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Effect of the planting date on macronutritional status of pot chrysanthemums from the Time group in all-year-round culture

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ABSTRACT

The aim of the study was to evaluate the usefulness of critical levels of macroelements recommended for a conventional method of culture for diagnosing the macronutritional status of Time group chrysanthemums in all-year-round culture. Four pot cultivars of the chrysanthemum *Dendranthema grandiflora* Tzvelev (syn. *Chrysanthemum* × *grandiflorum* /Ramat./ Kitam) were selected for the experiment: ‘Esperanto Time’, ‘Icon Time’, ‘Jewel Time’, and ‘Solar Time’. The research embraced 12 growth cycles starting on the second day of each month throughout the year 2002. From the moment of potting, the plants were treated with a short day. In periods of naturally long days, the day was shortened to 10.5 hours with the use of a black-out cover. No supplementary illumination was used from November to mid-February (a photoperiod of under 10 hours). The plants grown in peat substrate were fed using the fertigation system. The time of culture and the insolation associated with it had a significant effect on the content of nitrogen, phosphorus, potassium, calcium, and magnesium in the leaves. The time of culture affected the nitrogen and potassium levels the most, and magnesium the least. The critical levels of macroelements recommended for conventional and hydroponic methods of culture turned out to be of little use for diagnosing the nutritional status of Time group chrysanthemums in all-year-round culture. It is necessary to work out new critical or guide values allowing for the cyclicity of culture in various light conditions and the fertigation of plants grown in a limited volume of medium.

INTRODUCTION

The nutritional status of plants depends primarily on fertilisation. Sonneveld (1991) claims that the chemical composition of plants also depends on the cultivar, the plant development stage (Waters 1967, Komosa and Breś 1980), the proportion of ions in the root environment, and properties of the medium. According to Breś (1998), the factors modifying the content of elements in a plant can also include the systems of culture and fertilisation. All-year-round culture of chrysanthemums is based on the control of photoperiod. It is highly possible that an additional factor affecting plant mineral balance will be the time of culture, and hence insolation and temperature.

The currently recommended critical levels of macroelements worked out for diagnosing the nutritional status of chrysanthemums assume a conventional method of culture and feeding consisting of principal pre-plant fertilisation and one or two supplementary fertilisation. Such a system is characterised by a highly variable nutrient content in the medium. Modern growing practices make it possible to combine irrigation with fertilisation (fertigation). A constant supply of small amounts of nutrients greatly reduces water and nutritional stress in plants.

The aim of the research was to evaluate the usefulness of critical levels of macroelements recommended for a conventional method of culture for diagnosing the macronutritional status of Time group chrysanthemums in all-year-round culture.

MATERIAL AND METHODS

Four pot cultivars of the chrysanthemum *Dendranthema grandiflora* Tzvelev (syn. *Chrysanthemum* × *grandiflorum* /Ramat./Kitam) grown in sprays were selected for the experiment: ‘Esperanto Time’, ‘Icon Time’, ‘Jewel Time’, and ’Solar Time’. The research embraced 12 growth cycles. Starting with 2 January 2002, on the second day of each successive month of the year rooted cuttings of all the chrysanthemum cultivars were planted into pots 14 cm in diameter, 5 cuttings per pot. From the day of potting, the plants were treated with a short day. In periods of naturally long days, the day was shortened to 10.5 hours by shading. From November till mid-February (a day under 10 hours), no supplementary assimilation light was used to improve the light conditions in the period of insolation deficit. The plants were grown in a peat substrate mixed with PGMix and Radigen fertilisers. The results of a chemical analysis of the medium prepared for chrysanthemum culture are presented in Table 1.

