Further Studies on the Cormel Formation in Gladiolus

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Introduction

Shoot growth of gladiolus starts from the apical bud of corms or cormels of the preceeding year's. As the shoot grows, the basal part of the shoot axis swells gradually and develops into a new corm at the position above the mother corm or cormel. In a little while, stolons grow up at the base of the newly formed corm and develop new cormels at the tip of each stolon. In the practice of corm production, cormels are used as a planting stock and cultured under good supply of water and fertilizer to produce new corms and cormels.

Although the periodical development of plants developing from corms were investigated by many workers, no investigation was yet made about that of plants from cormels except for a brief comment by IWAMA et al.[6] in which the observation was restricted within the development of a flower bud.

It is known that the yield of cormels is largely differed with different cultivars, that is, some give only a little and others produce in much quantities. The ability of cormel production depend largely on the inherent properties of species or cultivars, but the environmental factors influence the productivity.

In the previous paper,[1] it was found that in the plants developed from mother corms the short day treatment after flowering increased the yield of cormels, but on the contrary the long day treatment reduced the same. It was also pointed out that gibberellin application before and around flowering increased the yield of cormels to a slight degree under the natural photoperiod in the summer month.

It has not been investigated whether or not plants developed from mother cormels show the same response to the photoperiodic or gibberellin treatment that plants from mother corms did.

The experiments reported here were carried out to compare plants developed from mother corms with those from mother cormels on the growth habit and the response to daylength or applied gibberellic acid. Furthermore, varietal peculiarities in the effects of daylength and gibberellin on the cormel formation were ascertained.

Materials and Methods

Experiment 1. Comparison of the growth and the cormel formation between plants developed from mother corms and those from mother cormels.

A. Experiment in **1967.** Corms and cormels of the cultivar Professor Goudrian were used. Cormels of 6–10 mm in diameter were selected for this experiment and planted in the field on May 12 at the experimental farm in University of Osaka Prefecture. After the cormels had sprouted, corms weighing 6–7 g were planted on June 6, so that the flowering time of the plants developed from mother cormels (cormel plants) might be in accordance with that of those from mother corms (corm plants).

For an investigation of the periodical development of corm plants and cormel plants,

ten samples from each group were collected at weekly intervals beginning from the sprouting time until the digging day. The buds were fixed in formalin-acetic acid-alcohol and later dissected under microscope to investigate the development of a flower bud. The developmental stages of the flower bud were distinguished according to KOSUGI[8] as shown in Fig. 1. The flowering date of each plant was recorded when the first floret opened.

Plants received either the short (10 hour day light, SD), the long (10 hour day light+6 hour illumination with incandescent lamps, LD) or the natural photoperiod (ND). The procedure of the photoperiodic treatment was the same as described in the previous report[1]. The natural photoperiod ranged from 14 hours through 12 hours during the treatment period, which is considered as a short day condition. The photoperiodic treatment was begun on August 23, when the first flower came to bloom on the corm plants.

On the other hand, a half of the plants in the natural day lot was sprayed with gibberellic acid solution of 250 ppm six times at weekly intervals. The gibberellin treatment was given both corm and cormel plants from August 15, when the inflorescence of corm plants appeared among foliage leaves. This lot is designated as NG.

Both plants from corm and cormel were harvested on October 6, six weeks after the average flowering date for corm plants. The length of the longest leaf, the fresh weight of tops, corms and cormels, and the number of leaves and cormels were recorded. Then the cormels were graded according to their diameter into four grades, i.e. larger than 8, 8–6, 6–4, and smaller than 4 mm.

B. Experiment in **1968.** The cultivars used were Snow Princess and Valeria. Cormels of 7–8 mm and 8–10 mm in diameter were selected for this experiment in Snow Princess and Varelia respectively. These cormels were presoaked in tap water on May 7 to hasten the sprouting and then planted in the field on May 14. Corms of both cultivars weighing 8–12 g were later planted on June 4.

