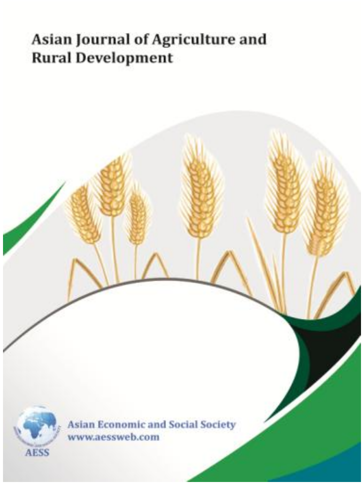
Publisher: Asian Economic and Social Society
ISSN (P): 2304-1455, ISSN (E): 2224-4433
Volume 2 No. 4 December 2012.



Management of the Root Knot Nematode (*Meloidogyne Javanica*. Treub) and Sore Shin (*Rhizoctonia Solani.* Kuhn) Using A Nematicide and Poor Host Crops in Rotations

U. Mazarura (Department of Crop Science, University of Zimbabwe, Mt Pleasant, Harare, Zimbabwe)

C. Chisango (Kutsaga Research Company, Harare, Zimbabwe)

M. Goss (Department of Crop Science, University of Zimbabwe, Mt Pleasant, Harare, Zimbabwe)

Citation: U. Mazarura, C. Chisango and M. Goss (2012) "Management of the Root Knot Nematode (*Meloidogyne Javanica*. Treub) and Sore Shin (*Rhizoctonia Solani*. Kuhn) Using A Nematicide and Poor Host Crops in Rotations", Asian Journal of Agriculture and Rural Development, Vol. 2, No. 4, pp. 668 – 675.

Asian Journal of Agriculture and Rural Development, 2(4), pp. 668-675.

Management of the Root Knot Nematode (*Meloidogyne Javanica*. Treub) and Sore Shin (*Rhizoctonia Solani.* Kuhn) Using A Nematicide and Poor Host Crops in Rotations

Author(s)

U. Mazarura
Department of Crop Science, University of Zimbabwe, Mt Pleasant, Harare, Zimbabwe

C. Chisango
Kutsaga Research Company, Harare, Zimbabwe

M. Goss
Department of Crop Science, University of Zimbabwe, Mt Pleasant, Harare, Zimbabwe

Abstract

In a long term study the effects of a nematicide and six rotations: root-knot-susceptible tobacco, Nicotiana tabacum L. cv.'KM10' grown continuously (ContKM10), root-knot-resistant tobacco cv. 'RK8' grown continuously (ContRK8), grass-grass-grass-KM10 (G-G-G-KM10), grass-grass-grass-RK8 (G-G-G-RK8), KM10-Crotalaria juncea (KM10-Cr) and RK8-Crotalaria juncea (RK8-Cr), on root knot nematode, Meloidogyne javanica and sore shin, Rhizoctonia solani infection were studied. The nematicide used was ethylene dibromide (EDB) and was applied to each tobacco crop, as is standard practice. Chloris gayana cv. 'Rhodes Katambora', presumably a poor host of nematodes, was the grass used in all the grass-grass-grass-Tobacco rotations. The treatments were arranged in a randomized complete block design. ContKM10, KM10-Cr, G-G-G-RK8, ContiRK8 and RK8-Cr reduced root knot galling while G-G-G-KM10 increased galling. Sore shin increased with every year of rotation regardless of rotation, except in the case of G-G-G-KM10 and G-G-G-RK8 which reduced infection relative to other rotations. With the exception of G-G-G-RK8, all rotations that included RK8 suppressed root knot infection but did not suppress sore shin infection. The rotations including KM10 suppressed nematodes only with EDB treatment yearly and did not suppress sore shin except the rotation G-G-G-KM10. The role of Crotolaria juncea was masked by either RK8 or EDB. Host plant resistance in the form of RK8 was effective in controlling nematodes but did not reduce sore shin except mildly when rotated with the grass. This work recommends the use of resistant cultivars with broad-spectrum resistances.

