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Macroelement concentration in leaves of chrysanthemums from the Time group grown in spring and summer-autumn seasons

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ABSTRACT

Three cultivars of chrysanthemums from the Time group were grown in the spring and summer-autumn seasons in 2003 – 2004. Three nutrient solutions with different nitrogen and potassium contents were applied. Samples of healthy, fully developed leaves were taken for chemical analyses when inflorescence buds appeared, and in the phase of full blooming. The concentration of total N, P, K, Ca and Mg in plant tissue was determined. The nutritional status of plants was very similar in spite of the fact that the plants were grown in different light conditions and different nutrient solutions were used. The paper also contains a proposal of more precise guide values for nitrogen (N 4.35-5.53% d.m.) and for potassium (K 6.36-7.97% d.m.).

INTRODUCTION

The application of day length control permits the growing of chrysanthemums (*Chrysanthemum × grandiflorum* Ramat./Kitam) year-round. However, the growing conditions are not equal, particularly with regards to real insolation and radiation. Therefore, plants grown in different light conditions differ primarily by photoperiod response and by the quality of flowers (De Jong 1982, Breś and Jerzy 2004a, Jerzy and Borkowska 2004). The effect of the growing season, and thereby of the radiation on the mineral balance of chrysanthemum in controlled cultivation (i.e. day length is artificially shortened), has not been explained. The objective of this work was to investigate whether the critical concentration of nutrients characterizing the nutritional status of chrysanthemums should depend on the growing season.

MATERIAL AND METHODS

Studies were carried out in 2003 – 2004 in a greenhouse equipped with a computer system controlling the length of day. Day length was shortened to 10 hours (from 7.00 a.m. to 5.00 p.m.) from the moment of the start of cultivation. For darkening purposes, material of Obscura A/B+B type was used. In the experiment, three mean-flowered pot cultivars of chrysanthemum from the Time group were used: ‘Doing Time’, ‘Jewel Time White’ and ‘Swing Time Improved’. Plants were fertilized using an individual drop irrigation system. Frequency of nutrient supply was controlled with a Soltimer energy meter. Each year, two experimental cycles were carried out – the first one (conventionally called the spring season cycle) lasted from mid-April till the end of June; the second one (summer-autumn season) lasted from mid-August till the end of October. Using the preparation B-Nine 85 SP retarded the plants’ growth. The exact terms of each particular experiment’s duration are shown in Table 1. Chrysanthemums were grown in a mixture of limed raised peat and coconut fibre (v/v = 9:1), in pots with 14 cm diameters filled with 0.71 dm^3 substrate. Three nutrient solutions with differing contents of nitrogen and potassium were used (Table 2).

The nutritional status of plants was assessed on the basis of chemical analyses of healthy, fully developed leaves. Leaf samples were taken twice during each cycle. The first samples were taken when inflorescence buds appeared; the second time, leaves were sampled in the phase of full blooming.

The total concentration of macroelements in dried plant material was determined after its mineralization in strong acids (Bakuła et. al 1972). The level of K, Ca, Mg was determined using absorption spectrophotometry. For analysis of P and B, spectrophotometric methods were used. Total N was determined by the micro-Kjeldahl procedure. Solar radiation was measured from 7:00 a.m. to 5:00 p.m. during the studies using a pyranometer. Because of a general similarity, the paper shows only diagrams characterizing radiation in 2004.

Table 1. Timetable of experiments

Treatment	Growing term			
	2003		2004	
	Spring	Summer-autumn	Spring	Summer-autumn
Beginning of pot cultivation	14.04	20.08	22.04	16.08
Topping	19.04	25.08	27.04	21.08
Leaf sampling I	15.05	22.09	20.05	20.09
Leaf sampling II	23.06	15.10	28.06	20.10

Table 2. Composition of nutrient solutions used in experiments (mg dm^{-3})

Nutrient	Solution 1	Solution 2	Solution 3
$N-NH_4$	<10	<10	<10
$N-NO_3$	150	180	210
P	40	40	40
K	210	252	294
Ca	100	100	100
Mg	40	40	40
Fe	2.5	2.5	2.5
Mn	1	1	1
Zn	0.4	0.4	0.4
Cu	0.1	0.1	0.1
B	0.3	0.3	0.3
Mo	0.048	0.048	0.048
pH	5.5	5.5	5.5
EC (mS cm^{-1})	1.5	1.8	2.2

