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Effect of Light Quality on the Tuber Sprouting of *Pinellia ternata* (Thunb.) Makino

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Summary

Pinellia ternata (Thunb.) Makino, a member of the Araceae family, is a medicinal plant, and the tubers are peeled and dried to be used as herbal medicine called “Han-ge”. *Pinellia ternata* is used in many traditional Chinese medicine prescriptions and is in high demand as herbal medicine ingredient. *Pinellia ternata* basically forms one leaf from the tuber, and the photosynthetic products form the next generation of tubers underground. In this experiment, we investigated the influence of the light quality of the cultivation light on the sprouting of the tubers, and the extent to which the tubers in the soil recognize and respond to the amount of light. The quality of the irradiated light clearly affected the sprouting of *Pinellia ternata* tubers. In the red LED light irradiation area, the tubers sprouted earlier than other light conditions and the cumulative number of sprouts was the highest. On the other hand, the other treatment areas sprouted later than the dark area, and the cumulative number of sprouts was the lowest in the blue LED irradiation area. The measurement results showed that approximately 0.5% of the light reaching the soil surface penetrates to a depth of about 5 mm from the soil surface.

INTRODUCTION

Pinellia ternata (Thunb.) Makino, a member of the Araceae family, is a medicinal plant, and the tubers are peeled and dried to be used as herbal medicine called "Han-ge". *Pinellia ternata* is used in many traditional Chinese medicine prescriptions, and is in high demand as herbal medicine ingredient, but currently it is almost entirely imported from China (Harashima, 2012). *Pinellia ternata* grows wild throughout Japan and is considered a weed in the protected cultivation fields, that is rarely actively cultivated.

In order to explore the possibility of domestic self-sufficiency, the authors borrowed facilities from Tamagawa University and attempted to produce it in a plant factory (Amaki et al., 2015). It was revealed that the life cycle of *Pinellia ternata* was repeated about once a year in the open field, but about four times a year under white-fluorescent lights in an environmentally controlled facility, but the total yield during four- time cycles was not profitable due to the production costs. In a simultaneous experiment using monochromatic light irradiation with light emitting diodes (LEDs), the sprouting of tubers was suppressed, especially under blue light irradiation. *Pinellia ternata* basically forms one leaf from the tuber, and the photosynthetic products form the next generation of tubers underground.

At the 27th IPPS-J Gifu annual meeting, we reported that six months of low temperatures (4°C) are necessary for *Pinellia ternatea* to flower, and that when grown under white-fluorescent lamps, sprouting of tubers was significantly delayed under short-day conditions compared to long-day conditions (Torii et al., 2022). In this report, we investigated the influence of the light quality of the cultivation light on the sprouting of the tubers again, and the extent to which the tubers in the soil recognize and respond to the amount of light.

MATERIALS AND METHODS

Pinellia ternata growing wild in the open field was dug up, and the tubers were planted in a 9 cm plastic pot filled with the medium of Akadama soil (small grain): Metro-mix 360 (Hyponex Japan Ltd., Oosaka, Japan) = 1:1, and cultivated and propagated in a glass greenhouse with a minimum night temperature of 16 °C until they were used for experiments. Some of the dug-up tubers were placed in a plant box (Magenta Box G7, Magenta, Chicago, USA) and stored in a refrigerator at 4 °C.

Sprouting of tubers under different light quality environments

Tubers cultivated in a greenhouse and tubers stored in a refrigerator were planted in groups of five in 9 cm plastic pots at about 1 cm depth (distance between the surface of the medium and the top of the tuber bud) filled with the medium of Akadama soil (small grain): Metro-mix 360 = 1:1 and cultivated in a fully enclosed artificial light irradiation room. The cultivation lights were white fluorescent lamps (FLR40S・EX-N/M-H, Toshiba Lighting and Technology Co., Ltd., Yokosuka, Japan), white LED (peak wavelength: 450nm + 550nm), blue LED (470nm), green LED (525nm), and red LED (660nm), and each of light was irradiated at 16 hours (8:00 – 24:00) and 8 hours of darkness (24:00-8:00). Additionally, a completely dark treatment area was also set up. The cultivation temperature was 23°C. The PPFD of the irradiation light was 80 $\mu mol \cdot m^{-2} \cdot s^{-1}$ on the soil surface. Ten pots (total of 50 tubers) were used for each experimental treatment.

Incidence of light into the medium used

The medium used in this experiment was filled to a specified thickness in a container lined with Saran Wrap (polyvinylidene chloride film; Asahi Kasei Home Products Corporation, Tokyo, Japan), and an illuminance sensor was attached to a hole in the bottom of the container. In a dark environment, the amount of light passing through the medium was measured. An illuminance meter (T-1M, KONIKA MINOLTA JAPAN Inc., Tokyo, Japan) was used.

RESULTS AND DISCUSSION

Sprouting of tubers under different light quality environments

The quality of the irradiated light clearly affected the sprouting of *Pinellia ternatea* tubers (**Fig. 1**). In the red LED light irradiation area, the tubers sprouted earlier than other light condition area and the cumulative number of sprouts was the highest. On the other hand, the other treatment areas sprouted later than the dark area, and the cumulative number of sprouts was the lowest in the blue LED irradiation area. This delay in tuber sprouting due to monochromatic light irradiation was consistent with a previous report (Amaki et al., 2015).