Keywords: Nematodes, Rotation, Sore Shin, Tobacco

Introduction

Plant-parasitic nematodes like *Meloidogyne spp* cause major economic losses in many crop plants (Koenning et al., 1999). The reduction in yields maybe direct through cell destruction and transmission of viruses, or indirectly by providing infection sites for fungi and bacteria. Overall losses are estimated to be above US $100 billion/year throughout the world including an up to 20% reduction in yield in many cash crops (Koenning *et al*., 1999). The root knot nematodes, *Meloidogyne spp* are a major tobacco pest (Clayton et al., 1958; Schweppenhauser, 1975) and are also a problem in underexploited indigenous vegetables like sesame, *Ceratotheca sesamoide* (Izuogu et al., 2012). In the late 1950s, the importance of this pest decreased because of the development of vertical resistance (Clayton et al., 1958). In addition, such resistance was thought to lessen the effect of root knot in making the plant susceptible to soil borne pathogens (Powel et al., 1971).

Rhizoctonia solani, which causes sore shin is a soil borne pathogen that can reduce yield by as much as 15 per cent (Cole and Zvenyika, 1982) or even 50 per cent in some fields (Shew and Main, 1985). Fungicides can achieve good control of this pathogen, but a better approach is to use fungicides and a biological control agent such as *Trichoderma harzianum (T77)* (Cole and Zvenyika, 1988) and/or rotations.

Cropping rotations are the oldest effective approach for controlling nematodes of annual crops (Nusbaum and Ferris, 1973; Schmitt, 1991). Many reports showed that soil micro-organisms like nematodes could be reduced by rotations, thereby increasing yields of crops like soybean (Howard *et al*., 1998; Chen *et al*., 2001) and tobacco (Hiranslalee, et al., 1995). Some significant antagonism to root knot nematodes in many *Crotalaria spp* have been reported, justifying their inclusion in crop rotations in *Meloidogyne*-infested soils (Desaeger and Rao 1999, 2001). Robinson and Cook, 2001 also showed that Sunn hemp, *Crotalaria juncea* was a poor host of some nematodes and played a role in their management. Sunn hemp, which is a legume is increasingly receiving attention owing to its positive effect on soil organic matter as well as good green manure and nitrogen fixation properties (Rotar and Joy, 1983), and its ability to suppress plant-parasitic nematodes (*Wang et al.*, 2008). This study investigated the effects of long-term crop rotations and a nematicide on *M. Javanica* and *R. solani* in irrigated tobacco.

Materials and Methods

Experimental Design and Conditions

This experiment was carried out under irrigation on a sandy loam soil (72.8% sand, 8.8% silt and 18.4% clay) at Kutsaga Research Station (17º 55' S, 31º 08' ; Altitude 1480m, Average annual rainfall 882mm), Zimbabwe from 1990 to 2000. Tobacco was grown as a uniformity crop in 1990 and the year of first rotation (as per treatment) was 1991. This report covers the period 1994 to 2000 since in 1994 the longest rotation (grass-grass-grass-tobacco) had completed a full cycle (4 yrs). The design was four randomized complete blocks (replicated four times) with the six rotations namely;

i. Continuous root-knot-susceptible tobacco cv. KM10 (ContKM10),

ii. Continuous root-knot-resistant tobacco cv. RK8 (ContRK8),

iii. KM10 followed by *Crotalaria juncea* (as a winter green manure), (KM10-Cr),

iv. RK8 followed by *Crotalaria juncea* (as a winter green manure), (RK8-Cr),

v. Three years of the grass *Chloris gayana* cv. Katambora Rhodes followed by KM10, (G-G-G-KM10), and

vi. Three years of *Chloris gayana* followed by RK8 (G-G-G-RK8).

These symbols are used in all figures and tables throughout this paper. Each tobacco crop was treated with the nematicide Ethylene Dibromide (EDB), at 3ml EDB/planting station at planting using an injector gun as is standard practice. The treatments were laid out in a randomized complete block design in such a way that every component of a rotation was included in each block in every year. This allowed direct effects of a treatment component to be revealed every year and cycle analyses to explain residual or cumulative effects. Each plot was 4.8 m wide and 17.92 m long, giving 4 rows of 32 plants each.

