APHIDICIDIAL ACTIVITY OF SEVEN ESSENTIAL OILS AGAINST THE CABBAGE APHID, *BREVICORYNE BRASSICAE* L. (HEMIPTERA: APHIDIDAE)

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ABSTRACT: The aphidicidial activities of seven essential oils were investigated against *Brevicoryne brassicae* (Hemiptera: Aphididae) under laboratory conditions. Applications of each tested essential oil significantly reduced the reproduction potential of the cabbage aphid and resulted in higher mortality. Quantity of applied essential oils also had an important effect on daily fecundity. In general, these seven applied essential oils can be considered as an important aphidicide to control aphid population, particularly *J. excelsa, J. oxycedrus, L. nobilis* and *F. vulgare.*

KEYWORDS: Aphid, Aphidicide, Biological control, *Brevicoryne brassicae*, Essential oil.

Essential oils have been used to control pests of the stored products as alternative insecticides in various parts of the worlds (Buchbauer, 2000; Isman, 2000, Ngamo et al., 2007). Recently, botanical insecticides have long been considered as acceptable alternatives to synthetic chemical insecticides for pest management as they have low persistence in the environment, little mammalian toxicity and resulting in good selectivity and wide public acceptance (Bhathal and Singh, 1993; Isman, 2000, 2005; Sampson et al., 2005; Digilio et al., 2008).

Recent studies have indicated how various essential oil efficient against pests on plants. Most of the studies reported great potentials of the essential oils to control pests particularly in the greenhouse and in field (Isman, 2000; Sampson et al., 2005, Sarac and Tunç, 1995; Tunç and Sahinkaya, 1998, Tomova et al., 2005). Choi et al. (2003) showed significant insecticidal activity of 53 plant essential oil against *Trialeurodes vaporariorum* (Westwood) in Korea where it become important pest of various greenhouse vegetables. Pavela (2005) reported the toxic effect of twenty essential oils to the third instar larvae of *Spodoptera littoralis* (Boisduval). Rahman and Talukder (2006) reported bio insecticidal activity of different plant oils and showed that plant oils suppressed the oviposition ability of the *Callosobruchus maculatus* (Fabricius) and reduced their damage significantly. Zapata et al. (2006) demonstrated adverse effects of the selected extractions of *Cestrum parqui* L. on *Ceratitis capitata* (Wiedemann).

In insects, the aphid has a particular importance as a serious pest. In spite of the intense control strategies applied so far, aphid species have invaded new areas and have expanded their damage to crops all over the world. For example, in the United States, despite using the best pest control technology available, pest-caused losses of yield have been estimated to average about 30% annually, whereas in the developing countries to which Turkey belongs, pest-caused losses are even higher, averaging 50% or more (Ruberson, 1999). As natural enemy activity cannot prevent or hinder virus transmission an earlier aphid control and faster knockdown method should be preferred. The essential oils with their novel, highly bioactive compounds can be very well used as effective insecticides (Sampson et al., 2005) and thus should be considered seriously for control of the

aphids. Recently which information has been accumulated about the potential of essential oils in control of aphids and several studies reported usefulness applications. Tunç and Şahinkaya (1998) found that essential oils of cumin (*Cuminum cyminum* L.), anise (*Pimpinella anisium* L.), oregano (*Origanum syriacum* var. *bevanii* L.) and eucalyptus (*Eucalyptus camaldulensis* Dehn.) were effective as fumigants against the cotton aphid (*Aphis gossypii* Glover). Green peach aphid, *Myzus persicae* (Sulzer), show both behavioural effects and toxicity in a laboratory bioassay where aphids are placed on mustard cabbage leaf discs dipped in emulsions of an essential oil based insecticide. The frequency of *M. persicae* feeding and the mortality rate were inversely concentration-dependent (Isman, 2000). Tomova et al. (2005) tested the biological activity of essential oil volatiles obtained from *Tagetes minuta* L. against aphid species, *Acyrthosiphon pisum* (Harris), *M. persicae*, *Aulacorthum solani* (Kaltenbach). They demonstrated that *T. minuta* oil volatiles significantly have reduced the reproduction potential of the tested species. Jaastad (2007) showed that rapeseed oil significantly reduced damage by black cherry aphid, *Myzus cerasi* (Fabricius). Gorur et al. (2008) demonstrated adverse effects of *Thymus*, *Veronica* and *Agrimonia* essential oils on cabbage aphid. Particularly *Thymus* oil application resulted in significant decrease in fecundity and increase in mortality rate. Digilio et al. (2008) showed aphicidial activity of vapours of essential oils extracted from 12 Mediterranean plants against the pea aphid, *A. pisum* and green peach aphid, *M. persicae*.

