ECOLOGICAL CHEMISTRY AND ENGINEERING A

Vol. 18, No. 1 2011

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EFFECT OF VEGETATION PERIOD ON THE QUANTITATIVE RELATIONS BETWEEN NUTRITIVE COMPONENTS IN THE LEAVES OF ANTHURIUM (*Anthurium cultorum* Birdsey)

WPŁYW OKRESÓW WEGETACJI NA STOSUNKI ILOŚCIOWE MIĘDZY SKŁADNIKAMI POKARMOWYMI W LIŚCIACH ANTURIUM (*Anthurium cultorum* Birdsey)

Abstract: The main objective of studies was the determination of the quantitative relations between macro- and microelements in the leaves of anthurium (*Anthurium cultorum* Birdsey) cultivars: 'Baron', 'Choco', 'Midori', 'Pistache', 'President', 'Tropical' (Anthura B.V., the Netherlands) in the spring–summer and autumn–winter periods. Plants were grown in expanded clay using drip fertigation with standard nutrient (in 1 dm^3): < 14.0 mg NH_4-N, 105.0 mg NO_3-N, 31.0 mg P, 176.0 mg K, 60.0 mg Ca, 24.0 mg Mg, 48.0 mg SO_4-S, 0.840 mg Fe, 0.160 mg Mn, 0.200 mg Zn, 0.220 mg B, 0.032 mg Cu and 0.048 mg Mo, with pH 5.5–5.7 and EC 1.5–1.8 mS $\cdot$ cm^{-1}.

Significant differences were found in the quantitative amounts between some nutritive components in leaves, The leaves were fully developed, sampled from plants after freshly cut flowers. The mean N : K ratio from the last 3 years of studies in the spring–summer period was 1.0 : 2.7 and in the period of light deficit (autumn–winter period), it decreased to 1.0 : 2.4. In the same period, the relation Fe : Mn equaled 1.0 : 1.6 and with the improvement of light conditions (spring–summer period), it increased to 1.0 : 2.2. In the majority of the studied cultivars, there were significant changes in the Fe : Zn relation in autumn–winter and spring–summer periods. The awareness of changes in the qualitative relation between macro- and microelements is the basis for the modification of nutritive components in nutrients used for fertigation, depending on the vegetation period and protecting the environment against excessive quantities of used fertilizers.

Keywords: seasonal changes, plant analysis, nutrient ratio, macroelements, microelements, anthurium

Among the factors modifying the nutritive component content in plants and thereby the quantitative relations between them, one can mention the chemical composition of nutrient [1], plant age, cultivar [2] and the substrate [3, 4]. A modifying effect can be

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also exerted by the vegetation period with its light conditions involved in it such as real insolation, *photosynthetic radiation* PAR, solar radiation [5, 6].

The objective of the presented studies was the cognition of the quantitative changes between the nutritive components in the indicator parts of the standard cultivars of anthurium (*Anthurium cultorum* Birdsey), depending on the vegetation period. The autumn–winter and spring–summer periods have been distinguished. Consideration of the mutual relations between the components in plants and nutrients used for fertigation permits a more precise conclusion referring to the correctness of the applied fertilization. Modification of the chemical composition of the nutrients used for fertigation, basing on the knowledge referring to the cyclicity of quantitative relations between the nutritive components in leaves permits to improve the nutrition and yielding of plants and protect the environment against excessive quantities of used fertilizers.

Material and methods

Vegetative experiments were carried out in two production farms of Wielkopolska specialized in anthurium growing. Greenhouses of "Venlo" type were equipped with modern systems of fertigation, control and recording of climatic conditions, moisture and air control, as well as energy-saving courtains. The object of studies consisted of standard anthurium cultivars (*Anthurium cultorum* Birdsey): 'Baron','Choco', 'Midori', 'Pistache', 'President' and 'Tropical' (Anthura B.V., the Netherlands) grown in expanded clay (∅ 8–18 mm). Anthurium cuttings grown in pots of rockwool (75 cm) were planted into beds in the greenhouse on the 8–11th August 2000. Studies were started on 15th January 2002 (on 2-year old plants) and they were terminated on the 30th November 2004 (4-year old plants). One growing bed with dimensions 1.2 × 46 m, covered 55.2 m^2. On 1 m^2, 14 plants were growing. Agrotechnical treatments were carried out according to the actual recommendations for anthurium.

