of the households use pesticides and few use other products for soil pest control. This paper examined the existing vegetable production situation, major soil pests for vegetables and the needs of the farmers in respect to soil pests' management in Rwanda in 2014. From interviews of 110 vegetable farmers and 18 key informants, it was established that the main vegetable crops were cassava, beans, Irish potatoes and cabbages. The main method for vegetable production was intercropping. Production of vegetables was not intensive as evidenced by the limited use of high value inputs such as fertilizers and crop protection chemicals. The vegetable production constraints starting from the most serious were insect pests, diseases, lack of high quality seeds, high cost of pesticides and fertilizers. The key insect pests were white grubs, cutworms, termites and bean fly. Most of the farmers (76%) did not control the insect pests due to lack of knowledge, lack of alternative methods for pest management and high cost of pest control products especially the chemical pesticides. Chemical pesticides were reported as the main control method by 55% of those who controlled insect pests. This translates to only 13% of the farmers reporting use of chemical pesticides to control insect pests. This represents a 3% decline in the already low (16%) use of chemical pesticides to control insect pests. Conversely, pest infestation levels have been increasing over time. Diversification of the pest control methods is therefore warranted and has indeed been lauded as a key approach to improving pest control. Biologically-based crop protection technology using entomopathogenic nematodes is critical for improving insect pest control. This is due to the possibility of the technology being maintained over a large area without major efforts on the part of the already financially resource poor farmers. Facilitating access to information about the sources of the biologically-based insect pest control technology can enhance diversification of the insect control methods.

Key words: Soil pests, biological control, crop protection, entomopathogenic nematodes.

INTRODUCTION

Despite growth in Rwanda's agricultural sector, with food crops representing 33% of the National GDP and 70% of the population reliant on agriculture, food supply remains fragile. A factor which has significant impact on productivity is soil pests, whose effects filter through the whole value chain. Poor yields result in demand that exceeds supply, leading to higher food prices and reduced affordability by the poor. Poor quality products, particularly root crops damaged by soil insect pests, result in lower consumer acceptability and short shelf life, as a result of secondary infections. The situation is more critical in vegetable production where yield losses could be up to 100% attributed mainly to soil insect pests. The key vegetables in Rwanda were cassava (*Manihot esculenta*), beans (*Phaseolus vulgaris*) and cabbages (*Brassica oleracea var. capitata*) in Bugesera (East) and Nyamagabe (South), and Irish potato (*Solanum tuberosum*), beans and cabbages in Musanze (North). Other vegetables were tomato (*Solanum lycopersicum*), carrots (*Daucus carota*) and sweet potatoes (*Ipomoea batatas*). The main soil insect pests of economic importance reported in Rwanda include white grubs (*Scarabeid beetle larvae: Anomala* species, *Melonthini* species, *Hoplochelus* species); cutworms (*Agrotis* species) and bean fly (*Ophiomyia phaseoli*) (Anon, 2008). The main method that is used for insect pest control is chemical pesticides. Rwandan farmers have limited access to plant protection products. A survey of farmers conducted in 2008 revealed that only 16% of households use pesticides and few use other products for soil pest control (Anon, 2008). This is worsened by the fact that there are limited alternatives for the control of pests.

Under these circumstances a question that arises is how to make alternative insect pest control methods accessible to the vegetable farmers. In the same vein, the alternative pest control methods need to be known in order for the vegetable farmers to make informed choices. Low-input, environmentally friendly and economically sustainable plant protection technologies, such as entomopathogenic nematodes (EPNs), originating from China, have demonstrated capacity to improve protection of key vegetable crops against soil insect pests and increase productivity and would prove useful if made accessible to the vegetable farmers in Rwanda.

This paper examined why biologically based crop protection technology would be useful for Rwanda. In so doing, the paper addressed the following specific objectives: to examine the existing vegetable production situation in Rwanda; identify major soil insect pests for vegetables and the control measures used and identify the needs of farmers in respect to soil pests' control.

