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Photosynthesis and Photosynthate Partitioning in Sweet Potato Genotypes[1]

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***Abstract*. Field experiments were conducted during 1979 and 1980 growing seasons with sweet potato [*Ipomoea batatas* (L.) Lam.] genotypes at different stages of growth to determine leaf net photosynthetic rates (Pn) and photosynthate partitioning patterns. Net photosynthesis was measured in an open system with an infrared analyzer on the youngest and the fully expanded leaves still attached to the plant. Photosynthesis rates differed significantly in both years. Photosynthesis varied from 19.1 to 32.4 mg $CO_2dm^{-2}hr^{-1}$ in 1979 and from 25.8 to 36.9 mg $CO_2dm^{-2}hr^{-1}$ in 1980. A new selection, 75-96-1, averaged highest both years. Percentages of photosynthate partitioning to storage roots also differed significantly. About 45 days after planting, 'Centennial' and 'Georgia Jet' diverted the highest percentage, about 28%, of the total dry matter to the storage roots. But 'Georgia Red' diverted the highest percentages of photosynthate (51.0 and 56.4) to the storage roots 75 and 90 days after planting, respectively. Photosynthate partitioning to storage roots ranged from 11.2 to 56.4%, 90 days after planting. Final root yield correlated significantly (r = 0.69 to 0.87) with photosynthate partitioning at all stages of growth. During 1980, Pn and total dry matter yield also were significantly correlated. Harvest index was significantly correlated (r = 0.89) with final storage root yield. But Pn did not significantly correlate with either storage root yield or photosynthate partitioned to roots. Stomatal density was 2 to 3 times more on the abaxial than the adaxial surface of the leaves. Percentages of neither leaf nitrogen nor chlorophyll content of leaves differed significantly. High-yielding genotypes generally initiated storage root formation earlier and also partitioned more photosynthate to storage roots than low-yielding genotypes.**

Although some reports (5, 10, 11, 19, 22) have indicated lack of consistent and significant correlations between Pn and economic yield of crop plants, crop yield is largely determined by Pn potential of the plant and partitioning of photosynthate to the harvested portion. Differences in Pn and correlations with fruit yield are more likely when Pn is measured during reproductive growth, and even during senescence, than during vegetative growth (18). Photosynthesis differences in soybean [*Glycine max* (L.) Merr.] are greater during the reproductive than the vegetative stage (6, 7, 20).

The literature contains little information on Pn potential of root crops. Hahn (12) reported (from Fujise and Tsuno, 1962) that Pn for sweet potato was 12.0 mg $CO_2dm^{-2}hr^{-1}$. Wilson (21) also reported (from Tsuno and Fujise, 1965) that maximum Pn for mature sweet potato leaves was 20.0 mg $CO_2dm^{-2}hr^{-1}$. In cassava (*Manihot esculenta* Crantz), Pn correlated significantly with storage root yield and total plant dry weight (16). Huett and O'Neill (14) speculated that photosynthate source did not limit sweet potato yields. After studying the relationship of harvest index to yield of 16 sweet potato genotypes in Australia, Huett (13) concluded that high-yielding genotypes generally had a higher harvest index (ranging from 9.5 to 66.3%) than low-yielding types. Lowe and Wilson (15) found that in the West Indies final yield of sweet potato tubers correlated positively with harvest index, which varied from 64 to 84% for 6 genotypes.

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e Direct and indirect evidence from the literature indicates that differences in yields among genotypes are caused by a combination of physiological processes (8, 9, 11, 17, 18). So information on yield-related physiological processes for crops, including sweet potato, is needed. Study of Pn and photosynthate partitioning of sweet potatoes at different developmental stages may help us understand yield and Pn correlations. This study was to determine Pn of sweet potato genotypes during the different growth phases and photosynthate partitioning to storage roots (harvest index) during the growing period.

Materials and Methods

Plant culture. Two field experiments were conducted at the Fort Valley State College Agricultural Research Station using 20 sweet potato genotypes (Table 1) in 1979 and 16 genotypes in 1980. The soil was a Norfolk loamy sand, pH 6.2. Slips of sweet potato genotypes obtained from Coastal Plain Experiment Station, Tifton, Ga., were planted in mid-May both years on ridges 15.0 m long, 1.3 m apart, with a 0.3-m spacing between plants, in a randomized complete block, with 4 replications and 50 plants per genotype in each experimental row.

