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# MEASUREMENT OF DIURNAL CHANGE IN TUBER GROWTH OF SWEET POTATO PLANTS

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EGUCHI T., KITANO M. and EGUCHI H. *Measurement of diurnal change in tuber growth of sweet potato plants*. BIOTRONICS **26**, 67–72, 1997. Tuber volume of sweet potato plants (*Ipomoea batatas* Lam.) was measured in course of time by applying an on–line laser micrometer (LM) system, and diurnal change in tuber growth was analyzed. Tuber growth rate fluctuated synchronizing with the photoperiod, where the growth rate in the light was kept lower than that in the dark. Rapid increase and decrease in the growth rate were occurred after darkening and lightening, respectively. These results suggest that tuber growth of sweet potato plants responds to changes in the shoot environment, and the growth response was considered to be related to leaf transpiration through dynamics of plant water balance. Thus, diurnal pattern of tuber growth in sweet potato plants was revealed clearly by using the LM system.

**Key words:** *Ipomoea batatas* Lam.; tuber growth; diurnal change; on–line measurement; laser micrometer

## INTRODUCTION

Diurnal changes in growth of sink organs have been reported for fruit crops (*3, 4, 6, 7*), and those changes are considered to be related to environmental factors. In root crops as sweet potato plants (*Ipomoea batatas* Lam.), however, diurnal pattern of tuber growth remains unclear because of difficulties in on–line measurement of growth of the intact tuber. In the preceding paper (*2*), an on–line system for non–destructive measurement of tuber volume in sweet potato plants was developed by applying a laser micrometer (LM). The present paper deals with a measurement of diurnal change in tuber growth of sweet potato plants by using the LM system.

## MATERIALS AND METHODS

### *Plant materials*

Cut–stems of sweet potato plants (cv. Koganesengan) were cultured for about one month at an air temperature of 28℃ and a relative humidity of 70% under the natural light condition. After the cultivation, the plant with a single tuber was prepared as described previously (*1*), where fibrous roots directly

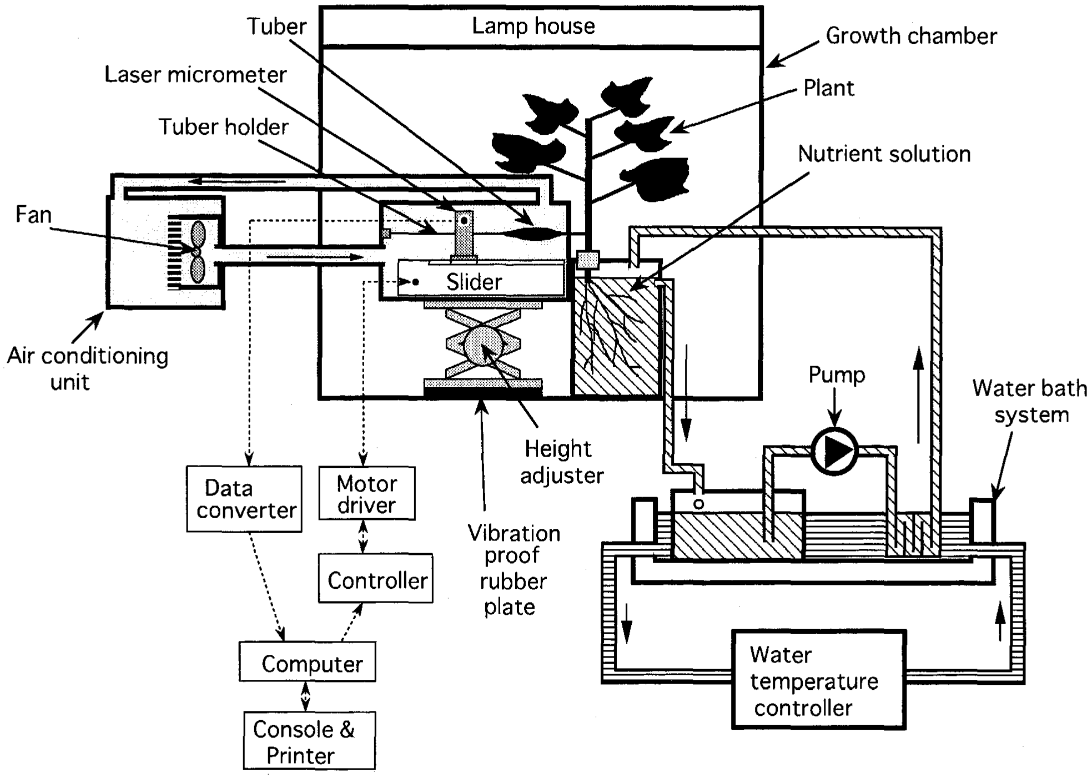


Fig. 1. Schematic diagram of a hydroponic system for time course measurement of tuber growth in sweet potato plants under controlled environments.