In this aspect, this study aimed to assess the aphidical activity of seven essential oils against cabbage aphid, *B. brassicae*.

MATERIAL AND METHODS

Essential oil extractions and supply

J. excelsa and *J. oxycedrus* essential oils were obtained from the aerial parts of plant species. The air-dried plants were ground and hydro distilled in a clevenger- like apparatus for 5-6 h. The essential oil was extracted with ether then dried over anhydrous magnesium sulphate. Finnigan DSQ and a HP 60m x 0.32 mm ID x 0.25 mm DB-5 capillary column were used. Column temperature was programmed from 40-280 ^{o}C . Column temperature was kept constant at 40 ^{o}C for the first 1 min. then was programmed at a rate of six ^{o}C / min. The temperature was kept constant again at 280 ^{o}C for an other 5 minutes. Injection type was (1:10) and dichloromethane was used as a solvent.

Foeniculum vulgare Miller, *Pimpinella anisum* L., *Rosmarinus officinalis* L., *Juglans regia* L. and *Laurus nobilis* L. pure essential oils were purchased directly from a commercial source. Essential oils were stored in appropriate conditions according to supplier's instruction.

Aphid

Cabbage aphids are an important pests of members of the Cruciferae including, cabbage, collards, cauliflower, swede, mustard, Brussel sprouts and radish. It is a vector of about 20 plant viruses (Blackman and Eastop, 2000). Stock cultures of cabbage aphid, *B. brassicae*, was provided from the Entomology laboratory cultures maintained on cabbage plants in Nigde University. Cabbage, *Brassica oleracea* L., was grown seeds in a glasshouse during experimental process without additional heating or illuminating. Rearing temperature was about 20 ^{o}C.

Experimental design

One host plant leaf was set on the surface of water agar (2 %) at the bottom of a Petri dish (9 cm diameter) (Roy et al., 1999) for all essential oil applications and

control group. Four apterous adult cabbage aphids of about similar size were carefully transferred onto the leaf with a fine brush. After allowing the aphids to establish, petri dishes were turned upside down and the essential oil was inserted into agar. The petri dishes were placed in plastic bags in an illuminated incubator at about 20 ^{o}C and under a L12:D12 photoperiod. Petri dishes with different volatiles and different concentrations were kept separately to prevent exposure of aphids to other treatments. The daily fecundity in each separate petri dish for each essential oil was recorded. Essential oils were tested at two dose levels; 1 µl and 2 µl per petri dish. For each essential oil, at both doses, three replicates and a control treatment (without essential oil application) were prepared. Mean daily fecundity for each essential oil treatment and control was presented by calculating each replicates mean daily fecundities. Mortality rate for each application was calculated as a daily percentage of the dead offspring to total daily offspring number.

Statistics

Both mean number of the offspring and standard error for the each essential oil treatment were calculated. A one-way ANOVA was performed to show differences between each oil application and each dose for all used essential oils. Following the ANOVA analyses, post-hoc test was performed to determine which mean has differed significantly. The statistical program SPSS 10.01 was used for all analyses.

RESULTS

The effect of *J. oxycedrus*, *J. excelsea*, *F. vulgare*, *P. anisum*, *R. officinalis*, *J. regia* and *L. nobilis* essential oils at 1 µl and 2µl doses were tested on the cabbage aphid, *B. brassicae*. It was clearly shown that the 7 plant's essential oils had adverse effects on the reproduction ability of the cabbage aphid population (Fig. 1). Daily fecundity of the cabbage aphid exposed to various essential oils decreased compared with control treatments.