Table 1. Chemical properties of growing medium prepared for chrysanthemum growing

Nutrient	[mg dm^{-3}]	Nutrient	[mg dm^{-3}]
$N\text{-}NH_4$	77	B	0.44
$N\text{-}NO_3$	93	Mn	10.20
P	61	Fe	86.30
K	291	Cu	2.50
Ca	680	Zn	4.60
Mg	186	Salinity	1.60 g NaCl dm^{-3}
Na	42	pH	6.23
Cl	30		
$S\text{-}SO_4$	322		

For the first few days after potting, the plants were sprinkled with water; later this practice was replaced with drip fertigation. To prepare the nutrient solution the rainwater was used. The composition of the stock solution prepared in a fertiliser mixer is presented in Table 2.

Table 2. Chemical properties of nutrient solution used for fertigation in winter

Nutrient	[mg dm^{-3}]	Nutrient	[mg dm^{-3}]
$N\text{-}NH_4$	1	Fe	2.711
$N\text{-}NO_3$	212	Mn	0.875
P	54	Zn	0.489
K	291	Cu	0.070
Ca	88	B	0.295
Mg	53	EC	2.2 mS cm^{-1}
Na	4	pH	5.5
Cl	2.5		
$S\text{-}SO_4$	93.5		

The plants were fertigated once, usually with 160 cm^3 per pot, with the feeding frequency depending on weather conditions. Depending on those conditions, the electrolitical conductivity of the nutrient solution varied between 1.8 mS cm^{-1} (in summer) and 2.2 mS cm^{-1} (in winter). The chrysanthemums were also fed with carbon dioxide. The gas concentration was kept at 1.1-1.2 µl dm^{-3} with closed windows, and at 550-600 µl dm^{-3} with opened ones. The chrysanthemums were retarded using the preparation B-Nine 85 SP at a concentration of 0.3%. Details of the cultivars under study, method and time of culture, photoperiod, and yield were included in Breś and Jerzy (2004).

The material used for chemical analyses was well-developed leaves from entire plants, when 30% of inflorescences were in flower. Total contents of N, P, K, Ca, and Mg were determined in dried plant material after its mineralisation in strong acids (Nowosielski 1974). Analysis of variance was applied to the results of the analyses and the LSD was calculated at the p = 0.05 significance level.

RESULTS AND DISCUSSION

A statistical evaluation of the results of the chemical analysis of chrysanthemum leaves is presented in Tables 3a and 3b.

Table 3a. Influence of growing term on the content of macronutrients in chrysanthemum leaves (% d.m.)

Beginning of cultivation	Photoperiodic response	N	P	K	Ca	Mg
			‘Esperanto Time’			
02.01.2002	62	5.67	1.27	8.58	2.99	0.57
02.02.2002	56	5.82	1.10	8.26	3.19	0.59
02.03.2002	55	4.57	1.03	7.07	3.35	0.55
02.04.2002	63	5.01	0.96	6.98	3.06	0.52
02.05.2002	65	5.03	0.66	6.89	2.57	0.49
02.06.2002	79	3.87	0.44	6.03	2.44	0.33
02.07.2002	67	3.55	0.55	5.19	2.00	0.44
02.08.2002	60	3.75	0.60	5.79	2.04	0.48
02.09.2002	57	4.14	0.74	5.36	2.38	0.46
02.10.2002	70	3.69	1.19	6.16	3.30	0.51
02.11.2002	82	3.87	1.11	6.11	2.97	0.53
02.12.2002	72	5.11	1.01	6.19	3.25	0.42
$LSD_{0.05}$		0.13	0.10	0.30	0.02	0.01
			‘Icon Time’			
02.01.2002	75	6.02	0.82	8.09	3.10	0.60
02.02.2002	62	5.96	0.85	7.76	3.31	0.60
02.03.2002	68	5.54	0.87	6.68	3.53	0.54
02.04.2002	70	5.74	0.94	5.92	3.30	0.54
02.05.2002	86	5.71	0.65	6.00	2.83	0.50

Beginning of cultivation	Photoperiodic response	N	P	K	Ca	Mg
02.06.2002	101	4.34	1.01	6.09	3.06	0.55
02.07.2002	78	3.48	0.45	4.33	2.54	0.64
02.08.2002	64	4.51	1.09	5.82	2.31	0.60
02.09.2002	63	4.10	0.69	4.60	3.15	0.52
02.10.2002	66	5.26	1.08	5.94	4.06	0.54
02.11.2002	110	3.95	1.07	6.06	3.38	0.62
02.12.2002	88	5.43	0.86	5.97	3.21	0.54
$LSD_{0.05}$		0.13	0.05	0.35	0.04	0.03

Table 3b. Influence of growing term on the content of macronutrient in chrysanthemum leaves (% d.m.)

