Re-examination on the Role of Vernalization and Photoperiod in the Flowering of *Brassica* Crops under Controlled Environment

Hiroshi SUGE

*Institute for Agricultural Research,
Tohoku University, Sendai 980*

Flowering response of 7 cultivars belonging to 3 different varieties of *Brassica campestris* were explored in their relation to vernalization, photoperiod and gibberellins (GAs) under controlled environment using growth cabinets. In 5 Japanese cultivars (Nozawana, Uzuki-Komatsuna, Shin-Santosai, Bansei-Mana and Shigatsu-Shirona) out of 7 ones tested, flowering did not occur under 8 hour photoperiods even though they had been vernalized (20 days) and received GA₃ although it induced stem elongation. In those cultivars GAs are likely to play a direct role in the bolting but probably are not directly functional in initiating flowering. Two Chinese cultivars tested here were unique for their flowering responses. Tsai Hsin was a day neutral cultivar with low vernalization requirement; it flowered either under 24 and 8 hour photoperiods in both of vernalized and nonvernalized plants. Hong Tsai Tai was a typical long-day plant and it did not require vernalization under 24 hour photoperiod. On the other hand, vernalization substituted the long-day requirement since seed-vernalized plants flowered even under short-days. Application of GA₃ induced the flowering in nonvernalized plants under 8 hour photoperiod and that of Ancymidol, an inhibitor of GA biosynthesis, inhibited the flowering of vernalized plants. In this cultivar, GAs seem to play some role not only in the bolting but also in the flowering itself.

KEY WORDS : *Brassica campestris*, vernalization, photoperiod, gibberellins, flowering, stem elongation.

Introduction

For the maximum flowering of Chinese cabbage, *Brassica campestris* var *pekinensis*, a combination of vernalization and long-day was required (LORENZ 1946). However, most of Japanese workers had a tendency to underestimate the role of day length in the flowering of Chinese cabbage (SUGIYAMA 1943, EGUCHI and KOIDE 1944, YAMASAKI 1956, SHINOHARA 1959, KAGAWA 1966) except recent studies done under controlled environmental conditions (MORI *et al.* 1979, SUGE and TAKAHASHI 1982).

Recently, SUGE and TAKAHASHI (1982) showed that some cultivars of Chinese cabbage did not flower under short-day conditions such as 8 hour photoperiod even though they had been seed-vernalized and received comparatively large amounts of GA₃ or GA₇ after the vernalization.

In this study, the role of vernalization and photoperiod in the flowering of other *Brassica* crops was explored under controlled environment in growth cabinets. GA relationships in the flowering response were also studied.

Other than Chinese cabbage, no data are available on the flowering response under controlled environmental conditions in *Brassica* crops.

Materials and Methods

First experiment: Seven cultivars of *Brassica campestris* having different vernalization requirement were selected as follows based on the result of the preliminary test.

Received September 15, 1983

1. *B. campestris* var *chinensis* cv. Hong Tsai Tai (紅菜苔)
2. *B. campestris* var *chinensis* cv. Tsai Hsin (菜心)
3. *B. campestris* var *rapifera* cv. Nozawana (野沢菜)
4. *B. campestris* var *rapifera* cv. Uzuki-Komatsuna (卯月小松菜)
5. *B. campestris* var *pekinensis* cv. Shin-Santosai (新山東菜)
6. *B. campestris* var *pekinensis* cv. Bansei-Mana (晩生真菜)
7. *B. campestris* var *chinensis* cv. Shigatsu-Shirona (四月しろ菜)

Seeds of 7 cultivars were germinated at room temperature for 2 days in the water contained in Petri dishes, and the germinating seeds were vernalized at 5°C for 20 days. Nonvernalized (control) seeds were soaked in dishes at room temperature for 2 days just prior to the end of vernalization, thus providing the seedlings of approximately the same size and appearance as the vernalized ones. Both lots of seedlings were planted in plastic containers filled with a 1:1 mixture of sand and vermiculite, and grown in the growth cabinets (Koito KG type) under 8 or 24 hour photoperiod. The light source consisted of twenty-two 80 watt fluorescent lamps (Toshiba), nine 400 watt extra high pressure mercury lamps (metal-haloid, "Yoko", Toshiba) and twelve 200 watt refractor lamps (Toshiba), providing about 15,000 lux at the plant level. Temperature was controlled at 23°C during the light and at 18°C during the dark period. Same temperature change was also adopted even in 24 hour photoperiod coincided with that of 8 hour photoperiod.

