Developmental Features of Hypo-Epigeous Type Plant in the Easter Lily (*Lilium longiflorum* Thunb.)

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Received for Publication August 4, 1977.

Introduction

In Japan, the Easter lily is generally scaled during the period from August to September. The newly developed bulblets sprout their leaves above the ground in late autumn, and grow into rosette when the temperature falls. Leaves differentiate during the winter season and the stem elongates in spring. In summer, leaves and/or the stem die to turn into 'yearling'.

As for the developmental features of the scale bulblet, the following items have widely been believed: 1) The first leaves are foliage leaves (the present authors call this plant with foliage scales as 'Hypogeous Type Plant, HTP'). 2) Bolting occurs on this HTP after a certain period of time (the authors call this plant as 'Hypo-Epigeous Type Plant, HETP'). 3) The stem of HETP elongates above the ground in spring.

Thus, the general growth behaviour of the scale bulblet has been believed to be the Growth Process 1 shown in Fig. 1.

According to this belief, it was expected that early sprouting of leaves in late autumn and increase in number of leaves during the winter season result in the accumulation of assimilates promoting the stem elongation in spring, which is to be followed by the initiation of stem roots essential for bulblet enlargement.

To make the leaves sprout as early as possible, therefore, the light-scaling[6] has been recommended in many horticultural guide books, since the light-scaling results in causing leaf emergence earlier than in the dark-scaling[7]. This light-scaling usually brings forth the Growth Process 1 or 2 (Fig. 1).

For the commercial bulb production, however, the light scaling is impossible because of the following reasons: 1) It needs more labour than in the dark scaling. 2) The parent scales are apt to die because of dryness. Therefore, in the bulb producing districts, e.g., Okino-erabu, Kagoshima Pref. and Munakata, Fukuoka Pref., the Easter lily has hitherto been dark scaled.

Matsuo[2] reported that this dark scaling brought more than 80% of Epigeous Type Plants (ETPs) and that the ratio of HTPs was contrarily quite low. The former indicated the existence of the Growth Process 3 on the growth of scale bulblet under natural conditions (Fig. 1). This bolting is favourable for the enlargement of the scale bulblet, since the stem root essential for the bulb growth[8] is expected to generate readily on the bolted stem.

This work was presented at the Autumn Meeting of the Japanese Society for Horticultural Science, Kagoshima, October 15, 1977.

