Efficacy of Garlic *(Allium sativum*) and Red Chilli Pepper (*Capsicum annum)* Extracts in the Control of Red Spider Mite *(Tetranychus urticae)* in Tomatoes *(Lycopersicon esculentum)*

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ABSTRACT--- ***A trial to assess the efficacy of extracts from garlic (Allium sativum) and red chilli (Capsicum frutescens) as natural pesticides in the control of red spider mite (Tetranychus evansi) on tomatoes was conducted in Buhera District, Zimbabwe between 2013 and 2014.The experiment was laid out in a Randomised Complete Block Design with three replicates and five treatments as follows; 1. Red chilli, 2. Garlic, 3. Red chilli + Garlic (in the ratio 1:1), 4. Control (no treatment) and 5. Dimethoate 40% ec. The treatments were applied two weeks after red spider infestation and fortnightly until harvesting. Significant differences (P<0.001) were observed with respect to plant height, red spider mite infestation, webbing and total yield of tomato fruits. At 12 weeks after planting dimethoate had the highest plant height of 55.4 cm followed by red chilli with 47.6 cm.The dimethoate treatment had the highest yield of 88.5 tonnes per hectare followed by a combination of red chilli and garlic with 85.2tonnes per hectare and no yield was recorded in the control treatment. The experiment showed that extracts of red chilli and garlic have potential to control red spider mite (Tetranychus evansi) in tomato production.***

Keywords--- Tetranychus evansi, tomato, Allium sativum, Capsicum frutescens, efficacy

1. INTRODUCTION

Tomato *(Lycopersicon esculentum)* is a subtropical plant belonging to the Solanaceae family and is one of the most widely grown vegetable in the world (Abdussamee *et al*, 2014; Mehraj *et al*., 2014; Kaur *et al*., 2014). It is the second most important vegetable crop after rape and cabbage in Zimbabwe (Jackson, 1994). It is an important source of nutrients such as vitamins A, C, E and constitutes an important part of the house hold diet and national economy (Idah *et al*, 2010; Bhowmik *et al*, 2012; Kaur *et al*., 2014).

Pest and disease particularly the red spider mite are among the major constraints in tomato production in the smallholder farming sector (Nyirenda *et al*, 2011; Sigei *et al*., 2014). The red spider mite *(Tetranychus evansi)* originated in South America (Gutierrez and Etienne, 1986; Boubou *et al*, 2011; Navajas *et al*, 2013) but is now one of the main tomato pests in Eastern and Southern Africa (Blair, 1983; Seif, 2003; Toroitich *et al*, 2014). This pest has become one of the most severe dry season pests of Solanaceae in Africa with estimated, crop losses of up to 90% in South East Africa (Knapp, 2000; Sibanda *et al*, 2000).

The rapid expansion of the red spider mite represent a threat to agriculture in many countries especially Zimbabwe where climatic conditions are conducive for its multiplication. In an attempt to model the potential distribution of the invasive tomato red spider mite, Migeon, *et al* (2009) found all of Sub Saharan Africa to be suitable for the red spider mite with the exception of the Namibian desert which is too dry and the Guinean coast which is too wet.

The control of the red spider mite in tomato production is a challenge because pesticides do not entirely solve the problem. Excessive use of insecticides has led to some species of pests developing resistance (Herron *et al*, 1998). About 450 pest species of insects and mites have now developed resistance to one or more major synthetic pesticides due indiscriminate use of insecticides which also can destroy natural enemies as well as other organisms within the ecosystem (Georghiou, 1986). Insecticides also contaminate the environment and pose a health hazard to humans. Dimethoate 40% EC, malathion 50% EC, and thiometon among others are traditionally used to control the red spider mite yet dimethoate is very toxic to humans and the environment (Forget, 1993). It has possible links to cancer and is suspected of causing birth defects in humans and animals (World Health Organisation, 1990).

