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INFLUENCE OF SELECTED INSECTICIDES ON VERMICOMPOSTING OF WASTES WITH PARTICIPATION OF THE EARTHWORM *Dendrobaena veneta*

WPŁYW WYBRANYCH INSEKTYCYDÓW NA WERMIKOMPOSTOWANIE ODPADÓW Z UDZIAŁEM DŻDŻOWNICY *Dendrobaena veneta*

Abstract: The studies concerned the possibility of vermicomposting organic wastes separated from kitchen wastes. Vermicomposting was conducted with the presence of the earthworm *Dendrobena veneta*. The occurrence of dipteran *Sciaridae* was reduced by application of Nomolt 150SC, Dimilin 25WP and Dar 2.5GR preparations into the substrate (in environmentally safe doses recommended by the producers). The aim of the studies was to determine the influence of these preparations on *D. veneta* characteristics and also on the rate of vermicomposting. The nutritional value of the vermicomposts produced was also recognized.

During 3-months of vermicomposting, no influence of Nomolt 150SC and Dimilin 25WP on earthworms was found. Dar 2.5GR brought about a significant increase in the number and biomass of cocoons laid by earthworms. The rate of vermicomposting did not depend on the presence of insecticides. The characteristics of the vermicomposts produced were as follows: pH in H_2O (min. 6.2–max 6.3); salt concentration (min. 3.9–max 4.1 g NaCl $\cdot$ dm^{-3}), abundance of phosphorus (min. 175–max 193 mg $\cdot$ dm^{-3}); potassium (min. 1267–max 1395 mg $\cdot$ dm^{-3}); calcium (min. 2418–max 2561 mg $\cdot$ dm^{-3}) and magnesium (min. 265–max 278 mg $\cdot$ dm^{-3}) and did not differ. Comparing the content of vermicomposts with the addition of insecticides in nitrate nitrogen to its content in the vermicompost from the control containers, a substantially higher content was indicated in the vermicompost produced by the largest population in contact with Dar 2.5GR.

Keywords: earthworm *Dendrobena veneta*, ecological box, Nomolt 150SC, Dimilin 25WP, Dar 2.5GR, vermicompost characteristics

Since the second half of the 20^{th} century, constant disturbance of mechanisms vital for maintaining an ecological balance have been noticed. There has been a rapid increase in emission of pollution of all environmental resources. The major causes of this phenomenon can be ranked as rapid industrialization, dramatic rising of traffic

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congestion, high level of urbanization, common use of chemicals and inappropriate waste management [1].

Kitchen wastes usually contain about 50 % of biodegradable elements. Acting pro-environmentally, they should be separated from the main stream of municipal wastes, so than they can be composted, subjected to fermentation or vermicomposted [2–8].

Vermicomposting of kitchen wastes can also proceed *on-site*, in earthworm ecological boxes (in Polish conditions described concerning to use the species *Eisenia fetida* (Sav.)) [9–11]. An ecological box constitutes an innovative pro-environmental solution of managing organic wastes *on-site*, but it can become bothersome due to adult forms of *Diptera* of the *Sciaridae* family and its larvae, competing with earthworms over organic wastes [12]. Effective ways for limiting the number of *Sciaridae* in ecological boxes are required.

The aim of the research was to determine the influence of preparations used to suppress *Diptera* (insecticides: Nomolt 150SC, Dimilin 25WP and Dar 2.5GR, in concentrations recommended by the producers as safe for the environment) on number, biomass and reproduction characteristics of the earthworm *Dendrobaena veneta* Rosa 1893. The rate of vermicomposting of kitchen organic wastes and characteristics of vermicompost produced, were also recognized.

Material and methods

The studies were conducted in a constant temperature room (ambient temperature was 20 °C), according to the scheme in Table 1.

Table 1

Plan of the kitchen wastes vermicomposting

Pot	Stratification layer	Waste vermicomposted	Basic population of *D. veneta* [g ± SD][b]	Insecticide[c]
1–3	2 dm³ of soil[a]	600 cm³ of kitchen organic waste and 300 cm³ of cellulose	10 ind. [14.910 ± 0.189]	Nomolt150SC
4–6			10 ind. [14.599 ± 0.169]	Dimilin 25WP
7–9			10 ind. [14.752 ± 0.287]	Dar 2.5GR
10–12			10 ind. [14.359 ± 0.425]	Control

[a] The composition of stratification layer (universal medium for ornamental plants Floro-hum: highmoor peat, lowmoor peat, pearlite, sand, microelements, mineral fertilizer NPK) at the beginning of the experiment; [b] SD – standard deviation; [c] in doses conformable to instruction of the producer.

