The Useful Characteristics of Japanese Summer-Flowering Cultivars in Chrysanthemum Year-round Production

By Michio SHIBATA

Department of Floriculture, National Research Institute of Vegetables, Ornamental Plants and Tea
(Ano, Mie, 514-23 Japan)

Introduction

It is said that the original types of the present chrysanthemums (*Chrysanthemum morifolium* Ramat.) were born in China more than 3,000 years ago[6]. However, the commercial production of chrysanthemums was started in U.S.A. from the end of the 19th century to the beginning of the 20th century. In 1920, the photoperiodism of plants was discovered by Garner and Allard in U.S.A. and the year-round growing of chrysanthemums by photoperiodic control was established in the middle of the 20th century[4] and widely spread to European countries.

The commercial production of chrysanthemums in Japan was started in the 1920's[2] after the introduction of cultivars for cut flower production from U.S.A.. However, these cultivars required the short-day treatment for summer production. In the Edo era (17th–19th centuries), May to June flowering chrysanthemums in Japan were originated from the mutants which appeared from autumn-flowering types but lost short-day requirement. On the other hand, summer-flowering cultivars which flower in July to September were developed by Mr. N. Koido by means of selection of seedlings of autumn-flowering types. As the result of development of summer-flowering cultivars, Japanese growers gradually came to avoid the control of flowering by the short-day treatment, which requires too much labor input. At present, Japanese year-round growing consists of the following system: December to March production mainly depends on autumn-flowering cultivars with artificial lighting. April to early May production depends on May to June-flowering cultivars or autumn-flowering ones. In both cases, plants derived from winter suckers are grown under plastic or glass structures without daylength control. And, May to November production mainly depends on natural flowering in the open field using summer- and autumn-flowering ones.

Spray chrysanthemums for year-round production by daylength control were introduced into Japan from the Netherlands and U.S.A. in 1974. However, high temperatures in summer cause the delay of flowering. Flower quality is also impaired by high temperatures[9]. In view of such a problem, the author started the breeding program for the year-round production of chrysanthemums of the spray type with heat tolerance. Cross-breeding between autumn-flowering cultivars (for year-round production*) and Japanese summer-flowering types developed by Koido was carried out. Judging from the characteristics of the hybrid progenies, the following characteristics of Japanese summer-flowering cultivars were found to be useful for the breeding of year-round chrysanthemums.

Heat tolerance

Post and Kamemoto[8] demonstrated that

* These autumn-flowering cultivars are usually used for year-round production. These cultivars are termed simply as autumn-flowering cultivars in this paper.

Table 1. The degree of heat delay in autumn-flowering chrysanthemums and Japanese summer-flowering types[9)]

Cultivar	Days to flower when short-day treatment began on indicated dates[a)]		Degree of heat delay (in days)
	July 4	August 22	
Gem[b)]	>84.0[d)]	59.5	>24.5
Fiducia[b)]	>84.0[d)]	63.6	>20.5
Spring Song[b)]	>84.0[d)]	68.6	>15.4
SP202[c)]	58.2	50.6	7.4
SP200[c)]	64.0	53.0	11.0

a): Short-day treatment begun on July 4 means that the treatment was given at high temperature than the treatment begun on August 22. Hence, the difference in no. of days to flower expresses heat delay.
b): Autumn-flowering cultivar.
c): Japaneses summer-flowering cultivar.
d): Not flowered till 12 weeks later.

very high temperature, 40°C, delayed flowering in some varieties even if the period of high temperature lasted for only two days. Furuta and Nelson[1)] demonstrated that average temperatures of 24°C and 27°C did not delay flowering, and 29°C retarded flowering by 11 days, while plants grown at a mean temperature of 38°C never flowered. It seems that the remarkable delay in flowering by heat (hereafter termed as heat delay) may occur in warm areas in Japan when the daily mean temperature exceeds 25°C[9)].

The degrees of heat delay of autumn-flowering cultivars such as Gem, Fiducia and Spring Song, Japanese summer-flowering types (SP200 and SP202) and seedlings of the hybrids between them were investigated. SP200 and SP202 slightly showed heat delay, while Gem, Fiducia and Spring Song showed remarkable heat delay (Table 1). The degree of heat delay of the hybrid progenies was very small (Table 2). There were no differences in reciprocal crosses. SP202 seemed to be a better parent for decreasing the heat delay than SP200.