The gibberellin treatment commenced on August 6 as soon as the inflorescences of corm plants appeared. The photoperiodic treatment was carried out from August 17 when corm plants were in full-flowering, and continued until the digging day. Fifty days after the average flowering date for each lot of the corm plants, both plants from corm and cormel were harvested and the data were taken as described above. The rest of the experimental conditions were the same as already described in the case of the previous year's experiment.

Experiment 2. Varietal peculiarities of gladiolus in relation to the effects of daylength and gibberellin on the cormel formation.

This experiment was carried out concomitantly with Experiment 1–B. In this case, in addition to the above two cultivars, corms of Spotlight and Professor Goudrian were planted in the field on June 4. The rest of the procedure and experimental conditions were the same as in Experiment 1–B.

Results

Experiment 1.

1. *Periodical development.*

The data in Fig. 1 are the results of the experiment for Professor Goudrian undertaken in 1967. There were no essential differences between the results of 1967 and those of 1968, except for the flower bud differentiation and its development as described later.

After sprouting, the number of foliage leaves visible without dissection increased at the rate of one leaf per 7 or 9 days in corm or cormel plants respectively. The length of the longest leaf was increased along with the increment of the number of leaves.

Differentiation of flower primordia on corm plants occurred at the stage having 3 leaves, 30 days after planting corms. On the other hand, cormel plants differentiated flower pri-