The critical values characterizing the nutritional status of chrysanthemums were elaborated for the species without a differentiation of cultivars (Lunt and Kofranek 1964, Reuter and Robinson 1988, Kerij et al.1990, Breś et al. 2002). In the presented paper, the results of the chemical analyses of leaves have been tabulated without the differentiation of cultivars as well. For this data, standard deviation and coefficient of variation have been calculated. Results of these calculations were utilized to determine the guide values for nitrogen and potassium. Furthermore, results of an analysis of two years of studies were statistically evaluated using analysis of variance at p = 0.05.

RESULTS AND DISCUSSION

Information referring to the nutritional status of plants grown in different light conditions is not numerous. The different responses of chrysanthemums to fertilization depending on the season were first noted by Joiner and Smith (1962). According to Breś and Jerzy (2004b), noticeable differences in the nutritional status of chrysanthemums occur in leaves of plants grown in summer and winter seasons, thus, in seasons radically differing in light conditions.

The studies presented in this paper were also carried out in two terms differing by light conditions: in the spring season, with the lapse of time, radiation increased, while in the summer-autumn season, it decreased. A comparison of radiation during both cycles of studies has been shown in the example from the year 2004 (Fig. 1.). The total radiation measured in MJ m^{-2} was smaller by 33-36% in the summer-autumn season in comparison with the spring season (mean values from 2003 – 2004).

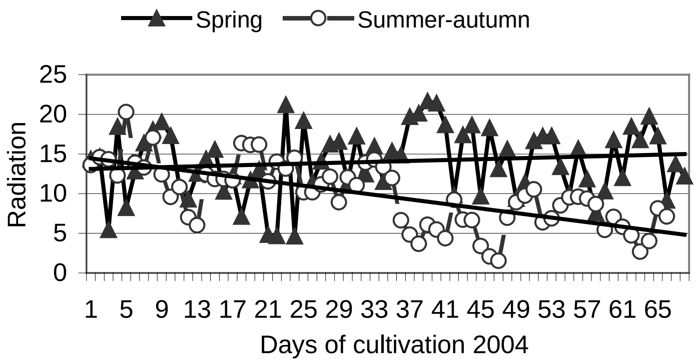

Fig. 1. Solar radiation in the period of experiments in 2004 (MJ m^{-2})

Nitrogen and potassium in examined ranges of ion concentrations had no effect on height and width of plants or number and diameter of inflorescences. No effect of the studied nutrient solutions on the plant flowering term was found. The plants, both in the spring and summer-autumn seasons, showed full commercial value (Breś et al. 2008).

The results of chemical analyses of chrysanthemum leaves are shown in Tables 3 and 4. A statistical analysis carried out on the basis of standard deviation and the variation coefficient indicates a high repeatability and homogeneity of the obtained results in spite of the application of different nutrient concentrations. In the majority of cases, the variation coefficient did not exceed 10%. The highest values and also the most differentiated coefficient were calculated for calcium (from 8.5% in summer-autumn season 2003 to 16.05% in spring season 2004) the lowest values were shown by potassium (from 1.76% in spring season 2003 to 5.11% in summer-autumn season 2004). The nutritional status of chrysanthemums was very similar in spite of different light conditions dominating in the period of experiments as well as different nitrogen and potassium concentration in solutions used for fertigation (Table 5, Fig. 2). Therefore, there is no need to differentiate the macroelements critical values for chrysanthemums from the Time group, whose complete growing cycle is contained in the period from April to October. Meziane and Shipley (2001), in experiments with 22 species of herbaceous plants, showed that at low nutrient supply levels the mass concentration of nitrogen was basically constant despite quantum irradiance changing from 200 to 1100 μmol m^{-2} s^{-1}. However, in an experiment with roses grown in a hydroponic system, nitrogen uptake rates in the summer days were twice as high as those in winter (Cabrera et al. 1995). Bouma (1983) reported that increased intensity of light caused a diminution of phosphorus concentration in leaves, leaf stalks and plant roots. According to Treder (2001), the accumulation of calcium in oriental lily leaves was not affected by nutrition but strongly dependent on light level. Plants grown with supplementary artificial light had almost twice as high a level of calcium in the leaves. No effect of light intensity for nitrogen and phosphorus was noted. Magalhaes and Wilcox (1983a, 1983b), in experiments with tomatoes, demonstrated that the total uptake of N, P, K, Ca and Mg increased with increasing irradiance for plants supplied with $N\text{-}NO_3$, but with $N\text{-}NH_4$ showed either no response or decreased uptake with irradiance.