The development of flower buds at high (30/25°C (day/night)) and optimum (20/15°C) temperatures in the phytotron was

Table 2. The degree of heat delay in progenies of hybrids between Japanese summer-flowering types and autumn-flowering chrysanthemums[9)]

Parent		No. of seedlings tested	Mean no. of days to flower		Degree of heat delay
Female	Male		July 4[a)]	August 22[a)]	
					days
SP202	Gem	187	53.7	51.8	1.9
Gem	SP202	64	54.5	52.0	2.5
SP202	Spring Song	17	56.2	52.0	3.6
Spring Song	SP202	7	52.1	51.3	0.8
SP200	Gem	14	62.1	54.8	7.3
Gem	SP200	15	62.9	55.6	7.3
Fiducia	SP200	15	68.5	60.5	8.0

a): See the footnote of Table 1.

also investigated. Japanese summer-flowering types and a selected hybrid strain, HT-2 (HT means heat tolerant) derived from the cross between SP202 and Gem, showed no heat delay of flower bud development under high temperatures with 12 hr daylength, 20,000 lux light intensity and 80% humidity, while the development of flower buds of the autumn-flowering cultivars, Gem and Pink Pearl, was remarkably delayed under high temperature conditions (Fig. 1).

It is concluded that Japanese summer-flowering cultivars are certainly tolerant to high temperature. This characteristic can easily be introduced into hybrid progenies by cross-breeding.

Response to daylengths

The relationship between the daylength and the number of days to flowering observed with many cultivars which flower during a period from July to October was shown by Kawata (Fig. 2)[3)]. The earlier the natural flowering time, the longer the critical daylength for flowering. Japanese summer-flowering cultivars need less short-day treatment in length in a day or in duration than year-round types. It is said, therefore, that Japanese summer-flowering cultivars need less

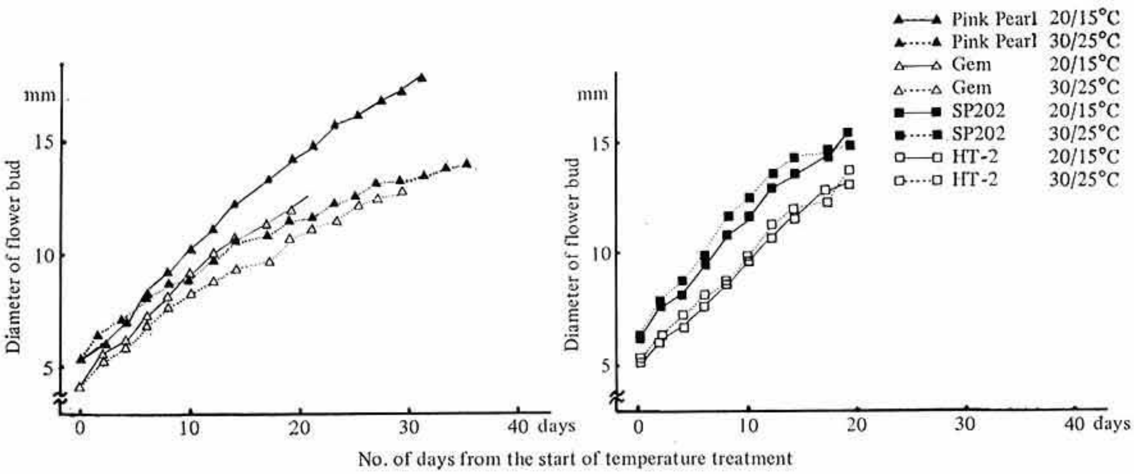

Fig. 1. The development of flower bud of autumn-flowering chrysanthemums, Japanese summer-flowering type, and their hybrid seedling clone under high temperature[10)]

