BROWN CENTER OF POTATOES -- WHAT HAVE WE LEARNED [1]

by
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The internal tuber disorders, brown center and hollow heart, have occurred sporadically in growers' fields for many years. These internal tuber disorders are caused by certain physiological conditions rather than by insects or diseases. Hollow heart appears as a cavity in the center (pith tissue) of the potato tuber. The size and shape of the cavity and color of the surrounding tissue can vary considerably (2). This disorder is often preceded by a small group of dead, brownish-colored cells. This stage is known as brown center or incipient hollow. Depending on rate of tuber growth, these cells can either dissipate or develop into hollow heart.

Temperature and soil moisture variations, plant spacing, fertilization, tuber set, amount of light, plant and tuber growth rates have been reported to influence the development of hollow heart. It is quite likely that a combination of factors is responsible for the problem when it occurs. The wide variation of results obtained from different experiments indicates that the occurrence of hollow heart is the result of a two-phase process with each phase being regulated by a different set of factors. The two phases are initiation (induction) and development (manifestation). None of the above factors have consistently resulted in the induction of these disorders nor provided evidence for the initial cause of cell death expressed in the initiation of brown center. Last year we reported (1) that temperature appeared to be more directly involved in the initiation phase of brown center. We have now devised a method which has quite consistently induced brown center in potato tubers (3) and will permit more detailed determinations of what causes the initial cell death and the interaction of the other factors reported to be involved in the manifestation of hollow heart.

Results of field experiments.

First, I would like to review for you and report some of the field experiments which we have conducted. Earlier planting dates generally resulted in higher amounts of brown center and hollow heart (Fig. 1 and 2). Planting dates were every 3 to 4 weeks from early April to late May with the main objective of studying low temperatures near the time of tuber initiation. Later planting dates normally result in more stems per hill (seed piece) and more tubers set per hill which might equal more competition and reduce the growth rate per tuber and subsequently less internal disorders. Yield decreased, but the percentage of number 1 tubers increased with later plantings (Fig. 3 and 4). More severe tillage (i.e., disruption of the root system) in the hilling operation has sometimes increased these disorders, but has not been consistent (Fig. 5 and 6).

Two levels of boron were established in plots at the Royal Slope Research Unit in 1975. Soil test analyses in 1978 showed 0.25 and 1.26 ppm boron in the "OB" and "+B" plots, respectively. Various numbered lines and named cultivars grown on these plots have given variable results, but also very low levels of tuber disorders (Fig. 7 and 8). Petiole analyses from plants showed little difference in boron levels. The fact that so many of these factors have been inconsistent in brown center induction, one can easily assume that some other factor must be involved in the initiation phase.

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1978 Growth Room Studies.

The preliminary report last year (1) showed that a low temperature exposure of plants at or shortly following tuber initiation resulted in the induction of brown center in a large percentage of tubers. This has been confirmed in several different experiments during 1978. This method will also allow more detailed and precise investigations on cell changes occurring during the very early stages of brown center initiation. Our early results indicated that a 3-week exposure of plants to temperatures of 50 to 55° F would induce brown center (3). More recently we have found that night temperatures of 50° F produced more brown center than night temperatures of 40 or 60° F (Fig. 9). The day temperature was 70° F for all plants. The severity of brown center is evaluated on the following rating scale: 1= no visible brown center, 2 = light, 3 = moderate, and 4 = severe brown center visible.

Potato plants at the time of tuberization, exposed to cool temperatures of 50/65° F (night/day) for three periods of seven days, exhibited brown center, but plants exposed to this same temperature for three two-day periods, or plants grown at warmer temperatures (65/75° F), did not develop brown center (Fig. 10). Potato plants grown at inductive air temperatures (55/65° F night/day) and different soil temperatures developed more severe brown center under the cooler soil temperatures (Fig. 11). Experiments are being conducted to investigate the effect of soil temperature at warmer, non-inductive air temperatures to determine if there is a differential effect of soil versus air temperature. A tremendous effect of soil temperature on tuber shape was also observed in the above experiments (Fig. 12). At warm soil temperatures (70° F) tubers were long, narrow, well-russeted and had distinct deep-set eyes. At cool soil temperatures, tubers were round, knobby, poorly russeted and had shallow eyes. Temperature is known to influence root and tuber growth, water and nutrient uptake and translocation, etc., but it remains to be seen what cause/effect relationship low temperature has with these and other factors in influencing brown center initiation.