Beginning of cultivation	Photoperiodic response	N	P	K	Ca	Mg
		'Jewel Time'				
02.01.2002	66	5.98	1.52	8.62	2.96	0.55
02.02.2002	59	5.81	1.03	8.89	2.85	0.46
02.03.2002	59	5.33	1.06	8.66	3.03	0.54
02.04.2002	55	5.72	1.21	7.86	2.83	0.38
02.05.2002	55	5.08	0.84	6.01	2.48	0.36
02.06.2002	73	4.96	0.92	7.78	2.59	0.40
02.07.2002	64	3.87	0.50	6.16	2.17	0.51
02.08.2002	54	4.53	0.63	7.30	2.26	0.52
02.09.2002	56	4.52	0.76	6.52	2.41	0.54
02.10.2002	69	4.70	1.26	6.77	2.24	0.53
02.11.2002	110	5.02	1.24	7.15	2.57	0.65
02.12.2002	88	5.60	0.97	7.85	2.72	0.54
$LSD_{0.05}$		0.15	0.07	0.39	0.02	0.01
		'Solar Time'				
02.01.2002	68	5.70	1.28	8.75	2.91	0.53
02.02.2002	59	5.26	1.23	8.21	2.82	0.41
02.03.2002	63	4.99	1.15	7.85	3.30	0.43
02.04.2002	69	4.86	0.99	6.73	2.58	0.36
02.05.2002	74	5.18	0.82	6.89	2.78	0.39
02.06.2002	87	4.34	0.49	5.82	2.44	0.26
02.07.2002	72	3.44	0.48	5.54	2.01	0.40
02.08.2002	63	3.96	0.70	5.92	2.04	0.38
02.09.2002	59	3.89	0.81	4.99	2.52	0.36
02.10.2002	69	4.02	1.20	6.49	3.91	0.43
02.11.2002	90	3.85	1.35	6.76	3.04	0.44
02.12.2002	77	525	1.31	6.95	2.42	0.35
$LSD_{0.05}$		0.17	0.09	0.29	0.03	0.01

The time of culture had a significant effect on the macronutritional status of the plants. The lowest levels of nitrogen, phosphorus, potassium, magnesium, and calcium were usually found in the leaves of plants grown in cycles 5-10 (beginning from May to November). The highest concentrations of the nutrients were usually recorded in the leaves of plants grown in cycles 1-5 and 11-12 (beginning, respectively, from January to May and from November to December).

The above findings are corroborated by figures 1-4 presenting the dependence between the time of culture and the nutritional status of the chrysanthemums in the form of multinomial trend lines. Their shapes, especially for nitrogen, potassium and calcium, are the reverse of the multinomial trend lines of real insolation (Fig. 5).