MATERIALS AND METHODS

Purposive sampling was used to select Eastern, Southern and Northern Provinces of Rwanda for data collection for the study that contributed to this paper. From each of the provinces one district was selected purposively based on the prevalence of the target crops and pests. The districts selected were Musanze in Northern Province, Bugesera in Eastern Province and Nyamagabe in Southern Province. These areas were purposively selected as the sites with suitable agro-ecological conditions for production of key vegetable crops and where key pests for the study were domicile. Data for the study was obtained from vegetable farmers and key informants.

Vegetable farmers were selected from each of the study areas using systematic sampling where the first respondent was selected randomly and thereafter every fifth prospective vegetable farmer was selected until the required sample size of 110 vegetable farmers was obtained. The vegetable farmers were distributed as Musanze (38), Nyamagabe (40) and Bugesera (32). The selection process used lists that were prepared by the agricultural extension officers in each of the districts. The lists were from the various sectors that had been identified as being involved in the production of the target vegetables.

Six key informants were selected using purposive sampling from each of the districts. Thus a total of 18 key informants participated in the study. They included staff at the Ministry of Agriculture in the various districts, Rwanda Agriculture Board (RAB) experts and other officers with specialist information in the target districts. Other key informants included the cooperative president, one member of the cooperative committee, one progressive farmer, and agriculture officer at the sector level, non-governmental organization (NGO) representative and project Agronomists. After selection of the respondents, household surveys and key informant interviews were conducted.

The reference period used for the study was the last season during the crop year which was 1st April 2013 to 31st March, 2014 and the data was collected in the months of April and May 2014. Data collected included land owned, proportion of land devoted to vegetable production, types of vegetables grown, input usage, production systems, pests and diseases of the vegetables, and methods of pest control. Data was collected using structured and pre-tested questionnaires/checklists.

Descriptive statistics were estimated including means, standard deviation and percentages. Comparisons were done at the district levels to establish differences and similarities. Inferential statistics were also generated to provide the requisite cause and effect relationships for specific variables in the study.

RESULTS AND DISCUSSION

Farm characteristics

The farmers own small land parcels of an average of 1.48 ha and devote relatively smaller portions of their land to

*Corresponding author. E-mail: r.musebe@cabi.org.

Table 1. Average land owned and area under different vegetables.

District	Land owned (ha.)	Area of cassava (ha)	Area of beans (ha)	Area of Irish potato (ha)	Area of cabbage (ha)
Bugesera	1.31 (0.24)	0.62 (0.15)	0.49 (0.09)	-	0.12 (0.03)
Musanze	1.77 (0.69)	-	0.33 (0.09)	0.71 (0.11)	0.01 (0.06)
Nyamagabe	1.34 (0.51)	0.10 (0.00)	0.07 (0.02)	0.12 (0.03)	0.06 (0.03)
All Districts	1.48 (0.31)	0.59 (0.15)	0.27 (0.04)	0.40 (0.07)	0.07 (0.02)

Values in parentheses are standard errors.

Table 2. Systems of vegetable production and reasons for the selected systems.

Vegetable	Source(s) of seeds	System of production	Reasons for the selected production system
Irish potatoes	Own, neighbours, RAB, Cooperative	mono cropping	Half of farmers use mono cropping system for Irish potatoes because it is a high yielding cropping system,
Cassava	RAB, Own, neighbours, Cooperative	Intercropping	To optimise on the use of space for effective yields
Beans	Own, RAB, Cooperative, neighbours	intercropping	To optimise on the use of space for effective yields
Cabbage	Own, RAB, Cooperative, neighbours	mono cropping	Avoid crop competition, prevent diseases spread and recommended by Government of Rwanda

vegetable production (Table 1). Land is mainly owned by individuals thereby making it possible to seek credit facilities to improve production of the vegetables as need arises. The main vegetable crops grown in order of importance that is based on area devoted to each crop were cassava, Irish potatoes, beans and cabbages.

