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Evaluating the effectiveness of botanical sprays in controlling Aphids (*Brevicoryne brassicae*) on rape (*Brassica napus L.*)

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Key words: *Brassica napus* (L), *Brevicoryne brassicae* (Linn), botanicals, yield.

Abstract

Rape, *Brassica napus* (L) is widely grown in Zimbabwe. Rape aphids, *Brevicoryne brassicae* (Linn) is the most damaging pest on rape. The use of synthetic pesticides poses serious challenges to ecological and financial sustainability. The aqueous pesticidal plant extracts combinations of garlic and chilli were exploratory evaluated for efficacy and optimum dosage rate in controlling aphids on rape at Midlands State University. The experiment was arranged as a Randomised Complete Block design (RCBD) with six treatments i.e. 10g garlic + 10g chilli, 7.5 garlic + 7.5g chilli, 5g garlic + 5 g chilli, 2.5 g garlic + 2.5g chilli, Dimethoate 40% EC (positive control) and plain distilled water (negative control).The treatments were replicated six times. Cloves of garlic and chilli were pounded into a pulp in mortar. The extracts were prepared by mixing crude aqueous plant extracts and boiled distilled water at 0, 0.5, 1, 1.5 and 2% (w/v). Liquid soap was added at 0.1% in the mixture. Dimethoate was diluted at 0.1% (v/v). The extracts were kept for 24 hr at room temperature and sieved through nested sieves with aperture sizes of 710 and 250μm. Sprays were applied weekly once the aphids had naturally established within the crop. A systematic random sampling was used to select plants for aphid counting in each row with k-factor three from the net plot 24 hours post spraying. Aphid population data and yield were recorded. The results showed that botanical sprays significantly ($p<0.05$) affected aphid population and yield. There was a general decrease in aphid populations and an increase in yield with increase in crude aqueous extracts concentration, 10g garlic + 10g chilli recording the lowest aphid count and the highest yield. The study showed that Garlic and chilli extracts have some pesticidal effects on rape aphids.

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Introduction

Brassicas are important as they are a key components of the local diet and nutritionally very important for people who cannot afford alternative vegetables (Oruku and Ndun'gu, 2001). Kales in particular are an important smallholder subsistence crop in Kenya, Ethiopia, Zimbabwe and Mozambique (Lo¨ hr and Kfir, 2004). Rape, *Brassica napus* (L) is grown for its leaves which are rich in vitamin A, thiamine and ascorbic acid; it has high levels of glucosinates, which during preparation form compounds with anti-oxidant and have anti-cancer activities (Holland *et.al.,* 1991).

Aphids, particulary the cabbage aphid (*Brevicoryne brassicae*) are the major pest causing economic damage to rape production in Zimbabwe (Dube *et.al.*, 1998). Under favorable conditions, feeding damage from large number of aphids can kill seedlings and young transplants, on larger plants, its feeding results in curling and yellowing of leaves, stunting plant growth and damaging of flowers (Ahmad and Akhtar, (2013).

Farmers predominantly use synthetic pesticides e.g. dimethoate to control aphids (Sibanda *et al.,* 2000), however these are expensive especially to poor smallholder farmers. Many pests including aphids have also developed resistance to organophosphates, carbamates and pyrethroids insecticides (Ahmad and Akhtar, 2013). An increase in aphid populations as a result of reduced populations of natural enemies (Dube *et al.*, 1998) as a result of routine insecticidal spray have also been noted.

Use of natural pesticides is progressively becoming recognised as one option to address yield losses due to pest attacks as well as reducing environmental degradation associated with the use of synthetic pesticides (Kopondo, 2004). It is within this challenge that it became imperative to explore possible utilisation of biological pesticides that are relatively cheap, accessible, safer and environmentally friendly. These biological pesticides have been shown to have little impact on natural enemies of pests (Schmutterer, 1997), are easily biodegradable (Devlin and Zettel, 1999), hence their use in crop protection is noted as a practically sustainable alternative. However, there is very little information about their effective active ingredients, preparations and application rates. The current study aims to evaluate different garlic and chilli extract concentrations for efficacy as a method of control of cabbage aphid.

Materials and methods

Study site

The trial was conducted at Midlands State University in Zimbabwe from July to November 2012. It is located 19° South and 29° East in natural agroecological region 3 at an elevation of about 1425 m above sea level. Soils are generally sandy formed from Gneissic granite. The average annual rainfall is between 600-750mm. Mean annual temperature is around 20-25°C.

Experiment design and treatments

The experiment was laid out in a randomised complete block design (RCBD) with six treatments replicated six times. Land slope was used as a blocking factor. 2m x 1m plots were prepared and a 0,5m pathway was left between plots and 1 m was left between blocks. Each plot had four crop rows at spacing of 0.15m in-row and 0.3m inter row.

