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INFLUENCE OF COMPOST FROM FISH BY-PRODUCTS ON NUTRIENT SUPPLY IN RADISH

WPŁYW KOMPOSTÓW Z PRODUKTÓW UBOCZNYCH GOSPODARKI RYBACKIEJ NA ZAWARTOŚĆ MAKROSKŁADNIKÓW W RZODKIEWCE

Abstract: Processing undesirable species of lake fish into compost can accompany the catching and removal of such fish, which aims to restrict the eutrophication of lakes. A pot experiment with radishes was conducted in order to assess composts containing caught fish from the Cyprinidae family (minnows), sawdust, straw, bark and brown coal. The experiment encompassed two series: I – composts at a dose of 1gN of compost per pot, II – composts and 0.5 g of urea. On average, the application of composts resulted in a 52.68 % increase in radish crop yield in the series without additional mineral fertilization and a 35.42 % increase in the series with additional mineral fertilization when compared to the control group. The average content of P, K, Ca, Na, and Mg in leaves was found to be higher in the series without mineral fertilization than in the control series. Radish roots of plants subjected to mineral fertilization contained, on average, more P, K, Ca, Na, and Mg as compared to the control. In the series with additional mineral fertilization, the average content of P, K, Ca, and Mg increased whilst Na decreased.

Keywords: fish by-products, fertilization, macroelements, radish

Processes aimed at restricting the eutrophication of lakes can be accompanied by processing the low-grade lake fish into composts on location where they had been caught. There is an imbalance between the individual elements of the trophic ladder in eutrophized water basins [1–3]. A decrease in the consumption of seaweed has been observed due to the disappearance of large forms of zooplankton, which plankton-eating fish feed on. There is a necessity to regulate the population of small minnows (the bleak *Alburnus alburnus*, the roach *Rutilus rutilus*, the bream *Abramis brama* and silver bream *Blicca bjoerkna*) by catching these undesirable species of fish, which have

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dominated eutrophized waters and this results in an increasing amount of fish waste [4]. The continuous search for ecological, environmentally-friendly methods of managing such waste material have given rise to developing a solution as to its management by composting low-grade minnows on location where they had been fished and compost produced in such a way has been subjected to assessment in terms of its suitability for application in agriculture [5–6].

The aim of the presented research is to determine the influence that the addition of composts produced from caught minnows and containing different variants of additives in accordance to the study method has on the content of macroelements in the above-ground plant parts and roots of radish (*Raphanus sativus* L.).

Materials and methods

The composts used in the experiment came from an experiment set up outdoors in 2010 which was conducted in specially constructed wooden crates measuring 50 × 60 × 60 cm. The basic substrate for obtaining compost were small cyprinid fish form Lake Kortowskie (Olsztyn, Poland): the bleak (*Alburnus alburnus*), common roach (*Rutilus rutilus*), common bream (*Abramis brama*) and white bream (*Blicca bjoerkna*). In order to realize the assumed study aims, and experiment was carried out on the following types of compost: C_1: 80 % fish + 20 % sawdust; C_2: 80 % fish + 20 % straw; C_3: 80 % fish + 20 % bark; C_4: 79.3 % fish + 19.7 % sawdust + 1 % brown coal; C_5: 79.3 % fish + 19.7 % straw + 1 % brown coal; C_6: 79.3 % fish + 19.7 % bark + 1 % brown coal. Selected chemical properties of the experimental materials are given in Table 1.

Table 1

Chemical properties of substances used for composting [g · kg^{-1} d.m.]

Parameter	Sawdust	Straw	Bark	Brown coal
Total organic matter	566.2	422.6	410.0	705.0
Total N	1.92	5.53	7.04	8.40
Phosphorous	0.40	1.12	0.62	—
Potassium	0.94	12.44	1.05	—
Magnesium	1.12	1.16	1.32	—
Calcium	1.22	2.62	1.51	—

During the course of the composting process, the humidity of materials was maintained at a constant level of 60–70 %, and the compost mass was mixed once a week to aerate it. Chemical properties of composts before application are given in Table 2. The vegetation pot experiment was conducted at a steady temperature of 22 $^oC \pm 2\ ^oC$ in the greenhouse facility of the University of Warmia and Mazury in Olsztyn (Poland). PCV pots filled with 5 kg of soil mixed that had been previously mixed with composts in accordance with the study procedure were used for this purpose. The soil used in the experiment was characterized by a pH of 5.7 and

Table 2

Mean chemical properties of final composts before application [$g \cdot kg^{-1}$ d.m.]