Drip irrigation in a closed system without nutrient recirculation was applied. In the experiment, the standard nutrient for drip irrigation for anthurium grown in inert substrates was used (in 1 dm^3): < 14.0 mg NH_4-N, 105.0 mg NO_3-N, 31.0 mg P, 176.0 mg K, 60.0 mg Ca, 24.0 mg Mg, 48.0 mg SO_4-S, 0.840 mg Fe, 0.160 mg Mn, 0.200 mg Zn, 0.220 mg B, 0.032 mg Cu and 0.048 mg Mo, with pH 5.5–5.7 and EC 1.5–1.8 mS · cm^{-1} [7]. The nutrient was distributed on beds by dripping lines with emitters located in 20 cm intervals. Frequency and time of irrigation depended on the season of the year. In summer, the fertigation was applied 6–8 times supplying 4–5 dm^3 of nutrient per 1 m^2, while in winter, fertigation was applied 2–3 times using 2–3 dm^3. About 20 % of nutrient leaked out from the root zone. In order to provide an adequate air and substrate moisture, the culture was sprinkled with rain water using micro-sprinklers.

Samples of plant material were taken in the years 2002–2004 in 2-months intervals, between the 14th and the 16th day of November, January and March (autumn–winter period) and of May, July and September (spring–summer period). The indicator parts were represented by fully developed leaves, taken from plants after freshly cut flowers [8]. The leaves were randomly taken from the total surface area of beds, from plants characteristic of the given cultivar, which were healthy, well yielding and without any symptoms of damages. One average sample of a given cultivar consisted of 15–20 leaves. The method of plant material mineralization and the determination of nutritive components content was presented in the earlier papers of authors [5, 6]. Data referring to the studied vegetation periods and the light conditions related to them, ie real insolation, solar radiation (irradiation, PAR), their effect on plant yielding and on the nutrition with macro- and microelements were discussed in the earlier works [5, 6].

Statistical analyses included quantitative relations between macro- and micro-components in 3 successive years of six standard anthurium cultivars with the consideration of two vegetation periods: spring–summer and autumn–winter periods. A multidimensional analysis of variance was carried out for individual classification.

Results and discussion

Macroelements

A significant effect of vegetation periods on the change of quantitative N:K relations in the plant indicator parts have been shown. The mean relation from 3 years between N : P : K : Ca : Mg : S in the autumn–winter period was the following one: 1.0 : 0.2 : 2.4 : 1.0 : 0.2 : 0.2, while in the spring–summer period, the relations were: 1.0 : 0.2 : 2.7 : 1.0 : 0.2 : 0.2 (Table 1). Relations between N : P, N : Mg and N : S in the autumn–winter season were comparatively stable. N : K ranges were from 1.0 : 2.2 (in 'Baron' cultivar) to 1.0 : 2.5 (in 'Midori' and 'Tropical' cultivars).

Table 1

N : P : K : Ca : Mg : S relations in the indicator parts of anthurium in different vegetation periods

