ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 16, No. 1–2 2009

Dorota KALEMBASA[1] and Elżbieta MALINOWSKA[1]

INFLUENCE OF MINERAL FERTILIZATION ON TOTAL CONTENTS OF Co, Li, AND Ti IN BIOMASS OF FIVE *MISCANTHUS* GENOTYPES

WPŁYW NAWOŻENIA MINERALNEGO NA ZAWARTOŚĆ OGÓLNĄ Co, Li AND Ti W BIOMASIE PIĘCIU GENOTYPÓW TRAWY *MISCANTHUS*

Abstract: The study involved five different genotypes of *Miscanthus* grass (ecotypes of different origin), ie two diploid: No. 1 and No. 19, as well as three triploid: No. 53, No. 63, and POL. After the second year of *Miscanthus* cultivation, total contents of Co, Li, and Ti were determined in a plant material, including leaves, stems, roots, and rhizomes. The mineral fertilization differentiated the contents of studied elements in majority of *Miscanthus* parts. The highest concentrations (mean for a fertilization) of Co and Ti were determined in roots and Li in rhizomes, while the lowest levels of Co, Li, and Ti were recorded in stems of tested grass. Greater Co accumulation for diploid (except from stems), Li for triploid, and Ti for triploid genotypes (except from leaves) was recorded.

Keywords: *Miscanthus* grass, biomass, cobalt, lithium, titanium, fertilization

Miscanthus is a gigantic grass species belonging to *Miscanthus* genus. That plant began to be used in 80s of the twentieth century [1]. At present, it is a valuable material for various industrial branches, namely for energetic purposes [2–4]. *Miscanthus* growth and development is affected by many factors: among others, morphological traits (rhizome size and genotype), agrotechnics, and fertilization [5].

The study aimed at evaluating the mineral fertilization influence and the genotype on cobalt, lithium, and titanium contents in leaves, stems, roots, and rhizomes of five *Miscanthus* genotypes at the second cultivation year.

[1] Department of Soil Science and Agricultural Chemistry, University of Podlasie in Siedlce, ul. B. Prusa 14, 08–110 Siedlce, tel. 025 643 13 52, email: kalembasa@ap.siedlce.pl

Materials and methods

The field experiment was set in autumn 2000 under soil and climatic conditions of middle-eastern Poland on the soil of loamy sand granulometric composition (according to PN-R-04033), with $pH_{KCl} = 6.73$. The organic carbon content was 37.4 g · kg^{-1}, and studied elements [mg · kg^{-1} of soil]: Co – 4.62, Li – 1.70, and Ti – 49.42. Five genotypes of *Miscanthus* were chosen: 2 diploid (2x) representing *Miscanthus sinensis* species (clone No. 1 from *Hybriden* grass group and clone No. 19 – German form "Goliath" – MGo); 3 triploid (3×) being the *Miscanthus sinensis* x *gigantheus* hybrids (clone No. 53 from Germany, clone No. 63 from Denmark, and clone POL from Poland). Rhizomes achieved from the rhizome reproduction were set on 1.5 m^2 area in three replications in completely randomized pattern. The experiment included two fertilization objects:

– control (with no fertilization);

– mineral fertilization [kg · ha^{-1}]: N_{60} P_{50} K_{100} in a form of ammonium nitrate, triple superphosphate, and potassium sulfate applied once a year before vegetation beginning.

Total contents of cobalt, lithium, and titanium were determined in the grass harvested in winter 2002 and divided into leaves, rhizomes, stems, and roots. The plant material was ground till 0.25 mm of particle diameter, aliquots of 1 g were weighed into the stoneware crucible, and then combusted in the muffle furnace at 450 ^{o}C for 15 hours. Portions of 10 cm^3 diluted HCl (1:1) were added into crucibles and evaporated till dryness on a sandy bath to decompose carbonates and separate silicates. After adding 5 cm^3 10 % HCl, the crucible content was transferred through hard filter paper to the measure flask and adjusted volume to 100 cm^3 with distilled water. Total contents of Co, Li, and Ti in plant material were determined by means of ICP-EAS technique.

Achieved results were statistically processed; differences between mean values for studied factors were estimated applying variance analysis (helped with FR Analvar 4.1 software), and in the case of difference significance, $LSD_{0.05}$ values were calculated according to Tukey's test.