Other greenhouse experiments have shown that at inductive low growing temperatures (55/65° F night/day), a more vigorous plant generally results in the initiation of higher percentage and more severe brown center. Plants treated with the growth regulator ethephon (Ethrel) resulted in significantly lower brown center severity and hollow heart (Fig. 13). The control plants had 50% of the tubers showing brown center and the ethephon-treated plants only 20% of the tubers with brown center. The ethephon treatments also reduced plant and tuber weight as shown below.

	wt/tuber (gms)	total tuber wt/plant (gms)	foliage wt/plant (gms)
Control	212	1052	963
Ethephon	128	247	746

Potato plants grown in large containers had a higher percentage of tubers with brown center than plants grown in small containers. Also, plants grown from new, one-year-old seed had more tubers with brown center compared to plants grown from two-year-old seed. This indicates a definite relationship of plant vigor response influenced by more stems and tubers per plant and foliage/root competition in relative growth rates.

Many questions remain yet at this point. Is there a certain size of tuber which is susceptible to the effects of low temperatures? What influence does time of tuber set have relative to time of temperature treatment? What period of cool temperature is necessary or effective? Different experimental methods are being developed to study these factors by directly observing and measuring individual tubers. These methods will be discussed in the presentation. Also, preliminary observations from electron microscopic studies will be presented. Potato tubers, after only five days at low temperatures, show changes in pith cell membrane and mitochondria integrity, more smooth endoplasmic reticulum than rough ER, and an increase in the level of proteinase inhibitors.

In summary, the results of these studies have more clearly shown the involvement of low temperature on the initiation phase of the brown center disorder and that the hollow heart disorder is a two-phase process in the Russet Burbank potato. Further studies will endeavor to elucidate the effect(s) that low temperature has in the initiation phase and interactive relationship with other factors as well as the manifestation into the second phase of hollow heart development. In addition to producing maximum yields, we must be aware of producing potatoes of maximum quality.

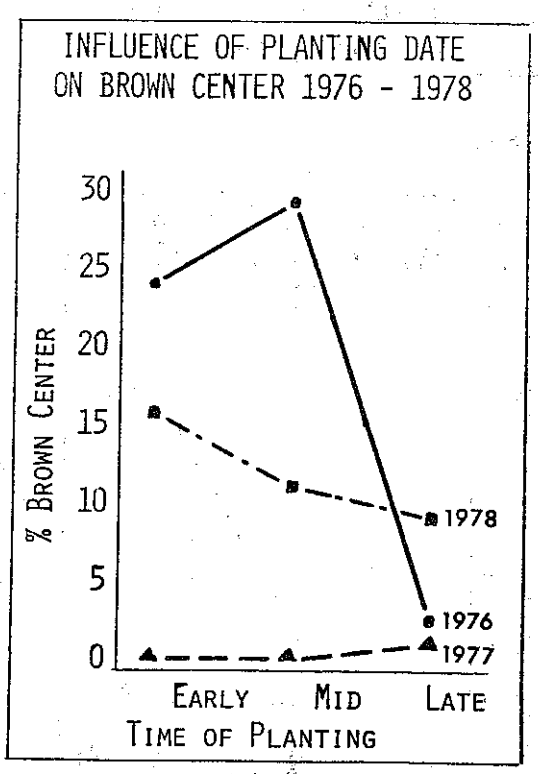
LITERATURE CITED

1. Hiller, L. K. 1978. Hollow heart of potatoes. Proc. Washington State Potato Conf. 17:19-20.

2. Levitt, J. 1942. A histological study of hollow heart in potatoes. Amer. Potato J. 19:134-144.

3. VanDenburgh, R. W., L. K. Hiller and D. C. Koller. 1979. Cool temperature induction of brown center in Russet Burbank potatoes. HortScience (in press).

