JOURNAL OF PLANT PROTECTION RESEARCH
Vol. 44, No. 1 (2004)

EFFECT OF MAGNETIZED WATER ON THE EFFECTIVENESS OF SELECTED ZOOCIDES IN THE CONTROL OF RED SPIDER MITE (*TETRANYCHUS URTICAE* KOCH) AND GRAIN WEEVIL (*SITOPHILUS GRANARIUS* L.)

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Accepted: March 18, 2004

Abstract: The results of experiments showed an effect of magnetized water on the effectiveness of some selected zoocides. The control of red spider mite (*Tetranychus urticae* Koch) by Ortus 05 SC showed the highest effectiveness with strongly magnetized water, with use of one magnetizer and two semi-rings. On the other hand, the application of Magus 200 SC in combination with magnetized water showed a decreased effectiveness of insecticide. In the control of grain weevil (*Sitophilus granarius* L.), an increase in the effectiveness was found for the zoocides Talstar 100 EC, Karate 025 EC and Winylofos 550 EC in combinations with strongly magnetized water (three magnetizers or one magnetizer with two rings). In case of Sumi-Alpha 050 EC, high effectiveness of the treatment was obtained in combinations where water was magnetized in lesser degree, with use of one or two magnetizers. No significant differences were found in the effect of magnetized water on germination of bean (*Phaseolus vulgaris* L.) and cuckoo flower (*Cardamine amara* L.) plants.

Key words: magnetized water, effectiveness of zoocides, chemical control, red spider mite, grain weevil

INTRODUCTION

Water used as diluent of almost all plant protection agents possesses properties which may negatively affect on their biological effectiveness in the control of pests. These water properties include, among others, pH reaction, hardness (minerals solved in water, mainly calcium and magnesium) and organic molecules suspended in water, the so called "dirty water" (Reeves 2000).

The properties of the spray mixture can be modified by different type of chemical agents – adjuvants (Adamczewski and Matysiak 1997; Woźnica 1999; Wachowiak 1993; Wachowiak and Kierzek 2002) and as well as by water conditioning installations (Biłozor 1994; Orłowski and Dobromilska 1998). Such installations include, among others, magnetic activators (magnetizers) that are more and more frequently applied in water, fuel and gas supply systems used in industry and motorizations. Magnetic field generated by the magnetizer orders and combines conglomerates, i.e. water molecule clusters, into bigger elements with an increased electric load catching ionized molecules with an opposite sign from the surroundings. The magnetizer's action changes gas concentration in water. An increased concentration is shown by oxygen (O_2), while the levels of carbon dioxide (CO_2), ozone (O_3) and chlorine (Cl_2) decrease. It has been found that after each water magnetization, its iron Fe^{2+} content increases. Because of the increased amount of oxygen, iron is oxidized to a trivalent form Fe^{3+}. Due to this reaction, there follows a quick precipitation of ferric hydroxide Fe $(OH)_3$ sediment. This causes that iron compounds in magnetized water do not increase the total hardness. The action of magnetic field changes the electrokinetic potential of water, the surface tension and viscosity, and it also contributes to the stabilization of pH reaction.

Magnetizers have found a wide application in different industry branches. Magnetizer rings are mounted on pipelines supplying fuel to combustion engines of different types, as well as on pipelines supplying gas to heating installations. Gas magnetizers are used for the breaking up and ordering of chaotically distributed hydrocarbon molecules into structures that combine more easily with oxygen molecules. Magnetizers play also an important role in water supply systems. After the installation of magnetizer on water supply pipe, the water flowing through it becomes softer. These types of installations are mounted in water supply systems distributing water with a better ability to remove boiler scale in household water supply systems, in swimming pools, in sports objects and hydrotherapeutic systems, as well as in installations used in agriculture and horticulture. Magnetically activated water has been found to exert a favourable effect on the acceleration of vegetation period and plant fertility (Orłowski and Dobromilska 1998). Actually, investigations are carried out on the effect of magnetized water on the effectiveness of plant protection treatments.