Table 1. Treatment combinations.

Treatment number	***Type of pesticide***
1	10g garlic + 10g chilli
2	7.5 garlic + 7.5g chilli
3	5.0 garlic + 5.0g chilli
4	2.5 garlic + 2.5g chilli
5	Dimethoate (positive control)
6	Plain water (negative control)

Experimental procedure

Treatments preparations and application

Garlic bulbs were peeled and 10g was weighed from the peels. 10g of chillies was also weighed. 10g garlic cloves and 10g chillies were mixed up and ground in a mortar. After grinding the mixture was then put in a glass jar with 1 litre of boiling distilled water and was left to soak for 24 hours. Filtration of the contents was done using 750 and 250 µm sieve sizes. 0.01% (v/v) of liquid soap was also added to the mixture prior to spraying as a sticking agent. 7.5 g garlic + 7.5g chillies, 5g garlic + 5g chillies and 2.5g garlic + 2.5 g were also weighed and the same procedure as on the 10g garlic + 10g chillies treatment was followed. Dimethoate a synthetic pesticide was prepared and applied as per manufacturer spray label instructions. The different botanical concentrations were sprayed at a rate of 1 litre per 5 m^2 using a knapsack sprayer. Botanical pesticides were sprayed weekly and whilst dimethoate was sprayed fortnightly respectively. Different knapsack sprayers were used for each treatment to avoid spray mixture contamination. Spraying started 3 weeks after transplanting, so as to allow establishment of aphids. Spray shields were used to prevent pesticide drift to neighbouring plots. Land preparation, fertilization and other agronomic procedures were done as per recommendations of the conventional rape production requirements. Irrigation was done using the bucket system and equal amount of water was applied to all plots as per required. The plots were kept weed free through out the experiment. Seedlings were transplanted into permanent beds after one week of hardening-off .

Data collection

The two outer rows were discarded and two centre rows represented the net plot. Sampling was done by randomly selecting three plants in each row in the net plots. Systematic random sampling was used on selecting plants and the k-factor used was 3. In the first and second rows plant numbers 1, 4, 7 and 3, 6, 9 were selected giving a total of six plants per plot. Data collection for aphid count started at 3 weeks after transplanting and continued for six consecutive weeks. This was done by counting all aphids that were present on the selected plant. Rape yield was harvested at 2 weeks interval starting from ? weeks after transplanting, equal number of leaves were harvested from each plant.

Data analysis

GENSTAT version 8.1, a computer statistical and data management package was used to analyze the generated data. The analysis of variance (ANOVA) for a randomized complete block design experiment was used to evaluate the data, means were separated using the least significant difference method (LSD). Treatment means were compared at probability $P<0.05$. Aphid counts were transformed with square root factor 12.

Results

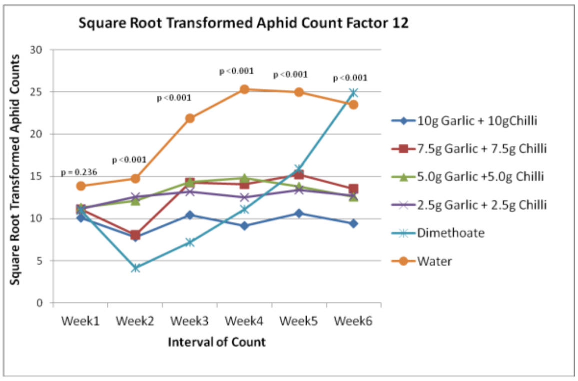

Fig. 1. Effects of botanical sprays on aphid populations at different time periods.

The results shows that, botanical sprays had a significant ($p<0.05$) effect on aphid population in all the weeks of data collection except in week 1. A general decrease in aphid populations was observed with an increase in concentration of botanical spray. Throughout the experiment the negative control (water) recorded the highest counts of aphids. On week 2 significant differences between treatments and control were observed. 10g garlic + 10g chilli, 7,5g garlic + 7.5g chilli, 5.0g garlic + 5.0g chilli, 2,5g garlic + 2.5g chilli and dimethoate reduced aphid population by 50.03%, 45.08%, 17.99%, 14.8% and 72.03% respectively as compared to negative control (water). Aphid counts recorded where 10g garlic + 10g chilli and where 7,5g garlic + 7.5g chilli was applied were not significantly different at week 2, however rom week 3 onwards data collected from 7,5g garlic + 7.5g chilli, 5.0g garlic + 5.0g chilli, and 2,5g garlic + 2.5g chilli was not significantly different from each other. After week 2, populations of aphids in the dimethoate treated plots started to exponentially increase. By week 4, 10g garlic + 10g chilli performed better than dimethoate and at week 5 onwards all botanicals performed better than dimethoate, it also recorded the highest number of aphids as compared to all the treatments in week 6.