Five days after the transfer the nonvernalized plants were divided into 2 groups each consisting 10-20 plants. A 20 ml of 10 ppm GA₃ solution was sprayed to run off 5 times at 2 days interval. The dates of bolting, flower bud appearance and anthesis and the stem height and the number of leaves per plant at anthesis were recorded in all the experiments. The experiments were stopped 70 days after transplanting and the shoot apices of the plants that had not yet reached the stage of bud appearance were examined under a binocular microscope. All plots consisted of more than 10 plants.

Second experiment: Further detailed experiment was done using 2 Chinese cultivars of *B. campestris* var *chinensis*, Hong Tsai Tai and Tsai Hsin since they were found to respond to GA₃ quite differently in the first experiment. Experimental procedures were almost the same as those shown in the first experiment except that α -cyclopropyl- α -(4-methoxyphenyl)-5-pyrimidine methanol (Ancymidol), an inhibitor of GA biosynthesis, was used.

At the necessary time, 20 ml of a 0.5 mM Ancymidol was applied to the soil of each pot 2 days after the planting.

The experiments were stopped 90 days after the start of the experiment. In the second experiment, plants were grown under only 8 hour photoperiod at 25/20°C, day/night temperature. All plots consisted of more than 10 plants.

Results

First experiment: Vernalization resulted in the 100% flowering of 4 cultivars out of 7 ones tested under long-days, while 3 cultivars did not reach 100% flowering although

vernalization increased percent of flowering plant evidently and decreased the number of days to flower bud appearance, number of days to first anthesis and number of leaves at anthesis. This may indicate that 20 days vernalization was not sufficient to satisfy low temperature requirement in those 3 cultivars, Shin-Santosai, Bansei-Mana and Shigatsu-Shirona (Table 1).

Under short-days, no flowering was detected, except 2 Chinese cultivars, Tsai Hsin and Hong Tsai Tai, even in the plants that had been vernalized and received GA treatment. Except those 2 Chinese cultivars, neither the nonvernalized plants nor the vernalized ones grown under short-days, with or without GA₃, flowered, although GA₃ caused stem elongation in all the plants (Table 1).

With Hong Tsai Tai, GA₃ induced flowering in nonvernalized plants even under short-days although vernalized plants flowered under the same conditions without GA₃ (Table 1).

Contrary to Hong Tsai Tai, Tsai Hsin flowered under short-days without vernalization and GA₃. GA₃ promoted the appearance of flower buds and first anthesis, however, the number of leaves at anthesis was almost the same between control and GA₃-treated plants (Table 1).

Second experiment: With Tsai Hsin, the application of Ancymidol after seed vernalization reduced the stem height, however, resulted in flowering in nonvernalized plants as well as in vernalized ones. The reduction of stem length was almost restored by the application of GA₃ in nonvernalized plants although GA₃ did not restore the reduction of stem height in vernalized plants, probably due to the very short growth duration in the latter. Ancymidol gave almost no effect on the number of leaves at anthesis (Tables 2 and 3, Fig. 1).

On the other hand, the flowering response was quite different with the cultivar Hong Tsai Tai. Vernalization treatment of seeds substituted the long-day requirement; vernalized plant flowered even under short-days whereas no flower formation was detected in nonvernalized plants under short-days. Nonvernalized plants remained in vegetative conditions under short-days, however the application of GA₃ induced the stem elongation and flowering in those plants. GA₃ also induced stem elongation and flowering even in nonvernalized plants to which Ancymidol had been applied. The application of Ancymidol to vernalized plants inhibited the flowering; half of the Ancymidol-treated plants did not produce flower bud until the end of the experiment and remained in vegetative conditions. Half of them produced flower buds and flowered finally, however, the appearance of flower buds delayed greatly when compared with the plants that had not received Ancymidol treatment. Further application of GA₃ to the plants which had received Ancymidol treatment again restored 100% flowering (Tables 2 and 3, Fig. 2).