The objective of the present studies was the evaluation of the effectiveness of the magnetic activator of new generation "Multimag" in the modification of the properties of spray mixtures containing plant protection agents. Several zoocides have been tested to evaluate their effectiveness in the control of red spider mite (*Tetranychus urticae* Koch) and grain weevil (*Sitophilus granarius* L.) with the application of water magnetized in different degrees. At the same time, the effect of magnetized water on the germination and growth of cuckoo flower (*Cardamine amara* L.) and bean (*P. vulgaris* L.) plants has been defined.

MATERIAL AND METHODS

Studies on the effect of magnetized water on the effectiveness of selected zoocides in the control of red spider mite (*T. urticae* Koch) and grain weevil (*S. gra-*

narius L.) were carried out in the years 2002 and 2003, in the Department of Plant Protection Methods Agricultural University in Poznań.

The tested plant protection agents were used in minimal doses (Tab. 1). The dose was regarded as a minimal one when it killed about 50% of the studied pest populations. The minimal dose was determined after a series of experiments with the application of the given product where the commercially recommended dose was decreased to a level giving 50% of effectiveness. Water for the experiment was taken from a water supply pipeline of 1/2 inch diameter on which one, two or three magnetizers were mounted (semi-ring with a stand), or one magnetizer with two additional semi-rings. In the control object, simple tap water was used. All treatments were carried out with a manual pressure sprayer "Mercury" (Kwazar Co.) using 100 ml of spray mixture per 1 m^2 of surface on which flower pots with bean plants infested by red spider mite (minimum 100 individuals on one plant), or Petri dishes with grain weevil (20 individuals) were treated. The experiment was carried out in 3 replications. The effectiveness of the tested plant protection agents was defined using Henderson-Tilton formula, based on the number of pest individuals found before and 24 hours after treatment.

The evaluation of the effect of water magnetization degree on plant germination and growth was carried out on bean and cuckoo flower plants. Two experiments were performed; one referred to the germination of seeds on Petri dishes (20 seeds of bean and 50 seeds of cuckoo flower plants on one dish). After 8 days, observations of seeds watered with waters magnetized in different degrees were performed. The second experiment with an identical design was established in flower-pot cultivation. The number of germinating plants was evaluated 21 days after seed sowing. The experiment was repeated three times.

All numerical results were statistically analysed using the Student's t-test at the significance level of $p=0.05$.

A chemical analysis of the water used in the different experimental combinations was carried out as well.

RESULTS AND DISCUSSION

Table 1 shows plant protection agents used in the experiments and the identified minimal doses for the control of the tested pest populations.

The minimal dose of the products used to control red spider mite was twice to four times smaller than the recommended one. In case of grain weevil, the Talstar 100 EC product was applied at the commercially recommended dose because it showed 50% effectiveness, while the dose of Sumi-Alpha 050 EC could be reduced even fifteen times.

A chemical analysis of different water combinations with different degrees of magnetization showed no differences in the physical qualities (Tab. 2). However, in the magnetized water, one could notice a small increase of the content of phosphorus, calcium, SO_4 anion group, iron and manganese. An increase of iron content in magnetized water was also reported by Szczypiorowski et al. (2001).

According to the authors of the present work, the reactions taking place in magnetized water and leading to a change of its content could have been influenced by the

Table 1. Zoocides and their doses included in the study

No.	Name of the zoocide	Biologically active substance and its content in g/l	Recommended dose per one litre of liquid	Minimal dose applied per one litre of liquid
		Red spider mite		
1.	Magus 200 SC	fenazaquin – 200 g	0.06 ml	0.015 ml
2.	Omite 30 WP	propargite – 300 g	1.00 g	0.500 g
3.	Ortus 05 SC	fenpyroximate – 50 g	1.60 ml	0.400 ml
4.	Talstar 100 EC	bifenthrin – 100 g	0.25 ml	0.125 ml
		Grain weevil		
5.	Karate 025 EC	lambda-cyhalothrin – 25 g	0.05 ml	0.005 ml
6.	Sumi-Alpha 050 EC	esfenvalerate – 50 g	0.03 ml	0.002 ml
7.	Talstar 100 EC	bifenthrin – 100 g	0.25 ml	0.250 ml
8.	Winylofos 550 EC	dichlorvos – 550 g	0.10 ml	0.025 ml

