FOLIA
HORTICULTURAE
Ann. 21/1, 2009, 81-93

Seasonal changes in the nutritional status and yielding of *Anthurium cultorum* Birdsey. Part I. Macroelements

Tomasz Kleiber[1], Andrzej Komosa[1], Jolanta Krzyszkowska[2], Krzysztof Moliński[2]

Poznań University of Life Sciences
[1]Department of Horticultural Plant Nutrition
Zgorzelecka 4, 60-198 Poznań, Poland
[2]Department of Mathematical and Statistical Methods,
Wojska Polskiego 28, 60-637 Poznań, Poland
e-mail: tkleiber@up.poznan.pl

Key words: anthurium, indicator parts, plant analyses, vegetation period

ABSTRACT

The aim of the research, which was carried out in the years 2002 – 2004, was the determination of the natural tendencies in the macroelement nutritional status and in the yielding of the standard cultivars of *Anthurium cultorum* Birdsey ('Baron', 'Choco', 'Midori', 'Pistache', 'President', 'Tropical' from Anthura B.V., the Netherlands) in the autumn-winter and spring-summer vegetations periods. The anthurium was grown in expanded clay with the use of standard nutrients in a drip fertigation system. It was found that an improvement of light conditions caused a significant increase in plant yielding. During the three years of the study, it was found that an essential influence was exerted by the vegetation period on the amount of phosphorus and potassium in the plants' leaves. In the spring-summer period, a considerable decrease of phosphorus content in the plants was observed, but at the same time, there was an increase of potassium content. In the spring-summer period, plant age affected the phosphorus and calcium content of the plants, while in the autumn-winter period, the phosphorus, potassium and calcium content was affected. A decrease in calcium, nitrogen and magnesium content was found in the spring-summer period, while the content of sulphur tended to increase. The obtained results could be a valuable instrument for the interpretation of index parts of plant analyses for diagnostic purposes.

INTRODUCTION

Poland is a one of the biggest anthurium producers in Europe; in terms of the volume of production it ranks second after Holland (Jabłońska 2005). The cultivation of this species in our country has been developing systematically (Mojsiej 2002). Recently, its yield has grown significantly thanks to the application of inert media (mainly expanded clay) and fertigation (Komosa and Kleiber 2003).

The nutrient status of a plant is one of main factors affecting the plant's yielding. A number of factors, both biotic and abiotic ones, can modify the chemical composition of plants. Among them, the most essential is the applied fertilization and the chemical composition of nutrients (Dufour and Guérin 2005). An influence is also exerted by the plants' age, the applied cultivar (Mills and Scoggins 1998), as well as the substrate type used for plant cultivation (Sonneveld and Voogt 1993, Anthura 1998). The nutritional status, particularly in case of permanent crops, can be also modified by the influence of vegetation periods, which differ between each other with regards to temperature, real insolation and solar radiation (e.g. the photosynthetically active radiation – PAR).

The influence of vegetation period on nutrient uptake was studied earlier for other species, such as *Dendranthema grandiflora* Tzvelev (Brześ and Jerzy 2004), greenhouse roses (Cabrera et al. 1995) or *Euonymus japonica* (Hershey and Paul 1983). Breś and Jerzy (2004) reported that in the winter the highest amount of nitrogen, phosphorus and calcium in the index parts of plants was found – but with an improvement of light conditions, the nutritional status of these macroelements decreased. Meanwhile Cabrera et al. (1995) showed that in the summer months, plants take in two times more nitrogen and the remaining components than they do in the winter months, and this fact has a positive effect on their nutritional status. The phenomenon of periodicity in the uptake of nutritive components was also confirmed in the case of *Euonymus japonica* (Hershey and Paul 1983).

The objective of the present study was the recognition of the natural tendencies of macroelement nutrition and the yielding of the standard cultivars of anthurium (*Anthurium cultorum* Birdsey) grown in expanded clay, with regard to the growing period. The knowledge of these relations will permit more precise diagnostics of the plant's nutritional status and enable possible modification of the chemical composition of the applied nutrient for fertigation, depending on the given vegetation period.

