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THE EFFECT OF DIFFERENT LENGTHS OF DAY AND DIFFERENT TEMPERATURE VALUES ON THE DEVELOPMENT OF MORPHOLOGICAL PROPERTIES OF CERTAIN CHRYSANTHEMUM CULTIVARS

Dragan Djurdjevac[1], Imre Molnar[2], Małgorzata Tokarska[1]
[1]*Department of Genetics and Animal Breeding, University of Agriculture in Wrocław, Poland*
[2]*University of Novi Sad, Faculty of Agriculture Novi Sad, Yugoslavia*

ABSTRACT

During one year, an average of 150 cut chrysanthemums are obtained from 1 m^2 of the glasshouse cultivation area, usually from three cultivation cycles together. Determination of optimum lighting conditions and vegetation temperature for chrysanthemums can make it possible to shorten a cultivation cycle, which will have a considerable effect on the improvement of production profitability.

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The studies applied a "short day" in the initial stage of chrysanthemum growth (0-35 days of vegetation) or in the second cycle (35-70 days of vegetation). The plants were cultivated at temperatures 14, 19 or 22°C.

It was found out that the use of a short day at the beginning of vegetation accelerated the blooming of chrysanthemums, Marble and Fred Sosmith cultivars, by about 30 days as compared to the plants in whose vegetation a short day was applied in the second stage of vegetation, and by about 120 days as compared to the plants cultivated during a natural length day. Spider cultivar chrysanthemums did not show any reaction to a short day effect.

Key words: chrysanthemum, photoperiodism

INTRODUCTION

The name chrysanthemum (*Chrysanthemum*) comes from Greek words, *chrysos* – gold, and *anthemos* – flower. Chrysanthemum belongs to the family *Asteraceae* = *Compositae* – complex, and is found in natural conditions in the Mediterranean area, Near East, East Asia and South Africa. There are nearly 200 cultivars of chrysanthemums.

For floriculture, of special interest is a group *Chrysanthemum indicum – hibridum* obtained through multiple crossing of various chrisanthemum cultivars. Depending on the purpose, in production one encounters the following species: *Chrysanthemum leucanthemum* L., *Chrysanthemum carinatum* Schousboe, *Chrysanthemum segatum* L., *Chrysanthemum coccinea* Willd. – perennial, *Chrysanthemum maximum* Ram. – perennial.

In mass production of chrysanthemums, the plants are multiplied through the seedlings: 6-8 centimeter long fragments of a stem with 3-4 leaves. The rooting of seedlings lasts 15-20 days, after which they are transferred to pots (fig. 1) or onto production bedding with the subsoil of peat dust and sand. Chrysanthemums do not have any special soil requirements if optimum conditions of water and air circulation are created.

Fig. 1. Seedlings at the beginning of studies

Chrysanthemums are characterized by remarkable photoperiodism, which means that their vegetative growth and flower formation are related to the day length (length of the light exposure period). The possibility of regulating the length of the light exposure period in glasshouses makes it possible to cultivate chrysanthemums both in autumn and winter, selling these beautiful flowers not only in the traditional autumn period (All Saints' Day).

Knowing the reaction of chrysanthemums to the length of the light exposure period, it will be possible to control the vegetation time, which will make it possible to increase the profitability of the cultivation, both by shortening the production cycle, and by directing the harvest onto a definite time [2].

The purpose of the studies was to determine the stage of chrysanthemum growth when they react the most to the length of day, and the effect of temperature on the length of the vegetation period. It was assumed that the strongest photoperiodism occurs at the beginning of vegetation.

MATERIALS AND METHODS

Three chrysanthemum cultivars were used in the experiments, namely Marble, Fred Sosmith and Spider. Well rooted seedlings, of similar heights (10 cm) were planted in the middle of March in pots containing 2/3 of the garden substrate and 1/3 sand. During the vegetation, after an agrochemical analysis had been made, they were fertilized with NPK in the proportion 18:3:10, which is optimum for this species in this vegetation period [1]. In the case of the appearance of *Oidium chrysanthemi*, Saprol preparation was used.