Irrigation and Cultural Practice

Irrigation was applied by sprinkler at 50% moisture depletion, estimated using the evaporation pan method. The land was ploughed and diced as is standard practice. Tobacco was grown on 0.2 m high ridges at a spacing of 1.2 m inter-row and 0.56 m intra-row. The Katambora Rhodes grass was seeded by broadcasting at 12 kg/ha and *Crotolaria juncea* was similarly seeded at 50 kg/ha and incorporated just before flowering. *C. juncea* was established with irrigation, grown for three months and ploughed under as a green manure before each tobacco crop in the relevant rotation. The tobacco crop was kept weed-free by mechanical and chemical weed control methods. The herbicide, Metolachlor 960 EC was applied at 2.3 L/ha within seven days of transplanting and settled in with 12 mm of irrigation.

Fertilisation

The tobacco crop received a basic application of 600 kg ha^{-1} compound fertiliser (4-18-15) and was pre-irrigated before planting at the beginning of each September. Topdressing applications of 100 kg N/ha and 10 kg N/ha as ammonium nitrate (34-0-0) were applied to RK8 at 3-4 weeks after planting and at topping, respectively, while KM10 received just the initial topdressing at 3-4 weeks after planting as is standard practice. The fertiliser was applied by dollop placement 10 cm from the plant and 5 cm deep. Lime was only applied as and when needed to correct pH to 5.5 ($CaCl_2$).

Root knot and sore shin rating

At the end of each tobacco season, the tobacco was assessed for root knot nematode galling by using a scale of 0 to 8 (Daulton and Nusbaum, 1961). Zero represented no galling and 8 extremely heavy galling and mass invasion without root development. For each treatment, 60 plants were dug and assessed for root knot nematode galling. For each treatment, a single row was used for sore shin assessments. In this row, seedlings were transplanted at 0.28 m within the row. At three weeks, each alternate seedling was removed, leaving the remainder spaced at 0.56 m, and assessed for sore shin. In all, 30 plants were thus assessed. This assessment was done using a scale of 0 to 5, where 0 signified no damage, 1 for 0-1% damage on plants with damage on stems, 2 for 1.1-10% damage for plants with up to two lesions on stems and slight root discoloration. A score of 3 was assigned for 11-25 % damage of plants with several lesions on stems and about one third of root discoloration, 4 for >26% damage of plants with extensive lesions on stem and root discoloured and, 5 for dead plants (Cole and Cole 1978).

Statistical Analysis

ANOVA on tobacco yield, root knot galling scores and sore shin rating scores was done after each season and at the end of the two cycles using SAS software Version 6 in order to show treatment effects yearly and rotation effects after the complete cycle. Selected treatments (see table 1) were further compared using orthogonal contrasts.

