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Control of Cabbage Aphid, *Brevicoryne brassicae* (L.) Using Kaolin and Neem Oil

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ABSTRACT

Effect of alternative products in the control of cabbage aphid, *Brevicoryne brassicae* (L.), was studied in two greenhouse experiments. Neem oil, rock dusts Rocksil and protesyl (kaolin), citrus oil, pyroligneous extract (alone or mixed with pepper+citronella) and the neem oil+pyroligneous were sprayed on kale plants. Four and three sprayings were done in first and in second experiments, respectively. Evaluations were done previous and after spraying by counting and recording number of insects per leaf. It was found that plants treated with neem oil 1% and protesyl 5% showed less cabbage aphid population than control nevertheless reduction occurred just after the third spraying. Citrus oil did not reduce aphid population and caused toxicity to plants. In the second assay, in general, neem treated plants showed lesser infestation than control. In the first assessment, higher aphid infestation was found in the plants treated with neem oil (0.5%) than neem oil (0.5%)+pyroligneous (1%). Inconsistent results were found when pyroligneous and the home formulation of pyroligneous with citronella and pepper were used alone. The results showed that neem oil and kaolin are suitable alternatives reduce cabbage aphid in kale plants.

Key words: Azadirachtin, natural products, plants extracts, alternative control

INTRODUCTION

The control of insect pests in vegetables is currently done almost exclusively using chemical insecticides. In general the greens and vegetables have several continuous harvests and pest control is done in the same period in which plants are reaped. Pesticide residues occur frequently and are public health concern. Avoiding pesticides by the development of alternative strategies to manage phytosanitary problems is an important need mostly for horticultural activity (Marques-Francovig *et al*., 2014). In addition, organic production is a growing tendency worldwide (Willer *et al*., 2008) and pest management is a problem that still limits its expansion (Zehnder *et al*., 2007).

The cabbage aphid, *Brevicoryne brassicae* (L.) (Hemiptera: Aphididae), is an important pest in Brassicae. It demands systematic control and several sprayings are achieved during plant cycle. Products derived from the Indian neem (*Azadirachta indica* A. Juss.) could be an appropriate option to manage pests (Meena *et al*., 2013), mostly those small scale crops that do not take up large space. They offer deterrent action and grown regulation, as was observed for *Macrosiphum rosae* (L.) (Hemiptera: Aphididae) and *Macrosiphoniella sanborni* (Gillete) (Koul, 1999), on rose plant. The commercial neem oil has relatively high cost (about US$ 60.00/L in Brazil). The addition of

other products could eventually improve its efficiency and thus reduce doses and costs. The pyroligneous extract, made by the condensation of smoke in the process of wood's pyrolyses in charcoal production has been proposed as a protective of plants and as an element that improves the activity of other substances, including neem (Guirado *et al.*, 2007). Regionally, farmers use homemade formulations of pyroligneous acid with citronella (*Cymbopogon nardus* (L.) Rendel) and pepper (*Capsicum frutescens* (L.)) to control pests. However, results of studies showing positive results were not found in literature.

The citrus oil, formed by several volatile compounds, as terpenes, alcohols, esters, fatty aldehydes and triglycerides (Fernandes *et al.*, 2002), causes inhibition or decrease of the growth, decrease in the reproductive capacity, suppression of the appetite and causing death through starvation or direct toxicity in the insects (Viegas Junior, 2003).

Use of kaolin clay in the management of insects and diseases (kaolin-based particle film) was successfully evaluated in apple (Thomas, 2002; Sackett *et al.*, 2005) and pear (Puterka *et al.*, 2000) orchards. The formulations also protect the fruits against injuries caused by the sun due to the formation of a reflective particle film in the surface (Glenn *et al.*, 1999). Another rock powder, Rocksil, has been used for organic farmers to obtain the same effects of kaolin. Studies with kaolin protecting film have been concentrated in temperate climates and the development of formulations using local inert materials is a requirement in tropical regions.

Alternative strategies may be a way of reducing or even eliminating pesticides in fruits, vegetables and greens since detailed investigations define exactly which pests can be controlled by specific alternatives and their doses. Considering the needs of information in the efficiency of control measures to cabbage aphid, the effect of some products in the management of cabbage aphid as an alternative to replacement pesticides in kale was studied. Evaluation of insecticidal effects of the neem oil, rock dusts Rocksil and Protesyl (kaolin), citrus oil, pyroligneous extract (alone or mixed with pepper+citronella) and the neem oil+pyroligneous against cabbage aphid was the aim of present study.