MATERIAL AND METHODS

The research study was carried out in two production farms in west Poland (Wielkopolska) possessing two greenhouses of the Venlo type (from the Netherlands), which are equipped with modern fertigation systems, a climate control and registration system, air moisture control and energy saving curtains. The object of the studies consisted of the standard cultivars of anthurium (*Anthurium cultorum* Birdsey): 'Baron', 'Choco', 'Midori', 'Pistache', 'President' and 'Tropical' (Anthura, the Netherlands) grown in expanded clay (ø 8-18 cm). Seedlings grown in flowerpots made of mineral wool (75 cm^3 in volume) were planted into beds in the greenhouse on the 8-11th of August 2000. Research studies were started on the 15th of January 2002 (on two-year-old plants) and the experiment ended on the 30th of November 2004 (four-year-old plants). One bed had dimensions of 1.2 × 46.0 m and 55.2 m^2. On one m^2, 14 plants were grown, i.e. 772 plants were planted in one bed. Agrotechnical treatments were carried out according to the current recommendations for anthurium.

Drip irrigation in a closed system without nutrient recirculation was applied. The experiment included a standard nutrient for drip irrigation of anthurium grown in inert mediums of (in mg per dm^3) N-NH_4 < 14, N-NO_3 105, P 31, K 176, Ca 60, Mg 24, S-SO_4 48, Fe 0.840, Mn 0.160, Zn 0.200, B 0.220, Cu 0.032, Mo 0.048, pH 5.5-5.7, EC 1.5-1.8 mS cm^{-1} (Komosa 2000). The nutrient solution was distributed to the beds by drip-irrigation lines with emitters located every 20 cm. The frequency and time of fertigation depended on the season of the year. In summer, fertigation was applied 6-8 times per day, supplying 4-5 dm^3 of nutrient per 1 m^2. In winter, the procedure was repeated 2-3 times per day and 2-3 dm^3 were applied. About 20% of nutrients were leaked out from the root environment. In order to ensure adequate air humidity and substrate moisture, the cultivation was sprinkled with rainwater using micro-sprinklers.

Periods of vegetation

A moderately warm climate is characterized by the occurrence of cyclical changes in the real insolation and solar radiation (included PAR) during the annual course. In the spring-summer period (April – September), PAR showed the average monthly value of 345 μmol m^{-2}, real insolation lasted 228 hours and radiation showed the value of 43589 J cm^{-2} (Table 1). In the autumn-winter period (from October to March), which is usually characterized by a light deficit, the real insolation, solar radiation and PAR were smaller by 59.7%, 70.9% and 65.6%, respectively.

Table 1. Value of PAR, real insolation and solar radiation in the successive periods (monthly mean values)

Vegetation period	Year	PAR (μmol m^{-2} $month^{-1}$)	Solar radiation (J cm^{-2} $month^{-1}$)	Real insolation (h $month^{-1}$)
Autumn-winter	2002	160	15536	100
	2003	130	10187	68
	2004	126	12276	67
	Mean	139	12666	78
Spring-summer	2002	338	43564	224
	2003	353	43246	234
	2004	343	43957	227
	Mean	345	43589	228

Samples of plant material were taken every two months, between the 14^{th} and the 16^{th} day of the month in the autumn-winter period (in January, March and November) and in the spring-summer period (in May, July and September) in the years 2002 – 2004. The indicator parts of anthurium consisted of fully developed leaves from plants after fresh flower cutting (De Kreij et al. 1990). The leaves were randomly sampled from the total area of beds, from plants characteristic of the given cultivar, that were healthy, well yielding and without any symptoms of damages. One sample of each cultivar consisted of 15-20 leaves; a farm was the replication for a cultivar. Collected samples were dried at 40-50°C, after which they were ground. In order to determine the general forms of P, K, Ca and Mg, the plant material was mineralized in a concentrated sulphuric acid; N – was mineralized in a mixture of sulphuric acid and sulphosalicylic acid, S – was mineralized in a mixture of nitric and perchloric acids (3:1 v/v) (IUNG 1972). After the mineralization of plant material, the following determinations were done: N – by the distillation method according to Kjeldahl on a Parnas-Wagner apparatus; P – by the colorimetric method with molybdate ammonium, according to Schillak; K, Ca, Mg – by the AAS method, in the apparatus of Carl-Zeiss-Jena; S was determined nephelometrically with $BaCl_2$.