The future of synthetic insecticides is threatened by a shift in farming practices from inorganic to organic. Consumer preference has also shifted from vegetables grown with chemicals to those grown naturally (Machakaire and Magumise 2005). Various organic substances that have insecticidal effects have been identified. Natural pesticides such as neem, marigold, garlic, and chilli pepper are effective in controlling soft bodied pests such as the red spider mite and aphids (Rusch, *et al*, 2010). Thus this research seeks to evaluate the pesticidal potential of garlic and red chilli pepper against red spider mite on tomato.

2. MATERIALS AND METHODS

Experimental site

This research was carried in Buhera District, located in Natural Region IV of Zimbabwe. The site has a grid reference of 19º19'S and 31º26'E and an altitude of 908m above sea level. The annual rainfall of this area ranges from 600 to 800 mm and is characterized by mid-season dry spells with summer temperatures ranging between 30 and 40^{o}C and winter temperatures between 6 and 25^{o}C (Nyamapfene, 1991).

Experimental design and treatments

The experiment was laid out as a randomized complete block design with 3 replicates and 5 treatments. The treatments evaluated were: 1. Red chilli, 2. Garlic, 3. Red chilli + Garlic (in the ratio 1:1), 4. Control (no treatment) and 5. Dimethoate 40% ec.

Experimental procedure

Clay loam soil from the same area was used to fill the planting pots. A determinate medium to late tomato cultivar Rodade was used for the experiment. Transplanting was carried out six weeks after sowing and infestation of tomato plants with red spider mite was carried out two weeks after transplanting. Infestation was carried out by placing already infested tomato seedlings in each of the 25 plots next to the healthy tomato plants and were removed after one week.

Red chilli and garlic extraction and application

100g fresh red chillies were ground and mixed with 2 litres of warm water and 5ml of vegetable oil for 24 hours. The oil was added to enhance the solubility of capsaicin (Reddy and Sasikala, 2013). Water was then added to make a total volume of 4 litres. This mixture was filtered and 30ml of dish washing liquid was added as a sticking agent. The mixture was strained using a fine cloth.

500g of concentrated cloves of garlic was crushed and soaked for 24 hours in 5 litres of water. The mixture was then filtered and 30ml of dish washing liquid and 5ml of vegetable oil were added to the garlic mixture. The mixture was strained using a fine cloth. Garlic and red chilli extracts were mixed in the ratio 1:1 during preparation for the red chilli plus garlic treatment. Application of insecticides started two weeks after red spider mite infestation and every 2 weeks thereafter until harvesting.

Data collection

Plant height was recorded 2 weeks after transplanting and every 2 weeks thereafter until harvesting. Level of infestation by red spider mite on leaves was assessed by randomly selecting three leaves from each plot. The leaves were selected from the bottom, middle and terminal end of the plant (Muzemu *et al*, 2011) and each leaf's level of infestation was assessed using the following rating score: 0% - no red spider mites, 1% - 10% - low intensity of red spider mites, 10% - 50% - medium intensity of red spider mite, 50% -100% - extreme intensity of red spider mite. A hand lens of magnification ×10 was used to identify the red spider mites. Level of webbing on leaves was assessed using three randomly selected leaves from each plot and estimated using a rating score as follows; 0%, 20%, 40%, 60%, 80% and 100% of leaf coverage. Fruits were harvested and graded into marketable and non-marketable according to Moran (1992).

Data analysis

Analysis of variance was carried out using Genstat version 12 and the least significant differences at 0.05 probability level was used to separate means.

3. RESULTS AND DISCUSSION

Plant height

Significant differences (P<0.001) among the treatments were observed with respect to plant height. From week 4 up to week 12, dimethoate had the highest plant height (55.4cm) followed by red chilli (49.2cm), a comination of red chilli and garlic (44.4) and the control had the lowest plant height (15.4cm) (Figure 1).
The results on plant height showed that lack of insecticidal treatment results in reduced growth. This is because mites indirectly damage tomatoes by feeding on foliage, reducing the rate of photosynthesis and causing stunted growth (Weidhaas, 1979; Ferragut *et al*, 2013). Red chilli was effective in controlling red spider mites. Red chilli contains an active ingredient capsaicin (8-methyl-N-vanillyl-6-nonemide) which acts as a mite feeding depressant and repellent (Copping, 2001; Neumann, 2001). The treatment containing garlic and red chilli also proved to be effective in maintaining growth rate in terms of plant height. Hosh and Halidh (1997) showed that the essential oil in garlic diallyl disulphide has insecticidal properties that are effective against many pests including the red spider mite.