Year	Autumn–Winter Period						Spring–Summer Period					
	N	P	K	Ca	Mg	S	N	P	K	Ca	Mg	S
'Baron'												
2002	1.0	0.2	1.8	1.4	0.1	0.2	1.0	0.2	2.2	1.2	0.1	0.2
2003	1.0	0.3	2.5	1.2	0.2	0.2	1.0	0.2	2.7	1.2	0.1	0.3
2004	1.0	0.3	2.3	0.8	0.1	0.2	1.0	0.3	2.7	1.1	0.2	0.2
Mean	1.0	0.3	2.2 a	1.1	0.1	0.2	1.0	0.2	2.5 b	1.2	0.1	0.2
'Choco'												
2002	1.0	0.2	2.0	1.2	0.2	0.3	1.0	0.2	2.6	1.2	0.2	0.2
2003	1.0	0.3	2.5	0.9	0.1	0.2	1.0	0.2	2.7	0.9	0.1	0.2
2004	1.0	0.3	2.4	0.7	0.1	0.2	1.0	0.3	2.5	0.9	0.2	0.3
Mean	1.0	0.3	2.3	0.9	0.1	0.2	1.0	0.2	2.6	1.0	0.2	0.2
'Midori'												
2002	1.0	0.1	2.3	1.4	0.2	0.3	1.0	0.1	2.7	1.1	0.2	0.3
2003	1.0	0.2	2.7	1.0	0.2	0.3	1.0	0.2	3.1	1.0	0.1	0.3
2004	1.0	0.3	2.6	0.6	0.2	0.2	1.0	0.3	3.3	1.0	0.2	0.3
Mean	1.0	0.2	2.5 a	1.0	0.2	0.3	1.0	0.2	3.0 b	1.0	0.2	0.3

Table 1 contd.

Year	Autumn–Winter Period						Spring–Summer Period					
	N	P	K	Ca	Mg	S	N	P	K	Ca	Mg	S
‘Pistache’												
2002	1.0	0.1	1.9	1.2	0.2	0.2	1.0	0.1	2.4	1.1	0.2	0.2
2003	1.0	0.3	2.6	0.9	0.2	0.2	1.0	0.2	3.0	1.0	0.2	0.2
2004	1.0	0.3	2.6	0.7	0.2	0.2	1.0	0.3	2.7	0.9	0.2	0.2
Mean	1.0	0.3	2.4	0.9	0.2	0.2	1.0	0.2	2.7	1.0	0.2	0.2
‘President’												
2002	1.0	0.2	2.2	1.4	0.2	0.1	1.0	0.2	2.6	1.2	0.2	0.2
2003	1.0	0.3	2.7	1.1	0.2	0.2	1.0	0.2	2.8	1.2	0.2	0.2
2004	1.0	0.3	2.4	0.9	0.2	0.1	1.0	0.3	2.6	1.0	0.2	0.2
Mean	1.0	0.3	2.4	1.1	0.2	0.1	1.0	0.2	2.7	1.1	0.2	0.2
‘Tropical’												
2002	1.0	0.2	2.2	1.2	0.2	0.2	1.0	0.2	2.7	1.1	0.2	0.2
2003	1.0	0.3	2.8	1.1	0.2	0.2	1.0	0.3	3.0	1.0	0.1	0.2
2004	1.0	0.3	2.6	0.8	0.2	0.2	1.0	0.3	3.0	0.9	0.2	0.2
Mean	1.0	0.3	2.5 a	1.0	0.2	0.2	1.0	0.3	2.9 b	1.0	0.2	0.2
Mean												
2002	1.0	0.2	2.1	1.3	0.2	0.2	1.0	0.2	2.5	1.2	0.2	0.2
2003	1.0	0.2	2.6	1.0	0.2	0.2	1.0	0.2	2.8	1.0	0.1	0.2
2004	1.0	0.3	2.5	0.8	0.2	0.2	1.0	0.3	2.7	1.0	0.2	0.2
Mean	1.0	0.2	2.4 a	1.0	0.2	0.2	1.0	0.2	2.7 b	1.0	0.2	0.2

Significant changes in N : K relations were shown in the autumn–winter period, in comparison with the spring–summer period for the cultivars: ‘Baron’, ‘Midori’ and ‘Tropical’. With the improvement of light conditions there increased the N : K relation for the mean value from the studied cultivars, from 1.0 : 2.4 (in the autumn–winter period) to 1.0 : 2.7 (in the spring–summer period).