Vegetable production systems and input usage

The main methods for vegetable production were intercropping and mono cropping, while the preferred method was mono cropping for varieties that are more commercial than subsistence (Table 2). Additionally, mono cropping is the system that is recommended by the government. The main sources of the seeds used for vegetable production were the cooperatives followed by Rwanda Agriculture Board (RAB) and own seed sources (farmer saved seed).

Production of vegetables was not intensive as less high value inputs were used. In particular, the use of fertilizer and crop protection chemicals was limited. The main sources of inputs were the agro-dealers who included retailers (68.4%), cooperative (10.5%) and companies (21.1%). The main products sold by the agro-dealers were pesticides and other inputs such as seeds and fertilizers. The agro-dealers had most of the highly used inputs but indicated that given financial support they would be able to supply other inputs on demand.

The agro-dealers provided some information on the use of the products that they sell. Twenty five percent of the agro-dealers give advice on proper use of the pesticides, while 23% reported that they advise on the dosage required for specific pest and disease scenarios. Use of protective gear was reported to have been provided by 7% of the agro-dealers. Informal discussions between agro-dealers and the buyers also involved advice on pooling resources for purchase of pesticides or even land for group production endeavours. All the interviewed agro-dealers reported that they would be willing to disseminate a technology aimed at reducing pest infestation levels. If required they would be able to provide facilities for storage of the products based on the capacity of the trader.

Vegetable production constraints

The vegetable production constraints as reported by the vegetable farmers in order of importance were pests and diseases, high cost of inputs especially pesticides and fertilizers and lack of inputs particularly pesticides (Figure 1). In the entire grouping of constraints at the production level, pests were rated as the most serious (IITA, 2010). The farmers' views about vegetable production constraints were consistent with those of the key informants. Lack of quality planting materials referred to shortage of good quality seeds and cuttings in the case of

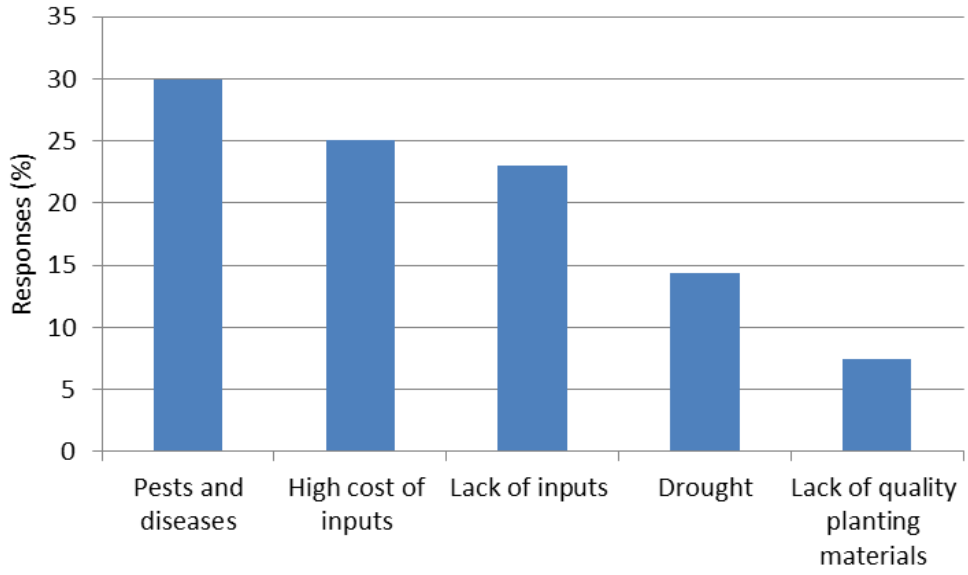

Figure 1. Vegetable production constraints.