Garlic as a treatment on its own was not as effective as the combination of red chilli pepper and garlic in terms of consistent plant height. These results suggest that although garlic contains insecticidal properties (Kazem and El-Shereif, 2010; Ranjbar-Bahadori *et al*, 2014) it alone might not be able to suppress the persistent effects of the red spider mite on the tomato plants especially in the conducive environmental conditions. Kazem and El-Shereif, (2010) also noted that the combination of red chilli pepper and garlic is more effective in controlling pests than garlic on its own. Dimethoate was able to maintain growth rate although its repeated use results in development of pesticide resistance (WHO, 1990).

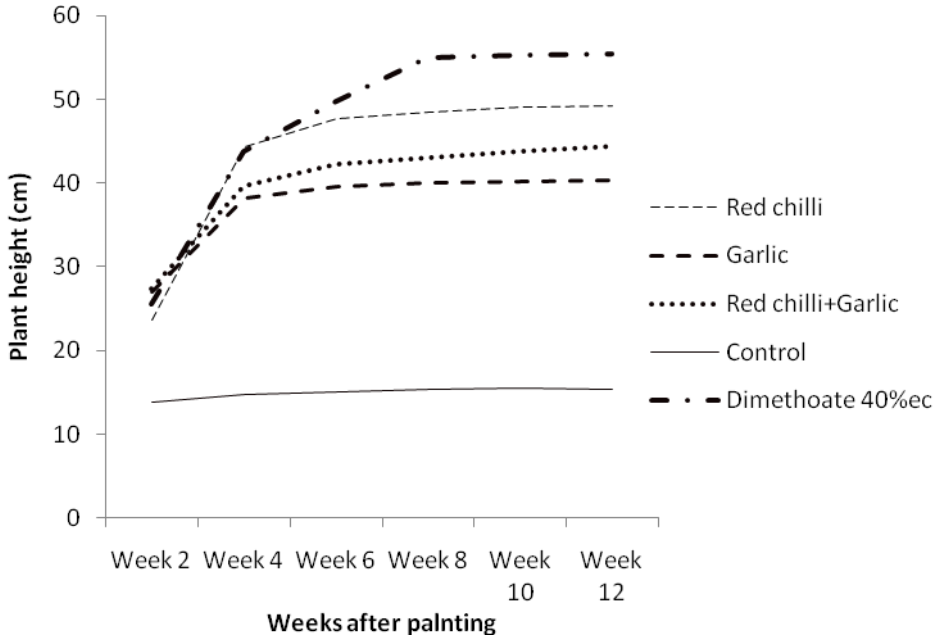

Fig: 4.1 Average Plant height in relation to treatment used over a 12 week period

Red spider mite infestation

There were significant differences among the treatments ((P<0.001) in red spider infestation. All treatment with the exception of the control maintained spider mite infestation below 40%. There where no significant differences (P>0.05) among the natural treatments and Dimethoate during the 12 week growth period (Figure 2). Control had the highest infestation of 100% by the week 12 followed by garlic (27%), the combination of red chilli and garlic (22.3%), red chilli (18.3%) and dimethoate (9%).

