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IMPACT OF HIGH PRESSURE INSTALLATION ON THE VIABILITY OF INSECTICIDE NEMATODES

Summary

The results were presented of research into the impact of high pressure installation elements: the piston pump and sprayers with double flat spray: TeeJet DGTJ-60: 110/02, 110/03, 110/04 on the viability of entomopathogenic nematodes Steinernema feltiae. The research was carried out with the pressure of liquid in the installation of 10.0 MPa. The measurements of the number of living nematodes in fluid samples collected from the container, from the pipe that feeds the sprayer and from liquid collected under the sprayer were compared. A 17.7% decrease of the viability of nematodes caused by the pump was found and a 23.6% viability decrease was established caused by the sprayers.
***Key words**: sprayer, liquid pressure, application of insecticide nematodes*

WPŁYW INSTALACJI WYSOKOCIŚNIENIOWEJ NA PRZEŻYWALNOŚĆ OWADOBÓJCZYCH NICIENI

Streszczenie

Przedstawiono wyniki badań wpływu elementów instalacji wysoko ciśnieniowej: pompy tłokowej i rozpylaczy o podwójnym strumieniu płaskim TeeJet DGTJ-60: 11002, 11003, 11004 na przeżywalność owadobójczych nicieni Steinernema feltiae. Badania przeprowadzono przy ciśnieniu cieczy w instalacji równym 10,0 MPa. Porównano pomiary liczby żywych nicieni w próbach płynu pobranego ze zbiornika, z przewodu zasilającego rozpylacz i z cieczy zebranej pod rozpylaczem. Stwierdzono 17,7% spadek przeżywalności nicieni spowodowany przez pompę oraz 23,6% spadek przeżywalności spowodowany przez rozpylacze.
***Słowa kluczowe**: rozpylacz, ciśnienie cieczy, aplikacja owadobójczych nicieni*

1. Introduction

Organic farming that produces food with non-chemical methods has harnessed living organisms including entomopathogenic nematodes to fight plants pests [11, 12, 13]. Similarly as chemical pesticides, they are dispersed on crops with the use of spraying machines. The effectiveness of the elimination of plant pests by biological plant protection agents depends on the survival of these organisms in the installation of spraying machines. Research conducted until now concerning the loss of insecticide nematodes during spraying focused mainly on an assessment of the impact of the individual elements of the installations of field spraying machines on their viability. During the research conducted, it was found that serious losses of nematodes may occur in those elements of spraying machines through which liquid circles repeatedly. It was also found that the value of the liquid pressure and the multiplicity of the flow of liquid with nematodes through the installation of the spraying machine exerts a significant influence on the decreased viability of nematodes. The largest losses occur in such places of the installation as the hydraulic agitator nozzle and the bypass valve [1, 3, 5, 6, 14]. The decrease of the viability of nematodes during the flow through these elements was also dependent on the sizes of the slits and the diameters of those holes which liquid moved through [7].

The measurement of the pressure in the installation of the spraying machine with a nano-meter during spraying is a static pressure measurement. It was examined whether the destructive activity of the flowing liquid in relation to nematodes is the effect of static or dynamic pressure. As a result of this research, no harmful influence of static pressure on the viability of insecticide nematodes was found. Nematodes survived static pressure of 52.5 MPa without any losses [4, 8]. It was found that the losses of nematodes inside the spraying machine are solely caused by the activity of dynamic pressure connected with the energy of the flowing liquid, while pressure measured with a nano-meter is the exponent of the energy contained in the fluid flowing in the installation.

To date, it has been found that changes in the viability of nematodes in sprayers with a single flow of liquid with nematodes and with pressure even up to 2.0 MPa are so small that it is difficult to observe them. A decreased viability of nematodes in the liquid sprayed by sprayers could be denoted only after the multiple flow of liquid [7, 5].

The influence of pumps with various designs (rotodynamic, membrane and roller ones) on the destruction of nematodes with the liquid pressure of 828 kPa was also examined. No influence was found of these devices on a reduction in the number of living nematodes pumped through them together with liquid [9].

The impact of high pressure (up to 10.690 kPa) created by the press on the losses of nematodes in the liquid was examined. In the research there were used 10 ml of the samples of liquid containing insecticide nematodes of the species of *Steinernama carpocapsae, heterorhabditis bacteriophora* and *heterorhabditis megidis*. The liquid flowed through them through a sprayer by a steal pipe with the inner diameter of 1.5 mm and the length of 52 mm [10]. Significant losses of nematodes were found reaching even up to 45% for the *Steinernama carpocapsa* species and 75%

for *heterorhabditis bacteriophora and heterorhabditis megidis.*

Until now the research into the viability of insecticide nematodes in the hydraulic installation has focused on the elimination of those factors that are harmful to the life of nematodes during their application.