There were an overall differences between the effect of different plant's essential oil ($F_{[7, 242]}$= 131.46, P<0.000001). Post-hoc analyses showed that these effects are due to significant differences between most of the treatments (i.e.Tukey $HSD_{[26.18]}$=8.07, P<0.00001 between control and *J. oxycedrus* oil treatment, Tukey $HSD_{[26.18]}$=1.25, P<0.00001 between *J. regia* and *L. nobilis* oil treatment). It was shown that *J. excelsa, J. oxycedrus* and *L. nobilis* essential oils had stronger effects than other plants essential oils. Daily fecundity of the cabbage aphid on these 3 plant essential oil applications were significantly different from others (i.e. Tukey $HSD_{[26.18]}$=2.11, P<0.00001 between *J. excelsea* and *P. anisum*, Tukey $HSD_{[26.18]}$=1.25, P<0.00001 between *L. nobilis* and *J. regia*). In order to remove control results experiments effects on an overall implications, similar tests were performed without control results. There were also considerable amount of differences between applications of seven essential oils without including control measurements ($F_{[6, 233]}$= 44.21, P<0.000001).

In addition to overall adverse effects of plant essential oil on reproduction potential of cabbage aphid, there was also dose-dependent significant adverse effects ($F_{[1, 238]}$= 10.42, P=0.001). The increase of the dosage of applied essential oil from 1 µl to 2 µl adversely affected the daily fecundity. *F. vulgare* and *P. anisum* essential oils applications clearly showed this effect (Fig. 2).

Insecticidal effects of the tested essential oils on cabbage aphid were followed for about 5 days for both 1 µl and 2 µl dose applications. It was shown that exposure time did not result in any important changes in daily fecundity (Fig. 4).

Essential oil applications also caused a higher offspring mortality rate compared with control treatments. Particularly application of *F. vulgare*, *J. oxycedrus* and *J. excelsea* resulted in higher mortality rate than others (Fig. 3).

DISCUSSION

The presented results of this study showed strong adverse effects of *J. excelsea*, *J. oxycedrus*, *F. vulgare*, *P. anisum*, *R. officinalis*, *J. regia* and *L. nobilis* essential oils on the reproductive performance of cabbage aphids. However, there were differences in the bio insecticidal effects of seven essential oils despite the fact that they all had significant aphidicial activity on the cabbage aphid. These findings are parallel with the results presented by Tomova et al. (2005), Sampson et al. (2005) and Digilio et al. (2008). Sampson et al. (2005) reported an increase in the mortality rate of turnip aphid, *Lipaphis pseudobrassicae* Davis, when reared on different essential oils. Tomova et al. (2005) demonstrated significant effects of the *T. minuta* oil against three aphid species indicating a potential for aphid control. *T. vulgaris* essential oil application resulted in about 80 % mortality in cabbage aphid. Klingauf et al. (1983) results are parallel with our findings where they reported almost 100 % mortality caused by essential oils of the anise and eucalyptus against rose-grain aphid, *Metopolophium dirhodum* (Walker). Gorur et al. (2008) reported similar effects of *Thymus vulgaris* L., *Veronica officinalis* L. and *Agrimonia eupatoria* L. essential oil against cabbage aphid. *Thymus* oil application resulted in about 85 % mortality in cabbage aphid population. In contrary to Gorur et al. (2008) findings, there were clear dose effects of essential oil on daily fecundity of the cabbage aphid. Cabbage aphid population showed significantly lower performance on 2 µl dose application. These differences might be due to very low performance of cabbage aphid exposed to both 1 µl and 2 µl *Thymus* essential oil. Kanat and Alma (2003) reported that different concentrations of various plants resulted in different insecticidal activity against larvae of pine processionary moth, *Thaumetopoea pityocampa* Schiff. Digilio et al. (2008) also showed that application dose of various essential oils resulted in significant differences in mortality rate for *M. persicae* and *A. pisum*.

Considering other control strategies of pests, both efficiency and being environmental friendly reasons makes essential oils much preferable insecticides against different pest groups, particularly against the aphid. Recent studies showed that compared with the other control strategies, essential oil applications have several advantages. Their applications affect aphids and some other pest in a short time by killing them faster and reducing their reproduction potential. Using essential oil as an aphidicide is also safer for the environment and human health because of their low toxicity and shorter degradation time.

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LITERATURE CITED

Bhathal, S. S. & Singh, D. 1993. Toxic and developmental effects of some neem products against mustard aphid, *Lipaphis erysimi* (Kalt.) through leaf surface treatment. Journal of Insect Science, 6: 226-228.