Results and Discussion

Root Knot Nematode and Yield Responses

The direct effects of each treatment for each year on galling index are in Fig 1A and B. With regard to KM10, the rotation G-G-G-KM10 showed higher galling over years compared to ContiKM10 or KM10-Cr (Fig 1A). The latter rotations though not different, except in year 8 when KM10-Cr > ContiKM10, showed galling decreasing with progressive year of rotation. In the case of RK8, galling was low and the same for all rotations over years (Fig 1B) showing that the root knot resistance in this cultivar was effective in suppressing nematode damage. The cumulative rotation effect (Table 1) confirmed the above trends showing significant high ($P<0.001$) galling in G-G-G-KM10 compared to ContKM10 or KM10-Cr while in RK8 the treatments were the same showing the dominance of the host plant resistance in RK8. All rotations that included RK8 showed reduced root knot galling. The continuous fall in galling with year of rotation in the rotations ContKM10 and KM-Cr (Fig 1A) possibly indicate the cumulative effect on the nematode population of yearly treatment with a nematicide and/or significant alterations of some soil properties that were detrimental to the pest. In the case of G-G-G-KM10 this nematicide effect was not discernible presumably because the EDB was only applied once in four years as opposed to yearly as was the case with the other rotations which had no grass in the sequence. Pen-Mouratov *et al.* (2004) reported negative correlation between nematodes and soil moisture and positive correlation between nematodes and soil organic matter. In this study, this could also have been the case since grass-grass-grass tobacco rotations had a higher soil organic matter (Mazarura and Chisango, 2012). Soo 2005) confirmed that partial root zone drying significantly reduced *M. javanica*. Indeed, in this trial the soil organic content fell in the ContKM10 and KM10-Cr rotations and showed a strong positive correlation with galling. Further, since the main growth of an irrigated crop in Zimbabwe occurs during the hottest and driest months of the year, this must have compounded the effect on the nematodes. The role of *Crotolaria juncea* in the suppression of nematodes seemed to have been masked by EDB or that, since it was grown for only three months, its effect was minimal. The reduction in galling in ContKM10 and KM10-Cr should have been accompanied by a rise in yield but, in fact, the opposite was true (Table 1). This perhaps, is because galling was measured at season end, making measurements less precise since yields are known to respond to infestation only within a month of transplanting (Brodie and Dukes, 1972). In this study the high yield associated with the rotation G-G-G- KM10 despite a higher galling and the lower yields in spite of lower galling in the rotations ContKM10 and KM10-Cr (Fig 2A, Table 1) must indicate that factors other than nematode galling were limiting. Indeed, a comparison of galling in ContRK8, RK8-Cr and G-G-G-RK8 (Fig 2B) showed that galling was the same but yield was significantly higher ($p<0.01$) with the G-G-G-RK8 sequence relative to the rotations ContRK8 and RK8-Cr implying that other factors, perhaps, associated with an increased soil organic carbon were at play. In fact, the yield in KM10 rotations was highly correlated with soil organic matter and soil nitrogen (Mazarura and Chisango, 2012). In the case of RK8, this study showed that host resistance had a major role to play in nematode management as all the rotations that included RK8, showed significant nematode suppression.

Sore Shin Response

The direct effects of each treatment component for each year on sore shin infection shown in Fig 1C and D indicated an increase in infection with year of rotation regardless of cropping sequence. The rotations G-G-G-KM10 and G-G-G-RK8 tended to be lower than the other rotations and this is confirmed by the cumulative data (Table 1). Reportedly, root knot resistance in RK8 ought to have conferred tolerance to *Rhizoctonia solani* (Batten and Powell, 1971) but this was not the case. These results also showed clearly that although yields appeared acceptable as per industry standards (2500-3500 kg/ha), sore shin rating increased, creating a danger for any subsequent crop.

Conclusions

The standard grass-grass-grass-tobacco rotation controlled nematodes only when the tobacco cultivar had inherent resistance to root knot. This host plant resistance in the form of RK8 was highly effective in controlling nematodes but did not reduce sore shin infection except mildly when rotated with the grass. It is likely that the combination of RK8 and a fumigant will protect this resistance from breaking down. The use of a susceptible cultivar even with a fumigant led to a yield reduction. This work also shows that the practice by Zimbabwean farmers of growing irrigated tobacco continuously for even up to 15 years is only driven by economics as yields seem to remain economical but at the expense of disease build-up and hence sustainability.

Recommendations

This work recommends the use of resistant cultivars with a broad spectrum of resistances. Further work needs to be done to explore other rotation crops that would eliminate the use of the nematicide since chemical control is both expensive and carries an environmental risk with regard to ground water contamination.

