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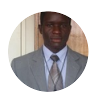
Simbarashe Muzemu
University of Zimbabwe



James Chitamba
Midlands State University

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Pesticidal efficacy of crude aqueous extracts of *Tephrosia vogelii* L., *Allium sativum* L. and *Solanum incanum* L. in controlling aphids (*Brevicoryne brassicae* L.) in rape (*Brassica napus* L.)

Authors:
Shepherd Mudzingwa[1], Simbarashe Muzemu*,[1] and James Chitamba[2]-

Institution:
1. Department of Horticulture, Faculty of Natural Resources Management and Agriculture, Midlands State University, P. Bag 9055, Gweru, Zimbabwe.

2. Department of Agronomy, Faculty of Natural Resources Management and Agriculture, Midlands State University, P. Bag 9055, Gweru, Zimbabwe.

Corresponding author:
Simbarashe Muzemu.

ABSTRACT:

Cabbage aphid (*Brevicoryne brassicae* L.) is one of the most problematic pests in smallholder vegetable production, causing significant yield losses in heavy infestations. Current control strategy focuses on use of synthetic pesticides that consequently lead to decimation of natural enemies, development of insect resistance and resurgence and upset biodiversity. Botanical pesticides have been used widely in smallholder farmers but not much documented literature exists on efficacy of these products. A field trial was done to assess the efficacy of crude aqueous extracts of *Tephrosia vogelii*, *Allium sativum* and *Solanum incanum* in controlling *Brevicoryne brassicae* in *Brassica napus* production. The trial was laid in a randomized complete block design (RCBD) with five treatments replicated four times. The five treatments used in the experiment were *T. vogelii*, *A. sativum*, *S. incanum*, dimethoate and control. Wingless adult female aphids were inoculated three weeks after transplanting of seedlings. Spraying and data collection were done weekly for four weeks. Data was collected on aphid nymph and adult counts on the third leaf from the aerial plant part of randomly selected plants from each treatment for 24 hours after the application of treatments and total plant fresh weight per each treatment. There were significant differences (p<0.05) in the efficacy of botanicals and synthetics in controlling aphids, with dimethoate being the most effective followed by *T. vogelii*, *A. sativum*, *S. incanum* and lastly the control. The treatments applied had a significant effect (p<0.05) on the yield of rape. It was concluded that *T. vogelii*, *S. incanum* and *A. sativum* aqueous crude extracts have some pesticidal effects on aphid in rape production.

Keywords:
Brevicoryne brassicae, botanical pesticides, efficacy, *Tephrosia vogelii, Allium sativum*, *Solanum incanum*, crude aqueous extracts.

Email:
smuzemu@gmail.com, muzemus@msu.ac.zw

Web Address:
http://www.jagri.info documents/AG0040.pdf.

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INTRODUCTION

Rape, *Brassica napus* L., is one of the most important and widely grown vegetable crops for resource poor small scale farmers of Zimbabwe for subsistence and a source of income. Pests and diseases are major constraints causing losses in quality, marketability and up to 80% on yield (Dobson *et al*., 2002). Due to the resource constraints such as pesticides, the management and control of pests and diseases is poor in most small scale farming sector. Rape is mostly prone to aphid attack in most parts of the world where it is produced mainly because of resource constraints (Langer, 1999). According to Dobson *et al*. (2002), aphids represent pests that are not effectively controlled by the current pest management measures in small holder farming.

Botanical extracts are naturally occurring insecticide compounds derived from plants. They contain groups of active ingredients of diverse chemical nature and have an average residual life of 2-5 days thus reducing pressure for selection of resistant types relative to synthetics (Johnson, 1998). Wilson (2001) also reported that botanical extracts are known to have a knock down effect on insects at concentrations harmless to mammals. The botanicals can be processed into various forms and these include crude plant material, plant extracts and pure chemicals isolated from the plants (Johnson, 1998). Application of these natural insecticides by farmers and natives revealed a lot of practices based on superstition have to be demystified with scientific findings (Aguayo, 2000). Despite the growth in widespread use of botanicals in smallholder farmers of Zimbabwe, not much scientific research has been done in terms of determining efficacy of the specifically used botanical products, their toxicity, effective application rates and selection of the most effective types (Roy *et al*., 2005).

