

Incorporating *Crotalaria* species in cropping systems for the management of root-knot nematodes in indigenous vegetable crops in Western Kenya

Mbogoh, J.M.¹, Omami, E.¹, Ochuodho, J.¹, Kipkoech, A.K.¹, Njira, P.² & Ngode, L.¹

¹Chepkoilel University College, School of Agriculture and Biotechnology, P. O. Box 1125, Eldoret, Kenya

²Moi University, P. O. Box 3900, Eldoret, Kenya

Corresponding author: jmbogo@gmail.com

Abstract

There is rekindled interest and increased demand for African Leafy Vegetables (ALVs) by rural and urban dwellers of all socio-economic classes in Kenya. This has stimulated production of these vegetables but their supply has not been able to meet the demand, leading to low consumption levels. This has led to high occurrence of disorders such as acute megaloblastic anaemia, blindness and low immunity resulting in severe birth defects, malaria, HIV/AIDs and worse still deaths of more than four million children and mothers annually. Root-knot nematodes (RKNs) especially *Meloidogyne* spp. are key vegetable production constraints in western Kenya. They reduce plant growth by lowering water and mineral uptake and by enhancing crop damage by certain pathogens. Because of being less environmentally harmful and due to the increased demand for organic produce, the use of antagonistic crops in nematode management is a potentially valuable alternative to chemical nematicides. The objective of this study is to assess the effectiveness of *Crotalaria* species in rotation or as an intercrop in managing RKNs in susceptible vegetable crops like *Solanum* spp. and *Cleome* spp. Results will enable farmers to design and implement effective crop cycles that will result in increased vegetable production in nematode prone fields of Western Kenya.

Key words: African Leafy Vegetables, *Cleome* spp., *Crotalaria* species, *Meloidogyne*, *Solanum* spp.

Résumé

Il y a un regain d'intérêt et une demande accrue pour les légumes à feuilles africains par les habitants des zones rurales et urbaines de toutes les classes socio-économiques au Kenya. Cela a stimulé la production de ces légumes, mais leur offre n'a pas été en mesure de répondre à la demande, conduisant à des niveaux de consommation faibles. Cela a conduit à la fréquence élevée des troubles tels que *acutemegaloblasticanaemia*, la cécité et la faible immunité entraînant des malformations

congénitales graves, le paludisme, le VIH / sida et des décès pire encore de plus de quatre millions d'enfants et de mères par an. Les nématodes à galles (RKNs), en particulier *Meloidogyne spp.* sont les principaux obstacles à la production de légumes dans l'ouest du Kenya. Ils réduisent la croissance des plantes en réduisant l'absorption de l'eau et des minéraux et en augmentant les dégâts causés par certains agents pathogènes. Par le fait d'être moins nocif pour l'environnement et en raison de la demande accrue pour les produits organiques, l'utilisation de cultures antagonistes dans la gestion des nématodes est une alternative potentiellement précieuse pour les nématicides chimiques. L'objectif de cette étude est d'évaluer l'efficacité de *Crotalaria species* dans la rotation ou en culture intercalaire dans la gestion de RKNs dans les cultures légumières sensibles comme *Solanum spp.* et *Cleome spp.* Les résultats permettront aux agriculteurs de concevoir et de mettre en œuvre des cycles de culture efficaces qui donneront lieu à la production accrue de légumes dans les champs sujets aux nématodes à l'ouest du Kenya.

Mots clés: Légumes à feuilles Africains, *Cleome spp.*, *Crotalaria species*, *Meloidogyne*, *Solanum spp.*

Background

African Leafy Vegetables (ALVs) are regarded as an important commodity in the diet of many African communities. Most of the vegetables are grown by low-income communities and thus, play a crucial role in food security and in improving the nutritional status of poor families (Gotor and Irungu, 2010). The current level of production of ALVs does not meet domestic demand (Republic of Kenya, 2004), leading to low consumption levels (Kimiye et al., 2007). One of the factors leading to yield decline is field infestation by root-knot nematodes (RKNs) mainly *Meloidogyne incognita*, *M. javanica* and *M. arenaria*. They alter the plant physiology by producing specific enzymes that induce giant cell formation within the root at the feeding site. The giant cells then act as sinks by "attracting" energy rich plant metabolites, which are consumed by the nematode. The abnormal cells disrupt moisture and nutrient transport within the plant (Anwar and McKenry 2010). The RKNs attack a wide variety of vegetable crops globally (Abad et al., 2008). Particularly, they damage vegetables in tropical and subtropical countries and cause losses of up to 80% in heavily infested fields (Kaskavalci, 2007).

