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THE EFFECT OF OSMOCOTE FERTILISERS ON GROWTH AND NUTRIENT STATUS OF *ANEMANTHELE LESSONIANA* (STEUD). VELDKAMP. AND *BOUTELOUA GRACILIS* (KUNTH). LAG. EX GRIFFITHS

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Abstract

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The increasing importance of ornamental grasses in horticultural cultures results in the need to determine their cultivation requirements. A particularly essential role is played by the selection of fertilisers and specification of nutrient requirements. An experiment on the effect of Osmocote fertilisers on growth and nutrient status of *Anemanthele lessoniana* (Steud). Veldkamp. and *Bouteloua gracilis* (Kunth). Lag. ex Griffiths was conducted in the years 2008 – 2009. The differentiating factors included the type of fertiliser, i.e. Osmocote Exact Standard 16:11:11 and Osmocote Exact High Start 11:11:19, and fertiliser doses of 2 and 4 g·dm^{-3}. In the culture of *Anemanthele lessoniana* and *Bouteloua gracilis* it is recommended to apply Osmocote 11:11:19 at a dose of 4 g·dm^{-3}. The best quality plants in their aboveground parts contained the following amounts of macronutrients and sodium [%]: *Anemanthele lessoniana* – N - 1.54, P – 0.35, K – 2.10, Ca – 0.61, Mg – 0.14, Na – 0.10, while in *Bouteloua gracilis* it was – N – 1.75, P – 0.59, K – 2.31, Ca – 0.91, Mg – 0.36 and Na – 0.05, respectively.

Key words: ornamental grasses, slow-release fertilizer, leaf length, fresh weight, macronutrients

Introduction

Grasses are increasingly often used in green areas as ornamental plants (Dana, 2002; Henschke, 2013). They are planted in both perennial planting arrangements and on seasonal flower beds. *Anemanthele lessoniana* originates from New Zealand, where it grows in the USDA Hardiness Zones 6-8. In Poland it is planted as an annual or perennial plant, ornamental thanks to leaves colored orange towards the end of summer. It was awarded the title of Herbaceous Perennial of the year 2004 by the Royal Horticultural Society and the Award of Garden Merit (Meyer, 2013). *Bouteloua gracilis* is an herbaceous perennial growing in USDA Hardiness Zone 4, with showy inflorescences and attractive narrow leaves. Thanks to easy propagation of both species by sowing kernels these grasses may also supplement the assortment of balcony plants (Armitage, 1997; Pilon, 2006; Hanke 2008). Since they are species only recently introduced to horticultural production, cultivation recommendations need to be developed for them. Studies conducted to date concerned the occurrence of *Anemanthele lessoniana* in New Zealand (Head and Give, 2001) and use of *Bouteloua gracilis* as a fodder crop (Joern and Mole, 2005). So far there are no fertilizer recommendations for the cultivation of these grass species in containers.

Fertilisation is an important treatment in horticultural cultivation. Slow-release fertilizers, particularly Osmocote, are typically used in basal fertilisation in pot cultures (Szczepaniak and Kozik, 2004; Korszun and Zalewska, 2004; Shaviv, 2006). Depending on the requirements of individual species and varieties various types and application rates of this fertilizer may be used. Slow-release fertilizers are divided in terms of their release time and mineral contents. They may significantly affect plant growth. Slow-release nitrogen fertilizers cause abundant vegetative growth of the aboveground parts (Bosiacki, 2008), which is not always desirable in pot culture. Plants to be sold in pots should be well-tillered, compact and

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decorative. In grass growing the selection of fertilizer may be of great importance, since some species are capable of running C4 photosynthesis (Waller and Lewis, 1979). These plants are characterized by a greater efficiency of photosynthesis and greater biomass yield.

The aim of this study was to determine growth intensity of *Anemanthele lessoniana* (Steud). Veldkamp. and *Bouteloua gracilis* (Kunth). Lag. ex Griffiths grown in pots applying two types of Osmocote fertilisers at two different rates.

