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Phloem Development in Sweet Potato Cultivars

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Abstract. **Phloem cross-sectional areas (PCSA) in main stems and storage root stalks were determined for 3 cultivars of sweet potato [*Ipomoea batatas* (L.) Lam] for 98 days, starting 14 days after transplanting at 10-day intervals. As the number of storage roots increased, the total amount of phloem in the storage root stalks available for translocation was greater than that in the main stem. For the last 3 harvest periods, 'Jasper' was the only cultivar with less phloem in the storage root stalks than in the main stem. The correlation between PCSA of the storage root stalks and storage root weight was nonsignificant for 'Jasper' and 'Porto Rico' but significant for 'Centennial', which suggested that the amount of phloem tissue is not critical for storage root development.**

Photosynthate is translocated from the site of production through the phloem to regions of utilization or to storage sinks. Phloem transport occurs along a pathway consisting of sieve tubes extending from the source regions (where solutes are moved into the sieve tubes) to sink regions (where they are utilized or stored) (9). Enyi (3) stated that the proportion of dry matter partitioned to various organs of the sweet potato plant was a cultivar characteristic. Data reported by Austin et al. (1) and Huett and O'Neill (5) give distinct differences in the distribution of dry matter among the various plant organs.

Wilson and Lowe (10) believed that the development of phloic bundles and secondary phloem in the "tuber stalk" (the part of the root system connecting the storage root to the main stem) of sweet potatoes may control the rate of translocation of assimilates to the storage roots. Therefore, this control of assimilate and the time period of storage root growth could then control the yield of sweet potatoes. This area of direct phloic control of storage root growth has not been studied previously.

This study was conducted to determine the amount of phloem development in various locations in the sweet potato plant and to identify possible physical restraints to solute movement in the phloem.

Slips of 'Centennial', 'Jasper', and 'Porto Rico' sweet potatoes were produced in a greenhouse and on June 23 were transplanted to the field 30 cm apart in rows spaced 96 cm apart. The experimental design was a randomized complete block, with 30-m plots replicated 3 times. A 13N–5.6P–10K fertilizer was applied at a rate of 336 kg/ha during bed preparation. The plots were sprinkle-irrigated as needed during the growing season.

Sampling was begun 14 days after planting and was continued at 10-day intervals until October 6, 1980. One plant from each replicated plot was harvested at each sampling period. Adjacent plants were not sampled. The plants were cut at ground level and the roots were dug from the soil without breaking the storage roots from the main root system.

Anatomical investigations were carried out by sampling at 3 different locations on the plants for each cultivar, at each harvest period. The locations from which the samples were taken are shown in Fig. 1. The tissue samples from the same location from each cultivar harvested on the same day were placed in a solution of 5 ml formaldehyde, 5 ml glacial acetic acid, and 90 ml of 70% ethyl alcohol (FAA) in a common vial. However, for harvest periods 94 and 104 days after transplanting, tissue samples were stored separately. The storage roots and storage root stalks of all plants harvested at these last 2 harvest periods were sampled in a manner in which the storage root and its stalk could be identified. The location of each storage root in relation to the main axes was determined. Position 1 was the storage root closest to the soil surface; the others were numbered sequentially as depth increased.

Tissue segments were carried through an alcohol–xylene dehydration series and infiltrated with paraffin according to Sass (7). Sections 12 μm thick were mounted on slides and stained using safranin and fast green (4). Five microscopic observations were made on tissue segments selected at random and were averaged for their respective locations on the plant for each cultivar. Phloem cross-sectional area (PCSA) was determined by direct measurement of photographs taken of the prepared slides. PCSA in position E (Fig. 1) was calculated for each cultivar by multiplying the average number of storage roots per plant for that cultivar by the average PCSA of a storage root stalk for that cultivar.

There were no consistent differences among cultivars for the number of leaves, length of main vine, or storage root number (data not presented). Storage root initiation for all cultivars was apparent by the 44th day after transplanting. Because storage roots were not detectable prior to this time, no data are given for harvest periods before the 44th day after transplanting.

There were differences among cultivars as to the location of the smaller PCSA (Table 1). The smallest PCSA, of the 3 locations measured, was that in the storage root stalk (E) for 'Jasper' for all harvest periods except one (84 days after transplanting). For 'Porto Rico', the smallest PCSA was found in the main stem just above ground level (C) for all harvest dates except one, in which location E was the smallest (54 days after transplanting). With 'Centennial', the location with the smallest PCSA was inconsistent. Location E was the smallest for the first 4 harvest periods (44 to 74 days after transplanting). Location C gave the smallest PCSA for the 5th and 7th harvest periods (84 days and 104 days after transplanting, respectively). The location of the smallest PCSA 94 days after transplanting was the section of the main stem just below ground level (D). Averaged over all sampling periods, 'Porto Rico' had the largest PCSA, significantly larger than that found in 'Jasper', which had the smallest.