In the containers, sized 21 · 15 · 10 cm, constant humidity (about 70 %) was maintained following the standard [13]. The stratification layer in the containers characteristics was as follow: pH in H_2O – 6.2; salt concentration – 0.5 g NaCl · dm^{-3}, the concentration of nitrate nitrogen – 1.75 mg · dm^{-3}; available phosphorus – 63 mg · dm^{-3}; potassium – 186 mg · dm^{-3}; calcium – 1027 mg · dm^{-3} and magnesium – 141 mg · dm^{-3}.

Vermicomposted waste mass consisted of 150 cm^3 residues of boiled pasta, bread, potato and apple peelings (in total 600 cm^3 of waste) mixed with 300 cm^3 of cellulose (fragmented egg packaging), introduced to improve conditions of vermicomposting [10]. In order to check the possibility of using the insecticides limiting the occurrence of dipteran *Sciaridae* in ecological boxes, the following preparations were added once into the vermicomposted wastes mass: Nomolt 150SC (in dose of 5 $cm^3 \cdot m^{-2}$, active substance teflubenzuron), Dimilin 25WP (in dose of 4 $g \cdot m^{-2}$, active substance diflubenzuron) and Dar 2.5GR (in dose 400 $g \cdot m^{-2}$, active substance chlorfenvinfos).

The number and biomass of earthworms and cocoons were checked every two weeks during a period of three months vermicomposting (the whole volume of containers was searched by hand).

Mean daily rate of wastes vermicomposting (cm^3 per day) was calculated due to their separation from the stratification layer (the wastes were placed in nylon nets with meshes enabling the earthworms to have an easy access). The rate of wastes transformation into vermicompost was determined repeatedly (during each inspection of the state of earthworm population), by measuring the volume of untreated wastes.

The results obtained were transformed into the volume of the processed residues according to the following formula:

$$a_t = 900 - b_t$$

where: a_t – the volume of the residues processed at the consecutive checkings,
b_t – the volume of the unprocessed residues.

Before determining the characteristics of the vermicomposts produced, some samples were taken at random (3 from each medium), fragmented, and then mixed. From this prepared volume, research samples were measured out: the pH in water using a potentiometric method and the concentration of salt by a conductometric method [g $NaCl \cdot dm^{-3}$] were determined. The content of nitrate-nitrogen was measured using an ionometer and ion-selective electrode; available phosphorus was determined by the vanadic-molybdenic method. The content of available potassium and calcium was determined using a flame photometer, and available magnesium was checked using a spectrophotometer by means atomic absorption [$mg \cdot dm^{-3}$].

The results obtained (shown as average ± standard deviation, n = 6), were analyzed by applying an Excel spreadsheet. The mean values were compared by variation method, using T-Tukey's test and Statistica PL programme.

Results

Analyzing the effect of the insecticides used on the earthworm population condition, a different effect of these preparations on number and biomass was found (Table 2). The presence of Nomolt and Dimilin reduced the number and biomass of the mean earthworm population compared with the control, but insignificantly ($p > 0.05$). The presence of preparation Dar 2.5GR affected the earthworms *D. veneta* most favourably, by increasing both their total number and biomass. Statistical analysis of these results did not confirm a significant difference compared to the control ($p > 0.05$).

Table 2

The number and biomass of mean population of *D. veneta* earthworm in contact with insecticides

Parameter	Nomolt 150SC	Dimilin 25WP	Dar 2.5GR	Control
Number [specimen / box]	11 ± 4	10 ± 4	26 ± 28	16 ± 9
Biomass [g]	14.057 ± 2.732	13.425 ± 3.473	22.155 ± 7.630	18.143 ± 6.015

The stress occurred by the presence of insecticide Nomolt 150SC caused the decrease in number and biomass of adult earthworms of *D. veneta* (Table 3). It seems, that their life strategy, in contact with this xenobiotic was being realized through investing energy in the next generation – the earthworms were laying heavier cocoons than in the control treatment (Table 4). Statistical analysis of these results did not confirm a significant difference ($p > 0.05$).

Table 3

Influence of insecticides on number and sum of biomass of mature individuals of *D. veneta*

Parameter	Nomolt 150SC	Dimilin 25WP	Dar 2.5GR	Control
Number [specimen / box]	8 ± 2	8 ± 3	10 ± 1	11 ± 4
Biomass [g]	13.5 ± 2.5	12.9 ± 3.7	18.7 ± 2.3	16.8 ± 4.5

Table 4

Influence of insecticides on the number and sum of biomass of cocoons laid by *D. veneta*

Parameter	Nomolt 150SC	Dimilin 25WP	Dar 2.5GR	Control
Number [cocoons / box]	12 ± 9	9 ± 7	26 ± 22^a	10 ± 4^b
Sum of biomass [g]	0.315 ± 0.246	0.213 ± 0.166	0.642 ± 0.546^a	0.249 ± 0.217^b
Biomass of 10 cocoons [g]	0.193 ± 0.122	0.161 ± 0.125	0.165 ± 0.129	0.169 ± 0.132

a, b – mean in columns denoted with identical letters do not differ significantly ($p < 0.05$) according to T-Tukey's test.