Discussion

Low temperature (vernalization) and long-day are the main causal factors for the induction of flowering in winter annual *Brassica* crops. Other than Chinese cabbage (SUGE and TAKAHASHI 1982), however, data reported are fragmentary and no detailed

Table 1. Flowering response of vernalized and nonvernalized plants grown under 8- and 24-hour photoperiods, 23/18°C (day/night) temperature

Cultivar	Vernalization ^{b)}	Daylength (hr)	GA ₃	Days to bolting	Flowering (%)	Days to appearance of flower bud ²⁾	Days to first anthesis ²⁾	Stem height at first anthesis ²⁾ (cm)	Final stem height ³⁾ (cm)	No. of leaves at anthesis ⁴⁾
Hong Tsai Tai (紅葉苔)	+	{ 24 8 8	-	7.0±0.0	100	11.8±1.0	17.3±0.9	16.1±3.2	24.8±4.9	3.6±0.6
			-	13.6±1.2	100 ⁵⁾	—	—	—	4.2±1.6	11.2±1.7
	-	{ 24 8 8	+	7.0±0.0	100	51.6±3.5	52.3±0.6	35.0±7.0	97.8±17.7	10.0±0.9
			-	10.0±0.0	100	13.8±0.4	19.7±0.5	15.0±2.3	41.1±8.7	4.3±1.0
Tsai Hsin (菜心)	+	{ 24 8 8	-	10.0±0.0	100	13.3±0.5	17.5±0.7	14.5±2.7	26.7±5.2	3.5±0.5
			-	14.1±0.9	100	41.0±6.1	41.2±6.3	21.5±4.6	83.5±18.9	9.7±2.9
	-	{ 24 8 8	+	10.1±0.0	100	33.4±3.3	38.7±3.9	22.8±3.7	79.8±22.5	9.5±1.5
			-	12.0±0.0	100	15.5±0.5	19.3±0.5	17.1±2.2	30.5±4.6	4.3±0.9
Nozawana (野沢菜)	+	{ 24 8 8	-	21.0±0.0	100	52.6±3.6	55.0±3.1	19.1±1.9	53.7±10.0	10.4±1.3
			+	21.0±0.0	100	44.8±3.0	49.6±1.4	28.6±5.1	68.4±11.2	10.2±1.2
	-	{ 24 8 8	-	14.0±0.0	100	17.3±2.3	21.1±1.6	20.8±6.0	55.8±14.0	6.0±1.5
			+	—	0	—	—	—	>1	>15
Uzuki-Komatsuna (卯月小松菜)	+	{ 24 8 8	-	14.0±0.0	0	—	—	—	7.5±2.4	>13
			+	14.0±0.0	0	—	—	—	—	—
	-	{ 24 8 8	-	19.5±0.0	85.4	22.0±2.8	25.5±1.3	19.0±5.0	48.5±12.5	6.6±1.3
			+	—	0	—	—	—	<1	>13
Uzuki-Komatsuna (卯月小松菜)	+	{ 24 8 8	-	24.0±0.0	0	—	—	—	9.6±2.6	>13
			+	—	0	—	—	—	—	—
	-	{ 24 8 8	-	14.8±0.0	100	17.6±0.8	22.8±1.3	22.3±5.1	44.3±12.0	5.7±1.1
			+	18.5±0.0	0	—	—	—	1.7±0.6	>13
Uzuki-Komatsuna (卯月小松菜)	+	{ 24 8 8	-	14.8±0.0	0	—	—	—	11.0±4.0	>10
			+	14.8±0.0	0	—	—	—	—	—
	-	{ 24 8 8	-	21.1±1.2	66.7	31.3±1.6	31.5±1.7	16.2±3.1	40.9±11.8	8.3±3.0
			+	22.5±2.4	0	—	—	—	2.4±0.6	>13
Uzuki-Komatsuna (卯月小松菜)	-	{ 24 8 8	-	24.0±0.0	0	—	—	—	10.6±2.2	>10
			+	—	0	—	—	—	—	—