extended from the tuber were all excised. Five leaves at least were kept in the material plant, because the single tuber of the plant with three leaves shows source–limited growth (*1*).

*Tuber growth measurement and environmental conditions*

For growth analysis of intact tuber, the LM system for tuber volume measurement was installed in the hydroponic system, where the tuber was grown in the air space (*2*). Figure 1 shows a schematic diagram of the hydroponic system for on–line measurement of tuber growth under controlled environment. Shoot environment was controlled by a growth chamber at an air temperature of 28℃, a relative humidity of 70%, a light intensity of 300 $\mu$mol $m^{-2}$ $s^{-1}$ and a photoperiod of 12 h (07 : 00–19 : 00). Tuber environment was controlled by an air conditioning unit at an air temperature of 28℃, a relative humidity of 70%. Fibrous root environment was controlled by a water bath system at a nutrient solution temperature of 28℃. Tuber volume was measured by using the LM system at 30 min intervals. The measurement was carried out for five plants.

## RESULTS AND DISCUSSION

By using the LM system, diurnal change in volume was clearly observed in

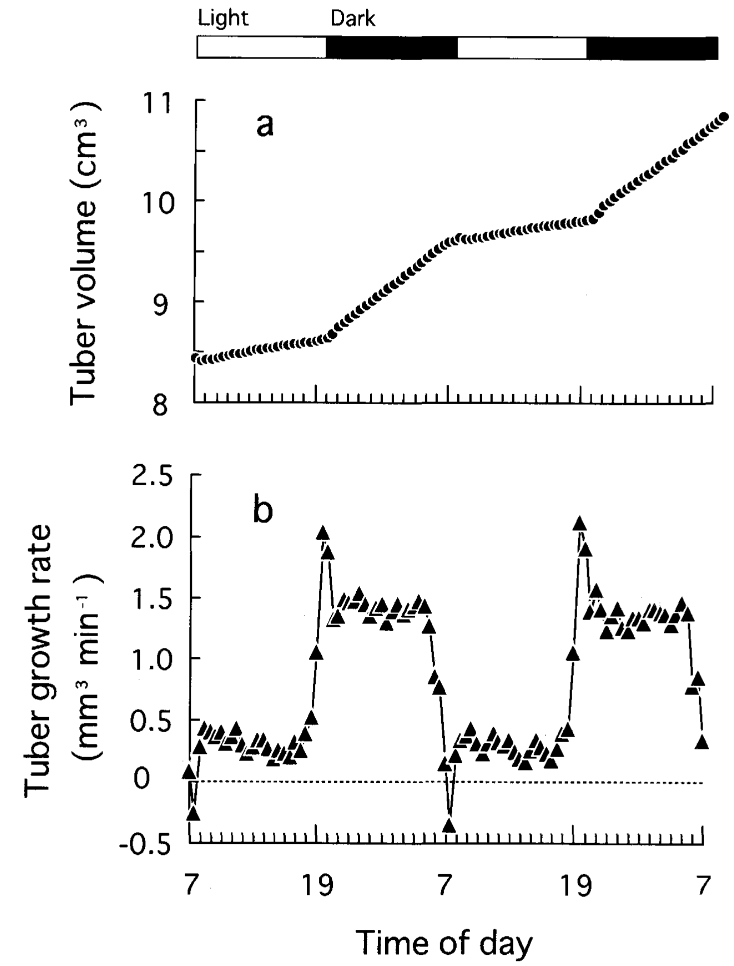


Fig. 2. Time course patterns of tuber volume (a) and the growth rate (b) in a sweet potato plant.

sweet potato tubers growing in the hydroponic system. Figure 2 shows examples of time course patterns of tuber volume (a) and the growth rate (b). Tuber volume changed with diurnal rhythm, and the volume increased largely in the dark. Tuber growth rate increased rapidly just after darkening and reached a peak. Thereafter the growth rate became almost steady during 21 : 00–05 : 00. On the other hand, the growth rate dropped to negative value temporarily after lightening, and subsequently the growth rate was almost steady during 09 : 00–18 : 00. The steady growth rate in the light was apparently lower than that in the dark. This diurnal fluctuation of tuber growth rate was commonly observed in all tubers with different sizes.