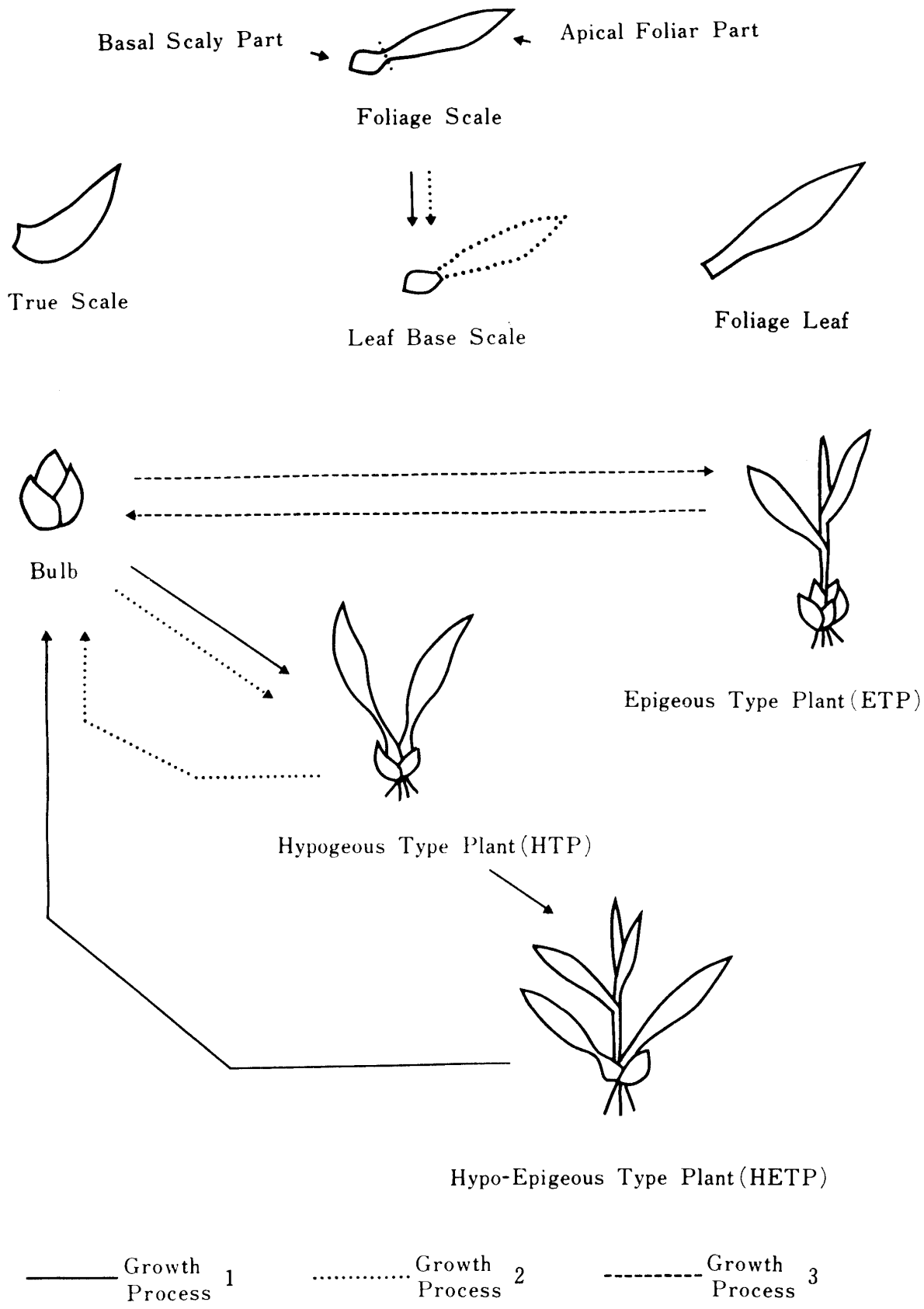

Fig. 1. Types of leaves, plants and growth sequences in lilies (Modified after Matsuo[1], and Matsuo and Arisumi[5]).

In spite of the fact that most of plantlets are ETPs in case of dark scaling as shown by Matsuo[2], they have hitherto been considered to be HTPs. This misunderstanding may be due to the extreme difficulty in distinguishing ETPs from HTPs, as the Easter lily shows rosette type growth during the winter season after the emergence of leaves, even if it bolted in autumn.

Moreover, Matsuo[3,4] reported that light promotes sprouting of foliage scales rather than promotes bolting, *i.e.*, foliage leaf development. Most of the leaves emerging at first in case of light scaling, therefore, are foliage scales as believed hitherto. In other words, it happens that when the Easter lily is light scaled, most of the plantlets are HTPs[4,6]. In the following spring, most of the HTPs as well as all of the rosetted ETPs elongate their stems above the ground. On this occasion HETPs are first to be distinguished from HTPs or ETPs.

On the other hand, Matsuo[3,6] observed some HETPs in December in both cases of light and dark scaling, though the ratio of HETPs varied with scaling factors and was generally low as compared with that in spring.

These data mentioned above lead us to the solution of the problem at what time HTPs bolt to grow into HETPs prior to noticeable stem elongation in spring.

This experiment was, therefore, designed to distinguish the developmental features of HETP from those of HTP.

Materials and Methods

The Easter lily cv. 'Hinomoto' bulbs (14~15 *cm* in girth) produced in Okino-erabu Island were obtained on July 15, 1976. They were stored at ca. 25°*C* in darkness until the commencement of the experiment on Aug. 1, 1976. 150 bulbs were soaked in 45°*C* water for 30 *min* prior to collecting the middle scales. The number of the middle scales obtained from one parent bulb was 10.1 ± 2.4. All of these parent scales were mixed up and then divided into 7 lots. They were scaled in wooden boxes ($60 \times 36 \times 12$ *cm*) filled with the mixture of sand and loam in equal volumes.

The upper 1/2~1/3 of the parent scale was exposed to the air (light-scaled). They were grown outdoors and watered as needed to maintain adequate moisture.

After the beginning of leaf emergence, 1:500 Hyponex solution was given monthly. After the end of October, when ca. 80% of the scale bulblets sprouted their leaves, plantlets were sampled with about one month interval and the number of the HETPs were counted. The HETP ratio was presented as percentage of the HETPs to the newly developed scale bulblets for each lot.

Lot number, sampling date and the number of the parent scales and those of the newly developed scale bulblets were presented in Table 1.

Results and Discussion

As shown in Fig. 2, increase in the ratio of the HETPs was observed in the two periods; during Oct. to Nov. and March to April.

