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Is *Impatiens balsamina* a qualitative short-day plant?

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Abstract

Impatiens balsamina which, in literature on the physiology of flowering, is assigned to qualitative short-day plants, flowers under Polish climatic conditions from June until September. It flowers, therefore, during the period of the longest day. The photoperiodic responses of *I. balsamina* plants raised from seeds obtained from botanical gardens located within the range of 23°-65° N. lat. were studied. The experiment revealed marked differences in the photoperiodic responses within the species. Qualitative short-day plants, quantitative short-day plants and day-neutral plants were found in the studied material. An evident correlation was found between the place of origin of the studied seeds and the photoperiodic sensitivity of the plants raised from them.

Key words: Impatiens balsamina, photoperiodic reaction, flowering

INTRODUCTION

Recently, several studies have appeared reporting successful attempts at floral induction by gibberellin treatment of short-day plants under conditions of a non-inductive, long photoperiod. *Impatiens balsamina* (Nanda et al. 1967b, 1969, 1976), *Chrysanthemum morifolium* (Pharis 1972) and *Zinnia elegans* (Sawhney and Sawhney 1976) were among the species studied. These studies have raised understandable interest due to their controversial character when viewed from the standpoint of current theories on flowering (Lang 1965, Zeevaart 1976, Chailakhyan 1976, 1982).

I. balsamina, which was classified by Nanda and Krishnamoorthy (1967a) as a qualitative short-day plant, originates from Southern Asia (India, Malaya, China) (Encke 1958), and also was brought to and naturalized in Africa (Ghana, Cameroun, Kenya, Mozambique) (Grey-Wilson 1980). It flowers there from June to autumn. In these regions, the maximum day-length is 14 hrs (Staszewski and Uhorczak 1966).

Botanical gardens all over world presently exhibit *I. balsamina* as an introduced plant. Under the climatic conditions of Poland, *I. balsamina* flowers in June, that is, during the period of the longest day. Austin (1935) describes this plant as an intermediate one between long-day (LD) and short-day (SD) plants. Simon (1974, 1975) states that *I. balsamina* is a quantitative short-day plant. In Polish horticultural literature, *I. balsamina* is given as an example of a LD plant (Wójcicki 1965) or a day-neutral plant (Chmiel 1980).

In order to try to explain the reasons for such marked differences in the photoperiodic classification of this plant, the photoperiodic reactions of *I. balsamina* plants raised directly from seeds obtained from 19 botanical gardens, were studied. These gardens are located under different latitudes (from 23° to 65° N. lat.), and include gardens located as close as possible to the natural habitat of this species.

MATERIAL AND METHODS

The experiments were run under field (1978-1980) or greenhouse conditions (1983) on the grounds of the Lublin Botanical Garden (51° N. lat.). The seeds obtained from the particular botanical gardens were divided into two portions, 10 seeds in each, and planted on May 4th or 7th in 1978-1980 and on May 18th in 1983. After the first pair of leaves was formed, one set of seedlings was grown under the conditions of a short, 8-hour photoperiod (the plants were screened from 15°° to 7°° with lightproof boxes allowing air-flow); the second group was left under the conditions of a naturally long day which exceeded 15 hrs from May to August. Not until after September 1 did the day length fall below the critical value for *I. balsamina* given by Nanda and Surinder Kumar (1966) as 13 hrs 30 min. In this way, those plants grown under LD conditions which did not flower by September, found themselves under natural SD conditions. The formation of flower buds and flowers was observed and noted for all of the plants in all of the experimental groups. The total number of flowers per plant (including well-developed buds and fruit) at the end of the flowering period was counted separately for the main and lateral shoots. In addition, the number of lateral shoots and the height of the plants were recorded.