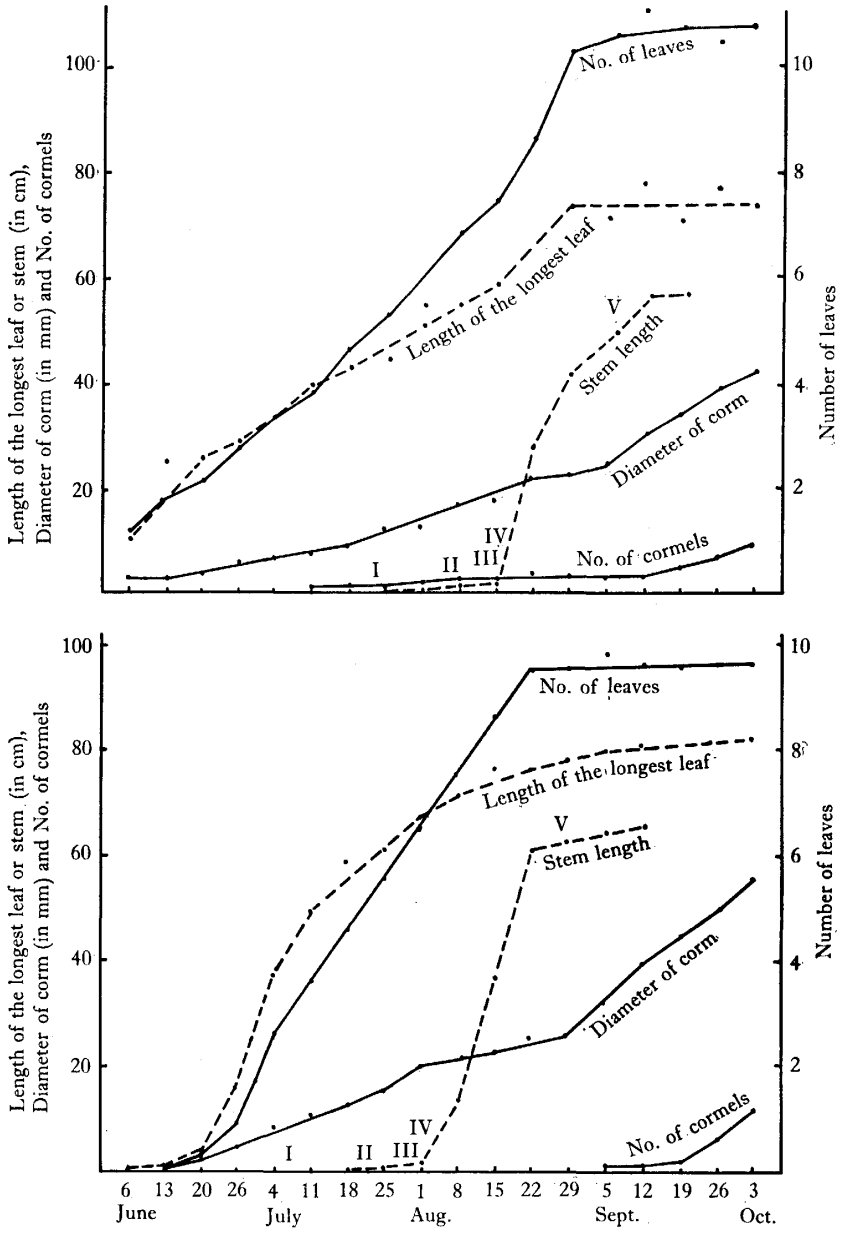

Fig. 1. Comparison of the periodical development between the plants developed from mother corms (lower) and those from mother cormels (upper) (cultivar Professor Goudrian).
I, II, ···: Showing the respective stage of the flower bud development.
I : Differentiation stage,
II : Tepal formation stage,
III: Stamen formation stage,
IV: Pistil formation stage,
V : Average flowering date.

mordia at the 5 leaf stage, about 70 days after planting cormels. But the observation in 1968 for Snow Princess and Valeria showed that flower primordia were differentiated at the 2 leaf stage in corm plants, while at the 4–5 leaf stage in cormel plants. The development of flower bud from differentiation to flowering was in the same pace with both plants from corm and cormel.

The growth of new corms in diameter progressed gradually after sprouting. It hardly took place from the appearance of the inflorescence to the opening of the first floret and thereafter became remarkable in cormel plants as well as in corm plants.

The development of new cormels occurred after flowering in corm plants, while new cormels had been already formed before the flower bud differentiation in cormel plants. But a marked increase in the number of new cormels was observed after flowering in both plants from corm and cormel.

2. *Differences between corm plants and cormel plants in the effects of daylength and gibberellin on the cormel formation.*

A. Experiment in 1967. There were no differences in the top growth among the lots in both corm and cormel plants. (Table 1) However, the top weight in corm plants was usually much heavier than that of cormel plants. Corm weight in ND and NG lots was superior to that in LD and SD lots. This result may be due to the limitation of natural day light within 10 hours per day under both short and long day conditions. But no essential differences in corm weight among the lots were observed.

Table 1. Effects of daylength and gibberellin on the growth and development of gladiolus plants. (Means of the plants in each lot, cultivar Professor Goudrian)

Lot	Number of plants used	Length of the longest leaf (cm)	Number of leaves	Fresh weight of			Number of cormels*	Percentage of flowering
				top (g)	corm (g)	cormel (g)		
The plants developed from mother corms								
LD	32	77.8	9.3	90.2	54.8	0.7	2.5 (100)	100
SD	32	80.9	9.2	88.2	56.9	1.4	11.9 (476)	100
ND	32	80.5	9.4	86.6	59.1	2.2	13.4 (100)	100
NG	32	78.5	9.5	83.5	58.3	2.1	18.2 (136)	100
The plants developed from mother cormels								
LD	75	80.7	10.4	36.4	21.8	1.0	8.4 (100)	33.3
SD	58	75.0	9.9	33.1	21.0	1.1	10.0 (114)	44.8
ND	103	76.4	10.1	37.6	24.4	1.6	12.3 (100)	65.0
NG	51	80.6	10.1	37.3	31.1	2.0	15.7 (128)	68.6

* Figures in parentheses show the number of cormels in the SD or NG lot as per cent of that of the LD or ND lot in each plant, respectively.

