[Article ID : 01/VII/11/0721]

SCOPE OF BRASSICACEAE PLANTS AS POTENTIAL BIOFUMIGANTS FOR THE MANAGEMENT OF THE ROOTKNOT NEMATODE IN VEGETABLES PRODUCTION - A REVIEW

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Abstract

Biofumigation is that the practice of using volatile chemicals released from decomposing material to suppress soil pathogens, insects and germinating weed seeds. It has been used as an alternative to methyl bromide and other synthetic pesticides in horticulture and agriculture in general. Biofumigation use plant material and naturally produced compounds and is an increasingly feasible method of pest management. This pest management technique is an eco-friendly potential tool adopted to suppress the pest in the soil. Brassicas are mainly used for biofumigation to manage root-knot nematodes. The decomposition of the plant tissues in these families releases glucosinolates that break down into nematotoxic isothiocyanates which are biocidal. The potential of biofumigation have increasingly explored by research endeavors. However, there is need for research into brassicas that can be used for biofumigation. There is also a need for research on methods of incorporating the biofumigant plants into the soil. Breeding for brassicas with high isothiocyanates content also has got to be done. There should even be effort to teach farmers about biofumigtion since most farmers aren't conscious of this system. The reaction of target pests, the choice of biofumigant and ideal environments for efficacy is still to be evaluated.

Keywords : biofumigation, root-knot nematode,*Brassicaceae*.

Introduction

Nematodes are the most widely dispersed phylum of multicellular animals. While many are free living and have little to no impact on plant health, some species have adapted to parasitize plants. They often present an intractable problem especially to smallholders in the tropics and subtropics. They are the "hidden enemy" and the damage they do go unrecognized because the symptoms above ground are not specific and the pests are not visible to the naked eye. Nematode predation is difficult to trace due to the nature of the pest in causing the damage. They cause extensive damage to a wide variety of economically important crops (Sasser, 1980) and remain as one of the most serious pest faced by vegetable growing farmers. They are of great importance both in terms of their damage to crops and the difficulty of their control. The control of the pest has little chance of success and is uneconomical because they mostly live inside the soil and feed on the internal plant tissues. Annual yield losses on worldwide scale that are attributed to plant-parasitic nematode are estimated to range between 5% to 12% (Sasser and Freckman, 1987) reducing production by millions of tones every year. Depending on climate, crops grown, nematodes density levels, and economic factors, a number of tactics can be employed to minimize nematode damage (Ploeg 2008).

Of plant parasitic nematodes, Root-knot nematodes are a group of semi-sedentary endoprasitic nematodes which are considered as one of the most important species in terms of both its worldwide geographical distribution and very large host range, reaching up to 3,000 different plant species (Lamberti, 1979) is a major limiting factor in vegetable production. They are economically damaging nematodes on a range of crops in subtropical and tropical climates (Koenning *et al*. 1999; Stirling and Stirling 2003) which form specialized feeding cells in the roots of their host plants and utilize the photosynthate produced in leaves for their energy needs (Kochba and Samish, 1971). As a result of such parasitism, root weight increases while shoot weight declines (Fortnum *et al*., 1991) leading to crop losses of around 15% in tropical countries (Sasser 1979). They are almost always present to some extent in agricultural soils and their populations increase to damaging levels when susceptible hosts are grown on the same land for many years. Crops also become much more susceptible to the effects of nematodes under adverse conditions of poor soil fertility or moisture stress (Hillocks 2002). Moreover yield losses of 50-80% caused by these nematodes in vegetable crops are common (Siddiqi 2000). Symptoms of root-knot nematode attack include formation of galls on the roots and wilting of the upper parts of the infected plants. Moreover, soil-borne pathogens can more easily penetrate in roots infected by nematodes, thus causing damage superior to the one caused by the nematode itself.

Nematodes can be controlled by using chemical nematicides, but the range of available compounds is limited, expensive and their uses have negative impacts on the environment and on public health. Most chemical nematicides are either less effective or too expensive and related to a negative impact on the environment and public health (Braun and Supkoff, 1994). In addition, “the impacts of many pesticides on the environment and human health are currently being re-evaluated” (Obenauf, 2004). So there is increased interest in non-chemical nematode management strategies. As a result, there's growing interest in alternative methods of management that are economically viable and non-polluting. an alternate management strategy that's receiving increased interest is fumigation. In the past decades soil fumigation with methyl bromide has been the most common method of nematode control (Abou-Jawdah *et al*., 2000) and was almost exclusively used throughout many years. However, despite of its efficiency in controlling of a good range of soil borne pests and pathogens in high-value horticultural crops, this fumigant was found to be together of the foremost powerful Ozone Depleting Substances (ODS). Due to increasing environmental concerns, in 1997 parties of the Montreal Protocol for the protection of the Ozone layer agreed to phase out Methyl Bromide and replace it with safe and viable alternatives throughout the world. In recent years the phasing out of methyl bromide has the effect of bringing into sharp focus the need for alternative strategies for the management of soil borne pests and diseases, not just for users of methyl bromide but in a general senseis becoming imperative necessity.