Statistical analyses

The macroelement contents and the yield of six anthurium cultivars in three successive years of growth, with the consideration of spring-summer and autumn-winter vegetation periods, were subject to analyses with the use of a linear model describing factorial experiments. For each cultivar, a multi-dimensional analysis of variance was carried out for a two-way classification. Furthermore, homogeneous groups of the studied years were created applying Tukey's test (Morrison 1976). All numerical analyses were performed using the STATISTICA 8.0 package.

RESULTS

Plant yielding

A significant yielding improvement was found (its growth increased by 94.1%) in the spring-summer period as compared with the autumn-winter period (Table 2). The yielding of plants in the spring-summer period was stable (10.5-10.9 flowers per m^2 per month). Along with the aging of the plants, there appeared to be a tendency towards better yielding in the autumn-winter period (for example, in 'Choco', the growth increased by 156%).

Table 2. Effect of vegetation periods on the yielding of anthurium (flower pieces m^{-2} $month^{-1}$)

Cultivar	Autumn-winter				Spring-summer			
	2002	2003	2004	Mean*	2002	2003	2004	Mean*
'Baron'	3.2	5.0	5.6	4.6 a	8.7	8.0	7.6	8.1 b
'Choco'	3.2	5.8	8.2	5.7 a	10.5	11.3	12.9	11.6 b
'Midori'	4.6	6.4	8.0	6.3 a	12.8	12.5	14.7	13.3 b
'Pistache'	3.5	5.4	6.8	5.2 a	9.9	10.5	12.6	11.0 b
'President'	2.7	4.1	4.5	3.8 a	8.0	6.7	6.3	7.0 b
'Tropical'	4.8	7.9	9.3	7.3 a	13.8	13.9	11.4	13.0 b
Mean	3.7	5.8	7.1	5.5 a	10.6	10.5	10.9	10.7 b

*Mean values marked with different letters within rows differ significantly at p = 0.05

Content of nutrients in the indicator parts of plants

Both in the spring-summer period and in the autumn-winter period, the nutrition of the studied cultivars with regards to nitrogen was found to be stable (Tables 3 and 6). Differentiated changes in the content of this macroelement were determined in case of 'Baron' and 'Pistache' cultivars only in the autumn-winter period. Among the mean values for the studied cultivars, the highest nitrogen content was found in the youngest plants (year 2002), while the lowest was in case of the three-year-old plants (year 2003).

In reference to phosphorus, it was found that the vegetation period exerted a significant influence on the plants' nutritional status with regards to this element (Tables 3 and 6). In the period of light deficit, there occurred a significant increase of phosphorus content in the indicator parts of the plants. With the advanced age of the plants – in both vegetation periods – there followed an essential increase of the phosphorus content in the majority of the studied cultivars. Phosphorus content significantly increased as the plants aged. Significantly, the least content of this element was found in the case of two-year-old plants (year 2002), while the greatest phosphorus content was present in the oldest plants (year 2004).

A significant increase of potassium content was found in the plant indicator parts in the spring-summer period, as compared to the autumn-winter period (Tables 4 and 6).