In corm plants, the differences in both the number of cormels and the cormel weight between LD and SD lots were remarkable. The number of cormels in the SD lot was nearly five times as large as that in the LD lot. The cormel weight in the SD lot doubled than that of the LD lot. However, in cormel plants, the difference in cormel weight between LD and SD lots was very small, but the short day treatment slightly increased the number of cormels. The results of the grading of cormels in corm plants showed that the number of cormels in all grades was larger in the SD lot than that of the LD lot. (Fig. 2)

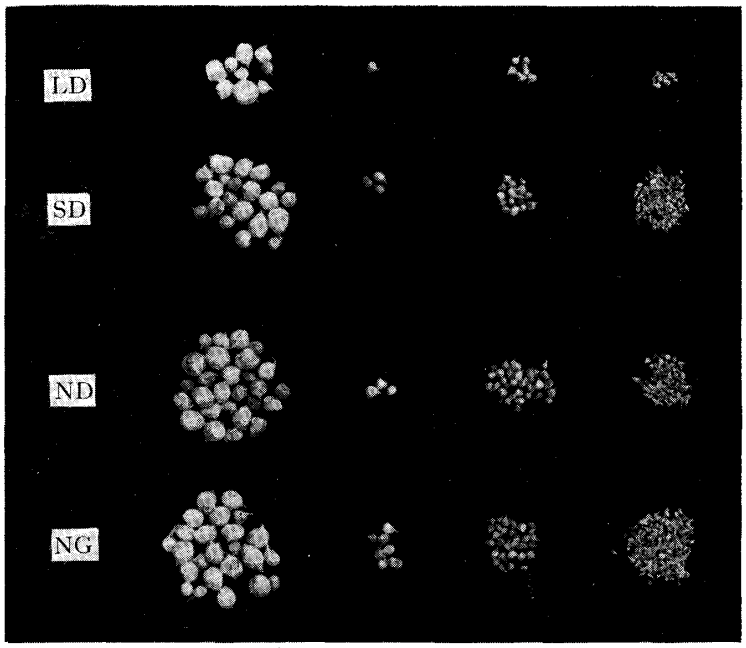

Fig. 2. Comparison of the cormels produced in the plants developed from mother corms among the long day (LD), the short day (SD), the natural day (ND) and the gibberellin treated lot (NG) (cultivar Professor Goudrian). The cormels taken from 10 plants in each lot are arranged into four grades according to their diameter. Left to right: larger than 8, 8–6, 6–4, and smaller than 4 mm in diameter.

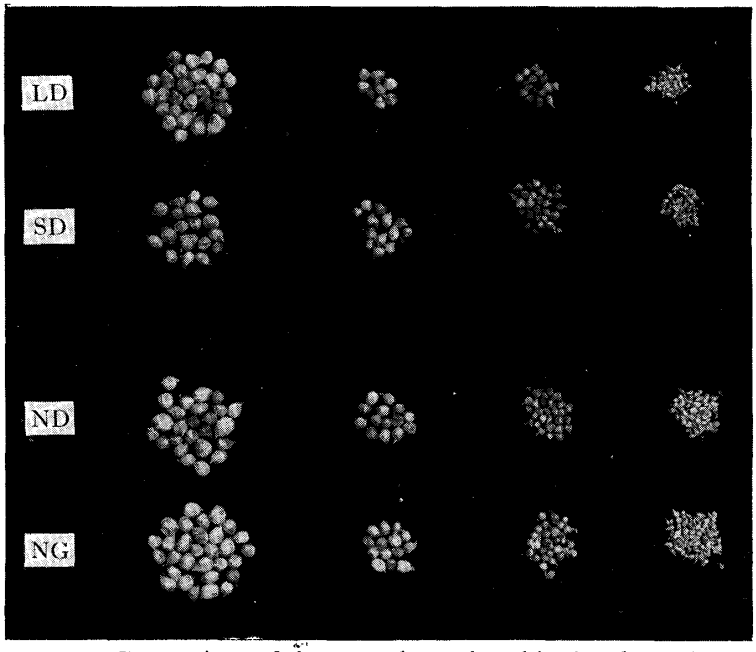

Fig. 3. Comparison of the cormels produced in the plants developed from mother cormels among LD, SD, ND and NG lots (cultivar Professor Goudrian). Abbreviations and other procedure are the same as in Fig. 2.