RESULTS AND DISCUSSION

The results showing the effect of long and short photoperiods on the initiation of buds and flowering of the experimental plants are presented

in Table 1. Under SD conditions, all of the plants developed flower buds 40-57 days after sowing. The reactions of the plants grown under LD conditions were, however, distinctly different. Three series of plants did not develop buds by the end of the natural LD period, that is, by the end of August (one series from Kunming in 1979 and two from Havana in 1983). Flower buds on these plants did not develop until September and October, after 1-5 weeks of daylight lasting shorter than 13.5 hrs. In the two remaining groups of plants from these botanical gardens, a considerable delay in the initiation of floral buds was observed (over 100 days after sowing), and only after the length of the natural daylight came close to the critical value (13 hrs 55 min — plants from Kunming, 14 hrs 22 min — plants from Havana). A similar reaction was observed in all of the plants from Pekin (40° N. lat.). However, the plants from botanical gardens located above 40° N. lat. developed buds under LD conditions in the same time as plants cultivated under SD conditions, or only slightly later, with the exception of Moscow (20 days) and Tallinn (26 days).

In all of the studied plants, the flower buds which were formed under SD and LD conditions developed into flowers. No "floral bud reversion" as described by Krishnamoorthy and Nanda (1968) was observed. Flower development in all of the flowers of a given experimental group (100% of all flowering plants) was always observed earlier under SD conditions, with the exception of plants raised from seeds from Coimbra (40° N. lat.), which flowered simultaneously under SD and LD conditions. However, the intensity of flowering was clearly greater under LD conditions. The average number of flowers per plant was often several times larger on plants grown under LD conditions (e.g. plants from Cambridge — an average of 80 flowers per plant under SD and 440 flowers per plant under LD). This is related to a large extent to the more intense growth and development of the lateral branches. The number of flowers on the lateral branches was low under SD conditions (up to a score) whereas under LD conditions, several score to several hundred developed. For example, plants from Budakalasz had an average of 40 flowers on the main shoot and 60 on the lateral under SD conditions while under LD the number of flowers was 50 and 230 respectively.

Three types of plants with different photoperiodical sensitivities appeared among the studied plants:

1. Qualitative short-day plants, in which initiation of flowering was possible only under SD conditions (3 series from Kunming and Havana — 23° N. lat.).
2. Quantitative short-day plants, in which flowering began decidedly earlier under SD conditions (e.g. plants from Pekin — 40° N. lat.).
3. Day-neutral plants, in which initiation of flowering began simultaneously

Table 1

The effect of day length on the initiation of floral buds and flowering of *I. balsamina* L.

Seed origin	Garden geographical location (N.lat.)	Date of sowing	Days from sowing to bud development		Days from sowing to flower formation in 100% of plants		Natural LD length at bud initiation	
			SD	LD	SD	LD	h	min.
Havana	23°	1980.05.07	45	102	84	125	14	22
Havana	23°	1983.05.18	48	–	94	–		
Havana	23°	1983.05.18	57	–	94	–		
Kunming	23°	1978.05.04	47	116	89	170	13	55
Kunming	23°	1979.05.04	40	–	65	–		
Peking	40°	1979.05.04	50	104	74	129	14	22
Peking	40°	1980.05.07	45	103	72	125	14	22
Peking	40°	1983.05.18	48	106	74	132	13	30
Coimbra	40°	1978.05.04	47	54	95	95	16	47
Toronto	43	1983.05.18	48	62	69	132	16	
Alma-Ata	44°	1978.05.04	47	54	83	96	16	47
Jalta	44°	1979.05.04	50	50	74	97	16	47
Bucuresti	44°	1979.05.04	50	50	74	97	16	47
Padova	45°	1979.05.04	50	64	79	103	16	35
Trieste	45°	1979.05.04	50	50	74	97	16	47
Milano	45°	1979.05.04	50	50	64	103	16	47
Budakalasz	47°	1978.05.04	47	54	77	96	16	47
Budakalasz	47°	1978.05.04	47	54	77	96	16	47
Brno	49°	1978.05.04	47	54	77	96	16	47
Cambridge	52°	1979.05.04	50	50	74	97	16	47
Moscow	56°	1978.05.04	47	67	73	98	16	30
Tallinn	59°	1980.05.04	45	71	67	103	16	15
Reykjavik	64°	1979.05.04	50	60	74	97	16	41
Oulu	65°	1978.05.04	47	54	73	87	16	47
Oulu	65°	1979.05.04	50	50	80	97	16	47

Experiments were carried out in the Botanical Garden of Lublin – 51° N.lat. Each experimental group consisted of 10 plants. Repetitions for the same stands were made with seeds from a different harvests obtained from respective botanical garden. SD – 8 hours short day. LD – long day: natural day from May till the end of August the length of which changed from 15 hours at the beginning of May. through 16 hours 48 min. in the half of June. until 14 hours at the end of August.

under SD and LD conditions (plants from most European botanical gardens from 40 to 65° N. lat.).