Red chilli and the combination of garlic and red chilli were as effective as dimethoate 40% EC in suppressing mite infestation over the 12 week period. Efficacy of the natural treatments were due to their insecticidal properties (Kazem and El-Shereif, 2010; Ranjbar-Bahadori *et al*, 2014). Pahla *et al*., (2014) also found a combination of garlic and chilli to be effective in suppressing pests. This could be due to the repellent and insecticidal properties of both red chilli and garlic. The pungency of garlic could have deterred the red spider mites from feeding (Dobson *et al*., 2002)

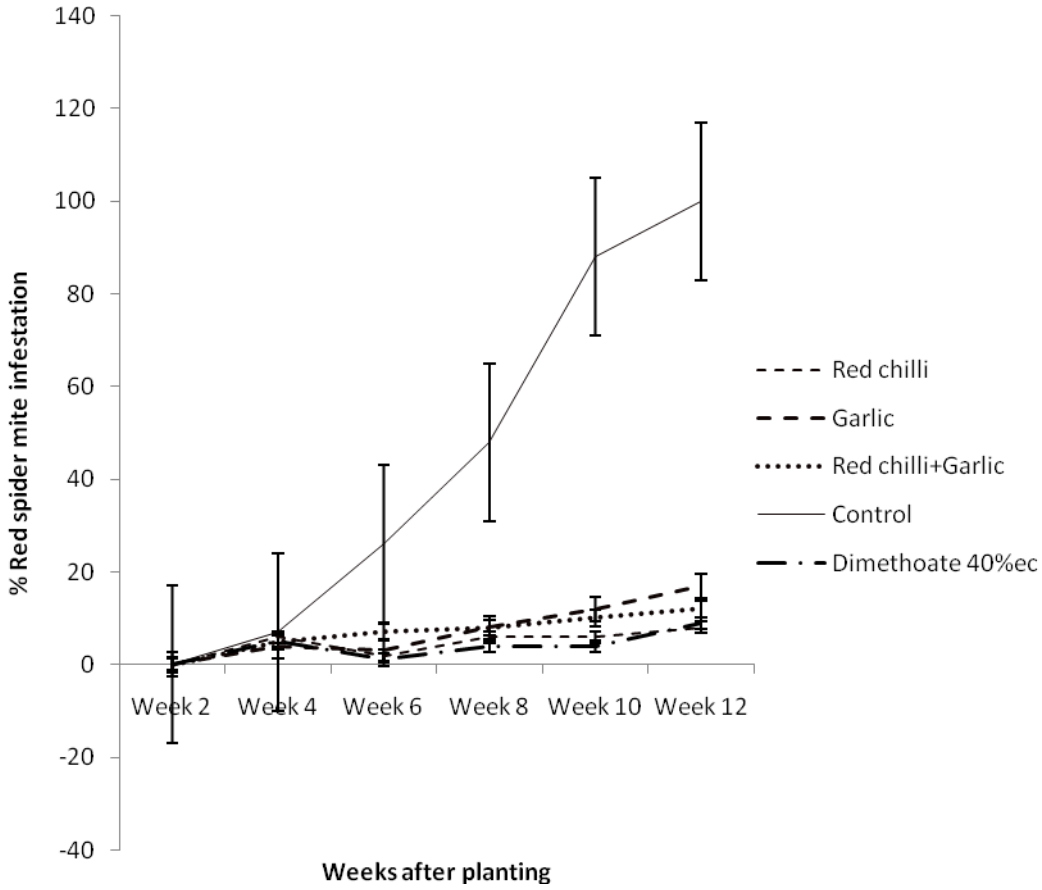

Figure 2: Average red spider mite infestation in relation to treatment used over a 12 week period

Level of webbing

There were significant differences among the treatments used in relation to webbing of plants (P<0.001%). Dimethoate and the natural treatments suppressed the level of webbing by the red spider mite. The control had the highest percent webbing of 95.6%, followed by garlic (17%), red chilli plus garlic (14.3%), red chilli (14%) and dimethoate with 2.3% webbing. The control treatment recorded a high red spider mite infestation which resulted in high level of webbing. The high webbing percentage provided the female mites with a place to lay eggs (Hatch, 2005). Dense webbing also hinders photosynthesis and enhances accumulation of dust. Tomato fruit produced becomes reddish and produces gum-like exudates, shrivels, and may split causing a great reduction in market value. Partial or total yield losses may result from heavy mite infestations (Tselila *et al*, 2013).