Shin-Santosai (新山東菜)	+	{ 24 8 8	—	20.3±0.0	81.0	31.9±5.4	35.7±5.6	17.5±9.1	49.5±11.1	9.3±2.1
			—	25.8±1.2	0	—	—	—	2.3±0.6	>15
			+	24.0±0.0	0	—	—	—	13.8±4.4	>13
Bansei-Mana (晩生真菜)	—	{ 24 8 8	—	24.0±3.8	57.1	37.6±5.0	40.5±3.7	17.3±4.0	42.5±13.6	11.7±2.7
			—	24.0±0.0	0	—	—	—	2.8±1.0	>13
			+	24.0±0.0	0	—	—	—	14.3±2.0	>13
Shigatsu-Shirona (四月しろ菜)	+	{ 24 8 8	—	18.0±0.0	50.0	36.2±7.7	40.0±3.6	12.8±4.5	35.0±6.0	8.8±1.2
			—	21.1±1.3	0	—	—	—	1.5±0.6	>13
			+	18.0±0.0	0	—	—	—	13.1±0.6	>13
(晩生真菜)	—	{ 24 8 8	—	21.6±0.5	18.9	37.6±8.8	37.5±9.7	16.0±2.8	35.5±8.6	9.0±1.4
			—	—	0	—	—	—	<1	>13
			+	24.0±0.0	0	—	—	—	12.5±2.6	>13
Shigatsu-Shirona (四月しろ菜)	+	{ 24 8 8	—	17.0±0.0	65.5	35.0±8.0	33.1±11.9	16.3±3.5	33.8±7.5	10.2±1.9
			—	18.0±0.5	0	—	—	—	4.0±2.1	>15
			+	17.0±0.0	0	—	—	—	14.6±3.2	>13
(四月しろ菜)	—	{ 24 8 8	—	21.0±0.0	17.0	41.8±2.7	41.5±8.2	13.8±4.8	36.0±15.9	10.4±3.2
			—	25.0±0.0	0	—	—	—	3.5±1.2	>13
			+	24.0±0.0	0	—	—	—	14.9±5.2	>13

- 1) Vernalized 20 days at 5°C.
- 2) Average for flowering plants in long-days.
- 3) Average at 70 days after the start of the experiment in short days.
- 4) Number of leaves was determined under the microscope for the plants in which flower buds were not appeared.
- 5) All plants differentiated flower buds.

Table 2. Effect of GA₃ and Ancymidol applied after seed vernalization on the stem elongation of 2 different cultivars of *Brassica campestris* var *chinensis* under 8 hour photoperiod and 25/20°C (day/night) temperature

Cultivar	Vernalization ¹⁾	Ancymidol ²⁾ (0.5 mM)	GA	GA plant/ application (μg)	Total GA (μg)	Bolting (%)	No. of days to bolting	Stem height at first anthesis ³⁾ (cm)	Final stem height (cm)
Tsai Hsin (菜心)	+	-	-	0	0	100	6.0± 0.0	19.6± 1.8	45.8± 8.4
			+	5	15	100	6.0± 0.0	20.0± 1.9	42.8± 9.0
		+	-	0	0	100	—	6.4± 2.0	17.9± 4.2
			+	5	15	100	12.0± 0.0	13.2± 2.8	20.7± 5.4
	-	-	-	0	0	100	26.4± 0.8	24.0± 5.8	66.8± 15.9
			+	5	15	100	21.1± 0.9	25.4± 4.2	60.0± 12.4
		+	-	0	0	100	—	11.3± 2.4	25.1± 7.3
			+	5	15	100	12.0± 0.0	25.8± 6.5	64.1± 10.0
Hong Tsai Tai (紅菜苔)	+	-	-	0	0	100	6.0± 0.0	23.5± 6.9	57.0± 17.4
			+	5	15	100	6.0± 0.0	31.0± 6.9	54.2± 14.3
		+	-	0	0	50	51.1± 18.1	24.4± 10.0	70.0± 22.3
			+	5	15	100	12.0± 0.0	23.0± 0.0	41.7± 15.1
	-	-	-	0	0	0	—	—	2.9± 0.6
			+	20	260	100	15.9± 0.3	37.0± 7.3	38.3± 22.1
		+	-	0	0	0	—	—	1.0± 0.2
			+	20	260	100	20.0± 1.1	43.1± 11.7	73.2± 12.4

1) Vernalized 35 days at 5°C.

