Midstorage Heating.Increased Plant Production from Bedded Sweetpotato Roots

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Abstract. 'Red Jewel' sweetpotato [*Ipomoea batatas* (L.)] roots were cured [$32 \pm 1\text{C}$, $85\% \pm 5\%$ relative humidity (RH)] for 7 days immediately after harvest and cured for 0 or 8 additional days before being stored ($16 \pm 1\text{C}$, $85\% \pm 5\%$ RH). Midway through storage, roots were heated ($32 \pm 1\text{C}$, $85\% \pm 5\%$ RH) for 0, 2, 4, 6, 8, 10, 12, or 14 days and placed back into storage. Before being bedded, roots were presprouted ($32 \pm 1\text{C}$, $85\% \pm 5\%$ RH) for 0 or 8 days. Plant emergence was accelerated with extended curing or presprouting and with increased midstorage heating duration. Early plant production increased with increasing duration of midstorage heating of roots not subjected to extended curing or presprouting. Eight days of extended curing eliminated response to midstorage heating; but, with 8 days of presprouting, a quadratic response to midstorage heating peaked at ≈ 8 days. However, when combined with midstorage heating, presprouting had more of an effect than extended curing on early plant production. Briefly extending curing, midstorage heating, and presprouting each independently increased the cumulative number of midseason plants, but only presprouting influenced total plant production. Treatments did not influence deterioration of bedded roots or number of sprouts <20 cm produced during 10 weeks of harvest.

Propagating sweetpotato plants from bedded roots is expensive for commercial sweetpotato growers in the United States. Practices that reduce the time from bedding to plant harvest or increase the total number of plants produced from bedded roots can reduce this expense. Presprouting sweetpotato roots for 3 weeks [$32 \pm 1\text{C}$, $85\% \pm 5\%$ relative humidity (RH)] before bedding is a standard method of increasing plant production (Deonier and Kushman, 1960), but rising energy costs have reduced the economy of this practice. Presprouting for 9 or 10 days increases the number of early and total plants produced and reduces the times from bedding to emergence, emergence to first harvest, and bedding to first harvest (Hall, 1987, '1990).

Sweetpotato roots should be cured ($32 \pm 1\text{C}$, $85\% \pm 5\%$ RH) for ≈ 1 week after harvest to heal wounds, and then the roots should be stored ($16 \pm 1\text{C}$, 75% to 80% RH) to maintain quality (Steinbauer and Kushman, 1971). Extending the curing duration from ≈ 7 to 18 days increased plant production but was not as effective as similar presprouting durations (Deonier and Kushman, 1960). Extended curing

has not been adopted as a commercial practice, partly because of excess sprouting, shrinkage, and shortened storage life in storage facilities lacking refrigeration (Steinbauer and Kushman, 1971). Roots in these facilities were subjected to temperatures $> 16\text{C}$ for several weeks. Previous research has shown that extending the curing period for up to 12 days successfully accelerated plant emergence and increased the number of early and total plants produced from bedded roots under controlled storage conditions (Hall, 1992).

Curing and presprouting conditions are identical, and the same facility can be used for both practices. Most commercial sweetpotato growers move sweetpotatoes from the field on pallets to a specially constructed curing facility (Steinbauer and Kushman, 1971). After the sweetpotatoes are cured, the pallets are moved to properly maintained storage areas. Harvest lasts for several weeks; during peak harvests, it may not be feasible to extend the curing of roots that will be used for plant production. Also, the grower may not decide until harvest is completed which sweetpotatoes or what quantity will be used later to produce plants. Therefore, sweetpotatoes often are moved back to the curing facility for presprouting immediately before bedding. Sometimes roots cannot be bedded immediately after presprouting because of unfavorable weather conditions, or weather conditions may become favorable for bedding before sufficient sweetpotatoes have been presprouted. Also, a lack of space may preclude presprouting of some roots immediately before bedding. Heating sweetpotatoes midway through storage as a substitute for presprouting has not been investigated. The

objective of this study was to determine if briefly applying heat midway through storage, either with or without briefly extending curing or presprouting immediately before bedding, would influence plant production from bedded sweetpotato roots.