Materials and Methods

The greenhouse experiments were conducted in the years 2008 and 2009 to assess the effect of Osmocote fertilizers on growth and nutrient status of *Anemanthele lessoniana* and *Bouteloua gracilis*. The experimental factors included the type of fertilizer (Osmocote Exact Standard 16:11:11 and Osmocote Exact High Start 11:11:19) and fertilizer application rate (2g and 4g per 1 dm^3). Each of the four combinations in the first 9 weeks of culture comprised 5 replications - 5 pots with plants, while in the next 9 weeks of culture there were 4 replications - 5 pots with plants. Results (means from the two years of the experiments) were analyzed statistically separately for each species, for 9 and 18 weeks of culture separately, using the analysis of variance for the two-factorial experiment. The Newman–Keuls test at the significance level $\alpha = 0.05$ was applied to verify the detailed hypotheses.

Plant material comprised seedlings produced by Syngenta Sp. z o.o. in multi-trays of 250 cells. One multitray cell contained 10 seedlings of *Anemanthele lessoniana* and 6 seedlings of *Bouteloua gracilis* with mean leaf length in 2008 of 18.5 and 17.5 cm, while in 2009 mean leaf length was 16.5 and 15.5 cm, respectively. In both years of the study on May 20th seedlings were transplanted directly from multitrays to pots of 0.5 dm^3. Plants were grown for 9 weeks and next on July 20th they were transplanted to pots of 1.0 dm^3 and they were grown for the next 9 weeks until September 20th. Culture lasted for 18 weeks. The substrate used in culture was TS2 peat substrate by Klasmann, developed specifically to grow herbaceous perennials. This substrate with pH 5.8 (H_2O) contains peat fraction of 0 - 25 mm, 40 $g \cdot dm^{-3}$ R.H.P. perlite and 1.5 $g \cdot dm^{-3}$ PG Mix all-in-one fertilizer (14:16:18). Plants were grown using two Osmocote fertilizers with a 3 – 4-month nutrient release time, one with nitrogen as the main component, Osmocote Exact Standard 16:11:11, and the other with potassium as the main component, Osmocote Exact High Start 11:11:19. Each of the fertilizers was applied at doses of 2 and 4 $g \cdot dm^{-3}$. The fertilizers were applied as top-dressing, during stage I with a 0.5% solution (50 cm^3 per pot) and in stage II with a 0.1% solution (100 cm^3 per pot). Fertilizer Kristalon 20:5:10 was applied as top-dressing for plants grown with Osmocote Exact Standard, while for those fertilized with Osmocote Exact High Start top-dressing was applied using Peters Professional Special 15:11:29. At each stage of culture starting from week 4 top-dressing was applied 5 times at weekly intervals. Amounts of nutrients supplied at individual stages of culture are given in Table 1.

Plants were measured in weeks 9 and 18 of culture in 2008 and 2009. The following measurements were recorded: leaf length (cm) – on three fully developed leaves on randomly selected shoots; tussock diameter (cm) measured at the plant base, immediately above the substrate surface; the number of inflorescence culms in *Bouteloua gracilis*; fresh weight of aboveground parts (g) cut immediately above the substrate surface in five randomly selected plants from each combination. In week 18 of culture additionally bulk samples of aboveground parts were collected from plants for analyses of macronutrient and sodium contents. Samples were dried at 50°C, then homogenized and after wet mineralization the following were determined: N content according to Kjeldahl, P content by colorimetric using ammonium molybdate, contents of K, Ca, Na by photometry, and Mg content by atomic absorption.

Table 1
The amount of various ingredients provided at different stages of cultivation in each pot

Fertlizer	Dosages g dm^{-3}	Ingredient dose mg per pot								
		N			P			K		
		Stage I	Stage II	Sum I + II	Stage I	Stage II	Sum I + II	Stage I	Stage II	Sum I + II
Osmocote 16:11:11	2	290	365	**655**	104	112.2	**216.2**	213.8	244.9	**458.7**
	4	450	525	**975**	152.4	160.6	**313**	305.1	336.2	**641.3**
Osmocote 11:11:29	2	233.8	290	**523.8**	104	112.2	**216.5**	299.9	390.2	**690.1**
	4	343.8	400	**743.8**	152.4	160.6	**313**	457.6	547.9	**1005.5**