Figure 1.



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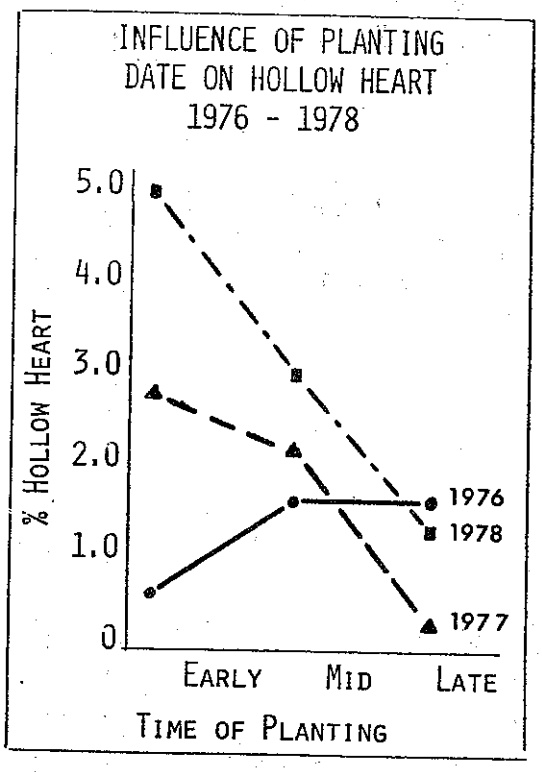

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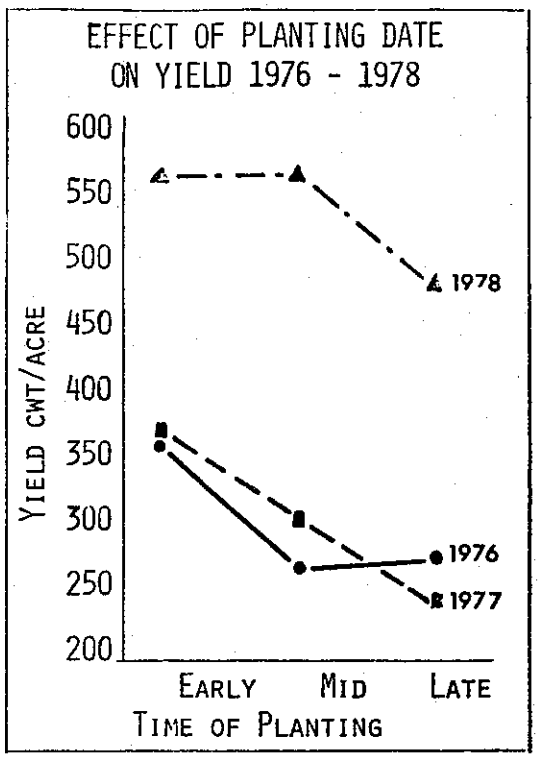

