obtained by Robie (*8*) shows that at 700°K, the pH_2O for the reaction

$$\overset{\text{Tremolite}}{Ca_2Mg_5Si_8O_{22}(OH)_2} \rightarrow \overset{\text{Diopside}}{2CaMgSi_2O_6} + \overset{\text{Enstatite}}{3MgSiO_3} + \overset{\text{Quartz}}{SiO_2} + \overset{\text{Gas}}{H_2O} \quad (4)$$

is only 0.04 atm. From this it would seem that very small amounts of water in the rocks of Venus would be adequate to stabilize tremolite. In contrast, the pH_2O at 700°K in the reaction

$$\overset{\text{Talc}}{Mg_3Si_4O_{10}(OH)_2} \rightarrow \overset{\text{Enstatite}}{3MgSiO_3} + \overset{\text{Quartz}}{SiO_2} + \overset{\text{Gas}}{H_2O} \quad (5)$$

is 2200 atm. While confined to much higher temperatures, the experimental data of Yoder and Eugster (*9, 10*) seem to indicate that certain micas might also be stable in the rocks of Venus.

The atmosphere of Venus apparently shows signs of vigorous convection as indicated by the spectra and cloud colors (*3*); the latter may be caused by rock dust. Convection should not only aid in achieving the observed uniform circumplanetary temperatures (*1*), but should also make wind erosion one of the dominant modifying forces of the surface rocks. In addition, the finely divided state of the rock dust would aid in the chemical equilibration with atmospheric gases.

The interaction of the atmosphere and lithosphere of Venus suggested here appears to be in conflict with the recent interpretation of Sagan (*2*), who proposed that the high CO_2 pressure may be attributed to the failure of the carbonation equilibrium of $MgSiO_3$. The calculations of Weeks (*7*) referred to here indicate that the equilibrium values of pCO_2 over the magnesium carbonates, magnesite and dolomite, are higher than the deduced lower atmospheric values by hundreds of atmospheres at 700°K. Also, Sagan did not differentiate such compounds as $CaCO_3$, which have stability fields very different from $MgCO_3$ and $CaMgC_2O_6$. Thus, the high content of atmospheric CO_2 may be largely a result of the high temperature of the lithosphere.

Because of the similarity in scale of Venus and Earth it seems reasonable to suppose that similar orogenic processes occur on the two planets, sedimentary subsidence basins and metamorphic cycles also being features of the planetary history of Venus. The sediments should consist of wind-borne materials, and, assuming that water is scarce in the lithosphere, the dominant initial lithification process should be sintering. A relatively weak crust, and therefore a low relief, might be expected because of the higher temperature. If chemical equilibrium is approached on the surface, one might also expect the plutonic rocks to be undergoing a continuous transition during elevation and exhumation, so that relics of deep seated processes would be rare on the surface.

Some of the major unknown factors in the foregoing analysis are: (i) the rates of attainment of the equilibria; (ii) the competition between certain photochemical reactions in the upper atmosphere with the thermochemical equilibria; and (iii) the differential movement of various species from the planetary interior and their loss into space. In this regard it seems highly significant that no hydrogen compound has yet been detected on Venus. This agrees with the expected greater rate of loss of hydrogen as compared with the cooler or more massive planets. In general, the character of the atmosphere as discussed here is consistent with this hypothesis (*11*).

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Light-Induced Inhibition of Potato Tuber Sprouting

Abstract. *In freshly harvested Alaska-grown potato tubers there is a "rest period" during which time no sprout growth can be visibly detected. This is followed by a physiological stage of development when sprout growth will occur in the dark but is suppressed by light. Following this is a stage of gradual resumption of growth of light-suppressed sprouts and a lessening of the inhibitory responses in tubers planted at successive lengthening periods of time after harvest.*