Results

Leaf length in *A. lessoniana* at week 9 of culture ranged from 59.0 cm to 60.6 cm and at week 18 it ranged from 67.8 cm to 71.8 cm, while tussock diameter ranged from 6.2 cm to 6.7 cm and from 10.2 cm to 12.1 cm. Fresh weight of the aboveground parts in plants at week 9 of culture fell within the range from 11.8 g to 13.8 g, whereas at week 18 it was from 31.3 g to 39.0 g. Leaf length in *B. gracilis* at week 9 of culture ranged from 59.7 cm to 63.1 cm and in week 18 - from 62.0 cm to 64.1 cm, tussock diameter ranged from 8.4 cm to 8.8 cm and from 9.5 cm to 12.4 cm, respectively, while fresh weight of aboveground parts in plants at week 9 of culture fell within the range from 7.3 g to 8.7 g and at week 18 - from 15.4 g to 19.8 g.

The type of applied fertilizer and its dose had a significant effect on the analyzed traits in *A. lessoniana* (Table 2). Significantly longer leaves and a greater fresh weight at both measurement dates were recorded for plants grown following the application of Osmocote 16:11:11. In turn, the fertilizer with higher potassium content had a positive effect on plant diameter. At week 18 of culture, irrespective of the application rate, plants fertilized with Osmocote 11:11:19 had a greater tussock diameter.

At stage I of culture, irrespective of the type of fertilizer, an increase in its dose did not have a significant effect on the investigated traits of plants. At week 18 of culture longer leaves were observed in plants grown using a lower application rate of fertilizers (2 g·dm^{-3} substrate), while tussocks with a significantly greater diameter and greater fresh weight of aboveground parts in *A. lessoniana* were obtained at a higher fertilizer dose (4 g·dm^{-3} substrate).

When analyzing factor interactions it was found that both the dose and type of fertilizer had a significant effect on fresh weight in *A. lessoniana*. Following the application of the higher dose of Osmocote 16:11:11 fresh weight of the aboveground parts of plants was greater by 24.6% in relation to plants with the lowest fresh weight, grown using Osmocote 11:11:19 applied at 2 g·dm^{-3} substrate.

Analysis of variance showed that the type of fertilizer and its dose had an effect on the analyzed traits in *B. gracilis* at both stages of culture (Table 3). The use of Osmocote 16:11:11 at both stages of culture resulted in a significantly greater fresh weight of plants, while at the first stage it influenced the number of inflorescences. In turn, following the application of Osmocote 11:11:19 tussocks of plants were of a significantly greater diameter throughout the entire experiment and they had longer leaves at stage II. Irrespective of the type of Osmocote fertilizers their application at 4 g·dm^{-3} substrate had a significant effect on an increase in fresh weight of aboveground parts and the number of inflorescences at both stages of culture and a greater tussock diameter at stage II than it was the case for the dose of 2 g·dm^{-3} substrate. In terms of factor interaction it was found that the longest leaves both at weeks 9 and 18 of culture were found in plants grown in the substrate with Osmocote11:11:19 applied at 2 g·dm^{-3}. This fertilizer used at the higher dose resulted in the production of plants with a greater tussock diameter and a greater number of inflorescences, but it was only at week 18 of the experiment. Those plants had a

Table 2
Influence of two types of Osmocote fertilizers used in different dosages on length of the leaves, circumference of clumps and the fresh matter of the aboveground part of *Anemanthele lessoniana*; the average for the four combinations and the combination of boundary

	Fertilizer	Dosages g·dm^{-3}		Mean		Fertilizer	Dosages g·dm^{-3}		Mean
		2	4				2	4	
9th week	Length of the leaves (cm)				18th week				
	Osmocote 16:11:11	60.6 b*	60.5 b	60.5 b		Osmocote 16:11:11	71.8 c	69.9 b	70.8 b
	Osmocote 11:11:19	60.0ab	59.0 a	59.5 a		Osmocote 11:11:19	68.4 a	67.8 a	68.1 a
	Mean	60.3 a	59.7 a			Mean	70.1 b	68.8 a	
	Circumference of clumps (cm)								
	Osmocote 16:11:11	6.5 b	6.2 a	6.3 a		Osmocote 16:11:11	10.2 a	10.2 a	10.2 a
	Osmocote 11:11:19	6.2 a	6.7 c	6.4 a		Osmocote 11:11:19	11.0 b	12.1 c	11.5 b
	Mean	6.3 a	6.4 a			Mean	10.6 a	11.1 b	
	Fresh matter of the aboveground part of the plant (g)								
	Osmocote 16:11:11	13.6 ab	13.8 b	13.7 b		Osmocote 16:11:11	37.0 b	39.0 c	38.0 b
	Osmocote 11:11:19	11.8 a	12.6ab	12.2 a		Osmocote 11:11:19	31.3 a	36.1 b	33.7 a
	Mean	12.7 a	13.2 a			Mean	34.1 a	37.6 b	

