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Effect of Fertilizer and Watering Methods on Growth and Yields of Pot-grown Sweet Potato Genotypes

M.C. Acock[1] and J.O. Garner, Jr.[2]
Department of Horticulture, Mississippi State University, Mississippi State, MS 39762

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Abstract. **A high fertilizer rate reduced the number but not the weight, of storage roots of sweet potatoes [*Ipomoea batatas* (L.) Lam.] grown in greenhouse pots. Increased water availability had little effect on the small, bush type 'Vardaman' but enhanced growth and yield of the large, prostrate type L1-207. Differences between conditions of this experiment and field conditions are discussed.**

High rates of nitrogen fertilization (4, 5, 6) and high moisture levels (8, 9) or rainfall (2, 3) favor vine growth over storage root growth in sweet potatoes. Reduction in storage root yield under these circumstances has been attributed to competition from vines for available assimilates. This experiment was initiated (a) to investigate whether sweet potato genotypes which varied in vegetative vigor were affected similarly by varying fertilizer rates and water supplies and (b) to consider whether vine competition could account for reductions in storage root yield.

The experiment was a randomized complete block design in a 2 genotype × 2 fertilizer level × 2 watering methods factorial arrangement with 8 replications and 2 harvest dates. The factors were: (a) vine vigor high (LI-207) or low ['Vardman' (M3-702)]; (b) fertilization rates of 19N–3P–10K slow-release fertilizer added as a top dressing high (HF = 80g/pot) or low (LF = 16 g/pot); and (c) water availability high (CM = capillary mat) or low (HW = hand watering). Cuttings of 'Vardaman' and L1-207 taken on 17 Mar. 1983 were placed in 11.4-liter, black plastic pots filled with Cornell Peat-lite Mix consisting of equal volumes of sphagnum peatmoss and medium grade vermiculite plus 4.56 kg dolomitic lime, 1.82 kg 0N–9P–0K, 1.40 kg calcium nitrate and 0.17 kg fritted trace elements per cubic meter. The pots were spaced about 0.6 m apart between and within rows on a concrete greenhouse bench. Capillary matting on the bench was covered by 4-mil-thick black plastic with cutouts to accommodate plants receiving CM watering. Greenhouse temperatures ranged from 18° to 43°C. All plants (including CM plants) were watered daily with a hose and water breaker except when plants were very young. Those on capillary matting had access to water at all times through the bottom of the pot.

Plants were harvested 9 weeks (19 May) and 18 weeks (12 July) from transplanting. Plants were separated into vine and storage roots at each harvest. Plant material was dried at 40–42°C in large forced air ovens for a minimum of 1 week, then transferred to 80° ovens for 24 hr before weighing. After the 1st harvest, remaining plants were respaced in the greenhouse about 0.8 m apart between and within rows. Roots which had penetrated the CM were broken during this rearrangement. At the 2nd harvest, storage roots were sorted into canners (2.5 to 5.1 cm in diameter and 6.1 to 17.8 cm in length), no. 1's (5.1 to 8.9 cm in diameter and 9.6 to 22.9 cm in length), jumbos (>8.9 cm in diameter and >22.9 cm in length) and culls (either too small to be canners or misshapened). Numbers of storage roots and collective fresh weights in each category were determined. The relationship between fresh and dry weight was determined by taking 1 storage root from each plant, weighing it, slicing it into disks, drying in an 80° oven for 3 days, and reweighing.

Under a given set of growing conditions, L1-207 always partitioned more dry matter to the vine than did 'Vardaman'. This response did not result in reduced storage root production. In fact, L1-207 yielded more storage root dry weight than 'Vardaman' at 18 weeks (Table 1). Plants treated with HF partitioned more of their total dry weight into the vine than those treated with LF and had fewer storage roots (Table 1). Storage root dry weight yield at 18 weeks was not affected by this difference in storage root number. Although HF plants produced a reduced number of storage roots, more of them were classified as no. 1's (Table 1). L1-207 was more responsive to HF treatment than 'Vardaman', producing relatively more vine and storage root dry weight at 18 weeks and demonstrating a greater difference in storage root number between LF and HF treatments (Table 2).

High water availability (CM) had no effect on dry matter partitioning to the vine (Table 1) but increased total, vine, and storage root dry weight. Plants grown under the CM system had a greater number of storage roots at 9 weeks than those receiving HW (Table 1) and this number of storage roots was associated with increased vine growth for both genotypes (Table 3). Storage root yield of L1-207 was enhanced at 18 weeks in CM plants compared with HW plants, but watering method did not influence yield of 'Vardaman' (Table 3).