These results indicate that the probable reason for the discrepancies on the photoperiodic requirements of *I. balsamina* seen in literature on this subject, is differentiation in the photoperiodic requirements within this species. Quite a different problem, still needing to be resolved, is the mechanism generating these differences in plants belonging to the same species.

The photoperiodic requirements of plants are a sign of their adaptation to the conditions prevailing in their natural habitat. It can be supposed that the type of photoperiodic reaction of *I. balsamina* is not fixed, but can be changed through selection under different photoperiodic and climatic conditions. It is puzzling, though, that *I. balsamina*, which originated from India, China, Malaya, does not flower under natural conditions in Chandigarh, India, 31° N. lat. (Nanda and Surinder Kumar 1966). Nanda presents the supposition that flowering may be inhibited in Chandigarh by the very high temperature during the summer (40°-45°C) which accompanies the lengthening of the day. On the other hand, *I. balsamina* flowers in moderate climates where hot summers often occur jointly with distinctly long days.

The data on the flowering of *I. balsamina* obtained from several botanical gardens where these plants have been raised for a good number of years is interesting also. In the botanical garden in Coimbra (41° N. lat.), *I. balsamina* flowers in June, whereas the day length there exceeds 14 hrs (the data on the length of day is given after Staszewski and Uhorczak 1966). In Cambridge, where the day length in July exceeds 16 hrs (52° N. lat.), it flowers from July to September. In Oulu (65° N. lat.), *I balsamina* begins to flower (in greenhouses) in May, and after it is transferred to a field, it flowers to the end of summer. The length of the photoperiod in Oulu starting from May, exceeds 17 hrs, in July it comes close to 21 hrs and the length of daylight in June and July is 24 hrs. It should also be reminded here that the plants raised from seeds from Havana, where the photoperiodic conditions are similar to those in the natural habitat of *I. balsamina*, exhibited the photoperiodic sensitivity of SD plants, either qualitative or quantitative. This kind of differentiation into qualitative or quantitative SD plants also took place in plants from the botanical garden in Kunming.

It should be emphasized that the experiments discussed in this paper are of a preliminary nature. Due to the large number of plants, the study had to be done under field conditions. Further studies, using selected plants with different photoperiodic sensitivities, will be possible to run in conditions allowing the temperature to be controlled and the day length to be regulated.

Nevertheless, while considering the results of Nanda et al. (1967b, 1969, 1976) and their possible influence on theories explaining the mechanism of flowering, it should be taken into account that in *I. balsamina*, changes in its type of photoperiodic sensitivity take place relatively easily as the result of changed climatic and photoperiodical conditions, and that plants of this species cannot always be classified as qualitative short-day plants

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Czy Impatiens balsamina jest rośliną dnia krótkiego?

Streszczenie

Impatiens balsamina L. zaliczana w literaturze dotyczącej fizjologii kwitnienia do roślin krótkiego dnia o reakcji jakościowej, kwitnie w warunkach klimatycznych Polski od czerwca do września, a więc w okresie najdłuższego dnia. Przebadano reakcję fotoperiodyczną roślin *I. balsamina*, wyprowadzonych z nasion otrzymanych z ogrodów botanicznych położonych między 23° a 65° szer. geogr. pn. Wykazano ogromne zróżnicowanie reakcji fotoperiodycznej w obrębie gatunku. Wśród badanych roślin wyróżniono: rośliny krótkiego dnia o reakcji jakościowej, rośliny krótkiego dnia o reakcji ilościowej oraz rośliny neutralne. Stwierdzono zależność między typem reakcji fotoperiodycznej badanych roślin a szerokością geograficzną miejsca, z którego zostały sprowadzone nasiona.