1. Increase in the ratio of the HETPs during Oct. to Nov.

On account of the fact that each lot was sampled in each time, *i.e.*, the same plantlets were not observed consecutively, it was not clear whether this increase was due to

Table 1. Experimental lots, sampling dates and numbers of the parent scales and of the newly developed scale bulblets

Lot number	1	2	3	4	5	6	7
Sampling date	Oct. 28 1976	Nov. 25	Dec. 28	Feb. 1 1977	March 3	April 11	May 18
Number of parent scales	176	176	176	176	224	224	224
Number of boxes used	1	1	1	1	2	2	2
Number of scale bulblets developed	385	380	388	395	386	413	402

the sampling error or not. However, the authors are sure of the fact that the increase in the percentage of the HETPs is to be observed some time during this period, since the HETP ratios showed almost the same figures for the lots 2, 3, 4 and 5 (Fig. 2) and it was also observed that emergence of the foliage scales occurred earlier than bolting, *i.e.*, emergence of the foliage leaves[4,6].

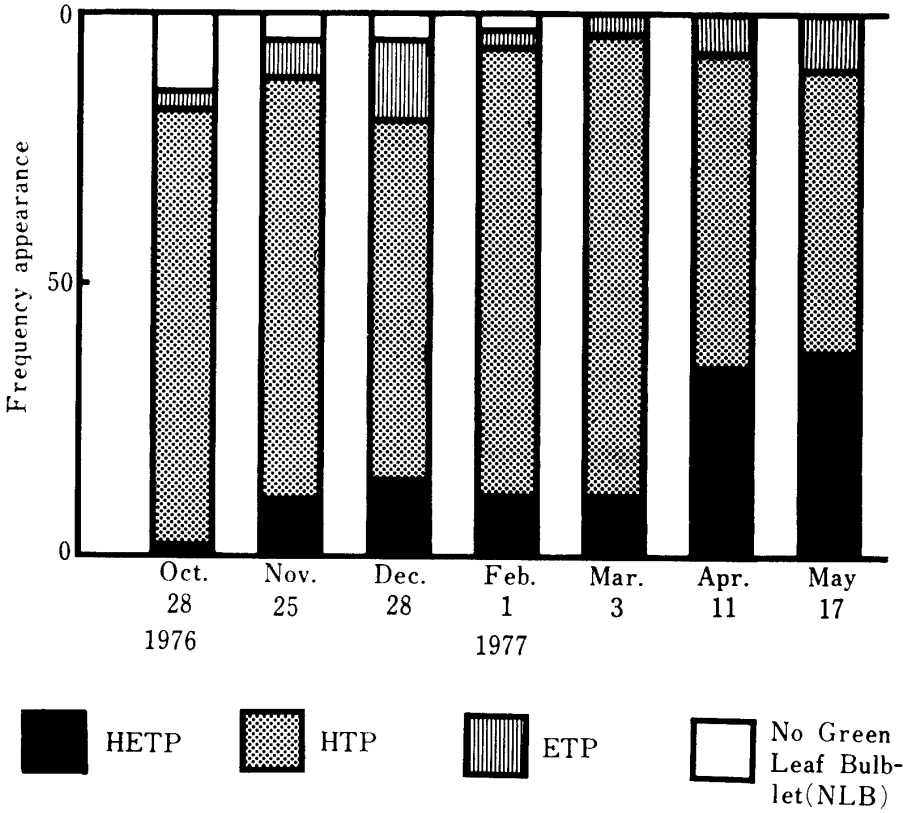

Fig. 2. Frequency appearance (%) of different plant type in the Easter lily.

Whether this may be due to the sampling error or not, it is clear that some of HETPs appear within the first 2 months after the beginning of leaf emergence of the scale bulblet.

The following situations were known or observed on these HETPs appearing in late autumn. 1) There was a tendency that the bulblet size is nearly equal to that of ETP and is greater than that of HTP[6]. 2) The frequency appearance of HETP is rather lower than in April or May (Table 2 and Fig. 2). 3) They have only 1~3 foliage scales (prelim-

inary experiment). 4) On Feb. 1 and March 3, ca. 90% of them have 1~3 foliage scales (Table 2).

Table 2. Relationship between the number of foliage scales and frequency appearance (%) of Hypo-Epigeous Type Plants (HEPTs)

Lot number	Sampling date	Average number of foliage scales	Frequency appearance of HETPs with foliage scales; 1~3	4~6	7~8	Total HETPs
4	Feb. 1	1.9±1.3	9.3	1.2	0.0	10.5
			(88.6)	(11.4)	(0.0)	(100.0)
5	March 3	2.1±1.0	9.8	0.5	0.0	10.3
			(95.1)	(4.9)	(0.0)	(100.0)
6	April 11 1977	3.8±2.0	13.6	16.6	4.1	34.3
			(39.6)	(48.4)	(12.0)	(100.0)

N.B. 1. Frequency appearance was presented as percentage of the HETPs to the scale bulblets developed on the lot.
2. Numbers in parenthesis show the percentage of the HETPs of each class to the total HETPs.