* Average marked with at least one same letter are not significantly different at the level of $\alpha = 0.05$

diameter greater by 30% in relation to the smallest (in plants fertilized with Osmocote 16:11:11 applied at 2 g·dm^{-3} substrate), while the number of inflorescences was greater by approx. 21%. At week 9 of culture the greatest number of inflorescences was recorded for plants fertilized with the greater dose of Osmocote 16:11:11. The fertilizer with nitrogen as the main component had a significant effect also on the fresh weight of aboveground parts. When applied at the higher dose it resulted in the production of the greatest fresh weight of aboveground parts at both stages of culture.

After 18 weeks of culture nitrogen content in the aboveground parts of *A. lessoniana* ranged from 1.50 to 1.77%, with the higher values recorded following the application of Osmocote 16:11:11. In turn, K content ranged from 1.94 to 2.16% and did not depend on the type of applied fertilizer, but it was greater following the treatment with higher application rates of the fertilizers (Table 4). Contents of P, Mg and Na in aboveground parts of *A. lessoniana* were similar in all the combinations. The lowest calcium content was recorded in plants grown in the substrate with Osmocote 11:11:19 applied at 2 g·dm^{-3} substrate. In the aboveground parts of *B. gracilis* nitrogen content ranged from 1.63 to 1.87% and - similarly as in *A. lessoniana* -greater values were found following the application of Osmocote 16:11:11, and after the treatment at higher doses. Fertilizer Osmocote 16:11:11 also influenced the higher contents of Ca and Mg in plants. The content of K ranged from 1.99 to 2.31%, and similarly as in *A. lessoniana* it did not depend on the type of fertilizer and it was greater following the treatment with the higher application rates. Contents of P and Na in aboveground parts of *B. gracilis* were similar in all the combinations.

Discussion

In this experiment growth of plants significantly depended on the type and dose of applied fertilizer. In the culture of *Anemanthele lessoniana* the fertilizer with nitrogen as the main component (Osmocote 16:11:11) resulted in the production of plants with longer leaves and a greater fresh weight of aboveground parts, while that with potassium as the main component (Osmocote 11:11:19) influenced tussock diameter. In the culture of *Bouteloua gracilis* the fertilizer with potassium as the main component had an advantageous effect on leaf length and tussock diameter. After the application of the fertilizer with nitrogen as the main component plants produced a greater fresh weight, while at week 9 they also developed a greater number of inflorescences. An advantageous effect of increased nitrogen doses in the range from 0 to 6 g·m^{-2} on the increase in biomass in *B. gracilis* as the fodder crop was reported by Joern and Mole (2005).

Table 3
Influence of two types of Osmocote fertilizers used in different dosages on length of the leaves, circumference of clumps, number of inflorescence and the fresh matter of the aboveground part of *Bouteloua gracilis*; the average for the four combinations and the combination of boundary

