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Effectiveness of different bio–rational insecticides applied on wheat plants to control cereal aphids

Laborstudie zur Wirksamkeit verschiedener Insektizide auf Blattläuse an Weizen

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Abstract

The efficacy of range of compounds: three botanical insecticides (NeemAzal T/S, Trifolio S-forte and an extract of *Quassia amara* L.) and two pyrethroid insecticides, lambda-cyhalothrin (Karate 9.4% S.C) and deltamethrin (Decis 2.8% E.C.) were evaluated to control *Rhopalosiphum padi* (L.) and *Metopolophium dirhodum* (Wlk.). Different concentrations were used to study efficiency of the tested compounds on both aphid species 24, 48 and 72 hours post treatment in the laboratory. Bio-residual activity of these compounds was evaluated on wheat plants in the greenhouse. *M. dirhodum* was more susceptible than *R. padi* in all treatments. The mortality reached 100% after 24 h in *M. dirhodum* and after 48 h in *R. padi*. Most of the tested compounds caused acceptable levels of cereal aphid's control. A sharp decrease in persistence of the bioactivity of tested compounds against the 4th instar of *R. padi* and *M. dirhodum* was noticed after 7 days from application. Bio-residual activity declined with days, started with more than 80% on zero time and reached 12% after 7 days in Decis, while it was 70% on zero time and reached 10% after 7 days in Karate. Decis, Karate and NeemAzal T/S are considered the most effective in controlling cereal aphids.

Key words: aphids, bioassay, bio-residual, neem, pyrethroids, *Quassia amara*

Zusammenfassung

Die Getreideblattläuse, *Rhopalosiphum padi* (L.) und *Metopolophium dirhodum* (Wlk.), gelten als wichtigste Schädlinge an Weizen. Die Wirksamkeit von drei botanischen Insektiziden und zwei Pyrethroid-Insektiziden wurde ausgewertet. Es wurden verschiedene Konzentrationen verwendet, um die Effizienz der getesteten Verbindungen 24, 48 und 72 Stunden nach der Behandlung im Labor zu prüfen. Die Bio-Restaktivität dieser Testsubstanzen wurde im Gewächshaus analysiert. Gegenüber allen Testsubstanzen zeigte *M. dirhodum* eine höhere Empfindlichkeit als *R. padi*. Eine Sterblichkeit von 100% erreichte *M. dirhodum* nach 24 Stunden, während bei *R. padi* eine 100% tige Mortalität nach 48 Stunden registriert wurde. Die meisten Testsubstanzen regulierten Getreideblattläuse auf akzeptablem Niveau. Die Bio-Restaktivität lag bei Decis nach 7 Tagen bei 12% und erreichte bei Karate nach 7 Tagen einen Wert von 10%. Die Ergebnisse zeigen, daß Karate, Decis und NeemAzal T/S geeignet sind, Getreideblattläuse effizient zu bekämpfen. Die Ergebnisse sollten unter Feldbedingungen evaluiert werden.

Stichwörter: Bioassay, Bio-Restaktivität, Getreideblattläuse, Neem, Pyrethroide, *Quassia*

1 Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops and a staple food throughout the world. Cereal aphids, especially *Rhopalosiphum padi* (L.) and *Metopolophium dirhodum* (Wlk.), are sporadic pests of wheat (George 1974; Carter et al. 1980). The aphids initiate feeding at the base of the leaves near the top of the plant. As the colony develops, the leaf edges begin to roll inward, enclosing the aphids in tubular, protective structure.

The strategy of control adopted against those aphid species depends on the damage they cause and the cost of control (Watt et al. 1984). The probability of an outbreak and the accuracy of any available forecast (Watt 1983), also Watt (1983), sets the loss in grain weight caused by an outbreak at 12.5% (an average level reported by George and Gair (1979)) and the control measures envisaged were assumed to be completely effective. However, aphid control is unlikely to prevent damage to the extent predicted, as there are usually unavoidable delays in applying insecticides (Vickerman and Wratten 1979). The grower must, therefore, make tactical decisions based on the changing pest burden on his crops (Dewar and Carter 1984). The amount of damage caused by aphids depends on the aphid infestation and its timing; the effect of a given number of aphids on wheat yield declines as the crop matures (Lee et al. 1981; Holt et al. 1984).