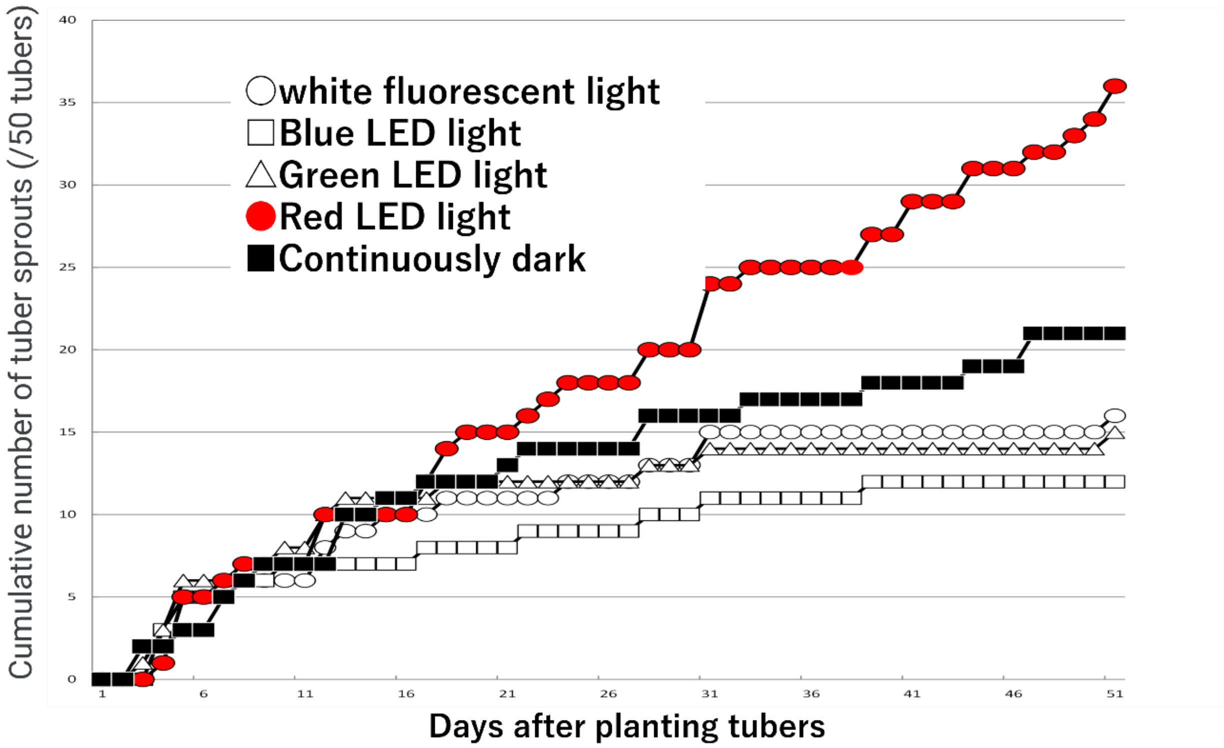

Figure 1. Effect of light quality conditions during cultivation on the sprouting of *Pinellia ternata* tubers.

Incidence of light into the medium used

However, there have been no previous studies on whether the tubers in the soil recognize the irradiated light or the limiting illuminance. The measurement results showed that approximately 0.5% of the light reaching the soil surface penetrates to a depth of about 5 mm from the soil surface (**Table 1**), and it is believed that the quality of this light is involved in the photomorphogenesis of tubers. Light other than blue light is incident up to a depth of 20 mm from the surface of the medium (**Table 1**), and it is believed that this light is recognized by the bud of *Pinellia ternata* tubers. In the cultivation experiment, the PPFD of 80 μmol・m^{-2}・s^{-1} at the soil surface is equivalent to 6,000 lx in white fluorescent light, and even if the incidence rate is 0.1%, 6 lx of light reaches a depth of 20 mm. It is known that the release of the seedling hook is a physiological response of plants to the low amount of light, and the minimum light required for this is said to be 40 μlx (Bickford and Dunn, 1972), and the light irradiation conditions used in this experiment are believed to be sufficient to have a physiological effect on *Pinellia ternata*.

Table 1 Percentage of incident light intensity by depth in the medium for cultivating *Pinellia ternata*.

Moisture condition of medium	Measurement depth (mm)	Relative light intensity (%: soil surface is 100)			
		Light quality of irradiated light			
		Mixed White LED	Blue LED	Green LED	Red LED
Dry	1	7	0.6	5.5	5.7
	5	0.6	0.1	0.4	0.5
	10	0.3	0.1	0.2	0.3
	15	0.2	0.1	0.1	0.2
	20	0.1	0	0.1	0.1
Wet	1	－*	－	－	－
	5	1.9	0.2	4.3	2.8
	10	0.3	0	0.2	0.3
	15	0.3	0	0.1	0.2
	20	0.1	0	0.1	0.1

* Did not measure at a depth of 1 mm in wet condition.

Similar experiments have been conducted for several years in our laboratory, but the numerical results of the light response seem to vary depending on the time since digging, the size of the tuber, and whether it was exposed to low temperatures. In the future, it will be necessary to examine these factors and the response to light. However, from the our results so far, it is clear that low temperature treatment causes the tuber to flower, which is a negative factor for tuber production, and that cultivation under white light in a constant environment such as a plant factory causes the tuber's secondary buds to form secondary tubers on top of the parent tuber, resulting in a shape that is unsuitable for use as a herbal medicine (Amaki et al., 2015; Torii et al., 2022). Since it is also clear from multiple experiments that blue light suppresses tuber sprouting, it may be possible to suppress secondary spherical sprouts and cultivate tubers with a shape suitable for herbal medicines by irradiating blue light when the leaves wither.

LITERATURE CITED

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