MATERIALS AND METHODS

Two experiments were conducted in a greenhouse in Londrina, PR (23°23' latitude South and 51°11' longitude West). Kale was sown on horticultural substrate Plantmax® (Eucatex, São Paulo, SP) in Styrofoam trays, on October 27th 2006. When the seedlings had three to four leaves they were transferred to vessels (two seedlings per vessel) (2 kg) containing ravine soil and 60 g of 4-14-8 formulated fertilizer. Afterwards, the less vigorous seedling was eliminated. Kale leaves containing cabbage aphids were collected in a commercial orchard and placed on the leaves of the seedlings for infestation, from 46-52 Days After Sowing (DAS). Before the first spraying, one leaf of each plant was randomly chosen and marked on each plant and the number of wingless cabbage aphid was quantified. Four replications were used. Spraying was carried out with a hand sprayer pressure 2.5 L (Practical model 2000, Brudden).

The treatments, their origins and concentrations are described in Table 1. Agril® was used as spreader-sticker mixed with all treatments and one additional just with Agril® in the spray solution. Pyroligneous was used alone or mixed with citronella (*Cymbopogon nardus* (L.) Rendel) leaves and pepper (*Capsicum frutescens* (L.)) cv., malagueta fruits. This home formulation was prepared as made by growers (boiled for 2 h) regionally. Concentrations used were based on information provided by manufacturers or reports of farmers.

For the first experiment, the seedlings were transferred to vessels 14 DAS. Spraying started 75 DAS and was repeated weekly more three times. The evaluations were done two and five days

Table 1: Concentrations and origins of products sprayed in kale plants infested with *Brevicoryne brassicae* aphid (Experiment 1 and 2)

Treatments[1]	Origin
Experiment 1	
Water (control)	--
Citrus oil (2%)	COROL, Rolândia, PR
Pyroligneous (2%)	Carvoaria coroados, Londrina, PR
Neem oil (1%)	Natuneem-Natural rural, Araraquara, SP
Protesyl (5%)	Fertirico, Curitiba, PR
Agril (0.5 mL L^{-1})	Visual química do brasil, Ribeirão preto, SP
Pyroligneous (Pepper and citronella) (1%)	Carvoaria coroados
Rocksil (2%)	Lia ulmasud, Galpão Taguatinga do sul, DF
Experiment 2	
Water (control)	--
Neem oil (1%)	Natuneem-Natural rural
Neem oil (0.5%)	Natuneem-Natural rural
Neem oil (1%)+Pyroligneous (1%)	Natuneem-Natural rural, Carvoaria coroados
Neem oil (0.5%)+Pyroligneous (1%)	Natuneem-Natural rural, Carvoaria coroados
Pyroligneous (Pepper and citronella) (1%)	Carvoaria coroados
Pyroligneous (Pepper and citronella) (2%)	Carvoaria coroados

[1]Except for control (both experiments), the adhesive spreader Agril® was used (0.5 mL L^{-1} of solution) in all experiments

after sprayings, taking note the number of insects in the market leaves. For the second assay, the seedlings were transplanted 95 DAS. Three weekly sprays were achieved starting 111 DAS. Pyroligneous mixed with neem oil was used to evaluate possible improvement of neem efficiency. The evaluations were performed 2 and 5 days after sprayings, taking note the number of insects in the market leaves.

Statistical analysis: The randomized design was used. Data were subjected to ANOVA and means were compared by Tukey test at 5% of significance. The control efficiency was calculated by Abbott (1925).

RESULTS

In the first experiment, from first to fourth assessment, cabbage aphid population was similar in the treatments (Table 2). The lack of efficiency of treatments probably was related to high aphid population. During the evaluation period, an increasing population of the pest was observed in control, what demonstrates appropriate conditions for its developing and reproduction. In late assessments (01/26, 01/29 and 02/1) -after the third spraying, plants treated with neem oil 1% and Protesyl 5% had lower aphid populations than control. For these two treatments, in this assessment, a relatively high efficiency was obtained (99 and 90%, respectively). Intermediate populations were found for the other treatments (citrus oil, pyroligneous, pyroligneous+citronella+pepper and Agril). Citrus oil caused toxicity to plants.

In the second assay, in general, neem treated plants showed lesser infestation than control in all evaluations (Table 3). In the first assessment, higher aphid infestation was found in plants treated with neem oil (0.5%) than in neem oil (0.5%)+pyroligneous (1%) (33.0 vs., 94.0% efficiency, respectively). An apparent improvement of neem oil efficiency when mixed with pyroligneous was observed for other assessments and concentration (also 1.0%) but significant difference was not detected.

