Effects of Photoperiod on Flower Bud Initiation of Some Okra (*Abelmoschus esculentus*) Cultivars in Spring and Autumn

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Summary

Effects of photoperiod on flower bud initiation of eight okra (*Abelmoschus esculentus*) cultivars were investigated in spring and autumn. The plants received 10 hr of natural day-length in short-day (SD) or natural day-lengths (ND) ranging from 14.16 to 14.29 in the spring and 11.07 to 12.17 in the autumn. To adjust for a 16-hr photoperiod (LD), the ND was extended with fluorescent lights ($3 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$). Flower buds of 'Clemson Spineless' and 'Emerald' were initiated at the lower node, and they occurred earlier under SD than did those under LD or ND in the spring. Promotive effects of the short-day response in 'Clemson Spineless' and 'Emerald' were not clear in autumn; photoperiodic responses of both cultivars may have been modified by low air temperatures. On the other hand, flower buds of 'Benny', 'Gulliver', 'Natsu no Megumi', 'Star Debut', 'Star Light' and 'Suisei Gokaku' which were initiated at the similar node, occurred simultaneously, regardless of day-length and season. Flower bud initiation of all cultivars continued under short-day in spring and all day-length treatments in autumn. In contrast, a reversion to the vegetative phase occurred not only in 'Clemson Spineless' and 'Emerald' but also in 'Benny', 'Star Debut' and 'Suisei Gokaku' under LD and ND in the spring. Based on these results, 'Clemson Spineless', 'Emerald', 'Benny', 'Star Debut' and 'Suisei Gokaku' are believed to be quantitative short-day plants for flower bud initiation, whereas 'Gulliver', 'Natsu no Megumi' and 'Star Light' are day-neutral.

Key Words: appearance of flower buds, day-neutral, node number, reversion, short-day.

Introduction

Okra plants (*Abelmoschus esculentus*) are important vegetables grown throughout the tropical, subtropical and temperate regions. They grow rapidly; the immature fruits reach marketable size within a few days after anthesis. Rithichai et al. (2002) reported that flowers of okra were formed at the axillary positions of basal nodes, initially and then successively from the first flower up to the node next to a shoot apex. At the critical turning point from vegetative to reproductive stage, an epicalyx was initiated in an axillary bud. Although the flowering is affected by environmental factors, the inductive conditions that lead to flower bud initiation of

okra are not well known.

Several reports suggested the importance of environmental factors, such as day-length and temperature in flowering of okra, but the effects of day-length are conflicting. Arulrajah and Ormrod (1973), Oyolu (1977), and Wyatt (1985) reported that some okra cultivars, such as 'Clemson Spineless' were quantitative SD and ND cultivars. Nwoke (1980) classified both early and late cultivars of okra as short-day plants, whereas Tenga and Ormrod (1985) found that okra exhibited a wide variation of day-length responses. Day-length and temperature play an important role as signals for starting the reproductive phase. Arulrajah and Ormrod (1973) reported that flower bud initiation and development of okra were retarded under long photoperiods and high temperatures as did Tenga and Ormrod (1985). Thus, there is a necessity to investigate the effects of day-length on flower bud initiation in okra.

Although okra is a tropical crop, it can be grown during warm and hot seasons in the temperate zones. Differences in environmental conditions between Japan and the tropics are day-lengths and temperatures.

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Studies on flower bud initiation and development of okra (2).

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During the summer in Japan, it is hot, but the day-length is gradually decreasing. To establish an okra cultivation system for the hot season in Japan, an understanding of day-lengths for flower bud initiation and development is needed.

In this study, effects of day-length on flower bud initiation of eight okra cultivars were investigated in the spring and autumn.

Materials and Methods

Eight okra cultivars were used. Seeds of 'Benny', 'Clemson Spineless', 'Emerald' and 'Gulliver' were obtained from Takii Seed Co., Takayama Seed Co., Marutane Seed Co., Kanako Seed Co., respectively. Seeds of 'Natsu no Megumi' and 'Suisei Gokaku' were obtained from Watanabe Niji Co. Seeds of 'Star Debut' and 'Star Light' were obtained from Musashino Seed Co.