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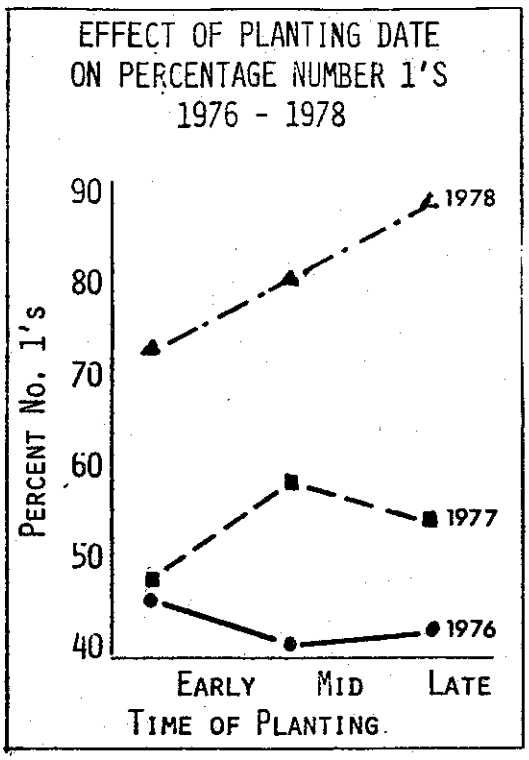

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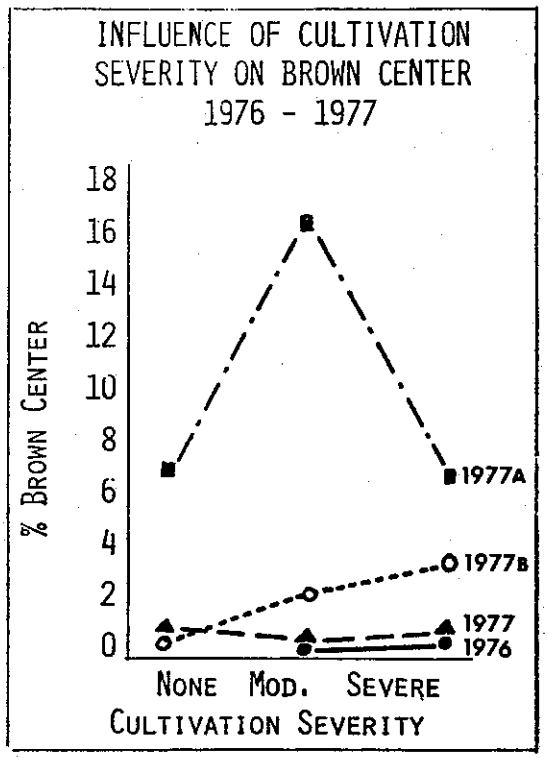

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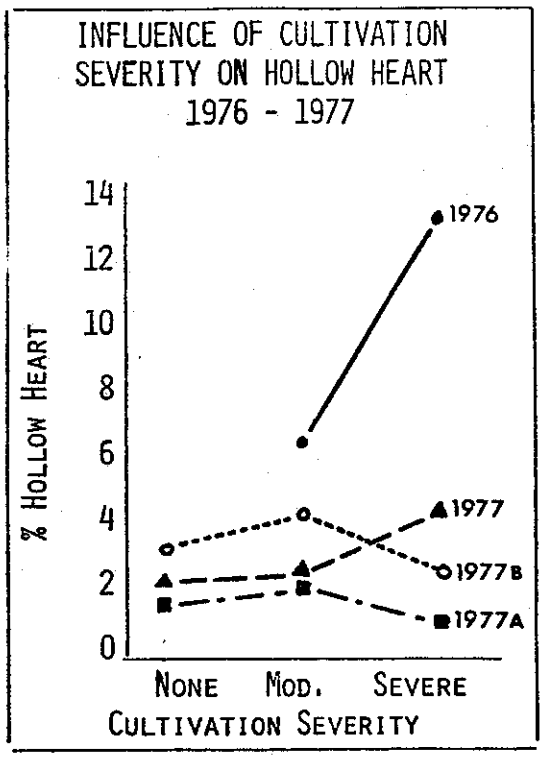

