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EFFECTIVENESS OF NATURAL HERBS, FEVER TEA (*Lippia javanica)* AND MEXICAN MARIGOLD (*Tagetes minuta)* AS SUBSTITUTES TO SYNTHETIC PESTICIDES IN CONTROLLING APHID SPECIES (*Brevicoryne brassica*) ON CABBAGE (*Brassica capitata).*

[EFECTIVIDAD DE *Lippia javanica* Y *Tagetes minuta* COMO SUBSTITUTOS DE PESTICIDAS SINTETICOS PARA EL CONTROL DE AFIDOS (*Brevicoryne brassica*) DE EL REPOLLO (*Brassica capitata*)]

C.A.T. Katsvanga[1*] and S. Chigwaza[2]
[1]*Department of Environmental Sciences*
E-mail: ckatsvanga@yahoo.co.uk
[2]*Department of Biological Sciences*
Bindura University of Science Education
P. Bag 1020 Bindura, Zimbabwe.
***** *Corresponding Author*

SUMMARY

Effectiveness of *Lippia javanica* and *Tagetes minuta* as natural pesticides was assessed in terms of how much they reduce aphid populations on *Brassica capitata*. Their effectiveness was compared against two synthetic pesticides, Aphid kill and Bexadust "L". The powdered forms of both herbs, the 1:1 and 1:2 dilutions of *T. minuta* and the 1:2 dilution of *L. javanica* did not reduce aphid populations. The 1:1 dilution of *L. javanica* reduced aphid populations by 24.65%, the standard solution (extract of 1kg herb in 1L water) of *T. minuta* by 8.75% and *L. javanica* by 53.16%. Aphid kill and Bexadust "L" reduced the aphid numbers by 78.32% and 96.68% respectively. It was concluded that *L. javanica* standard solution was fairly effective in controlling aphids on cabbages, though it did not match synthetic pesticides.

Key words: Natural herb, Effective herb/pesticide, Standard Solution, Synthetic pesticides, Powdered herb

RESUMEN

Se evaluó la efectividad de *Lippia javanica* y *Tagetes minuta* como pesticidas naturales en cuanto a su capacidad para reducir la población de afidos en *Brassica capitata*. La efectividad se compare contra dos pesticides sintéticos, "Aphid kill" y "Bexadust L". El polvo, la dilución 1:1 y 1:2 de *T. minuta* y la dilución 1:2 de *L. javanica* no redujerón la población de afidos. La dilución 1:1 de *L. javanica* redujó la población en un 24.65%. Se encontró reducción de afidos con la solución estándar (extracto de 1kg planta en 1L de agua) de *T. minuta* (8.75%) y *L. javanica* (53.16%). "Aphid kill" y "Bexadust L" redujeron los afidos en un 78.32% y 96.68% respectivamente. Se concluyó que la solución estándar de *L. javanica* tuvo cierta efectividad en el control de los afidos pero no en un nivel similar al de los pesticidas sinteticos.

Palabras clave: Plantas pesticidas, pesticides sintéticos, afidos.

INTRODUCTION

One of the most common vegetable varieties grown both on commercial and subsistence basis in Zimbabwe is *Brassica capitata*, commonly known as cabbage. It is an important source of vitamin A, thiamine and ascorbic acid as well as plant protein, (Gulmour, 1983). It is however prone to pests, especially worms and aphids. There are various species of aphids that attack different crops e.g. *Brevicoryne brassica* on vegetables, *Mysus persicae* on potatoes and *Aphis gossypii* on cotton. Many species of aphids have complex life histories, some have single hosts and asexual reproduction, and others have single hosts and asexual alternating with sexual reproduction. The third groups which includes *B. brassicae* has alternating hosts and alternating asexual and sexual reproduction. In all the three groups, a complete cycle may take only 10 to 14 days (Smith and Kubo, 2001). Aphids suck sap from the plant and if in large numbers, remove sufficient sap to kill the leaves and growing tips. Affected leaves wrap or curl inwards around the clusters of aphids, (Roberts and Small, 1983, Dube et al, 1999). Aphids have been found to be vectors of viral diseases for example, the Cotton Mosaic Virus (CMV), and they produce honeydew, which attracts a large number of pests like ants and fruit flies, that in turn spread young aphids (Gulmour, 1983).