Blackman, R. L. & Eastop, V. F. 2000. Aphids on the World's crops: An identification and information guide. Second Edition, John Wiley & Sons Ltd., U.K., p. 414.

Buchbauer, G. 2000.The detailed analysis of essential oils leads to the understanding of their properties. Perfumer and Flavorist, 25: 64-67.

Choi, W. I., Lee, L. H., Choi, R. B., Park, H. M., & Ahn, Y. J. 2003. Toxicity of plant essential oils to *Trialeurodes varporariorum* (Homoptera: Aleyrodidae). Journal of Economic Entomology, 96(5): 1479-1484.

Digilio, M. C., Mancini, E., Voto, E., & De Feo, V. 2008. Insecticide activity of Mediterranean essential oils. Journal of Plant Interactions, 3(1): 17-23.

Görür, G., Abdullah, M. I., & Işık, M. 2008. Insecticidal activity of the *Thymus*, *Veronica* and *Agrimonia's* essential oils against the cabbage aphid, *Brevicoryne brassicae* Acta Phytopathologica et Entomologica Hungarica, 43(1): 203-210.

Isman, M. B. 2000. Plant essential oil for pest and disease management. Crop Protection, 19: 603-608.

Isman, M. B. 2005. Botanical insecticides, deterrents and repellents in modern agriculture and an increasing regulated world. Annual Review of Entomology, 51: 45-66.

Jaastad, G. 2007. Late dormant rapeseed oil treatment against black cherry aphid and cherry fruit moth in sweet cherries. Journal of Applied Entomology, 131(4): 284-288.

Kanat, M. & Alma, M. H. 2003. Insecticidal effects of essential oils from various plants against larvae of pine processionary moth (*Thaumetopoea pityocampa* Schiff) (Lepidoptera:Thaumetopoeidae). Pest Management Science, 60: 173-177.

Klingauf, F., Bestman, H. J., Vostrovsky, O. & Michaelis, K. 1983. Wirkung von atherischen ¨Olen auf Schadinsekten. Mitteilungen der Deutschen Gesellschaft für Allgemeine und Angewandte Entomologie, 4: 123–126.

Ngamo, T. S. L., Ngatanko, I., Ngassoum, M. B., Mapongmestsem, P. M. & Hance, T. 2007. Persistence of insecticidal activities of crude essential oils of three aromatic plants towards four major stored product insect pests, African Journal of Agricultural Research, 2(4): 173-177.

Pavela, R. 2005. Insecticidal activity of some essential oils against larvae of *Spodoptera littoralis*. Fitoterapia, 76:691-696.

Rahman, A. & Talukder, F. A. 2006. Bioefficacy of some plant derivatives that protect grain against the pulse beetle, *Callosobruchus maculatus*. Journal of Insect Science, 6: 03.

Roy, H. E., Pell, J. K. & Alderson, P. G. 1999. Effects of fungal infection on the alarm responses of pea aphids. Journal of Invertebrate Pathology, 74: 69-75.

Ruberson, J. R. 1999. Handbook of Pest Management. Published by Marcel Dekkar Inc., New York, p. 842.

Sampson, B. J., Tabanca, N., Kirimer, N., Demirci, B., Baser, K. H. C., Khan, I. A., Spiersi, J. M., & Wedge, D. E. 2005. Insecticidal activity of 23 essential oils and their major compounds against adult *Lipaphis pseudobrassicae* (Davis) (Aphididae: Homoptera). Pest Management Science, 61: 1122-1128.

Sarac, A., & Tunc, I. 1995. Toxicity of essential oil vapours to stored product insects. *Zeitschrift fuer Pflanzenkrankheiten und* Pflanzenschutz, 102: 69-74.

Tomova, B. S., Waterhouse, J. S., & Doberski, J. 2005. The effect of fractionated Tagetes oil volatiles on aphid reproduction. Entomologia Experimentalis et Applicata, 115: 153-159.

Tunç, I., & Şahinkaya, S. 1998. Sensitivity of two greenhouse pests to vapours of essential oils. Entomologia Experimentalis et Applicata, 86: 183-187.

Zapata, N., Budia, F., Vinuela, E. & Medina, P. 2006. Insecticidal effects of various concentrations of selected extractions of *Cestrum parqui* on adult and immature *Ceratitis capitata*. Ecotoxicology, 99(2): 359-365.