The yield of 'Vardaman' was not affected significantly by fertilizer rate or watering method. The absorbing roots of 'Vardaman' plants did not penetrate through the capillary

Table 1. Effects of genotypes, fertilizer rates, and watering methods on growth and production of sweet potato.

Measurement	No. of weeks	Genotypes		Fertilizer rate[z]		Watering method[y]	
		'Vardaman'	L1-207	LF	HF	HW	CM
Total dry wt	9	115	211	162	163	139	186
(g/plant)	18	523	933	630	826	632	823
Vine dry wt	9	74	178	112	141	109	144
(g/plant)	18	136	334	160 a	310 b	203	267
Storage root	9	41 a	32 a	51 b	22 a	30 a	43 b
dry wt (g/plant)	18	387	598	470	516	429	557
Partitioning	9	66 a[w]	86 b	67 a	84 b	76 a	75 a
to vine (%)	18	26 a	35 b	24 a	37 b	31 a	30 a
Storage roots	9	17 a	15 a	18 b	14 a	14 a	18 b
(no./plant)	18	11	13	13 b	10 a	10	13
Canners[v]	18	7	8	9 b	5 a	6	9
No. 1's	18	4	5	4 a	5 b	4	5
Jumbos	18	0.0 a	0.2 a	0.1 a	0.1 a	0.1 a	0.1 a

[z]LF = 16 g/pot; HF = 80 g/pot of slow-release 19N–3P–10K.
[y]HW = hand-watered; CM = capillary-mat-watered.
[x]Mean separation in rows between main effects by Least Significant Difference, 5% level.
[w]Percentages may not agree with figures given above due to rounding differences.
[v]Canners: 2.5 to 5.1 cm in diameter; 5.1 to 17.8 cm in length.
No. 1's: 5.1 to 8.9 cm in diameter; 7.6 to 22.9 cm in length.
Jumbos: >8.9 cm in diameter; >22.9 cm in length.
Culls: <2.5 cm in diameter or <5.1 cm in length or misshapened.

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[1]Former Graduate Student.
[2]Associate Professor.

Table 2. Effect of fertilizer rate on growth and production of 'Vardaman' and L1-207.

Measurement	No. of weeks	'Vardaman'		L1-207	
		LF[z]	HF	LF	HF
Total dry wt	9	123 a[y]	107 a	202 b	220 b
(g/plant)	18	488 a	557 a	771 b	1100 c
Vine dry wt	9	68 a	80 a	155 b	202 c
(g/plant)	18	95 a	176 b	224 c	445 d
Storage root dry wt	9	55	27	46	18
(g/plant)	18	393 a	381 a	547 b	650 c
Partitioning to vine	9	56[x]	76	79	93
(%)	18	20	33	29	41
Storage roots	9	19	16	17	13
no./plant	18	12 ab	10 a	14 b	11 a
Canners[w]	18	9	5	10	6
No. 1's	18	3	5	4	5
Jumbos	18	0.0	0.1	0.1	0.2

[z]LF = 16g/pot; HF = 80 g/pot slow-release 19N–3P–10K.
[y]Mean separation in rows by Student Newman Keuls' multiple range test, 5% level.
[x]Percentages may not agree with figures given above due to rounding differences.
[w]Canner: 2.5 to 5.1 cm in diameter; 5.1 to 17.8 cm in length.
No. 1's: 5.1 to 8.9 cm in diameter; 7.6 to 22.9 cm in length.
Jumbos: > 8.9 cm in diameter; > 22.9 cm in length.
Culls: < 2.5 cm in diameter or < 5.1 cm in length or misshapened.

Table 3. Effect of watering method on growth and production of 'Vardaman' and L1-207 sweet potatoes.

Measurement	No. of weeks	'Vardaman'		L1-207	
		HW[z]	CM	HW	CM
Total dry wt	9	104 a[y]	126 b	174 c	247 d
(g/plant)	18	510 a	535 a	754 b	1110 c
Vine dry wt	9	66 a	83 b	152 c	204 d
(g/plant)	18	135 a	137 a	272 c	397 c
Storage root dry	9	39	43	22	42
(g/plant)	18	376 a	398 a	482 b	715 c
Partitioning to vine	9	66[x]	66	87	84
(%)	18	27	25	35	35
Storage roots	9	15	19	13	17
(no./plant)	18	11 a	11 a	9 a	16 b
Canners[w]	18	6 a	7 a	5 a	10 b
No. 1's	18	4 a	4 a	4 a	6 b
Jumbos	18	0.1	0.0	0.2	0.1