The studies may indicate that the earthworm *D. veneta* is most sensitive to contact with Dimilin 25WP preparation. Both; the whole population (Table 2), and mature individuals (Table 3) and cocoons (Table 4) were smallest in number in containers with this xenobiotic. Similar relations concerned biomass characteristics. Using this insecticide in doses recommended by the producer, determined however the fact that statistical analysis of the results obtained did not confirm the significance of differences obtained (compared with the control) ($p > 0.05$).

On the other hand, it seems that Dar 2.5GR was the most favorable of the preparations tested. The stress caused by its presence did not reduce the number and biomass of mean earthworm population (compared with the control) (Table 2), but even significantly increased the number ($p < 0.01$) and total biomass of the cocoons laid ($p < 0.05$) (Table 4).

The studies conducted allowed calculation of mean daily rate of vermicomposting in all the ecological boxes being observed (Table 5). It fluctuated from 22 to 24 cm^3 per day (the highest was found in the boxes containing insecticide Dar 2.5GR). Statistical analysis of the results did not confirm the significance of the difference obtained ($p > 0.05$).

Table 5

Influence of insecticides on a daily rate ± SD of vermicomposting [in cm^3]

Nomolt 150SC	Dimilin 25WP	Dar 2.5GR	Control
22 ± 16	23 ± 21	24 ± 13	22 ± 18

All vermicomposts from the research containers were rich in plant nutrients. Vermicomposting of organic waste enriched them compared with the initial stratification layer respectively: in nitrate-nitrogen by more than ten thousand times, in phosphorus by 290 %, in potassium by 715 %, calcium by 241 % and magnesium by 189 %) (Table 6).

Table 6

Characteristics of produced vermicomposts (determined in fresh mass, at humidity of 70 %)

Characteristics	Initial medium	Agent tested				Optimal value*
		Nomolt 150SC	Dimilin 25WP	Dar 2.5GR	Control	
pH in H_2O	6.2	6.3 ± 0.0	6.3 ± 0.1	6.3 ± 0.1	6.2 ± 0.0	6.0–7.5
Salinity [g NaCl · dm^{-3}]	0.5	4.1 ± 0.0	4.1 ± 4.1	4.1 ± 0.3	3.9 ± 0.2	about 1.0
$N\text{-}NO_3$ [mg · dm^{-3}]	1.8	409^a ± 18	410^a ± 29	518^b ± 33	423^a ± 21	50–120
P [mg · dm^{-3}]	63	175 ± 23	176 ± 10	190 ± 15	193 ± 18	40–80
K [mg · dm^{-3}]	186	1307 ± 54	1350 ± 101	1395 ± 138	1267 ± 73	125–250
Ca [mg · dm^{-3}]	1027	2479 ± 136	2561 ± 35	2418 ± 143	2442 ± 90	1000–2000
Mg [mg · dm^{-3}]	141	258 ± 13	278 ± 32	265 ± 6	265 ± 12	60–120

* The optimal level for garden plants according to Konczak-Konarkowska [14]; [a, b] difference statistically significant ($p < 0.05$).

Comparing the content of nutrients in vermicomposts with xenobiotics with their content in vermicomposts from control containers, only significantly higher content of nitrogen in vermicomposts produced by the largest population in contact with Dar 2.5 GR was noticed. All the obtained media were excessively saline (Table 6).

Discussion

The obtained results of the earthworm *D. veneta* population in contact with the insecticides tested characteristics may indicate relatively good selection (also by the producers of these preparations) of concentrations of the preparations used. The conducted studies and statistical analysis of the results did not confirm the significance of their negative influence on earthworms during the period of three months of vermicomposting. Apart from different resistance to stress caused by the presence of the insecticides being tested, differentiation of the average number and biomass *D. veneta* can be justified by the fact of more or less efficient influence of the preparations used against dipteran *Sciaridae* larvae, competing with earthworms over organic wastes. More efficient restriction of the number of these larvae could enable a better access of earthworms to organic wastes, which alleviate stress more effectively.

In the condition of the conducted experiment, in contact with earthworms *D. veneta*, Dar 2.5GR turned out to be the least harmful. Meanwhile, numerous studies show that earthworm species may differently respond to contact with xenobiotics. It depends, not only on their individual predisposition, but also on a series of biotic and abiotic factors [15–19]. Results from Garczynska's studies on effect of the same preparations in doses indicated by the producers on the earthworm *E. fetida* [20], phosphoorganic preparation Dar 2.5GR, influenced earthworms of this species (smaller than earthworm *D. veneta*) the most negatively.

