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Efficacy of lantana (*Lantana camara*) extract application against aphids (*Brevicoryne brassicae*) in rape (*Brassica napus*) over varied periods of time

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Contact bioefficacy of lantana (*Lantana camara* L.) leaf extract (LLE) against rape aphids (*Brevicoryne brassicae* L.) in three rape (*Brassica napus* L.) seed brands at given time (hours) periods was explored. Samples of pounded young leaves mixed with distilled water (3 kg l^{-1}, 2 kg l^{-1} and 1 kg l^{-1}) were prepared. Dimethoate (7.5 ml 10 l^{-1}) and distilled water were the positive and negative controls, respectively. Treatments were arranged in a randomized complete block design (RCBD); 3 x 5 factorial arrangement, replicated 5 times. Adult aphids (10) were introduced to each plant. Aphid mortality at 6, 12, 18 and 24 h after application of treatments was evaluated. There was no significant interaction between seed brand and treatment at all times. Lantana treatments showed significant mortality effect ($p < 0.001$) on aphids at all times. The highest LLC (3 kg l^{-1}) showed the highest aphid mortality at each period of time after application, and of all the periods, the longest time after application (24 h), showed the highest mortality (9.67). It is recommended that smallholder farmers use 3 kg l^{-1} LLC to control aphids on rape, and allow 24 h after application to get the greatest kill.

Key words: Lantana leaf extract, rape, aphid mortality, hours after application.

INTRODUCTION

Rape (*Brassica napus* L.) is a major vegetable crop cultivated worldwide. It is known for its fast growth whereby prolific leaf production has been evidenced, and both fresh and dried leaves are utilized as relish (Oldham, 1999). In Southern Africa, and particularly in underdeveloped countries like Zimbabwe, the vegetable's nutritional value (Nyakudya et al., 2010) has considerable potentials for ameliorating some of the most widespread and debilitating nutritional disorders (Ijarotimi et al., 2003). The production of rape and other leaf vegetables for local and export markets is one of such profitable agricultural enterprise, and in Africa South of the Sahara, smallholder vegetable production is a fast expanding enterprise due to the increasing demand from the rapidly

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increasing populations (Kuntashula et al., 2004).

However, rape is attacked by a number of pests; amongst these, rape aphids (*Brevicoryne brassicae* L.), which also attack cabbage (*B. oleracea* var. *oleracea*), are the most serious (Khan et al., 2015). Three rape seed brands (Prime seeds, Avanos and Starke Aryes) are mainly grown in Southern Africa but how they comparably respond to lantana sprays when infested by aphids is unknown. Aphids have high reproductive potential. Each adult produces up to 60 nymphs which develop and reproduce in about one week (Ulusoy and Olmez, 2006). Attack by aphid colonies and the aphid damage due to sap sucking, can cause yield losses from 80% to complete crop failure, if the attack and damage start at seedling stage (Singh and Bakhetia, 1987).

Synthetic chemical insecticides have been used for many years in the control of aphids and are currently available (Shiberu and Negeri, 2016). Nevertheless, use of synthetic chemicals promotes development of pesticide resistance in the target pests (Belmain et al., 2013), pest resurgence and emergence of secondary pests. Synthetic pesticides affect non-target insect species (Shiberu and Negeri, 2016), cause food and groundwater contaminations, pollution and pesticide residue, which accumulate in beneficial organisms and human beings (Georghiou, 2000). They have high costs and associated toxicity risks which discourage rape growers from integrating them in their pest management system (Canhilal et al., 2006). Farmers always complain of local unavailability of synthetic products, poorly labeled or packaged products, and also frequently adulterated and sometimes, some products being sold after expiry date (Stevenson et al., 2012). Dayan et al. (2009) reported that there is a need to develop cheaper and safer alternatives for insect pest control, including plant-based products. Biopesticides are very important to the rural poor who are vulnerable and marginalized. Many smallholder rape growers are, herewith, shifting focus to more reliable, sustainable and environmentally friendly agents of pest control, the biopesticides. Indeed, because rape is a fast-growing vegetable, and yet highly susceptible to aphids, which are highly reproductive, it is necessary to determine a biopesticide which, at a highly efficacious concentration, can potentially control the pest in a short time so as to cherish the maximum leaf production of the crop.

Rajashekar et al. (2014) reported lantana to be efficacious against storage pests, while Muzemu et al. (2011) reported that different plant extracts are biopesticidal against rape aphids. Lantana has wide variety of chemical substances, including triterpenes, mono and sesquiterpenes, iridoid and phenyl ethanoid glycosides, nafthoquinones and flavonoids, among other compounds (Ghisalberti, 2000). The lantadene content of lantana leaves is variable, and potentially toxic plants contain at least 80 and 200 mg kg^{-1} of lantadenes A and B, respectively (Ghisalberti, 2000). In practice, this is equivalent to a dosage of 40 g of fresh material per kilogram of weight.

