Page 618 to 625

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Some Integrated Practices to Manage Root-Knot Nematodes on Tomatoes: A Mini Review

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Abstract

Pests and diseases are attacking the grown crops and cause remarkable damages annually. Phytonematodes are one of the most drastic pests. Therefore, plant parasitic nematodes attracted the attention of the investigators who work at the field of pest management. The root-knot nematodes are found to be the most important and being responsible for at least 90% of all damage caused by nematodes. Root-knot nematodes are attacking most of vegetable plants and reduce the market value of the fruit. Using of non-fumigant nematicides is the famous and the common solution for the problem of Phytonematodes in Egypt. However, the biological control (e.g. fungi & bacteria), Bio pesticides and soil amended with organic matter are the available solutions which help farmers in spite of they have limited usage.

Keywords: *Root-knot nematodes; Chemical Control; Antagonistic Microorganisms; Bio Pesticides*

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Introduction

Agriculture plays an important role in the survival of humans and animals. Thus, provide food to world populace is one of the major challenges that face us in our present era. According to FAO statistics there are about 925 million people worldwide are suffering from chronically hungry due to drastic poverty (FAO, 2010). Therefore, the global food production estimated to be raised by 70% by 2050 to feed over 9 billion people worldwide (Hassan., *et al*. 2013).

The global food production such as vegetables, fruits, cereals and beans crops are attack by several pests and pathogens. One of the most famous and widespread pests is the plant parasitic nematodes (PPNs) which cause damages by billions of dollars yearly. The root-knot nematodes cause yield losses in tomato more than 27% annually (Kaur., *et al*. 2011).

The Symptoms which caused by root-knot nematode infected plants are generally the plant yield suppression due to the poor development of root systems and leaf nutritional deficiencies such as chlorosis and wilting. The number of second-stage juveniles (J2) caused

direct damages in crops because their penetration to root of host plants and reproduce rate inside the plant roots (Karssen and Moens, 2006). Since chemical control of plant parasitic nematode by the involvement of synthetic nematicides one of the most potent and effective method for nematode management. However, apart from its very high cost, disturbing the ecological equilibrium of soil, water, and environment. The appropriate and sapient usage of natural bio-pesticides and integrated soil amendment on site specific will deliver one of the best messages for future of sustainable nematode management.

The alternative methods to control plant parasitic nematodes are antagonistic microorganisms, soil addition with organic matter, botanical pesticides, crop rotation and plant extracts. Thus, this work aimed to throw a light for the usage of alternative approaches which is a necessary thing for the sustainable management of root knot nematode in order to improve plant growth, crop productivity and reduction in nematode infestation below economic threshold level.

Tomatoes Production

In last century, tomato (Solanum lycopersicum, Mill) (Family: Solanaceae) has become a major world food crop. Nowadays, tomatoes are grown commercially in 159 countries around the world. China, the United States, India, Turkey, Egypt, Italy and Iran are the main producers of tomatoes (Ibrahim., *et al*. 2015). In Egypt, the tomato is considered one of the most important vegetable crops for fresh consumption and processing (Abd El-Ghany, 2011). Also, tomatoes considered rich source in carbohydrates, minerals and vitamins (Howeedy., *et al*. 2003 and Ibrahim., *et al*. 2010).

According to FAOSTAT, in 2012, Egypt ranked as one of the top producers of tomatoes (8,625,219 tones). The obtained data indicated that the cultivated area of tomato in Egypt increased considerably during the last two decades (Ibrahim., *et al*. 2015). In 2011, the total cultivated area, and productivity of tomato in Egypt, was estimated by 505.823 feddan (feddan = 4200 m^2), yielding 805.3701 tons with an average of 15.92 tons/feddan (Anonymous, 2011). According to the last estimates from the Egyptian Ministry of Agriculture and Land Reclamation in 2013, the production of tomato increased to 16.636 tons/feddan with a total yield of 8.571.050 tons from a total area of 515.225 feddan (Anonymous, 2013).

The Economic Importance of Root-Knot Nematodes

The production of tomato plants are affected by several factors such as rain fall, temperature, soil fertility, time of planting, plant density, insect infestations and diseases infection. The tomato plants are attacked by several destructive pests that cause great damages. One of the major and important pests is plant-parasitic nematode specially root-knot nematodes, *Meloidogyne* spp., (Ibrahim., *et al*. 2010). Globally, it was estimated that the root knot nematodes caused tomato yield losses by 27% (Sharma and Sharma, 2015).

There are thousands of nematodes genera, but the root-knot nematodes (Meloidogyne spp.) were and still the most dominant and destructive genus around the world. It can parasite on approximately 5500 host species (Trudgill and Blok, 2001). The losses caused by infestation of plant parasitic nematodes in crop production estimated by 14.6%, whereas in the developed temperate countries, it was estimated as 8.8% (Nicol., *et al*. 2011). In addition, nematodes cause an estimated $118b annual loss to world crops (Atkinson., *et al*. 2012). Moreover, about 48% of global nematicides are targeted only root-knot nematodes across differ crops (Haydock., *et al*. 2006).