Literature Summary

The use of non-host or poor host plant species in cropping systems with susceptible crops especially in soils infected with plant parasitic nematodes is one of the most effective nematodemanagement methods. Such crops include the *Crotalaria* spp. that produce allelopathic compounds against several nematode species. Moreover, *Crotalaria* spp. are known to associate with rhizobium bacteria in nitrogen fixation. This is important, as nutrient availability is a central to plant tolerance to nematode infection. However, there is no definite cropping system that has been developed in relation to nematode management (Wang *et al.*, 2002). This study aims at assessing the effectiveness of different cropping and rotation systems incorporating *Crotalaria* spp. in management of nematodes in vegetables production systems of western Kenya.

Sequential cropping system is recognised as a strategy in root-knot nematode management but it has not been adopted by farmers because of the less profitable crops involved in the system, yet they need to plant commercial crops. In addition, a lot of skill is required in designing and implementation of effective crop cycles for the management of such pathogens as root-knot nematode because of their broad host range (Yamada, 2002). Previous studies have focused on plants such as *Tagetes* spp., *Asparagus* spp., sesame, and neem, which release root exudates that are toxic to the nematodes. Low or lack of commercial value of the most intensively studied plants is a major hindrance to their adoption into cropping systems. Suitability of a crop for incorporation into a rotation cycle is not only determined by its efficiency in nematode suppression but also by the economic returns (Otupa *et al.*, 2006).

The challenge to research is therefore, to identify nematode suppressive crops that satisfy the economic considerations in cropping systems (Otupa *et al.*, 2009). *Crotalaria* species are an efficient tool for sustainable cropping systems in subtropical agriculture as they also have economic and food value. They inhibit the formation of galls, the production of egg masses and release root exudates toxic to nematodes (Vargas-Ayala, 2000). In mixed cropping the compounds from *Crotalaria* species may interact with other classes of chemicals from neighbouring plants and these compounds sometimes may have a greater allelopathic effect than the individual compounds alone when *Crotalaria* is in a monocrop. Moreover, *Crotalaria* spp. is known to enhance multiplication of natural enemies of phytopathogenic nematodes, such as fungi that directly feed on nematodes eggs. 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 tolerant to nematode damage (Wang and McSorley, 2004).

Study Description

A baseline survey was conducted in Busia, Bungoma and Kakamega counties of Western Kenya in February 2012 in various ALVs farms to determine the prevalence of RKNs. Soil and root samples from the farms were collected for nematode identification and multiplication. Screening for nematode susceptibility was done for seven species of *Cleome* and *Solanum*. The most susceptible species together with *Crotalaria* spp. were used to design effective rotation programmes to manage RKNs. In subsequent seasons, multi-location trials of the best rotational programs will be done to assess the effectiveness of the rotational program in controlling RKNs in farmers' fields. Experiments have been set up to assess the effects of intercropping *Crotalaria* spp. and other vegetables on the nematostatics and nematicidal properties of this species in greenhouses at Chepkoilel University College. Root-knot nematodes motility and mortality will be tested using extracted root leachates from each treatment in ELISA type plates. In later stages of the study, a socio-economic analysis of households in Western Kenya will be carried out to assess the factors that are likely to influence adoption of *Crotalaria* spp. as a crop of choice in control of nematodes in vegetable fields. Data collected will be subjected to analysis of variance (ANOVA) using GENSTAT statistical package and means will be separated using LSD.

Research Application

This study is expected to promote cultural nematode control by using *Crotalaria* spp. as antagonistic crops that have food and commercial value to increase indigenous vegetable yields both in tropics and sub-tropics. The study will lead to the development of effective sequential cropping cycles for management of RKNs as well as provide information on the different nematostatics and nematicidal properties of the *Crotalaria* spp. when planted in different cropping systems.

There is increased demand for ALVs yet the demand has outstripped their supply leading to low consumption levels. The findings of this study will be of great benefit to African leafy vegetable growers especially those in nematode prone areas. The efficacy of *Crotalaria* species in parasitic nematode management will have positive impact on the livelihood of

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- Kenyan due to expected increase in indigenous vegetable production. This will address the current crisis of food insecurity in Kenya. Agronomists and other scientists researching on plant protection fields will have increased knowledge on the mode of action of *Crotalaria* spp. on parasitic nematodes.
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