Results and discussion

Cobalt concentration in analyzed plant material varied (Table 1). Its highest amounts were found in roots of diploid (1.45 mg · kg^{-1}) and triploid genotypes (1.35 mg · kg^{-1}); while the lowest levels in stems (0.183 and 0.224 mg · kg^{-1}, respectively). Kalembasa et al [6] and Jeżowski et al [7] reported similar dependence of other elements accumulation – ie potassium, copper, nickel, and chromium – in particular parts of *Miscanthus* grass. NPK fertilization did not make significant differences in cobalt content in studied parts of diploid genotypes, whereas considerable differences were observed for its levels in leaves, stems, and roots of triploid clones. Increase of cobalt concentration due to fertilization was recorded in leaves and stems of studied grass: more for triploid genotypes as well as in roots and rhizomes of only triploid genotypes. Studies revealed that leaves, rhizomes, and roots of diploid clones were characterized by higher cobalt accumulation as compared to triploid ones. Contents of cobalt [mg · kg^{-1}] at analyzed

Table1

Total content of cobalt [mg · kg^{-1} d.m.] in above- and underground parts of *Miscanthus*

Genotypes	Leaves			Stems			Rhizomes			Roots		
	0	NPK	mean	0	NPK	mean	0	NPK	mean	0	NPK	mean
	diploid genotypes											
No. 1	0.233	0.136	0.184	0.187	0.202	0.195	0.372	0.383	0.377	1.63	1.13	1.38
No. 19	0.200	0.526	0.363	0.098	0.245	0.172	0.245	0.189	0.217	1.53	1.53	1.53
Mean for diploid genotypes	0.217	0.331	0.274	0.143	0.224	0.183	0.309	0.286	0.297	1.58	1.33	1.45
Changes in cobalt content in analysed parts of plant	0.114			0.081			–0.023			–0.250		
$LSD_{0.05}$ for:												
A – fertilization	n.s.			n.s.			n.s.			n.s.		
B – genotypes	0.171			n.s.			0.141			n.s.		
A/B – interaction	0.242			n.s.			n.s.			n.s.		
B/A – interaction	0.242			n.s.			n.s.			n.s.		
	triploid genotypes											
No. 53	0.203	0.247	0.225	0.099	0.247	0.173	0.227	0.214	0.220	1.06	1.68	1.37
No. 63	0.153	0.296	0.225	0.110	0.234	0.172	0.207	0.194	0.201	1.29	1.30	1.29
POL	0.142	0.456	0.299	0.197	0.456	0.327	0.384	0.430	0.407	1.44	1.36	1.40
Mean for triploid genotypes	0.166	0.333	0.249	0.135	0.312	0.224	0.273	0.351	0.276	1.26	1.45	1.35
Changes in cobalt content in analysed parts of plant	0.167			0.177			0.078			0.190		
$LSD_{0.05}$ for:												
A – fertilization	0.093			0.082			n.s.			0.165		
B – genotypes	n.s.			0.122			0.143			n.s.		
A/B – interaction	n.s.			n.s.			n.s.			0.286		
B/A – interaction	n.s.			n.s.			n.s.			0.351		

n.s. – non significant difference

Miscanthus grass can be lined up in a form of the following sequence (mean for the fertilization):

– roots: No. 19 (1.53) > POL (1.40) > No. 1 (1.38) > No. 53 (1.37) > No. 63 (1.29);

– rhizomes: POL (0.407) > No. 1 (0.377) > No. 53 (0.220) > No. 19 (0.217) > No. 63 (0.210);

– leaves: No. 19 (0.363) > POL (0.299) > No. 53 (0.225) = No. 63 (0.225) > No. 1 (0.184);

– stems: POL (0.327) > No. 1 (0.195) > No. 53 (0.173) > No. 63 (0.172) = No. 19 (0.172).

The highest lithium levels were found in *Miscanthus* underground parts, namely in rhizomes of all studied genotypes (Table 2). Rhizomes of diploid genotypes contained (mean for fertilization) 26.19 mg Li · kg^{-1}, while triploid ones 34.21 mg Li · kg^{-1}. Diploid genotypes were characterized by lower average lithium accumulation than triploid ones for all analyzed parts of the grass. Mineral fertilization affected the decrease of the element concentration in leaves, stems, and roots of diploid clones, as well as leaves and rhizomes of triploid genotypes. Lithium contents [mg · kg^{-1}] in studied parts of *Miscanthus* can be lined up in the following sequences (mean for fertilization):

– rhizomes: POL (42.22) > No. 63 (33.15) > No. 19 (28.28) > No. 53 (27.25) > No. 1 (24.11);

– roots: POL (19.81) > No. 53 (16.17) > No. 63 (15.77) > No. 19 (13.55) > No. 1 (6.78);

– leaves: POL (16.54) > No. 19 (13.17) > No. 63 (11.45) > No. 53 (7.42) > No. 1 (7.20);

– stems: No. 63 (17.77) > No. 53 (12.49) > POL (9.71) > No. 19 (9.56) > No. 1 (5.63).