[z]HW = hand-watered; CM = capillary-mat-watered.
[y]Mean separation in rows by Student Newman Keuls' multiple range test, 5% level.
[x]Percentages may not agree with figures given above due to rounding differences.
[w]Canners: 2.5 to 5.1 cm in diameter; 5.1 to 17.8 cm in length.
No. 1's: 5.1 to 8.9 cm in diameter; 7.6 to 22.9 cm in length.
Jumbos: > 8.9 cm in diameter; > 22.9 cm in length.
Culls: < 2.5 cm in diameter or < 5.1 cm in length or misshapened.

Table 4. Mean fresh weight of storage roots (excluding culls) at 18 weeks in grams per plant for hand-watered (HW) and capillary-mat-watered (CM) sweet potatoes treated with 16 g (LF) or 80 g (HF) of slow-release fertilizer 19N–3P–10K.

Fertilizer rate[z]	'Vardaman'		L1-207	
	HW	CM	HW	CM
LF	1650 a[z]	1700 a	2000 a	2460 b
HF	1740 a	1850 a	2000 a	3190 c

[z]Mean separation by Student Newman Keuls' multiple range test, 5% level.

matting to the same extent as L1-207 plants, possibly explaining their insensitivity to both fertilizer rate and watering method. L1-207, which had a vigorous absorbing root system, responded as though limited by hand watering at both fertilizer rates. The highest storage root yield was obtained for L1-207 plants treated with the high fertilizer rate and watered by CM (Table 4).

These results are contrary to the widely held belief that high fertilizer rates reduce storage root yield in the sweet potato. The high rate did reduce storage root number but not total storage root production. Initiation of storage roots may have been delayed by high fertilization (4). This delay could explain why HF-treated plants relative to LF had less storage root dry weight at 9 weeks. However, by 18 weeks the HF plants had equalled or surpassed LF plants in storage root production. The LF treatment did enhance storage root initiation and favor storage root growth over vine growth, but the limitation on vine growth had a detrimental effect on yield for L1-207.

High rainfall has been reported to favor vine growth over storage root growth (2, 3). However, no partitioning differences were found for different watering methods in this experiment. It is unlikely, then, that the effect of high rainfall can be traced to differences in water supply. The CM watering system is ideal for maintaining aeration without limiting water supply and aids in studying the effects of watering separated from possible aeration effects. Soil aeration is highly dependent on soil type and can be altered by high rainfall, leaving the possibility that reduced storage root growth under high rainfall may result from limited soil oxygen levels rather than vine competition.

'Vardaman' has been described as somewhat drought tolerant (1). This cultivar consistently out-performed L1-207 in a 2-year study on nonirrigated field plots in Mississippi (7). However, 'Vardaman' plants did not respond to the additional water supply from CM whereas L1-207 did. Irrigation may improve yield of L1-207 while it may have little effect on 'Vardaman'.

There was no evidence from this experiment that vine growth competed with storage root growth. The amount of vine growth was associated positively with storage root yield at 18 weeks whether or not treatment affected the partitioning pattern. HF treatment increased vine growth but storage root yield was not reduced significantly. The difference in association between vine and storage root yield at 9 and at 18 weeks for the different fertilizer rates indicates the importance of reporting the stage of development of the plants when results are recorded. CM treatment demonstrated that vine growth need not interfere with storage root growth. Restricting the water supply by hand-watering did limit vine growth, but it also resulted in reduced storage root initiation and growth. A major effect of HF treatment with a slow-release fertilizer seems to be an inhibitory effect on the storage root initiation process.

A number of aspects of this experiment differ from field conditions. Because these plants were greenhouse grown, they were set out earlier in the growing season without fear of frost damage. They were spaced generously, and the artificial growing medium provided better aeration than is obtainable in many fields. The plants were treated with a slow-release fertilizer allowing a uniform nutrient supply during the season. However, while the results of this experiment might not translate to field response directly, they do suggest that some of the factors thought to reduce productivity in the field, such as high fertility or high rainfall, may only correlate with the causative factors involved. Also, the idea that excessive vine growth reduces storage root yields through competition for assimilates is highly questionable from the results obtained.