Table 3. Mean contents of nitrogen and phosphorus in the indicator parts of anthurium (% in d.m.), depending on the vegetation period

Cultivar	Autumn-winter				Spring-summer			
	2002*	2003*	2004*	Mean**	2002*	2003*	2004*	Mean**
				N				
'Baron'	1.62 b	1.39 a	1.57 ab	1.52	1.60	1.45	1.50	1.52
'Choco'	1.87	1.67	1.76	1.77 b	1.67	1.63	1.62	1.64 a
'Midori'	1.57	1.43	1.45	1.48	1.49	1.35	1.35	1.40
'Pistache'	1.68 b	1.52 a	1.61ab	1.60	1.62	1.52	1.61	1.58
'President'	1.60	1.56	1.60	1.58	1.62	1.57	1.54	1.58
'Tropical'	1.64	1.53	1.60	1.59	1.59	1.50	1.51	1.53
				P				
'Baron'	0.27	0.40	0.43	0.36	0.28 a	0.41 b	0.43 b	0.37
'Choco'	0.29 a	0.43 ab	0.56 b	0.43	0.26 a	0.39 b	0.46 b	0.37
'Midori'	0.19 a	0.35 ab	0.48 b	0.34	0.20 a	0.31 ab	0.45 b	0.32
'Pistache'	0.24 a	0.42 ab	0.49 b	0.38	0.24 a	0.37 b	0.41 b	0.34
'President'	0.32	0.44	0.47	0.41	0.30 a	0.36 ab	0.44 b	0.36
'Tropical'	0.29	0.47	0.48	0.42	0.25 a	0.38 ab	0.43 b	0.35

*Values marked with different letters within the vegetation period differ significantly at $p = 0.05$
** Mean values from the vegetation period marked with different letters differ significantly at $p = 0.05$

Table 4. Mean contents of potassium and calcium in the indicator parts of anthurium (% in d.m.), depending on the vegetation period

Cultivar	Autumn-winter				Spring-summer			
	2002*	2003*	2004*	Mean**	2002*	2003*	2004*	Mean**
				K				
'Baron'	2.97 a	3.52 b	3.60 b	3.36 a	3.52 a	3.97 b	3.96 b	3.81 b
'Choco'	3.69	4.21	4.27	4.06	4.26	4.35	4.03	4.21
'Midori'	3.57 a	3.83 b	3.76 ab	3.72 a	3.96 a	4.18 ab	4.33 b	4.16 b
'Pistache'	3.27	3.94	4.14	3.78	3.91 a	4.50 b	4.27 ab	4.22
'President'	3.45 a	4.15 b	3.86 b	3.82 a	4.18 ab	4.40 b	4.02 a	4.20 b
'Tropical'	3.53	4.21	4.16	3.97 a	4.25	4.54	4.42	4.40 b
				Ca				
'Baron'	2.26 b	1.67 ab	1.21 a	1.71	1.95	1.69	1.60	1.75
'Choco'	2.20 b	1.50 a	1.30 a	1.67	1.97	1.39	1.48	1.61
'Midori'	2.19 c	1.39 b	0.87 a	1.49	1.66	1.29	1.19	1.37
'Pistache'	2.03 b	1.43 ab	1.10 a	1.52	1.79	1.48	1.36	1.54
'President'	2.16	1.74	1.48	1.79	1.99 b	1.84 ab	1.58 a	1.80
'Tropical'	2.04	1.63	1.22	1.63	1.76	1.45	1.38	1.53

Explanations: see Table 3

Table 5. Mean contents of magnesium and sulphur in the indicator parts of anthurium (% in d.m.), depending on the vegetation period