Scientific research on the use of botanical pesticides is now gaining momentum since the consumer preference has also shifted from foods that are grown with chemicals to the organically grown foods. (Nas, 2004). The agrochemical industry is also facing problems such as pest resistance to pesticides and the high costs of developing new products, thus there has been a renewed interest in biological control agents and naturally occurring pesticides to help curb the problem of pests (Bridge, 1996). It is therefore apparent that a cheap and environmentally alternative, like botanical pesticides, would be an appropriate solution. The research was conducted also in response to the continuing need to combat insect pests which have not yielded to effective control, thus the need to find alternatives for existing chemicals and to provide a ready supply in future to meet insecticide shortages. Thus natural methods of plant protection, which use locally available resources, have assumed a new importance in an age when a host of commercial products are available.

The present study was carried out with the main objective of assessing the efficacy of crude aqueous extracts of *Tephrosia vogelii*, *Allium sativum* and *Solanum incanum* in controlling *Brevicoryne brassicae* in *Brassica napus* production.

MATERIALS AND METHODS

Study site

The research was done at Fambidzanai Permaculture Centre, located at 7°51'50 S and 31°1'47 E, in Harare, Zimbabwe. The site is in natural farming region IIa of Zimbabwe's Agroecological Zones and receives an average annual rainfall of 750-1000 mm. It is on an altitude of 1150 m above sea level and has sandy clay loam soils.

Land preparation and seedling establishment

Planting stations were dug using hoes and 20 beds measuring 2 m^2 each were prepared. Beds and transplants were spaced at 0.5 m and 0.3 m × 0.3 m respectively. Seedlings were raised in a greenhouse nursery. A basal dressing of vermiculite compost manure was applied a week before transplanting at a rate of 10

Table 1: Different treatments sprayed and their concentrations

Treatment	Concentration (mass/ volume of water)
Tephrosia vogelii	200 g/ℓ
Allium sativum	300 g/ℓ
Solanum incanum	500 g/ℓ
Dimethoate	10 ml/ℓ (0.1%) (v/v)
Plain tape water (control)	1 ℓ

kg per 2 m^2 as a nutrient supplement to facilitate good crop stand establishment. Liquid manure prepared from piggery manure and diluted at a ratio of 1:4, was applied three weeks after transplanting as top dress at a rate of 250 ml per planting station and at two weeks interval thereafter. Irrigation and weed management followed general recommended crop production practices.

Test pest inoculation, spraying and sampling

Ten adult wingless female aphids were inoculated three weeks after transplanting of seedlings. Ten aphids were introduced to each plant and left for 14 days to allow them to acclimatize and reproduce before spraying. From the 5^{th} week after transplanting, spraying began and it was done at weekly intervals for four weeks. A hand held sprayer fitted with a cone nozzle was used for spraying with prepared concentrates without further dilution. Dimethoate was used as per manufacturer label instructions. Plain water was applied to simulate water diluents in other sprayers. Six sample plants were randomly selected from each seedbed and aphid count was done on the third leaf from the aerial plant part. Enumeration of aphids in situ was done using handheld lenses for 24 hours after treatments. Sampling was done weekly for four consecutive weeks.

Experimental design and treatments

A randomized complete block design (RCBD), with five treatments replicated for four times (four blocks) was used (Table 1).

Preparation of crude aqueous plant extracts

Bulbs of *A. sativum* were washed, peeled and sterilized using sodium hypochlorite before preparation. Cloves were pounded using pestle and mortar, measured into 300 g and soaked in 1 litre of water. The mixtures were thoroughly stirred with a spatula and left to settle for 24 hours. Mutton cloth was used to filter residue before spraying (Stoll, 2000; Berger, 1994). 200 g and 500 g fresh leaves of *T. vogelii* and *S. incanum* respectively were processed using procedures same as for *A. sativum*.

Data collection and analysis

Data on aphid population and leaf fresh weight was collected. Data was analyzed using GenStat Discovery version 3.0. Least significant difference (LSD) was used in mean separation at 5% significance level.

RESULTS AND DISCUSSION

Efficacy of botanical extracts on controlling nymph and adult aphid population

There was a significant difference ($p<0.05$) in nymph aphid population among the treatments in all the time periods (weeks 1, 2, 3 and 4). From week two up to week four, dimethoate achieved 100% than control as evidenced by 0 nymph aphid population hence it was the most effective control agent available (Figure 1). The control was significantly different ($p<0.05$) from all the other treatments except in week one where it had the same effect as *S. incanum.* The *A. sativum* and *T .vogelii* treatments were significantly different from each other in weeks three and four. Dimethoate significantly differed from all botanical treatments except in week four where it had the same effect as *T. vogelii* (Figure 1). Generally, dimethoate was the most effective followed by *T. vogelii*, *A. sativum*, *S. incanum* and lastly the control.