Table 2. Effect of water magnetization on the chemical and physical properties of it

No.		Experimental object				
		one magnetizer	two magnetizers	three magnetizers	one magnetizer and two semi-rings	control
		Macro and microelements in mg/l				
1.	NO_3	1.100	0.700	1.100	0.700	1.100
2.	P	0.840	0.890	0.710	0.800	0.670
3.	K	2.200	2.200	2.200	2.300	2.300
4.	Ca	88.700	89.300	89.100	90.900	86.600
5.	Mg	12.000	12.500	12.400	12.500	11.900
6.	Na	24.700	25.000	24.900	25.000	24.500
7.	Cl	28.600	27.900	30.200	25.000	30.500
8.	SO_4	66.000	66.400	66.700	67.300	57.800
9.	HCO_3	4.07	4.050	4.140	4.120	4.020
10.	Fe	0.083	0.086	0.085	0.110	0.073
11.	Mn	0.013	0.010	0.006	0.005	trace element
12.	Zn	0.048	0.049	0.047	0.047	0.047
13.	Cu	0.012	0.013	0.009	0.009	0.018
14.	B	0.008	0.007	0.009	0.008	0.006
		Physical properties				
15.	pH	7.600	7.840	7.860	7.860	7.870
16.	EC*	0.7430	0.739	0.735	0.737	0.719
17.	Dc**	72.000	72.000	72.000	72.000	72.000

* EC – electric conductivity (mS)

** Dc – surface tension (mN/m)

chemical processes taking place in the spray mixture prepared with different plant protection agents. Maybe, the chemical composition of the product and the content of adjuvants introduced into the tank mixture could have been modified by water conditioning affecting thereby on the biological effectiveness of plant protection agents.

Results shown in table 3 indicate that different degrees of water magnetization give slightly different reactions depending on the applied plant protection agents.

Table 3. Effect of magnetized water on the effectiveness of zoocides in the control of red spider mite (*Tetranychus urticae* Koch)

No.	Experimental object	Mean effectiveness of applied products in percentage			
		Magus 200 SC	Omite 30 WP	Ortus 05 SC	Talstar 100 EC
1.	One magnetizer	67.02 ab	66.74 a	66.60 a	75.61 a
2.	Two magnetizers	48.42 a	67.71 a	72.97 ab	55.16 a
3.	Three magnetizers	61.34 ab	76.43 a	72.00 ab	69.81 a
4.	One magnetizer and two semi-ring	64.74 ab	69.80 a	79.67 b	52.91 a
5.	Control	77.96 b	66.74 a	61.90 ab	69.76 a

Mean values marked with the same letter do not differ at the significance level p = 0.05 according to the Duncan's t-test

The control of red spider mite by Talstar 100 EC and Omite 30 WP did not show any significant differences in the effectiveness of these products. On the other hand, the application of Magus 200 SC in combination with magnetized water showed a decrease of the product effectiveness and it was particularly visible when two magnetizers were applied. In turn, Ortus 05 SC showed the highest effectiveness with strongly magnetized water, i.e. with the use of one magnetizer and two semi-rings.

In the control of grain weevil, there was an increase in the effectiveness of the preparation Talstar 100 EC, Karate 025 EC and Winylofos 550 EC in combinations where strongly magnetized waters (three magnetizers or one magnetizer with two rings) were used (Tab. 4). The results were not always statistically significant nevertheless, the tendencies were distinctly visible. In case of Sumi-Alpha 050 EC preparation, high effectiveness of the treatment was obtained in combinations with less magnetized water, i.e. with use one or two magnetizers.

The obtained results of the biological effectiveness of selected zoocides in the control of red spider mite and grain weevil confirm the earlier considerations about chemical processes taking place in the spray mixture prepared with magnetized water. A high diversity in the biological effectiveness was observed in the particular plant protection agents and in the forms of the spray mixture.