These data suggest firstly that scale bulblets which might be directed to turn into HETPs during this period, would be physiologically in an intermediate state between the Growth Processes 2 and 3 and secondly that, though bolting of HETPs is generally preceded by the emergence of foliage scales, there is a possibility that both of the emergence of foliage scales and the bolting might occur simultaneously on some scale bulblets. In reality, Matsuo[3,4] observed such bulblets though in small numbers.

2. Increase in the ratio of the HETPs during March to April

It is also not clear whether this increase was due to the sampling error or not, as noted in the case of HETP increase during Oct. to Nov. In the present case, however, two facts may be considered as a hint to solve this problem. The first is that the Easter lily develops their leaves during winter. The second is that when the plants bolt, stem roots are to be generated after a certain period of time.

According to the first hint, it is expected that, as the bolting of HTP comes to occur later, the resultant HETP is to have a greater number of foliage scale. Therefore, the number of the foliage scales was counted for the lots 4, 5 and 6. As expected, it was greater for the lot 6 than for the lots 4 and 5 (Table 2). That is, most of the HETPs had 1~3 foliage scales for the lots 4 or 5, whereas ca. 60% of HETPs had 4 or more foliage scales for the lot 6. On the preliminary experiment, the authors also observed that the HETPs appeared within 2 months after the beginning of leaf emergence, had only 1~3 of foliage scales. Therefore, these data show that ca. 60% of HETPs bolted after they had differentiated foliage scales during the winter.

The second hint indicates that when the plants bolt earlier, the resultant HETPs may be greater in the number of stem roots and/or the percentage of plants with stem roots. Thus, the number of stem roots was examined for the lots 4 and 6.

As presented in Table 3, ca. 10% of HETPs had stem roots on Feb. 1, 1977 (lot 4). About 2 months later, April 11, however, more than 30% of HETPs had stem roots but the total percentage of the HETPs with stem roots was ca. 10% of all scale bulblets de-

veloped. This was nearly equal to the percentage of the whole HETPs observed on Feb. 1. On the other hand, the HETPs without stem roots were ca. 20% of all scale bulblets, which were corresponded to ca. 60% of whole HETPs. This means that ca. 60% of HETPs bolted later than Feb. 1.

Table 3. Frequency appearance of Hypo-Epigeous Type Plants (HETPs) with stem roots

Lot number	Sampling date	Frequency appearance of HETPs with stem roots; 0	1~3	4~6	7~	Total HETPs
4	Feb. 1	9.4	0.8	0.3	0.0	10.5
		(89.5)	(7.6)	(2.9)	(0.0)	(100.0)
6	Apr. 11	22.0	8.0	3.6	0.7	34.3
		(64.1)	(23.3)	(10.5)	(2.0)	(100.0)

N.B. 1. Frequency appearance was presented as percentage of the HETPs to the scale bulblets developed on the lot.
2. Numbers in parenthesis show the percentage of the HETPs of each class to the HETPs.

As mentioned above, increasing in the number of foliage scales and high percentage of HETPs without stem roots in spring, indicate that higher percentage of HETPs for the lots 6 and 7 occurred not at the beginning of leaf emergence but it was during March that most of HTPs actually bolted to grow into HETPs.

Thus, bolting in March occurred after some foliage scales had developed. This means that the growth of plant during winter may bring forth some physiological changes which may be indispensable for the bolting in spring. This phenomenon is, therefore, quite different from the appearance of HETPs in autumn, in which the physiological condition may be an intermediate state between the Growth Processes 2 and 3.

Summary

This experiment was carried out to clarify developmental features of the Hypo-Epigeous Type Plant (HETP) in the Easter lily scale bulblets.

The ratio of HETPs was below 2% on Oct. 28, 1976, and it was ca. 10% on Nov. 25, Dec. 28, 1976, Feb. 1, or March 3, 1977. On April 11 or May 18, 1977, it was over 30%.

The number of the foliage scales of the HETP was greater on April 11 than on Feb. 1.

On April 11, the percentage of HETPs without or with stem roots was ca. 20% or ca. 10%, respectively. The latter value was nearly equal to the total percentage of HETPs on Feb. 1.

These data indicate that some of HETPs develop, at first, in late autumn, but most of HETPs in spring.

Acknowledgements

The authors want to express their gratitude to Professor Emeritus Yuzuru Ogura, University of Tokyo, and Professor Hideo Tagawa. Kagoshima University, for their

suggestions in authors' advocating the terminology in Fig. 1. Thanks are also due to Mr. Masayoshi Kobayashi, Kagoshima Prefecture Agricultural Experiment Station, for his kindness in supplying lily bulbs.

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