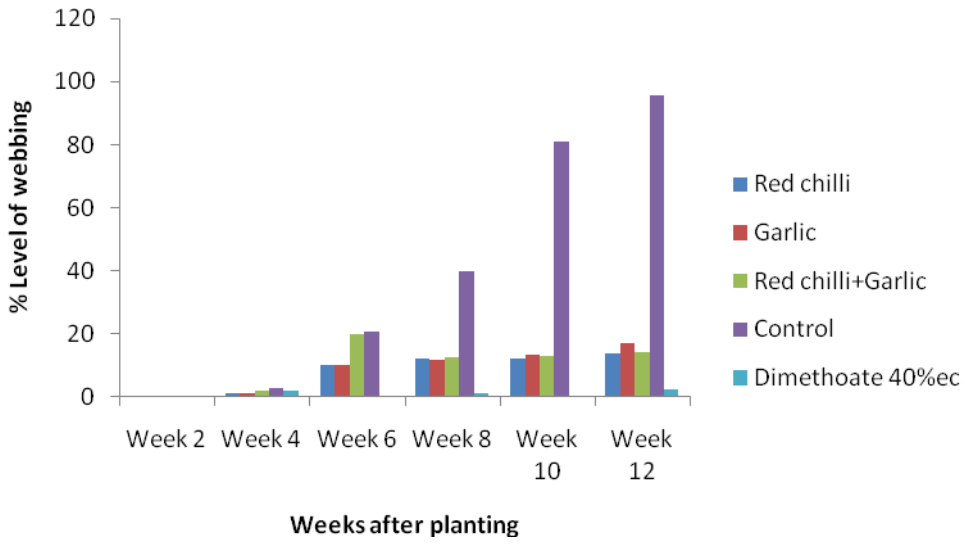

Figure: 3 Average level of webbing in relation to treatment used

Total yield of tomato fruit

The results showed a significant treatment effect on the total yield of tomato fruit. The mean yields were; Dimethoate 40% EC (39.0t/ha), red chilli pepper (27.4t/ha); red chilli pepper+ garlic (28.2t/ha), garlic (13.7t/ha) and control (1.9t/ha). The low yields resulted from red spider mite infestation because the mites reduced photosynthesis, flowering and fruiting (Weidhaas, 1979; Ferragut et al., (2013). Natural pestcides were effective in controlling red spider mites. Garlic however recorded low yields compared to the other treatments apart from the control. The low concentration of garlic spray used in this experiment could have failed to control the mites.