The experiment with the length of the light exposure period was done according to the manner presented in table 1.

Table 1. Length of the light exposure period

Vegetation period	Experimental series		
	I (DK)	II (KD)	Control (P)
I stage 0-35 days	16 hrs /24 hrs	10 hrs /24 hrs	natural length
II stage 35-70 days	10 hrs /24 hrs	natural length	natural length
III stage 70-84 days	natural length	natural length	natural length

Experimental series (DK). A method taken from the production practice was used, which consisted in extra light exposure of the plants in the first stage of vegetation (the day was 16 hour-long), fig. 2. In the second stage, the plants were subjected to the effect of a short day (10 hours), while in the third they grew in the conditions of a natural day length.

Experimental series (KD). Plants were subjected to the effect of a short day (10 hours' light) in the first stage of vegetation (immediately after the rooted seedlings were planted), fig. 1. In the other stages they developed in the conditions of a natural day length.

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Fig. 2. Extra light

Experimental series (P) is a control group – plants grew in the conditions of a natural day length of the geographic latitude 42.259 N, 19.833 E.

The time of light exposure was regulated through covering the plants with black foil, or providing extra light (with Argenta Super-Lux lamps, where the condition of minimum lighting of 75 lx was kept), fig. 2.

The experiment in series I and II was conducted in three temperature ranges, namely low 14°C, medium 19°C, and high 22°C, while the control group was kept only in medium temperature.

The experiments determined the following:

- the height of plants,
- the number of leaves and their area,
- the time when the first buds appeared,
- the time between the planting and full blooming,
- the number of blooming plants.

The results were analyzed statistically, and the differences between the mean values (provided in tables) were tested using t Student test ($p \leq 0.05$).

RESULTS

The first comparison of the plants' development and properties was made after 84 days (12 weeks). As follows from the data presented in table 2, chrysanthemums of Marble cultivar

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subjected to the effect of a long day at the beginning of cultivation (experimental series DK), were much bigger (statistically significant differences) than those chrysanthemums of this cultivation which were exposed to light from 10 hours per 24 hours at the comparable period (experimental series KD). Similar relations can be observed in chrysanthemums of other varieties, and the differences in the height of plants subjected to the effect of a long day (DK) and a short day (KD) were really statistically significant only for Spider cultivar cultivated at the temperature of 14°C.

Table 2. Mean height of plants in cm after 84 days

Cultivar	Low temperature		Medium temperature		High temperature		Control
	DK	KD	DK	KD	DK	KD	P
Marble	42.6*	33.0*	59.0*	39.0*	72.0*	48.3*	55.6
Fred Sosmith	38.0	37.4	45.6	38.5	48.0	39.8	49.1
Spider	53.2*	40.3*	47.7	47.1	51.0	44.5	52.8

*** difference $p \leq 0.05$**

The differences in the plants' height in the first period were so evident that clear differentiation in the number and leaf area were expected. It turned out, however, that both the number of plants and their area were related neither to the length of the light exposure period and the temperature in which plants were cultivated nor the chrysanthemum cultivar (tab. 3).

The plants subjected to the effect of a short day at the beginning of vegetation were characterized by bigger height, but on the other hand they began the generative cycle earlier through earlier formation of buds and blooms (tab. 4). It can be observed that chrysanthemums cultivated at medium temperature (19°C) formed buds faster than at lower temperature (14°C) and, what is the most important, not later than those cultivated at high temperature (22°C).