Carter et al. (1989) stated that insecticides applied to control aphids on winter wheat resulted in yield increases. As pyrethroids are broad-spectrum insecticides, the possible long-term consequences for natural enemy populations have to be assessed before they can be recommended for use in cereals (Ruscoe 1977; Jutsum et al. 1984; Niehoff and Poehling 1995; Sipes 1999; Khan and Maqbool 2002). The application of deltamethrin reduced the cereal aphid's populations and enhanced the wheat yield (Mann et al. 1991; Hill et al. 1993; Wiles and Jepson 1995). Lai (1992) conducted an experiment to test the efficacy of various insecticides against wheat aphids with cypermethrin at 10 g ha^{-1} and deltamethrin at 10 g ha^{-1} providing good control of aphids. The commercial relevance of Decis and Karate was increased for their good efficiency in controlling many insect pests in Germany. Other control materials of cereal aphids are botanical insecticides; Neem and *Quassia amara* L. had given a good control for *Helicoverpa armigera* (Hüb.) (Aggarwal et al. 2006) and *Quassia* extract achieved a considered control for cereal aphids (Sengonca and Brüggen 1991; Holaschka et al. 2006).

This paper aims to quantify the economic value of aphid control. This study compares the effectiveness of some tested compounds in terms of aphid control to reduce damage of cereal aphids on wheat plants.

2 Materials and methods

2.1 *Wheat plants and cereal aphids*

Wheat, *T. aestivum* (Tommi cultivar), were sown in small pots in the controlled greenhouse. The wheat plants (3-week old) were used in bioassay and bioresidual studies. Susceptible strains of *R. padi* and *M. dirhodum* were provided by Dr. Schliephake from Julius Kühn Institute in Quedlinburg, Germany. These aphid species were populated on wheat plants till having sufficient aphids to start the experiments. Young apterous females (4th instar) were used in this study. This study was conducted in Plant Protection group in Institute of Agricultural and Nutritional Sciences, in Halle University, Halle, Germany.

2.2 *Tested compounds*

Three botanical insecticides are NeemAzal T/S (50, 100, 200, 300, 400 and 500 µl); Trifolio S-forte (100, 200, 400, 700 and 800 µl) and *Quassia amara* (0.5, 1, 2, 4, 6 and 8 mg) which were provided by Trifolio-M GmbH, Lahnau, Germany. The two pyrethroid insecticides are lambda-cyhalothrin (Karate 9.4% S.C) (0.3, 0.6, 1.25, 2.5, 5 and 10 ppm) and deltamethrin (Decis 2.8% E.C.) (2.5, 5, 10, 20, 30 and 40 ppm); they were evaluated on 4th nymphal instar of two cereal aphids, *R. padi* and *M. dirhodum*.

A stock solution of each tested compound was prepared and subsequent serial concentrations were made by diluting with water (v/v) or (w/v) to give the necessary concentrations inducing (20–80%) mortality for each material. Concentration of each insecticide was prepared from time to time as needed.

2.3 *Bioassay studies of tested compounds (leaf-dip bioassay)*

Wheat leaves were dipped in the prepared insecticidal solution for 10 seconds then left for complete dryness on towel paper. Then leaves were placed upside down in a small Petri dish (10 mm diameter); ten healthy apterous adults were placed on the treated leaves surface of each Petri dish. Leaves dipped in tap water were used as control. Three replicate batches of aphids (i.e. 30 insects) were used per each concentration. Petri dishes containing aphids were carefully closed and kept to count mortality percents (24, 48 and 72 hours after application). All Petri dishes were kept in an incubator (25 ± 2°C and R.H. 62 ± 3%). The mortality percents were corrected according to Abbott's formula (Abbott 1925). All the mortality data were statistically analyzed according to the method adopted by Finney (1971).

2.4 *Residual efficacy assays*

Bio residual activity of tested compounds, Decis, Karate, and NeemAzal T/S was studied on both aphid species on wheat plants under greenhouse conditions. Treatments were applied using a calibrated sprayer that delivered spray solution to wheat plants (Jansson et al. 1998). 20-day old plants were sprayed by recommended rates mentioned above. Control treatment was only sprayed with water. Random samples of treated leaves were taken at 0, 1, 3, 5, and 7 days after spraying. Ten nymphs of the 4th instar were transferred to a Petri dish in which the treated leaves were placed. The Petri dishes were kept in an incubator for 24 hours after which mortality counts were made. The mortality percentages were corrected according to Abbott's formula (Abbott 1925). The whole data were analyzed by linear model (ANOVA) using Statistix 8 (Thomas and Maurice 2008). Significant differences were noted at $P < 0.05$ for all trials.