An effect of magnetized water on the efficacy of plant protection agents was reported by Wachowiak and Kierzek (2002). They carried out observations on con-

Table 4. Effect of magnetized water on the effectiveness of zoocides in the control of grain weevil (*Sitophilus granatius* L.)

No.	Experimental object	Mean effectiveness of preparations in percentage			
		Karate 025 EC	Sumi-Alpha 050 EC	Talstar 100 EC	Winylofos 550 EC
1.	One magnetizer	46.55 a	80.69 b	39.86 a	42.30 a
2.	Two magnetizers	43.31 a	98.85 c	54.39 ab	37.72 a
3.	Three magnetizers	72.96 b	48.33 a	77.97 ab	48.79 a
4.	One magnetizer and two semi-ring	66.98 a	51.36 ab	87.22 b	70.48 a
5.	Control	43.16 a	60.64 ab	53.01 ab	43.16 a

Explanation – see table 3

trol of potato late blight [*Phytophthora infestans* (Mont.) de Bary] using selected fungicides.

In the experiments presented in table 5, no significant differences were found in the effect of magnetized water on the germination of bean and cuckoo flower plants. It refers both to the test carried out on Petri dishes and to flower pot tests. These results confirm the results of Haber (1990). That author found that magnetized water did not exert any perceivable effect on the germination term and on the appearance of the seedlings of tomato (*Lycopersicon esculentum* Mill.), ageratum (*Ageratum* L.), petunia (*Petunia* Juss.), ragwort (*Senecio* L.) and tagetes (*Tagetes* L). Differences started to appear only when the seedlings were out. Studies on the effect of magnetic water conditioning on the yield and quality of greenhouse tomato were carried out by Orłowski and Dobromilska (1998). Those authors found an effect of magnetized water on the increase of the number of flower, fruit ovaries and the number of racemes on plant. However, the phenomenon of a positive effect of magnetized water on plants has not been ultimately investigated yet and it requires further studies with different plant protection agents and their proportions in the tank mixture.

Table 5. Effect of magnetized water on the energy and germination ability of the seeds of bean (*Phaseolus vulgaris* L.) and cuckoo flower (*Cardamine amara* L.)

No.	Experimental object	Germinations of bean in % after		Germinations of cuckoo flower in % after	
		8 days[1]	21 days[2]	8 days[1]	21 days[2]
1.	One magnetizer	53.35 a	66.65 a	87.34 a	60.00 a
2.	Two magnetizers	63.35 a	65.00 a	82.66 a	64.00 a
3.	Three magnetizers	31.65 a	66.65 a	80.66 a	69.34 a
4.	One magnetizers and two semi-rings	38.35 a	83.35 a	75.34 a	68.66 a
5.	Control	41.65 a	60.00 a	82.66 a	64.66 a

[1]Experiment on Petri dishes
[2]Experiment in flower pots with soil
Mean values marked with the same letter do not differ at the significance level p = 0.05 according to the Student's t-test

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POLISH SUMMARY

WPŁYW MAGNETYZOWANEJ WODY NA SKUTECZNOŚĆ DZIAŁANIA WYBRANYCH ZOOCYDÓW W ZWALCZANIU PRZĘDZIORKA CHMIELOWCA (*TETRANYCHUS URTICAE* KOCH) I WOŁKA ZBOŻOWEGO (*SITOPHILUS GRANARIUS* L.)

Badania nad wpływem magnetyzowanej wody na skuteczność działania wybranych zoocydów w zwalczaniu przędziorka chmielowca (*Tetranychus urticae* Koch) i wołka zbożowego (*Sitophilus granarius* L.) przeprowadzono w latach 2002 i 2003, w Katedrze Metod Ochrony Roślin Akademii Rolniczej w Poznaniu.