The germinated seeds were sown individually in 15 cm diameter plastic pots on June 11, 2001 and September 19, 2001. The growing media consisted of sterilized soil: sand: vermiculite: compost; 2:1:1:1 by volume. Fifteen plants of each cultivar and treatment were spaced 30 × 30 cm apart after seeding. Day-length treatments were started 4 days after sowing (DAS); the seedling emerged on June 15 in the spring and September 23 in the autumn.

Day-length treatments consisted of short-day (10 hr;

SD), long-day (16 hr; LD) and natural day-length (ND); $n = 12$ plants per treatment. Under SD, the plants received 10 hr of natural day-length starting from sunrise; under LD, plants were exposed to natural day-length from sunrise and supplemented with fluorescent lights to extend the day to a 16-hr photoperiod. Eight 18 W tubes were placed 1.5 m above ground level in the tunnel. Lighting started 30 min before sunset and provided $3 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ at 50 cm above ground level. Lighting continued till the plants receiving light for 16 hr after sunrise and turned off around 9:00 PM. The shades were removed afterwards. Natural day-length was 14.29 hr at the beginning (June 11) which shortened into 14.16 hr at the end of experiment (July 16) in spring, whereas in the autumn, the photoperiod was 12.17 hr at the beginning (September 19) which shortened to 11.07 hr at the end of experiment (October 23). Day-length treatments were terminated 5 weeks after sowing.

SD plants were situated in the middle between ND and LD ones in the glasshouse. To accommodate the SD plants, a tunnel (1 m wide, 1.5 m high, and 12 m long) was constructed. The tunnel was covered with two layers of silver polyethylene film daily around 3:00 PM. after the plants had received natural day-length for 10 hr. During the dark period, the tunnel was ventilated by an electric fan to keep the temperatures the same as on the outside. Minimum and maximum air temperatures

Fig. 1. Changes of air temperature inside and outside of the covering in the glasshouse. Each data represent the mean of 5 days.

inside the shading and the glasshouse were recorded.

An appearance of flower buds was determined daily until flower buds (4–5 mm in diameter) became visible about. The number of nodes, bearing flower buds counted from the cotyledon node, was recorded. At the end of the experiment, whole plants were sampled. Shoot apices and axillary buds were fixed in FAA solution and later dissected under a stereoscopic microscope. Floral stages of the first flower bud and the flower buds at the upper positions were determined based on our previous study (Rithichai et al., 2002). The reversion to a vegetative phase occasionally occurred. After flower buds were formed, some axillary buds reverted to the vegetative stage. When a reversal occurred, and then re-reverted to the reproductive phase (second reproductive), the number of plants with re-reversed flower buds and the number of nodes bearing the re-reversed flower buds were recorded. Stem length from the cotyledonary node to shoot apex and stem diameter were measured at the mid-position between the cotyledon node and shoot apex 4 weeks after

sowing.

Results

Air temperature

The air temperature differed little between the inside and outside of the tunnels in both seasons (Fig. 1). Minimum air temperature was a little higher under the canopy than on the outside. Air temperature increased gradually throughout the experiment in spring, but it was fairly low in autumn, especially the minimum.

The number of nodes bearing flower buds

Flower buds of 'Clemson Spineless' and 'Emerald' were initiated at the lower node in SD than LD and ND in spring (Table 1). Flower buds of 'Clemson Spineless' were differentiated at the 3 ± 0 node in SD, whereas they appeared at the 7.3 ± 2.8 node in ND and the 5.9 ± 3.6 node in LD. The number of nodes bearing flower buds of both cultivars, however, was not clear in autumn regardless of day-length. However, flower buds of

Table 1. Effects of the day-length on the number of nodes bearing flower buds of eight okra cultivars.

Cultivar	Spring			Autumn		
	ND ^z	SD	LD	ND	SD	LD
Benny	3.0 ± 0.0^y	2.5 ± 0.5	2.8 ± 0.4	3.0 ± 0.0	3.0 ± 0.0	3.0 ± 0.0
Clemson Spineless	7.3 ± 2.8	3.0 ± 0.0	5.9 ± 3.6	3.0 ± 0.0	3.0 ± 0.0	3.5 ± 1.4
Emerald	8.5 ± 4.9	3.2 ± 0.4	7.7 ± 5.1^x	3.7 ± 0.5	3.2 ± 0.4	4.3 ± 2.0
Gulliver	2.2 ± 0.4	2.3 ± 0.5	2.1 ± 0.3	3.0 ± 0.0	2.9 ± 0.3	2.9 ± 0.3
Natsu no Megumi	2.6 ± 0.5	2.4 ± 0.5	2.4 ± 0.5	3.0 ± 0.0	3.0 ± 0.0	3.0 ± 0.0
Star Debut	3.0 ± 0.0	3.0 ± 0.0	3.0 ± 0.0	3.0 ± 0.0	3.0 ± 0.0	3.0 ± 0.0
Star Light	2.5 ± 0.5	2.2 ± 0.4	2.1 ± 0.3	3.0 ± 0.0	3.0 ± 0.0	2.9 ± 0.3
Suisei Gokaku	2.5 ± 0.5	2.6 ± 0.5	2.6 ± 0.5	3.0 ± 0.0	3.0 ± 0.0	2.9 ± 0.3