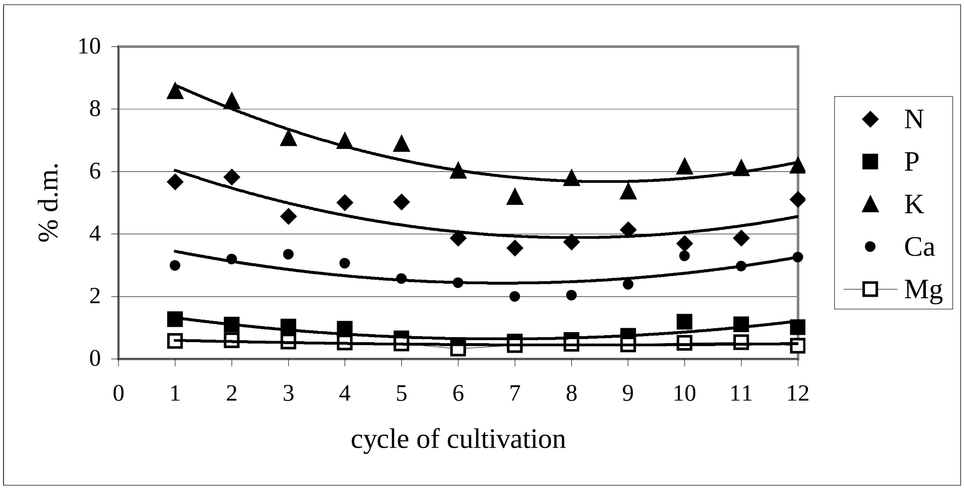

Figure 1. Multinomial trend line for macronutrient content in the leaves of ‘Esperanto Time’ chrysanthemum during growing season

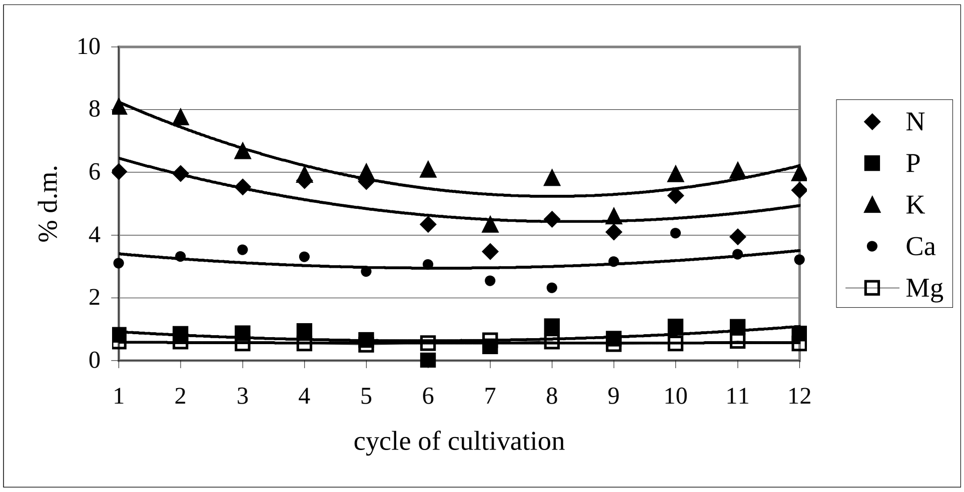

Figure 2. Multinomial trend line for macronutrient content in the leaves of ‘Icon Time’ chrysanthemum during growing season

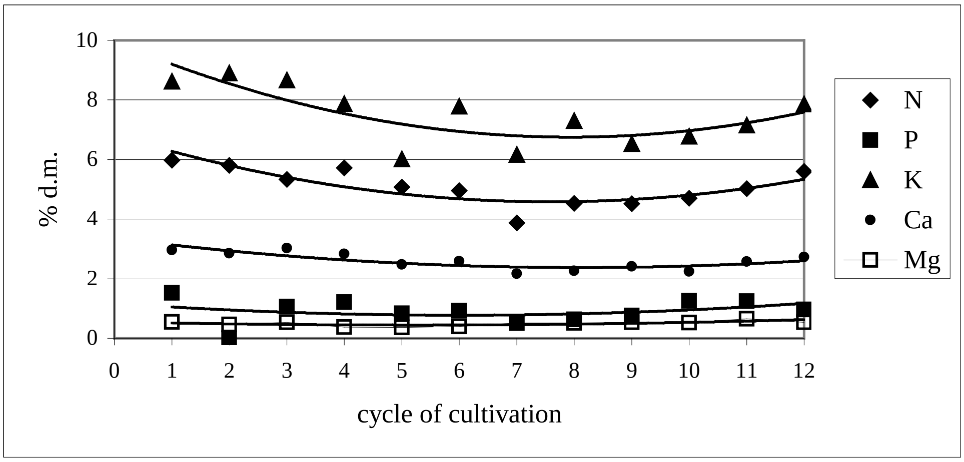

Figure 3. Multinomial trend line for macronutrient content in the leaves of 'Jewel Time' chrysanthemum during growing season