Fertilizer, 50 kg N, 44 kg P, and 123 kg K per ha, was applied in 2 equal doses, one before making ridges, the other before earthing up, about 40 days after planting. Three irrigations, about 3–4 cm each, were applied during the 1979 growing season as needed, but about every 10 days during July, August, and September in 1980. Weeds were controlled manually without herbicides. Malathion, 1 ml/liter of water, was used twice each year to control insects.

Table 1. Photosynthetic rates of sweet potato genotypes in the field, 1979 and 1980.

	Photosynthetic rates (mg $CO_2dm^{-2}hr^{-1}$)[z]				
	1979	1980			
Genotype	Aug. 8–Oct. 8	July 10–19	Aug. 4–8	Sept. 5–9	Mean
75-96-1	32.4	38.9	38.4	33.4	36.9
Jewel[y]	31.7	28.9	38.5	30.4	32.6
71-63-1	30.3	37.4	28.9	29.2	31.8
61-15-35	29.9	—	—	—	—
Georgia Jet[y]	27.9	34.7	30.8	29.7	31.7
Georgia Red[y]	27.6	31.3	24.1	28.7	28.0
Muguga	27.3	32.6	31.8	31.0	32.0
73-74-6	26.9	—	—	—	—
73-75x50-2	26.3	—	—	—	—
Centennial[y]	26.0	28.9	25.4	25.2	26.5
73-42-1	25.6	32.3	33.6	31.7	32.5
Whitestar	25.6	31.8	23.8	21.7	25.8
TI-1894[y]	25.4	37.9	30.4	30.3	32.9
Red Jewel[y]	23.5	34.4	32.9	28.5	31.9
Red Porto Rico[y]	22.3	31.0	25.0	29.1	28.4
Pelican Processor	22.2	33.3	30.4	26.9	30.2
BPR-M 2[y]	22.1	—	—	—	—
Rojo Blanco	22.1	35.7	34.1	30.4	33.4
Creole	21.1	—	—	—	—
Coastal Sweet[y]	19.1	33.4	27.6	28.6	29.8
73-42x61-2	—	34.9	31.7	30.1	32.3
Mean	25.8	33.6	30.5	29.0	31.0
LSD 5%	7.2	NS	5.1	NS	3.7

[z]Pn values for each genotype are the average of 4 determinations in 1980 and 8 determinations in 1979.
[y]Cultivars used for human consumption (under U.S. conditions). All others are starch or industrial types.

For diurnal measurement of Pn, plants were grown in the greenhouse in pots from terminal vine cuttings, planted Oct. 15, 1979, in pots placed under multivapor lamps that with sunlight provided 1000 to 2000 $\mu E\ m^{-2}s^{-1}$ of PAR. The photoperiod was 16 hours. Other growing conditions were previously reported (2).

Plant samples. Each year from June 30 to early October, plant samples were taken at 2-week intervals for growth analyses. Each sample consisted of 2 plants per genotype for each replication in 1980 and 1 plant per genotype in 1979. To avoid border effects, samples were taken in the same row direction, from the site of the first sampling both years. During 1980, 1 plant of each genotype on the end of each row was left intact in each of 4 replications to harvest, October 8. These plants were harvested separately to determine photosynthate partitioning on fresh weight basis.

Plants were separated into leaves, branches, petioles, and tubers which were chopped into small pieces after washing, and dried at 60°C, along with other plant parts, to constant weight. The criteria used to distinguish storage roots from fibrous roots was that storage roots had comparatively less root hair, color conforming to genotypes, and were at least 1.0 cm in diameter.

Percentages of photosynthate partitioned to storage roots were calculated by dividing the storage root dry weight by total dry weight of branches, leaves, petioles, and storage roots. At harvest, all roots at least 2.5 cm in diameter were included in root yield. Leaf samples for nitrogen and chlorophyll determinations were taken in mid-August and freeze-dried. Harvest index was calculated the same way as photosynthate partitioning to storage roots but fresh weights of plant parts were used from final harvest.