Compost[a]	N_{tot}	P	K	Na	Ca	Mg	C_{org}	C:N
Compost C_1	9.21	2.61	3.07	0.30	3.75	0.60	425.74	46.2
Compost C_2	12.13	2.56	3.74	0.31	3.19	0.62	418.59	34.5
Compost C_3	11.46	2.43	3.77	0.33	3.17	0.65	382.80	33.4
Compost C_4	9.93	2.53	3.15	0.31	4.04	0.61	413.38	41.6
Compost C_5	12.59	2.49	3.95	0.34	3.70	0.67	428.71	34.1
Compost C_6	12.22	2.50	3.99	0.35	3.68	0.63	369.96	30.3
Mean C_1–C_6	11.26	2.52	3.61	0.32	3.59	0.63	406.53	36.7

[a] C_1: 80 % fish + 20 % sawdust; C_2: 80 % fish + 20 % straw; C_3: 80 % fish + 20 % bark; C_4: 79.3 % fish + 19.7 % sawdust + 1 % brown coal; C_5: 79.3 % fish + 19.7 % straw + 1 % brown coal; C_6: 79.3 % fish + 19.7 % bark + 1 % brown coal.

granulometric composition of 86 % sand (2.0–0.05 mm), 11.2 % dust (0.05–0.002 mm) and 2.2 % suspended fraction (< 0.002 mm) obtained from the arable layer of a farm field. The content of organic carbon and nitrogen in this soil was: C_{org} – 6.30 $g \cdot kg^{-1}$, N_{tot} – 0.54 $g \cdot kg^{-1}$, absorbable elements: phosphorus – 84.76 $mg \cdot kg^{-1}$, magnesium – 76.37 $mg \cdot kg^{-1}$ and potassium – 57.89 $mg \cdot kg^{-1}$ soil. The soil samples were air-dried and passed through a 5-mm sieve prior to the greenhouse pot experiment. The experiment consisted of two series, each conducted in four replicates. In the first, composts were applied in the amount of 1 gN compost per pot. In the second, 0.5gN-min. in the form of urea was applied in addition to the compost. Control objects were accounted for – not fertilized nor subjected to mineral fertilization. The effect of fertilizations was tested on radish (*Raphanus sativus* L.) of the Rowa variety. The density was 5 plants per pot. During the vegetation soil humidity was maintained at the level of 60 % capillary water capacity. The radishes were picked upon reaching full maturity.

The collected plant samples was analyzed in order to determine yield of aerial parts, mass of above-ground parts as well as roots from each pot. Plant samples were fragmented, dried at 60 ^{o}C, ground, and mineralized in concentrated sulphuric (VI) acid with hydrogen peroxide added as a catalyst. After mineralization of the plant samples, the content of phosphorus and potassium was analysed with the vanadium-molybdenum method [7], calcium and sodium with atomic emission spectroscopy – AES on FLAPHO 4 CZJ model [8]. Magnesium with atomic absorption spectroscopy – AAS [8], dry mass by means of the dryer method at a temperature of 105 ^{o}C. All reagents were of analytical reagent grade unless otherwise stated. Double deionized water (Milli-Q Millipore 0.055 μS/cm resistivity) was used for all dilutions.

The results were subjected to statistical analyses, calculating the average values and significance of differences between average macroelement contents in the above-ground plant parts and roots of radish by means of one factor analysis of variance based on the smallest significant differences using Statistica version 9.0.