Commercial growers use synthetic organic pesticides like Malathion, Diazinon and Dimethoate (Allcock and Leece, 1980), to control these aphids but small-scale growers and peasant farmers, faced with limited access to financial resources cannot afford them. A survey in Zimbabwe in 1994 showed that the number of small-

scale farmers who used natural pesticides in addition to chemicals changed from 20% before 1989 to 80%. In Botswana the cost of one litre of a common pesticide is US$80 and no one can afford this (Berger, 1994).

However, besides the cost factor, synthetic organic chemicals have proved not to be the absolute solution to pest problems (Shwab et al 1985, Berger, 1994). They agreeably have a high knockdown effect on pest organisms but concern about the long-term consequences of using synthetic pesticides has arisen for several ecological reasons. These include destruction of predators that control pests or pollinators of fruit trees, resistance development and pesticide residue biomagnification in humans and wildlife, (Georghiou 1986, Clegg and Mackean, 1994).

Epidemiological data show that workers who handle synthetic organic pesticides more than twenty days a year have an increased risk of developing certain types of cancer, (Dahama, 2001). Significant inhibition of plasma and red blood cells cholinesterase activity has also been recorded in workers exposed to an average of 0,7mg/m^3 of pesticides, (Nhachi and Kasilo, 1996).

The annual amount of synthetic pesticides applied worldwide is reported at 5,000,000 tons. The yearly consumption of pesticides in developing countries was estimated at 600 000 tonnes in 1988 with a drastic increase of 184% during 1980 to 1984 in Africa alone (WHO, 1990). This according to Schwab *et al* (1995) does not only cause acute poisoning but also sub-acute and sub-chronic damage to human health. Therefore synthetic pesticide use is highly discouraged during the raising of local and export horticultural products (Heri, 2000) as manifested by consumer pressure e.g. the Ethical Trading Initiative (ETI) forcing Zimbabwean growers and exporters to the European Union (EU) to move towards Integrated Pest Management and Biological Control.

The main objectives of this investigation were to establish the effectiveness of *L. javanica* and *T. minuta* in reducing aphid populations on *Brassica capitata* and how they compare with synthetic pesticides through different application modes and dilutions, then finally determine how long the herb remains active after application.

MATERIALS AND METHODS

Study area and Experimental design.

The investigation was carried out at Gutu in the Masvingo Province of Zimbabwe in December when the cabbages are more susceptible to aphid attack. The experiment consisted of 150 cabbage plants divided into 10 treatments in a randomized block design. An isolated garden was used to avoid spread of aphids to other vegetable plants not included in the research. Thirty strip beds each of length 1.5 m were prepared. The distance between any two beds was 1 m and five seedlings of cabbage plants were planted in each bed. The intra- row space was 30 cm. Nitrogen fertilizer was applied at the planting stage and watering was done regularly for 3 weeks until the plants developed at least three fairly big leaves. Wingless female aphids were obtained from abandoned vegetable gardens and each cabbage plant was inoculated with 10 aphids. The aphids were allowed to reproduce over a one-week period.
The bio-pesticides used were *T. minuta* and *L. javanica* and the synthetic organic pesticides, Bexadust L, a powdered chemical, whose active ingredient is Gamma B.H.C- 0,6% and Aphid Kill, a liquid organophosphate pesticide containing Malathion 50% by mass.