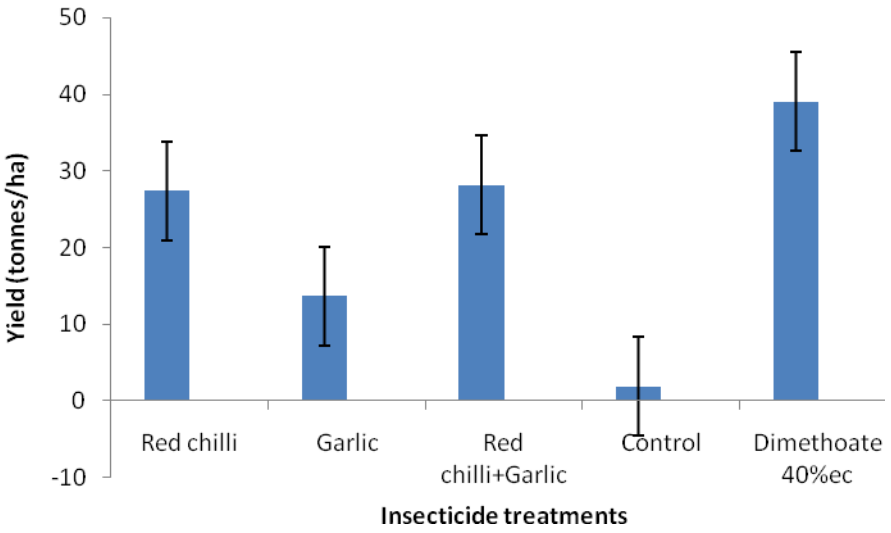

Figure 4 Total tomato fruit yield

4. MARKETABLE FRUIT YIELD

A significant difference (P<0.001) was also noted on the percentage of marketable fruit yield. Dimethoate recorded a highest marketable yield of 88.5% a followed by a combination of red chilli and garlic (85.2%) and no marketable yield was recorded on the unsprayed treatment (Figure 5). Red spider mite feeding on plants result in reduced rate of photosynthesis, an increase in leaf transpiration, premature loss of leaves resulting in reduced plant vigour, fruit size, fruit quality and yield (Moran, 1992; Kovach and Gorsuch, 1985).

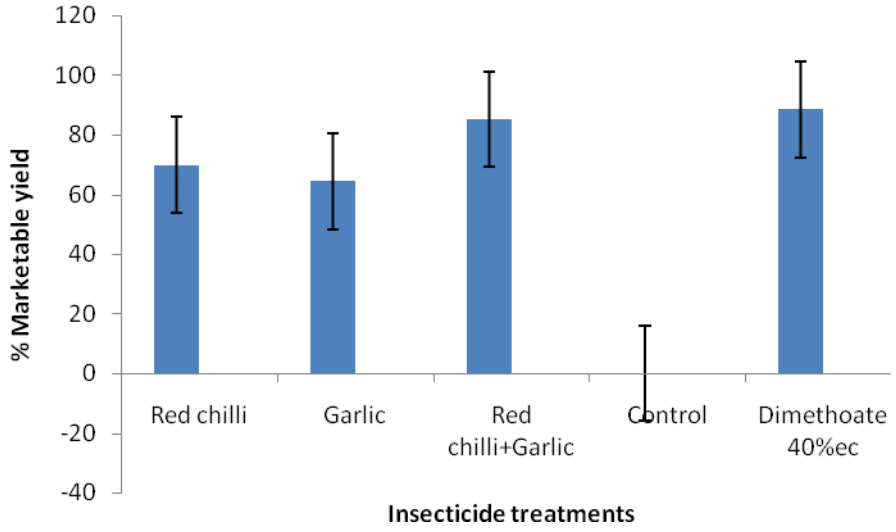

Figure 5: Average total marketable tomato fruit yield in relation to treatments used

5. CONCLUSION

Red chilli and garlic were effective in supressing red spider mites resulting in increased growth, low infestation and webbing and high marketable yield of tomatoes.