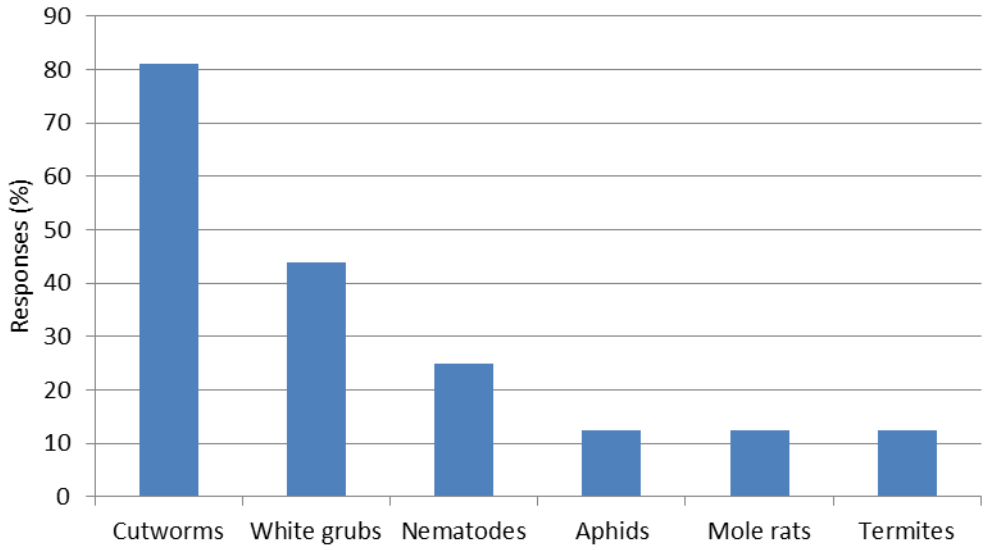

Figure 2. Key vegetable pests in the survey area.

vegetative propagated vegetables. Lack of pesticides, occasioned by high costs or inability to get the required types of pesticides, suggests the need for alternative methods for pest control.

Vegetable pest control and opportunities for improvement

The key pests of vegetables in the area were cutworms, white grubs and nematodes. This is corroborated by the percentage of farmers reporting prevalence of the pests (Figure 2). Other pests included aphids, mole rats and termites.

Vegetable crop losses due to pest damage were an average of 39%. Some farmers reported 100% loss due to damage by the pests. Key informants also agreed that there were instances where 100% crop loss occurred due to pest damage. Nyamagabe district had the highest average loss while Bugesera had the lowest loss (Figure 3).

Only 24% of the farmers reported having attempted to

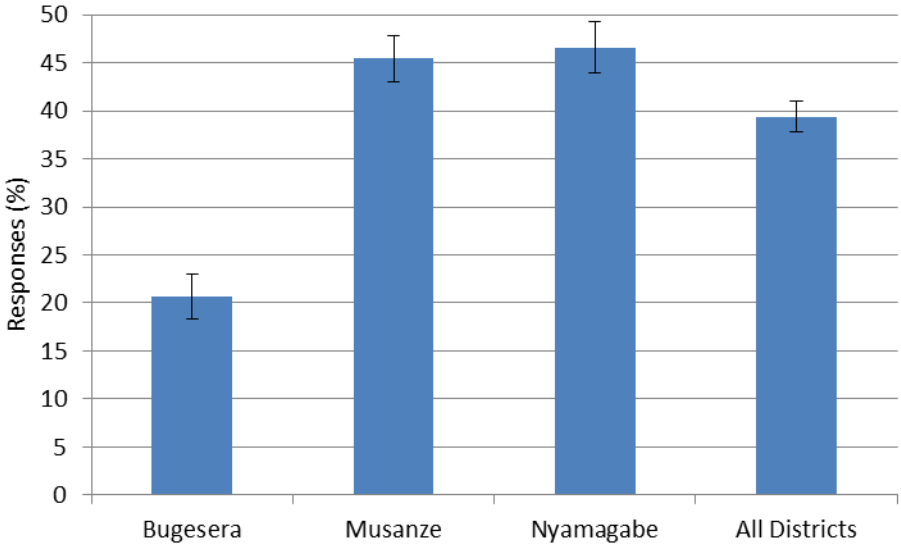

Figure 3. Average vegetable loss due to pest infestation in different districts.