Table 3. Mean number of leaves per plant and the mean area of chrysanthemum leaves after 84 days of vegetation

Cultivar	Low temperature		Medium temperature		High temperature		Control
	DK	KD	DK	KD	DK	KD	P
	Mean number of leaves						
Marble	20.0	17.6	15.8	15.8	24.4	17.3	22.0
Fred Sosmith	18.6	21.5	22.3	20.3	24.5	19.5	22.2
Spider	21.8	16.7	18.1	16.5	21.6	16.8	22.6
	Mean leaf area in cm^2						
Marble	520.84	458.12	411.43	411.27	635.42	450.52	572.66
Fred Sosmith	484.38	559.64	580.73	528.40	638.02	507.81	577.87
Spider	567.67	434.7	471.36	429.49	562.50	437.30	588.54

Table 4. Appearance of inflorescence buds up till the 84th day of the experiment

Cultivar	Low temperature		Medium temperature		High temperature		Control
	DK	KD	DK	KD	DK	KD	P
Marble	–	38	78	28	78	32	–
Fred Sosmith	–	40	78	31	80	34	–
Spider	–	41	79	34	70	36	–

Marble cultivar chrysanthemums subjected to the effect of a short day at the beginning of vegetation, cultivated at temperature 19°C (medium) were in full bloom (fig. 4, tab. 5). Fred Sosmith cultivar began to bloom (KD series, medium and high temperatures) (fig. 5), while Spider cultivar chrysanthemums practically did not bloom although they set the buds like the other cultivars (fig. 6).

The fact that the plants cultivated at temperature 19°C began their generative cycle evidently earlier makes it possible to recognize this temperature as optimum (in the case when a controlled day length was applied). It follows from literature [3] that raising the temperature of vegetation to 25°C and higher ones distinctly delays the development of chrysanthemums or completely stops their blooming, while at temperature of about 10°C the majority of chrysanthemum cultivars do not bloom at all.

Fig. 3. Control group after 84 days

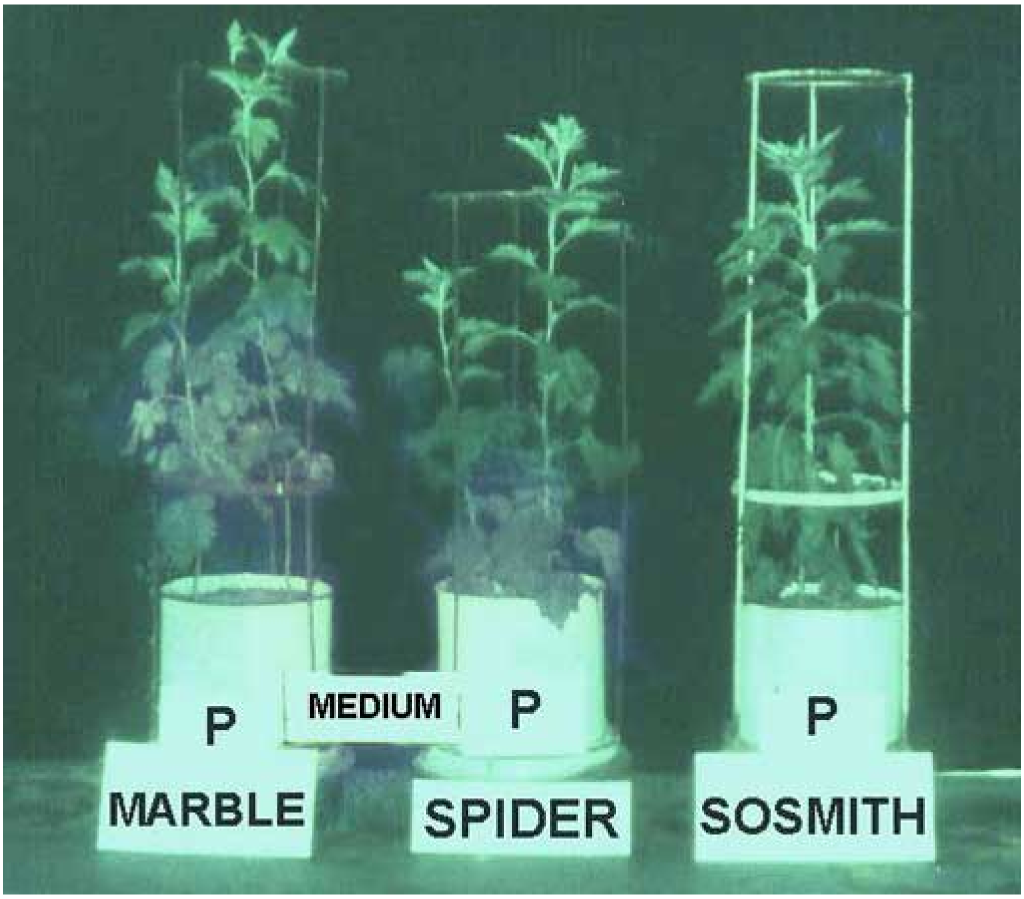

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Fig. 4. Marble cultivar after 84 days