6. REFERENCES

- Abdussamee. H., Hussain.M., AliM., Siddique.M.S., Jatoi, S.U.K., Shahbaz Talib Sahi.S.T and Hannan.A (2014), Genetic response of tomato germplasm against early blight and its management through fungicides**,** *App. Sci. Report*, 2 (3), pp 119-127.
- Bhowmik.D., K.P. Sampath Kumar.K.P., Paswan.S., Srivastava. S, (2012), Tomato-A Natural Medicine and Its Health Benefits, *Journal of Pharmacognosy and Phytochemistry*, Vol. 1 No. 1, pp 33-43.
- Blair, B.W, (1983), Tetranychus evansi Baker & Pritchard (Acari: Tetranychidae). a new pest of tobacco in Zimbabwe. Bergerac, France: CORESTA Phytopathol and Agron Study Group pp 1-6.
- Boubou , A., Migeon, A., Roderick, G.K., Navajas, M (2011), Recent emergence and worldwide spread of the red tomato spider mite, *Tetranychus evansi*: genetic variation and multiple cryptic invasions. Recent emergence and multiple cryptic invasions of *Tetranychus evansi*, Biol Invasions, Vol 13, pp 81–92.
- Copping, L.G., (2001). The BioPesticide Mannual, 2nd edition. British Crop Protection Council: Farnham, UK pp.171-172
- Dobson, H., Cooper, J., Karuma, J. and Chiimba, W., (2002). Vegetable pest management. Natural Resources Institutte. University of Greenwich, Chatham, Maritime, Kent 4.4TB
- Ferragut, F., Navia., D and Ochoa, R. (2013). New mite invasions in citrus in the early years of the 21st century. Exp Appl Acarol Vol.59 pp.145–164
- Forget G. (1993) Balancing the need for pesticides with the risk to human health. In: Forget G,Goodman T, de Villiers A, editors. Impact of Pesticide Use on Health in Developing Countries. IDRC, Ottawa: 2.
- Georghiou, G. P. (1986). The magnitude of the resistance problem, pp. 14-43 In: National Academy of Sciences [ed.], Pesticide resistance: strategies and tactics for management. National Academy of Sciences, Washington, D.C
- Gutierrez J, and Etienne J (1986) *Les Tetranychidae de l'ile de la Reunion et quelques- uns de leur predateurs*. Agronamie Trop 41 : 84-91
- Hatch J, (2005) *How to get rid of spider mites,* Saint Paul Media
- Herron G.A., Edge V.E., Wilson L.J. and Rophail J. (1998), Organophosphate resistance in spider mites (Acari: Tetranychidae) from cotton in Australia. Exp. Appl. Acarol. 22: 17–30.
- Hosh, M and Halidh, T (1997) Repellency of some plant extracts to stored products: beetles, Asian Regional Centre for Tropical Biology.

