EFFECT OF ROOT TEMPERATURE ON SINK STRENGTH OF TUBEROUS ROOT IN SWEET POTATO PLANTS (IPOMOEA BATATAS LAM.)

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EFFECT OF ROOT TEMPERATURE ON SINK STRENGTH OF TUBEROUS ROOT IN SWEET POTATO PLANTS (*IPOMOEA BATATAS* LAM.)

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Eguchi T,. Kitano M. and Eguchi H. *Effect of root temperature on sink strength of tuberous root in sweet potato plants* (Ipomoea batatas *Lam.*). BIOTRONICS **23**, 75–80, 1994. Eflect of root temperature on sink strength of tuberous root in sweet potato plants was examined at root temperatures of 20 to 32℃ under a constant air condition of 28℃ and 70% RH. Dry weight, volume and dry matter content of tuberous root became higher at root temperatures of 24 to 26℃. However, sink strength of tuberous root, which was estimated by its dry weight per unit leaf area, was highest at a root temperature of 24℃ possibly because of lower sink activities at lower root temperatures and lower sink capacities with higher respiratory loss at higher root temperatures.

Key words: *Ipomoea batatas* Lam.; tuberous root; root temperature; sink–source relationship; sink strength; translocation

INTRODUCTION

Translocation of photoassimilates is affected by both source and sink properties through changes in the assimilate concentrations in the organs (*3, 5, 7, 13*). There are several reports indicating the interactions between properties of source and sink, i.e. sink–regulation of photosynthesis and source–regulation of sink growth (*1, 11, 12*). Sink strength is defined as the absolute rate of assimilate import by sink organ, which can be obtained from the rate of dry matter accumulation as rough estimates (*14*). Environmental effects on sink strength can be examined by changes in sink properties such as sink capacity (e. g. organ size) and sink activity (e. g. rate of starch synthesis). In sweet potato plants (*Ipomoea batatas* Lam.), major part of assimilate flow can be studied as a single direction from source leaf to tuberous root by excision of terminal and axillary buds, and the present paper deals with analysis of root temperature effect on sink strength of tuberous root in sweet potato plants under controlled environments.

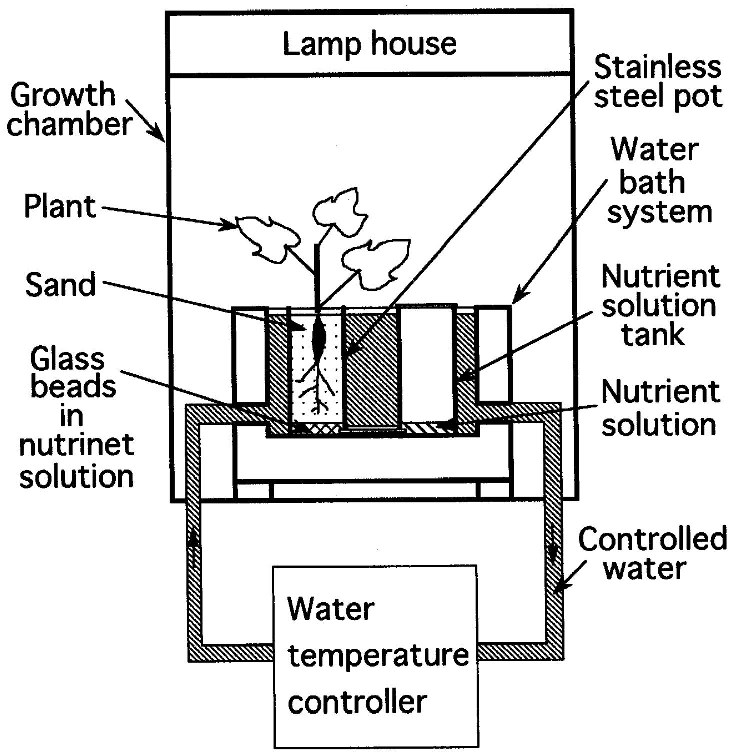

Fig. 1. Schematic diagram of root temperature control system.

MATERIALS AND METHODS

Plant materials

Stems with three unfolding leaves (fourth, fifth and sixth leaves from the apex) were cut from sweet potato plants (*I. batatas* cv. Koganesengan) grown at an air temperature of 25℃ and a relative humidity of 70% in a phytotron glass room. Terminal and axillary buds were excised, and the cut-stems were cultured for rooting in the phytotron glass room, where the leaves were shaded for depressing water loss. After 10 d cultivation, all roots except for the longest primary root were excised, and the plants with the single primary root and three leaves were used for plant materials.