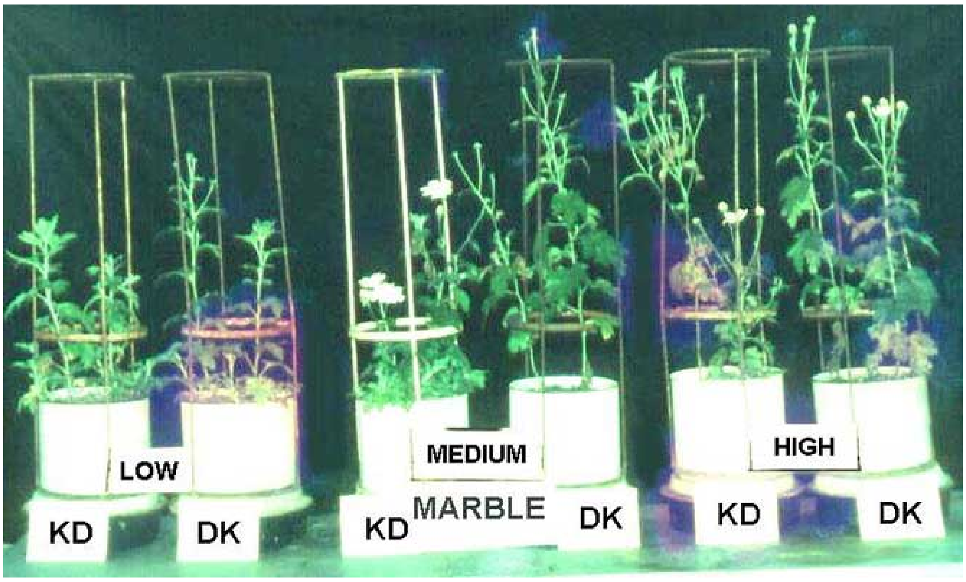

Fig. 5. Fred Sosmith cultivar

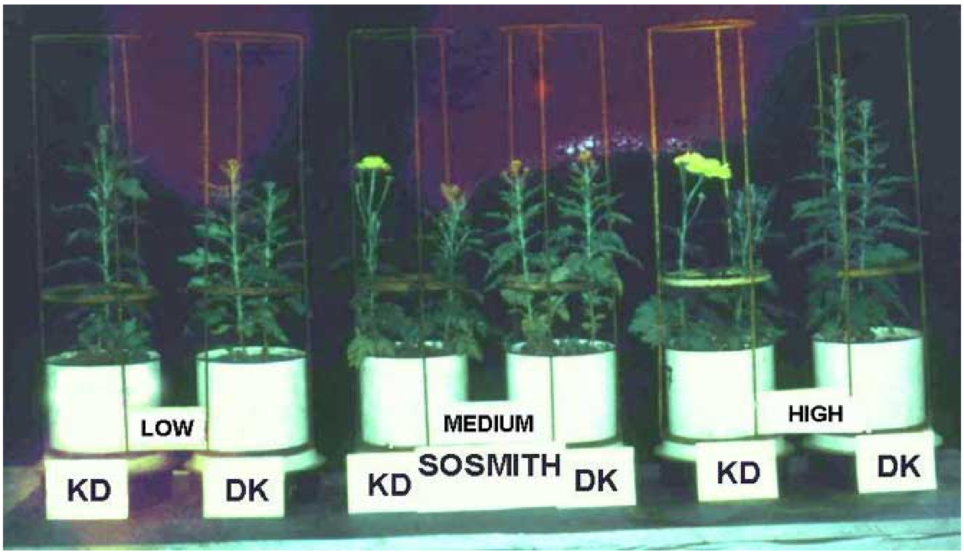

Fig. 6. Spider cultivar

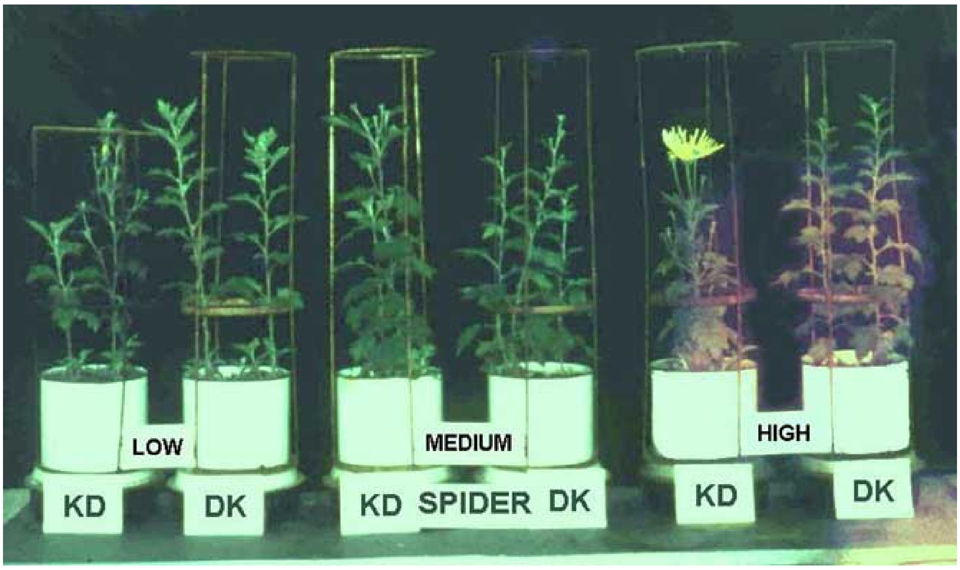

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Table 5. The number of blooming flowers after 84 days in %

Cultivar	Low temperature		Medium temperature		High temperature		Control
	DK	KD	DK	KD	DK	KD	P
Marble	–	–	–	87.5	–	–	–
Fred Sosmith	–	–	–	37.5	–	25.0	–
Spider	–	–	–	–	–	12.5	–

In the further part of the experiment, i.e. in the third stage of vegetation, all tests were conducted in the conditions of a natural day length, and the measurements were performed after 125 days (18 weeks).

As follows from the data presented in table 6 the mean height of plants subjected to the effects of a short day at the beginning of vegetation (experimental series KD) did not significantly differ from the height of plants from the experimental series DK. This was due to a clearly more intensive growth of plants from the KD series between 84th and 125th days of vegetation. This confirmed an earlier statement that during longer light exposure chrysanthemums are characterized by more intensive vegetative growth. Therefore, the differences in the height of plants occurred after 84 days of vegetation (tab. 2) were leveled. For Fred Sosmith cultivar the height of plants and the increments of the plants' height were much lower than for Marble and Spider cultivars, which can result from the specific properties of this cultivar of chrysanthemums.