Testowane środki ochrony roślin stosowano w dawkach minimalnych. Za dawkę minimalną uznano taką ilość preparatu, która powodowała śmiertelność u około 50% osobników badanych szkodników. Do doświadczeń stosowano wodę pobieraną z instalacji wodociągowej o średnicy 1/2 cala, na której montowano jeden, dwa, lub trzy magnetyzery (półpierścień z podstawką dolną) względnie jeden magnetyzer i dodatkowo dwa półpierścienie. W obiekcie kontrolnym stosowano zwykłą wodę wodociągową. Wszystkie zabiegi wykonano ręcznym opryskiwaczem ciśnieniowym „Mercury" firmy Kwazar, stosując 100 ml cieczy użytkowej na 1m^2 powierzchni, na której traktowano doniczki fasoli opanowanej przez przędziorka chmielowca lub szalki Petriego z wyłożonymi chrząszczami wołka zbożowego.

Ocenę wpływu stopnia namagnetyzowania wody na energię i zdolność kiełkowania nasion przeprowadzono na fasoli i rzeżusze. Wykonano dwa doświadczenia, z których jedno dotyczyło kiełkowania nasion na szalkach Petriego. Obserwacje kiełkujących nasion podlewanych wodą o różnym stopniu namagnetyzowania wykonano po 8 dniach. Drugie doświadczenie w identycznym układzie założono w uprawie doniczkowej. Liczebność kiełkujących roślin oceniano po 21 dniach od wysiewu nasion.

W przeprowadzonych badaniach stwierdzono wpływ magnetyzowanej wody na skuteczność działania niektórych zoocydów. Preparat Ortus 05 stosowany do zwalczania przędziorka chmielowca wykazywał największą skuteczność działania z wodą silnie namagnetyzowaną, tj. przy wykorzystaniu jednego magnetyzera i dodatkowo dwóch półpierścieni. Z kolei przy zastosowaniu środka Magus 200 SC w kombinacji z wodą namagnetyzowaną zanotowano obniżenie efektywności preparatu, co było szczególnie widoczne przy użyciu dwóch magnetyzerów.

W badaniach nad zwalczaniem wołka zbożowego stwierdzono wzrost skuteczności preparatów Talstar 100 EC, Karate 025 EC i Winylofos 550 EC w kombinacjach, w których stosowano wodę silnie namagnetyzowaną (trzy magnetyzery lub jeden magnetyzer z dodatkowymi dwoma półpierścieniami). W przypadku preparatu Sumi-Alpha 050 EC wysoką skuteczność zabiegu uzyskano w kombinacjach, w których woda była mniej namagnetyzowana, tj. przy użyciu jednego lub dwóch magnetyzerów.

W przeprowadzonych badaniach nie stwierdzono wpływu magnetyzowanej wody na energię i zdolność kiełkowania nasion fasoli i rzeżuchy.

Book Review

S.S. Izhevskii. 2003. Slovar-Spravochnik po Biologicheskoy Zashchite Rastenii ot Vrediteley [Dictionary-Guide on Biological Protection of Plants Against Pests]. Academia, Moskva, 206 pp. [In Russian]

This is a very comprehensive specialized dictionary that will be welcomed by plant protection specialists. Of special value will be to those who work with insects and mites, as it has the following subtitle: "Biology, Ecology, Application of Beneficial Insects and Mites".

The author is an internationally recognized specialist in biological control of pests and quarantine regulations. He also has a teaching experience so he arranged the book in such a way that it can be recommended as a textbook for the university students.

In "Introduction" (p. 3–6) the author provides some general information on studies of beneficial insects in the world and in Russia. He also stresses the aim and the scope of dictionary that contains over 1200 Russian and English common and scientific names, terms and definitions.

The dictionary is arranged according to Russian words but always with corresponding English terms in parentheses. With over 1200 entries the book well covers the complete field of biological plant protection, ecology and biocenology.

Naturally, the dictionary is primarily addressed to persons with knowledge of Russian language. However, it will be also very useful to persons with knowledge of English language, as it contains two indexes: "Index of Latin names" (p. 177–184) and index "English-Russian dictionary index" (p. 185–206).

I strongly recommend this book to all persons active in plant protection and this has been foreseen by the publisher as book is printed in 20,000 copies.

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