All combinations of two extended curing durations, eight midstorage heating durations, and two presprouting durations were imposed on 'Red Jewel' sweetpotato roots harvested on 19 Nov. 1986. Roots 4 to 6 cm in diameter and 8 to 10 cm in length were selected and assigned randomly to 10-root lots. Each lot was cured ($32 \pm 1\text{C}$, $85\% \pm 5\%$ RH) for 7 days and then cured for either 0 or 8 more days before being stored ($16 \pm 1\text{C}$, $85\% \pm 5\%$ RH). Roots from each of the two curing treatments were subjected to midstorage heating ($32 \pm 1\text{C}$, $85\% \pm 5\%$ RH) on 31 Dec. 1986 and 1 Jan., 2 Jan., 3 Jan., 4 Jan., 5 Jan., and 6 Jan. 1987 for 14, 12, 10, 8, 6, 4, and 2 days, respectively, and then returned to normal storage. Roots not subjected to midstorage heating remained in storage. All roots were presprouted ($32 \pm 1\text{C}$, $85\% \pm 5\%$ RH) for 0 or 8 days immediately before being bedded on 18 Feb. 1987. After being presprouted, each lot was immersed for 15 sec in 640 g of 75% wettable powder 2,6-dichloro-4-nitroaniline (dicloran) in 40 liters of water, air-dried, and placed in 30×40 -cm contiguous plots in a ground bed in a greenhouse. All plots were covered with 5 cm of fumigated Tifton loamy sand (fine-loamy, siliceous, thermic Plinthic Paleudults). Roots were watered immediately after being bedded and thereafter when the bed surface was dry to a depth of 1 cm to ensure adequate moisture levels for plant production. After the first plant harvest, granular fertilizer [$(\text{g}\cdot\text{m}^{-2})$ 28.0N-12.3P-23.2K] was applied to the bed surface followed by 5 mm of water to wash all granules from the foliage to the bed surface. The air minimum in the greenhouse was 24C and soil was $28 \pm 4\text{C}$. Plants 20 cm high were harvested weekly from individual plots for 10 consecutive weeks, beginning when the first plant in a plot reached 20 cm above the bed surface. The date of initial harvest varied by 2 weeks, depending on the treatment combination. The roots were removed from the bed after the 10th week. The remaining sprouts <20 cm high and buds >2 mm long on the roots were counted and the roots were examined for deterioration. Data presented are the days from bedding to first plant emergence and the cumulative number of plants harvested per plot through the first 2 weeks (early plants), 6 weeks (midseason plants), and 10 weeks (total plants) after harvests began. The number of sprouts <20 cm high and buds >2 mm long are not included in the total number of plants.

The design was a randomized complete block with four replications of extended curing, midstorage heating, and presprouting in a $2 \times 8 \times 2$ factorial. Data for number of days from bedding to first plant emergence, cumulative number of early and midseason plants, total plant count, and number of sprouts and buds were subjected to $x^{1/2}$ transformation. Negligible deterioration of roots precluded analysis. Data were tested by analysis of vari-

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ante. There were no differences in the number of sprouts <20 cm high and buds >2 mm long remaining on roots removed from the plant bed. All transformed means were back-transformed for presentation.

Eight days of extended curing, up to 14 days of midstorage heating, or 8 days of presprouting reduced the time interval from bedding until plant emergence and increased the cumulative number of midseason plants (Table 1). The lack of interaction between these treatments for the cumulative number of midseason plants and for days from bedding indicated that the treatments acted additively. Only presprouting increased the total number of plants produced after 10 weeks of harvest.