	Fertilizer	Dosages, g·dm^{-3}		Mean		Fertilizer	Dosages g·dm^{-3}		Mean
		2	4				2	4	
9th week	Length of the leaves (cm)				18th week				
	Osmocote 16:11:11	60.6 a*	60.3 a	60.4 a		Osmocote 16:11:11	62.0 a	62.0 a	62.0 a
	Osmocote 11:11:19	63.1 b	59.7 a	61.4 a		Osmocote 11:11:19	64.1 b	62.1 a	63.1 b
	Mean	61.8 b	60.0 a			Mean	63.1 a	62.0 a	
	Circumference of clumps (cm)								
	Osmocote 16:11:11	8.4 a	8.5 ab	8.5 ab		Osmocote 16:11:11	9.5 a	10.4 b	9.9 a
	Osmocote 11:11:19	8.7 bc	8.8 c	8.7 b		Osmocote 11:11:19	11.0 c	12.4 d	11.7 b
	Mean	8.5 a	8.6 a			Mean	10.2 a	11.4 b	
	Number of inflorescence								
	Osmocote 16:11:11	1.6 a	2.8 b	2.2 b		Osmocote 16:11:11	4.7 a	5.1 a	4.9 a
	Osmocote 11:11:19	1.4 a	1.6 a	1.5 a		Osmocote 11:11:19	4.7 a	5.7 b	5.2 a
	Mean	1.5 a	2.2 b			Mean	4.7 a	5.4 b	
	Fresh matter of the aboveground part of the plant (g)								
	Osmocote 16:11:11	7.3 a	8.7 b	8.0 b		Osmocote 16:11:11	18.2bc	19.8 c	19.0 b
	Osmocote 11:11:19	6.8 a	7.4 a	7.1 a		Osmocote 11:11:19	15.4 a	17.5 b	16.4 a
	Mean	7.0 a	8.0 b			Mean	16.8 a	18.7 b	

* Average marked with at least one same letter are not significantly different at the level of α = 0.05

Table 4
The content of sodium and macronutrients in the leaves of *Anemanthele lessoniana* and *Bouteloua gracilis* after 18 weeks of cultivation according to the fertilization of plants (average of 2008, 2009)

Fertilizer	Dosages, g·dm^{-3}	N	P	K	Ca	Mg	Na
		%					
Anemanthele lessoniana							
Osmocote 16:11:11	2	1.72	0.34	1.94	0.67	0.17	0.10
	4	1.77	0.32	2.16	0.66	0.18	0.10
Osmocote 11:11:19	2	1.50	0.30	2.00	0.43	0.12	0.10
	4	1.54	0.35	2.10	0.61	0.14	0.10
Boutelua gracilis							
Osmocote 16:11:11	2	1.80	0.57	1.99	0.96	0.47	0.10
	4	1.87	0.58	2.14	1.08	0.43	0.06
Osmocote 11:11:19	2	1.63	0.58	1.99	0.87	0.44	0.07
	4	1.75	0.59	2.31	0.91	0.36	0.05

Bouteloua gracilis is a grass with C4 photosynthesis (Lecain et al., 2003). Ercoli et al. (1999) are of an opinion that these grasses, e.g. *Miscanthus x gigantheus,* as a rule require higher nitrogen fertilization rates. This is confirmed by a study of Gillen and Berg (1998), which showed a better ground cover by *B. gracilis* used as a fodder crop in locations of its natural occurrence.

Similarly, *A. lessoniana*, which is probably a grass with C3 photosynthesis (literature sources give no information on the subject, but such photosynthesis type is suggested by its provenance), responded positively to nitrogen fertilization. In grasses grown in containers the fresh weight of plants is not a measure of their ornamental value. This is determined by their tillering and flowering. Plants should form a large number of shoots and not necessarily reach great dimensions. Since the aboveground parts of the analyzed ornamental grasses are composed of unbranched, leaved culms collected into dense tussocks, it is very difficult to determine their number. In this experiment the number of culms is indicated by the tussock diameter measured immediately above the substrate surface. Both grasses had the greatest diameters after the application of Osmocote 11:11:19.

The dose of fertilizers in this experiment also had a significant effect on plant growth. The application of the higher dose (4 g·dm^{-3} substrate), irrespective of fertilizer type, in *A. lessoniana* and *B. gracilis* resulted in the production of plants with greater tussock diameters and fresh weight of their aboveground parts. In *B. gracilis* more abundant flowering was also observed. In turn, Henschke et al. (2014) in *Carex comans* grown in pots obtained longer leaves, greater diameters and fresh weight of the aboveground parts following the application of slow-release fertilizer at a lower dose (2g·dm^{-3} substrate).

Analysis of interactions between the factors in this experiment indicates a significant increase in tussock diameter in both grass species following the application of Osmocote 11:11:19 at 4 g·dm^{-3} substrate. At the same dose of Osmocote 16:11:11 a greater fresh weight of aboveground parts was recorded. Similarly, Kozik and Wechta (2003) and Kozik et al. (2004), after the application of a higher dose of Osmocote Plus (15:11:13) in the culture of *Coreopsis grandiflora* 'Early Sunrise' obtained plants with a higher number of shoots and a greater fresh weight. It needs to be stressed here that in this experiment the higher application rate of Osmocote 11:11:19 resulted in the production of shorter leaves, although the differences were proven statistically only in *B. gracilis*.