Table 3. Nutrient concentration in leaves of chrysanthemums (% d.w.) grown in spring and summer-autumn seasons in 2003 (mean values for 3 cultivars)

Term of leaf sampling	Nutrient solution	N	P	K	Ca	Mg
	Spring season					
I	1	5.08	0.96	7.45	2.11	0.67
	2	5.19	0.94	7.51	1.78	0.59
	3	5.21	0.98	7.30	1.79	0.58
II	1	4.69	1.05	7.13	2.24	0.66
	2	4.91	1.13	7.48	2.10	0.57
	3	5.33	1.19	7.42	2.01	0.54
Standard deviation		0.21	0.09	0.13	0.17	0.05
Coefficient of variation		4.14	8.65	1.76	8.50	8.33
	Summer-autumn season					
I	1	5.28	1.11	7.30	2.29	0.63
	2	5.37	1.22	7.57	2.18	0.61
	3	5.72	1.25	7.71	2.24	0.58
II	1	5.43	1.16	7.00	2.99	0.67
	2	5.16	1.29	7.61	2.82	0.67
	3	5.65	1.31	7.71	2.72	0.60
Standard deviation		0.20	0.07	0.26	0.31	0.04
Coefficient of variation		3.67	5.73	3.47	12.20	6.34

Table 4. Nutrient concentration in leaves of chrysanthemums (% d.w.) grown in spring and summer-autumn seasons in 2004 (mean values for 3 cultivars)

Term of leaf sampling	Nutrient solution	N	P	K	Ca	Mg
	Spring season					
I	1	5.28	1.35	7.27	1.81	0.50
	2	5.89	1.43	7.70	1.64	0.55
	3	6.05	1.38	7.77	1.92	0.54
II	1	4.80	1.21	7.87	2.64	0.60
	2	5.12	1.38	7.69	2.41	0.56
	3	5.20	1.44	7.86	2.28	0.53
Standard deviation		0.44	0.08	0.20	0.35	0.03
Coefficient of variation		8.16	5.83	2.60	16.05	5.45
	Summer-autumn season					
I	1	5.64	0.88	7.77	2.08	0.52
	2	5.75	1.05	7.85	2.04	0.51
	3	5.55	1.00	7.92	1.92	0.50
II	1	5.19	0.82	6.81	2.57	0.54
	2	5.01	0.81	7.34	2.46	0.51
	3	5.48	0.78	7.76	2.40	0.52
Standard deviation		0.26	0.10	0.39	0.24	0.01
Coefficient of variation		5.65	11.39	5.11	10.74	2.46

Table 5. Influence of growing season on N, P, K, Ca, Mg concentration in leaves of chrysanthemums grown in 2003 – 2004 (mean values for 3 cultivars)

Year	N		P		K		Ca		Mg	
	S*	SA**	S	SA	S	SA	S	SA	S	SA
2003	5.07	5.44	1.04	1.22	7.38	7.48	2.01	2.54	0.60	0.63
2004	5.39	5.44	1.37	0.89	7.69	7.58	2.12	2.25	0.55	0.52
Mean for seasons	5.23	5.44	1.21	1.06	7.54	7.53	2.07	2.40	0.58	0.58
$LSD_{0.05}$ for seasons	n.s.		n.s.		n.s.		n.s.		n.s.	