Lantana grows widely as wild species throughout the tropical, sub tropical and temperate parts of world and is locally and cheaply available, but there is little literature on the control of aphids using lantana. The current research sought to determine the efficacy of lantana leaf extract (LLE) in controlling aphids in rape by assessing adult aphid mortality over varied periods of time (hours) when the aphids are exposed to the treatment.

MATERIALS AND METHODS

Study site

The knockdown and toxic effects of lantana leaf extract as a biopesticide control of aphids was investigated in different periods of time (hours) in Watsomba, Mutasa District, Manicaland, Zimbabwe. The climate is tropical; the weather is always cool in early summer (August to September), while October is the hottest month with minimum temperatures averaging 16°C and maximum often reaching 32°C. The location in terms of Global Positioning System (GPS) is: latitude 18°40´50.99''S 32° 37´59.99''E.

Fertilizers

Basal fertilizer rates were used at a rate of 70 kg N ha^{-1}, 160 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1}. Top-dressing fertilizer was ammonium nitrate (AN), applied to rape at a rate of 34.5 kg N ha^{-1}, 2 times at 3-week interval from 2 weeks after transplanting.

Nursery establishment

Certified seed was obtained from Farm Supplies Company in Mutare city (location: 18°58´ 14.5200'' S 32°40´ 15.0960'' E) and sown on nursery bed of 6 m long × 1 m wide where the seedlings were raised. Sowing was done on 1 August 2016. Planting depth was 12 mm with furrows 100 mm apart. Nursery management included watering and weed control. Seedlings were transplanted at 4 weeks of age.

Layout of the experiment

Three different seed brands were used as blocking factor (Prime seeds, Avanos and Starke Aryes). There were 3 large blocks; each measured 19 m length x 10.75 m width. The blocks were separated by 2 m pathway. Within each block were smaller blocks of 19 m length x 1.35 m width. Each plot measured 3 m length x 1.35 m width. Each plot was separated from the other by 1 m between plots and between blocks by 2 m. Transplants were spaced at an in-row spacing of 15 cm and inter-row of 45 cm.

Lantana leaf extract preparation

Young lantana leaves were pounded to a paste and then ratios of pounded lantana: distilled water (3:1, 2:1 and 1.1) were used to come up with concentrations. The final concentrations were therefore 3, 2 and 1 kg l^{-1} which were the LLE treatments used in the experiment (Table 1). The extract concentrations were first filtered through a clean sterilized muslin cloth and then through an

Table 1. Lantana leaf extract (LLE) treatment codes and concentrations.

Treatment code	Name of treatment and concentration
T1	Dimethoate 7.5 ml 10 l^{-1} of distilled water (positive control)
T2	LLE 3 kg l^{-1}
T3	LLE 2 kg l^{-1}
T4	LLE 1 kg l^{-1}
T5	No LLE (distilled water)

ordinary filter paper. After the filtering process, each concentration (obtained from 1 l distilled water which had been mixed with each of the pounded amounts of moringa leaves (3, 2 and 1 kg) was then mixed with 5 g of sugar, and stored in air tight glass bottles at 4°C before it was used. Sugar was integrated with all treatments to act as a sticking agent and as an attractant. Sugar was used in horticultural crops (Cao et al., 2016). Sugar has sweetness characteristic which attracts pests to a host, or retains a pest on a host, implying that it has a strong impact on aphid-host choice (Powell et al., 2006), but there is no evidence of adverse interference with any treatments' effect, nor showing that contact synthetic pesticides were improved by addition of sugars (Shelly et al., 2014).

Source of aphids and introduction on rape

Live adult aphids were collected in mid-October 2016 on a white paper from an infested rape field. The adult aphids (*Brevicoryne brassicae*) were identified by Zimbabwe Open University Horticultural Crops Section, Entomomlogy Clinic.

Infestation

After a thorough check of the experimental plants that were clean of aphid infestation, 10 adult aphids (Schwartzberg and Tumlinson, 2013) were immediately introduced on each plant on the same day and about the same time, 6 weeks after transplanting and physically checking that they were healthy and active. The infestation period was 10 min after introducing the adult aphids to the plants, before application of treatments. This implies that there were 10 aphids per plant; infestation time before treatment was 10 min. Each of the rape plants were also physically re-examined *in situ* to determine the consistence of the number of adult aphids previously introduced (10) per plant (Muzemu et al., 2011). No aphid was observed to escape as the number per plant remained 10; the shortness of the infestation period before applying the treatments allowed no aphid to escape before treatments were applied. The sugar in the treatments also aided in retaining the aphids on the plants.