Results and discussion

The growth and crop yield of radish (*Raphanus sativus* L.) indicated a clear differentiation, which was influenced by the type of compost (C_1–C_6) as well as mineral fertilization (Table 3). The average crop yield of above-ground plant parts and roots in the series without additional mineral fertilization was 52.68 % higher, and in the N-min. series – 35.42 % higher, when compared to the control objects. The influence of varied organic and mineral fertilization on the crop yield of radish has been confirmed by studies conducted by Islam et al [9], Ebid et al [10], Liao et al [11] and Akoumianakis et al [12]. Asghar et al [13] reported a positive effect of composts from organic wastes along with mineral fertilizers on the crop yield of above-ground parts and roots of radish plants. The composts applied in the experiment resulted in different crop yields of above-ground radish parts and roots. The highest crop yield of plants subjected to additional mineral fertilization was noted in the case of applying compost containing bark with the addition of brown coal. The addition of brown coal (composts C_4–C_6) significantly influenced the crop yield of above-ground plant parts and roots in both of the study series as compared to composts which did not contain it (C_1–C_3). Mineral fertilization increased mainly the crop yield of above-ground parts in the control objects.

Table 3

Effect of fish compost application on the yield above part and root of radish (*Raphanus sativus* L.) fresh matter

Fertilization	Series without mineral N				Series with mineral N			
	Yield [g]			Relative to control [%]	Yield [g]			Relative to control [%]
	Leaves	Root	Total		Leaves	Root	Total	
Without fertilization	42.40	30.12	72.52	100.00	54.13	32.19	86.32	100.00
Compost C_1	60.39	37.20	97.59	134.56	68.35	41.94	110.29	127.77
Compost C_2	65.24	43.51	108.75	149.96	66.46	40.40	106.86	123.80
Compost C_3	68.57	38.99	107.56	148.32	66.50	40.81	107.31	124.32
Compost C_4	64.74	45.14	109.88	151.52	75.59	47.49	123.08	142.59
Compost C_5	70.40	47.33	117.73	162.34	71.13	51.15	122.28	141.66
Compost C_6	74.36	48.45	122.81	169.35	78.50	53.03	131.53	152.37
Mean C_1–C_6	67.28^a	43.44^b	110.72^c	152.68	71.01^a	45.80^b	116.81^c	135.42
$LSD_{0.05}$	14.71	10.04	20.45		15.62	11.01	19.66	

$^{a–a,\ b–b,\ c–c}$ – significant differences at $p < 0.05$.

Dry mass content took on varied levels, which were influenced by the variant of fertilization (Table 4). Nitrogen fertilization influences the fresh mass yield more than it does the dry mass [11, 12, 14]. The application of composts resulted in decreasing the dry mass content in radish roots in both of the series compared to the control objects, while significant differences were not found between the dry matter content of the

Table 4

Dry matter content [%] in above-ground parts of radish (*Raphanussativus* L.) accounting for the fertilization variant

Fertilization	Series without mineral N		Series with mineral N	
	Leaves	Root	Leaves	Root
Without fertilization	4.25	7.15	4.26	7.19
Compost C_1	4.15	6.78	4.19	6.79
Compost C_2	4.00	6.68	4.16	6.81
Compost C_3	4.07	6.74	4.15	6.77
Compost C_4	3.98	6.65	4.10	6.54
Compost C_5	3.90	6.48	4.07	6.44
Compost C_6	3.89	6.23	4.05	6.21
Mean C_1–C_6	4.00^{a}	6.59^{b}	4.12^{a}	6.59^{b}
$LSD_{0.05}$	n.s.	0.77	n.s.	0.81

$^{a\text{–}a}$ – insignificant differences at $p < 0.05$, $^{b\text{–}b}$ – significant differences at $p < 0.05$.

above-ground plant parts in both experimental series. Similar dependencies were revealed by Lu et al [15] when subjecting radish, tomato and Chinese cabbage to intense organic and mineral fertilization. The applied fertilization resulted in various contents of macroelements in the dry mass of above-ground plant parts of radish (Table 5).

Table 5

Macroelement content in radish leaves [$g \cdot kg^{-1}$ d.m.]