Table 2

Mutual relations between N : P : K : Ca : Mg : S in the indicator parts of anthurium according to different authors (in each case, the accepted N content is 1.0)

Author	N	P	K	Ca	Mg	S
De Kreij et al [8][a]	1.0	0.1	1.7	0.7	0.2	—
Higaki et al [9][b]	1.0	0.1	1.1	0.6	0.2	0.1
Sonneveld and Vogt [4][c]	1.0	0.1	1.7	0.5	0.2	0.1
Mills and Scoggins [2][d]	1.0[e]	0.1	0.9	0.4	0.2	—
Mills and Scoggins [2][d]	1.0[f]	0.2	1.0	0.7	0.3	—

a – leaves from plants after freshly cut flowers, traditional cultivation; b – traditional cultivation; c – young fully developed leaves of ‘Tropical’ and ‘Cuba’ cultivars, polyphenolic foam; d – cultivation in volcanic slag; e – young leaves in 90 % mature, pale green, 10 days before full maturity; f – mature leaves, dark green with a growing in 3/4 mature flower; e–f: – cultivars: ‘Kaumana’, ‘Kozohara’, ‘Nitta Orange’, ‘Ozaki’.

The determined relations between the nutritive components were compared with data reported by other authors (Table 2). It was found that mutual N : P and N : Mg relations were similar to those reported earlier [2, 8], while in case of N : S as reported by other authors [4, 9]. The determined N : K relation (which in the autumn–winter period showed 1.0 : 2.4 and in the spring–summer period changed to 1.0 : 2.7) was higher than in the studies of other scientists. There was reported that a significant effect on the relations between macroelements in plants were exerted by the chemical composition of the applied nutrient [1].

Microelements

It was shown that vegetation periods exert an effect on the change in the quantitative relations between Fe : Mn : Zn : Cu : B in the indicator parts of anthurium (Table 3).

Table 3

Fe : Ma : Zn : Cu : B relations in the indicator parts of anthuriu min different vegetation periods

Year	Autumn–Winter					Spring–Summer				
	Fe	Mn	Zn	Cu	B	Fe	Mn	Zn	Cu	B
‘Baron’										
2002	1.0	1.2	0.9	0.1	1.2	1.0	1.9	1.3	0.1	1.2
2003	1.0	1.6	0.8	0.1	1.3	1.0	1.6	1.0	0.1	1.2
2004	1.0	2.5	0.8	0.1	1.4	1.0	1.9	1.3	0.1	1.0
Mean	1.0	1.8	0.8 a	0.1	1.3	1.0	1.8	1.2 b	0.1	1.1
‘Choco’										
2002	1.0	2.0	1.8	0.2	1.7	1.0	2.4	2.0	0.2	1.5
2003	1.0	2.1	1.3	0.1	1.8	1.0	2.6	1.4	0.2	2.1
2004	1.0	1.8	1.3	0.1	1.7	1.0	1.3	1.2	0.1	1.2
Mean	1.0	2.0	1.5	0.1	1.7	1.0	2.1	1.5	0.2	1.6
‘Midori’										
2002	1.0	2.1	1.6	0.1	1.3	1.0	3.5	2.4	0.2	2.0
2003	1.0	2.2	1.2	0.1	1.7	1.0	2.9	1.4	0.1	2.0
2004	1.0	1.8	1.1	0.1	1.8	1.0	3.5	1.5	0.1	1.3
Mean	1.0	2.0 a	1.3 a	0.1	1.6	1.0	3.3 b	1.8 b	0.1	1.8
‘Pistache’										
2002	1.0	2.0	1.3	0.1	1.4	1.0	1.8	1.4	0.1	1.5
2003	1.0	1.5	0.9	0.1	1.7	1.0	2.1	1.0	0.1	1.5
2004	1.0	1.3	0.7	0.1	1.3	1.0	1.2	0.9	0.1	1.2
Mean	1.0	1.6	1.0	0.1	1.5	1.0	1.7	1.1	0.1	1.4
‘President’										
2002	1.0	1.1	1.2	0.1	0.8	1.0	2.2	1.8	0.1	1.4
2003	1.0	1.2	0.9	0.1	1.1	1.0	1.9	1.1	0.1	1.7

Table 3 contd.