Photosynthesis measurements. Net photosynthesis was measured in an open system with a Beckman infrared analyzer, Model 215B, in full sunlight (1500 – 2000 $\mu E\ m^{-2}s^{-1}$) between 1030 and 1500 HR EST. Fully expanded, attached, 12- to 15-day old leaves were enclosed in a 23 × 21.5 cm, air-tight plexiglass photosynthesis chamber 6.5 cm high, as detailed previously (2). Leaf temperature was maintained at 30±2°C and was monitored with a thermocouple touching the underside of the leaf. The leaf chamber contained a small fan to mix the air and reduce leaf boundary-layer resistance. Commercially available compressed air, containing approximately 330 ppm CO_2, was bubbled through water before entering the leaf chamber. A portion of the air, after passing the leaf chamber, was passed through $CaSO_4$ before entering the infrared analyzer. Air flow was about 4.8 liters per minute. Tygon tubing was used to conduct reference and sample air to the infrared analyzer.

During 1979, Pn was determined for 2 leaves of each genotype in each replication only once from August 8 to early October. In 1980, Pn was measured on each genotype in all 4 replications, once each during: July 10–19 (Pn I), August 4–8 (Pn II), and September 5–9 (Pn III). Diurnal changes in Pn of 3 sweet potato genotypes were measured in a greenhouse as previously described (2).

Leaf area was measured with an automatic leaf-area meter, (Model LI-3100, Lambda Instruments Corp., Lincoln, Neb.); leaf nitrogen, by micro-kjeldahl method; and chlorophyll, by Arnon's procedure (1). For stomatal counting, leaf impressions were made by dipping the attached leaves in Rhoplex, grade AC-33 (Rohm and Hass Co., Charlotte, N.C.). Stomatal impressions were peeled off after 6 hours drying in the sun, from abaxial and adaxial surfaces, then stored separately in Petri dishes. Stomata were counted with a microscope at 12 locations for each leaf impression. Specific leaf weight (SLW-mg/cm^2) was determined for leaf blades measured.

Results and Discussion

Diurnal changes in Pn for 3 sweet potato genotypes are presented in Table 2. Photosynthesis was nearly steady between 0600 and 1600 HR, with a slight increase for 'Pelican Processor' up to 1200–1400 HR, and rapid decline for all three after 1600 HR. So Pn then was measured between 1030 and 1500 HR because it varied only slightly then. Research by Fujise and Tsuno, 1962, reported by Hahn (12) showed that Pn of sweet potato leaves was 12.0 mg $CO_2dm^{-2}hr^{-1}$ between 0900 and 1300 HR but decreased gradually to about 2.0 mg $CO_2dm^{-2}hr^{-1}$ at 1700 HR, a reduction of about 83% between 1300–1700 HR. The decline in Pn of the genotypes reported here between 1600–2000 HR was 32.7 to 38.1% as much as at peak time rates.

Average Pn rates of sweet potato genotypes reported here ranged from 19.1 mg $CO_2dm^{-2}hr^{-1}$ for 'Coastal Sweet' to 32.4 mg $CO_2dm^{-2}hr^{-1}$ for new selection, 75-96-1, respectively, in 1979, and from 25.8 to 36.9 mg $CO_2dm^{-2}hr^{-1}$ in 1980. The selection, 75-96-1, showed the highest Pn both years except for August 4–8, 1980 (Pn II), when 'Jewel' had the highest rate (38.5 mg $CO_2dm^{-2}hr^{-1}$). Generally, Pn of all the genotypes averaged about 20% higher in 1980 than in 1979. Rate of photosynthesis for 'Red Jewel', 'Pelican Processor', 'Rojo Blanco', and 'Coastal Sweet' was 30 to 56% higher in 1980 than in 1979. The Pn of most of the genotypes with less Pn in 1979 than in 1980, decreased similarly from July to September, 1980. So the late measurement of Pn in 1979 may explain the lower values for 1979.

Again, as in an earlier report (2), Pn for sweet potato genotypes, though similar to most C_3 species (10, 22), was about 1.5 to 2 times higher than reported in the early 1960s (12, 21). Similar time- and technique-related trends in soybean Pn are evident in a recent report by Sinclair (20) and previous research by Dreger et al. (7) and Dornhoff and Shibles (6).

During 1980, Pn from July 10–19 (Pn I) did not correlate significantly with Pn from August 4–8 (Pn II) and September 5–9 (Pn III) as presented in Table 3. Pn II and Pn III correlated significantly (r = 0.72), indicating that Pn rankings in August and September did not change much. Photosynthesis for 1979 and 1980 did not correlate significantly. Lack of consistent rankings among genotypes for all measurements indicates the interaction of Pn with environment and plant maturity, and illustrates that yield cannot be predicted well from Pn.