Table 6. Mean height of plants (in cm) and increase of height in the period between 84th and 125th days of vegetation (in cm)

Cultivar	Low temperature		Medium temperature		High temperature		Control
	DK	KD	DK	KD	DK	KD	P
	Mean height of plants						
Marble	60.4	58.7	78.3	69.6	96.4	90.7	100.5
Fred Sosmith	43.3	43.1	48.8	46.4	53.5	48.7	53.6
Spider	77.6	75.1	60.7	67.0	58.1	55.7	71.9
	Increments between 84th and 125th days						
Marble	17.8*	25.7*	19.3*	30.6*	24.4*	42.4*	44.9
Fred Sosmith	5.3	5.7	3.2	7.9	5.5	8.9	4.5
Spider	24.4*	34.8*	13.0*	19.9*	7.1	11.2	19.1

*** difference $p \leq 0.05$**

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Like after 84 days of vegetation, the number of leaves on plants after 125 days (table 7) was related neither to the length of the light exposure period nor to the temperature. An exception were Fred Sosmith and Spider cultivars, which were subjected to the effect of a short day in the second period of vegetation (DK series) and cultivated at high temperature and which had strong lateral branching, which – in turn – caused an increased number of leaves. Lateral branching was also observed in Spider cultivar chrysanthemums cultivated at medium temperature, KD series.