*S – spring, **SA – summer-autumn, n.s. – not significant differences

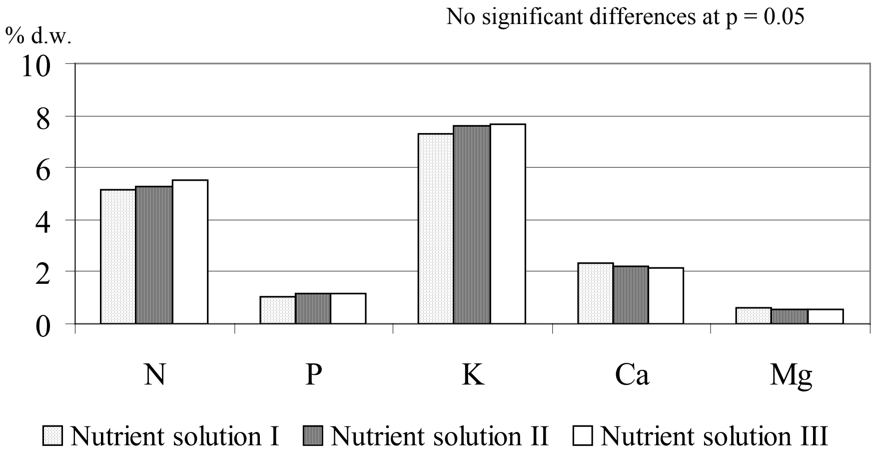

Fig. 2. Influence of nutrient solution on macroelement concentration in leaves of chrysanthemums from the Time group (means for 2003 – 2004)

The advantage of fertigation is mainly uniform delivery of nutrients for plants. Therefore, in the substrate, the amount of elements does not change significantly. Traditional technology of fertilisation (pre-plant and top-dressing fertilisation) does not provide such stability. Plants respond better to smaller amounts of fertilizer delivered more frequently. As shown in the presented studies, it also exerts an effect on the equalisation of macroelements in leaves during chrysanthemum growing. According to literature data, the optimal ranges of macroelements for chrysanthemums are very wide, especially for nitrogen: from 2.25 to 6.00% of leaf dry weight, and from 2.54 to 10% for potassium (Lunt and Kofranek 1964, Reuter and Robinson 1988, Kerij et al.1990, Breś et al. 2002). High divergences between the values given by the above-mentioned authors suggest that a closer determination of the recommendations is necessary. Because of the short growing cycle of chrysanthemums (in presented experiments from 56 to 72 days), and also because of the comparatively small differences in nutrient concentration in leaves resulting from the terms of sampling (time of inflorescence buds' appearance and in full bloom – Tables 3 and 4), universal guide values have been proposed for the entire period of cultivation. Using the results from three years of chemical analyses of leaves on the basis of the Kenworthy method (1961), modified by Kleiber (2005), more precise guide values for nitrogen and potassium have been created. A 15% range deviation of the mean value was assumed for the calculation. These values for plants grown in the period from April to October should have the following values: for N 4.4-6.2%; for K 6.4-8.7% of the dry weight of leaves. These ranges are distinctly narrower than the so far existing recommendations, and in the majority, they are a consequence of fertigation permitting a constant inflow of components throughout the entire period of chrysanthemum growing.

CONCLUSIONS

1. In controlled cultivation, no significant effect of differentiated light conditions, dominating in the period from April to October on the macroelement nutritional status of chrysanthemums from the Time group has been found.
2. The application of nutrient solutions differing in their content of nitrogen (150 to 210 mg $N\text{-}NO_3$ dm^{-3}) and potassium (210 to 294 mg K dm^{-3}) did not exert any effect on the differentiation of plant nutrition status.
3. The use of fertigation favours the stabilization of chrysanthemum nutritional status in the period of cultivation. It permitted a determination of more precise guide values for chrysanthemums grown from April to October. The modified values are the following: for N, 4.4-6.2%; for K, 6.4-8.7% of the dry weight of leaves.

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ZAWARTOŚĆ MAKROSKŁADNIKÓW W LIŚCIACH CHRYZANTEM Z GRUPY TIME UPRAWIANYCH WIOSNĄ ORAZ W SEZONIE LETNIO-JESIENNYM

Streszczenie: Trzy odmiany chryzantem z grupy Time uprawiano wiosną oraz w sezonie letnio-jesiennym w latach 2003 – 2004. Stosowano 3 pożywki różniące się zawartością azotu i potasu. Próby liści do analizy chemicznej pobierano, gdy pojawiły się pąki kwiatostanowe oraz podczas pełni kwitnienia. W liściach oznaczono całkowite zawartości N, P, K, Ca i Mg. Stan odżywienia roślin był bardzo podobny, mimo uprawy roślin w różnych warunkach świetlnych oraz mimo stosowania różnych pożywek. Zaproponowano także uściślenie zawartości wskaźnikowych dla azotu i potasu (N 4.4-6.2% s.m., K 6.4-8.7% s.m.).

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