Cultivar	Autumn-winter				Spring-summer			
	2002*	2003*	2004*	Mean**	2002*	2003*	2004*	Mean**
				Mg				
‘Baron’	0.15	0.23	0.20	0.19	0.23 ab	0.17 a	0.26 b	0.22
‘Choco’	0.30	0.25	0.24	0.26	0.30 b	0.17 a	0.26 b	0.24
‘Midori’	0.25	0.25	0.22	0.24	0.26	0.19	0.24	0.23
‘Pistache’	0.34	0.31	0.26	0.30	0.35	0.24	0.30	0.30
‘President’	0.33	0.34	0.33	0.33	0.36	0.28	0.32	0.32
‘Tropical’	0.32	0.24	0.25	0.27	0.26 b	0.18 a	0.27 b	0.24
				S				
‘Baron’	0.33	0.31	0.30	0.31	0.35	0.39	0.33	0.36
‘Choco’	0.48 b	0.38 a	0.38 a	0.41	0.37	0.36	0.41	0.38
‘Midori’	0.49 b	0.43 b	0.34 a	0.42	0.44	0.39	0.37	0.40
‘Pistache’	0.31	0.27	0.29	0.29	0.34	0.31	0.29	0.31
‘President’	0.23	0.25	0.21	0.23 a	0.29	0.27	0.26	0.27 b
‘Tropical’	0.25	0.31	0.26	0.27	0.32	0.30	0.30	0.30

Explanations: see Table 3

Table 6. Mean contents of macroelements in the indicator parts of anthurium (% in d.m.), depending on the vegetation period

Nutrient	Autumn-winter				Spring-summer			
	2002*	2003*	2004*	Mean**	2002*	2003*	2004*	Mean**
N	1.66 b	1.52 a	1.60 ab	1.59	1.60 b	1.50 a	1.52 ab	1.54
P	0.27 a	0.42 b	0.49 c	0.39 b	0.25 a	0.37 b	0.44 c	0.35 a
K	3.41 a	3.98 b	3.97 b	3.79 a	4.01 a	4.32 b	4.17 ab	4.17 b
Ca	2.15 c	1.56 b	1.20 a	1.63	1.85 b	1.52 a	1.43 a	1.60
Mg	0.28	0.27	0.25	0.27	0.29 b	0.21 a	0.27 b	0.26
S	0.35	0.32	0.30	0.32	0.35	0.34	0.32	0.34

Explanations: see Table 3

Furthermore, in the autumn-winter period, there were significant differences between the cultivars. A stable potassium content was determined in the cultivars ‘Choco’, ‘Pistache’ and ‘Tropical’; however, the mean value from all studied cultivars showed a significant increase of the potassium content in the oldest plants. Differentiated changes of potassium content were found for the mean value from cultivars in the spring-summer period. Similarly as in the autumn-winter period, there appeared some differences between the cultivars. Stable potassium nutrition within each vegetation period was found in the ‘Choco’ and ‘Tropical’ cultivars, while the ‘Baron’ and ‘Midori’ cultivars showed a significant increase of potassium content.

Table 7. Comparison of chemical analysis results of anthurium indicator parts with the ranges of macronutrient levels recommended by selected authors

Nutrient	Recommended values (% d.m.)	Percent of results incorporated in the range of recommended contents	
		Autumn-winter	Spring-summer
Mills i Scoggins (1998)[1]			
N	2.21-3.83(a)	0.0	0.0
P	0.25-0.55	83.3	83.3
K	1.80-3.41	11.1	0.0
Ca	0.73-1.60	50.0	50.0
Mg	0.49-0.69	0.0	0.0
S	-	-	-
Mills i Scoggins (1998)[1]			
N	1.19-2.06(b)	100.0	100.0
P	0.11-0.38	38.9	50.0
K	0.99-2.37	0.0	0.0
Ca	0.59-1.55	50.0	44.4
Mg	0.39-0.64	0.0	0.0
S	-	-	
Uchida (2000)[1]			
N	1.87	-	-
P	0.15-0.19	5.6	0.0
K	2.00	-	-
Ca	1.50	-	-
Mg	0.34-1.00	5.6	11.1
S	0.16-0.75	100.0	100.0
Chen i in. (2003)[1]			
N	3.00-4.00	0.0	0.0
P	0.20-0.60	94.4	100.0
K	2.00-5.00	100.0	100.0
Ca	1.00-3.00	94.4	100.0
Mg	0.30-1.00	38.9	16.7
S	0.20-0.60	100.0	100.0
Anthura (1998)[2]			
N	1.96-2.24	0.0	0.0
P	0.15-0.31	27.8	33.3
K	3.52-3.91	38.9	5.6
Ca	1.00-2.00	61.1	100.0
Mg	0.34-0.49	5.6	11.1
S	0.22	-	-

Climate: 1 – tropical, marine climate; 2 – temperate warm marine climate;
a – young leaves, in 90% ripe, pale-green, 10 days before full maturity;
b – mature leaves, dark-green, with a growing flower mature in 75%.