Year	Autumn–Winter					Spring–Summer				
	Fe	Mn	Zn	Cu	B	Fe	Mn	Zn	Cu	B
2004	1.0	1.2	1.0	0.1	1.4	1.0	1.4	1.0	0.1	1.0
Mean	1.0	1.2 a	1.0 a	0.1	1.1	1.0	1.8 b	1.3 b	0.1	1.4
‘Tropical’										
2002	1.0	0.9	1.0	0.1	0.8	1.0	2.6	1.7	0.1	1.8
2003	1.0	2.1	1.2	0.1	1.3	1.0	2.4	1.0	0.1	1.6
2004	1.0	1.6	0.9	0.1	1.2	1.0	2.1	1.1	0.1	1.0
Mean	1.0	1.5 a	1.0 a	0.1	1.1 a	1.0	2.4 b	1.3 b	0.1	1.5 b
Mean										
2002	1.0	1.5	1.2	0.1	1.1	1.0	2.4	1.7	0.2	1.6
2003	1.0	1.7	1.0	0.1	1.5	1.0	2.2	1.1	0.1	1.6
2004	1.0	1.7	1.0	0.1	1.5	1.0	1.9	1.2	0.1	1.1
Mean	1.0	1.6 a	1.1	0.1	1.4	1.0	2.2 b	1.3	0.1	1.4

The mean (from 3 years of studies) relation between microelements in the autumn–winter period was: 1.0 : 1.6 : 1.1 : 0.1 : 1.4, while in the spring–summer period, it was: 1.0 : 2.2 : 1.3 : 0.1 : 1.4. With the improvement of light conditions, there followed a significant increase of the mean Fe : Mn relation (from 1.0 : 1.6 to 1.0 : 2.2). Furthermore, for the majority of the studied cultivars, significant changes were shown in the Fe : Zn relation between the autumn–winter period and the spring–summer period. For the mean value from the studied cultivars, in the studied vegetation periods, the relations Fe : Zn, Fe : Cu and Fe : B were similar. The quantitative Fe : Mn ratios determined in our studies were similar to the literature data [2, 4, 9] (Table 4).

Table 4

Mutual relations between: Fe : Mn : Zn : Cu : B in the indicator parts of anthurium according to different authors (in each case, the accepted Fe content is 1.0)

Autor	Fe	Mn	Zn	Cu	B
De Kreij et al [8][a]	1.0	1.1	1.3	0.1	0.9
Higaki et al [9][b]	1.0	2.2	0.5	0.1	0.2
Sonneveld and Vogt [4][c]	1.0	1.4[e]	0.7	0.1	0.8
Mills and Scoggins [2][d]	1.0[f]	2.5	1.3	0.3	0.3
Mills and Scoggins [2][d]	1.0[g]	2.3	0.7	0.2	0.4

a – leaves from plants after freshly cut flower, traditional cultivation; b – traditional cultivation; c – young fully developed leaves of cultivars: ‘Tropical’ and ‘Cuba’, polyphenolic foam, d – cultivation in volcanic slag; e – ‘Cuba’ cultivar; f – young leaves, in 90 % mature, pale green, 10 days before full maturity; g – mature leaves, dark green, with a growing in 3/4 mature flower; f–g – cultivars: ‘Kaumana’, ‘Kozahara’, ‘Nitta Orange’, ‘Ozaki’.

The determined Fe : Zn relations were similar to the data reported by De Kreij et al [8] and for the mature leaves stated by Mills and Scoggins [2]. A similar Fe : Cu relation was reported by other authors [4, 8, 9]. A wider relation Fe : B (than reported in the literature) was found in anthurium leaves.

The quated relations between macroelements indicate that in leaves, there was a greater amount of potassium than of nitrogen, while such relations do not correspond with those found in the nutrient used for fertigation. In turn, in case of microelemens, there was a greater participation of Mn, Zn and B than Fe, while in the nutrients, there dominated the content of Fe. The above situation indicates that there is a need of studies referring to the optimization of nutrient, particularly in the range of the potassium and iron levels.