Table 3. Percentage of farmers reporting different levels of effective control.

Ability to control	Bugesera	Musanze	Nyamagabe	All districts
Very good	0.00	10.53	0.00	3.67
Good	16.13	42.11	0.00	19.27
Fair	35.48	5.26	2.50	12.84
Poor	48.39	42.11	97.50	64.22

control soil pests. Despite the efforts of the farmers to control pests, effective control was not achieved. The perception of effective control was the capacity to clear and or kill all pests. Most of the farmers (64.22%) were not able to effectively control the soil pests (Table 3). There were significant differences ($p<0.01$) in farmer capacity to control pests effectively in the different districts. Nyamagabe and Bugesera district had the lowest capacity to effectively control pests.

The main methods for controlling pests were reported as use of pesticides (55%) and hand picking (15%) (Figure 4). Other methods included use of quality seeds and uprooting diseased plants.

Hand picking had an advantage of not being costly and required less techical know-how. Pesticides were reported as expensive (Bruno and Henry, 2011) and also contributing to environmetal contamination. Cost of controllilng using pesticides was 51.70% higher than the cost of hand picking as reported by 58.33% of the farmers (Table 4). Hence, the need for alternative pest control approaches. Key informants noted that there were other control options such as cultural practices and biological control using some benefiacial insects. Farmers lacked a good understanding of the beneficial insects that would be used for control of vegatable pests. However, farmers expressed preference for the use of beneficial insects because of lower costs involved. Given successful use of entomopathogenic nematodes (EPNs) in other parts of the world (Carol et al., 2012; Clara et al., 2002; Smart, 1995), tests conducted by the research station in Rwanda and discussions it emerged that EPNs would be a good alternative control option. This is justified by problems associated with pest control and farmer efforts to undertake control.

About 76% of the vegetable farmers reported that they do not control pests. The farmers who did not control cited a number of reasons (Table 4). The main reasons for failure to control pests were lack of knowledge, high costs of the pesticides and pest resistance to pesticides.

Since use of pesticides was the main pest control option, additional assessment was conducted to establish factors that were limiting use of pesticides. It was established that costs of pesticides was the main factor (Table 5).

The factors that limit farmer capacity to control can be addressed by increasing farmer access to many pest control options. Among the approaches are options that help farmers to address the pests in soil with ease as is the case with biological control. In the case of biological control, use of EPNs is considered critical. This is

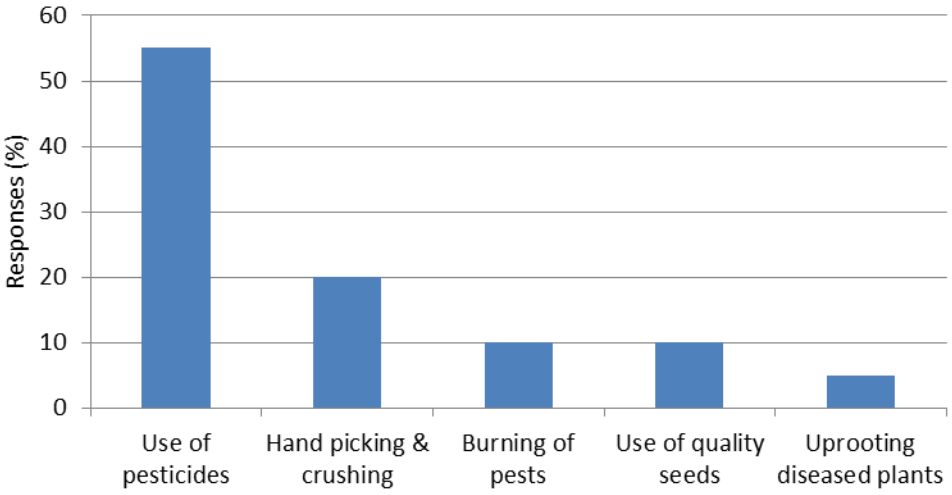

Figure 4. Methods used for pest control.