Visible radiation causes many types of metabolic, tropic, and morphogenic responses in plants (*1*). Little research has been conducted on specific photomorphogenic responses of the potato plant or tuber. Wassink *et al.* (*2*) observed a strong, light-induced suppression of sprout growth in tubers that had been desprouted and were not planted. Their data do not, however, indicate the physiological stage of development of the potato tubers nor the length of time after harvest that the experiment was conducted. No reports have been found in the literature of potato tubers exhibiting a differential response at different physiological ages, in sprout or shoot growth as influenced by light. During studies of the nature of the "rest period" (*3*) of tubers a suppression of shoot elongation and leaf expansion by light has been observed in Alaska-grown potatoes. This photomorphogenic response is apparently restricted to a particular physiological stage of development in potato tubers.

Recent review articles by Burton (*4*) and Bruinsma (*5*) summarize the European, American, and Japanese literature on the physiology of "dormancy" in potato tubers. No reasonable explanation of the "dormancy" or "rest period" of tubers has been proposed as a result of much research effort into the nature of the phenomenon. The observations reported here may aid in an explanation of the potato tuber "rest period" and understanding of the postharvest physiology.

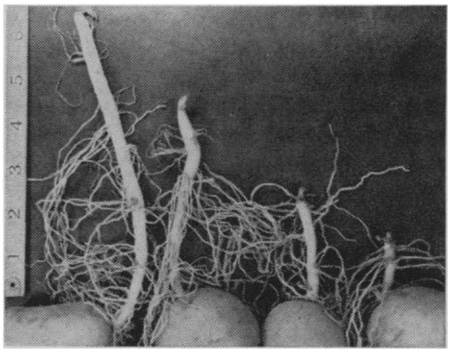

Fig. 1. Sprout growth on tubers that were planted the same date at 6, 4, 2, and 1 inches deep in sand. Typical root growth and light suppression of sprout tips at the sand surface are illustrated.

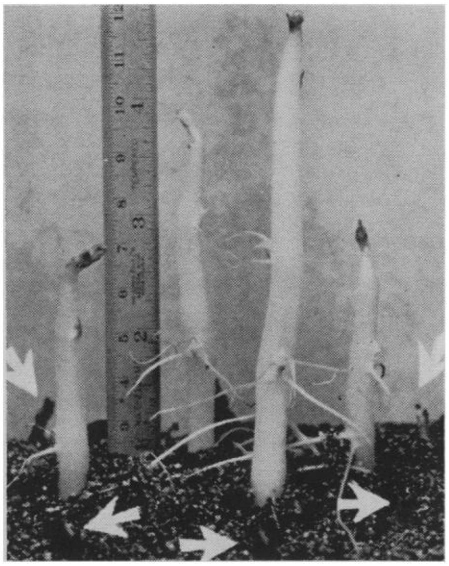

Fig. 2. Sprout growth that occurs in the dark under a metal can is shown. Some light-suppressed sprout tips are indicated by the arrows.

Potato tubers of varieties Alaska 114, Kennebec, Ontario, and Stately, grown at Palmer, Alaska, 62°N latitude, were harvested 10 September 1961 and stored at 3.34°C. On 18 October 1961 whole tubers were planted approximately 1 inch (2.54 cm) deep in moist sand in a greenhouse held at about 21° to 24°C with supplemental light of incandescent and fluorescent sources to supply radiation at approximately 11,000 lu/m^2 for 12 hours per day.

Tips of potato sprouts that had emerged from sand by 10 November did not produce further visible growth until 50 to 70 days later, depending on the variety. When resumption of sprout growth did occur, it was slow at first, with inhibitory effects still evident on the expanding leaves for some time.

Table 1. Average number of days from planting to sprout emergence and from planting to 1-inch (2.54-cm) sprout height above the soil surface of Alaska 114 tubers harvested 13 September, stored at two temperatures, and planted at various dates.