Specific leaf weights differed significantly only for August 1980 Pn measurements (Table 4). Specific leaf weights for August 1980 (Table 3) correlated significantly with Pn I (r = 0.50) and Pn II (r = 0.62). Specific leaf weights were higher in 1979 than in 1980. Bowes et al. (3) reported such environment-related inconsistencies and lack of correlations between SLW and Pn for soybeans.

Table 2. Diurnal trends in net photosynthesis of 3 sweet potato genotypes.

	Net photosynthesis (mg $CO_2dm^{-2}hr^{-1}$)		
Time interval[z] (hr)	Pelican Processor	Coastal Sweet	Centennial
6–8	23.6 ± 3.1[y]	19.8 ± 3.5	18.4 ± 0.5
8–10	24.4 ± 2.4	19.8 ± 3.6	18.7 ± 0.5
10–12	25.0 ± 2.8	20.5 ± 3.1	19.0 ± 0.8
12–14	26.6 ± 4.1	19.8 ± 4.1	19.3 ± 2.9
14–16	25.4 ± 3.6	19.1 ± 4.9	18.4 ± 2.2
16–18	21.8 ± 3.0	15.6 ± 5.6	15.8 ± 3.1
18–20	17.9 ± 0.7	12.7 ± 5.6	12.4 ± 4.6

[z]Light on at 0530 and off at 2030 HR.
[y]± SD.

Table 3. Correlation coefficients for some traits of sweet potato genotypes, (n = 16) 1980.

	Correlation coefficient (r)					
	Pn[y] measurement			SLW[x]	Total dry wt[w]	
Trait[z]	Pn I	Pn II	Pn III	4–8 Aug.	45 days	75 days
Pn I	—	0.34	0.45	0.50*	−0.11	0.47
Pn II	—	—	0.72**	0.62**	0.53*	0.64**
Pn III	—	—	—	0.47	0.52*	0.50*

[z]Pn I = Pn measured July 10–19, Pn II = Pn measured August 4–8, Pn III = Pn measured September 5–9.
[y]Pn = Net photosynthesis.
[x]SLW = Specific leaf weight for August 4–8 leaves used for photosynthesis measurement.
[w]Total dry wt/plant 45 and 75 days after planting.
*, **Significant at the 5% (*) and 1% (**) level of probability.

Table 4. Specific leaf dry weight of sweet potato genotypes[z] in the field, 1979 and 1980.

	Specific leaf dry wt (mg/cm^2)				
	1979	1980			
Genotype	Aug. 8–Oct. 8	July 10–19	Aug. 4–8	Sept. 5–9	Mean
71-63-1	7.2	4.6	4.7	4.4	4.6
Georgia Red	6.5	4.7	4.6	4.1	4.5
Georgia Jet	6.3	4.6	4.1	3.6	4.1
Whitestar	6.2	5.0	3.9	4.3	4.4
75-96-1	6.0	5.0	5.7	4.7	5.1
73-75x50-2	6.0	—	—	—	—
73-74-6	5.7	—	—	—	—
Muguga	5.6	4.5	4.5	3.8	4.3
Rojo Blanco	5.6	5.1	5.2	4.7	5.0
Jewel	5.6	4.5	4.9	4.1	4.5
Centennial	5.4	5.0	4.4	4.0	4.5
73-42-1	5.3	4.3	4.0	3.9	4.1
Red Porto Rico	5.1	4.6	4.3	4.0	4.3
Coastal Sweet	5.1	5.2	4.5	4.3	4.7
Creole	5.1	—	—	—	—
61-15-35	5.0	—	—	—	—
Red Jewel	4.9	4.8	5.4	4.3	4.9
Pelican Processor	4.6	4.7	4.7	4.3	4.6
BPR-M 2	4.3	—	—	—	—
TI-1894	3.8	5.5	4.8	4.3	4.9
73-42x61-2	—	4.0	4.6	4.1	4.2
Mean	5.5	4.8	4.7	4.2	4.5
LSD 5%	NS	NS	0.8	NS	0.5

[z]Specific leaf wt of leaves used for measuring photosynthesis at the dates shown. Each value is the average of four determinations in 1980 and 8 determinations in 1979.