Fertilization	Series without mineral N					Series with mineral N				
	P	K	Ca	Na	Mg	P	K	Ca	Na	Mg
Without fertilization	3.23	17.01	22.08	3.64	2.88	3.41	11.25	25.98	4.32	3.59
Compost C_1	4.57	19.78	20.60	4.70	3.85	4.14	18.27	27.82	4.62	3.86
Compost C_2	3.44	23.79	21.94	3.19	3.09	3.90	26.30	24.62	2.89	3.28
Compost C_3	3.84	13.76	28.28	4.47	3.75	4.21	16.77	26.90	4.02	3.67
Compost C_4	3.88	18.27	25.54	3.72	3.67	3.66	14.76	30.62	3.27	3.61
Compost C_5	3.42	16.27	24.62	3.19	3.48	4.47	21.78	24.64	3.42	3.37
Compost C_6	3.22	14.26	22.38	3.42	3.07	3.74	18.77	24.18	3.64	3.32
Mean C_1–C_6	3.73^{a}	17.69^{b}	23.0^{c}	3.78^{d}	3.49^{e}	4.02^{a}	19.44^{b}	26.46^{c}	3.64^{d}	3.52^{e}
$LSD_{0.05}$	0.81	3.92	4.10	0.84	0.59	0.72	3.98	3.44	0.83	0.69

$^{a\text{–}a,\ b\text{–}b,\ c\text{–}c,\ d\text{–}d,\ e\text{–}e}$ – significant differences at $p < 0.05$.

These factors influenced the quantitative changes in the individual elements as well as their totals, although to different degrees. The average content of the sum of macroelements: phosphorus (P), potassium (K), sodium (Na), calcium (Ca), and Magnesium (Mg) in the series with additional mineral fertilization was 10.43 % higher in the series with additional mineral fertilization than in the series to which only composts had been applied. In terms of the individual elements, a positive influence of N-min was observed in the increasing values of average phosphorus, potassium, calcium and magnesium contents in both analyzed plant organs. The average content of phosphorus, potassium, calcium, sodium and magnesium in the above-ground plant parts of radish was higher in the series containing only composts, whereas the series with additional mineral fertilization led to an increase in the average content of phosphorus, potassium, and calcium but decrease in sodium and magnesium. Phosphorus content (4.57 $g \cdot kg^{-1}$ d.m.) in the above-ground parts of the analyzed plant in the series without mineral fertilization was most affected by the addition of compost containing fish waste and sawdust. The lowest content of phosphorus totaling 3.22 $g \cdot kg^{-1}$ d.m. in the same series was observed in plants grow in soil containing compost, bark and brown coal. Asghar et al [13] report that fertilization with vegetable and fruit compost alone has little influence on the phosphorus content in the above-ground plant parts of radish. Urea fertilization increased the accumulation of phosphorus and potassium in the above-ground parts of the tested plant. In the series with mineral fertilization, phosphorus content in the above-ground plant parts ranged from 11.25 $g \cdot kg^{-1}$ d.m. in the series without fertilization to 26.30 $g \cdot kg^{-1}$ d.m. upon the application of compost containing fish waste and straw (C_2). The above-ground plant parts of radish grown on compost composed of a mixture of fish waste and sawdust without additional mineral fertilization were characterized by the lowest content of calcium, determined to be 20.60 $g \cdot kg^{-1}$ d.m. The highest value (30.62 $g \cdot kg^{-1}$ d.m.) occurred in the second series of the experiment, when compost produced from fish waste, sawdust and the addition of brown coal was used. The biggest differences in terms of sodium content were observed in the above-ground parts of the analyzed plant, where its value ranged from 3.19 $g \cdot kg^{-1}$ d.m. in plants fertilized with compost containing fish waste and straw to 4.70 $g \cdot kg^{-1}$ d.m. in the case of compost with fish waste and sawdust. Magnesium content was lowest in the series without N-min. (2.88 $g \cdot kg^{-1}$ d.m.) and highest in plants fertilized with compost containing fish waste and sawdust (C_1) (3.86 $g \cdot kg^{-1}$ d.m.). The obtained results can be compared to studies carried out by Krzebietke [16] in which the author showed that the content of macroelements in the leaves of butter lettuce subjected to nitrogen fertilization to be as follows: 4.9–6.0 $g \cdot kg^{-1}$ d.m. phosphorus, 40.2–45.2 $g \cdot kg^{-1}$ d.m. potassium, 17.1–23.0 $g \cdot kg^{-1}$ d.m. calcium, 0.8–7.3 $g \cdot kg^{-1}$ d.m. sodium and 2.8–4.0 $g \cdot kg^{-1}$ d.m. magnesium. The type of compost as well as the application a mineral fertilizer significantly modified the contents of selected macroelements in the roots of radish (*Raphanus sativus* L.) (Table 6). A positive influence of mineral fertilization was observed only in the case of the average potassium content in the above mentioned plant organ. The roots of radish fertilized with composts without additional mineral fertilization contained more phosphorus, potassium, calcium, sodium, and magnesium than those in the control group. In the case of plants that underwent additional mineral fertilization, the average content of phosphorus, potassium, calcium and magnesium were shown to increase, accompanied by a decrease in sodium. The lowest (3.22 $g \cdot kg^{-1}$ d.m. in the control group) as well as highest (4.49 $g \cdot kg^{-1}$ d.m. in the group with C3 compost) phosphorus content in radish roots were noted in the series without additional mineral fertilization. The content of potassium in