Date planted	Average number of days to emergence	Average number of days to 1-inch height
Tubers stored at 21°C		
14 Sept. 1962	44	
28 Sept. 1962	35	
10 Oct. 1962	27	85
Tubers stored at 3°C		
10 Oct. 1962	36	98
9 Nov. 1962	27	79
7 Dec. 1962	23	54
7 Jan. 1963	22	31
4 Feb. 1963	23	25
20 Feb. 1963	20	25

Whole tubers of Alaska 114 potatoes were planted 4 December 1961 in moist sand at 1-, 2-, 4-, and 6-inch depths (2.5, 5, 10, and 15 cm). Figure 1 shows Alaska 114 tubers photographed 2 January 1962, 29 days after planting, when the last sprout had emerged into the light. Typical light suppression of sprout growth upon exposure to light at the sand surface, root growth, and apical dominance of tubers are illustrated.

During 1962 these observations were verified and data collected on Alaska 114 tubers that show the approximate length of the "rest period" and of the light suppression period. Tubers were harvested 13 September and divided into two lots, one stored at about 3°C and the other held at about 21°C until planting. Ten whole tubers for each treatment were planted at several dates so that the apical eye was 1 inch (2.54 cm) deep in moist sand in a greenhouse with temperatures ranging from about 16° to about 21°C. Supplemental light of incandescent and fluorescent sources was supplied to provide radiation for 12 hours daily at approximately 11,000 lu/m^2 incident light at the sand surface.

Table 1 shows the dates of planting and average number of days from planting to sprout emergence and from planting to 1-inch (2.54-cm) sprout height for potatoes held at 3° or 21°C until planting.

The longer time necessary for sprout emergence of tubers planted shortly after harvest corresponds to the normal "rest period" which has been found to vary in most varieties of potato. In whole unplanted tubers held in the dark at 21°C, the first visible indication of sprout growth was 47 days after harvest. The time required for first visible sprouting was decreased slightly when tubers were planted in moist sand. The average number of days from emergence until the plants reached a 1-inch (2.54-cm) height decreased from 62 days to 2 days as the planting was delayed after harvest, showing a period of time when sprout growth is suppressed as the sprouts emerge into the light. As inhibited shoots resumed growth, leaf expansion was gradual in early plantings as compared with a rapid rate of expansion in the later plantings.

Sprout tips of tubers that were planted 15 November and that emerged 5 December were returned to darkness 8 December 1962 by placing a metal can over them. Figure 2 shows results of returning these light-inhibited sprouts to darkness. The photograph was made 13 days after the can was placed over the inhibited sprouts and shows the shoot growth and root growth typical of such a treatment as compared with inhibited sprouts that were not covered.

In the Alaska 114 tubers investigated, there was observed a "rest period" during which time no sprout growth occurred. This was followed by a stage when sprout growth occurred in the dark but was inhibited by light. This stage was followed by a stage when planted tubers sprouted and produced normal shoot growth with fully expanded leaves.

Kawakami (*6*) reported on a plant response due to age of seed tubers after harvest that appears similar to that noted in the present study when potatoes gradually resume growth after light-induced growth cessation. This condition may well be a photomorphogenic response similar to that observed in these studies.

In the potatoes investigated there seems to be a photosensitive stage when light induces a suppression of sprout growth. During this stage almost no visible growth in the light can be detected for several months. This photosensitive response disappears after storage or after a period of time when planted. The response to light is gradually lost, with suppression of leaf expansion present for a time after resumption of sprout elongation occurs.

Experiments are in progress to further describe this response and to determine if potatoes grown in more southern latitudes have a similar response.

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3. "Rest period" of potato tubers is defined as the period of time immediately after harvest when the tuber does not produce sprouts when it is in an environment favorable to growth. "Dormant period" is often recognized as that period after harvest when potato tubers may be stored at a temperature suboptimal for sprouting without beginning to sprout and includes the "rest period." Confusion exists in the literature in regard to the definition of these periods, with some authors making no distinction between the terms "rest period," "dormant period," and "dormancy." In this report a precise distinction is not recognized, especially in view of the response herein reported.
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