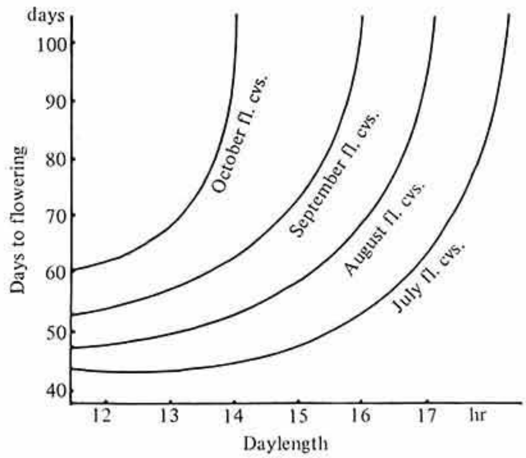

Fig. 2. Schematic diagram showing the relation between the daylength and the number of days from the start of photoperiodic treatment to anthesis in many Japanese July to October-flowering cultivars (by Kawata, 1987[3)])

labor for daylength treatment.

The number of days to flowering and the number of leaves in 12 hr, 13 hr and 14 hr daylengths of HT-strains, selected from the seedlings of the hybrid between SP202 and Gem, were investigated. The results are shown in Table 3. Gem flowered only at a daylength of 12 hr, although there was no difference in the number of leaves between 12 hr and 13 hr daylengths. It implies that the flower initiation of Gem occurred simultaneously in these two daylengths. It was estimated that the critical daylength for rapid flower initiation was between 13 hr and 14 hr and that for rapid flower development was 12 hr. Compared with this, SP202 and HT-strains could flower even with 14 hr of daylength. There was no difference in the number of days to flowering between 12 hr and 13 hr daylengths. The delay of flowering at 14 hr daylength was only one week or so. The number of leaves of SP202 and HT-strains in 12 hr, 13 hr and 14 hr daylengths were almost the same. Therefore it can be estimated that the critical daylength for rapid flower initiation of SP202 and HT-strains is over 14 hr and that for rapid flower development is between 13 hr and 14 hr.

It is concluded that HT-strains have longer critical daylength for rapid flower initiation and development than autumn-flowering cultivars.

The number of leaves of HT-strains produced under long day condition with light interruption* (LD) was also investigated (Table 3). It is said that the large number

* In case of chrysanthemums, the long day treatment is given by interrupting the dark (night) period with lighting.

Table 3. Effect of daylength under high temperature of summer on the number of days to flower and the number of leaves[9]

Cultivar	Days to flower				No. of leaves			
	12 hr	13 hr	14 hr	LD	12 hr	13 hr	14 hr	LD
Gem[a]	70.0	—[d]	—[d]	—[d]	17.7	18.9	29.0	40.9
SP202[b]	55.7	54.6	59.0	—[d]	19.9	20.5	21.1	49.9
HT-1[c]	52.1	52.8	57.5	—[d]	20.0	19.0	20.0	42.8
HT-2[c]	56.3	55.5	62.4	—[d]	20.8	22.1	20.5	43.1
HT-6[c]	51.9	52.9	58.0	—[d]	17.8	17.7	17.6	40.9

a): Autumn-flowering cultivar. b): Japanese summer-flowering cultivar. c): Selected clones from the hybrid seedings between SP202 and Gem. d): Not flowered.

of leaves observed in LD, 30 at least, is necessary for year-round chrysanthemums to reduce the risk of producing premature budding in the cropping house[5]. As the number of leaves in LD of HT-strains was more than 40, it seems that the HT-strains are promising as year-round chrysanthemums.

Reaction period

Earliness of year-round chrysanthemums is usually expressed by the number of weeks from the start of the short-day treatment to flowering i.e. the reaction period, under optimum conditions. It is a very important characteristic in view of effective use of facilities for the production.

The seasonal variation of the reaction period in short-day treatment of HT-strains in the year-round experiment was investigated. The result is shown in Table 4. The mean reaction period of HT-strains was smaller than that of Miros (autumn-flowering cultivar), Gem and SP202. The minimum length of reaction period of HT-strains was also shorter than that of Miros and Gem. It is concluded that the reaction period of HT-strains is shorter than that of autumn-flowering cultivars. However, the flowering of SP202 and HT-strains was slightly delayed when temperature was comparatively low, and 30% of HT-1 plants rosetted in the 6th trial. It is estimated that SP202 and HT-strains are typical thermopositive type, of which flowering is delayed by low temperatures.