The purpose of the present research was to attempt to test the resistance of insecticide nematodes during a flow through the installation to a pressure that is higher than one in spraying machines as well as to assess losses in the critical places of the installation with this pressure.

2. Material and methods

In order to perform the research, a special test stand was built. It consisted of a hydraulic installation producing high pressure and of a measurement unit. The hydraulic installation included a container, an "Interpump W5015" high pressure piston pump driven by an electric engine and a bypass valve for pressure adjustments. The measurement unit presented in Fig. 1 was built of two manually controlled high pressure valves (1 and 4), a pressure sensor and a handle to install sprayers. The data from the liquid pressure sensor were sent via a NI DAQCARD-6024 card to the computer and registered with the use of the LabView - National Instruments Corporation programme. During the tests, the value of the liquid pressure was set to 10.0 MPa.

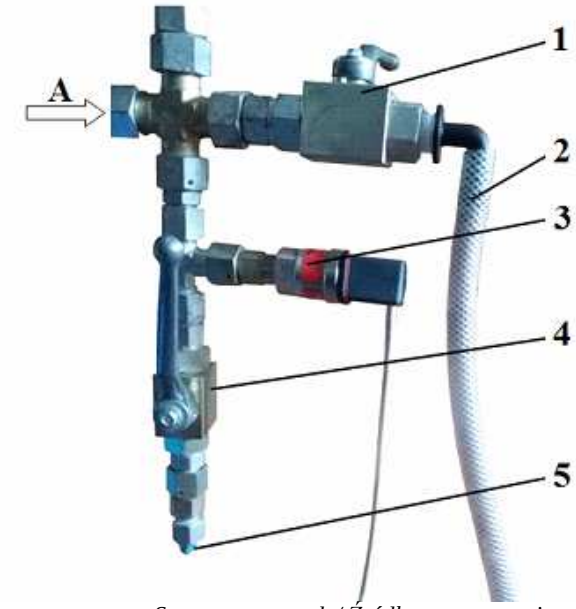

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Fig. 1. Measurement unit: A – intake of liquid flowing from high pressure installation, 1 – valve to collect liquid from sprayer feeding pipe, 2 – pipe to collect samples, 3 – pressure sensor , 4 – valve opening the inflow of liquid into the sprayer, 5 – sprayer

Rys. 1. Zespół pomiarowy: A – wlot cieczy wpływającej z instalacji wysokiego ciśnienia, 1 – zawór do pobierania cieczy z przewodu zasilającego rozpylacze, 2 – przewód do pobierania prób, 3 – czujnik ciśnienia, 4 – zawór otwierający dopływ cieczy do rozpylacza, 5 – rozpylacz

Research was made into changes in the viability of insecticide nematodes sprayed with the use of sprayers manufactured by TeeJet DGTJ-60 company with a double flat spray with a protection against carrying it away. In the research, three sizes of sprayers were used: 110/02, 110/03, 110/04 in the version with steel nozzles. These are sprayers with pre-orifice that produce streams of liquid directed ahead and backwards at the angle of 60° in relation to each other.

Entomopathogenic nematodes *Steinernema feltiae* that constitute the main agent in the Steinernema System preparation manufactured by Biobest company were mixed with water and used as the tested material. *Steinernema feltiae* nematodes are the components of many biological pesticides that serve the purpose of an elimination of pests with natural methods [13]. During the research, the samples of liquid were collected to ca. 100 ml containers from:

- the tank that fed the installation,
- the pipe that fed the sprayers,
- a container with liquid collected under the sprayers.

The samples of liquid from the pipe feeding the sprayers were collected after opening valve 1 for this purpose (Fig. 1). In the research, no liquid was taken into consideration which flowed through the control valve. The liquid which flowed through the control valve and the liquid which flowed through the sprayers did not return to the tank. Changes in the viability of nematodes were determined by comparing the totaled number of living nematodes in the established unit of liquid volume in samples taken from the containers. The numbers of nematodes was determined by totaling them up under a microscope in 0.05 ml samples collected with the use of a pipette. The experiment was repeated three times. Every time, 4 samples of liquid were collected to determine the number of living nematodes.