On the other hand, gibberellin application resulted in a considerable increase in the number of cormels in both corm and cormel plants, and the increase in the number of small cormels below 4 mm was especially remarkable. (Figs. 2 and 3)

In cormel plants, the plants in all the lots showed about 80% of flower bud differentiation, but more flower inflorescences were aborted in the LD and SD lots, probably because of the limitation of natural day light.

B. Experiment in 1968. The habit of growth recognized in Professor Goudrian in 1967 was also seen in Snow Princess and Valeria in 1968 as shown in Table 2. Namely, in corm plants, the number of cormels in the SD lot was superior to that in the LD lot. However, the promotive effect of short days on the cormel formation was remarkable in Valeria but small in Snow Princess, with which the later part of this report deals in detail. Also in cormel plants, it was ascertained that the short day condition was favourable for the cormel formation.

Furthermore, the number of cormels in both corm and cormel plants treated with gibberellin increased by 30 to 50 percent over the untreated ones, but the difference in the

Table 2. Effects of daylength and gibberellin on the growth and development of gladiolus plants. (Means of the plants in each lot)

Lot	Number of plants used	Length of the longest leaf (cm)	Number of leaves	Fresh weight of top (g)	Fresh weight of corm (g)	Fresh weight of cormel (g)	Number of cormels*	Percentage of flowering
Snow Princess								
The plants developed from mother corms								
LD	35	92.7	10.3	70.8	31.4	7.0	49.8 (100)	100
SD	35	91.2	9.9	64.6	32.3	8.0	56.6 (114)	100
ND	35	88.7	9.6	62.7	29.3	8.7	52.6 (100)	100
NG	35	87.5	10.0	61.2	31.5	9.2	73.1 (139)	100
The plants developed from mother cormels								
LD	70	81.0	9.1	23.2	14.8	4.3	57.1 (100)	44.3
SD	70	76.5	8.9	23.0	15.3	4.6	80.7 (141)	45.7
ND	56	81.8	9.3	22.3	15.0	6.5	103.9 (100)	33.9
NG	51	80.6	9.2	23.4	16.4	4.9	133.1 (128)	29.4
Valeria								
The plants developed from mother corms								
LD	32	93.4	9.1	84.1	50.0	3.9	35.3 (100)	100
SD	30	93.4	9.0	89.8	46.8	7.8	92.7 (263)	100
ND	35	89.6	8.9	86.5	46.5	8.7	81.8 (100)	100
NG	32	90.8	9.0	91.6	52.2	13.1	146.1 (179)	100
The plants developed from mother cormels								
LD	35	77.4	9.4	35.1	23.0	3.8	39.8 (100)	54.3
SD	35	76.6	8.5	30.6	22.8	5.0	75.7 (190)	48.6
ND	31	80.0	8.5	27.4	23.1	6.5	89.4 (100)	29.0
NG	28	81.1	8.5	29.3	25.6	7.1	125.8 (141)	21.4

* Figures in parentheses show the number of cormels in the SD or NG lot as per cent of that of the LD or ND lot in each plant, respectively.

weight was rather small. In the case of cormel plants in Snow Princess, the weight of the treated plants was lower than that of the untreated ones, which showed the adverse effect in respect to the number of cormels. This result could be ascribed to the fact that a large proportion of the cormels were small in all lots and that the number of cormels below 4 mm was especially increased in the NG lot as shown in Fig. 4.