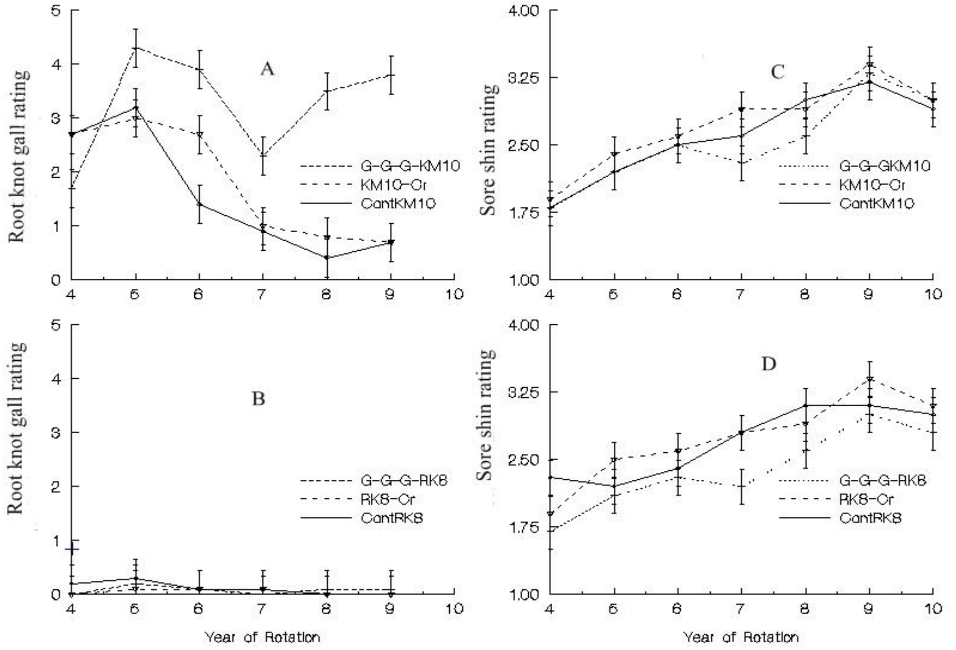


Figure 1: Yearly treatment effect on root knot galling for sequences involving KM10 (A), sequences involving RK8(B) and sore shin rating for sequences involving KM10 and sequences involving RK8. [ContiKM10 = root-knot-susceptible tobacco cv. KM10 grown continuously; ContRK8 = root-knot-resistant tobacco cv. RK8 grown continuously; G-G-G-KM10 = grass-grass-grass-KM10; G-G-G-RK8 = grass-garss-grass-RK8; KM10-Cr = KM10-*Crotalaria juncea* and RK8-Cr = RK8-*Crotalaria juncea*]

Table 1: Cumulative Effect of Rotations, After Two Complete 4 Year Cycles, on Tobacco Yield

Rotation	Yield	Root Knot	Sore shin
	(kg/ha)	galling	rating
ContKM10	3212	1.6	2.6
ContRK8	3675	0.1	2.7
KM10-Cr	3310	1.8	2.7
RK8-Cr	3748	0.1	2.7
G-G-G-KM10	3708	3.2	2.5
G-G-G-RK8	3899	0.1	2.5
CONTRAST	P	P	P
ContKM10 vs. G-G-G-KM10	***	***	ns
KM10-Cr vs. G-G-G-KM10	***	***	**
ContKM10 vs. KM10-Cr	ns	ns	ns
ContRK8 vs. G-G-G-RK8	***	ns	***
RK8-Cr vs. G-G-G-RK8	**	ns	***
Cont RK8, vs. RK8-Cr	ns	ns	ns

*** P > 0.001, ** P > 0.01, *P>0.05, ns = not significant at P>0.05

ContiKM10 = root-knot-susceptible tobacco cv. KM10 grown continuously; ContRK8 = root-knot-resistant tobacco cv. RK8 grown continuously; G-G-G-KM10 = grass-grass-grass-KM10; G-G-G-RK8 = grass-garss-grass-RK8; KM10-Cr = KM10-*Crotalaria juncea* and RK8-Cr = RK8-*Crotalaria juncea.*