Table 7. Mean number of leaves per plant and increase of this property between 84th and 125th days of vegetation

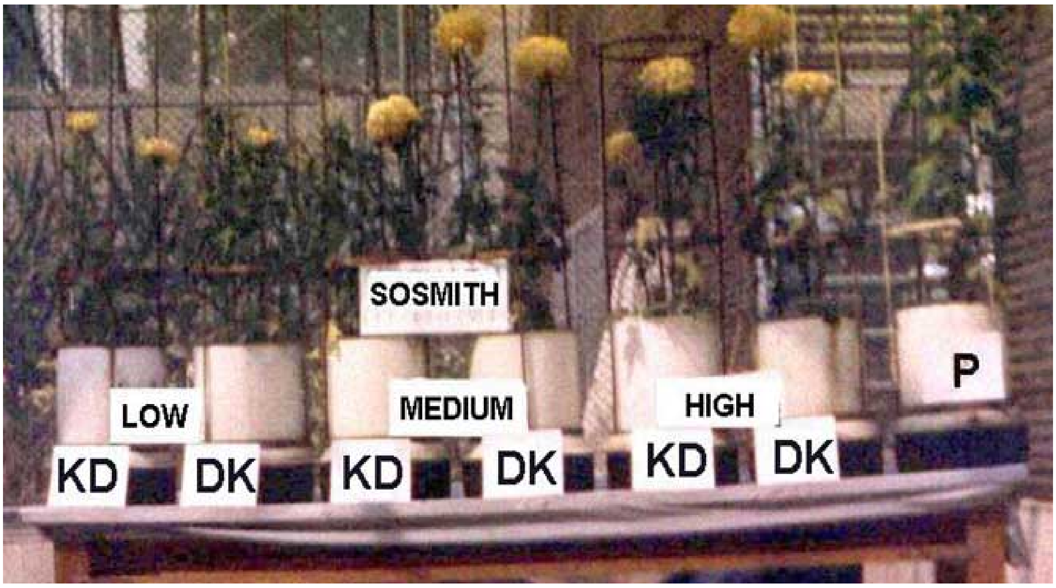
Cultivar	Low temperature		Medium temperature		High temperature		Control
	DK	KD	DK	KD	DK	KD	P
	Number of leaves						
Marble	69.4	67.6	74.8	73.7	66.0	65.3	80.5
Fred Sosmith	36.8	31.1	40.6	55.6	57.7*	33.7*	50.3
Spider	53.4	50.8	26.1	40.3	71*	25*	39.9
	Increase of number of leaves						
Marble	49.3	50.0	59.0	57.9	41.6	48.0	58.5
Fred Sosmith	18.1	9.6	17.9	34.9	33.4	14.2	28.1
Spider	31.5	34.0	8.1*	23.8*	49.4*	8.3*	17.3

***Arithmetical means for DK and KD are significantly different ($p \leq 0.05$).**

In the discussed period of vegetation (125 days), Marble and Fred Sosmith cultivars subjected to the effect of a short day in the first and second periods of vegetation grew intensively or had already finished full blooming (fig. 7). These cultivars from the control group did not bloom, and only singular blooms appeared on Spider cultivar.

It follows from table 8 that the period between the planting and full bloom of plants is clearly related to the time of light exposure at the beginning of vegetation. The plants exposed to light for 10 hours per 24 hours on the first 35 days of vegetation (KD series) cultivated at temperature 19°C bloomed by about 30 days earlier than the plants subjected to the effect of a short day in the second period of vegetation (DK series). The effect of a short day in the second period accelerates the blooming by about 80 days as compared to the plants which – throughout their vegetation – had the natural length of day (control group P). These relationships concern only Marble and Fred Sosmith cultivars, while Spider cultivar does not react to the length of the light exposure period.