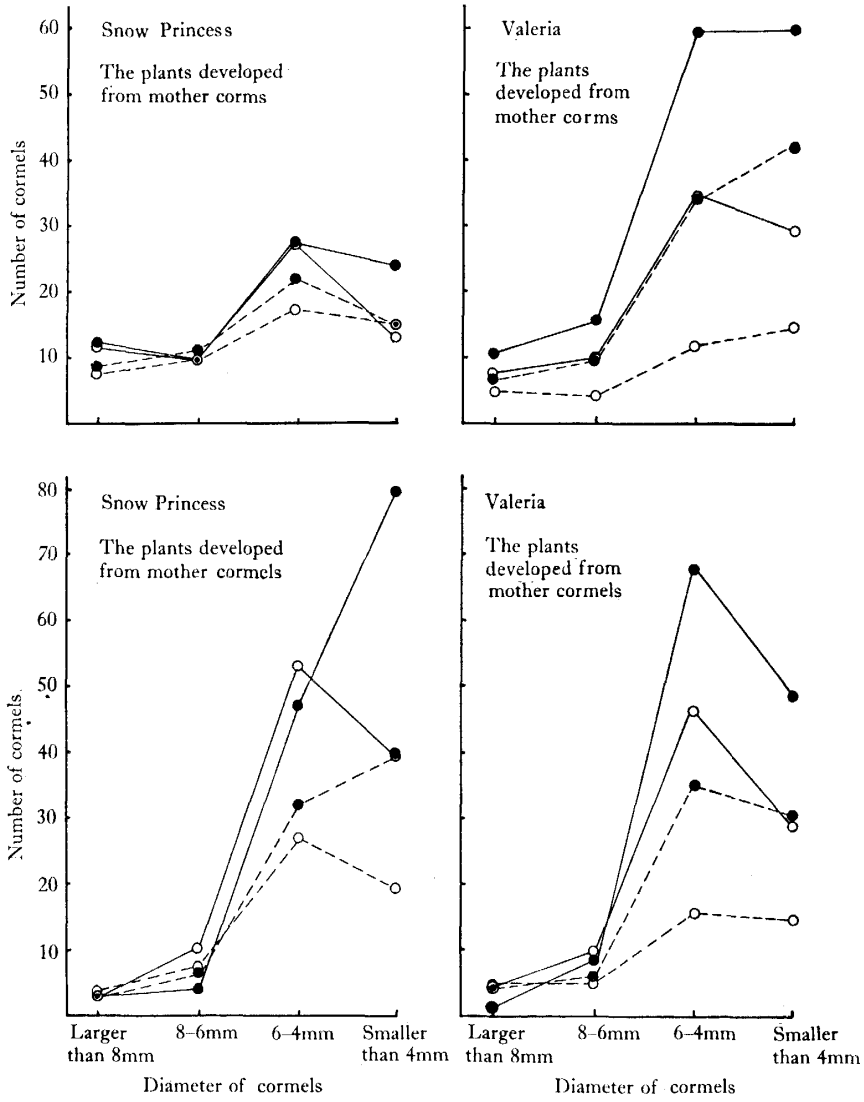

Fig. 4. The yield of cormels graded according to their diameter. ○·····○: the long day, ●·····●: the short day, ○——○: the natural day, ●——●: the gibberellin treated lot.

In cormel plants, the number of flowered plants was larger in LD or SD lots than that in ND or NG lots, regardless of the limitation of natural day light. Since most of the plants which flowered had shown the emergence of their inflorescences at the start of the photoperiodic treatment, this may not be related to such a day light condition as mentioned above with the experiment of 1967.

Experiment 2.

A great diversity was noticed among the cultivars used on the short day requirement for the cormel formation. (Table 3) The promotive effect of short days for the cormel formation

Table 3. Varietal peculiarities in the effects of daylength and gibberellin on the cormel formation.

Lot	Average number of cormels at the harvesting time			
	Snow Princess	Spotlight	Professor Goudrian	Valeria
LD	49.8 (100)	29.4 (100)	17.4 (100)	35.3 (100)
SD	56.6 (114)	40.3 (137)	61.4 (353)	92.7 (263)
ND	52.6 (100)	44.9 (100)	57.4 (100)	81.8 (100)
NG	73.1 (139)	64.0 (142)	93.7 (163)	146.1 (179)

Figures in parentheses show the number of cormels in the SD or NG lot as per cent of that of the LD or ND lot in each cultivar, respectively.

was remarkable in cultivars Professor Goudrian and Valeria, in which the number of cormels in the SD lot was 353% and 263% of that in the LD lot respectively. However, the effect was not so apparent in both cultivars, Spotlight and Snow Princess.