With the use of a stopwatch and a measuring vessel the flow rate of water out flowing at the pressure of 10.0 MPa from the tested sprayers were determined. The results are presented in Fig. 2.

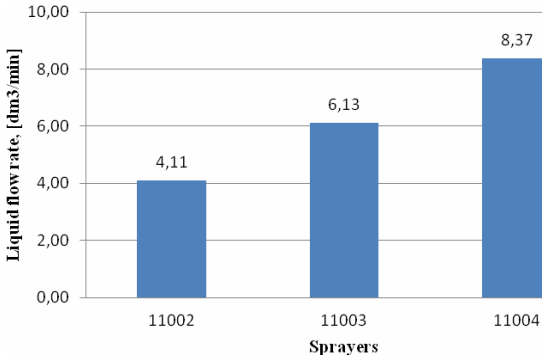

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Fig. 2. Flow rate of water out flowing from DGTJ-60 sprayers: 110/02, 110/03, 110/04 at the pressure of 100 bar

Rys. 2. Natężenie wypływu wody z rozpylaczy DGTJ-60: 110/02, 110/03, 110/04 przy ciśnieniu 100 barów

3. Results and discussion

Differences in the number of living *Steinernema feltiae* nematodes contained in the liquid before spraying and after spraying with the examined sprayers are presented in Fig. 3. It depicts changes in the viability of nematodes determined on the basis of their number in 0.05 ml samples in the liquid flowing through the pipe feeding the sprayers and in the liquid collected under the sprayers.

An analysis of the variance of the results did not demonstrate any essential difference with the statistical significance level ($p \leq 0.05$) between the results of the number of living nematodes in samples taken from the pipe feeding the nozzles

and between the results of the number of nematodes in the samples of liquid flowing out of the individual sprayers.

The averaged results of the number of *Steinernema feltiae* nematodes in liquid sprayed with the DTJ-60 sprayers examined at the pressure of 10.0 MPa and in the high pressure installation are presented in Fig. 4. In this figure, the averaged results of the measurement of the number of nematodes in the liquid found in the tank feeding the installation and in the pipe feeding the sprayers are included in the chart.

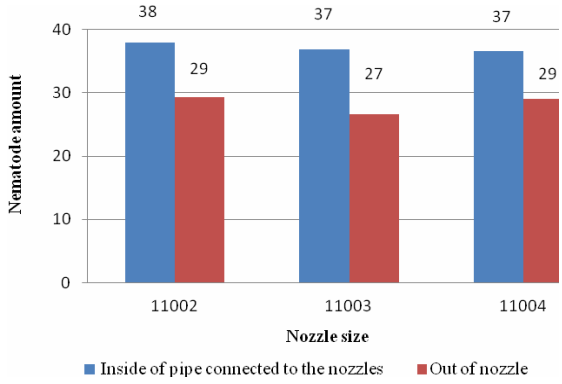

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Fig. 3. Changes in the viability of *Steinernema feltiae* nematodes in the liquid sprayed by individual DTJ-60 sprayers at the pressure of 10.0 MPa, liquid samples analyzed: 0.05 ml
Rys. 3. Zmiany przeżywalności nicieni Steinernema feltiae w cieczy rozpylonej przez poszczególne rozpylacze DTJ-60 przy ciśnieniu 10,0 MPa, analizowane próby cieczy: 0,05 ml

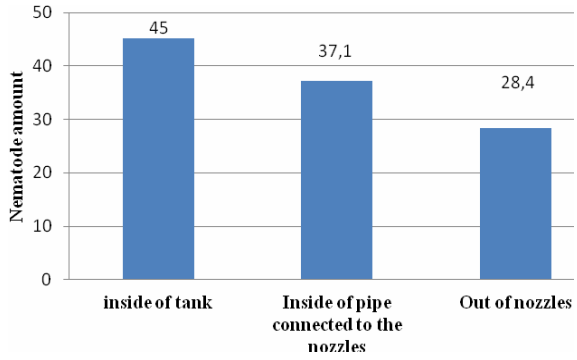

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Fig. 4. Changes in the number of living *Steinernema feltiae* nematodes in the high pressure installation and in DTJ-60 sprayers at the pressure of 100 bar (Least Significant Difference - LSD = 2.839), samples of liquid analyzed: 0.05 ml
Rys. 4. Zmiany liczby żywych nicieni Steinernema feltiae w instalacji wysokiego ciśnienia w rozpylaczach DTJ-60 przy ciśnieniu 100 barów (NUR = 2,839), analizowane próby cieczy: 0,05 ml

An analysis of the variance of the results demonstrated an essential difference (with the statistical significance level ($p \leq 0.05$), Least Significant Difference - LSD = 2.839) between the values of the number of living nematodes in the liquid in the pipe feeding the sprayers and in the liquid collected under the sprayers. The decrease in the viability of nematodes in DGTJ-60 sprayers: 110/02, 110/03, 110/04 at the pressure of liquid of 100 bar achieved 23.6% on average.