- Idah.P.A., Musa.J.J and Abdullahi.M, (2010), Effects of Storage Period on Some Nutritional Properties of Orange and Tomato, *AU J.T.*13 (3), pp 181-185.
- Jackson, J.E (1994) *Vegetable crop production in Communal areas in Mashonaland.* In: Jackson J. E, Turner A. D and Matanda M. E, Smallholder horticulture in Zimbabwe, University of Zimbabwe Publications Pp 115-120
- Kaur H, Kaur H, Rishi P. (2014).Nematicidal effect of neem and Bt on *Meloidogyne incognita* infesting tomato plant by seed dressing treatment. *Discovery Agriculture, Vol 2(6), pp.*28-40
- Kazem, M.G.T and El-Shereif, S. A.E.H.N. (2010). Toxic Effect of Capsicum and Garlic Xylene Extracts in Toxicity of Boiled Linseed Oil Formulations against Some Piercing Sucking Cotton Pests. American-Eurasian J. Agric. & Environ. Sci., 8 (4): pp. 390-396
- Knapp, M (2000*) Important mite crop pest in Africa. XI international Congress of Acarology*, Merida, Mexico
- Korvach, J. and Gorsuch, C.S., (1985). Effect of Tetranychus urticae populations on peach production in South Carolina. Journal of Agricultural Entomology Vol. 2(1) pp46-51
- Machakaire, V and Magumise, I (2005*) Integrated pest management: Cost Saving techniques for smallerholder farmers CDT*, Harare, Zimbabwe.
- Mehraj, H., Mutahera,S., Roni, M.Z.K., Nahiyan, A.S.M., and Jamal Uddin, A.F.M.(2014) Performance Assessment of Twenty Tomato Cultivar for Summer Cultivation in Bangladesh. J. Sci. Tech. Env. Info. Vol. 01(01) pp.45-53
- Migeon A, Ferragut F, Escudero-Colomar L, Fiaboe K, Knapp M, de Moraes G, Ueckermann E, Navajas M (2009) Modelling the potential distribution of the invasive tomato red spider mite, *Tetranychus evansi* (Acari: Tetranychidae). Exp Appl Acarol Vol 48, pp 199–212.
- Moran F. T, (1992) *Success in vegetable and fruit production*, Longman Zimbabwe
- Muzemu, S., Mvumi, B.M., Nyirenda S.M., Sileshi, G.W., Sola, P., Chikukura, L., Kamanula, J.F., Belmain, S.R. and Stevenson, P.C., (2011). Pesticidal effects of indigenous plant extracts against rape aphids and tomato red spider mites. African Crop Science Proceedings, Vol. 10 pp. 171-173.
- Navajas, M., de Mores,G.J., Auger,P., and Migeon, P, (2013) Review of the invasion of *Tetranychus evansi*: biology, colonization pathways, potential expansion and prospects for biological control. *Experimental and Applied Acarology Vol* 59, pp 43-59.
- Neumann, R. H (2001) *Capsicum based pesticides and methods use* PatentGenius.Com
- Nyamapfeni K (1991) Soils of Zimbabwe Nehanda Publishers
- Nyirenda, S.P, Sileshi, G. W., Belmain, S.R., Kamanula, J. F., Mvimi, B.M., Sola, P., Nyirenda, J. K. C. and Stevenson, P.C., 2011. Farmers' etho-ecological knowledge of vegetable pests and their management using pesticidal plants in Northern Malawi and Eastern Zambia. African Journal of Agricultural Research Vol 6:1525-1537
- Pahla, I., Moyo, M., Muzemu, S. and Muziri, T. (2014). Evaluating the effectiveness of botanical sprays in controlling aphids (Brevicoryne brassicae) on rape (Brassica napus L.). International Journal of Agronomy and Agricultural Research Vol. 5 (1) pp1-6.
- Ranjbar-Bahadori, Sh., Farhadifar, N and Mohammadyar, L.(2014) Assessment of Susceptibility of the Poultry Red Mite, *Dermanyssus gallinae* (Acari: Dermanyssidae) to Some Plant Preparations with Focus on Exposure Time World Academy of Science, Engineering and Technology International Journal of Biological, Veterinary, Agricultural and Food Engineering Vol:8 No(6).pp.561- 564.
- Reddy, M. V. B. and Sasikala, P., (2013). Capsaicin and colour extraction from different varieties of green and red chilli peppers of Andhrapradesh. International Journal of Advanced Scientific and Technical Research Vol 2 pp554-572
- Rusch, A., Valantin-Morison, M., Sarthou, J., and Roger-Estrade J., (2010) Biological Control of Insect Pests in Agroecosystems: Effects of Crop Management, Farming Systems, and Semi-natural Habitats at the Landscape Scale: A Review, Advances in Agronomy Vol. 109: 219-248
- Seif, A. A Valera ,A. M and Nyambo, B (2003) *Tomato pests and diseases in Somalia and their control* edited by Harberd a, J. Integrated Pest Management Project in Somalia. UNA.IPM Project
- Sibanda, T, Dobson H. M, Cooper J. F, Manyangarirwa W, Chimba W (2000) *Pest management challenges for smaller vegetable farmers in Zimbabwe*. Crop Prot 19: 807-815.Doi:10. 1016/S0261-2194(00)00108-3
- Sigei K.G., Ngeno K. H., Kibe, M. A., Mwangi, M and Mutai C. M. (2014). Challenges and Strategies to Improve Tomato Competitiveness along the Tomato Value Chain in Kenya International Journal of Business and Management Vol. 9, No. 9; 2014
- Toroitich, F.J., Knapp, M., Nderitu, J.H., Olubayo, F.M and Obonyo, M, (2014), Susceptibility of geographically isolated populations of the Tomato red spider mite (*Tetranychus evansi* Baker & Pritchard)

to commonly used acaricides on tomato crops in Kenya, Journal of Entomological and Acarological Research, Vol 46: 1469 pp 18-23

- Tselila,B.D., Ueckermann, E.A and Uri, G.(2013). An annotated list of spider mites (Acari: Prostigmata: etranychidae) of Israel.Israel Journal of Entomology Vol 43. Pp. 125- 148.
- World Health Organization (1990) Public health impact of pesticides used in Agriculture, Geneva, Switzerland
- Weidas, T.A. (1979). Spider mites and other Acarina on trees and shrubs.Journal of Arboriculture. Vol 5(1) pp 9-15.