The effect of gibberellin application as well as the short day treatment on the cormel formation was larger in cultivars, Professor Goudrian and Valeria than in Spotlight and Snow Princess.

The progress in the number of cormels from the middle of August to the beginning of October under the natural day condition was shown in Fig. 5. In cultivars, Snow Princess and Spotlight, the cormel formation was already recognized before flowering and the number of cormels was progressively increased after flowering. On the contrary, in cutivars, Professor Goudrian and Valeria, the cormels were formed around the flowering time and increased in number rapidly 30 days after flowering.

Since the prevailing photoperiod shortens from day to day as the season advanced, the

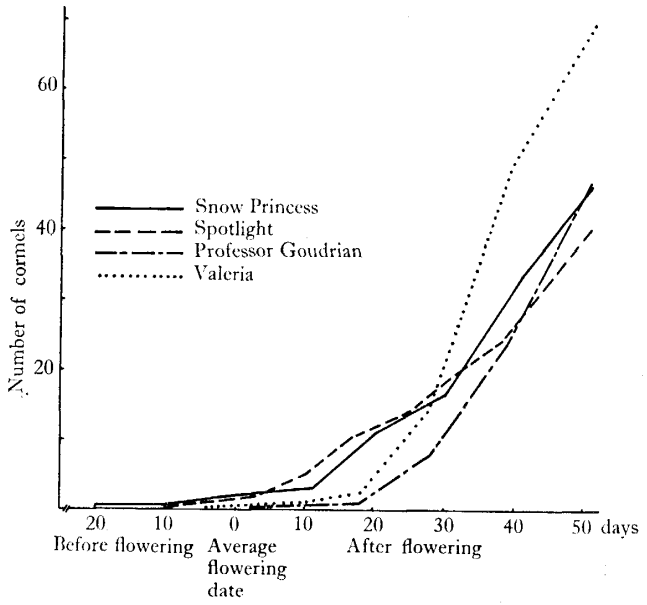

Fig. 5. Comparison among the four cultivars used of the course of increase in the number of cormels under the natural day condition from late summer to early autumn.

The curves were drawn by taking the average flowering date of each cultivar as a basis.

stronger the plant requires the short photoperiod, the later the rise in the number of cormels occurs. In cultivars, Professor Goudrian and Valeria, which exhibited the strong short day requirement, the number of cormels was increased rapidly after the plants had been subjected to the natural short day condition as shown in Fig. 5.

Discussion

From the results of these experiments it is concluded that a short day condition around and after flowering is favourable for the cormel formation in cormel plants as well as in corm plants. But the thickening of corms was hardly affected by the daylength both plants from corm and cormel. These results were entirely in line with those of the previous reports.[1)]

Numerous reports dealing with the photoperiodical induction of bulb or tuber formation have been made in several crops; onion, garlic, potato, dahlia and begonia. However, so far as we are aware, no detailed investigation in which different planting stocks result in the different responses to daylength in the bulb or tuber formation has been reported. In *Begonia evansiana* the plants raised from tubers did not readily respond to the short day treatment, while the plants developed from seeds were sensitive to short days and formed aerial tubers. But there were no differences in the effect of the short day treatment between the plants raised from underground mother tubers and those from aerial mother tubers[3)]. In dahlia plants MAATSCH et al. reported that in a certain cultivar the plants developed from mother tuberous roots did form the tuberous root even in a long day condition, while the plants from cuttings did not[9)]. Also KONISHI et al. observed that under the natural condition in autumn the plants propagated from tuberous roots formed new tuberous roots earlier than the plants propagated from cuttings did[7)].