The poorest lithium bioaccumulation was recorded for diploid clone No. 1, while the richest for triploid clone POL (except from the stems).

Mineral NPK fertilization significantly differentiated titanium content in studied parts of tested plant (Table 3). Due to the fertilization, total concentration of titanium increase, except from stems of diploid genotypes (–0.390 mg · kg^{-1}) and leaves of triploid clones (–0.590 mg · kg^{-1}). Underground organs (roots and rhizomes) were characterized by almost 20-fold higher concentration of the element than aboveground parts (leaves and stems). Total contents of titanium (mg · kg^{-1}) in under- and aboveground parts of *Miscanthus* can be lined up in following sequences (mean for fertilization):

– roots: POL (75.16) > No. 53 (70.75) > No. 63 (63.86) > No. 19 (55.26) > No. 1 (52.35);

– rhizomes: No. 63 (34.45) > No. 53 (34.09) > No. 1 (31.34) > No. 19 (26.60) > POL (24.44);

– leaves: No. 19 (4.05) > No. 1 (3.47) > POL (2.79) > No. 63 (2.58) > No. 53 (2.50);

– stems: No. 53 (2.62) > POL (2.46) > No. 63 (2.22) > No. 19 (1.79) > No. 1 (0.853).

Underground parts of five studied genotypes of *Miscanthus* genus (rhizomes and roots) contained more cobalt, lithium, and titanium than aboveground organs (leaves

Table 2

Total content of lithium [mg · kg^{-1} d.m.] in above- and underground parts of *Miscanthus*

Genotypes	Leaves			Stems			Rhizomes			Roots		
	0	NPK	mean	0	NPK	mean	0	NPK	mean	0	NPK	mean
	diploid genotypes											
No. 1	8.27	6.12	7.20	6.60	4.67	5.63	15.23	32.98	24.11	6.28	7.27	6.78
No. 19	15.80	3.66	13.17	10.74	8.42	9.56	26.73	29.82	28.28	14.22	12.88	13.55
Mean for diploid genotypes	12.04	4.89	10.18	8.67	6.55	7.60	20.98	31.40	26.19	10.25	10.08	10.16
Changes in lithium content in analysed parts of plant	–7.15			–2.12			10.42			–0.170		
$LSD_{0.05}$ for:												
A – fertilization	3.37			10.03			8.02			n.s.		
B – genotypes	3.37			10.03			n.s.			2.81		
A/B – interaction	4.76			n.s.			n.s.			n.s.		
B/A – interaction	4.76			n.s.			n.s.			n.s.		
	triploid genotypes											
No. 53	8.48	6.35	7.42	7.45	17.54	12.49	30.25	24.24	27.25	15.16	17.19	16.17
No. 63	18.58	4.32	11.45	4.50	31.04	17.77	40.33	25.98	33.15	18.98	12.57	15.77
POL	25.46	7.63	16.54	1.49	17.92	9.71	59.17	25.28	42.22	17.58	22.09	19.81
Mean for triploid genotypes	17.51	6.10	11.80	4.48	22.17	13.32	43.25	25.17	34.21	17.22	17.28	17.25
Changes in lithium content in analysed parts of plant	–11.41			17.69			–18.08			0.060		
$LSD_{0.05}$ for:												
A – fertilization	0.686			3.95			10.87			n.s.		
B – genotypes	1.03			5.92			n.s.			3.08		
A/B – interaction	1.89			6.84			n.s.			3.56		
B/A – interaction	1.46			8.37			n.s.			4.35		

n.s. – non significant difference

Table 3

Total content of titanium [$mg \cdot kg^{-1}$ d.m.] in above- and underground parts of *Miscanthus*

Genotypes	Leaves			Stems			Rhizomes			Roots		
	0	NPK	mean	0	NPK	mean	0	NPK	mean	0	NPK	mean
	diploid genotypes											
No. 1	3.11	3.83	3.47	0.829	0.878	0.853	24.98	37.69	31.34	45.46	59.23	52.35
No. 19	3.75	4.35	4.05	2.20	1.37	1.79	25.03	28.18	26.60	17.71	92.81	55.26
Mean for diploid genotypes	3.43	4.09	3.76	1.51	1.12	1.32	25.01	32.94	28.97	31.59	76.02	53.80
Changes in titanium content in analysed parts of plant		0.660			–0.390			7.93			44.43	
$LSD_{0.05}$ for: A – fertilization B – genotypes A/B – interaction B/A – interaction		 0.136 0.136 n.s. n.s.			 0.067 0.067 0.095 0.095			 1.75 1.75 2.48 2.48			 4.11 n.s. 5.82 5.82	
	triploid genotypes											
No. 53	2.69	2.31	2.50	2.71	2.52	2.62	33.14	35.14	34.09	52.11	89.39	70.75
No. 63	3.56	1.80	2.58	1.84	2.60	2.22	32.14	36.76	34.45	44.06	83.66	63.86
POL	2.61	2.97	2.79	1.15	3.62	2.46	21.29	27.59	24.44	69.73	80.58	75.16
Mean for triploid genotypes	2.95	2.36	2.62	1.90	2.91	2.43	28.86	33.15	30.99	55.30	84.54	69.92
Changes in titanium content in analysed parts of plant		–0.590			1.01			4.29			29.24	
$LSD_{0.05}$ for: A – fertilization B – genotypes A/B – interaction B/A – interaction		 0.199 n.s. 0.345 0.422			 0.319 n.s. 0.552 0.676			 3.63 5.44 n.s. n.s.			 10.27 n.s. n.s. n.s.	

