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Cool Temperature Induction of Brown Center in 'Russet Burbank' Potatoes[1]

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Abstract. **A study was conducted to determine if subjecting potato plants (*Solanum tuberosum* L. cv. Russet Burbank) to cool growing temperatures during and shortly after tuber formation would induce the development of brown center or hollow heart. Plants were moved at weekly intervals following tuber initiation from warm growing conditions into a 3-week cool environment (10° nights/18°C days). Plants were then returned to warm conditions (18° nights/23° days) for a period of several weeks and harvested. Those plants given the 3-week cool treatment or grown continuously in the cool after tuber initiation showed a significantly higher incidence of brown center.**

Hollow heart is a physiological disorder of potato tubers. Historically, it has been characterized by the death of small groups of cells in the pith region of the tuber. Later, the areas of dead cells become surrounded by a wound cambium layer, several cells in thickness, and if the disorder progresses, a hollow area can develop (6). The disorder often does not progress beyond the stage of initial cell death, so the result is a brownish, discolored area in the pith tissue commonly known as brown center. The various manifestations of this disorder result in serious economic losses to potato growers each year. The causes of hollow heart and brown center are not known, although many factors, both physiological and cultural, have been investigated (1, 2, 3, 5, 7, 8, 9, 10, 11, 12).

Observation of brown center development in commercial fields during 1975 and in plots at the WSU Royal Slope Research Unit during the early summer of 1976 led to the current investigation. The growing seasons were characterized by warm weather after planting followed by slowly decreasing temperatures until shortly after tuber initiation. This was followed by the onset of very warm weather late in the month of June. Those plants that had set tubers before the start of warm weather exhibited extensive brown center development, leading us to suspect that low temperature might be involved in the initiation of the disorder (Table 1).

Table 1. The effect of planting dates in 1976 on the percentage of tubers showing brown center and hollow heart.

Planting date[z]	Brown center (%)[y]	Hollow heart (%)[y]
1. April 13	24.5	0.5
2. May 6	28.5	1.5
3. May 25	3.5	1.5

[z]In planting dates 1 and 2, initial tuberization occurred before and during cool temperatures.

[y]Percentages based on samples of 200 tubers.

Greenhouse studies were conducted to test the hypothesis that low temperature during or shortly following tuber formation could induce the development of brown center or hollow heart in the newly forming tubers. 'Russet Burbank' potato seed pieces were cut to 54 g, washed, treated for 1 min in a 0.5% sodium hypochlorite solution, rinsed, placed in a perforated polyethylene bag and held at 15.5°C (60°F) for 3 weeks to suberize the cut surfaces and initiate some sprout development before planting. On November 10, 1977, the seed pieces were planted in 19 liter (5-gal) nursery tubs filled with a 3:1 mixture of Arcillite and Mica-Peat (a peat/vermiculite product of Langley Peat Ltd., Ft. Langley, BC) that had been previously sterilized. All plants were grown in a greenhouse that provided a 14-hr photoperiod and growing temperatures of 23°C (75°F) days/18°C (65°F) nights. Day length was maintained and supplemental lighting provided by high pressure sodium lights. On December 12, all plants were about 8 to 13 cm in height. On that date, the plants were randomly divided into 8 treatments with 6 plants per treatment. Two growing temperature regimes were used in this experiment – the warm temperature described above and a cool treatment providing 18°C (65°F) days/ 10°C (50°F) nights. The 8 treatments are described in Table 2.

Tuber initiation occurred about January 2, 1978, and was determined on the basis of test plants that were dug and examined for the presence of rhizomes that had passed the hook stage and were beginning to swell at the tips. None of the tubers were more than 5 mm in diameter. It is recognized that tuber initiation occurs over a period of time, but it was not possible in this experiment to identify individual tubers that were present on the plants on January 2 and distinguish between them and tubers which formed later.

During the course of the experiment, the plants were watered daily or as necessary, and at no time did the soil moisture tension exceed 50 centibars (measured by Irrometer tensiometer). Plants were fertilized weekly with 3 g of a commercial 16N-6.9P-13.3K fertilizer and 2 liters of Hoagland's micronutrient solution prepared according to Epstein (4).

The plants were harvested on February 27, and all tubers over 20 g in weight were cut longitudinally and examined for the presence of brown center or hollow heart. Three arbitrary categories were used for the evaluation of brown center – light, moderate and severe (Fig. 1). Light was character-

Table 2. Explanation of the 8 temperature treatments used in this study.