2) Ancymidol (0.5mM) was applied in the rate of 10ml/pot.

3) Average on flowering plants.

experiment was conducted under controlled environments using growth cabinets. As for the Chinese cabbage, SUGE and TAKAHASHI (1982) studied the role of GAs in stem elongation and flowering in their relation to vernalization and photoperiod. They found that GA₃, 2,200 μg in total, was not able to induce flowering in nonvernalized plant grown under 8 hour photoperiod in 4 different cultivars out of 6 ones tested, but 560 μg GA₃ raised percentages of flowering in the vernalized plant that flowered under 8 hour photoperiod which varied from 0 to 30.0, 33.3 and 58.8% depending cultivars. In a cultivar, Harumaki-Gokuwase, all the plants remained in vegetative conditions under 8 hour photoperiod even though they had been vernalized 20 days and received 560 μg GA₃ in total, although GA₃ induced their stem elongation.

GA content of vernalized seedlings increased within the first 3 days after they were transferred from short-day to long-day conditions. Bolting was inhibited slightly by Ancymidol applied during vernalization; it was almost completely inhibited in case Ancymidol was applied after seed vernalization. The experiment revealed that Ancymidol actually reduced GA content. Ancymidol, however, had essentially no effect on flowering. SUGE and TAKAHASHI (1982) concluded that GAs are likely to play a direct role in the bolting of Chinese cabbage, but probably are not directly functional in initiating flowering. This is also the case in a Japanese cultivar of radish (SUGE and RAPPAPORT 1968).

Flowering responses of various cultivars tested this time resembled fundamentally to those of Chinese cabbage (SUGE and TAKAHASHI 1982) although several cultivars were

Table 3. Effect of GA₃ and Ancymidol applied after seed vernalization on the flowering of 2 different cultivars of *Brassica campestris* var *chinensis* under 8 hour photoperiod and 25/20°C (day/night) temperature

Cultivar	Vernli- zation ¹⁾	Ancy- midol ²⁾ (0.5 mM)	GA	GA plant/ applica- tion (μ g)	Total GA (μ g)	Flow- ering (%)	Days to ap- pearance of flower bud ³⁾	Days to first anthesis ³⁾	No. of leaves at anthesis ⁴⁾
Tsai Hsin (菜心)	+	-	-	0	0	100	13.0 $\pm$ 0.0	21.2 $\pm$ 1.0	5.3 $\pm$ 1.2
			+	5	15	100	13.0 $\pm$ 0.0	20.5 $\pm$ 0.7	5.6 $\pm$ 1.3
		+	-	0	0	100	13.0 $\pm$ 0.0	31.7 $\pm$ 4.8	4.7 $\pm$ 0.8
			+	5	15	100	13.0 $\pm$ 0.0	24.3 $\pm$ 3.6	4.4 $\pm$ 0.9
	-	-	-	0	0	100	50.2 $\pm$ 2.3	59.4 $\pm$ 4.2	14.0 $\pm$ 1.9
			+	5	15	100	33.6 $\pm$ 2.0	44.3 $\pm$ 4.2	12.1 $\pm$ 1.4
		+	-	0	0	100	53.2 $\pm$ 6.7	64.9 $\pm$ 8.3	12.5 $\pm$ 2.1
			+	5	15	100	34.9 $\pm$ 0.6	53.3 $\pm$ 5.5	12.6 $\pm$ 1.7
Hong Tsai Tai (紅菜苔)	+	-	-	0	0	100	22.8 $\pm$ 4.3	38.4 $\pm$ 8.5	7.6 $\pm$ 2.7
			+	5	15	100	19.5 $\pm$ 2.6	30.8 $\pm$ 2.8	6.3 $\pm$ 1.3
		+	-	0	0	50	71.3 $\pm$ 18.2	82.3 $\pm$ 7.3	13.0 $\pm$ 2.2
			+	5	15	100	26.6 $\pm$ 5.5	41.3 $\pm$ 6.0	6.5 $\pm$ 1.6
	-	-	-	0	0	0	—	—	>15
			+	20	260	100	49.5 $\pm$ 4.0	70.5 $\pm$ 12.4	9.2 $\pm$ 1.0
		+	-	0	0	0	—	—	>15
			+	20	260	100	68.3 $\pm$ 4.9	86.3 $\pm$ 7.8	11.4 $\pm$ 2.3