Table 4. Reasons for failure to control soil pests

Reason for no control	Responses (%)
Lack of knowledge of the control method and the pests	48.50
Difficulty to apply the pest control products in the soil	7.92
High costs of the pesticides	15.85
Lack of pesticides	10.34
Not effective/efficient pesticides	17.41

Table 5. Problems of accessing pesticides reported by farmers (%).

Problems of accessing pesticides	Responses (%)
Agro-dealer shops are far from the farmers' homes	5.95
Farmers do not know appropriate pesticides and the methods of use	13.10
Expensive (high cost)	58.33
Lack of capital	11.90
Not readily available	10.71

because of the many opportunities and appropriateness of biological control to small farmers who are unable to afford expensive chemicals (Greathead, 1986) as is the case in Rwanda. In addition, use of EPNs can be maintained over a large area without a lot of efforts on the part of the farmer (Divya and Sankar, 2009; Nyasani et al., 2007; Parwinder, 2001). The key soil pests in Rwanda are known to be susceptible to EPNs. For example, there is promising field efficacy of EPNs against cutworms (Georgis et al. 2006). EPNs are most efficacious in habitats that provide protection from environmental extremes, especially in the soil, which is the natural habitat (Hazir et al., 2003). The agro-ecosystems in Rwanda provide a very conducive environment for the EPNs. EPNs are safe to humans and other non-target organisms and have no known negative effects on the environment (Hazir et al., 2003). EPNs can be used effectively in integrated pest management, which makes them very suitable for use in Rwanda. Biologically based pest management strategies present opportunities through predation or parasitism of pests and plant direct or indirect defense mechanisms that can all be important components of sustainable pest management programs (Chidawanyika et al., 2012). The use of EPNs is therefore expected to generate long-term benefits to the farmers in Rwanda.

The farmers also reported that providing training on soil pests and existing control options is a key approach. The

need for training was alluded to by 56.2% of the respondents. Other farmers noted that there was need for manuals and other materials to help in pest identification. Similarly, all plausible methods of control need to be made available to the farming community. It was noted that proven technologies would be preferred by the farmers based on financial resource base. Financial support to help purchase the crop protection products were also cited as key in the fight against pests.

Some vegetable farmers did not have clear information regarding EPNs but noted that an environmentally safe technology that is easy to apply to control soil insect pests would be preferred. In this case EPNs would be the preferred choice. The farmers who were aware of the EPNs noted that the EPNs would address the soil insect pests in a form that does not require the farmers to physically access the soil pests, especially where it is difficult to locate the pests. There is interest in the use of other methods for the control of pests that attack vegetables but no explicit information exists on alternative methods for control of pests. This in essence suggests that there is potential for the use of EPNs contingent upon the requisite promotion efforts. This assertion is consistent with the understanding among the farming community that pesticides, which is the common control method is expensive. Providing information about pest control is also necessary to facilitate endeavours aimed at pest control.

There are indications among some farmers albeit very few that there exists alternative pest control approaches including the EPNs meaning that if such farmers could be identified through the village headmen it could help in dissemination of the EPNs technology. There were no reported social norms that could hinder the dissemination of any biologically based technology aimed at improving the pest control scenario in the study area. The farmers' needs for effective pest control are a range of methods for pest control, training on the use of the various techniques for pest control and facilitation to use the requisite methods.

Conclusions

Many vegetable types are produced in Rwanda and there is preference for the vegetables by both the farmers and consumers as reported by those involved in the vegetable trade. The main production system is intercropping although the drive is towards mono cropping. Production processes are less intensive as indicated by the limited use of fertilizers and pesticides. The overall production process is fraught with limited technical know-how and hence calls for effective extension from basic production practices to pest control and post-harvest handling.