n.s. – non significant difference

and stems). It probably resulted from the autumn translocation of nutrients towards underground rhizomes that determine the sensitivity to low temperatures and wintering [8]. Accumulation of elements, namely toxic, in roots is very positive phenomenon at energetic utilization of plants.

Conclusions

1. Mineral fertilization of *Miscanthus* genus grass differentiated contents of cobalt, lithium, and titanium in majority of analyzed above- and underground organs of the plant.
2. Much more cobalt was found in roots, while lithium and titanium in rhizomes than in stems and leaves of studied grass.
3. Higher cobalt accumulation for diploid (except from stems), lithium for triploid, and titanium for triploid genotypes (except from leaves) was recorded.

References

[1] Deuter M. and Jeżowski S.: *Szanse i problemy hodowli traw z rodzaju Miscanthus jako roślin alternatywnych*. Hodow. Rośl. Nasienn., 1998, (2), 45–48.
[2] Jeżowski S.: Konferencja polsko-niemiecka na temat wykorzystania trzciny chińskiej, Połczyn Zdrój, 2000, 27–29.09, p. 21–25.
[3] Majtkowski W.: Mat. międzynar. konf. „Odnawialne źródła energii u progu XXI wieku", Warszawa 2001, 10–11.12. EC BREC/IBMER, 297–304.
[4] El Bassam N.: Materiały OECD Workshop on Biomass and Agriculture, Vienna, Austria 2003, 10–13.06, p. 1–10.
[5] Pude R. and Jeżowski S.: Biul. Inst. Hodow. Aklimatyz. Rośl., 2003, **227**(2), 573–583.
[6] Kalembasa D., Malinowska E., Jaremko D. and Jeżowski S.: Nawozy i Nawoż., 2005, **3**(24): 359–364.
[7] Jeżowski S., Kalembasa D. and Malinowska E.: [in:] Alternative plants for substainable agriculture, (eds. S. Jeżowski., M.K. Wojciechowicz and E. Zentkeler), Pagen, Institute of Plant Genetics, PAS Poznań, Monograph, 2006, **5**, 99–107.
[8] Roszewski R.: [in:] Nowe rośliny uprawne na cele spożywcze, przemysłowe i jako odnawialne źródło energii. Wyd. SGGW, Warszawa 1996, p. 123–135.

WPŁYW NAWOŻENIA MINERALNEGO NA ZAWARTOŚĆ OGÓLNĄ Co, Li AND Ti W BIOMASIE PIĘCIU GENOTYPÓW TRAWY *MISCANTHUS*

Katedra Gleboznawstwa i Chemii Rolniczej, Akademia Podlaska w Siedlcach

Abstrakt: W badaniach wykorzystano pięć różnych genotypów trawy *Miscanthus* (ekotypów różnego pochodzenia), tj. dwa diploidalne: nr 1 i nr 19 oraz trzy triploidalne: nr 53, 63 i POL. Po zakończeniu II roku uprawy miskanta zbadano ogólną zawartość Co, Li i Ti w materiale roślinnym, obejmującym liście, łodygi, korzenie i rizomy. Nawożenie mineralne zróżnicowało zawartość analizowanych pierwiastków w większości badanych części miskanta. Największą zawartość (średnia z nawożenia) Co i Ti stwierdzono w korzeniach, Li w rhizomach, natomiast najmniejszą zawartość Co, Li i Ti oznaczono w łodygach badanej trawy. Zanotowano większą kumulację Co dla genotypów diploidalnych (z wyjątkiem łodyg), Li dla triploidalnych, Ti dla triploidalnych (za wyjątkiem liści).

Słowa kluczowe: trawa *Miscanthus*, biomasa, kobalt, lit, tytan, nawożenie