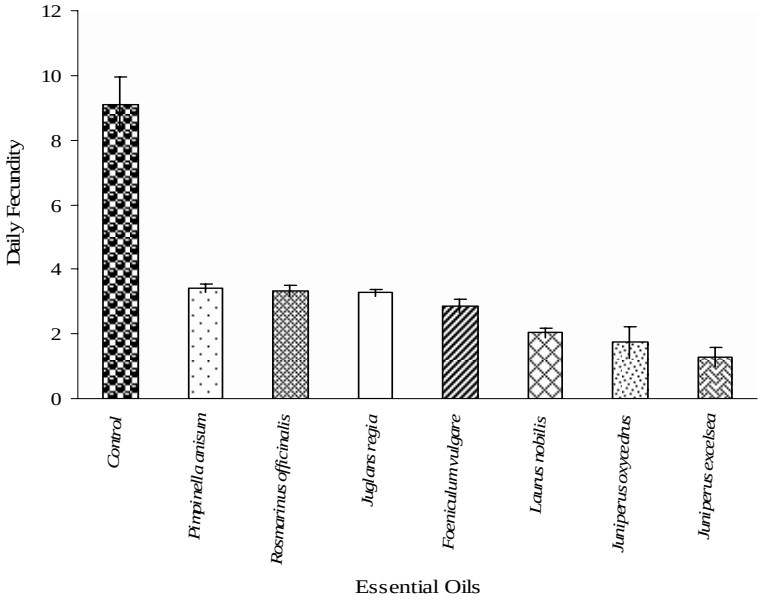


Figure 1. Mean daily fecundity of the cabbage aphid population exposed to three different plant essential oils (Each bar represent the mean±SE).

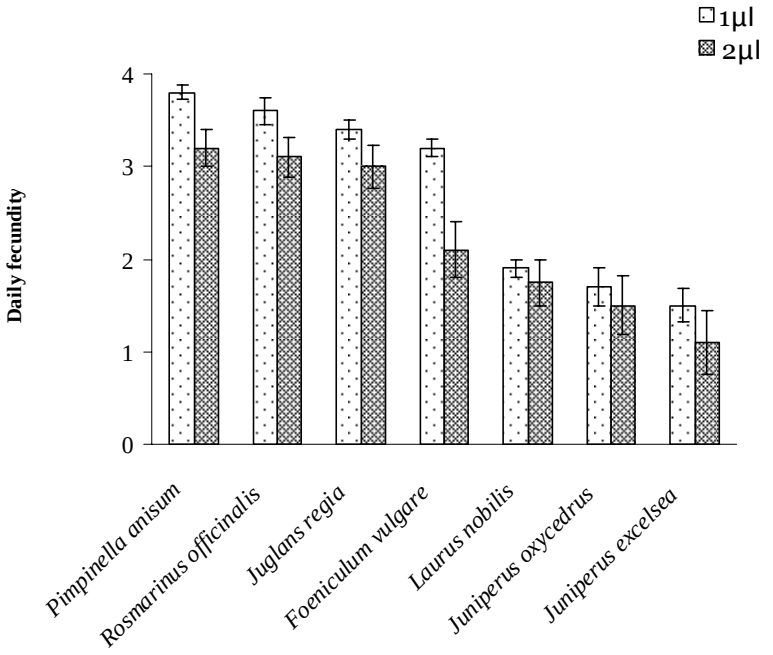


Figure 2. Dose dependent effects of essential oils on daily fecundity of the *Brevicoryne brassicae* (Each bar represent the mean±SE)