The treatments had significant effect ($p<0.05$) on adult aphid population in all the four sampling times (Figure 2). Mean adult aphid populations were highest

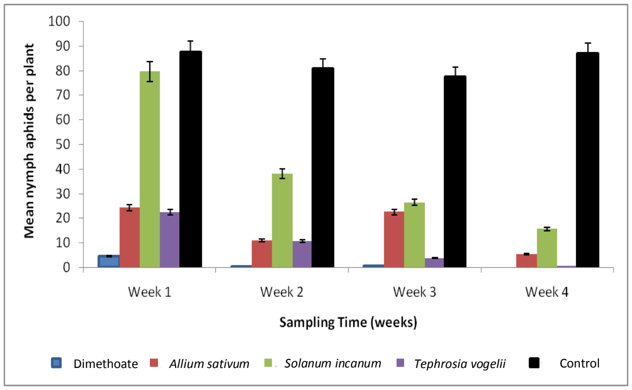

Figure 1: Effect of different crude botanical extracts on mean nymph aphid population

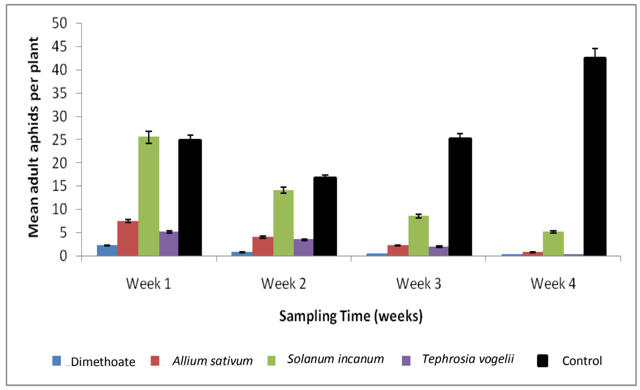

Figure 2: Effect of different crude botanical extracts on mean adult aphid population

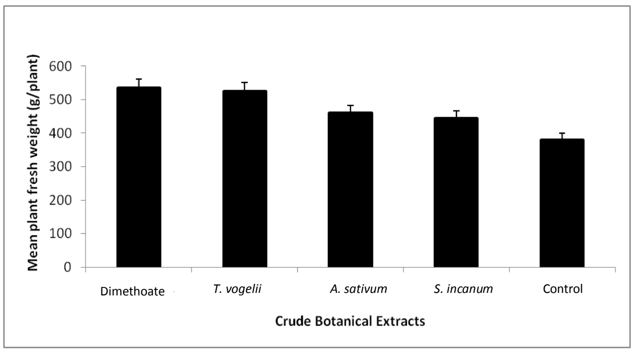

Figure 3: Effect of different crude botanical extracts on mean rape yield

(42.38) in the control and lowest (0.5) in dimethoate. The control treatment was equally less effective as the *Solanum incanum* L. in controlling adult aphids during the first week (Figure 2). Among the botanical extracts, *Tephrosia vogelii* L. was the most effective in controlling adult aphids followed by *Allium sativum* L. and lastly *S. incanum*. *T. vogelii* and *A. sativum* performed equally effective in control adult aphids in all the sampling periods except at week 1 (Figure 2).

The study demonstrated that aqueous crude extracts of test plants were effective in controlling aphid nymph and adult populations. Dimethoate and *T. vogelii* were the most effective treatments in the control of aphids as evidenced by lowest nymph and adult populations accompanied by highest fresh rape leaf weight as compared to other treatments. There was an increase in adult and nymph aphid infestation coupled with a decrease in plant fresh weight in the control treatment. These differences in efficacies of the treatments might be due to the differences in the chemical, physical properties and potency of active compounds in the various treatments used. The findings that *T. vogelii and A. sativum* reduces aphid population agree with the results obtained by Braizer (2001) and those of Buss and Park-Brown (2002) on *S. incanum* effectiveness.

Reduced efficacy in botanical pesticides relative to synthetic pesticide may be attributed to the fact that spray droplets of botanicals did not come into direct contact with the aphids due to reduced mobility of nymph aphids such that those in leaf folds and on underside were spared of spray droplets. Dimethoate, in contrary, is a systemic pesticide which once taken into the plant system will result in toxicity to sucking pests when they suck sap (Dobson *et al.,* 2002).

