Effect of High Energy Electron Irradiation on Respiration of Whole Sugar Beet Roots[1]

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The uncontrolled loss of sugar in the process of respiration, while sugar beets are piled to await processing, results in a sizable monetary loss each year. Irradiation of the roots has been suggested as a possible method of reducing respiration. Spikes and Stout (1)[3] report that discs cut from gamma irradiated sugar beet roots respired more rapidly for at least 40 to 50 days than non-irradiated samples.

Gamma rays have sufficient penetrating power to enter the cells without regard to their position in the root. In contrast, high energy electrons penetrate only the outer few millimeters of tissues of the sugar beet root. Since high energy electrons might affect respiration differently than gamma rays, simple experiments were undertaken to determine their effect on respiration of whole sugar beet roots.

Methods and Materials

Sugar beet roots were selected from the field for uniformity and freedom from injury. They were washed and stored in a cold room until ready for use. Each sample used to determine the rate of respiration contained 9 or 10 roots and weighed between 20 and 25 pounds.

Since large-scale temperature control equipment was not available, respiration was determined simultaneously on paired samples, one sample being the untreated control. Respiration rates were determined before irradiation and after irradiation of the paired mate of the control.

The samples were removed from the cold room 12 to 15 hours before respiration was measured and 12 to 15 hours prior to irradiating the roots. They were also maintained at room temperature for 3 to 24 hours following irradiation.

The roots were carried through the beam on a conveyor. Each root was irradiated on two sides: following exposure of the upper surface, the root was turned over to expose the lower surface. A root thus received some irradiation on all surfaces. The amounts of irradiation listed in Table 1 were applied to both

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[3] Numbers in parentheses refer to literature cited.

the upper and lower surfaces of each root. The median point of the roots was 47 centimeters from the window of the electron beam machine. Dosimetry was based on an ionization chamber calibration of the beam by the General Electric Company.

Respiration was determined by means of flow-trains, each consisting of: 1 empty gallon jug; two 1-gallon jugs, each half full of concentrated potassium hydroxide through which air was bubbled to free it of carbon dioxide; a small flask of barium hydroxide; a respiration chamber (an oil drum remodelled to about 40 to 45 liters capacity); and 3 flasks containing barium hydroxide to trap the carbon dioxide liberated in respiration. Following removal of carbon dioxide from the system, the carbon dioxide of respiration was collected for 3 hours. Air was passed through each flow-train at approximately 0.21 cubic feet per minute. The milli-equivalents of carbon dioxide respired were calculated from the titrimetric data.

Table 1.—Effect of High Energy Electron Irradiation on the Respiration of Whole Sugar Beet Roots.

Irradiation Dose REP	Approx. Percentage Increase in Respiration After	
	24-48 Hours	2 Weeks
50,000	25	
100,000	50	25
300,000	40[1]	15[1]
750,000	10	[2]
3,000,000	10	[2]

[1] The magnitude of the percentage increase may be somewhat in error due to difficulty with the flow-train in which the control was placed in the inital respiration comparisons.

[2] Radiation killed the surface tissues. Growth of saprophytic molds on surface of roots made further respiration determinations impossible.

Discussion of Results

Table 1 shows the effect of high energy electron irradiation on respiration of sugar beet roots. Except for the single determination for the 3,000,000 rep dose, each percentage increase in respiration is the average for two paired samples.

The 50,000 and 100,000 rep doses increased respiration markedly but no injury was apparent. Patches of slight darkening were visible on the surface of the roots receiving the 300,000 rep dose. The two high rates of irradiation apparently killed some of the surface tissues within 24 hours. These tissues no longer respired and, in addition, may have acted as a barrier to gaseous exchange. This could account for the relatively small increase in respiration noted for the two highest treatments. The death of the surface tissues permitted growth of saprophytic molds. A larger portion of the root surface was covered with mold in the 3,000,000 rep treatment after two weeks.

Conclusions

Small doses of high energy electron irradiation stimulate the respiratory process without any visible injury to the sugar beet roots. As the dose increases, injury of the surface tissues becomes increasingly severe. The stimulatory effect on respiration induced by the high energy electrons is prolonged but appears to subside gradually.

The effect of high energy electrons on respiration in sugar beet roots appears to be similar to that observed by Spikes and Stout (1) for gamma irradiated roots.

Apparently, treating sugar beet roots with ionizing radiations, whether shallow or deep penetrating, will increase the rate of respiration for a period of time. Such treatment is not effective in suppressing the rate of respiration of sugar beet roots prior to storing them in piles.

Literature Cited

(1) SPIKES, J. D. and STOUT, M. 1956. Effect of gamma irradiation on the respiration and re-growth of sugar beets. Unpublished data presented at the Ninth Meeting of Amer. Soc. Sugar Beet Technol.