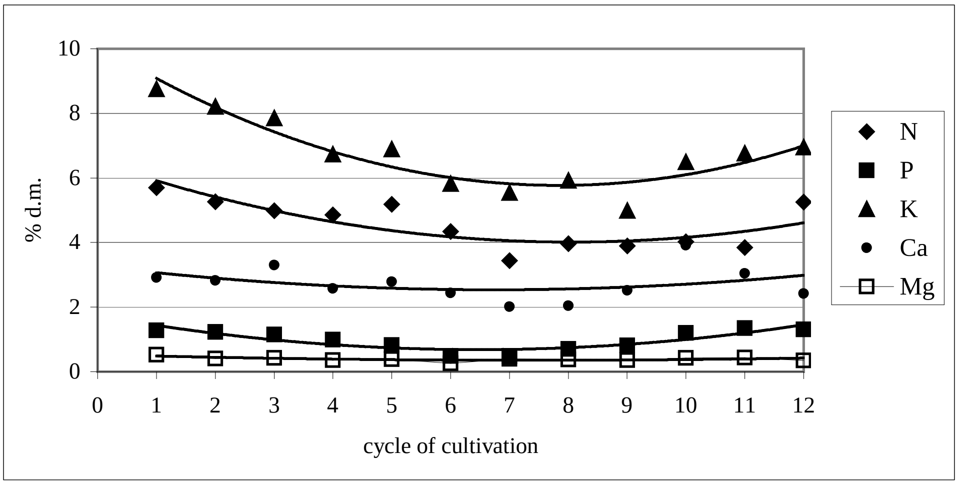

Figure 4. Multinomial trend line for macronutrient content in the leaves of 'Solar Time' chrysanthemum during growing season

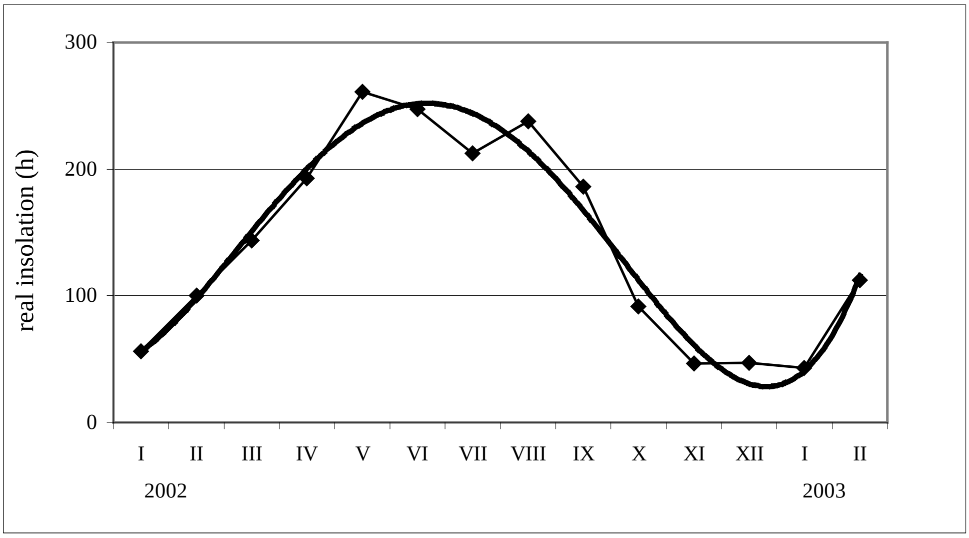

Figure 5. Real insolation during the experiment and its multinomial trend line

Maximum N, P, K, and Ca contents were recorded in the leaves of chrysanthemums grown in periods of light deficit. In the months of the highest insolation, the nutritional status of the plants was markedly poorer. This regularity was less pronounced in the case of magnesium. The different responses of chrysanthemums to fertilisation depending on the season were also noted by Joiner and Smith (1962), but their research was not that detailed. According to Bouma (1983), the higher light intensity reduces the level of phosphorus in the leaves, petioles, and roots of plants.