Botanical products were effective in reducing aphid populations due to the fact that they contain a group of active ingredients which act concertedly on both behavioral and physiological processes and hence their effectiveness (Sexana, 1987). *T. vogelii* contains a compound named rotenone which is responsible for the efficacy of the extract. Rotenone ($C_{23}H_{22}0_6$) is a selective, non specific and non systemic chemical which is both a contact and stomach poison to insects. It kills pests slowly by stopping them from feeding almost immediately and exerts its toxic action by acting as a general inhibitor of cellular respiration to a wide range of insect pests including aphids (Gaskins *et al*., 1992). *T. vogelii* has multiple action properties of rotenone. Rotenone exhibits teratogenic effect and reproductive effects if applied to pests. Teratogenicity is when the pests give birth to deformed off-springs as a result of an applied selection pressure, thus resulting in reduced nymph population on *T. vogelii* treatment (Briggs, 1992).

The effectiveness of *A. sativum* can be attributed to the fact that it contains a group of closely related compounds (allicins) produced upon crushing of the cloves and are responsible for the pesticidal properties of *Allium spp*. Research findings have shown that allicin in Alliums can be classified as insecticides, acaricides, nematicides, herbicides, fungicides, bactericides and repellents against arthropods (Tada *et al*., 1988). On the other hand, solanine ($C_{45}H_{73}NO_{15}$) in *S. incanum* is a poisonous glyco-alkaloid, made of the alkaloid solanidine and carbohydrate (glycol-) side-chains with both fungicidal and pesticidal properties. It interacts with the growth and development of the insect and the interaction may consequently lead to death. These characteristic differences in properties account for the variations in efficacy of the tested plant extracts.

The results from the present study agree with those of Elwell and Maas (1995), where they observed that *T. vogelii*, when used with warm water provides the best protection against aphids. *A. sativum* was second and black nightshade was third in terms of aphid populations. According to Aguayo (2000), most botanicals used for plant protection exhibit an insect deterrent rather than insecticidal effect. Therefore reduction in level of efficacy within the botanicals may be due to the exhibition of deterrent effects as such from solanine in *S. incanum.* This coupled with their slow activity, rapid degradation by UV light, short life cycle for most aphids (five to six days) and the congregation on underside of leaves and on leaf folds of aphids, may have contributed to the less effectiveness of botanicals in controlling aphids relative to the synthetic dimethoate (Davis, 2006).

The control had highest aphid populations throughout the sampling period. This concurs with the findings of Minja *et al*. (2001) who noted that if aphid population is left unchecked, they enormously multiply and are only limited with food source besides other selection pressures. The rapid proliferation can be attributed to their rapid development time (8-12 days) from first instar nymph to adult, reproduction is possible in absence of males and extended reproductive life-span (30 days at 5-6 nymphs/day).

Effect of aphid infestation on rape fresh yield

The treatments applied had a significant effect ($p<0.05$) on the yield of rape. Highest mean rape fresh yield was recorded on dimethoate treatment followed by *T. vogelii*, *A. sativum* and *S. incanum*. The lowest yield was recorded from the control treatment. Dimethoate and *T. vogelii* had statistically similar yields and so were *S. incanum* and *A. sativum* (Figure 3). However, the control treatment had yield which was significantly different from all the treatments (Figure 3).

There was an inverse variation relationship between aphid populations per unit area and weight gain of a plant. Both aphid nymphs and the adults are sap sucking pests that feed by extracting photosynthates which are the sources of energy and vital raw materials for cell division and elongation for the growth and development in the plant. The leaf becomes severely distorted when the saliva of aphids are injected into it (Alford, 1999). Hamman (1985) observed that if left unchecked, aphids in agro ecology can stunt plant growth, deform and discolor leaves and fruits or cause galls on leaves, stems and roots. According to Minja *et al*., (2001) aphid infestation and feeding damage results in curling and yellowing of leaves and stunting plant growth. This reduces the leaf area index and consequently the total quantities of carbohydrates that contribute to plant biomass resulting in lower fresh yields.

CONCLUSION

T. vogelii, *S. incanum* and *A. sativum* aqueous crude extracts have some pesticidal effects on rape aphid *B. brassicae* in *B. napus* production. The most efficacious crude botanical extract was *T. vogelii* in controlling both adult and nymph aphid populations as the recommended synthetic pesticide, dimethoate. The three extracts managed to effectively reduce the losses in yield caused by aphids, giving higher fresh weight compared to the control.

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