Conclusion

Some advantages were obtained by the introduction of useful characteristics of Japanese summer-flowering cultivars into autumn-flowering cultivars by the cross-breeding. First, the selected seedling clones of the hy-

Table 4. Seasonal variation in the number of days from the start of short-day treatment, successively conducted, to flowering[9]

Cultivar	No. of days to flower						
	Mar. 25[a]	May 20[a]	Jul. 8[a]	Sep. 2[a]	Oct. 28[a]	Dec. 24[a]	Mean
Miros[b]	59.3	81.7	108.0	70.0	56.1	55.8	71.8
Gem	48.6	52.6	88.4	55.2	47.3	48.6	56.8
SP202	44.4	42.8[c]	56.4	52.3	51.6	54.2	50.3
HT-1	48.6	39.3	52.4	42.9	41.6	46.4[d]	45.2
HT-2	51.7	45.2	52.4	47.4	45.8	51.6	49.0
HT-6	45.8	42.5	54.6	47.4	45.2	63.3	49.3

a): Start of short-day treatment. b): Autumn-flowering cultivar. c): The number of days underlined is minimum number of days found for each cultivar. d): 30% rosetted.

brid flowered normally and regularly as scheduled even under high temperature conditions. Secondly, they were able to flower under the day length longer than that required by the autumn-flowering cultivars. Thirdly, they showed a shorter reaction period to the short-day treatment than the latter. As mentioned above, Japanese summer-flowering chrysanthemums are very useful materials in the breeding for heat tolerance, long critical daylength for flowering, and earliness.

On the other hand, the selected clones of HT-strains showed lower adaptability to low temperatures, though they showed desirable characteristics under high temperature conditions. It is suggested, therefore, that year-round production of spray chrysanthemums in Japan is best achieved by growing the cultivars such as HT-strains in summer, followed by growing the autumn-flowering cultivars during the period from autumn to spring. The successfully developed heat-tolerant strains support the possibility of growing chrysanthemums in tropical or subtropical areas, where chrysanthemums have scarcely been grown because of high temperatures.

Acknowledgement

I should like to thank Mr. Naoshiro Koido of Koido-bishoen, Matsumoto, Nagano, Japan, who kindly supplied his seedlings.

References

1) Furuta, T. & Nelson, K. S.: The effects of high temperature on the development of chrysanthemum flower buds. *Proc. Amer. Soc. Hort. Sci.*, 61, 548–550 (1953).

2) Kawata, J.: Japanese cultivars and wild species; their useful characteristics for chrysanthemum breeding. *In* Proc. Eucarpia Meet. Chrysanthemums, 33–48 (1978).

3) Kawata, J.: The phasic development of chrysanthemums as a basic for regulation of vegetative growth and flowering in Japan. *Act Hort.*, 197, 115–123 (1987).

4) Langhans, R. (ed.): Chrysanthemums–A manual of the culture, diseases, insects and economics of chrysanthemums. The New York State Extension Service Chrysanthemum School with the cooperation of the New York State Flower Growers Association, Inc. New York (1964).

5) Langton, F. A.: Breeding summer-flowering chrysanthemums. *In* Proc. Eucarpia Meet. Chrysanthemums, 77–83 (1978).

6) Machin, B. & Scope, N.: Chrysanthemum year-round growing. Blandford Press. Dorset. (1978).

7) Okada, M.: Effects of daylength and temperature on flowering of summer and August-flowering chrysanthemums. *J. Jpn. Soc. Hort. Sci.*, 21, 251–255 (1953) [In Japanese with English summary].

8) Post, K. & Kamemoto, H.: A study on the number of short photoperiods required for flower bud initiation and effect of interrupted treatment on flower spray formation in two commercial varieties of chrysanthemums. *Proc. Amer. Soc. Hort. Sci.*, 55, 477–482 (1950).

9) Shibata, M. & Kawata, J.: The introduction of heat tolerance for flowering from Japanese summer-flowering chrysanthemums into year-round chrysanthemums. *Acta Hort.*, 197, 77–84 (1987).

10) Shibata, M. & Amano, M.: The breeding of spray type chrysanthemum for summer production. 3. Response to temperatures of spray type chrysanthemums for summer production. *In* Abst. Spring Meet. Jpn. Soc. Hort. Sci., 404–405 (1987) [In Japanese].

(Received for publication, September 11, 1987)