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Root Protein Quantity and Quality in a Seedling Population of Sweet Potatoes

Lynn F. Dickey[1], Wanda W. Collins[2], and Clyde T. Young[3]
North Carolina State University, Raleigh, North Caroilina 27650

William M. Walter, Jr.[4]
ARS, U.S. Department of Agriculture, SEA, Southern Region, North Carolina State University, Raleigh, NC 27650

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Abstract. **A population of 100 sweet potato seedlings from 7 parent clones was grown for one season in order to evaluate root protein quantity and quality. Protein content of the 100 seedlings ranged from 4.38% to 8.98% with a mean of 6.29%; the 7 parents ranged from 4.96% to 6.53% with a mean of 5.72%. The mean of the seedlings was not significantly different from that of the parents. The 10 seedlings with highest protein (7.40% to 8.98%) were selected for further study of protein quality. Levels of nonprotein nitrogen (NPN) in these high protein selections were not significantly different from those of the parents. The correlation between the percentage of protein and the percentage of NPN was low (r = 0.30). The amino acid pattern in the high protein selections differed significantly from the parents with lower levels of valine, cysteine, methionine, tyrosine, and phenylalanine. Trypsin inhibitor activity (TIA) levels in the selected seedlings did not vary significantly from the parents. TIA and the percentage of protein were not significantly correlated (r = 0.15). The results indicate it is possible to obtain high protein cultivars without increasing the percentages of NPN and TIA. With the exception of valine, the aromatic and sulfur-containing amino acids, the overall protein quality was not changed in the seedlings with increased protein content.**

Sweet potato is consumed as a staple in many protein-poor countries thoughout the tropics, subtropics, and at least half the temperate zone (19). The consumption of low protein foods such as sweet potato seems to be one of the most important factors contributing to protein malnutrition in developing countries (4).

Although sweet potato protein content (quantity) can be increased through the use of various cultural management practices (3, 8, 12, 24), the most consistent means of increasing plant protein content may be through breeding and selection of high protein cultivars. Genetic variability for protein content seems to exist in sweet potato. The protein content ranges from 1.7% to 11.8% on a dry weight basis (DWB) (13). Similarly, Li (7) reported a range from 1.27% to 10.07% in varius Chinese cultivars.

Li (9) indicated that a mass selection technique would be effective in increasing protein and maintaining high yield. If the measurement of total protein in sweet potatoes in based on nitrogen content, however, it is necessary to distinguish between protein nitrogen and nonprotein-nitrogen (NPN). Levels as high as 40% of the total nitrogen have been found to be NPN (14, 15). The NPN fraction can contain as much as 83.4% amino acid, composed of asparagine (61%), aspartic acid (11%), glutamic acid (4%), serine (4%), and threonine (39%) (14).

In addition to protein quantity, the nutritional value (or quality) of the protein also should be considered. One important quality factor of sweet potato is the amino acid composition. Sweet potato contains an excess of all essential amino acids except tryptophan and total sulfur amino acids, which are limiting by comparison with the Food and Agricultural Organization of the United Nations (FAO) reference protein (13). Genetic variability in tryptophan content has been reported, however, so breeding and selection may improve this quality factor (13).

The presence of trypsin inhibitors in sweet potato (11, 16, 21) may contribute to decreased protein quality. Trypsin inhibitors can affect protein digestion adversely by inhibiting proteolysis. It has been suggested that the presence of these inhibitors in sweet potato is partially responsible for the disease enteritis necroticans (EN) in man and animals (5, 6). Significant variability in trypsin inhibitors has been found in sweet potato (11). Therefore, the level of trypsin inhibitors should be considered in potentially high protein cultivars which might be utilized in areas where EN and protein malnutrition is a problem.

The objectives of this study were: 1) to screen parents and the 1st generation seedling sweet potato population for protein content: and 2) to select the top 10% for further examination of protein quality as related to protein quantity.

One hundred open-pollinated seeds from seven parents were germinated and increased asexually to 9 plants per seedling. These 9 clonal plants were arranged in 3 replications (3 plants per plot) and grown in the field in a randomized complete block design. The 7 parents were replicated 4 times in a separate field, with 10 plants per plot. The plants were grown following standard cultural practices (23) at the Horticultural Crops Research Station at Clinton, N.C., for 102 days.

Six freshly harvested roots from each plot of the parents and seedlings were thoroughly washed, shredded, mixed, and a 180-g subsample was taken. Samples were frozen and

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[1]Horticultural Science Research Technician. Present address: Dept. of Biochemistry, N.C. State Univ. Raleigh, NC 27650.
[2]Associate Professor of Horticultural Science.
[3]Professor of Food Science.
[4]Professor of Food Science.