Nitrogen content in the aboveground parts of *A. lessoniana* and *B. gracilis* was greater following the treatment with Osmocote 16:11:11. The type of fertiliser did not influence K content in plants. Irrespective of the type of fertiliser an increase in its application rate resulted in an increased content of nitrogen and potassium in grass leaves. As it was shown by Kozik and Henschke (2004), nitrogen content in leaves of *Delphinium grandiflorum* 'Blauer Spiegel' was greater, while that of potassium was lower following the application of Osmocote Plus at higher doses. In this study the difference in fertilisation rates did not have a significant effect on contents of phosphorus or sodium in aboveground parts of grasses. Their higher content was only shown in *B. gracilis* and not in *A. lessoniana*. In turn, Schroeter-Zakrzewska and Kleiber (2012) showed a significantly better phosphorus nutrient status of cobbity daisy following the application of Osmocote 16:11:11 in comparison to Osmocote 11:11:19. Moreover, those authors did not find significant differences in the contents of the other macro- and micronutrients in plants. Since in this

experiment the optimal quality plants (well-tillered, compact and flowering) were produced after the application of Osmocote 11:11:19 at 4 g·dm^{-3} substrate, the following nutrient contents in the aboveground parts may be considered appropriate [%]: *A. lessoniana* – N – 1.54, P – 0.35, K – 2.10, Ca – 0.61, Mg – 0.14, Na – 0.10, while in *B. gracilis* – N – 1.75, P – 0.59, K - 2.31, Ca – 0.91, Mg – 0.36 and Na – 0.05, respectively.

Conclusions

The application of Osmocote 16:11:11 in growing *Anemanthele lessoniana* produced plants with longer leaves and a greater fresh weight of the aboveground parts, while in the culture of *Bouteloua gracilis* it provided plants with a greater fresh weight of the aboveground parts.

The higher fertiliser application rate (4 g·dm^{-3}) resulted in the production of *Anemanthele lessoniana* with a greater tussock diameter and fresh weight of the aboveground parts, while in *Bouteloua gracilis* it was also with a higher number of inflorescences.

In the culture of *Anemanthele lessoniana* and *Bouteloua gracilis* due to the greater tussock diameter it is recommended to apply Osmocote 11:11:19 at 4 g·dm^{-3}.

The best quality plants in their aboveground parts contained the following contents of macronutrients and sodium [%]: *Anemanthele lessoniana* – N – 1.54, P – 0.35, K – 2.10, Ca – 0.61, Mg – 0.14, Na – 0.10, while in *Bouteloua gracilis* it was N – 1.75, P – 0.59, K – 2.31, Ca – 0.91, Mg – 0.36 and Na – 0.05, respectively.

References

Armitage, A. M., 1997. Herbaceous perennial plants. A treatise on their identification, culture, and garden attributes. Second edition Champaign, III.: *Stipes Publishing* 1997, pp. 230-234.

Bosiacki, M., 2008. Effect of type of Osmocote fertilizers on the growth and yielding of *Clematis* from Jackmanii group 'John Paul II' cultivar. *Acta Sci. Pol., Hortorum Cultus,* **7** (1): 63-71.

Dana, M. N., 2002. Ornamental grasses and sedges as new crops. Trends. In: J. Janick and A. Whipkey (eds.), Trends in new crops and new uses. *ASHS Press, Alexandria*, VA, pp. 473-476.

Ercoli, L., M. Mariotti, A. Masoni and F. Bonari, 1999. Effect of irrigation and nitrogen fertilization on biomass yield and effciency of energy use in crop production of *Miscanthus*. *Field Crops Reserch,* **63**: 3-11.

Gillen, R. L.and W. A. Berg, 1998. Nitrogen fertilization of native grass planting in western Oklahoma. *J. Range. Management,* **51**: 436-441.

Head, N. and D. Given, 2001. Threatened plants of Canterbury including a revised species list. *Journal/Centerbury Botanical Society,* **35:** 5-14.

