ON-LINE SYSTEM FOR VOLUME MEASUREMENT IN SWEET POTATO TUBER

Eguchi, Toshihiko
Biotron Institute Kyushu University

Kitano, Masaharu
Biotron Institute Kyushu University

Eguchi, Hiromi
Biotron Institute Kyushu University

出版情報：BIOTRONICS. 26, pp.103-106, 1997-12. Biotron Institute, Kyushu University
バージョン：

ON-LINE SYSTEM FOR VOLUME MEASUREMENT IN SWEET POTATO TUBER

T. Eguchi, M. Kitano and H. Eguchi

Biotron Institute, Kyushu University 12, Fukuoka 812-8581, Japan

(Received March 31, 1996; accepted April 15, 1996)

Eguchi T., Kitano M. and Eguchi H. *On-line system for volume measurement in sweet potato tuber.* BIOTRONICS **26**, 103–106, 1997. An on-line system for non-destructive measurement of tuber volume in sweet potato plants (*Ipomoea batatas* Lam.) was newly developed by applying a laser micrometer (LM). Diameters of the tuber were scanned by moving the LM along the longitudinal axis of the tuber at constant speed, and the volume was evaluated by an integral method. The LM system made it possible to measure volume of an attached tuber with high accuracy and resolution.

Key words: *Ipomoea batatas* Lam.; laser micrometer; on-line system; tuber volume

INTRODUCTION

Tuber growth in sweet potato plants (*Ipomoea batatas* Lam.) has been analyzed by destructive measurement of dry weights or diameters of tubers harvested at intervals of several days (*3–6*), and an on-line measurement of growth of an intact tuber remains difficult. A laser micrometer (LM) is a device for non-contact measurement of diameter of an object held in the air. In the previous paper (*2*), it was demonstrated that a sweet potato tuber can grow in an air space of a hydroponic system newly developed. Therefore, the LM is considered to be applicable to on-line measurement of size of a sweet potato tuber growing in the air space of the hydroponic system. The present paper deals with an LM system for on-line measurement of tuber volume in sweet potato plants.

MEASUREMENT SYSTEM

Laser micrometer system and tuber volume evaluation

Figure 1a shows a schematic diagram of an on-line LM system newly developed for tuber volume measurement. The system consisted of a LM with a data converter (3Z4L-4403V, Omron Corp., resolution: $0.05\,\mu m$), a slider unit (slider: SPH20B10-2PD; motor driver: DFU1514; controller: LPC100M, Oriental Motor Corp.) and a personal computer (PC-9801DA, NEC). The LM settled on the slider was moved along the longitudinal axis of a tuber at constant speed,

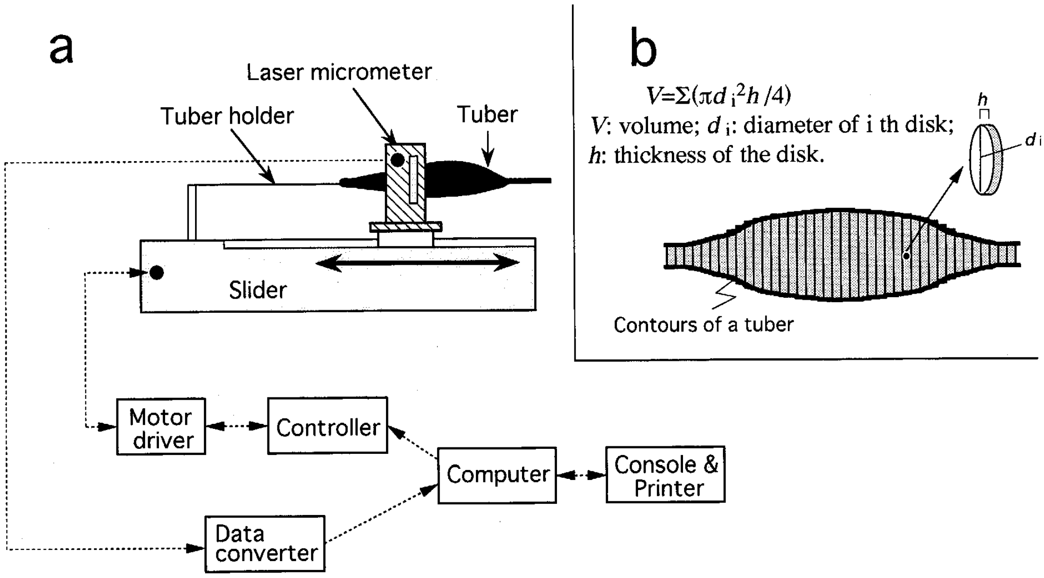

Fig. 1. Schematic diagram of a laser micrometer (LM) system for on-line measurement of tuber volume of sweet potato plants (a), and method of tuber volume evaluation (b).

Table 1. Moving speed, sampling interval of diameter data and disk thickness for tuber volume evaluation in each measuring condition (A~D) of the LM system.