^z Plants were grown under short-day (SD), long-day (LD) and natural day-length (ND).

^y Mean $\pm$ SD.

^x Only seven plants produced flower buds at the end of experiment.

Table 2. Effects of the day-length on the number of days from sowing to the appearance of flower buds of eight okra cultivars.

Cultivar	Spring			Autumn		
	ND ^z	SD	LD	ND	SD	LD
Benny	18.8 ± 0.8^y	18.6 ± 0.5	18.7 ± 0.8	22.2 ± 0.7	22.7 ± 1.3	22.9 ± 0.8
Clemson Spineless	25.4 ± 3.1^x	19.7 ± 0.5	22.5 ± 2.9^w	23.6 ± 1.3	24.1 ± 1.6	26.5 ± 1.0^w
Emerald	$>35^v$	20.7 ± 1.0	$>35^v$	25.7 ± 2.0^u	24.2 ± 2.1	25.2 ± 2.0^w
Gulliver	18.4 ± 0.5	19.5 ± 0.8	18.5 ± 0.5	23.0 ± 0.0	25.0 ± 1.5	24.5 ± 1.4
Natsu no Megumi	18.4 ± 0.5	19.8 ± 0.9	18.8 ± 0.8	21.9 ± 0.5	22.9 ± 1.2	23.2 ± 0.6
Star Debut	18.7 ± 0.7	19.3 ± 0.5	18.6 ± 0.8	22.7 ± 1.2	23.5 ± 1.9	25.9 ± 1.0
Star Light	18.1 ± 0.3	18.8 ± 0.6	18.3 ± 0.6	22.7 ± 0.7	22.4 ± 0.5	24.3 ± 1.4
Suisei Gokaku	19.2 ± 0.7	19.8 ± 0.9	19.1 ± 0.8	23.6 ± 1.1	26.0 ± 0.7	25.9 ± 1.0

^z Plants were grown under short-day (SD), long-day (LD) and natural day-length (ND) for 5 weeks.

^y Mean $\pm$ SD.

^{x,w,u} Average of nine, ten and eleven plants, respectively, as those plants bearing flower buds at the end of experiment.

^v The number of plants bearing flower buds was not over 50% (6 plants) at the end of experiment.

Average number of days from sowing to the appearance of flower buds was determined as over 35 days.

Table 3. Effects of the day-length on flower bud development of three okra cultivars in spring at 5 weeks after sowing.

Cultivar	Day-length ^z	Floral stage ^y							No. of plants bearing fruit
		0	1	2	3	4	5	6	7
Benny	ND							12 ^x	
	SD							6	4
	LD							12	
Clemson Spineless	ND							12	
	SD				1		1	10	2
	LD							10	
Emerald	ND							2	10
	SD								12
	LD	5			2			1	4

^z Plants were grown under short-day (SD), long-day (LD) and natural day-length (ND).^y 0) vegetative; 1) dome initiation; 2) epicalyx initiation; 3) calyx initiation; 4) petal and stamen initiation; 5) carpel initiation and stamen development; 6) stamen and carpel development; 7) anthesis.^x Plant number.**Table 4.** Effects of the day-length on the reversion to vegetative phase and re-reversion to reproductive phase of five okra cultivars in spring.