One Kg of leaves from *L.javanica* and *T.minuta* were collected for the preparation of powdered herbs. They were dried in shade and ground to powder in a mortar. The liquid herbs were prepared as follows; 1kg of plant leaves (*Lippia* and *Tagetes*) were chopped separately and pounded into a pulp. One litre of water was added and the plant mixture was well stirred. The plant mixture was pressed through a cloth (Nhachi and Kasilo, 1996). This produced a standard solution from which dilutions of 1:1 and 1:2 were prepared. Mixing 1 part standard solution with 1 part water produced the 1:1 dilution and mixing 1 part standard solution with 2 parts of water produced the 1:2 dilutions.

Soap solution was added to each of the three solutions in the ratio 1 herb: 4 soap solution. The soap solution was prepared by diluting 100g of liquid soap in 5 litres of water (or an equivalent ratio). The soap solution here acted as a sticking agent (Nhachi and Kasilo, 1996). The herbs were stored in tightly closed plastic containers in a cupboard because they lose activity if left open, http://herbsforhealth.about.com/cs/pestcontrol and degrade rapidly in sunlight, air and moisture, (Buss and Park-Brown, 2002).

Enumeration of aphids

After the multiplication phase of the aphids (1 week), enumeration of aphids on each plant was done before application of the herbs. Application of the herbs and synthetic pesticides in both liquid and powder was done. The liquid herb was applied as a full cover spray on each plant while the powder was sprinkled until a fair amount of herb dust covered the plant. For the synthetic chemicals, application prescriptions on each label were closely followed. Enumeration of aphids on each plant was done on a daily basis to find out the period over which the herb or chemical remained active. Re-application was done as soon as the number

of aphids recorded began to rise. This was done over 2 weeks. Assessment of the effectiveness of each treatment was by calculating the average percentage decrease or increase of aphids caused by each application for the three trials, (Tables 1 and 2). Effects of these treatments were then measured by physically counting the number of aphids on each plant after treatment.

Statistical analysis

Differences in aphid population reduction and effectiveness of each biocide and synthetic pesticide were analysed using a one-way analysis of variance (ANOVA) in a completely randomized design. ANOVA was used to examine the effect of each biocide on aphids for each dilution and then to assess the differences amongst the range of pesticides and biocides used. Multiple comparisons of means were done using Least Significant Differences (LSD) test.

RESULTS

The findings on the effectiveness of *L. javanica* and *T. minuta* as natural pesticides below show the best form of application i.e. liquid or powder, the most effective concentration of the liquid herbs and the period during which the herbs remained active. The effects of different forms of application of *L. javanica* and *T. minuta* on aphid populations are presented in Table 1.

Lippia javanica

The standard solution and the 1:1 dilution caused a significant (P<0.0000) decrease in the number of aphids. However, the mean percentage decrease of aphids caused by the standard solution was significantly higher (p<0,0001) than the mean percentage decrease caused by the 1:1 dilution. The 1:2 dilution and the powder forms showed no effect on aphid populations, which instead continued to increase.

Tagetes minuta

Only the standard solution caused a mean percentage decrease of 8.75%. The aphid populations treated with the 1:1 dilution, 1:2 dilution and the powder forms instead continued to increase although the mean percentage increases differ significantly (p<0.0001).

Comparison of the standard solutions with synthetic pesticides

Figure 1 gives the most effective concentrations of *L. javanica* and *T. minuta* (standard solutions) compared with the synthetic pesticides, Aphid kill and Bexadust "L". *L. javanica* and *T. minuta* caused mean percentage decreases of 53.16 and 8.75 respectively while Aphid kill and Bexadust "L" caused mean percentage decreases 78.32 and 96.68 respectively. The values differed quite significantly (p<0.0001) amongst the four pesticides.

Table 1. Decrease (-) or increase (+) of aphids on *Brassica capitata* after treatment with *Lippia javanica*. Values presented are least square means and their standard errors.