3 Results

3.1 *Bioassay of tested compounds on cereal aphids*

3.1.1 Karate treatment. Mortality percents of *R. padi* ranged from 19.3 to 86.7% at rate of 0.3 and 10 ppm post 24 hours, while ranged from 33.3 to 100% after 48 hours and from 41.6 to 100% post 72 hours at rate of 0.3 and 10 ppm, respectively. Mortality percents of *M. dirhodum* ranged from 26.7 to 100% at rate of 0.3 and 10 ppm post 24 hours, while ranged from 39.2 to 100% after 48 hours and from 62.5 to 100% post 72 hours at rates of 0.3 and 10 ppm, respectively (Table 1).

3.1.2 Decis treatment. Mortality percents of *R. padi* ranged from 13.9 to 82.7% at rate of 5 and 40 ppm post 24 hours, while ranged from 18.6 to 96.3% after 48 hours and from 40 to 100% post 72 hours at rate of 5 and 40 ppm, respectively. Mortality percents of *M. dirhodum* ranged from 14.8 to 85.2% at rate of 2.5 and 30 ppm post 24 hours, while ranged from 43.9 to 100% after 48 hours and from 62.5 to 100% post 72 hours at rate of 2.5 and 30 ppm, respectively (Table 1).

3.1.3 NeemAzal T/S treatment. Mortality percents of *R. padi* ranged from 0.0 to 46.4% at rate of 50 and 500 µl post 24 hours, while ranged from 6.7 to 65.4% after 48 hours and from 16.7 to 87.8% post 72 hours at rate of 50 and 500 µl, respectively. Mortality percents of *M. dirhodum* ranged from 0.0 to 40.8% at rates of 50 and 400 µl post 24 hours, while ranged from 11.5 to 73.1% after 48 hours and from 20.9 to 95.9% post 72 hours at rates of 50 and 400 µl, respectively (Table 1).

3.1.4 Trifolio S-forte treatment. Mortality percents of *R. padi* ranged from 0.0 to 10.3% at rate of 100 and 800 µl post 24 hours, while ranged from 0.0 to 38.9% after 48 hours and from 17.8 to 85.7% post 72 hours at rate of 100 and 800 µl, respectively. Mortality percents of *M. dirhodum* ranged from 3.5 to 13.9% at rate of 100 and 800 µl post 24 hours, while ranged from 0.0 to 61.1% after 48 hours and from 19.2 to 96.0% post 72 hours at rate of 100 and 800 µl, respectively (Table 1).

3.1.5 *Quassia amara* treatment. Mortality percents of *R. padi* ranged from 0.0 to 20.0% at rate of 0.5 and 8 mg post 24 hours, while ranged from 7.0 to 33.3% after 48 hours and from 15.5 to 92.0% post 72 hours at rate of 0.5 and 8 mg, respectively. Mortality percents of *M. dirhodum* ranged from 6.9 to 22.2% at rate of 0.5 and 8 mg post 24 hours, while ranged from 27.0 to 50.0% after 48 hours and from 33.4 to 96.0% post 72 hours at rate of 0.5 and 8 mg, respectively (Table 1).

Generally, *M. dirhodum* was more susceptible than *R. padi*. The mortality percents reached to 100% after 24 h on *M. dirhodum*, while achieved on *R. padi* after 48 h. The highest mortality was recorded in pyrethroids (Karate, then Decis) compared to botanical insecticides which ordered as (NeemAzal T/S, Trifolio S- forte and *Quassia amara*). The best concentrations were in Karate (10 ppm), Decis (30–40 ppm), NeemAzal T/S (400–500 µl), Trifolio S-forte (800 µl) and *Quassia amara* (8 mg) (Table 1).

3.2 *Residual efficacy assays*

A sharp decrease in persistence of the bioactivity of tested compounds against the 4th instars of *R. padi* and *M. dirhodum* could be noticed after 7 days from application. Residual effi-

Table 1: Effect of botanical and synthetic insecticides (Abbott values) on the mortality of 4th instars of *Rhopalosiphum padi* and *Metopolophium dirhodum* under laboratory conditions. Different letters indicate significant differences in all treatments.