The range in leaf-nitrogen percentages was from 2.6 for selection 75-96-1 to 3.5 for 'Whitestar' and 'Georgia Red' (Table 5). Chlorophyll contents (a + b) of sweet potatoes varied from 7.6 to 10.6 (mg/g dry weight) but did not differ significantly among genotypes. Stomatal density varied from 47 to 87, and 163 to 253 for adaxial and abaxial leaf surfaces, respectively. 'Red Porto Rico', like 'Unit I Porto Rico' as reported earlier (2), had the lowest stomatal density on the adaxial surface of all genotypes tested. Among the 16 genotypes, number 75-96-1 had the most stomata on both the adaxial and abaxial surfaces. The average stomatal density on the abaxial surface was 2 to 3 times more than on the adaxial surface for these genotypes. Leaf-nitrogen percentages, chlorophyll contents, and stomatal densities did not correlate significantly with either Pn or storage root yield.

Since the trends in the photosynthate partitioning data for both years were similar (even with one plant per sample in 1979), only the photosynthate partitioning data for 1980 are presented (Table 6). Photosynthate partitioning percentages varied widely (significantly) among genotypes at all sampling times. Such an inherent variability among sweet potatoes has been reported by others (13, 15).

In some genotypes, a significant portion of the photosynthate began diverting to storage roots about 45 days after the crop was planted. 'Centennial' and 'Georgia Jet' had 28.7 and 27.5%, respectively, of the total dry matter accumulated in the storage roots at 45 days, while 5 other genotypes partitioned less than 10.0% of the photosynthate to the storage roots during the same time. By mid-July, photosynthate percentages diverted to storage roots ranged from 9.7% for 'Muguga' to 41.6% for 'Centennial'. When plants were about 75 days old, 'Georgia Red' and selection 71-63-1 had diverted the highest percentages (51.0 and 50.0, respectively) of photosynthate to storage roots. At that stage of growth, rankings for photosynthate percentages partitioned to storage roots had changed from initial sampling time percentages, so bulking rates differed among the genotypes. Dry matter accumulations in storage roots during August over July were less consistent than during previous sampling times, perhaps because certain genotypes already matured.

Table 5. Percent leaf nitrogen, chlorophyll and stomatal density of sweet potatoes, 1980.

Genotype	Nitrogen (% dry wt)	Chlorophyll 'a + b' (mg/g dry wt)	Stomatal density (mm^{-2}) Adaxial surface	Abaxial surface
Whitestar	3.5	9.4	71	191
Georgia Red	3.5	10.6	65	176
TI-1894	3.4	10.3	67	169
73-42-1	3.4	8.2	79	185
Red Jewel	3.2	8.4	58	192
Muguga	3.1	10.3	67	228
73-42x61-2	3.1	10.3	63	163
Red Porto Rico	3.1	7.9	47	174
71-63-1	3.1	8.5	71	210
Georgia Jet	3.1	9.0	67	199
Pelican Processor	3.1	8.2	84	253
Centennial	3.0	7.6	64	218
Jewel	2.9	8.0	78	239
Rojo Blanco	2.8	9.6	64	244
Coastal Sweet	2.6	8.1	65	192
75-96-1	2.6	7.6	87	253
Mean	3.1	8.9	68	205
LSD 5%	NS	NS	18	43

Photosynthate partitioning percentages for October 8 (harvest index), calculated on fresh weight basis from 1 intact plant, were similar to those during late July and early August. The harvest index ranged from 3.9 for 'Muguga' to 58.6 for 'Georgia Jet', respectively. Harvest index (on fresh weight basis) correlated significantly (r = 0.74 to 0.90) with photosynthate partitioning percentages (dry weight basis) at all stages sampled.

Rigid clonal selection that sweet potato breeders use in selecting high-yielding individual hills in sweet potato lines may explain the high correlation between harvest index and yield. But harvest index was reported not to indicate yielding potential of soybeans because yield and maturity date are negatively associated (4).