Modification of the chemical composition of nutrients used for fertigation basing on the knowledge of the cyclicity of changes in the relations between nutritive components in the indicator parts of plants may exert a positive effect on the yielding of production crops.

Conclusions

1. A significant effect of vegetation seasons was found to be exerted on the change in the quantitative N : K relations in plant indicator parts. In the spring–summer period, the N : K relation was 1.0 : 2.7, while in the autumn–winter period, it was 1.0 : 2.4.
2. With the aging of plants, in the 3-year period of studies, a decrease of the N : Ca relation was found in the plant indicator parts. In the spring–summer period, the N : Ca relation showing 1.0 : 1.3 decreased to 1.0 : 0.8, while in the autumn–winter period, it decreased from 1.0 : 1.2 to 1.0 : 0.9.
3. With the deterioration of light conditions, the Fe : Mn relation in plant indicator parts decreased from 1.0 : 2.2 (in spring–summer period) to 1.0 : 1.6 (in autumn–winter period).
4. For the majority of the studied cultivars, it was found that with the deficit of light, there followed a significant decrease in the Fe : Zn relation in plant indicator parts.
5. Knowledge of the quantitative changes between nutritive components in plant indicator parts, depending on the vegetation period, gives a basis for the modification of the chemical composition of nutrients.

Acknowledgement

The Study was cofinanced by the State Committee for Scientific Research (KBN), grant No. 0381/P06/2004.

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WPŁYW OKRESÓW WEGETACJI NA STOSUNKI ILOŚCIOWE MIĘDZY SKŁADNIKAMI POKARMOWYMI W LIŚCIACH ANTURIUM (*Anthurium cultorum* Birdsey)

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Abstrakt: Głównym celem badań było określenie relacji ilościowych między makro- i mikroelementami w liściach anturium (*Anthurium cultorum* Birdsey) odmian: 'Baron', 'Choco', 'Midori', 'Pistache', 'President', 'Tropical' (Anthura B.V., The Netherlands) w okresie wiosenno-letnim i jesienno-zimowym. Rośliny uprawiano w keramzycie z zastosowaniem fertygacji kroplowej pożywką standardową zawierającą (w 1 dm^3): < 14,0 mg N-NH_4, 105,0 mg N-NO_3, 31,0 mg P, 176,0 mg K, 60,0 mg Ca, 24,0 mg Mg, 48,0 mg S-SO_4, 0,840 mg Fe, 0,160 mg Mn, 0,200 mg Zn, 0,220 mg B, 0,032 mg Cu oraz 0,048 mg Mo, o pH 5,5–5,7 i EC 1,5–1,8 $mS \cdot cm^{-1}$.

Stwierdzono istotne zmiany w relacjach ilościowych między niektórymi składnikami pokarmowymi w organa wskaźnikowych, którymi były w pełni wyrośnięte liście, pobrane z roślin po świeżo ściętym kwiecie. Średni z 3 lat badań stosunek N : K w okresie wiosenno-letnim wynosił 1,0 : 2,7, a w okresie deficytu światła (okres jesienno-zimowy) malał do 1,0 : 2,4. W tym samym okresie stosunek Fe : Mn wynosił 1,0 : 1,6, a wraz z poprawą warunków świetlnych (okres wiosenno-letni) wzrastał do 1,0 : 2,2. W większości badanych odmian zaznaczyły się istotne zmiany stosunku Fe : Zn w okresie jesienno-zimowym i wiosenno-letnim. Znajomość zmian stosunków ilościowych między makro- i mikroelementami stanowi podstawę do modyfikacji zawartości składników pokarmowych w pożywkach stosowanych do fertygacji w zależności od okresu wegetacji, chroniąc środowisko przed nadmiernym stosowaniem nawozów.

Słowa kluczowe: okresowe zmiany, analizy roślin, relacje między składnikami, makroelementy, mikroelementy, anturium