Form of application	*L. javanica*	*T. minuta*
	% of aphids	
Standard solution	-53.16 [a] ± 5.37	-8.75[a] ± 3.57
1:1 dilution	-24.65 [b] ± 2.14	+4.15[b] ± 2.56
1:2 dilution	+15.98 [c] ± 4.85	+36.13[c] ± 4.15
Powder	+24.37 [c] ± 9.52	+14.87[d] ± 1.89

[abc] Means in the same column with different superscripts are significantly different (p<0.05).

Active period of the pesticides

After the first application, *L. javanica* and *T. minuta* remained active for 3 days while during the second, third, fourth and fifth applications the herbs remained active for 2 days only. Aphid kill was active for a period of 4 days and Bexadust "L" continued to kill the aphids for a period of 6 days.

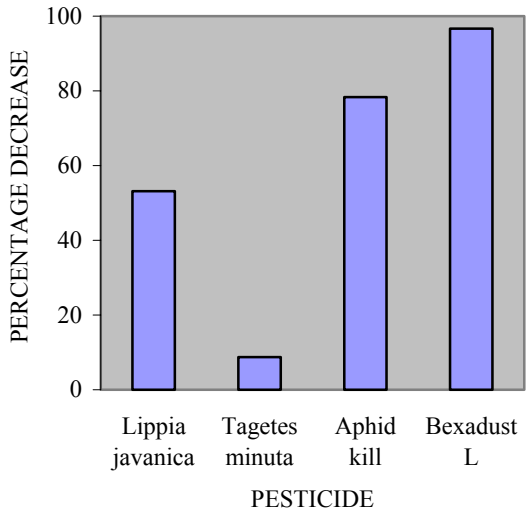

Figure 1: Comparison of the percentage decreases in aphid populations caused by *L. javanica, T. minuta* (standard solutions), Aphid kill and Bexadust "L".

DISCUSSION

Plant-derived products are increasingly being used to combat crop pests because they are natural and often assumed to be safe to the environment (Kumar et al 2000). Mankowski and Lewis (2001) described these

natural herbs as botanical insecticides, naturally derived insect toxins from plants. They have usually been regarded as apart of the plant's defense against plant feeding insects and other herbivores (Rosental and Janzen, 1979).

The finding that *L. javanica* reduces aphid populations on *Brassica capitata* is in agreement with the results obtained by Brazier (1995). *L. javanica* liquid extract contains an essential oil, osdienen, which has been known to repel and intoxicate insects as dead aphids could also be observed on treated plants. Although *L. javanica* was able to reduce the number of aphids on the vegetables, not all the dilutions did quite well. The results showed that the higher the concentration, the more effective it was. The standard solution which produced a percentage decrease of 53.16 in the number of aphids proved to be more effective than the 1:1 dilution which only reduced the number of aphids by 24.65%. The more dilute solution of 1:2 had very little effect on the aphids as the aphids actually increased by 15.98%. This trend suggests that the toxicity or the repellent effect of the active ingredient in the herb decreased with decrease in concentration.

For the two herbs, *L. javanica* and *T. minuta*, the standard solutions prepared by the method outlined by Nhachi and Kasilo (1996) proved to be the most effective concentrations, although their effects have been found to differ significantly. *L. javanica*, which caused a higher mean percentage decrease in aphid populations than *T. minuta* (Table 1), has been found to be more effective. The result that the 1:1 dilution of *L. javanica* had a higher mean percentage decrease of aphids, (24.65%) also supports that it worked more effectively than *T. minuta* in reducing aphid populations. However this should not be considered as conclusive.

The 1:2 dilution of *L. javanica*, the 1:1 and the 1:2 dilutions of *T. minuta* had very negligible effect resulting in aphids actually increasing in numbers, (Table 1). This shows that these dilutions cannot be used effectively to control aphids on vegetables. Although *T. minuta* did not significantly reduce aphid populations in comparison to *L. javanica*, it has been used as an insecticide, and nematocide (Philogene et al. 1985;Perich et al. 1994; Weaver et al. 1994, 1997), and fungicide (Welty and Prestbye 1993). Whole plant extracts of *T. minuta* contain a phototoxin alpha-terthienyl, which is even highly insecticidal (Philogene et al 1985). However, the reduced effectiveness on aphids compared to *L. javanica* could be explained by seasonal variation in activeness of essential oils being more active and concentrated in the plant in September compared to May (Kumar et al. 2000).