Cultivar	Day-length ^z	1 st reproductive ^y		2 nd reproductive ^x		3 rd reproductive ^w		4 th reproductive ^v	
		Plant no.	Node no.	Plant no.	Node no.	Plant no.	Node no.	Plant no.	Node no.
Benny	ND	12	3.0	12	8.3	6	10.8	–	–
	LD	12	2.8	11	11.5	1	11.0	–	–
Clemson Spineless	ND	12	7.3	9	11.8	3	14.0	–	–
	LD	12	5.9	9	9.1	6	12.8	1	18.0
Emerald	ND	12	8.5	6	10.2	2	11.5	1	10.0
	LD	7	7.7	4	13.0	1	16.0	–	–
Star Debut	ND	12	3.0	7	8.0	2	8.5	–	–
	LD	12	3.0	9	11.1	3	12.3	–	–
Suisei Gokaku	ND	12	2.5	5	8.6	1	9.0	–	–
	LD	12	2.6	3	9.0	1	10.0	–	–

No plants of all cultivars in SD reverted to vegetative phase after the appearance of flower buds. Some plants reverted to vegetative phase after flower buds were formed in ND and LD. Then some axillary buds re-reverted to reproductive phase.

Those plants with re-reversed flower buds were counted as second, third or fourth reproductive.

^z Plants were grown under short-day (SD), long-day (LD) and natural day-length (ND).^y The number of reproductive plants and mean number of nodes bearing flower buds in the first reproductive.^{x,w,v} The number of plants with re-reversed lower buds and mean number of nodes bearing the re-reversed flower buds in the second, third and fourth reproductive, respectively.

‘Benny’, ‘Gulliver’, ‘Natsu no Megumi’, ‘Star Debut’, ‘Star Light’ and ‘Suisei Gokaku’ were initiated at almost the same node in all day-length treatments.

Days from sowing to the appearance of flower buds

In spring, flower buds of ‘Clemson Spineless’ appeared at 19.7 ± 0.5 DAS in SD (Table 2), but at 25.4 ± 3.1 and 22.5 ± 2.9 DAS in ND and LD, respectively. Although ‘Emerald’ flower buds occurred at the same time as ‘Clemson Spineless’ in SD, they appeared more than 35 DAS in ND and LD. In contrast, ‘Clemson Spineless’ and ‘Emerald’ flower buds appeared almost simultaneously in all day-length treatments in autumn. The appearance of flower buds in the other six cultivars

was similar, regardless of day-length and season.

Flower bud development

In spring, flower buds of ‘Clemson Spineless’ reached floral stage 6 and the anthesis stage under SD (Table 3), but they developed slower under LD, as 1, 1, and 10 plants arrived at the floral stage 3, 5, and 6, respectively. Under ND, all plants stayed at the floral stage 6. Similarly, flower bud development of ‘Emerald’ was significantly delayed under LD; five plants remained at the vegetative stage. Although flower bud development of both cultivars were delayed under ND and LD in autumn, no plants stayed at the vegetative stage (data not shown).

Table 5. Effects of the day-length on stem length of eight okra cultivars at 4 weeks after sowing.

Cultivar	Spring			Autumn		
	ND ^z	SD	LD	ND	SD	LD
Benny	17.3 ± 1.7 ^y	11.3 ± 0.8	23.7 ± 2.0	6.9 ± 0.8	5.9 ± 0.8	6.8 ± 0.7
Clemson Spineless	15.5 ± 1.1	11.0 ± 0.7	15.2 ± 1.4	6.6 ± 0.8	5.0 ± 0.6	5.7 ± 0.4
Emerald	14.0 ± 1.3	9.4 ± 0.8	14.5 ± 1.4	5.7 ± 0.9	4.6 ± 0.6	5.5 ± 0.8
Gulliver	11.4 ± 0.9	10.2 ± 0.9	12.7 ± 0.9	6.1 ± 0.4	4.8 ± 0.7	5.9 ± 0.5
Natsu no Megumi	11.3 ± 0.6	8.7 ± 0.9	13.2 ± 1.0	7.3 ± 0.4	6.0 ± 0.6	6.3 ± 0.5
Star Debut	11.8 ± 0.8	8.1 ± 1.0	12.3 ± 0.7	5.8 ± 0.7	4.3 ± 0.8	5.0 ± 0.5
Star Light	11.6 ± 0.7	9.5 ± 0.6	12.0 ± 1.0	6.3 ± 0.5	5.7 ± 0.5	6.0 ± 0.4
Suisei Gokaku	12.3 ± 0.6	11.3 ± 1.1	12.3 ± 1.1	6.7 ± 1.0	5.3 ± 0.7	6.0 ± 0.8

^z Plants were grown under short-day (SD), long-day (LD) and natural day-length (ND).