Root-knot nematodes have wide range of hosts including vegetables, fruit trees, oil crops, fiber crops, grains crops and leguminous crops, next to weeds which is considered secondary host to nematodes (Khalil, 2013a). About 90% of damages caused by plant parasitic nematodes are attributed to, *Meloidogyne javanica* (Treub) Chitw., *M. incognita* (Kofoid and White) Chitw., *M. arenaria* (Neal) Chitw., and *M. hapla* Chitw. (Castagnone-Sereno, 2002).

Management Practices of Plant Parasitic Nematodes

There are certain methods used as an attempt to manage the plant parasitic nematodes especially the root-knot nematodes on crops with varying levels of success under different conditions including synthetic nematicides, resistant plant varieties, botanical pesticides,

antagonistic microorganisms (e.g. fungi and bacteria), organic amendments, soil solarization, beneficial fungi (Mycorrhiza) and plant extracts (Randhawa., *et al*. 2001; Dawar., *et al*. 2008; Radwan., *et al*. 2012 and Renčo., *et al*. 2014).

Fumigant and non-fumigant Nematicides

It has been estimated that about 2.5 million tons of pesticides are used on crops each year and the worldwide damage caused due to pesticides misuse reaches $100 billion annually (Koul., *et al*. 2008). Also, the misuse of chemical nematicides leads to phytotoxicity, environmental pollution and nematodes resistance (Adegbite and Adesiyan, 2005). It also has the disadvantage of being toxic to man and animals when used improperly (Luc., *et al*. 1990). Nevertheless, the farmers still depending on chemical nematicides because of their activity in crop protection for a long period and its quick action toward the parasitic nematodes.

The conventional methods to manage PPN includes the soil fumigants (mixture of 1,2-dichloropropane and 1,3-dichloropropene, 1,3-Dichloropropene, Ethylene Dibromide, 1,2-Dibromo-3-Chloropropane, Chloropicrin, Metam-sodium, Dazomet, Methyl Isothiocyanate, Sodium Tetrathiocarbonate, Methyl Bromide and Methyl Iodide). While, the non-volatile pesticides are follow carbamates group (Aldicarb, Aldoxycarb, Carbofuran and Oxamyl), and organophosphates group (Ethoprop, Fenamiphos, Cadusafos and Fosthiazate). The mechanism of both carbamates and organophosphates groups are cholinesterase inhibitor which prevents the breakdown of acetylcholine in the synapse (Khalil, 2013a).

Therefore, the researchers seek about alternative route to manage plant nematodes, and found that biological control is one of the best available option tools can used in integrated nematodes management (INM).

The Microbial Agents

Recently, many reports indicated that several microbes are produced as active ingredients in commercial products to control different pests including the root-knot nematodes in varied crops. The bio-agents are effective and promising trend in INM programs. However, such products are likely to be less effective than chemicals, and will, therefore, have to be used in an integrated manner with other control techniques (Stirling, 1991).

Fungi: One of the most famous microorganisms is Paecilomyces lilacinus (Thom) Samson, which is a soil- inhabiting fungus applied for the first time as bio- control agent for managing M. incognita under field application by Jatala., *et al*. (1980). It is a highly occurrence in the tropics and subtropic (Morgan., *et al*. 1984 and Chen., *et al*. 1996), and can be found in most of agricultural soils (Brand., *et al*. 2010).

It has capability of parasitizing on nematode eggs, juveniles and females especially root-knot and cyst nematodes (Jatala, 1986; Kiewnick and Sikora, 2006 and Brand., *et al*. 2010). Furthermore, strains of this fungus have been formulated for managing plant parasitic nematodes in several countries (Kiewnick and Sikora, 2003 and Khalil, 2013b).

On the other hand, Trichoderma species are free-living fungi that are common in soil and root ecosystems. The antagonistic impact of Trichoderma spp. towards root-knot nematodes were documented (Ibrahim., *et al*. 2010 and Izuogu and Abiri, 2015). Recently, numbers of Trichoderma isolates are used commercially to manage certain pathogens in the soil (Naserinasab., *et al*. 2011 and Khalil, 2013b).

Bacteria: Bacteria represent an important group of bio-control agents and several commercial products are nowadays available to control plant-parasitic nematodes (Hallmann., *et al*. 2009). Bacillus is one of the largest groups of the bacteria that have shown diversified effects on plant-parasitic nematodes. Bacillus subtilis, is one of the famous rhizobacterium that gained global attention as a biopesticide. The potential of Bacillus spp against plant pathogenic nematodes have been reported by many investigators (Radwan, 2007; Prakob., *et al*. 2009 and Yu., *et al*. 2015).