1) Vernalized 35 days at 5°C. 2) Ancymidol (0.5mM) was applied in the rate of 10ml/pot.

3) Average on flowering plants. 4) Number of leaves was determined under microscope for the plants in which flower buds were not appeared.

found to have more low temperature requirement since 20 days vernalization was not sufficient to induce 100% flowering even under long-days, whereas 6 cultivars of Chinese cabbage tested by SUGE and TAKAHASHI (1982) all flowered under long-days with 20 days vernalization.

However, among 7 cultivars tested here, 2 Chinese cultivars, Hong Tsai Tai and Tsai Hsin, were somewhat different in their flowering responses from other 5 Japanese cultivars, may be due to their low latitudinal origin of 30°N and less than 25°N respectively. SHINOHARA (1980) suggested the importance of photoperiod in the flowering of *Brassica* crops in the subtropics and tropics.

Five Japanese cultivars remained in vegetative conditions under short-days even though they had been seed-vernalized and received GA₃, although GA₃ induced stem elongation. This is almost the same with a Chinese cabbage cultivar, Harumaki-Gokuwase (SUGE and TAKAHASHI 1982).

Tsai Hsin was a day-neutral cultivar since it flowered under short-days without vernalization. Vernalization treatment of seeds was only slightly effective to promote flowering, thus the requirement for low temperature may exist also slightly in this cultivar.

On the other hand, flowering response of Hong Tsai Tai is interesting. The cultivar also has almost no low temperature requirement since the number of leaves at anthesis

Fig. 1. The response of Tsai Hsin to GA_3 and Ancymidol under the condition of 8 hour photoperiod and 25/20°C, day/night temperature. From right to left, Control, GA_3 -treated, Ancymidol-treated and Ancymidol and GA_3 -treated. A and B indicate vernalized and nonvernalized plants, respectively. Note the flowering in Ancymidol-treated plants either in vernalized (A) and nonvernalized (B) plot. Photographs were taken at 23 days (A) and 53 (B) days after the start of the experiments.

Fig. 2. The response of Hong Tsai Tai to GA_3 and Ancymidol under the condition of 8 hour photoperiod and 25/20°C, day/night temperature. From right to left, Control, GA_3 -treated, Ancymidol-treated and Ancymidol and GA_3 -treated. A and B indicate vernalized and nonvernalized plants, respectively. Note the inhibition of flowering in Ancymidol-treated plants in vernalized plot (A) and the induction of flowering in GA_3 -treated plants in nonvernalized plot (B). Photographs were taken at 43 days (A) and 70 days (B) after the start of the experiments.

were 3.6 and 4.3 for vernalized and nonvernalized plants under long-days respectively. However, this was a typical long-day plant since it could not flower under short-day in nonvernalized plants. GA_3 could substitute this long-day requirement. With other Japanese cultivars tested here, GA_3 could not substitute their long-day requirement because GA_3 could not induce flowering even in vernalized plants grown under short-days although it promoted stem elongation as mentioned above.

Thus, contrary to Chinese cabbage or other Japanese cultivars of *B. campestris*, GAs may play some significant role not only in the stem elongation but also in the flowering itself in Hong Tsai Tai. The fact that the application of Ancymidol, an inhibitor of GA biosynthesis, to vernalized plants reduced the flowering plants also supports the

view that endogenous GAs may have some role in the flowering of this cultivar.

The author would like thank to Dr. M. HIRAO of Mikado Seed Grower's Co. Ltd. and Dr. K. HINATA of Tohoku University for their kind suggestions on the taxonomy of *Brassica* crops. The present work was supported partially by a grant-in-aid from the Ministry of Agriculture, Forestry and Fishery, the Japanese Government.