Tested insecticides	Concentration	Mean percentage mortality of *Rhopalosiphum padi* after			Mean percentage mortality of *Metopolophium dirhodum* after		
		24h	48h	72h	24h	48h	72h
Karate	10 (ppm)	86.70 B	100.00 A	100.00 A	100.00 A	100.00 A	100.00 A
	5	73.30 C	88.89 B	100.00 A	88.47 B	100.00 A	100.00 A
	2.5	60.00 D	74.11 C	83.33 B	65.40 D	91.63 AB	100.00 A
	1.25	42.33 E	59.22 D	79.16 C	46.70 E	83.38 B	95.88 AB
	0.625	33.33 F	48.11 E	58.34 D	38.52 F	79.13 C	87.50 B
	0.313	19.26 GH	33.33 F	41.66 E	26.67 G	39.16 F	62.50 D
Decis	40 (ppm)	82.73 B	96.33 A	100.00 A	–	–	–
	30	51.71 D	88.89 B	96.04 A	85.22 B	100.00 A	100.00 A
	20	34.54 F	63.00 D	75.99 C	63.00 D	87.99 B	100.00 A
	10	20.68 G	33.33 F	48.02 E	40.78 EF	72.03 C	83.38 B
	5	13.86 H	18.56 GH	39.98 F	25.89 G	55.94 D	75.00 C
	2.5	–	–	–	14.78 H	43.94 E	62.50 D
Neem Azal T/S	500 (μl)	46.41 E	65.40 D	87.80 B	–	–	–
	400	35.69 F	57.67 D	79.95 BC	40.76 EF	73.13 C	95.86 A
	300	21.76 G	34.60 F	60.02 D	29.67 F	57.67 D	87.50 B
	200	17.47 GH	23.07 G	43.94 E	22.22 G	50.06 DE	66.63 D
	100	7.07 I	11.33 H	19.93 GH	3.67 J	34.60 F	50.00 DE
	50	0.00 K	6.67 I	16.67 GH	0.00 K	11.53 H	20.88 G
Trifolio S-forte	800 (μl)	10.34 H	38.91 F	85.74 B	13.86 H	61.16 D	96.04 A
	700	6.93 I	21.44 G	71.38 C	10.34 HI	46.14 E	84.03 B
	400	6.93 I	17.79 GH	49.95 E	3.52 J	23.07 G	55.94 D
	200	3.52 J	10.72 H	25.00 G	3.52 J	11.53 H	36.01 F
	100	0.00 K	0.00 K	17.79 GH	3.52 J	0.00 K	19.24 G
Quassia amara	8 (mg 100 ml^{-1})	20.00 G	33.33 F	92.00 AB	22.22 G	50.02 DE	96.00 A
	6	14.78 H	26.95 G	76.02 C	10.00 H	60.00 D	84.01 B
	4	6.93 I	28.39 G	46.14 E	17.27 GH	53.86 DE	75.00 C
	2	6.93 I	28.39 G	38.52 F	10.34 H	50.06 DE	62.50 D
	1	0.00 K	14.19 H	19.26 GH	10.34 H	34.60 F	45.88 E
	0.5	0.00 K	7.04 I	15.46 H	6.93 I	26.99 G	33.38 F

cacy data under glasshouse conditions were correlated with the spectrum and laboratory data. Bio-residual activity for Decis started with (83.3–80.0%) on zero time and reached to (17.4–12.7%) after 7 days on *M. dirhodum* and *R. padi*, respectively. The corresponding values with Karate were (60–72%) and (13.2–10.0%). On the other hand, bio- residual activity of NeemAzal T/S ranged from 22.2–20.0% on zero time and reached to 0.0–7.9% on *M. dirhodum* and *R. padi*, respectively. In general mean persistence of bioactivity for Decis, Karate and NeemAzal T/S on *M. dirhodum* was 48.3, 42.7 and 14.7%, respectively. The corresponding values on *R. padi* were 48.6, 38.5 and 15.7% (Fig. 1).

4 Discussion

R. padi and *M. dirhodum* caused significant damage (in statistical and economic terms) on wheat plants under greenhouse conditions. It is noted that the both of cereal aphids show quite different reactions to tested compounds. One possible explanation for the lesser impact of the concentrations on *R. padi* than *M. dirhodum* is due to different behaviour of both aphid species with tested compounds. A significant improvement in aphid performance was observed when sublethal concentrations of Karate and Decis were supplied to aphids through detached leaves. Similar results have been obtained with sublethal concentrations of other toxicants given to wheat aphids (Mann et al. 1991). Similar results are obtained by Sengonca and Brüggen (1991) and Holaschka et al. (2006), who mentioned that the spray Neem and Quassia extract, caused mortality over 95% against *R. padi*. Furthermore, our results indicate that the NeemAzal T/S, Trifolio S-forte and Quassia achieved a satisfactory control level on *R. padi* and *M. dirhodum* and in the same time keep the environment clean.

Bio-residual activityof the tested compounds declined with days; this result is similar with those obtained by Drager (1974) and Aharonson et al. (1979). Neem products also serve as a feeding deterrent for some insects. Depending on the stage of life-cycle, insect death may not occur for several days. However, upon ingestion of minute quantities, insects become quiescent and stop feeding. Residual insecticidal activity is evident for up to seven days, depending on both aphid species and concentrations.