The differences between the minimum content of the elements in leaves found in the summer months and their maximum levels found in the winter months were considerable, at times even exceeding 50%. Magnesium levels showed the lowest variability, 0.25-0.65% d.m., and potassium the highest, 4.29-9.27% d.m. (Table 4).

Table 4. Statistical description of macronutrient content in chrysanthemum leaves (% d.m.)

Statistical description	N	P	K	Ca	Mg
Mean	4.79	0.93	6.72	2.82	0.49
Standard deviation	0.78	0.27	1.14	0.48	0.09
Range	2.72	1.12	4.98	2.07	0.40
Minimum	3.36	0.41	4.29	1.99	0.25
Maximum	6.08	1.53	9.27	4.06	0.65

Favourable light conditions, and as a result a higher frequency of fertilisation due to fertigation, made the plants grow more vigorously and to a greater size (Breś and Jerzy 2004). An exception were the chrysanthemums from the last two cycles of the experiment, in which the retardant B-Nine was not applied at all (cycle 11) or only applied once (cycle 12). However, as the results of chemical analyses showed, this need not mean better plant nutrition. This fact was described as an effect of the dilution of a nutrient in an increased plant mass, or as the Piper-Steenbjerg effect (Steenbjerg 1951, Finck 1976). An additional factor modifying nutrient uptake can be the temperature. Both its increase above and decrease below an optimum level result in reduced nitrogen, phosphorus and potassium uptake (Bouma and Dowling 1969 a, 1969 b, Marschner 1995). The optimum temperature for chrysanthemums is 17-21^{o}C (Lint and Heij 1987, Whealy et al. 1987).

To diagnose the macronutritional status of the plants, the results of the analyses of leaves of the chrysanthemum cultivars under study were compared with recommendations by various authors worked out for traditional and hydroponic methods of culture (Table 5).

Because of the significant effect of the time of culture on the nutrient levels in leaves, a separate comparison was made for plants potted from January to June and those potted from July to December. Only a small percent of the results of the chemical analysis coincided with the intervals recommended by Solecka (1984). The results were slightly better when compared with the recommendations by Kreij et al. (1990). It seems that the best results were obtained with the use of levels recommended by Lunt et al. (1964). The intervals they propose, however, are too wide, and hence of little use in diagnosing the nutritional status of plants. With the exception of phosphorus and calcium, a satisfactory comparison was that with the indicator levels proposed by Reuter and Robinson (1988). The results of the present research best matched those recommended by Breś et al. (2002). The standard levels they proposed had been worked out on the basis of experiments with the fertigation of stock plants of chrysanthemums. In most cases the recommendations of the authors listed in Table 3 are more useful in the autumn-winter growing cycles than the spring-summer ones.

The wide discrepancies among recommendations of the particular authors prove that it is necessary to work out new guide values or critical nutrient levels for diagnostic purposes in the culture of chrysanthemums of the Time group. They have to accommodate the time of culture (insolation) and the specific system of fertilisation combined with irrigation.