Literature cited

- EGUCHI, T. and M. KOIDE 1944. On the relationship between seeding time and flower bud differentiation and vernalization in Japanese radish and *Brassica* vegetable crops. Jour. Japan. Soc. Hort. Sci. **15** : 1~27.
- EGUCHI, T., A. KAGAWA and T. MATSUMURA 1960. Studies on the seed production in Chinese cabbage (*Brassica pekinensis* Rupr.) I. On the flower bud differentiation in Chinese cabbage. Bull. Natl. Inst. Agric. Sci. Ser. E **8** : 49~58.
- KAGAWA, A. 1966. Studies on the effect of thermo-induction in floral initiation of chinese cabbage. Bull. Fac. Agric. Gifu Univ. **22** : 29~39.
- LORENZ, O. A. 1946. Response of Chinese cabbage to temperature and photoperiod. Proc. Amer. Soc. Hort. Sci. **47** : 309~319.
- MORI, K., H. EGUCHI and T. MATSUI 1979. Mathematical model of flower stalk development in Chinese cabbage affected by low temperature and photoperiod. Environ. Control in Biol. **17** : 17~26.
- SHINOHARA, S. 1959. Genecological studies on the phasic development of flowering centering on the Cruciferous crops, especially on the role of vernalization on ripening seeds. Technical Bull. Shizuoka Pref. Agric. Exp. Sta. N. **6** : 1~166.
- SHINOHARA, S. 1980. Phenomenon of premature bolting and flower formation physiology in radish and *Brassica* greens. In Guidebook for development of vegetable horticulture with capable seed production in the monsoon subtropics. Yokendo, Tokyo. pp.100~102.
- SUGE, H. and L. RAPPAPORT 1968. Role of gibberellins in stem elongation and flowering in Japanese radish. Plant Physiol. **43** : 1208~1214.
- SUGE, H. and H. TAKAHASHI 1982. The role of gibberellins in the stem elongation and flowering of Chinese cabbage, *Brassica campestris* var. *pekinensis* in their relation to vernalization and photoperiod. Rep. Inst. Agric. Res. Tohoku Univ. **33** : 15~34.
- SUGIYAMA, N. 1943. On the bolting of several species in Cruciferae vegetables. Jour. Jap. Soc. Hort. Sci. **14** : 267~276.
- YAMASAKI, K. 1956. Thermo-stage for the green plant of Chinese cabbage grown in spring. Bull. Hort. Div. Tokai-Kinki Agric. Exp. Sta. **1** : 34~47.

ブラシカ属作物の開花における春化と日長の
役割についての制御環境下での再検討

菅 洋

(東北大学農学研究所)

Brassica campestris の3変種に属する7栽培品種を用いて、その開花における春化と日長の役割をジベレリンとの関連においてファイトロンを用いて研究した。

供試7品種中5種の日本品種(野沢菜, 卯月小松菜, 新山東菜, 晩生真菜, 四月しろ菜)は20日間種子春化しても, 8時間日長下では花芽分化しなかった。GA₃はこれらの植物に茎伸長をひきおこすが花芽分化させなかった。これらの品種では, GAは抽苔には直接関与しているが, 花芽分化には直接的には関与していないものと結論される。

また, これらの結果より, ブラシカ属野菜の開花における日長の役割を過少評価していた従来の説は訂正を必要とするものと判断される。

2種の中国品種は, その開花反応が特異である。菜心は春化要求の小さい中日性品種で, 種子春化の有無にかかわらず24時間日長下8時間日長下ともに開花した。他方, 紅菜苔は, 春化要求は小さいが, 典型的な長日植物であった。しかしながら, 春化処理は長日要求に代替し, 種子春化すると8時間日長下でも開花した。8時間日長下の非春化植物にGA₃をやると開花をひきおこした。一方, 種子春化した植物をGA生合成阻害剤のAncymidolで処理すると開花を阻害した。紅菜苔ではGAは, 茎伸長だけでなく開花それ自体にもなにか役割を演じていると推定される。