The cumulative number of early plants increased with extended curing, midstorage heating, or presprouting (Table 1). When roots did not receive extended curing or presprouting, early plant production increased with increasing duration of midstorage heating (Table 2). Eight days of extended curing eliminated response to midstorage heating; but, with 8 days

of presprouting, a quadratic response to midstorage heating peaked at ≈ 8 days of heating. Midstorage heating was more effective in increasing early plant production when combined with presprouting than with extended curing. Eight days of extended curing increased early plant counts for short midstorage heating periods of up to ≈ 6 days, but the advantage of extended curing was canceled or greatly reduced if midstorage heating lasted 28 days. However, presprouting increased the number of early plants for up to 12 days of midstorage heating. There was a significant interaction in magnitude but not direction between extended curing and presprouting on the number of early plants (Table 1). Eight days of presprouting, compared with no presprouting, increased the number of plants produced from roots not receiving extended curing (26 vs. 10; $P \leq 0.01$) and from roots receiving 8 days of extended curing (32 vs. 20; $P \leq 0.01$). Also, receiving 8 days of extended curing, compared with not receiving extended curing, increased plant production from nonpresprouted

roots (20 vs. 10; $P \leq 0.01$) and from roots presprouted for 8 days (32 vs. 26; $P \leq 0.01$).

Previous research (Hall, 1992), evaluated sweetpotato plant production as influenced by 0-, 4-, 8-, and 12-day curing extensions and 0-, 4-, 8-, and 12-day presprouting durations and their interactions. In the current study, comparisons of midstorage heating with an 8-day curing extension and with 8 days of presprouting were included to evaluate the effects on sweetpotato plant production of each treatment separately and combined. The present findings agree with earlier ones (Hall, 1987, 1990, 1992) that presprouting for less than the standard 3 weeks reduces the time from bedding until plant emergence and increases the early and total number of plants produced. However, this study showed an increase in cumulative early and midseason plant production from a curing extension but not the previously reported increase in total plant production (Hall, 1992). Although not practiced commercially, the present findings show that applying midstorage heating effectively increased cumulative early and midseason plant production in the absence of extended curing or presprouting. Also, extending the curing period by 8 days and presprouting for 8 days enhanced the influence of midstorage heating on cumulative early and midseason sweetpotato plant production. The possibility of applying midstorage heat alone or combined with extended curing, presprouting, or both to increase sweetpotato plant production may be an alternative for growers facing timing or strategy problems in presprouting sweetpotato roots immediately before bedding.

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Table 1. Number of days from bedding until emergence and cumulative number of early and midseason plants and total plants harvested from plots of 10 bedded sweetpotato roots as influenced by extended curing, midstorage heating, and presprouting.

Heat treatment (days)	Emergence (days from bedding)	Cumulative no. plants produced		
		Early	Midseason	Total
Extended curing (C)				
0	20 [*]	17	41	73
8	18 ^{**}	26 ^{**}	46 ^{**}	77
Significance				NS
Midstorage heating (M)				
0	20	14	39	72
2	21	16	40	71
4	18	24	46	78
6	19	17	41	74
8	19	23	45	77
10	18	29	49	78
12	18	22	42	73
14	17	27	47	77
Significance	L**	L**Q*	L**	NS
Presprouting (P)				
0	20	20	37	73
8	17 ^{**}	29 ^{**}	48 ^{**}	78 ^{**}
Significance				
Interactions				
C × M	NS	**	NS	NS
C × P	NS	*	NS	NS
M × P	NS	*	NS	NS
C × M × P	NS	NS	NS	NS

^{*}Means may not average because of rounding, because analyses were conducted on transformed data, and because back-transformed means are presented.

^{ns,*,**} Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively; L = linear, Q = quadratic.

Table 2. Cumulative number of early plants harvested from plots of 10 bedded sweetpotato roots as influenced by midstorage heating and extended curing or presprouting.

Treatment	Midstorage heating (days)							
	0	2	4	6	8	10	12	14
Extended curing (days)								
0	7 [*]	11	18	12	21	29	20	27 ^{L**}
8	23 ^{**}	22 [*]	30 [*]	23 ^{**}	25	30	26 [*]	28 ^{NS}
Significance					NS	NS	*	NS
Presprouting (days)								
0	9	8	16	12	13	24	18	25 ^{L**}
8	20 ^{**}	27 ^{**}	32 [*]	22 ^{**}	36 ^{**}	35 ^{**}	28 ^{**}	30 ^{L*Q*}
Significance								NS

^{*}Means may not average because of rounding, because analyses were conducted on transformed data, and because back-transformed means are presented.

^{ns,*,**} Nonsignificant or significant at $P \leq 0.01$ or 0.05, respectively L = linear, Q = quadratic.