Figure 3 shows relationships between tuber size and tuber growth rates per unit volume (i.e. relative growth rates) under the respective steady states in the dark and in the light. There was no significant correlation between relative growth rate and tuber size, and almost the same growth rates were found in all tubers under the respective light conditions. This means that high reproducibility of relative growth rate can be expected in tubers with different

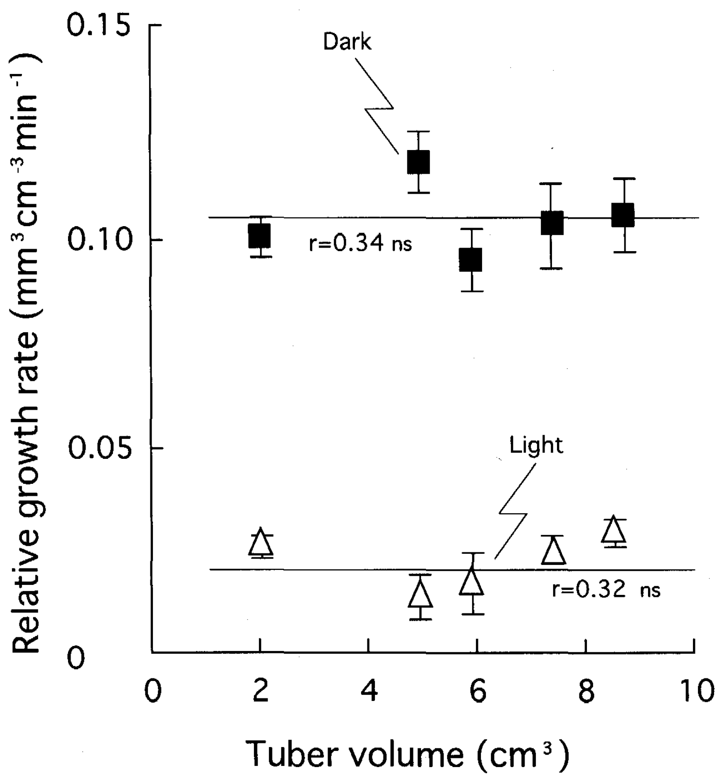


Fig. 3. Relationships between tuber size and relative growth rates under the respective steady states in the dark and in the light. Means of relative growth rates in the dark during 21:00–05:00 and those in the light during 09:00–17:00 are plotted with 95% confidence intervals. Regression lines of those growth rates are shown with correlation coefficients (ns: not significant).

sizes grown under the identical condition of controlled environment. Therefore, typical pattern of diurnal change in tuber growth under the environmental condition of this study was represented as Figure 4, where means of relative growth rates obtained from five plants are plotted. The peak (*PK*) of 0.17 $mm^3$ $cm^{-3}$ $min^{-1}$ arose just after darkening, and thereafter relative growth rate in the dark (*DGR*) was kept at about 0.11 $mm^3$ $cm^{-3}$ $min^{-1}$. Just after lightening, the growth rate dropped to the bottom (*BT*) of $-0.04$ $mm^3$ $cm^{-3}$ $min^{-1}$, and thereafter the growth rate in the light (*LGR*) was kept at about 0.02 $mm^3$ $cm^{-3}$ $min^{-1}$. Thus, relative growth rate of a sweet potato tuber fluctuated synchronizing with the photoperiod, and the growth was obviously depressed in the light. The depressed sink growth in the light was also observed in various fruit crops (*3, 4, 6, 7*). Especially in orange (*3*) and tomato (*4*) plants, it has been reported that fruit growth was depressed under low water potentials in leaf and stem resulted from active leaf transpiration during the daytime. In regard to transient changes in tuber growth as *PK* and *BT*, it has been reported that temporary disturbances of water balance in a cucumber plant just after darkening and lightening were buffered by the stem water storage (*5*). The similar event as observed in a cucumber stem may occur in a sweet potato tuber