Table 6

Macroelements content in radish roots [g · kg^{-1} d.m.]

Fertilization	Series without mineral N					Series with mineral N				
	P	K	Ca	Na	Mg	P	K	Ca	Na	Mg
Without fertilization	3.94	22.77	3.95	2.13	1.89	3.96	22.28	4.02	2.43	2.07
Compost C_1	4.19	26.30	3.98	2.88	2.16	4.46	27.30	4.33	2.28	2.04
Compost C_2	4.08	28.31	4.23	1.93	2.15	4.38	29.81	4.65	1.63	1.89
Compost C_3	4.49	25.80	4.82	2.63	2.16	4.26	26.30	4.37	2.18	2.34
Compost C_4	4.44	30.32	4.67	2.53	2.32	4.42	30.81	4.65	2.03	2.17
Compost C_5	4.44	28.31	4.70	1.93	2.07	4.29	29.31	4.33	1.94	1.93
Compost C_6	4.30	26.80	4.93	2.03	1.91	4.28	27.30	4.37	2.13	2.28
Mean C_1–C_6	4.32[a]	27.64[b]	4.56[c]	2.32[d]	2.13[e]	4.35[a]	28.47[b]	4.45[c]	2.03[d]	2.11[e]
$LSD_{0.05}$	n.s.	4.92	0.72	0.56	0.34	0.42	3.94	0.55	0.43	0.42

[a–a, c–c, d–d, e–e] – significant differences at $p < 0.05$, [b–b] – insignificant differences at $p < 0.05$.

the roots of plants grown with a mineral fertilizer ranged from 22.28 g · kg^{-1} d.m. (control) to 30.81 g · kg^{-1} d.m. (compost C_4). The group of plants grown in compost made of fish waste, sawdust and the addition of brown coal was characterized by the highest concentration of calcium (4.82 g · kg^{-1} d.m.) in the roots of radish planted in pots with additional mineral fertilization was noted in of the group in where compost was made of fish waste, sawdust, and the addition of brown coal. There was some variety in the sodium content of radish roots depending on the type of fertilization applied, and the lowest value (1.63 g · kg^{-1} d.m.) of this macroelement occurred in those plants which had been fertilized with urea (N-min) and compost containing fish waste and straw. Magnesium content was lowest in the control object (without fertilization) and determined to be 1.89 g · kg^{-1}. Similar values of macrolements in radish roots were reported by Asghar et al [13] and Djurovka et al [17]. In their studies on the influence of fertilization with compost and mineral fertilizers on the content of macroelements in radish roots, Asghar et al [13] determined that the concentration of phosphorus increased in objects fertilized with compost along with doses of urea. Potassium content in the roots however, was not influenced by neither organic nor mineral fertilization. In studies conducted by Lu et al. [14] on the concentration of potassium and phosphorus in radish shoots and the fleshy root of radish, potassium content did not depend on the type of mineral fertilization or different doses of manure, but did appear to increase along with increased organic fertilization. Islam et al [9] revealed that organic mineral fertilization has a beneficial effect on the absorption of potassium and phosphorus by radish when compared to organic fertilization by itself.