	Treatment	Description
I	Warm control	Grown continually in warm regime
II	Cool control	Grown continually (after Dec. 12) in cool regime
III	Control until TI[z]	Grown in cool (after Dec. 12) until TI, then returned to warm regime for remainder of experiment
IV	Cool at TI	Grown in warm regime until the designated time interval after TI, given 3 weeks of cool, then returned to warm regime
V	Cool at TI + 1 wk	
VI	Cool at TI + 2 wk	
VII	Cool at TI + 3 wk	
VIII	Cool at TI + 4 wk	

[z]TI = Tuber initiation.

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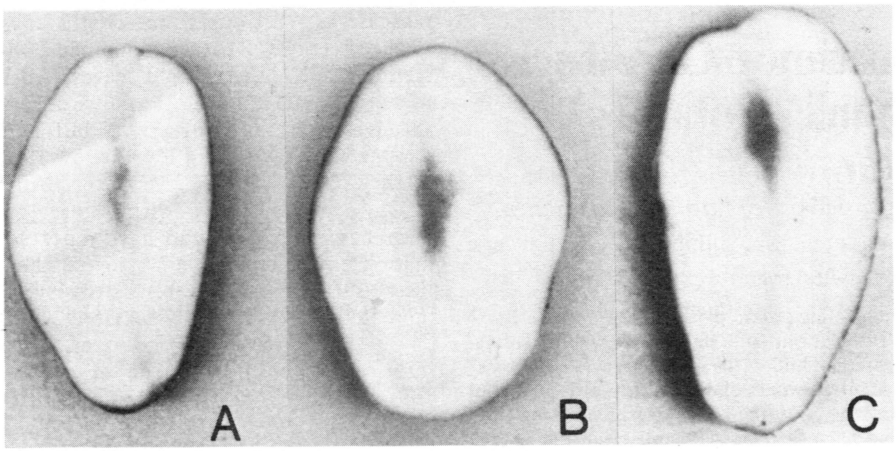

Fig. 1. Brown center categories: A) Light. B) Moderate. C) Severe.

ized by the presence of small, isolated groups of discolored cells dispersed in otherwise normal appearing pith tissue; moderate by the presence of a consolidated, discolored brown area; and severe by a much larger and very darkly discolored area that was watersoaked in appearance.

Those plants that were subjected to 3 weeks of cool growing conditions at or shortly following tuber initiation developed a significantly higher percentage of brown center than either those grown at warm temperatures or those grown in the cool until tuber initiation and then transferred to warm conditions (Table 3). Plants grown continuously under cool conditions had even more brown center than those plants given a 3-week cool treatment, although the difference was not significant.

Since tuber formation may take place over a considerable period of time, it is possible that additional tubers formed following the 3-week cool treatments and were unaffected. If this did occur, then the percentages of brown center observed at the conclusion of the experiment may not accurately reflect the full extent of brown center development in those tubers actually present on the plants during the 3-week induction period. The fact that Treatment III failed to produce any tubers with brown center, also suggests that the effect of cool temperature may be directly on the tubers rather than the plant. It is also possible that the effect of cool temperature is manifested only in tubers at a particular stage of growth or in a certain stage of growth in relation to the growth of parent plant. In a previous replication of the same experiment, only those plants given cool treatments within 2 weeks of tuber initiation exhibited brown center development. With the exception of Treatment VIII, a similar trend is evident in this experiment also (Table 3).

This technique may be useful for further investigation into the causes of these physiological disorders and for possible evaluation of cultivar resistance or susceptibility to brown center.

Table 3. Percentage of brown center induced in various temperature treatments.

	Temperature treatment	Brown center level (%)			
		Severe	Moderate	Light	Total
I	Warm control	0	0	0	0 a[y]
II	Cool control	3.0	18.2	33.3	54.5 b
III	Cool to TI[z] then warm	0	0	0	0 a
IV	Cool at TI	0	8.8	26.5	35.3 b
V	Cool at TI + 1 wk	0	10.7	25.0	35.7 b
VI	Cool at TI + 2 wk	0	0	12.5	12.5 b
VII	Cool at TI + 3 wk	3.7	0	11.1	14.8 b
VIII	Cool at TI + 4 wk	3.0	3.0	21.2	27.2 b

[z]TI = Tuber initiation.

[y]Mean separation within column by LSD at 5% level.

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