Utilization of Potatoes for Life Support Systems in Space. IV. Effect of CO₂ Enrichment.¹

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Abstract

Potatoes (Solanum tuberosum L.) cvs. Norland and Russet Burbank were grown in solid stands in separate controlled environment rooms at two CO₂ levels, 365 µmol mol⁻¹ (ppm) and 1000 µmol mol⁻¹. Rooms were maintained under continuous fluorescent light (450 µmol s⁻¹ m⁻² PPF), 16°C and 70% relative humidity. Norland plants were grown for 110 days and Russet Burbank plants for 126 days. CO₂ assimilation rates (net photosynthetic rates) of exposed, upper canopy leaves were measured at weekly intervals beginning at 21-days-age for Norland and 28-days-age for Russet Burbank. Elevation of CO₂ increased CO₂ assimilation rates of Norland leaves by approximately 24%, but decreased rates of Russet Burbank leaves by approximately 12%. Assimilation rates of Norland leaves under the high CO₂ decreased as plants matured so that their rates were similar to rates under the low CO₂ levels after 70-days-age. Assimilation rates of Russet Burbank leaves under high CO₂ remained depressed in comparison to low CO₂ plants throughout the period of measurements. Yield data showed only marginal benefits from CO₂ enrichment: tuber dry weight increased 2% for Norland and 12% for Russet Burbank, total plant dry weight was increased 6% for Norland and 4% for Russet Burbank. The best productivity obtained in this study (21.9 g tuber dry wt m⁻² day⁻¹ from Norland at 1000 µmol mol⁻¹ of CO₂) indicates that the dietary energy needs of one human in space could be supplied from 34 m² of potatoes.

Compendio

Se hicieron crecer papas (Solanum tuberosum L.) de los cvs. Norland y Russet Burbank en soportes macizos en cámaras separadas de ambiente controlado, a dos niveles de CO₂ 365 µmol mol⁻¹ (ppm) y 1000 µmol mol⁻¹. Las cámaras se mantuvieron bajo luz fluorescente constante (450 µmol s⁻¹

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m⁻² PPF), a 16°C y 70% de humedad relativa. Se dejaron crecer las plantas Norland por 110 días y las Russet Burbank por 126 días. Se midieron las tasas de asimilación de CO₂ (tasas fotosintéticas netas) de las hojas expuestas en la parte superior del follaje, a intervalos semanales, empezando a los 21 días de edad para Norland y 28 días de edad para Russet Burbank. El aumento de CO₂ incrementó las tasas de asimilación de CO₂ de las hojas de Norland en un 24% aproximadamente, pero las tasas de las hojas de Russet Burbank disminuyeron en un 12%. Las tasas de asimilación de las hojas de Norland a niveles altos de CO₂ disminuyeron a medida que las plantas maduraron, de tal manera que las tasas fueron similares a las obtenidas a niveles bajos de CO₂, después de los 70 días de edad. Las tasas de asimilación de las hojas de Russet Burbank a niveles bajos de CO₂ permanecieron reducidas en comparación con las plantas a CO₂ bajo, por todo el periodo en que se hicieron las mediciones. Los datos sobre rendimientos muestran solamente beneficios marginales debidos al enriquecimiento con CO₂: el peso seco del tubérculo se incrementó en un 2% en Norland y 12% en Russet Burbank, el peso seco total de la planta se incrementó en 6% para Norland y 4% para Russet Burbank. La mayor productividad obtenida en este estudio (21.9 g de peso seco del tubérculo m⁻² por día⁻¹ para Norland a 1000 mol/mol⁻¹ de CO₂) indica que las necesidades dietéticas de energía de un hombre en el espacio podrían suministrarse de 34 m² de papas.

**Introduction**

Previous studies have documented the benefits of potatoes as a crop for controlled ecological life support systems (CELSS) proposed for space colonies (9, 11, 12). To date, however, productivity studies have been conducted only at ambient CO₂ level, approximately 350 mol mol⁻¹ (ppm) (11, 12). One would expect that total growth can be accelerated and yields increased by elevating the atmospheric CO₂ level (6). Yet previous studies with potatoes grown with CO₂ enrichment have shown mixed results: Arthur, et al. (1) reported better tuberization of Irish Cobbler plants at CO₂ levels 10 times that of ambient, ≈ 3000 μmol mol⁻¹, and Collins (4) reported significant increases in Kennebec yields when CO₂ levels were elevated to 600 to 700 μmol mol⁻¹. But a recent study by Goudriaan and de Ruiter (5) reported a slight negative effect on the growth of Alpha plants with 700 μmol mol⁻¹ CO₂ levels.

To more accurately assess the usefulness and response of potato to elevated carbon dioxide levels in life support farms for space colonies, we grew Norland and Russet Burbank in solid stands in walk-in controlled environment rooms. Atmospheres of the growth rooms were enriched to 1000 μmol mol⁻¹ CO₂ and compared to rooms maintained with ambient air exchange to determine effect of CO₂ on tuber and total plant production.