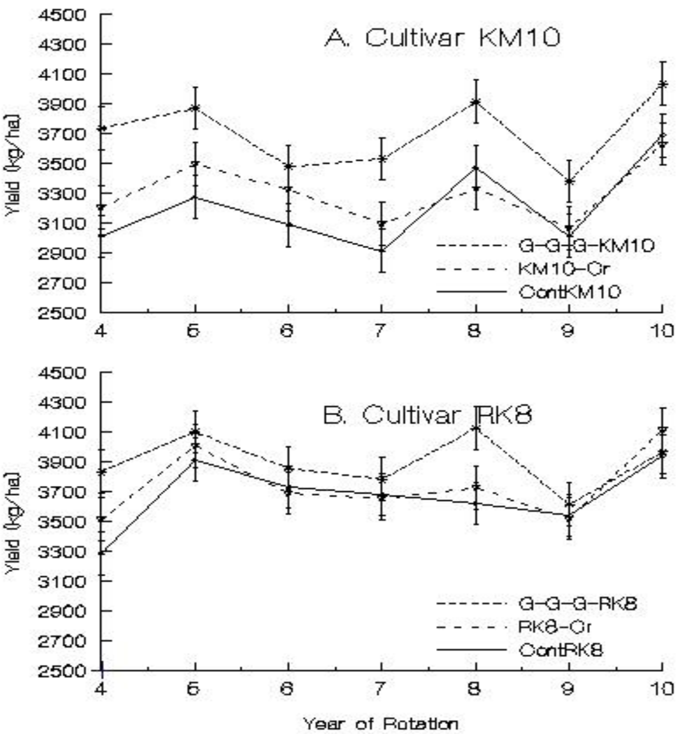


Figure 2: Yield responses to various cropping sequences. Bars are SED.
[ContiKM10 = root-knot-susceptible tobacco cv. KM10 grown continuously; ContRK8 = root-knot-resistant tobacco cv. RK8 grown continuously; G-G-G-KM10 = grass-grass-grass-KM10; G-G-G-RK8 = grass-garss-grass-RK8; KM10-Cr = KM10-*Crotalaria juncea* and RK8-Cr = RK8-*Crotalaria juncea*]

References

Brodie, B. B. and Dukes, P. D. (1972) "The relationship between tobacco yield and time of infection with Meloidogyne javanica", *J Nematol.* Vol. 4(2), pp. 80-83.

Batten, C. K. and Powell, N. T. (1971) "Rhizoctonia-Meloidogyne disease complex in flue-cured tobacco", *J. Nematol*. Vol. 3, pp. 164-9.

Chen, S., Porter, D. M., Reese, C. D. and Stienstra, W. C. (2001) "Crop sequence effects on soybean cyst nematode and soybean and corn yields", *Crop Sci.* Vol. 41, pp. 1843-1849 http://dx.doi.org/10.2135/cropsci2001.1843

Clayton, E. E., Graham, T. W., Todd, F. A., Gaines, J. G. and Clark, F. A. (1958) "Resistance to the root-knot disease of tobacco", *Tob. Sci.* Vol. 2, pp. 53-63.

Cole, D. L. and Cole, T. S. (1978) "Field control of sore shin (Rhizoctonia solani) of tobacco with benomyl and benodanil", *Ann. Appl. Biol.* Vol. 90, pp. 187-193. http://dx.doi.org/10.1111/j.1744-7348.1978.tb02626.x

Cole, J. S. and Zvenyika, Z. (1982) "A stem and root rot of tobacco transplants in Zimbabwe caused by Rhizoctonia solani Kuhn and Fusarium solani (Mart.) SACC", *Zimbabwe J. Agric. Res.* Vol. 20, pp. 149-152.

Cole, J. S. and Zvenyika, Z. (1988) "Integrated control of Rhizoctonia solani and Fusarium solani in tobacco transplants with Trichoderma harzianum and tridimenol", *Plant Pathol.* Vol. 37, pp. 271-277. http://dx.doi.org/10.1111/j.1365-3059.1988.tb02073.x

Daulton, R.A.C. and Nusbaum, C. J. (1961) "Effect of soil temperature on the survival of root knot nematodes Meloidogyne javanica and Meloidogyne hapla", *Nematologica* Vol. 6, pp. 280-294. http://dx.doi.org/10.1163/187529261X00144

Desaeger, J. and Rao, M. R. (1999) "The root-knot nematode (Meloidogyne spp.) problem in Sesbania and scope for managing it in Western Kenya", *Agrofor. Syst.* Vol. 47, pp. 273-288. http://dx.doi.org/10.1023/A:1006288018137

Desaeger, J. and Rao, M. R. (2001) "The potential of mixed covers of Sesbania, Tephrosia and Crotalaria to minimise nematode problems on subsequent crops", *Field Crops Res.* Vol. 70, pp. 111-128. http://dx.doi.org/10.1016/S0378-4290(01)00127-7

Hiranslalee A., Barker, K. R. and Beute M. K. (1995) "Effects of peanut – tobacco rotations on population dynamics of Meloidogyne arenaria in mixed race populations", *J. Nematol*. Vol. 27(2), pp. 178-188.