The quality of the edible plant parts depends not only on the concentration of macro- and microelements but also on their ratios, which can depend not only on the species of plant but also the proportions of cations in the fertilizers [18]. The optimal proportions between the individual elements should be higher than Ca: P – 2; Ca: Mg – 3; K: (Ca + Mg) – 1.6–2.2; K: Mg – 6; K: Ca – 2 [19, 20]. The studies confirmed that the

Table 7

Mass ratios between macroelements in radish roots accounting for fish compost fertilization

Fertilization	Series without mineral N					Series with mineral N				
	K : Ca	K : Mg	Ca : P	Ca : Mg	K : (Ca + Mg)	K : Ca	K : Mg	Ca : P	Ca : Mg	K : (Ca + Mg)
Without fertilization	5.76	12.05	1.00	2.09	3.90	5.54	10.76	1.02	1.94	3.66
Compost C_1	6.61	12.18	0.95	1.84	4.28	6.30	13.38	0.95	2.12	4.29
Compost C_2	6.69	13.17	1.04	1.97	4.44	6.41	15.77	1.06	2.46	4.56
Compost C_3	5.35	11.94	1.07	2.23	3.70	6.02	11.24	1.03	1.87	3.92
Compost C_4	6.49	13.07	1.05	2.01	4.34	6.63	14.20	1.05	2.14	4.52
Compost C_5	6.02	13.68	1.06	2.27	4.18	6.77	15.19	1.01	2.24	4.68
Compost C_6	5.44	14.03	1.15	2.58	3.92	6.25	11.97	1.02	1.92	4.11
Mean C_1–C_6	6.10	13.01	1.05	2.15	4.14	6.39	13.63	1.02	2.13	4.35

radish roots were characterized by an wider ranges of K: Ca, K: (Mg + Ca) and K: Mg (Table 7).

The ratios between Ca:P and Ca:Mg were favorable. Tariq and Mott [21] stated that the addition of boron (B) and calcium (Ca) has an influence on the ratios of K:Mg and K:Na cations in the leaves and roots of radish. Composts, in both series of the experiment, extended all cation ratios, however, the effect of individual composts varied. An exception to this was the ratio between Ca:P in the series with N-min., where the average effect of composts did not result in its change. The most significant reduction of K:Ca, K:Mg and K: (Mg + Ca) ratios in the first series was observed in plants in the group fertilized with compost containing fish waste and bark (C_3), and in the case of Ca:Mg – in the group containing C_2 (fish waste and straw). In the second series of the experiment, narrower proportions were noted only in the group of plants with compost made of a mixture of fish waste, straw and brown coal (C_5) – Ca:P and that with compost which contained bark (C_3) – Ca:Mg as compared to the control group.

Conclusions

The conducted experiment showed that the application of composts produced from by-products of the fishing industry had a positive effect on the crop yield of above-ground plant parts and roots of radish (*Raphanus sativus* L.). Additional mineral fertilization effected crop yield only to a small degree. This indicates that plants make good use of nitrogen. The highest crop yield was obtained upon the application of compost the contents of which included bark and the addition of brown coal. The addition of this component was also shown to have a positive effect in the other composts variants. In the series not subjected to mineral fertilization, the above-ground parts of radish contained, on average, more phosphorus, potassium, calcium, sodium and magnesium than the control group. The roots too were characterized by the highest phosphorus, potassium, calcium, and magnesium contents in the series without mineral fertilization as compared to the control group, but the sodium content was shown to decrease.

References

[1] Sondergaard M, Jeppeson E. J Applied Ecol. 2007;44:1089-1094. DOI: 10.1111/j.1365-2664.2007.01426.x.
[2] Heerdt G, Hootsmans M. Hydrobiol. 2007;584:305-316. DOI: 10.1007/s10750-007-0594-9.
[3] Ferreira JG, Bricker SB, Simas TC. J Environ Manage. 2007;82:433-445. DOI: 10.1016/j.jenvman.2006.01.003.
[4] Sřndergaard M, Jeppesen E, Lauridsen TL, Skov C, Nes EH, Roijackers R, et al. J Applied Ecol. 2007;44:1095-1105. DOI: 10.1111/j.1365-2664.2007.01363.x.
[5] Martin LM. Renew Energy. 1999;16:1102-1105. DOI: 10.1016/S0960-1481(98)00428-5.
[6] López-Mosquera ME, Fernández-Lema E, Villares R, Corral R, Alonso B. Procedia Environ Sci. 2011;9:113-117. DOI: 10.1016/j.proenv.2011.11.018.
[7] Cavell AJ. J Sci Food Agric. 1955;6:479-481.
[8] Szyszko E. Instrumental analytical method. PZWL Warsaw; 1982.
[9] Islam MM, Karim AJM, Jahiruddin M, Majid M, Miah MG, et al. Aust J Crop Sci. 2011;5:1370-1378.
[10] Ebid A, Ueno H, Ghoneim A, Asagi N. Compost Sci Utilization. 2008;16:152-158.