Experimental design, treatments and application for contact mode assessment

Each of the seed brands (Prime seeds, Avanos and Starke Aryes) had 80 plants $plot^{-1}$ and each plot had four lines; each cropline had 20 plants. Two rows at each plot centre were the net rows from where 5 plants were randomly chosen from each row for adult aphid count. Treatments [3, 2 and 1 kg l^{-1} pounded lantana leaves mixed with distilled water, including dimethoate 40% emulsifiable concentrate (EC) and distilled water, as positive and negative controls, respectively] were applied on different seed brands shortly (10 min) after introducing the adult aphids to the plants, before the aphids changed hosts or reproduced. A knapsack was used to apply the treatments at a rate of 1 l 5 m^{2-1} (Muzemu et al., 2011; Pahla et al., 2014). Plastic spray-shields were set up to prevent spray drift of the different treatments from affecting neighboring plots (Pahla et al., 2014). The shields also provided barrier to any aphid flights which might take place. The treatments were arranged in a randomized complete block design (RCBD), 3 x 5 factorial arrangement. Each treatment was replicated 5 times. Average mortality was recorded at 6, 12, 18 and 24 h (after application of treatments to the seed brands) by physically examining the entire rape plants *in situ* to assess the number of aphids left per plant and calculating the eliminated ones which were then subjected to statistical analysis.

Data analysis

Two-way analysis of variance (ANOVA) was used for the two factors: seed brand and treatment, using GenStat statistical package 14th Edition to analyze the data. Separation of treatment means of all treatments (including positive and negative controls) was then employed using the Bonferroni test at p = 0.05. The Bonferroni test was used in the current study because the number of contrasts to be estimated (or comparisons to be tested) was small. The Bonferroni test also allows equal and even unequal sample sizes to be tested if they inevitably occur in an experiment.

RESULTS

The lowest lantana concentration of adult aphid mortality at 6, 12, 18 and 24 h after application was significantly higher (p = 0.05) than the negative control. T1 was found to have all the 10 live aphids on the sampled plants.

Mortality of adult aphids 6 h after treatment

Mortality was affected by the LLE treatments ($F_{4,28}$ = 23.97; p < 0.001); there were also significant differences among seed brands ($F_{2,28}$ = 3.47; p = 0.045). However, there was no interaction between treatment and seed brand ($F_{8,28}$ = 0.37; p = 0.927). Although, T1 had significantly higher mortality than lantana treatment T2, T2 gave the highest mortality in all the other lantana

Table 2. Means for 6, 12, 18 and 24 h of adult aphid (*Brevicoryne brassicae*) mortality after application of treatments. Values are the mean ± standard error of the mean (SEM).

Treatment code	Means of adult aphid mortality (hours) after treatment application			
	6	12	18	24
T1	1.67±0.4^{d}	4.67±0.6^{d}	6.67±0.4^{d}	9.89±0.5^{d}
T2	1.22±0.2^{cd}	4.67±0.6^{d}	6.33±0.6^{d}	9.67±0.6^{d}
T3	0.67±0.4^{bc}	3.00±0.2^{c}	4.78±0.2^{c}	7.56±0.4^{c}
T4	0.22±0.3^{ab}	2.33±0.4^{b}	3.56±0.3^{b}	6.56±0.2^{b}
T5	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}

treatments; it showed highly significant difference ($p < 0.001$) (Table 2). Avanos and Prime seed showed the same adult aphid mortality (at T2), but higher than Starke Aryes at T3.

Results of Bonferroni test showed that adult aphid mortality of T5 was significantly higher ($p < 0.05$) as compared to the control at 6, 12, 18 and 24 h after application.

Mortality of adult aphids 12 h after treatment

There was significant effect ($F_{4,28} = 176.93$; $p < 0.001$) of LLE treatments on mortality but there were no significant differences among seed brands ($F_{2,28} = 3.15$; $p = 0.058$). There was also no interaction between treatment and seed brand ($F_{8,28} = 1.40$; $p = 0.240$). T1 and T2 were not significantly different; T2 was highly significantly different ($p < 0.001$) from the other LLE treatments. T2 also showed significantly larger mortality effect than T2 at 6 h after treatment (Table 2).

Mortality of adult aphids 18 h after treatment

Effect of LLE on aphid mortality after 18 h of application was significant ($F_{4,28} = 204.53$; $p < 0.001$), but seed brand effect was not significant ($F_{2,28} = 2.27$; $p = 0.084$). Seed brand-treatment had no interaction ($F_{8,28} = 0.54$; $p = 0.816$) while T2 was not significantly different from the T1, and had higher significance ($p < 0.001$) than all the lower LLE treatment concentrations (T3 and 4) and the negative control (Table 2).