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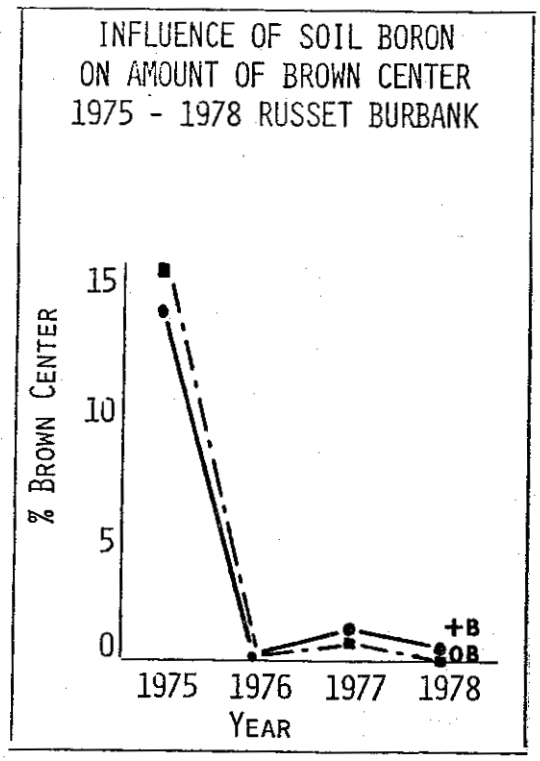

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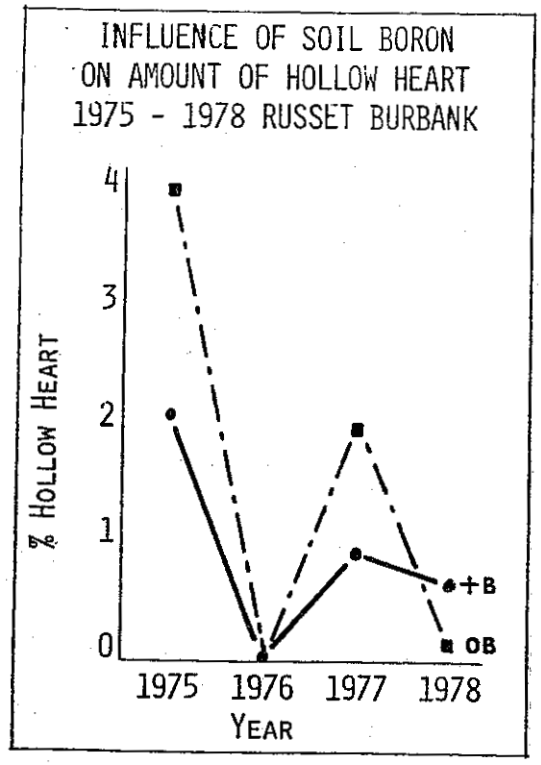

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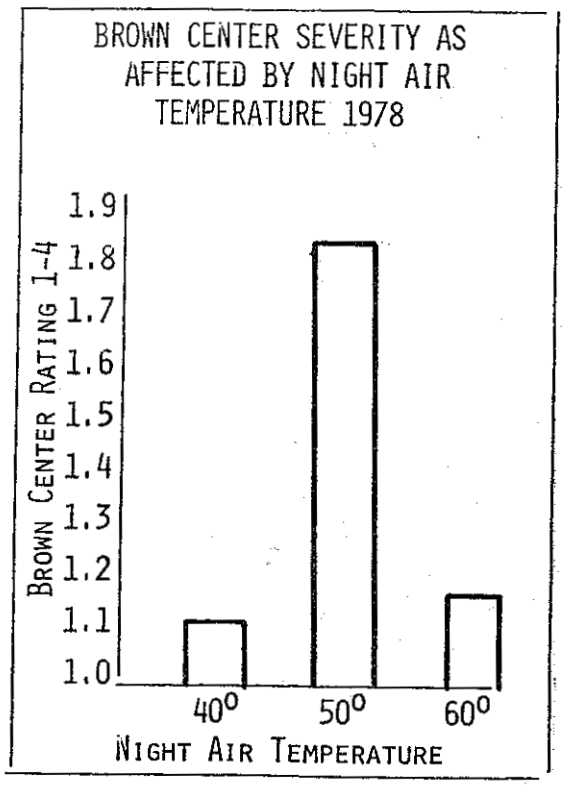


Figure 10.

