THE INFLUENCE OF STORAGE FACTORS ON ENDOGENOUS ETHYLENE PRODUCTION BY POTATO TUBERS

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Abstract
Throughout a 7-month storage period, Russet Burbank tubers continuously ventilated at 32 F (0 C) and 45 F (7.2 C) with atmospheres of 2% O2, air, 4% CO2, and intermittently ventilated with air, evolved ethylene at a rate no greater than 0.008 μ 1 Kg⁻¹ hr⁻¹. Tubers stored in 80% O2 and 12% CO2 produced ethylene at much higher rates. In all cases where sprouting occurred, the rate of ethylene production increased.

Inoculation with Fusarium roseum greatly stimulated ethylene production but inoculation with Alternaria solani did not.

Introduction
Ethylene has been reported to stimulate sprouting of potato tubers (10, 13), inhibit sprouting (4, 5), increase respiration rates (6, 9) and sugar concentrations (6), and alter enzyme activities (11). Burton was the first to speculate that potato tubers were capable of producing ethylene (3). Poapst et al. in 1968 provided the first rigorous chemical proof that potato tubers evolve ethylene (8). McGlasson in 1969 observed that dormant potato tubers evolved ethylene at a rate less than 0.015 μ 1 Kg⁻¹ hr⁻¹ (7).

Work in our laboratory has shown that forced ventilation of seed potatoes generally improved productivity when compared to no through ventilation (14). Seed potatoes were tolerant of low oxygen concentrations (14) but were injured by levels of oxygen above 40% (17). Moderate levels of CO2 were injurious, particularly at low temperatures (15, 16).

The primary objective of this investigation was to evaluate the influence of chronological and physiological age as modified by certain storage factors on endogenous ethylene production by potato tubers. A secondary objective was to determine the influence of two common storage pathogens, Fusarium roseum, var. sambucinum and Alternaria solani on ethylene production.

Materials and Methods
Storage test:
Russet Burbank foundation seed tubers grown in the San Luis Valley of Colorado in 1970 were used in this study. Tubers, 4 to 6 ounces in weight, were randomized into the various treatments and placed in air-tight 20 liter containers. Each container was equipped with an inlet and outlet. The average number of tubers per container was 145 with two containers joined in series for each treatment.

Atmospheres of 2% O2, air, 80% O2, 4% CO2 in air, and 12% CO2 in air were prepared with flowboards and capillaries using a compressed air source and bottled gases. The atmospheres were passed continuously through the...
containers at a flow rate of 8 liters per hour. An additional intermittent ventilation treatment was also included. This involved repeated sealing of the two containers for 48 hours followed by flushing with air, to create a constantly changing status of O₂ and CO₂. The concentration of CO₂ in this treatment varied from 0 to 8% and the level of O₂ varied inversely relative to CO₂ and ranged from 21 to 13%. Two temperatures were selected for the study, 32 F (0 C) and 45 F (7.2 C).

Ethylene was scrubbed from the atmospheres prior to entering the treatment chambers with an ice-cooled mercuric perchlorate solution according to the method of Young et al. (18). One hundred ml gas samples were collected every 3 weeks from the outlet ends of the treatment chambers and analyzed for ethylene by gas chromatography. Ethylene measurements were made using the freeze-out technique of Stephens and Burleson (12). A gas chromatograph with a flame ionization detector (Model 5750, Hewlett-Packard, USA) provided chromatograms for methane, ethylene, ethane, acetylene, and other assorted hydrocarbons.

Operating conditions were as follows: the column was 1.52 m x 2.38 m packed with Porapak N (100/120 mesh), oven temperature 140 F (60 C), detector temperature 410 F (210 C), nitrogen carrier gas at a flow rate of 80 ml/minute. A freeze trap (1/8th inch OD stainless steel tubing packed with chromatographic substrate consisting of 10% dimethyl sulfolane on 42/60 mesh C-22 firebrick) bent into a “U” shape was fitted onto a gas sampling valve of the chromatograph. For analysis, 100 ml gas samples were passed through the freeze trap which was immersed in a liquid O₂ bath. After concentration, the sample was volatilized at 32 F (0 C) and injected into the chromatograph. Concentrations of ethylene were estimated from the peak height of the traces on the gas chromatograph recorder charts calibrated with known concentrations of ethylene. All measurements were made in Ft. Collins, Colo. (0.835 atmospheres) and were not corrected to standard temperature and pressure.

**Evaluation of pathogenic infection:** Approximately 1 kg of Russet Burbank tubers, previously stored at 45 F (7.2 C) for 7 months, were placed in 4 liter jars equipped with inlet and outlet ports. The jars were flushed with ethylene free air to reduce the external ethylene concentration. Tubers were then removed and inoculated with *Fusarium roseum* var. *sambucinum* (LK) Sn. & H. and *Alternaria solani* (Ell. & G. Martin) L. R. Jones and Grout. The tubers were returned to each jar and a beaker of KOH pellets was added to remove CO₂. The jars were re-flushed with ethylene free air and then sealed. A rubber septum was placed on one port to permit collection of gas samples. A manometer was attached to the other port to indicate the O₂ requirement. Ethylene measurements were made daily for 12 days at 55 F (12.7 C) using the technique described above.

**Results**

*Effect of 2% oxygen:* In 2% O₂ at 32 F (0 C), ethylene production remained below 0.001 μ 1 Kg⁻¹ through 7 months of storage (Fig. 1). At 45 F (7.2 C), ethylene production remained below 0.001 μ 1 Kg⁻¹ hr⁻¹ through the first 14 weeks of storage. An increase then occurred that continued during the remainder of the experiment. The rise in ethylene production at 45 F (7.2 C) coincided with sprouting.

*Continuous air ventilation:* The pattern of ethylene production by Russet Burbank tubers continuously ventilated with air was similar to that in 2% O₂ (Fig. 1). However, measurements were erratic between the 3rd and 11th week