^y Mean ± SD (cm).

Flower buds of the other six cultivars developed into floral stage 6 or later floral stages in spring regardless of day-length; e.g., flower buds of 'Benny' developed into floral stage 6 under both ND and LD, whereas others progressed further under SD to floral stage 6, anthesis and fruiting, respectively. Flower bud development of 'Gulliver', 'Natsu no Megumi', 'Star Debut', 'Star Light' and 'Suisei Gokaku' followed the same tendency as 'Benny' (data not shown). In autumn, flower buds of these six cultivars reached floral stage 6 in all day-length treatments (data not shown).

The reversion to vegetative phase

In spring, the reversion to vegetative phase and reversion to reproductive phase were exhibited under ND and LD of 'Benny', 'Clemson Spineless', 'Emerald', 'Star Debut' and 'Suisei Gokaku', but flower buds of all cultivars were initiated successively under SD (Table 4). These cultivars showed two cycles of the reversion until the end of the experiment. But three cycles of the reversion occurred under LD of 'Clemson Spineless' and under ND of 'Emerald'. In autumn, reversion to the vegetative phase of all cultivars did not occur under any day-length treatments.

Plant growth

Okra plants developed faster in spring than they did in autumn as indicated by stem length (Table 5). In spring, stem length of all cultivars ranged from 11.3 ± 0.6 to 17.3 ± 1.7 cm under ND and LD except 'Benny', which elongated to 23.7 ± 2.0 cm under LD. Under SD, stem length varied from 8.1 ± 1.0 to 11.3 ± 1.1 cm. In autumn, shoot elongation was inhibited, ranging only from 4.3 ± 0.8 to 7.3 ± 0.4 cm, regardless of day-length and cultivar. Stem diameter exhibited the same trend as stem length (data not shown).

Discussion

Flower bud initiation of eight cultivars differed under the different photoperiods in this study. The earliness or lateness of flowering could be predicted by the amount

of vegetative growth, the number of nodes preceding the first flower, and the length of time to the appearance of flower bud or anthesis. For flower bud initiation, the length of time to the appearance of flower buds was the simplest parameter, but the number of nodes bearing flower buds was the most reliable parameter (Lang, 1965; Schwabe, 1971). Thus, the number of nodes bearing flower buds and days to the appearance of flower buds were considered as the major parameters for measuring the response of flower bud initiation to day-length in okra.

Two groups of plants in a flowering response to photoperiods were observed in this study. In the first group, flower bud initiation of 'Clemson Spineless' and 'Emerald' was promoted by short photoperiods in the spring, because flower buds were initiated at the lower node and appeared earlier. Conversely, flower bud initiation and development in 'Clemson Spineless' and 'Emerald' were delayed under long photoperiods; some plants remained at the vegetative stage for the duration of the experiment, indicating long photoperiods retarded flower bud initiation and development.

In the second group, flower buds of 'Benny', 'Gulliver', 'Natsu no Megumi', 'Star Debut', 'Star Light' and 'Suisei Gokaku' were initiated at the same node and appeared nearly simultaneously, regardless of day-length and season. Flower bud development of these cultivars reached floral stage 6 or later floral stages under any day-length treatments. These implied that day-length did not affect flower bud initiation in this group.

Reversion to the vegetative phase was observed not only in 'Clemson Spineless' and 'Emerald' but also in 'Benny', 'Star Debut' and 'Suisei Gokaku' under ND and LD in the spring. However, flower bud initiation of all cultivars continued after flower buds were formed under SD in the spring and all day-length treatments in autumn. That long photoperiod and high temperature resulted in reversion to vegetative stage in okra was confirmed in 'Clemson Spineless' and 'Emerald'. The reversion of both cultivars under long-day conditions in

the spring indicates that they strongly require a continuous short photoperiod for the induction of successive flowering, particularly at high temperature conditions. In the number of nodes bearing flower buds and time of appearance of flower buds, flower bud initiation in 'Benny', 'Star Debut' and 'Suisei Gokaku' differed little under various photoperiods. But they reverted to the vegetative phase under long-day conditions in the spring. These results imply that they still require a short photoperiod but of longer duration than 'Clemson Spineless' and 'Emerald' to initiate flower bud continuously. Reversion to the vegetative phase under unfavorable conditions was common when an induction was incomplete (Schwabe, 1971). Likewise, flower buds of *Hibiscus sabdariffa* were initiated normally under short photoperiods, but the plants reverted to vegetative phase when they were shifted to a 16-hr photoperiod after being grown for 2 weeks under an 8-hr photoperiod (Mansour, 1975).