Howard, D. D., Chambers, A. Y. and Lessman, G. M. (1998) "Rotation and fertilization effects on corn and soybean yields and soybean cyst nematode populations in a no-tillage system", *Agron. J.* Vol. 90, pp. 518-522. http://dx.doi.org/10.2134/agronj1998.00021962009000040013x

Izuogu, N. B., Egberongbe O. L. and Oyedunmade E. E. A. (2012) "Evaluation of Nematode Pests and Fungal Diseases of *Ceratotheca Sesamoides* in Ilorin", *Asian Journal of Agriculture and Rural Development*, Vol. 2, No. 1, pp. 103-106.

Koenning, S. R., C. Overstreet, J. W. Noling, P. A. Donald, J. O. Becker, and B. A. Fortnum (1999) "Survey of crop losses in response to phytoparasitic nematodes in the United States for 1994", Supplement to the *Journal of Nematology*, Vol. 31, pp. 587–618.

Mazarura, U. and Chisango, C. (2012) "Effect of long term cropping systems on soil chemical properties", *Asian Journal of Agriculture and Rural Development***,** Volume 2(4) (in press)

Nusbaum C. J. and Ferris, H. (1973) "The role of cropping systems in nematode population management", *Annu. Rev. Phytopathol.* Vol. 13, pp. 423-440. http://dx.doi.org/10.1146/annurev.py.11.090173.002231

Pen-Mouratov, S., Rakhimbaev, M., Barness, G. and Steinberger, Y. (2004) "Spatial and temporal dynamics of nematode populations under Zygophyllum dumosum in arid environments", *Eur. J. Soil. Biol.* Vol. 40, pp. 31–46. http://dx.doi.org/10.1016/j.ejsobi.2004.01.002

Powell, N. T., Melendez, D. L. and Batten, C. K. (1971) "Disease complexes in tobacco involving Meloidogyne incognita and certain soil-borne fungi", *Phytopathol.* Vol. 6, pp. 1332-1337. http://dx.doi.org/10.1094/Phyto-61-1332

Robinson, A. F. and Cook, C. G. (2001) "Root-knot and reniform nematode reproduction on kenaf and sunn hemp compared with that on nematode resistant and susceptible cotton", *Industrial Crops and Products*, Vol. 13, pp. 249–264 http://dx.doi.org/10.1016/S0926-6690(00)00082-0

Rotar, P. P. and Joy R. J. (1983) "Tropic Sun", sunn hemp; Crotalaria juncea L. Honolulu (HI): University of Hawaii. 7 p. (Research Extension Series; RES-36).

Schmitt, D. P. (1991) "Management of Hererodera glycines by cropping and cultural practices", *J. Nematol*. Vol. 23, pp. 348-352.

Schweppenhauser, M. A. (1975) "Sources of Nicotiana tabaccum resistance to Meloidogyne javanica", *Tob. Int*. Vol. 177, pp. 40-42.

Shew, H. D. and Main, C. E. (1985) "Rhizoctonia leaf spot of flue-cured tobacco in North Carolina", *Plant Dis*. Vol. 69, pp. 901-916.http://dx.doi.org/10.1094/PD-69-901

Soo Shin H., (2005) "Effect of irrigation systems, partial root zone drying irrigation and regulated deficit, on plant parasitic nematode populations in grapevine", Master thesis, University of Western Australia, Australia.

Wang, K., McSorley, R., Gallaher, R. and Kokalis-Burelle, N. (2008) "Cover crops and organic mulches for nematode, weed and plant health management", *Nematology*, Vol. 10(2), pp. 231-242. http://dx.doi.org/10.1163/156854108783476412

Wang, K., Sipes, B. S., Hooks, C. R. R. and Leary, J. (2011) "Improving the Status of Sunn hemp as a Cover Crop for Soil Health and Pest Management", http://www.ctahr.hawaii.edu/sustainag/news/articles/V8-Wang-sunnhemp.pdf. Accessed on 3 September, 2012.