Effects of botanical sprays on cumulative rape yield

Table 2. Effects of botanical sprays on cumulative rape yield.

Treatment	Cumulative Fresh mass (t/ha)
Dimethoate	58.7[c]
10.0g garlic + 10.0g chilli	68.2[a]
7.5g garlic + 7-5g chilli	62.6[b]
5.0g garlic + 5.0g chilli	57.3[c]
2.5g garlic + 2.5g chilli	55.1[cd]
Water	54.3[d]
Grand mean	62.1
F Probability	<.001
LSD	2.531
CV%	8.5

The data for fresh mass is presented as shown in table 2. The results showed a significant difference ($P<0.05$) in treatment effects on yield of rape. There was a general increase in rape yield as the concentration of botanicals increased. 10g garlic + 10g chilli, 7.5g garlic + 7.5g chilli, 5.0g garlic + 5.0g chilli, 2.5g garlic + 2.5g chilli increased yield by 25.59%, 16.5%, 10%, 5.09% respectively when compared to negative control (water). From the results, mean yields recorded where 5.0g garlic + 5.0g chilli was applied were not significantly different from those recorded where dimethoate was applied. 10g garlic + 10g chilli had the highest yield followed by 7.5g garlic + 7.5g chilli recording 68.2t/ha and 62.6t/ha respectively.

Discussion

In week 1 there were no significant differences on aphid population between the control and those which had been sprayed with botanical sprays. This could have been due to poor establishment of aphids in different plots since the experimental site used was initially a virgin land. However from week 2 onwards, application of botanicals significantly reduced aphid population. This could be because of the repellent and pesticidal effect of both garlic and chilli. When garlic cloves are cut odourless, sulphur containing amino acid derivative reacts with the enzyme allinase to form allicin and other sulphur compounds. The sulphur containing compounds are responsible for the garlic distinctive smell and pungency (Brewster, 1994).Strong smell produced is responsible for garlic preventing aphids from finding the crop plant (Dobson *et al* .2002). Amonkor and Baneji (1971) identified Diallyl di-sulphide, Diallyl tri-sulphide and Diallyl sulphide as major components having antagonistic properties against pests of economic importance including potato tuber moth, red cotton bug, red palm weevil, house flies and aphids.

At week six botanicals recorded aphid populations that were not significantly different from each other. This can be attributed to rape developing tough leaves that might have become less ideal for aphids. As kale grow silica or lignin accumulates in leaves increasing fibre content thus reducing leaf palatability (Jonsell, 2000). Aphids are wingless in general but will produce wings and fly away when food resources are limited especially when crowded (Dube *et al*, 1998), this could also have resulted in even distribution of the aphids within the botanicals at week 6. There was a sharp increase in aphid population on Dimethoate sprayed crop from two weeks. This can be attributed to resistance development of aphids to the synthetic organophosphate insecticide. This can also be linked to the life cycle of aphids that is approximately two weeks (Sibanda et.al, 2000), hence new resistant progenies could have been produced leading to increased failure by dimethoate to control aphids. Chilli as a constituency of the botanical formulation could also have contributed to reduction in aphid populations. According to Brust (2006) chilli acts as a stomach poison, anti-feedent and repellent to a number of pests due to a major ingredient capsaicin (8-methyl-n-vanillyl- 6-nonenamide) which is found in the pod. In insects, capsaicin's toxicity appears to be through metabolic disruption, membrane damage, and nervous system disfunction (Nhachi and Kasilo, 1996).

A significant difference was also noted on the kale yields of different treatments. Increase in concentration of botanicals was directly related to an increase in yield. This can be attributed to the reduction of aphid populations on the kale by botanicals. The nymph stage and adult forms damage the plants by sucking sap from the tender leaves, twigs, stems and inflorescence by means of piercing and sucking (Jonsell, 2000). Aphids, if in large numbers they remove sufficient sap to kill the leaves and growing tip. Infected seedlings become stunted and distorted; continual feeding on mature plants causes wilting, yellowing and general plant stunting (Hill, 1983), curling and subsequent drying up of leaves, hence reducing yields. Aphids also produces honey dew predisposing an affected plant to develop black sooty mold making the leaves age faster of the leaf and reducing photosynthesis (Jonsell, 2000)

Conclusion

Combinations of garlic and chilli had suppressive influence on pest numbers leading to increased rape yields. Application of 10g garlic + 10g chili performed best in terms of reduction of aphid population and also increasing yields. However more studies are required to validate these results under typical farmer conditions.

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