In variable temperature condition, in a laboratory, its presence determined a significant reduction in biomass of *E. fetida* and negatively influenced the next generation (reduced the number and biomass of the cocoons laid by the earthworms). In the constant temperature room conditions, at 20 ^{o}C, with *E. fetida*, Dar 2.5GR caused even more toxic effects. It resulted in the reduction of the number (by 41 % compared with the control) and biomass of the whole earthworm populations. It significantly reduced the number and biomass of all individual age class representatives (both mature and immature individuals and also cocoons). These facts influenced weakening of the earthworm population's condition and substantial lowering of the daily rate of vermicomposting of kitchen organic wastes, compared with the control [20].

During the current test, positive influence of vermicomposting on the content of nutrients accessible to plants has been indicated. It has been observed that the vermicomposts produced with the participation of earthworms *D. veneta* did not differ in respect of pH (min. 6.2; max 6.3) and salt concentration (min. 3.98; max 4.13) at the same time, the NaCl concentration ($g \cdot dm^{-3}$) exceeded tolerance threshold for plants (3 $g \cdot dm^{-3}$) [11]. It is worth mentioning that there have already been studies which confirm high salinity of the vermicomposts produced during vermicomposting of kitchen wastes [10, 21].

The vermicomposts obtained now, like the ones obtained in Kiepas-Kokot and Szczech studies [21] were rich in nutrients for plants. They did not differ in respect of the content of phosphorus, potassium, calcium and magnesium. Only the content of nitrate-nitrogen compared with the other variants of the experiment, was considerably higher in ecological boxes with Dar 2.5GR preparation.

Conclusions

1. The separated fraction of organic kitchen wastes can be vermicomposted *on-site* in earthworm ecological box, using the earthworm *Dendrobaena veneta* Rosa 1893. The nuisance concerned with keeping the box caused by the presence of *Sciaridae* can be limited by antidipteran preparations.

2. Among the insecticides being tested, Dar 2.5GR had the most favorable influence, taking density, biomass and reproduction of earthworms *D. veneta* into account.

3. Inserting all the tested insecticides into the ecological box did not differentiate a daily rate of vermicomposting of organic wastes.

4. The vermicomposts produced from organic kitchen waste were rich in nutrient components for plants (nitrogen, phosphorus, potassium, calcium and magnesium). Significantly the largest content of nitrate-nitrogen was found in the vermicompost with the addition of Dar 2.5GR preparation. As the salinity of vermicomposts coming from kitchen wastes exceeded the tolerance threshold for plants and the content of nutrient components was very high, the fertilizers produced should be diluted before inserting them into soil substrates of plants.

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WPŁYW WYBRANYCH INSEKTYCYDÓW NA WERMIKOMPOSTOWANIE ODPADÓW Z UDZIAŁEM DŻDŻOWNICY *Dendrobaena veneta*

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Abstrakt: Badania dotyczyły możliwości wermikompostowania w skrzynkach ekologicznych odpadów organicznych wydzielonych ze strumienia odpadów kuchennych. Wermikompostowanie prowadzono z udziałem dżdżownicy *D. veneta*, a występowanie muchówek *Sciaridae* ograniczano przez stosowanie do podłoży preparatów Nomolt 150SC, Dimilin 25WP i Dar 2,5GR, w bezpiecznych dla środowiska dawkach sugerowanych przez producentów. Celem badań było określenie wpływu tych preparatów na cechy dżdżownic *D. veneta*, a także tempo wermikompostowania odpadów i cechy wyprodukowanych wermikompostów.

W okresie 3 miesięcy prowadzonych badań nie stwierdzono wpływu insektycydów Nomolt 150SC i Dimilin 25WP na dżdżownice, a najkorzystniej oddziaływał na nie preparat Dar 2,5GR (powodował istotny wzrost liczby składanych kokonów i ich biomasy). Tempo wermikompostowania nie zależało od obecności insektycydów. Cechy wyprodukowanych wermikompostów: pH w H_2O (min. 6,2–max 6,3); stężenie soli (min. 3,9–max 4,1 g NaCl $\cdot$ dm^{-3}), zasobność w fosfor (min. 175–max 193 mg $\cdot$ dm^{-3}); potas (min. 1267–max 1395 mg $\cdot$ dm^{-3}); wapń (min. 2418–max 2561 mg $\cdot$ dm^{-3}) i magnez (min. 265–max 278 mg $\cdot$ dm^{-3}) nie różniły się. Porównując zasobność wermikompostów z dodatkiem insektycydów w azot azotanowy z jego zawartością w wermikompoście z pojemników kontrolnych, wykazano istotnie wyższą zawartość tylko w wermikompoście wytworzonym przez najliczniejszą populację w kontakcie z insektycydem Dar 2,5GR.

Słowa kluczowe: dżdżownice *D. veneta*, skrzynka ekologiczna, Nomolt 150SC, Dimilin 25WP, Dar 2,5GR, cechy wermikompostów