Biofumigation

Biofumigationcan be defined as a sustainable agronomic practice by using naturally produced plant compounds for managing soil pests. It may work as a stand-alone treatment or in combination with other strategies such as sanitation, organic amendments, or solarization (Wang *et al*. 2006; Collange*et al*., 2011).The first scientific article on biofumigation was published by Angus *et al* in 1994. It was defined by several researchers (Halberendt 1996; Kirkegaard and Sarwar 1998) as a process that occurs when volatile compounds with pesticidal properties are released during decomposition of plant materials or animal products. This practice primarily relieson volatile organic compounds when they or their byproducts are incorporated into soil by ploughing of above and below ground biomass residues to breakdown into secondary compounds. Therefore, soil biofumigation with the use of crops become the alternative in the production of vegetable crops. Some chemicals produced by certain plants have the potential in managing some pests and nematodes (Oka *et al*., 2006). A systematic approach to research into biofumigation with green manures should aim at overcoming a long history of empiricisms in recent advances in both basic and applied knowledge. Therefore, more emphasis is currently put in the development of environment friendly, efficient and sustainable alternative techniques (Katan*et al*., 1976).

Brassicaceae plants as biofumigants

Brassicas are able to produce about 30 to 40 different Glucosinolates which when combined with other factors negatively effect on the appearance of soil pests and diseases. Brassicaceae plants primarily grow in temperate regions and prefer deep, well-drained soils. They are less tolerant to heat when compared to many other plant families (Björkman *et al*. 2011). In the past decade, for the control of soil fungi, nematodes and other soil borne pests in sustainable vegetable production systems interest was shown towards growing cover crops in general and Brassicaceae plants as green manures (Lazzeri*et al*., 1993; Buskov*et al*., 2002; Davis *et al*., 1996). Many studies indicate that plants of the Brassicaceae family have the potential of replacing fumigant nematicides by releasing chemicals which suppress the nematodes in the production of a large variety of crops. However, most research on biofumigation has been focused by using brassicaceous crops (Kirkegaard and Matthiessen, 2004).

The suppressive effect of brassicaceous biofumigants on soil borne pathogens, weeds and plant-parasitic nematodes has been demonstrated in numerous laboratories, greenhouses and in field studies (Ploeg and Stapleton, 2001; Ploeg, 2008; Zasadaet al., 2010) and has been found that the biocidal activity of these plants is due to the presence of certain organic compounds in their cells called glucosinolates. Upon tissue disruption, a number of toxic products like thiocyanatesand isothiocyanates are known toreleased from these compounds during decomposition (Chew 1988; Brown *et al*. 1991)which are chemically similar to the active agent of methyl bromide. When provided with adequate moisture, Brassica varieties with high glucosinolate suppress soil borne pests by the releasing isothiocyanates in the soil (Morra and Kirkegaard, 2002). Among many Brassica plants, arugula (*Eruca sativa*) possesses biofumigant and trap crop qualities, and it has recently gained popularity as a potential alternative to Methyl Bromide.

In the past years extensive research has been carried on the efficiency of biofumigation for the management of plant parasitic nematodes on plants of the Solanaceae family, which have a particular degree of resistance or tolerance towards nematodes. Biofumigation with the use of green manure crops of the Brassica family is an effective management practice to reduce populations of plant parasitic nematodes. Thus plants of Brassica family have the potential to replace fumigant nematicides (Mojtahedi*et al*., 1991; McFadden *et al*., 1992; Spak*et al*., 1993). However, a far better understanding of the real effects of green manure crops on the root-knot nematodes is required so as to elaborate improved management strategies. Since biofumigation is a recent non-chemical plant protection management practice, very little information is out there on the applicability of this practice for the production of vegetable crops and efficacy on nematode management.

Conclusion

The intent of this review is more than a repetitious description of the history and mechanisms of the concept of biofumigation as a potential control method in root-knot nematode management. In view of environmental and human health risks, biofumigation is an attractive alternative. For farmers who had already applied organic matter or who grew cover crops, the switch to biofumigation to control nematodes may be a sensible one. To qualify the crop as a good biofumigant for the management of nematodes, the crop should be a poor host for the nematodes and lower the nematode population after incorporatingin soil (Viaene and Abawi, 1998). Although biofumigation often results in satisfactory levels of nematode control, the underlying mechanisms responsible for control are still largely unknown. In spite of this, biofumigation appears to be a very promising technique that could easily be integrated with other pest control measures and also it may offers alternative uses for some agricultural by-products. Biofumigation with Brassicaceae which stood as a promising alternative to conventional fumigation has its drawbacks too. Not all Brassicaceae plants are good biofumigants compare to several crops in the family with different host range.The fact that many crops in the same family are hosts to root-knot nematodes can result in an undesired population increase. Biofumigation is also an untargeted biocide. Non target free-living, beneficial nematodes (Henderson *et al*.2009; Ramirez *et al*. 2009), as well as other macro and micro soil organisms, may be harmed (Riga 2011; Zuluaga*et al*. 2015; Fouchée*et al*. 2016). Growing a biofumigant crop can be costly and due to unfamiliarity and delayedresults, a potentially daunting proposition (Grabau*et al*.2017). Interpretation of the initial effectiveness and successive efficacy of biofumigation is still underway. Biofumigation with crops in the management of the root-knot nematodes aimed at assessing the financial feasibility of the biofumigation techniques used and the final profitability of the crops in terms of cost to benefit ratio. With careful planning there is potential for high success in managing nematodes.

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