The major soil insect pests were cutworms, white grubs and nematodes. There were few control options at the disposal of the farmers. This was aggravated by the fact that very few farmers attempted control of pests. Only 24% of the farmers reported to have attempted control of soil pests. The main control method used was application of chemical pesticides by only about half of those that attempted control. Even for those that attempted control the success rate was low. Failure to control the soil pests and limited success rate was attributed to low financial resources and limited technical know-how. In particular, farmer access to chemical pesticides and other crop protection practices was restricted by limited financial resources. There was also limited knowledge regarding the pest control approaches and the methods for controlling pests were not diversified.

The vegetable farmers were willing to take on any technology that would help in the control of pests. There was however, preference for a technology that would have long term benefits and be compatible with integrated pest management. Hence, the use of biologically based crop protection technology would be the first choice. To this end entompathogenic nematodes (EPNs) appear to be the best choice given environmental suitability, low farmer financial resource base and the expected long term benefits. Success in this line would be guaranteed with appropriate information dissemination about the technology. Appropriate methods for dissemination of information would be important especially if they take into account the stakeholder capacity that includes education and financial resources. Pooling of resources and group activities may be necessary in the short run.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

ACKNOWLEDGEMENTS

This paper is derived as part of the project titled, "Transfer of biologically-based crop protection technology for soil pest control in vegetable production in Rwanda" that was implemented in Rwanda. The authors wish to express their appreciation to CABI and Rwanda Agriculture Board for implementing the project, which generated data that was used in preparation of this paper. Finally, the authors wish to acknowledge the funding from AgriTT Research Challenge Fund for the project.

REFERENCES

Anon. (2008) National Agricultural Survey (2008). National Institute of Statistics of Rwanda. www.statistics.gov.rw/publications/national-agricultural-surveynas-2008

Bruno S, Henry W (2011). Biological control and integrated crop protection. COLEACP-PIP. www.coleacp.org/pip.

Carol M, Caitlin B, Randy G, David SI, Todd M (2012). A Pacific Northwest Extension Publication • PNW544. Washington State University Extension, Oregon State University Extension Service and University of Idaho Extension.

Chidawanyika Frank, Pride Mudavanhu and Casper Nyamukondiwa (2012). Biologically Based Methods for Pest Management in Agriculture under Changing Climates: Challenges and Future Directions. Insects 3:1171-1189.

Clara IN, Nilda P, Luis V, Miguel AA (2002). The development and status of biologically based integrated pest management in Cuba. Integr. Pest Manage. Rev. 7:1-16.

Divya K, Sankar M (2009). Entomopathogenic nematodes in pest management. Indian J. Sci. Technol. 7(2):53-60.

Georgis R, Koppenhofer AM, Lacey LA, Be´lair G, Duncan LW, Grewal PS, Samish M, Tan L, Torr P, Van Tol RWHM (2006). Successes and failures in the use of parasitic nematodes for pest control. Biol. Control 38:103–123. Available online at www.sciencedirect.com

Greathead DJ (1986). Opportunities for biological control of insect pests in tropical Africa. Revue de Zoologie Africaine 100:85-96.

Hazir Sel uk, kaya HK, Stock PS, Keskün N (2003). Entomopathogenic Nematodes (Steinernematidae and Heterorhabditidae) for Biological Control of Soil Pests. Turk. J. Biol. 27:181-202.

IITA (2010). Integrated Pest Management and Crop Health — bringing together sustainable agroecosystems and people's health. White Paper. SP-IPM Secretariat, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria P 17.

Nyasani JO, Kimenju JW, Olubayo FM, Wilson JM (2007). Potential of using entomopathogenic nematodes in the management of diamondback moth *Plutella xylostella (L) (Lepidoptera: Plutellida*e) in Kenya. Afr. Crop Sci. Conf. Proceed. 8:1063-1066. African Crop Science Society.

Parwinder G (2001). Using Entomopathogenic Nematodes for Tiirfgrass Pest Management: A practical research digest for turf managers. Turfgrass Trends 10:5.

Smart GC Jr (1995). Entomopathogenic Nematodes for the Biological Control of Insects. Supp. J. Nematol. 27(4S):529-534.