There were however observations that during the first treatment of the plants with *T. minuta* 1:1 and *L. javanica* 1:2 dilutions, aphid numbers decreased by 2.8% and 9.3% respectively. Aphids then began to increase in numbers after the second, third and fourth treatments to levels too many to count. These observations also applied to both powdered herbs. This does not suggest that the aphids quickly developed resistance to the herbs but as concluded by Saxena, (1989) cited in Bajwa and Schaefers (1998), the chances of pests developing resistance to such substances are less likely as the biocides contain an array of chemical repellents that affect insect behavioral and physiological processes.

The liquid herbs could have been more effective than the observed results if only they were used immediately after preparation. This is so in the light that liquid herbs have been reported to lose activity if left open, (Mankowski and Lewis, 2001). They break down rapidly in sunlight, and in the presence of detoxification enzymes, (Buss and Park-Brown, 2002). Rapid breakdown means less persistence and reduced risks to non-targeted organisms. However, precise timing and/ or more frequent applications may be necessary, (Buss and Park-Brown, 2002).

Aphid populations continued to increase after the application of the powdered herbs, rendering the powder forms ineffective. Perhaps the powders had no much effect on sap-sucking pests like aphids although the dried leaves of *L. javanica* in particular help repel weevils in grain storage and keep away fleas, and also burning them to use as ashes enhances the repellent effect of dried *L. javanica* on insects (Brazier 1995, Dube et al 1999). The active period of the herbs has been shown to be less than 2 days on average as compared to the synthetic pesticides used, which ranged from 4 to 7 days. This suggests that synthetic pesticides remain more active over a longer period of time than the natural herbs used. Synthetic pesticides have generally shown higher mean percentage decreases in the number of aphids as compared to natural pesticides (Figure 1). On some plants, aphids could be reduced to zero by synthetic pesticides, giving vegetables of high quality. They have also been found to be easy and quick to use, (Bajwa and Schaefers, 1998). Synthetic chemicals are products with a high knockdown effect on pest organisms, but the earliest pesticides till the end of the second world war were poisons extracted from plants (Berger, 1994) e.g. nicotine from tobacco leaves and pyrethrum from certain daisy species (Clegg and Mackean, 1994).

For these reasons, farmers continue to prefer synthetic pesticides to natural herbs although they have been reported by many researchers to cause a lot of pollution, health hazards and untold damage to ecosystems, (Clegg and Mackean, 1994), Nhachi and Kasilo, 1996), (Heri, 2000) and (Dahama, 2001). Using fresh plant extracts would be more laborious

and time consuming as the average active period of the herbs has been found to be no more than 2 days. This also agrees with reasons provided by farmers in Kenya to find out why farmers are reluctant to use natural pesticides, (Percy and Bagnal-Oakeley, 1991 in Bajwa and Schaefers, 1998).

CONCLUSION

It can be concluded from the findings that herb standard solutions can be used effectively to reduce the number of aphids on vegetables although more frequent applications may be necessary. A higher concentration than the prepared standard solution gives better results, especially in killing more aphids and increasing the active period of the herb. In this form it can compare very well with the synthetic pesticides used in this research especially if the herbs are collected during a favourable season.

The use of both herbs in powder form has been found to be ineffective as aphids continued to increase in numbers. It has been established that synthetic pesticides which were used as controls have been found significantly more effective than the natural herbs notwithstanding of course the dangers they pose to the environment and life in general. Steam distillation should be tried as an extraction method where resources are available.

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