Environment control

Figure 1 shows the schematic diagram of root temperature control system. A water bath system was applied to root temperature control, where temperature-controlled water was circulated into the bath. Cylindrical stainless steel pot (21 cm height, 11 cm diameter) was filled with sand (0.15 to 2 mm grain diameter) in 18 cm thickness on 2 cm thick bottom layer of glass beads (5 mm diameter). The pots were placed in the water bath, and a nutrient solution tank was connected to supply nutrient solution at the level of glass beads layer. The material plants were transplanted to the pots, and the temperature of 7 cm depth, where the most thickened region of tuberous root was located, was represented as the root temperature. The root temperature was controlled at the respective desired values of 20, 22, 24, 26, 28, 30 and 32℃ with an accuracy of ±0.2℃. The water bath system was installed in a growth chamber (*10*), where the environment was controlled at an air temperature of 28℃, a relative humidity of 70% and a light intensity of 300 μmol m^{-2}s^{-1} (fluorescent lamps and incandescent lamps) in photoperiod of 12 h.

Analyses of root temperature effects

After transplanting the material plants to the root temperature control system, the plants were grown at a root temperature of 28℃ for 5 d, where the leaves were covered with polyethylene bags for depressing water loss. At the beginning of this experiment, the polyethylene bags were removed, and the root temperature was set at each desired value. Four plants were sampled at 40 d for measuring leaf area, volume of tuberous root, fresh and dry weights of each organ (leaf, stem, petiole, tuberous root and fibrous root). Tuberous root was defined as the thickened region of the primary root more than 3 mm in diameter. Volume of tuberous root was measured by soaking tuberous root into water in a measuring cylinder.

RESULTS AND DISCUSSION

Tuberous root formed at the respective root temperature conditions. Formation of tuberous root was examined by dry matter accumulation. Figure 2 shows dry weight of tuberous root at different root temperatures. Dry weight of tuberous root became higher at root temperatures of 24 to 26℃; the optimum root temperature for dry matter accumulation in tuberous root was 24 to 26℃. Dry weights at root temperatures of 20, 30 and 32℃ were lower than those of 24 and 26℃ (significant at 5% level).

Figure 3 shows volume of tuberous root at different root temperatures. Volume of tuberous root became higher at root temperatures of 24 to 26℃. Volumes of tuberous root at root temperatures of 30 and 32℃ were lower than those of 24 and 26℃ (significant at 5% level). Such lower volumes of tuberous root at the higher root temperatures could result in decrease in dry weight (Fig. 2). From the results, it was suggested that sink capacity of tuberous root is higher at root temperatures of 24 to 26℃ and is decreased at the higher temperatures.

Figure 4 shows dry matter content (dry weight / fresh weight) in tuberous root at different root temperatures. Dry matter content became higher at root temperatures of 24 to 26℃ and it was depressed at a root temperature of 20℃. Such lower dry matter content at a root temperature of 20℃ could result in decrease in dry weight (Fig. 2). Kimbrough (*9*) has suggested that the difference in dry matter content among tuberous roots under various environmental conditions is caused by the difference in starch accumulation, and temperature effect on starch accumulation has been reported in some plants (*2,*

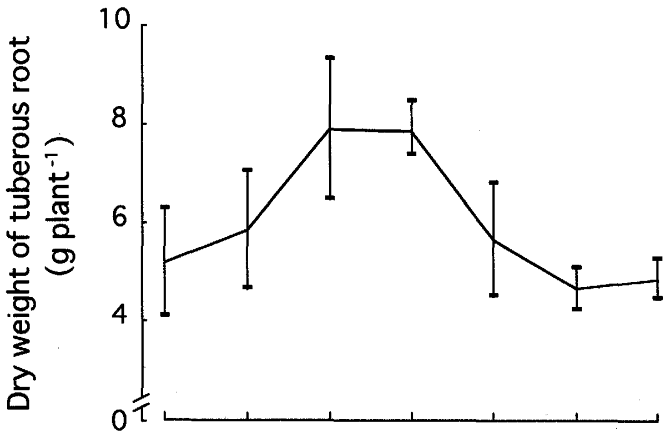

Fig. 2. Dry weight of tuberous root at different root temperatures. Means of four plants are plotted with 95% confidence intervals.

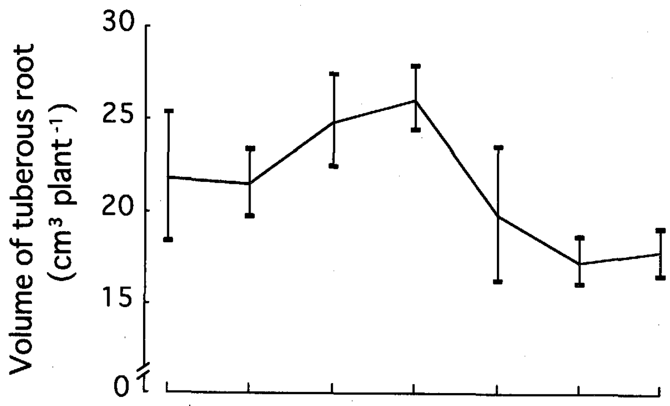

Fig. 3. Volume of tuberous root at different root temperatures. Means of four plants are plotted with 95% confidence intervals.