Bio-pesticides

Avermectins that belong to the macrocyclic lactones have been obtained from Gram-positive bacterium, *Streptomyces avermitilis*. Avermectins have four pair's compounds which contain four major components $A1_a$, $A2_a$, $B1_a$ and $B2_a$ and four minor components $A1_b$, $A2_b$, $B1_b$ and $B2_b$. Abamectin has shown low toxicity to non-target beneficial arthropods that help its acceptance into Integrated Pest Management (IPM) programs, besides supporting the safety to man and the environment (Lasota and Dybas, 1990).

Abamectin is a blend of avermectins $B1_a$ and $B1_b$, which contain at least about 80% avermectin Bla and 20% avermectin Blb (Pitterna., *et al*. 2009). These two components, $B1_a$ and Bl_b, have very similar biological and toxicological properties. Certain reports unanimously recorded that abamectin has nematicidal efficient against the root-knot nematode and other genera in several crops (Jansson and Rabatin, 1997; Monfort., *et al*. 2006; Saad., *et al*. 2012 and Muzhandu., *et al*. 2014).

Similarly, emamectin benzoate, which follow avermectins group, were effective against root-knot nematodes according to the received information from Jansson and Rabatin(1998), Abbas., *et al*. (2008) and Rehman., *et al*. (2009) , but emamectin was less effective than abamectin.

Soil Amendments

In the last few years there has been an increasing interest in using soil amendments and other composted materials as tool of the biological control to suppress plant parasitic nematode (Akhter and Malik, 2000). Organic amendments are cover several sources and products, including animal manures (poultry, cattle), green manures from cover crops or crop residues, industrial wastes (oil seed cakes), or town wastes; they have or have not been composted, and they have or do not have a particular biocide activity; some are applied on top of the soil as mulches and others are incorporated into the soil (Collange., *et al*. 2011).

The usage of organic matter was described for the first time by Linford., *et al*. (1938), since then many reviews have focused on the use of organic amendments to control plant-parasitic nematodes (Rodríguez-Kábana, 1986; Akhtar and Malik, 2000; Oka, 2010; Thoden., *et al*. 2011 and El-Sherbiny and Awd Allah, 2014).

Furthermore, a lot of investigations about utilizing many plant residues, wastes and pre planting soil bio-fumigants as soil treatment for managing plant-parasitic nematodes and other plant pathogens were documented by many authors (Hassan., *et al*. 2010; Anita, 2012; Kruger., *et al*. 2013 and El-Sherbiny and Awd Allah, 2014).

One of the exclusive approaches is using dried waste residues of certain ornamentals such as *Bougainvillea spectabilis* (Khalil and Shawky, 2008), *Erythrina humenea* (El-Sherbiny and Zen-El-Dein, 2012), *Erythrina indica* (Mohanty and Das, 1988), as soil amendments.

Vegetables wastes and/or residues proved to be effective against plant nematodes especially those belong to Brassica plant species as Cabbage and Cauliflower (El-Sherbiny and Awd Allah, 2014). Similarly, amended soil with weeds like *Chenopodium ambrosioides, Euphorbia peplus* and *Rumex dentatus* as green leaf manures gave significant influence against root-knot nematodes (Montasser., *et al*. 2012).

Plant Extracts

Currently, there has been considerable pressure in agriculture to decrease chemical pesticides and to look for their better alternatives. The plant kingdom is recognized as the most efficient producer of different biologically active compounds, which provide them with resistance against different pests. In present years some higher plant products have been formulated as eco-friendly botanical pesticides in managing agricultural pests. Botanicals are safe to the users and the environment. The products from higher plants are safe and economical and would be in high demand in the global pesticide market because of their diverse mode of application (Dubey., *et al*. 2011).

Different plants that belong to more than 57 families have nematicidal properties and it is possible to use these plants to manage root knot nematodes (Sukul, 1992).There is the need to develop effective and environmental friendly nematicides which are less toxic to man and animals but are effective against plant nematodes as synthetic ones. Following this, the nematicidal potential of some botanicals have been evaluated and some found to be toxic against the root knot nematodes (Adegbite and Adesiyan, 2005).

The usage of plant extracts for the management of root knot nematodes was carried out by many workers. Extracts prepared from different plants have been reported from time to time to have a variety of properties including insecticidal activity, repellence to pests, antifeedant effects, and insect growth regulation, toxicity to nematodes, mites and other agricultural pests, and also antifungal, antiviral and antibacterial properties against pathogens (Prakash and Rao, 1986 and 1997).

Conclusion

We can concluded that the field of plant nematodes management need to alternative approaches because of the shortage in available nematicides, in addition to the adverse effects of these chemical pesticides. On the other hand, all the above mentioned methods for managing plant parasitic nematodes are needed to use on wide scale. This culture must be widely disseminated to benefit the entire agricultural community, especially in the poor countries. These alternatives are highly reliable and effective.

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