[11] Liao Y, Rong X, Zheng S, Liu Q, Fan M, et al. Front Agric China. 2009;3:122-129. DOI: 10.1007/s11703-009-0041-y.
[12] Akoumianakis KA, Karapanos IC, Giakoumaki M, Alexopoulos AA, Passam HC. Int J Plant Prod. 2011;5:111-120.
[13] Asghar HN, Ishaq M, Zahir ZA, Khalid M, Arshad M. Pakistan J Botany. 2006;38:691-700.
[14] Chohura P, Kołota E. Acta Sci Pol Hortorum Cultus. 2011;10:23-30.
[15] Lu CB, Ye ZQ, Zhang XL, Lin XY, Ni WZ. Phys Chem Earth. 2011;36:387-394. DOI: 10.1016/j.pce.2010.03.030.
[16] Krzebietke S. J Elementol. 2008;13:581-588.
[17] Djurovka M, Marković V, Ilin Ž. Acta Hort. 1997;462:139-144.
[18] Ekholm P, Reinivuo H, Mattila P, Pakkala H, Koponen J, et al. J Food Compos Anal. 2007;20:487-495. DOI: 10.1016/j.jfca.2007.02.007.
[19] Francke A. Acta Sci Pol Hortorum Cultus. 2010;9:51-57.
[20] Wierzbicka B, Majkowska-Gadomska J, Nowak M. Acta Sci Pol Hortorum Cultus. 2007;6:3-8.
[21] Tariq M, Mott CJB. J Agric Biol Sci. 2007;2:4-13.

WPŁYW KOMPOSTÓW Z PRODUKTÓW UBOCZNYCH GOSPODARKI RYBACKIEJ NA ZAWARTOŚĆ MAKROSKŁADNIKÓW W RZODKIEWCE

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Abstrakt: Przetwarzanie małocennych gatunków ryb jeziorowych na komposty może towarzyszyć zabiegom ich odłowów stosowanych przy ograniczaniu eutrofizowacji jezior. W sposób mało kosztowny można uzyskać nawóz organiczny. W celu oceny kompostów, w których składzie znajdowały się odłowione ryby karpiowate, trociny, słoma, kora i węgiel brunatny założono doświadczenie wazonowe z rzodkiewką (*Raphanus sativus* L.). Doświadczenie obejmowało dwie serie: I – komposty w dawce 1 gN kompostu na wazon, II – komposty i 0,5 g mocznika. Stosowanie kompostów spowodowało średni wzrost plonu rzodkiewki o 52,68 % w obiektach bez dodatkowego nawożenia mineralnego, a w serii z dodatkowym nawożenie mineralnym o 35,42 % w stosunku do obiektów kontrolnych. Stwierdzono korzystne działanie węgla brunatnego w kompostach na plon zarówno części nadziemnych, jak i korzeni rzodkiewki. Liście zawierały średnio w stosunku do serii kontrolnej więcej P, K, Ca, Na i Mg w serii bez nawożenia mineralnego. W serii z mocznikiem wzrosła średnia zawartość P, K i Ca, a zmalała Na i Mg. Korzenie rzodkiewki zawierały średnio w stosunku do kontroli więcej P, K, Ca, Na i Mg w serii bez nawożenia mineralnego. W serii z dodatkowym nawożeniem mineralnym wzrosła średnia zawartość P, K, Ca i Mg, a zmalała Na.

Słowa kluczowe: odpady rybne, nawożenie, makroskładniki, rzodkiewka