Correlations between PCSA in the storage root stalks and the dry weight of the storage roots were low and only significant for 'Centennial' (Table 2). If the PCSA could limit storage root growth as suggested by Wilson (10), the correlation between PCSA of the storage root stalk and storage root dry weight of 'Jasper' should have been higher than that found for 'Centennial' and 'Porto Rico'. These data suggest that the amount of phloem tissue is not a critical factor for storage root de-

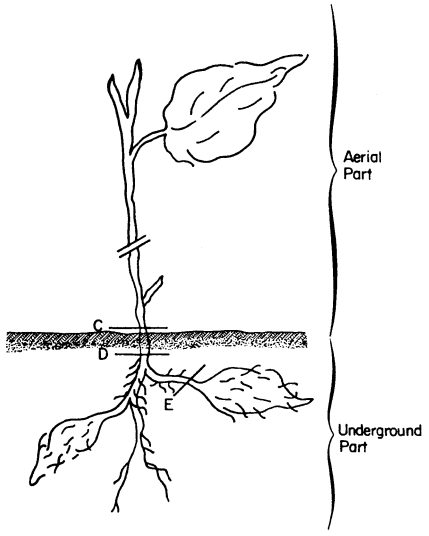

Fig. 1. Diagram of sweet potato plant indicating sampling positions C, D, and E.

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Table 1. Location and mean value of the smallest phloem cross-sectional area (PCSA) taken from 3 locations for 3 cultivars of sweet potatoes, 44 to 104 days after transplanting.

Time after transplanting (days)	Centennial		Jasper		Porto Rico	
	Location	Smallest PCSA (mm^2)	Location	Smallest PCSA (mm^2)	Location	Smallest PCSA (mm^2)
44	E[z]	1.00	E	.24	C	.96
54	E	.80	E	.50	E	1.49
64	E	1.32	E	1.17	C	2.60
74	E	1.69	E	.53	C	1.60
84	C	1.85	C	2.40	C	2.22
94	D	2.91	E	1.59	C	2.67
104	C	1.78	E	1.91	C	2.89
Mean[y]		1.62 ab		1.19 b		2.06 a

[z]E = storage root stalk; D = main stem just below soil level; C = main stem just above soil level.
[y]Mean separation by Student Newman Keuls' multiple range test, 1% level.

velopment and that the amount of phloem is more than adequate to carry available carbohydrates to the root system.

Table 2. Mean values of the phloem cross-sectional area (PCSA) of the storage root stalk, storage root dry weights, and correlation coefficient for 3 sweet potato cultivars over 2 harvest periods (94 to 104 days after transplanting).

Cultivar	PCSA (mm^2)	Storage root dry wt (g)	Correlation coefficient (r)
Centennial	1.57	28	0.84**
Jasper	0.48	36	0.13
Porto Rico	1.81	19	0.57

**Significant at the 1% level.

Muchow and Wilson (6) and Wardlaw and Moncur (8) reported that a reduction in the transport system did not affect the yield of *Sorghum bicolor* and *Triticum aestivum*, respectively. Wilson and Lowe (11) also reported that partial destruction of transport tissue in the stems of sweet potatoes did not reduce storage root yield significantly. The inherent ability of a sweet potato cultivar to produce photosynthate and a partitioning mechanism, other than phloem restriction, must control storage root yield. However, Bhagsari (2) reported that photosynthetic rates of 15 sweet potato genotypes showed no correlation with root yields. Yield appears to be related to genotypic ability to partition carbohydrates to the storage roots.

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The Effects of Storage Systems on Sweet Potato Quality

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Abstract. **A double-walled, black Quonset-like structure with outside air exchange proved to be a very good alternative to large, expensive commercial storage complexes for roots of sweet potato [*Ipomoea batatas* (L.)Lam.]. No significant differences were noted in important indicators of storage loss, such as intercellular space, specific gravity, or subsequent sensory qualities.**

Proper curing and storage of sweet potatoes are essential to maintain quality roots for year-round marketing and to preserve seed stock. Many studies have shown that a curing treatment of 4 to 7 days at 85% to 90% relative humidity and 28°C stimulates the formation of new cells immediately below the surface of the wound (1, 8, 9, 12, 13, 14, 18).

Ventilation is necessary to remove CO_2 and replenish O_2 for curing roots. Sound roots consume O_2 at about 57 dm^3 per ton per day and release an equivalent amount of CO_2 (9). At a rate of 57 dm^3 per ton per day, 35,375 dm^3 of air per 24 hr would have to be removed in a room holding 5000 boxes (25.2 kg) of sweet potatoes. Kushman (9) reported that 4 or 5 times this amount may actually be needed, since each exchange of air will not completely replace the O_2 consumed or remove the CO_2 produced.

After curing, sweet potatoes should be held at 12° to 16°C with a relative humidity of 85% to 90% (7, 10) and fresh air should be introduced at a rate equal to the capacity of the storage every 2 hr to prevent CO_2 accumulation (15).

The development of double plastic-covered structures for use by greenhouse operators provides for the construction of insulated buildings at a relatively low cost (6, 16, 19, 20). The inclusion of automatic, evaporative cooling and heating systems in the above greenhouses, with differential thermostats and humidistats, gives good control of temperature, humidity, and ventilation (4). Such structures for use as sweet potato storages near points of production would minimize hauling costs for the small farmer (9).

This study was undertaken to compare quality characteristics between sweet potatoes stored commercially and those stored in a black, double-walled, plastic-covered, Quonset-type structure, equipped with a fresh-air exchange system.

'Jewel' sweet potatoes, grown under standard cultural practices, were harvested using a Johnson harvester on October 26, 1980, on Justiss Farms near Daingerfield, Texas. After curing for 7 days at 30°C and 95% relative humidity, fourteen 454-kg crates of sweet potatoes were put into commercial storage. Fourteen additional 454-kg crates of roots were placed in a black, plastic-covered,

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