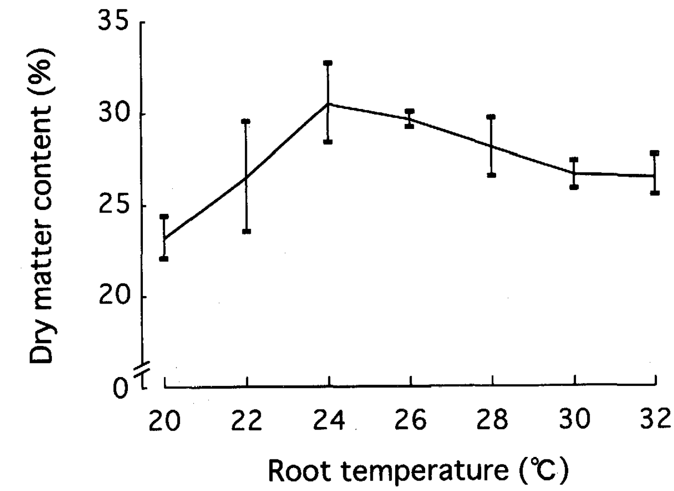

Fig. 4. Drymattercontentintuberous root at different root temperatures. Means of four plants are plotted with 95% confidence intervals.

4, 6, 8, 13). Engels and Marschner (*4*) have found that starch accumulation in potato tuber is depressed at low sink temperature by the decreased activity of starch synthesizing enzymes. From these facts, it was suggested that sink

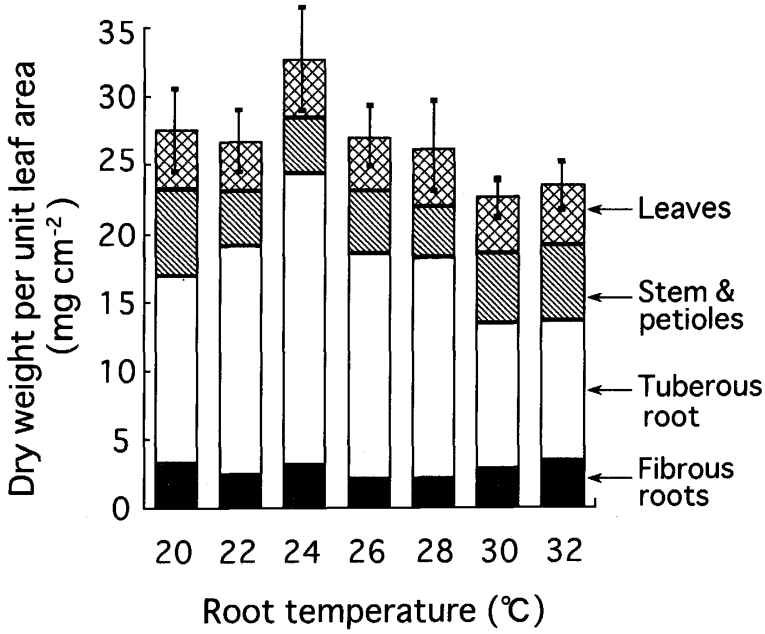

Fig. 5. Dry weight of each organ per unit leaf area at different root temperatures. Means of four plants are plotted. Bars show the 95% confidence intervals of the total dry weight per unit leaf area.

activity of tuberous root is higher at root temperatures of 24 to 26℃ and is depressed at the lower temperatures by decreased activity of starch synthesis.

In order to estimate the effect of root temperature on sink strength of tuberous root more clearly, dry weight per unit leaf area was measured in each organ (Fig. 5). The highest dry weight among organs was found in tuberous root at respective root temperatures, which confirmed that tuberous root can act as a major sink. The total dry weight was highest at a root temperature of 24℃ where dry weight of tuberous root per unit leaf area was extremely higher as compared with those at other root temperatures. Thus, it became clear that tuberous root shows the maximum sink strength at a root temperature of 24℃. Dry weights of stem and petioles per unit leaf area were relatively higher at root temperatures of 20, 30 and 32℃ where the dry matter accumulation in tuberous root was lower. Stem and petiole could act as secondary storage sinks when sink strength of tuberous root was remarkably depressed.

From these results, it could be considered that sink strength of tuberous root is maximized at a root temperature of 24℃ possibly because sink strength decreases with the depressed sink activity at the lower temperatures and also decreases with lower sink capacity with high respiratory loss at the higher temperatures.

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