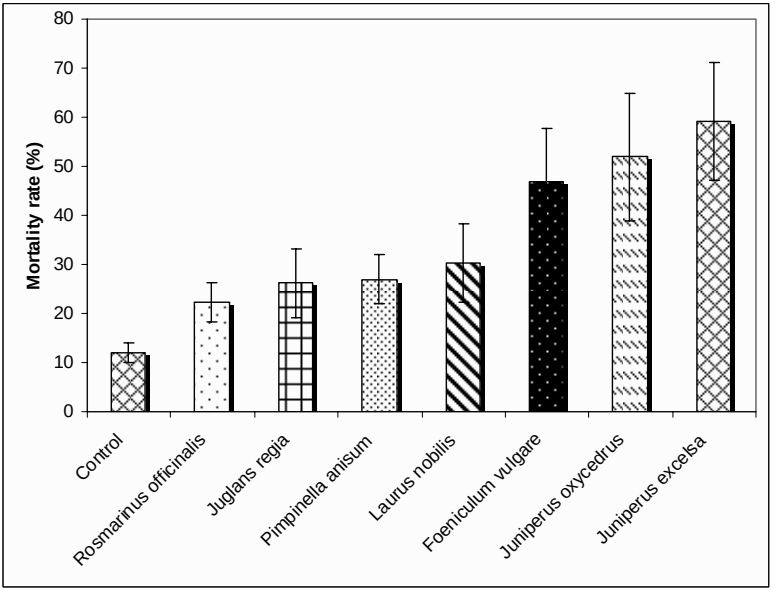
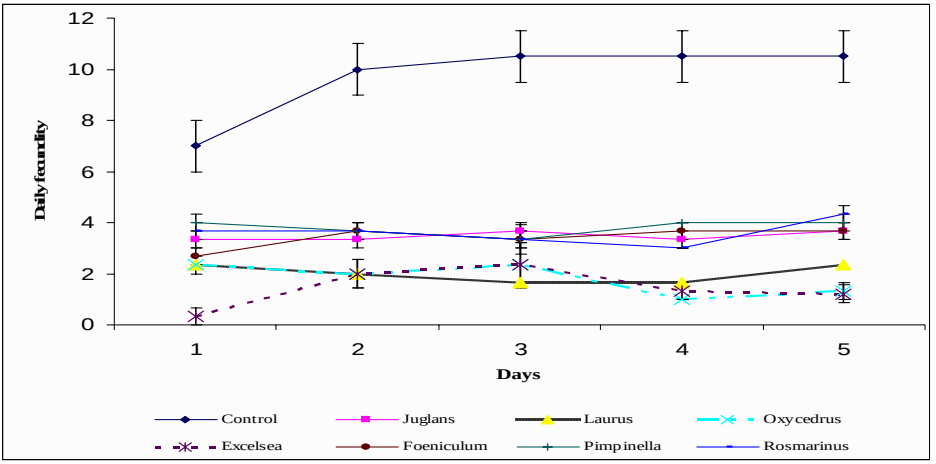
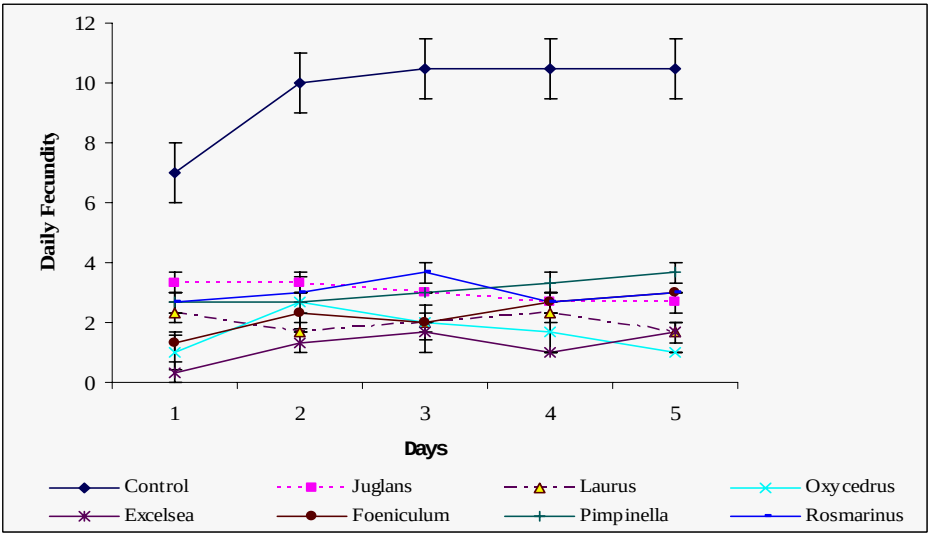


Figure 3. Mortality rate (%) of the cabbage aphid exposed to 7 essential oils.



a)



b)

Figure 4. Exposure period effects on the fecundity of cabbage aphid, a) for the 1 µl dose applications, b) for the 2 µl dose application.