With the aging of the plants, a significant decrease of the calcium content was determined in the majority of the cultivars (except for 'President' and 'Tropical') in the autumn-winter period (Tables 4 and 6). In turn, in the successive years of study, in the spring-summer period the majority of cultivars showed a stable content of this element. However, the mean value for the studied cultivars showed a tendency for the calcium content to decrease in the indicator parts of the plants.

There was no significant effect of the vegetation period on the plant nutrition with regard to magnesium (Tables 5 and 6). In the autumn-winter period, a stable magnesium content was determined in all of the studied cultivars (Tables 5 and 6). However, differences were shown in the nutrition with regard to magnesium between the particular cultivars in the spring-summer period. A stable magnesium content was found in the 'Midori', 'Pistache' and 'President' cultivars, while the remaining cultivars showed differentiated changes of Mg content.

Both in the autumn-winter period and in the spring-summer period, the nutrition with regard to sulphur was found to be stable (Tables 5 and 6). There were no differences between the successive years of studies. A decrease in sulphur content was only found in 'Choco' and 'Midori' in the autumn-winter period.

The macroelement nutritional status of anthurium plants was significantly affected by light conditions. Compared to autumn-winter, in the spring-summer period there was a natural tendency for a significant decrease of phosphorus content (-10.25%, with autumn-winter content being 100%), with a simultaneous increase of potassium content (+10%) in the plant indicator parts (Table 6). The age of plants significantly modified the plant nutrition with phosphorus (+76%) and calcium (-22.7%) in the spring-summer period, while the nutrition with phosphorus (+81.5%), potassium (+16.7%) and calcium (-55.8%) was modified in the autumn-winter period.

DISCUSSION

The decreased anthurium yield in some periods of the vegetation season confirmed earlier studies by Dufour and Guérin (2003). Leffring (1974) reported that a factor that limits the yielding of anthurium is light, which stimulates the growth of plants and the development of leaves contributing to the initiation of inflorescence and flower buds. This thesis was given also by Dai and Paull (1990), who argued that yielding periodicity of anthurium resulted from the variable light conditions.

In our own study, when the age of plants advanced, there was a natural tendency to an improvement of the nutritional status with phosphorus, but in reference to calcium, the tendency was rather towards a deterioration of its content. Dufour and Guérin (2005) showed that with the aging of plants, their nutrition with potassium deteriorated. The mentioned authors also suggested that the factor which modifies the nitrogen content in plant indicator parts is the N:P:Ca ratio of the nutrient used for fertigation. These authors also argued that the chemical composition of nutrients depends on the plant's developmental phase. The mentioned authors, for the cultivations carried in the equatorial climate, suggested decreasing the contents of phosphorus and potassium in the nutrient applied for fertigation when the plants enter into the generative phase.

In our own study, we have compared the plants' nutritional status with the ranges of macroelement contents recommended by other authors for cultivations carried out in different climatic conditions (Table 7). The determined ranges of nitrogen content in both vegetation periods were convergent only with those reported by Mills and Scoggins (1998). A comparatively high convergence has been found in the case of phosphorus content in plant indicator parts. Similar values of phosphorus were reported by Mills and Scoggins (1998) and by Chen et al. (2003). In turn, only Chen et al. (2003) reported potassium values similar to those found in our studies. The determined ranges of calcium content were similar to the values reported by Anthura (1998) and by Chen et al. (2003). The determined values of magnesium were different than those quoted in the literature. Our ranges of sulphur content were convergent with those reported by Uchida (2000) and by Chen et al. (2003). Generally, in our own research, the determined element contents showed a small degree of convergence with the ranges recommended by other authors. This may be a testimony of the modifying effect exerted on the nutritional status of anthurium by the climatic conditions occurring in Poland, or other factors such as the different chemical compositions of nutrients applied on the plants.