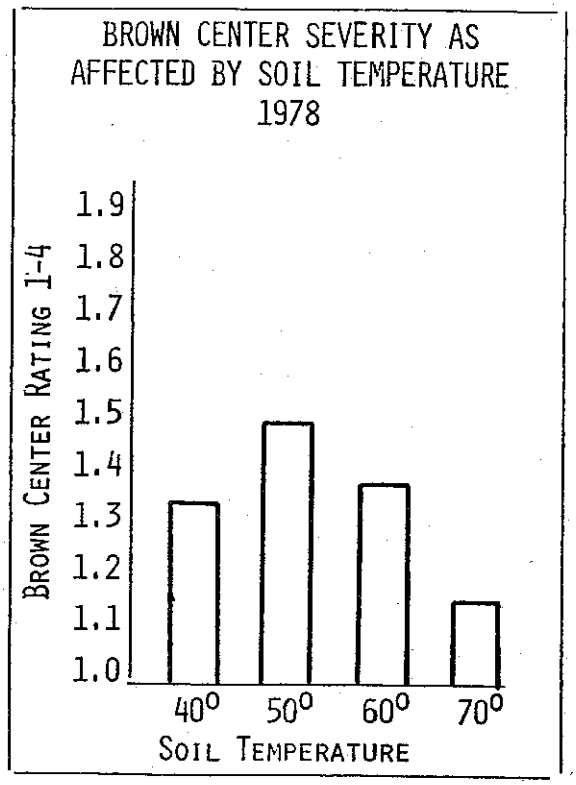
BROWN CENTER AS AFFECTED BY THE DURATION
OF EXPOSURE TO COOL TEMPERATURES

Averages for three trials, 1978

Trial number	1	2	3
Warm control	0	0	0
Cool 2 days	0	0	0
Cool 7 days	1.70	1.24	1.27

Brown center rating scale 1-4

Figure 11.



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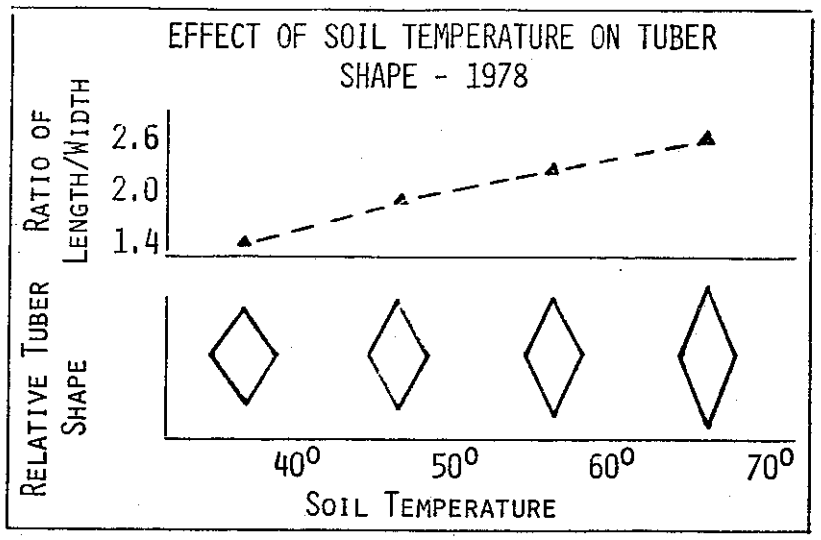

Figure 13. INFLUENCE OF ETHEPHON ON HOLLOW HEART AND BROWN CENTER SEVERITY

Averages for two trials, 1977-1978

HOLLOW HEART

Trial number	1	2
Control	7%	11%
Ethephon	0%	0%

BROWN CENTER

Trial number	1	2
Control	1.95	1.90
Ethephon	1.42	1.10

Brown center rating scale 1-4