Mortality of adult aphids 24 h after treatment

Lantana leaf extract significantly affected ($F_{4,28} = 436.10$; $p < 0.001$) mortality but seed brand effect was not significant ($F_{2,28} = 1.80$; $p = 0.184$). There was no interaction between seed brand and treatment factors ($F_{8,28} = 0.55$; $p = 0.809$). Table 2 shows that T2 was not significantly different ($p = 0.005$) from T1 but highly significant ($p < 0.001$) with regards to the other treatments.

At 24 h after application of LLE treatments, T3 and T4 had comparably higher lethality than the same treatments in shorter periods of time.

DISCUSSION

The study shows that lantana has effect on aphids. Biopesticides' effectiveness against aphids have been reported. Extracts of *Lippia javanica* leaf powder and *Solanum delagoense* ripe fruit pulp were found to possess pest control properties against rape aphids and tomato red spider mites (*Tetranychus evansi*), respectively (Muzemu et al., 2011). Plant extracts of *Artmesia vulgaris*, *Algeratum conyzoids*, *Vitex trifolia*, *Corcus calamus* and *Azadirachta indica* all exhibited insecticidal activity against cotton aphid (*Aphis gossypii*) (Devi et al., 2003). The current study is in agreement with the studies done by Rajashekar et al. (2014). Methanol extract from lantana leaf powder was found to be efficacious against test storage pests, *Sitophilus oryzae*, *Callosobruchus chinesis* and *Tribolium castaneum.*

High concentration of *L. javanica* leaf powder and *S. delagoense* ripe fruit pulp extracts used in previous studies showed that highest concentrations had the highest efficacy (Muzemu et al., 2011). The higher the concentration, the more the efficacy and the lower the concentration, the lower the efficacy, which results in only a repellent effect. In a study by Ogendo et al. (2003), 50% storage pests' mortality varied from five to six days after treatment with the highest concentration of 7.5 to 10.0% w/w lantana powder was used. In this study, the greatest kill was at 24 h (9.667) when 3 kg l^{-1} was used. It implies that the lantana treatments used were generally highly concentrated in order to effectively kill a large number of aphids. The degree of efficacy was greatly influenced by dosage or concentration of the extract used and the length of time after application; 24 h had the greatest kill. Higher concentrations over a longer duration are more likely to produce greater lethal effects. Lower concentrations result in only a repellent effect. The 10 live adult aphids found in the plots of T5 unlike T4 plots implied that lantanta at the lowest concentration (T4) was effective, probably as a repellant and that distilled water had no lethal effect. There was an increasing number of aphids which included nymphs weeks later. Toxicity is a function of time after application, and time after application is a function of dose and length of the time (Rozman et al., 2009). The positive control (dimethoate 40% EC) in the current study which caused a high mortality to aphids agrees with study of Bezerra-Silva et al. (2012) who assessed the contact effect of synthetic pesticide, and found that it is equally highly deleterious to *Bucephalogonia xanthophis.*

Most biopesticides used against aphids reported in literature showed deleterious effect. In the current study, lantana was effective in controlling aphids. For example, among the three seed brands, Avanos and Prime seed showed high aphid mortality record with no difference between the two seed brands in aphid mortality at T2. However, Avanos showed higher mortality at T3. The results suggest that different seed brands respond differently to lantana application when they are infested by aphids. In the current study, lantana was most effective on Avanos when tested at 6 h.

This means aphids can be controlled effectively by lantana plant derivatives. Seeds and leaf extract of flowering lantana (Baidoo and Adam, 2012) have also proved efficacious against cabbage aphid (Mekuaninte et al., 2011).

The use of natural products and their analogues have been considered for the management of agricultural insect pests. This is due to the fact that they are less detrimental to the environment than synthetic chemical insecticides. In the current study, mortality could have been due to the properties of the extract. *Lantanine* plant metabolite from lantana has been characterized as having defensive mechanisms against insect pests (Ghisalberti, 2000).

Conclusion

Lantana leaf extract used in the current study showed potential to control aphids in rape. The highest concentration (3 kg l^{-1}) showed the most efficacious effect on *B. brassicae* in *B. napus*. Lower concentrations showed lower efficacy. The least was recorded when no extract treatment (distilled water) was applied. The higher the concentration, the higher the efficacy, and the lower the concentration, the lower the efficacy, thus, resulting in only a repellent effect. The study has shown that the degree of efficacy of lantana leaf extract is greatly influenced by the dosage or concentration of the extract applied and the exposure time. The study also suggests that different seed brands respond differently to lantana application in terms of mortality of aphids infesting them.

Lantana can be of importance to the resource-poor farmers in many areas of developing countries. The mortality recorded for the treated plants was an indication that they can be used as alternatives to chemical insecticides. The findings of the present study therefore indicate that leaves of lantana have some toxic properties and therefore could be considered as potential source of biopesticide for economical and environmentally friendly pest control strategies against aphids in rape.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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