In our own research, a decrease of calcium, nitrogen and magnesium contents in the index parts of anthurium was found in the spring-summer period, while the content of sulphur tended to increase. It is possible that the decrease in some nutrients resulted from their dilution in the tissues as a consequence of intensive plant growth in a period with better light conditions. In the case of other plant species, dependences similar to those obtained in our own study, referring to the effect of vegetation period on plant nutritional status, were obtained by Breś and Jerzy (2004). These authors reported that the indicator parts of *Dendranthema grandiflora* Tzvelev (an annual plant) contained the highest amounts of nitrogen, phosphorus and calcium in months with a low real insolation (winter months). With an improvement of light conditions, the nutritional status with regard to these macroelements decreased.

However, Cabrera et al. (1995) showed that in summer months, greenhouse roses take in two times more nitrogen and the remaining components than they do in winter months, and this fact has a positive effect on their nutritional status. The intensity of element uptake by the plants is connected with their growth phase. The uptake of a greater amount of elements in the summer period can be the result of a greater number of photoassimilates supplied to the plant root system in that period. The phenomenon of periodicity in the uptake of nutritive components was also confirmed in case of *Euonymus japonica* (Hershey and Paul 1983).

CONLUSIONS

1. In the successive vegetation periods a periodicity of anthurium yielding was found. There appeared a trend towards a significant improvement of yielding in the spring-summer period, in comparison with the autumn-winter period.
2. A significant effect of vegetation period on the plant nutritional status was found. In the spring-summer period, the phosphorus content decreased significantly, while the potassium content increased in the plant indicator parts. In the spring-summer period, there appeared to be a tendency towards a decrease in plant nutrition with regard to calcium, nitrogen and magnesium, but at the same time, there was an increase of sulphur content.
3. The effect of plant age on the nutritional status with regard to macroelements was shown in the autumn-winter period. With the aging of plants, there followed a significant increase of potassium and phosphorus contents and at the same time, a decrease of calcium content and a stable content of magnesium and sulphur.
4. The plants' age exerted an influence on plant nutrition with regard to macroelements in the spring-summer period. With the aging of plants, there occurred a significant increase of phosphorus content, while at the same time, there was a decrease of calcium and of the stable sulphur content.

ACKNOWLEDGEMENT

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

REFERENCES

ANTHURA, 1998. Cultivation guide *Anthurium*. Anthura: 43.

BREŚ W., JERZY M., 2004. Effect of the planting date on macronutritional status of pot chrysanthemums from the Time group in all-year-round culture. Folia Hort. 16(2): 127-139.

CABRERA R.I., EVANS R.Y., PAUL J.L., 1995. Cyclic nitrogen uptake by greenhouse roses. Sci. Hort. 63: 57-66.

CHEN J., MCCONNELL D.B., HENNY R., EVERITT K.C., 2003. Cultural guidelines for commercial production of interiorscape anthurium. Environ. Hort. Dept. Florida Coop. Ext. Serv., Univ. of Florida.

DAI J., PAULL R.E., 1990. The role of leaf development on *Anthurium* flower growth. J. Amer. Soc. Hort. Sci. 115(6): 901-905.

DE KREIJ C., SONNEVELD C., WARMENHOVEN M.G., STRAVER N., 1990. Guide values for nutrient element contents of vegetables and flowers under glass. Voedingsoplossingen Glastuinbouw 15, 23.

DUFOUR L., GUÉRIN V., 2003. Low light intensity promotes growth, photosynthesis and yield of *Anthurium andreanum* Lind. in tropical conditions. Adv. Hort. Sci. 17(1): 9-14.