Henschke, M., 2013. Znaczenie traw ozdobnych w terenach zieleni [Importance of ornamental grasses in the areas of green]. In monograph: Rabina-Świder J., Skutnik E. Ogrodnictwo Ozdobne sektorem gospodarki narodowej [Ornamental Horticulture sector of the national economy]. *Katedra Roślin Ozdobnych SGGW Warszawa* 2013, pp. 119-123 (Pl).

Henschke, M., E. Kozik, E. Wojciechowska, A. Błaszyk and K. Araszkiewicz, 2014. Influence of fertilizers of Osmocote type and top – dressing onto the growth and nutrition state of *Carex comans* Berggr. 'Frosted Curls'. *Bulg. J. Agric. Sci*., **20**: 888-898.

Joern, A. and S. Mole, 2005. The plant stress hypothesis and variable responses by blue grama grass (*Bouteolua gracilis*) to water, mineral nitrogen and insect herbivory. *J. Chem. Ecol.,* **31 (**9): 2069-2090.

Korszun, S. and J. Zalewska, 2004. Zastosowanie nawozu Osmocote Exact Lo-Start w uprawie jałowca skalnego (*Juniperus scopulorum* Sarg.) odmiany 'Blue Arrow' w pojemnikach [The use of Osmocote Exact Lo-Start fertilizer in cultivation of rocky mountain juniperus (*Juniperus scopulorum* Sarg.) 'Blue Arrow' variety in containers]. *Folia Universitis Agriculturae Stetinensis, Agricultura,* **236** (94): 81-86 (Pl).

Kozik, E. and M. Henschke, 2004. Wstępna ocean wzrostu i kwitnienia ostróżki wielkokwiatowej (*Delphinium grandiflorum* L.) w uprawie doniczkowej w zależności od nawożenia Osmocote Plus [The preliminary estimation growth and flowering of *Delphinium grandiflorum* L. in pot cultures, according to Osmocote Plus supplies]. *Rocz. AR Pozn, Ogrodnictwo,* **360** (38): 111-117 (Pl).

Kozik, E., M. Henschke and N. Loch, 2004. Growth and flowering of *Coreopsis grandiflora* Hogg. under the influence of Osmocote Plus fertilizers. *Rocz. AR Pozn, Ogrodnictwo,* **356** (37): 117-122 (Pl).

Kozik, E. and M. Wechta, 2003. Wpływ nawozów Osmocote Plus na wzrost i kwitnienie nachyłka wielkokwiatowego (*Coreopsis grandiflora* Hogg.) 'Early Sunrise' [Effect of Osmocote Plus fertilizers on the growth and bloom of *Coreopsis grandiflora* Hogg. 'Early Sunrise']. *Folia Horticulture, Suplement* 2: 43-45 (Pl).

Lecain, D. R., J. A. Morgan, A. R. Mosier and J. A. Nelson, 2003. Soil and plant water relations determine photosynthetic responses of C_3 and C_4 grasses in a semi-arid ecosystem under elevated CO_2. *Annals of Botany,* **92**: 41-52.

Meyer, M. H., 2013. Ornamental Grass Trials. Proc. Intl. Trials Conference, Eds.: K.E. Cockshull et al., *Acta Hort.,* **980**: 59-66.

Pilon, P., 2006. Perennials solutions. A grower's guide to perennial production. *Ball Publishing, Batavia, Illinois USA*, pp. 436-447.

Schroeter – Zakrzewska, A. and T. Kleiber, 2012. Application of slow release fertilizers in growing marguerite daisy (*Argyranthemum frutescens*) Molimba® Group. *Ecol. Chem. Eng.,* **A 19** (12): 1471-1484.

Shaviv, A., 2006. Controlled Release Fertilizers. *IFA International workshop on enhanced-efficiency fertilizers, Frankfurt Germany* 28-30 June 2005, pp. 1-13.

Szczepaniak, S. and E. Kozik, 2004. Wpływ rodzaju i objętości podłoża oraz nawozów o spowolnionym działaniu na wzrost młodych roślin nachyłka wielkokwiatowego. *Rocz. AR Pozn.* 360, Ogrodn. **38**: 157-161 (Pl).

Waller, S. S. and J. K. Lewis, 1979. Occurrence of C_3 and C_4 photosynthetic pathways in North American grasses. *J. Range. Management,* **32** (1): 12-28.

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