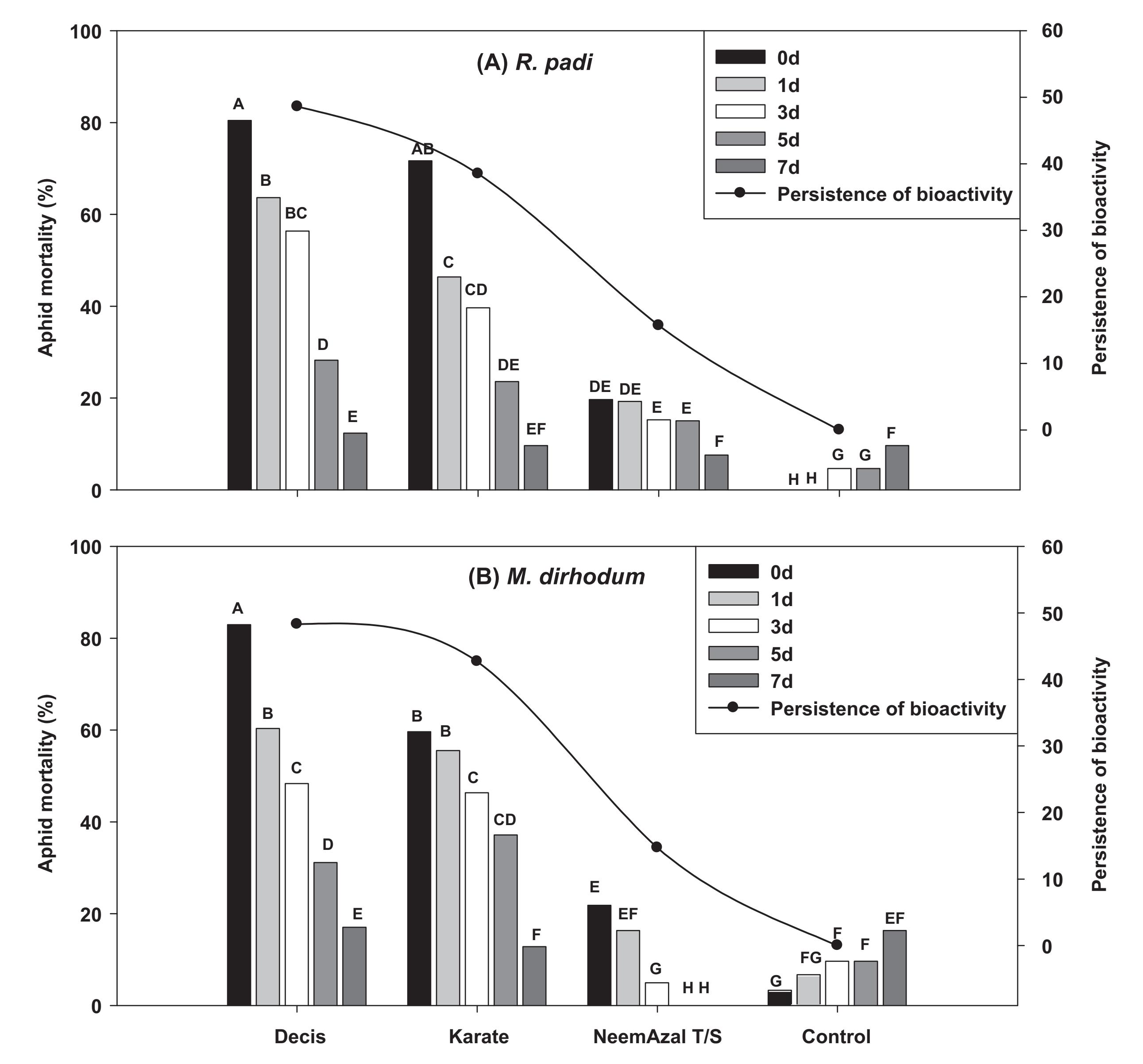

Fig. 1: Effect of Decis, Karate and NeemAzal T/S on mortality of 4th instar nymphs of *Rhopalosiphum padi* (A) and *Metopolophium dirhodum* (B) on wheat plants under greenhouse conditions. Different letters indicate significant differences in all treatments.

The survey and analysis revealed a considerable economic shortfall resulting from sub-optimal insecticide use on cereals. This point leads to a continuing need for a practical and accessible system of field-by-field decision-making for farmers to avoid the economic and environmental consequences of over-use of insecticides on cereals. Neem is active in organic agriculture to be used as a natural substance and to keep the environment clean. Therefore, Decis, Karate and NeemAzal T/S could be considered suitable for cereal aphid's control if the results can be repeated in wheat field studying their effectiveness in order to prove their field performance and IPM compatibility.

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