DUFOUR L., GUÉRIN V., 2005. Nutrient solution effects on the development and yield of *Anthurium andreanum* Lind. in tropical soilless conditions. Sci. Hort. 105: 269-282.

HERSHEY D.R., PAUL J.L., 1983. Ion absorption by woody plant with episodic growth. HortSci. 18: 357-359.

IUNG, 1972. Metody badań laboratoryjnych w stacjach chemiczno-rolniczych. Część II. Badanie materiału roślinnego. IUNG Puławy (Poland): 25-83.

JABŁOŃSKA L., 2005. Rozwój polskiego kwiaciarstwa w minionym 15-leciu. Mat. Ogólnop. Konf. „Postęp w produkcji roślin ozdobnych", Skierniewice, 31 stycznia – 1 lutego: 11-12.

KOMOSA A., 2000. Analiza podłoża i roślin jako wskaźniki odżywiania anturium. Mat. z V Konf. dla Producentów Anturium, ISiK Skierniewice, 12-13 kwietnia: 24-30.

KOMOSA A., KLEIBER T., 2003. Anturium – podłoża i odżywianie, Mat. VIII Konf. dla Producentów Anturium, ISiK Skierniewice, 25-26 marca: 5-15.

LEFFRING L., 1974. Influence of climatical conditions on growth and flower yield of *Anthurium andreanum*. Acta Hort. 51: 63-65.

MILLS H.A., SCOGGINS H.L., 1998. Nutronal levels for anthurium: young versus mature leaves. J. Plant Nutr. 21(1): 199-203.

MOJSIEJ U., 2002. Koszty produkcji kwiatów ciętych. Mat. VII Konf. dla Producentów Anturium, ISiK Skierniewice, 9-10 kwietnia: 5-12.

MORRISON D.F., 1976. Multivariate statistical methods. McGraw-Hill, Book Company.

SONNEVELD C., VOOGT W., 1993. The concentration of nutrients for growing *Anthurium andreanum* in substrate. Acta Hort. 342: 61-67.

UCHIDA R., 2000. Recommended plant tissue nutrient levels for some vegetable, fruit and ornamental foliage and flowering plants in Hawaii. Plant Nutrient Management in Hawaii's Soils; College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa: 57-64.

SEZONOWOŚĆ ZMIAN STANU ODŻYWIENIA ORAZ PLONOWANIA *ANTHURIUM CULTORUM* BIRDSEY.
CZ. I. MAKROELEMENTY

Streszczenie: Celem badań (lata 2002 – 2004) było określenie naturalnych tendencji stanu odżywienia makroelementami oraz plonowania standardowych odmian *Anthurium cultorum* Birdsey ('Baron', 'Choco', 'Midori', 'Pistache', 'President', 'Tropical' firmy Anthura B.V., Holandia) w sezonie jesienno--zimowym i wiosenno-letnim. Anturium uprawiano w keramzycie z zastosowaniem fertygacji kroplowej pożywką standardową. Wraz z poprawą warunków świetlnych stwierdzono istotny wzrost plonowania roślin. W trakcie 3 lat badań wykazano istotny wpływ warunków okresu uprawy na stan odżywienia roślin fosforem i potasem. W okresie wiosenno-letnim stwierdzono istotne obniżenia zawartości fosforu, przy wzroście zawartości potasu w liściach roślin. Stan odżywienia roślin fosforem i wapniem w okresie wiosenno-letnim, a fosforem, potasem i wapniem w okresie jesienno-zimowym zależał istotnie od wieku roślin. W okresie wiosenno-letnim stwierdzono na ogół spadek zawartości wapnia, azotu i magnezu, a wzrost zawartości siarki. Uzyskane wyniki mogą być wartościowym narzędziem w interpretacji wyników analizy części wskaźnikowych roślin w celach diagnostycznych.

Received November 12, 2008; accepted July 27, 2009