Table 2: Mean number of *Brevicoryne brassicae* aphids and control efficiency (%) in leaves of kale sprayed in January 10th, 16th, 22nd and 30th, 2007 in greenhouse-experiment one

Treatments	01/12	01/15	01/18	01/22	01/26	01/29	02/1
Water (control)	618.5^{a}	715.5^{a}	315.0^{a}	345.5^{a}	540.7^{a}	848.7^{a}	1012.0^{a}
Citrus oil (2%)	750.0^{a} (--)	910.5^{a} (--)	748.2^{a} (--)	803.0^{a} (--)	264.7^{ab} (51)	429.2^{ab} (49)	499.2^{ab} (51)
Pyroligneous (2%)	377.5^{a} (30)	592.2^{a} (17)	437.0^{a} (--)	961.0^{a} (--)	200.2^{ab} (63)	303.5^{ab} (64)	213.7^{ab} (79)
Neem oil (1%)	344.0^{a} (44)	311.7^{a} (56)	170.7^{a} (46)	371.7^{a} (--)	55.2^{b} (90)	72.2^{b} (91)	3.5^{b} (99)
Protesyl (5%)	375.5^{a} (39)	612.0^{a} (14)	569.0^{a} (--)	531.2^{a} (--)	54.7^{b} (90)	90.2^{b} (89)	100.5^{b} (90)
Agril	506.0^{a} (18)	582.7^{a} (18)	613.2^{a} (--)	660.7^{a} (--)	28.0^{ab} (48)	311.1^{ab} (63)	331.7^{ab} (67)
Pyroligneous (Pepper+citronella) (2%)	482.2^{a} (22)	431.5^{a} (40)	352.7^{a} (--)	493.0^{a} (--)	149.2^{ab} (72)	288.0^{ab} (66)	363.2^{ab} (64)
Rocksil (2%)	454.7^{a} (26)	321.2^{a} (55)	203.5^{a} (35)	330.5^{a} (4)	136.2^{ab} (75)	201.0^{ab} (76)	190.7^{ab} (81)

Means within a column followed by the same letter do not differ by Tukey test at 5% of probability

Table 3: Mean number of *Brevicoryne brassicae* aphids and control efficiency (%) in leaves of kale sprayed in February 16th and 23rd and March 2nd, 2007 in greenhouse-experiment two

Treatments	02/19	02/22	03/2	03/5	03/8
Water (control)	31.0^{ab}	48.0^{a}	15.7^{b}	15.7^{a}	20.0^{a}
Neem oil (1%)	12.2^{abcd} (61)	10.5^{b} (78)	1.5^{de} (90)	1.5^{cd} (90)	0.5^{c} (97)
Neem oil (0.5%)	20.5^{abc} (33)	10.7^{b} (78)	5.2^{c} (66)	5.25^{c} (67)	6.5^{b} (67)
Neem oil (1%)+Pyroligneous (1%)	6.2^{cd} (80)	3.5^{b} (93)	0.2^{e} (99)	0.25^{d} (99)	0.5^{c} (97)
Neem oil (0.5%)+Pyroligneous (1%)	1.7^{d} (94)	4.0^{b} (92)	3.5^{cd} (78)	3.2^{cd}(79,6)	4.2^{bc} (79)
Pyroligneous (Pepper+citronella) (1%)	10.2^{bcd} (67)	44.5^{a} (7)	4.7^{cd} (70)	33.7^{a} (--)	8.5^{b} (57.5)
Pyroligneous (Pepper+citronella) (2%)	31.5^{a} (--)	34.5^{a} (28)	51.5^{a} (--)	3.25^{cd} (80)	0^{c} (100)

Means within a column followed by the same letter do not differ by Tukey test at 5% probability

Inconsistent results were found when pyroligneous and the home formulation of pyroligneous with citronella and pepper were used alone. In some assessments populations were lower than control but in some other were higher (Table 2).

DISCUSSION

Toxicity of citric oils as found in this study has been reported to plenty crops (Ibrahim *et al*., 2001). Limonene toxicity was described to green dracaena (*Dracaena deremensis* Engl. 'Warneckii'), laua'e fern (*Phymatosorus scolopendria* (Burm. f.) Pic.Serm.), creeping club moss (*Lycopodium cernuum* L.), monstera (*Monstera deliciosa* Liebm.) and red ginger (*Alpina purpurate* (Vieill.) K. Schum.) (Hollingsworth, 2005).

The results of neem oil on cabbage aphid confirm previous reports of the effects of neem on *B. brassicae* (Okoth *et al*., 2002); repellency and antialimentar effect were described and caused reduction of pest population in cabbage (Kirpal *et al*., 1986); reduction of fertility and the fecundity (Koul, 1999) and high mortality (Verkerk *et al*., 1998) were also reported. Also for *Myzus persicae* (Sulzer) (Hemiptera: Aphididae), the efficiency of neem was demonstrated (Okoth *et al*., 2002; Venzon *et al*., 2007).