These reports show that the sensitivity to the photoperiod is lower in the presence of mother tubers or tuberous roots. Since in gladiolus mother cormels shrink much earlier than the mother corms, and if the plants developed from the mother corms they could be more sensitive to short days. However, the promoting effect of short days on the cormel formation seemed to be smaller in the case of cormel plants than in the case of corm ones. This may be related to the time when the short day treatment is given. In corm plants the development of new cormels occurred simultaneously with the start of the photoperiodic treatment, while in cormel plants new cormels were already formed by that time. Furthermore, this may be related to the low flowering percentage in cormel plants. In corm plants it was confirmed that the cormel formation was correlative with the presence of inflorescences and when the inflorescences were aborted or removed the cormel formation hastened.[5)] Also in cormel plants, more cormels were formed in the plants having none or undeveloped inflorescences than in those having normal flowers at the start of the photoperiodic treatment.

In the previous report, the effect of gibberellin on the cormel formation could not be made clear[1)]. But it was ascertained from the data obtained here that foliar application of gibberellin just after the emergence of inflorescences promoted the cormel formation in cormel plants as well as in corm plants. OKAZAWA observed inhibition of tuber formation in intact potato plants by gibberellin treatment even if the plants were grown under a short day condition which promotes tuber formation. Gibberellin completely inhibited the tuber formation on the stem segments of potato plants cultured aseptically on the synthetic media, and it stimulated the following linear growth of lateral shoots[10)]. Further, SELMAN et al. reported that applying gibberellic acid or indole-3-acetic acid alone or in combination, to young intact plants of kohlrabi increased stem height and checked stem swelling[11)]. These results are quite adverse to ours. However, CLAVER found that gibberellin treatment lengthened the period of tuber formation and caused the formation of secondary tubers. Finally, he conclud-

ed that gibberellin promotes tuberization[2].

In the case of gladiolus, cormels are formed by swelling of the tip of the branches developed from axillary buds, which are found in the axils of the sheathing scars and the sheathing leaves[4]. So cormel formation involves the two processes of the branching of axillary buds and the swelling of those branches. Here, it come into a question whether the applied gibberellin effects on the branching or on the swelling. Further anatomical works are needed to resolve the question and a successive experiment is being advanced in this regard.

The differences among cultivars of the photoperiodic responses in tuber or bulb formation may be derived from the results of their difference in the critical daylength or the degree of requirement for favourable daylength. In onions the effect of daylength on bulbing seem to be decisive, so the varietal difference of the critical daylength is important in this case. Whereas, the cormel formation of gladiolus progresses to some extent under long daylength unfavourable for the formation, but it progresses markedly unders short day condition. Therefore, the differences among cultivars in the short day requirement for the cormel formation seem to be principal in deciding the varietal difference. Though further extensive experiments are necessary for a definite tendency to be drawn in the varietal peculiarities in the cormel formation of gladiolus, the following facts may be said from the data obtained. In the cultivars as Professor Goudrian and Valeria in which the retarding effect of long days on the cormel formation is clear, the yield of cormels is small under the lengthening photoperiod in spring to summer cultivation. In such cultivars, the following practice is recommended in order to increase the cormel production; delaying the planting time so that the period after flowering falls in the advent of the shortening days of autumn, and delaying the digging so that the plants are exposed to the short photoperiod in the field as long as possible.

Summary

1. The effects of daylength and gibberellic acid on the cormel formation and some growing features in gladioli were investigated, using corms or cormels of four cultivars, i.e. Professor Goudrian, Snow Princess, Valeria and Spotlight.

2. The cormel formation was recognized around and after flowering in the plants developed from mother corms, while new cormels had been already formed before the flower bud differentiation in the plants from mother cormels.

3. A short day condition around and after flowering was favourable for the cormel formation in the plants developed from mother cormels as well as in those form mother corms.

4. Foliar application of gibberellic acid just after the emergence of inflorescences promoted the cormel formation under the natural photoperiod from late summer to early autumn in both plants developed from mother corms and cormels.

5. A great diversity was noticed among cultivars used on the short day requirement for the cormel formation.

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