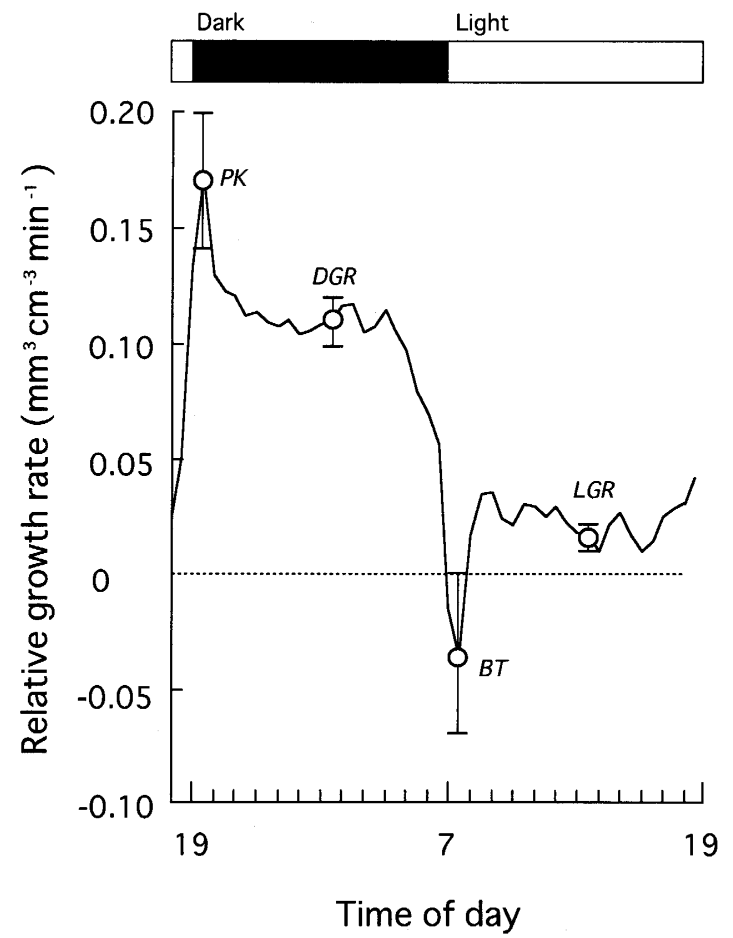


Fig. 4. Typical pattern of diurnal change in relative growth rate of a sweet potato tuber. Means of relative growth rates measured in five plants are plotted. The growth rates at the peak (*PK*), the bottom (*BT*), and the stedy states in the dark (*DGR*) and in the light (*LGR*) are shown as open circles with 95% confidence intervals. Those are means at 19:30, 01:30, 07:30 and 13:30, respectively.

at times just after darkening and lightening. From these facts, tuber growth of sweet potato plants was considered to be affected by leaf transpiration through dynamics of plant water balance.

In this study, tuber volume of sweet potato plants grown under controlled environment was measured in course of time by using the LM system, and diurnal pattern of tuber growth in sweet potato plants was revealed clearly.

## REFERENCES


1. Eguchi T., Kitano M. and Eguchi H. (1996) New system of hydroponics for growth analysis of sweet potato tuber. *Biotronics* **25**, 85–88.
2. Eguchi T., Kitano M. and Eguchi H. (1997) On-line system for volume measurement in sweet potato tuber. *Biotronics* **26**, 103–106.
3. Elfving D.C. and Kaufmann M.R. (1972) Diurnal and seasonal effects on plant water

relations and fruit diameter of citrus. *J. Am. Soc. Hort. Sci.* **97**, 566–570.

4. Johnson R. W., Dixon M. A. and Lee D. R. (1992) Water relations of the tomato during fruit growth. *Plant, Cell and Environ.* **15**, 947–953.
5. Kitano M. and Eguchi H. (1989) Quantitative analysis of transpiration stream dynamics in an intact cucumber stem by a heat flux control method. *Plant Physiol.* **89**, 643–647.
6. Tromp, J. (1984) Diurnal fruit shrinkage in apple as affected by leaf water potential and vapour pressure deficit of the air. *Sci. Hort.* **22**, 81–87.
7. Turkey, L. D. (1964) A linear electric device for continuous measurement and recording of fruit enlargement and contraction. *J. Am. Soc. Hort. Sci.* **84**, 653–660.