Table 5. Comparison of results of chemical analysis of chrysanthemum leaves to the range of macronutrient levels recommended by the selected authors

Nutrient	Recommended values % d.m.	Percent of results incorporated in the range of recommended contents	
		Cycle 1-6	Cycle 7-12
	Breś et al. (2002)		
N	3.25-5.41	52.27	96.97
P	0.35-1.00	47.73	46.97
K	4.34-7.50	46.21	93.94
Ca	1.70-3.50	81.82	89.39
Mg	0.50-1.20	33.33	36.36
	Kreij et al. (1990)		
N	3.92-5.04	31.06	46.96
P	0.30-0.69	15.15	22.73
K	2.54-6.05	12.88	50.00
Ca	1.00-3.01	43.94	16.67
Mg	0.29-0.97	78.79	59.09
	Reuter and Robinson (1988)		
N	2.25-4.50	40.28	75.70
P	0.30-0.80	29.86	34.86
K	4.00-7.00	64.58	92.42
Ca	0.60-1.50	0.00	0.00
Mg	0.30-0.60	88.19	81.82
	Solecka (1984)		
N	2.24-2.60	0.00	0.00
P	0.42-0.48	3.79	4.54
K	3.57-4.96	3.03	16.67
Ca	0.83-0.99	0.00	0.00
Mg	-	-	-
	Lunt et al. (1964)		
N	4.50-6.00	75.76	22.72
P	0.26-1.15	60.61	66.67
K	3.50-10.00	100.00	100.00
Ca	0.50-4.60	100.00	100.00
Mg	0.06-1.50	100.00	100.00

CONCLUSIONS

1. The time of culture and the insolation associated with it significantly affected the content of nitrogen, phosphorus, potassium, calcium, and magnesium in the leaves of pot chrysanthemums from the Time group. The effect of the time of culture was the most pronounced in the case of the nitrogen and potassium levels, and the least, in the case of magnesium.

2. The critical levels of macroelements recommended for conventional and hydroponic methods of culture are of little use for diagnosing the nutritional status of the Time group chrysanthemums in all-year-round culture.
3. It is necessary to work out new critical or guide values accommodating three parameters: the short growth period of the Time group chrysanthemums, the cyclicity of culture in various light conditions, and the fertigation of plants grown in a medium of limited volume.

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WPŁYW TERMINU SADZENIA NA STAN ODŻYWIENIA MAKROSKŁADNIKAMI CHRYZANTEM DONICZKOWYCH Z GRUPY TIME W UPRAWIE CAŁOROCZNEJ

Streszczenie: Celem badań była ocena przydatności zawartości krytycznych makroskładników opracowanych dla konwencjonalnej metody uprawy, dla diagnostyki stanu odżywienia makroskładnikami chryzantem z grupy Time w uprawie całorocznej. Do doświadczeń wybrano cztery doniczkowe odmiany chryzantemy wielkokwiatowej *Dendranthema grandiflora* Tzvelev (syn. *Chrysanthemum* × *grandiflorum* /Ramat. /Kitam.) uprawiane w formie gałązkowej: ‘Esperanto Time’, ‘Icon Time’, ‘Jewel Time’, ‘Solar Time’. Badania przeprowadzono w roku 2002. Obejmowały one 12 cykli uprawowych, które rozpoczynano każdego drugiego dnia miesiąca. Od momentu posadzenia, rośliny traktowano dniem krótkim. W okresach naturalnego długiego dnia stosowano zaciemnianie, uzyskując dzień 10,5 godzinny. Od listopada do połowy lutego (długość dnia poniżej 10 godzin) nie stosowano doświetlania roślin. Nawożenie

roślin prowadzono przy użyciu systemu fertygacyjnego. Termin uprawy i związane z nim usłonecznienie, istotnie wpłynęły na zawartość azotu, fosforu, potasu, wapnia i magnezu w liściach. Wpływ ten najsilniej ujawnił się w przypadku azotu i potasu, najsłabiej w przypadku magnezu. Opracowane dla konwencjonalnej oraz hydroponicznej metody uprawy zawartości krytyczne makroskładników okazały się być mało przydatne dla diagnostyki odżywienia chryzantem z grupy Time, w uprawie całorocznej. Konieczne jest opracowanie nowych zawartości krytycznych lub wskaźnikowych, uwzględniających cykliczność upraw w różnych warunkach świetlnych oraz specyfikę fertygacji roślin uprawianych w ograniczonej objętości podłoża.

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