There also occurred an essential difference between the number of living nematodes in the liquid in the pipe feeding the sprayers and the number of living nematodes in the tank feeding the hydraulic installation producing a high pressure of the liquid. The piston pump was probably responsible for the losses of nematodes in the high pressure installation. The value of the decrease of the viability of nematodes after the liquid flowing through the pump was 17.7%. The total decrease of the viability of nematodes in the installation was 37.1%.

4. Conclusions

1. A significant change was found: a reduction in the number of living nematodes in the liquid sprayed with DGTJ-60 sprayers: 110/02, 110/03, 110/04 at the pressure of 100 bar.
2. A significant lowering was found of the number of living nematodes in the liquid pumped with the piston pump at the pressure of 100 bar.
3. It was found that significant losses of nematodes occur already after a single flow of the liquid through the piston pump and DGTJ-60 sprayers: 110/02, 110/03, 110/04 at the liquid pressure of 100 bar.

5. References

[1] Brusselman E.: Optimizing the spray application of entomopathogenic nematodes in vegetables: From spray tank to nematode deposition. PhD Thesis. Ghent University, Belgium 2010.
[2] Chojnacki J.: Ocena przeżywalności biologicznych środków ochrony roślin: nicieni - Steinernema feltiae rozpraszanych za pomocą dyszy hydraulicznej. Inżynieria Rolnicza, 2006, 13(88), 47-53.
[3] Chojnacki J.: Śmiertelność nicieni w obiegu hydraulicznym opryskiwacza. Inżynieria Rolnicza, 2007, 3(91), 45-50.
[4] Chojnacki J.: The resistance of beneficial nematodes to liquid static pressure. 4th International Conference TAE 2010. Trends in Agricultural Engineering, Prague, 2010, 241-243.
[5] Chojnacki J.: Przeżywalność owadobójczych nicieni w mieszadle strumieniowym. Journal of Research and Applications in Agricultural Engineering. 2011, 56 (2), 27-31.
[6] Chojnacki J.: Wpływ przepływu cieczy przez zawór regulacyjny w instalacji opryskiwacza na przeżywalność owadobójczych nicieni. Journal of Research and Applications in Agricultural Engineering, 2011, 56 (1), 19-25.
[7] Chojnacki J.: Zmiany w przeżywalności owadobójczych nicieni podczas przepływu przez otwór w dyszy opryskiwacza. Journal of Research and Applications in Agricultural Engineering, 2011, 56 (1), 26-31.
[8] Chojnacki J.: The investigation of influence of static pressure periods in sprayers on entomopathogenic nematodes viability. EJPAU, 2011, 14(2).
[9] File J.P., Ozkan H.E., Derksen R.C., Grewal P.S.: Effects of pumping on entomopathogenic nematodes and temperature increase within a spray system. Applied Engineering in Agriculture, 2007, 23(4), 405-412.
[10] Fife J.P., Derksen R.C., Ozkan H.E., Grewal P.S.: The effect of pressure differentials on the viability and infectivity of entomopathogenic nematodes. Biological Control, 2003, 27, 65-72.
[11] Georgis R.: Formulation and application technology. W: Gaugler R., Kaya H.K.: Entomopathogenic nematodes in biological control. CRC Press, Boca Raton Florida, 1990, 173-191.
[12] Greval P.S., Peters A.: Formulation and Quality. W: Nematodes as Biocontrol Agents. Grewal, Echlers, Shapiro-Ilan. CABI Publishing, CAB International Wallingfoird Oxfordshire OX10 8DE UK, 2005, 79-90.
[13] Kowalska J., Pruszyński S.: Metody i środki proponowane do ochrony roślin w uprawach ekologicznych. Poznań: IOR, 2007.
[14] Nilsson U., Gripwall E.: Influence of application technique on the viability of the biological control agents *Vertcillium lecanii* and *Steinernema feltiae*. Crop Protection, 1999, 18 (1), 53-59.