In okra, flowering of the day-neutral plant did not respond to any photoperiod, even though that of a short-day plant was markedly delayed in long photoperiods (Arulrajah and Ormrod, 1973; Oyolu, 1977; Nwoke, 1980, 1985; Tenga and Ormrod, 1985; Wyatt, 1985). In this study, flowering of 'Clemson Spineless' was promoted by short-day, in accordance with the previous reports (Arulrajah and Ormrod, 1973; Tenga and Ormrod, 1985). In contrast, Wyatt (1985) reported that 'Clemson Spineless' did not respond to day-length. However, he measured flowering response on the basis of flowering rather than on flower bud initiation.

The promotive effects of a short photoperiod on flower bud initiation of 'Clemson Spineless' and 'Emerald' were unclear in autumn. Photoperiodic response in both cultivars may have been modified by low air temperatures. According to Salisbury (1982), it is common that a photoperiodic response is affected by temperatures. Some lower temperatures were reported to promote flowering in okra. Arulrajah and Ormrod (1973) noted that flower bud initiation of short-day okra cultivars was promoted at 25/20°C than at 30/25°C and 35/30°C under a 15-hr photoperiod. Similarly, flower bud initiation of okra was induced at cool temperature; of 30/20°C rather than 36/27°C under 12-hr and 15.5-hr photoperiods (Tenga and Ormrod, 1985).

Plant growth of okra was strongly inhibited by low temperature. In the autumn experiment, plants of all cultivars did not grow well. Tenga and Ormrod (1985) reported that vegetative growth of okra was more related to temperature than photoperiod; high night temperature produced taller plants than did cool night temperature.

Although okra plants, grown at low temperature, died after emergence; okra plants grown at high temperature reached maturity and produced fruits (Sionit et al., 1981).

Based on these results, it was thought that 'Clemson Spineless', 'Emerald', 'Benny', 'Star Debut' and 'Suisei Gokaku' require a short photoperiod for flower bud initiation, whereas 'Gulliver', 'Natsu no Megumi' and 'Star Light' are day-neutral.

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春季と秋季における数種オクラ (*Abelmoschus esculentus*) 品種の花芽形成に及ぼす日長の影響Panumart Rithichai¹・藤目幸擴¹・Sutevee Sukprakarn²・寺林 敏¹・奥田延幸³・伊達修一¹¹ 京都府立大学大学院農学研究科 606-8522 京都市左京区² Tropical Vegetable Research Center, Kasetsart University, Nakhonpathom 73140 Thailand³ 香川大学農学部 761-0795 香川県三木町

摘 要

オクラ (*Abelmoschus esculentus*) の花芽形成に及ぼす日長の影響を調べるため、春季と秋季の2回、8品種を供試して実験を行った。実験期間中の自然日長区の日長は春季では14.16~14.29, 秋季では11.07~12.17時間であった。短日区は自然日長を10時間に制限し、長日区では自然日長の日没前に蛍光灯 ($3 \mu\text{mol} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$) によって、16時間日長とした。春季実験で 'Clemson Spineless' と 'Emerald' は、自然日長区と長日区に比べて短日区では低節位に、また処理開始後早期に出らした。'Clemson Spineless' と 'Emerald' における、短日条件による花芽形成促進効果は、低温による生長抑制のためか秋季実験では顕著でなかった。'Benny',

'Gulliver', '夏のめぐみ', 'Star Debut', 'Star Light' と '翠星五角' は、日長の長短と季節に関わらずほぼ同一の節位に花芽を形成し、出らい時期もほぼ同じであった。春季実験の短日区と秋季実験の全処理区で花芽形成は連続して起こった。一方、春季実験の自然日長区、長日区の 'Clemson Spineless', 'Emerald', 'Benny', 'Star Debut' と '翠星五角' では、栄養生長への逆転が起こった。以上の結果から、'Clemson Spineless', 'Emerald', 'Benny', 'Star Debut' と '翠星五角' は花芽形成に対して短日要求性を示した。一方、'Gulliver', '夏のめぐみ' と 'Star Light' は、花芽形成に対して中性の要求性を示した。