Fig. 7. Fred Sosmith cultivar after 125 days



Summing up the results, a calendar of the development of Marble and Fred Sosmith cultivars is presented (tab. 9).

It should be emphasized that no reaction of Spider cultivar to the length of day used in the experiment was observed. Though chrysanthemums of this cultivar, subjected to the effect of a short day at the beginning of vegetation set the buds earlier than in DK series (table 4), the time necessary for full blooming of both these series was the same. Maybe in the case of this cultivar the period of the effect of a short day should be lengthened (eg. 50-60 days).

Table 9. A calendar of the development of Marble and Fred Sosmith cultivars in relation to the length of day

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Control												
DK test												
KD test												
	planting				blooming							

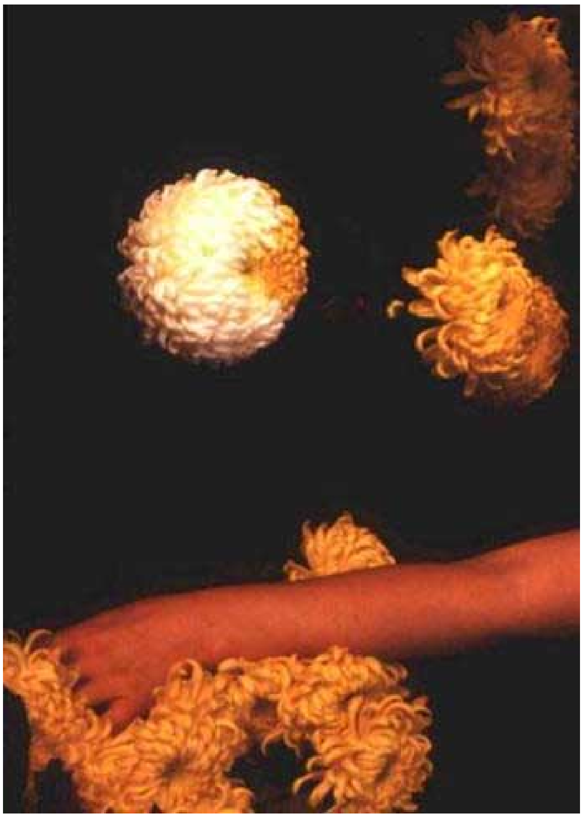
CONCLUSIONS

The use of a short day at the beginning of vegetation (0-35 days) and cultivation at medium temperature (19°C) accelerates the date of blooming for Marble and Fred Sosmith cultivars by about 30 days as compared to this cultivar subjected to the effect of a long day at the beginning of vegetation (0-35 days), and next to a short day (35-70 days), and by about 120 days as compared to chrysanthemums cultivated with a natural length of day.
This makes it possible to lower the production costs through giving up extra light exposure at the beginning of vegetation. Also, it satisfies the market demand for chrysanthemum flowers in the period when in natural conditions they do not appear on the market (fig. 8).
Among the plants from KD experiment, the studies observed an increased number of root offshoots. Besides, a chimera rarely observed in this species was observed (fig. 9).
Lack of reaction of Spider cultivar to the length of the light exposure period suggests that the reaction of photoperiodism can be a quality related to the species, or that this cultivar requires

more "drastic" differences in the period of light exposure. That is the reason why it is advisable to carry out such studies for all chrysanthemum cultivars used in cultivation.

Fig. 8. Ornamental values

Fig. 9. Chimera



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Submited:

Dragan Djurdjevac, Małgorzata Tokarska
University of Agriculture in Wrocław
Department of Genetics and Animal Breeding
7 Kożuchowska St., 51-631 Wrocław
tel. (+48 71) 320 57 60, 320 57 59
e-mail: dragan@gen.ar.wroc.pl

Imre Molnar
University of Novi Sad
Faculty of Agriculture Novi Sad, Yugoslavia