The same way as neem treated plants, the reduction of aphid population due to rock dust (Protesyl 5%) occurred only after the third spraying. Aphid records on Rocksil 2% were intermediate between best treatments and control. Protesyl consists of kaolin (95%) and a fixer. The Rocksil is a mixture of micronized mineral from volcanic origin, composed mainly of Al_2O_3, SiO_2 and S. Similar reduction of cabbage aphid occurred in Rocksil and protesyl treatments and similar mechanisms may be related. Greater control efficiency in the protesyl treatment than Rocksil may be related to the higher concentration (5×2%, respectively).

Previous studies refer to kaolin as a repellent or as capable of creating a protective barrier against insects. There is the formation of a physical barrier that interferes in the movements, feeding and oviposition of the insect (Glenn and Puterka, 2005). The material is deposited on the leaves, making them white which can alter the attractiveness of plants to insects that do not recognize primarily through sight and touch (Glenn *et al*., 1999). Thus, studies have demonstrated the effects of kaolin-based products in the selection of host plant by the insects, including aphids. Migrants winged *Ericaphis fimbriata* (Richards) (Hemiptera: Aphididae) discriminated treated and untreated plants, preferring those untreated with kaolin (Raworth *et al*., 2007). For aphid specie, *Carya illinoensis* (Wang.) K. Koch, multiple simultaneous effects of kaolin were observed what caused decreasing of pest population (Cottrell *et al*., 2002). *Schizaphis graminum* Rondani was previously successfully managed in wheat by using kaolin mostly in higher concentrations (3.75%) what caused mitigation of aphid damage and increasing yields when compared with control (Nateghi *et al*., 2013). The authors reported that among the aphids that selected the treated leaves, a high percentage of insects were recovered on the adaxial surface of leaves (did not complete the selection process of host plant, because they feed on the abaxial surface) compared to those recovered from untreated leaves. They observed under a microscope the film buildup on the aphid body, mainly on the tarsi which should have restricted the mobility and determined higher mortality in the treated plants compared to untreated.

The positive effect of combining neem with pyroligneous extracts was also related to control of *Cerotoma arcuata* Olivier (Coleoptera: Chrysomelidae) (Guirado *et al*., 2007). Pyroligneous is a very cheap byproduct of coal fabrication and neem products are relatively high. Hence improvement of the neem efficiency and reducing its dosages by addition of pyroligneous to the spray solution reduces control cost.

In some assessments, the pyroligneous with citronella and pepper reduced the aphid infestation, however on March 2nd (2%) and 5th (1%) higher aphid populations were found than control. A possible resurgence of the aphid in these treatments may have occurred. Cabbage aphids' parasitoids in general are abundant and may have been killed by this treatment. Efficiencies were highest in the last evaluation (Table 2 and 3). This fact was also observed to control whitefly, *Bemisia tabaci* (Genn.) (Hemiptera: Aleyrodidae), for which the effect of the pyroligneous occurred only after the fifth spray (De Azevedo *et al*., 2005). The authors attributed these results to a greater byproduct concentration (cumulative effect) in the plant and to a possible physiological activation making more resistant to pest attack.

Concerning to the mixture of pepper and citronella to pyroligneous, as has been done by some farmers, does not seem to significantly alter the extract efficiency. It is possible that the way of cooking, boiling the leaves in the pyroligneous, may have contributed to the loss of essential oil presented in plant species that act on the pests. Other forms of preparation may be investigated in the future.

Due to improvement of the neem efficiency by mixture with pyroligneous extract (Table 3), future investigation also may be done to evaluate gradients of varying doses of neem and pyroligneous. Besides this mixture, the rotation or even mixture of rock dusts protesyl and Rocksil with neem could be tested. The action mechanisms against the pest are different what becomes insect resistance less probable particularly for the aphids, for which there is need successive applications. This strategy has also been successful by mixing diatomaceous earth to neem (NeemAzal-T/S) providing significant increase in the control efficiency of *M. persicae* in artichoke (*Cynara cardunculus* var. *scolymus* (L.) Fiori) (El-Wakeil and Saleh, 2007) and also mixing

Paecilomyces lilacinus (Thom.) Samson to neem what triggered higher mortality of *Aphis gossypii* Glover under laboratory and semifield conditions (Wakil *et al*., 2012).

In summary, neem oil (0.5 and 1.0%) and kaolin were efficient, Rocksil (2%) was intermediate to reduce the cabbage aphid population. The addition of pyroligneous to neem used in low concentration (0.5%) improved its efficiency.

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