Significant differences in storage root yield were observed among sweet potato genotypes. 'Centennial', 'Georgia Jet', and selection 73-42-1 partitioned more photosynthate to storage roots than the other genotypes at first sampling, and yielded more than the other genotypes except 'Georgia Red', which was among the low photosynthesizing genotypes but had the highest root yield (32.9 MT/ ha). Storage root yield was significantly correlated (r = 0.89) with both harvest index for plants grown under partial competition and with photosynthate partitioning at each stage of sampling (r = 0.69 to 0.87). But storage root yield showed no significant correlation with Pn.

Significant differences in total dry weight (g/plant) were found for July 30 sampled plants only. Total dry matter for June 30 was significantly correlated with harvest index (r = 0.54) and storage root yield (r = 0.51). But a high correlation (r = 0.98) between total dry matter and harvest index was observed in Huetts' (13) sweet potato experiments.

Pn II and total dry weights were significantly correlated (r = 0.53 and 0.64) with plants sampled June 30 and July 30, 1980, respectively (Table 3). Pn III likewise was significantly correlated (r = 0.52 and 0.50) with total plant dry weight for June 30 and July 30, 1980, respectively. In view of the positive correlation, though weak, between Pn and dry matter accumulation during this period, 75 to 90 days after planting may be the most critical period for evaluating photosynthetic efficiency of sweet potatoes. More photosynthate accumulating in storage roots of 'Georgia Red' and such genotypes as 'Centennial', 'Georgia Jet', and selection 73-42-1 probably resulted from higher translocation to storage roots than to other plant parts. Like the high-yielding peanut genotypes (8), high-yielding sweet potatoes seem to translocate higher percentages of photosynthate to storage roots.

Harvest index data indicate that some genotypes have low efficiency in storage root production relative to their biological yield. For example, selection 75-96-1, despite the high photosynthetic capacity and high biological yield, was not efficient in partitioning carbon assimilates into the storage roots. Further research is needed to study the effect of environment and cultural practices on the stability of harvest index as a predicting tool for storage root yield.

Lack of strong correlations of Pn with total dry matter and leaf characteristics indicate that other physiological and biochemical processes also affect the final yield. Thus, it is desirable to identify genotypes having physiological processes and traits that contribute to and correlate with yield.

Table 6. photosynthate partitioning, storage root yield and total dry weight of sweet potatoes for 1980

Genotype	Photosynthesis partitioning[z]				Harvest index, Oct. 8 (% fresh wt)[y]	Fresh root yield[x] (MT/ha)	Total dry wt (g/plant)	
	June 30	July 15	July 30	Aug. 13			June 30	July 30
Centennial	28.7	41.6	45.5	52.8	39.0	29.9	60.0	175.3
Georgia Jet	27.5	39.8	47.4	50.3	58.6	25.7	65.5	151.8
73-42-1	21.4	38.8	46.8	46.7	51.3	30.8	78.7	146.0
Rojo Blanco	18.5	39.0	33.6	47.6	38.7	16.4	76.5	278.2
Jewel	14.5	34.2	40.5	35.0	24.1	15.8	70.1	179.3
75-96-1	14.4	15.8	34.5	28.0	28.3	23.7	77.2	268.0
71-63-1	14.3	33.2	50.0	47.8	36.0	19.3	27.3	151.9
					54.9			
Georgia Red	14.2	36.2	51.0	56.4		32.9	63.4	148.0
Red Jewel	13.0	30.1	39.9	35.8	23.7	18.3	50.6	179.3
Coastal Sweet	12.9	16.4	27.1	29.3	13.3	6.0	37.7	121.2
TI-1894	12.8	32.2	46.5	40.9	41.5	21.5	39.1	183.0
Whitestar	8.7	25.4	32.8	33.2	19.7	15.4	30.4	130.1
73-42x61-2	7.6	20.9	16.4	16.1	14.3	8.7	45.9	178.7
Muguga	7.3	9.7	11.3	11.2	3.9	2.2	42.8	175.3
Red Porto Rico	7.1	10.4	31.8	31.7	23.2	18.4	50.6	133.0
Pelican Processor	5.3	12.4	17.4	18.6	15.3	6.4	38.4	129.7
Mean	14.3	27.3	35.8	36.3	30.3	18.2	53.4	171.1
LSD 5%	10.4	12.0	16.5	17.7	16.2	13.6	NS	90.1

[z]Photosynthate partitioning expressed as ratio of tubers to total dry wt per plant basis.
[y]Single plant basis, grown for 145 days under partial competitive conditions.
[x]Crop harvested after 152 days.

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