Measuring condition	Moving speed of the LM ($mm\ s^{-1}$)	Sampling interval (ms)	Disk thickness (μm)
A	5	22.5	112.5
B	5	45.0	225.0
C	10	22.5	225.0
D	10	45.0	450.0

and diameters of the tuber were scanned. The linear movement of the LM was controlled by the computer through the slider controller. Scanning range of the LM system covered 30 mm (sensing range of the LM) × 200 mm (moving range of the LM on the slider). As shown in Figure 1b, tuber volume was evaluated by an integral method summing up volumes of thin disks as

$$V=\Sigma(\pi d_i^2 h/4),$$

where d_i is the i th disk diameter and h is the disk thickness determined by time interval of d_i sampling and moving speed of the LM. In this evaluation, tuber was defined as thickened part more than 3 mm in diameter (*1*), and thinner parts (d_i<3 mm) were excluded from the volume evaluation.

Plant materials and measurement conditions

Attached tubers differed in size and shape were used to examine a performance of the LM system in tuber volume measurement. Tuber volume was measured by using the LM system under four measuring conditions with different sampling intervals and moving speeds of the LM (A~D in Table 1), and thereafter each volume (V_{LM}) measured by using the LM system was compared with the tuber volume (V_{MC}) measured by using a measuring cylinder.

SYSTEM PERFORMANCE

Table 2 shows a comparison between V_{LM} and V_{MC} in tubers with different sizes and shapes. V_{LM} was almost the same with V_{MC} in all tubers under each measuring condition. Good agreement of V_{LM} with V_{MC} was confirmed by the linear regression analysis in each measuring condition: the regression equation between V_{LM} and V_{MC} was almost equivalent to $V_{MC}=V_{LM}$ ($r=0.999$, $P<0.001$). Variances in V_{LM} represented as 95% confidence intervals (CI) were extremely smaller than those in V_{MC}, and CI under the measuring condition of "C" seemed to be smaller than those under other conditions. These facts suggest that the tuber volume, irrespective of the size and shape, can be evaluated with high accuracy and resolution by using the LM system, and the measuring condition of "C" was considered to be appropriate condition in the LM system. Furthermore,

Table 2. Tuber volumes (V_{LM}) measured by using the LM system at various measuring conditions (A~D) and the comparison with the volume (V_{MC}) measured by the measuring cylinder method. Means of five measurements with 95% confidence intervals are shown. Sizes and shapes of tubers used are shown as the length, maximum diameter and shape index.

Length, L (mm)	Max. diameter, D (mm)	Shape index, L/D	V_{MC} (cm^3)	V_{LM} (cm^3) Measuring condition of the LM system			
				A	B	C	D
39	8.0	4.88	0.94 ±0.06	0.9421 ±0.0001	0.9408 ±0.0002	0.9408 ±0.0001	0.9404 ±0.0007
78	11.8	6.61	4.56 ±0.06	4.5659 ±0.0004	4.5599 ±0.0007	4.5598 ±0.0003	4.5566 ±0.0006
58	18.5	3.14	10.90 ±0.05	10.9000 ±0.0007	10.8921 ±0.0009	10.9027 ±0.0002	10.9017 ±0.0001
115	15.0	7.67	11.68 ±0.14	11.6851 ±0.0004	11.6787 ±0.0008	11.6753 ±0.0002	11.6789 ±0.0002
70	22.0	3.18	16.64 ±0.07	16.6390 ±0.0002	16.6412 ±0.0003	16.6425 ±0.0002	16.6407 ±0.0007
77	24.0	3.21	24.97 ±0.05	24.9561 ±0.0003	24.9506 ±0.0004	24.9581 ±0.0004	24.9551 ±0.0011
Linear regression equation (y; V_{MC}, x; V_{LM})				y=0.999x +0.130	y=0.999x +0.188	y=0.999x +0.008	y=0.999x +0.018
Correlation coefficient				r=0.999***	r=0.999***	r=0.999***	r=0.999***

***Significant at 0.1% level.

the drift induced by temperature changes in the LM system was found to be negligibly low, which was less than 0.01 μm/℃ (data not shown). Thus, the on-line LM system made it possible to measure volume of an attached tuber of sweet potato plants with high accuracy and resolution.

REFERENCES

1. Eguchi T., Kitano M. and Eguchi H. (1994) Root temperature effect on sink strength of tuberous root in sweet potato plants (*Ipomoea batatas* Lam.). *Biotronics* **23**, 75–80.
2. Eguchi T., Kitano M. and Eguchi H. (1996) New system of hydroponics for growth analysis of sweet potato tuber. *Biotronics* **25**, 85–88.
3. Kim Y. C. (1961) Effects of thermoperiodism on tuber formation in Ipomoea batatas under controlled conditions. *Plant Physiol.* **36**, 680–684.
4. Kokubu T. (1972) Thremmatological studies on the relationship between the structure of tuberous root and its starch accumulation in sweet potato varieties. *Bull. Fac. Agr., Kagoshima Univ.* **22**, 1–126.
5. Low S. B. and Wilson L. A. (1974) Comparative analysis of tuber development in six sweet potato (*Ipomoea batatas* (L.) Lam.) cultivars. 1. Tuber initiation, tuber growth and partition of assimilate. *Ann. Bot.* **38**, 307–317.
6. Naka J. (1962) Physiological studies on the growing process of sweet potato plants. *Mem. Fac. Agr., Kagawa Univ.* **9**, 3–96.