Tobacco plants on bench extending from east, left, to center, right, across half the width of phytotron room demonstrate uniformity of light possible through the glass blocks in roof plus artificial illumination.

Light Quality for Plant Growth EXCELLENT IN NEW PHYTOTRON

F. P. ZSCHEILE • H. R. DREVER • B. R. HOUSTON

Excellent light quality for plant growth was attained in the new Davis campus phytotron (described in the November 1961 issue of California Agriculture) through the use of prismatic glass blocks to direct sunlight downward onto the growing benches—plus supplemental light when needed from photocell-controlled electric lamps. This article details preliminary experiments with plant growth in the large, early model phytotron, including comparisons with plant growth in conventional greenhouses.

Many plants were grown in the summer of 1959 with sunlight only—when such light was near its maximum in the phytotron. The glass blocks were oriented to give high light intensities at noon. The temperature in the controlled climate chamber was kept at 70° F continuously. An olive tree, pear tree and grapevine in large tubs of soil retained good leaf color and grew continuously into September. The pear crop matured.

The following plants appeared to grow and bloom as well in summer in the phytotron as during the winter in the greenhouse (although temperature conditions were not optimum for all): sunflower, oat, barley, wheat, corn, string bean, soybean, and cotton. Some signs of low total light energy were present but light quality appeared satisfactory.

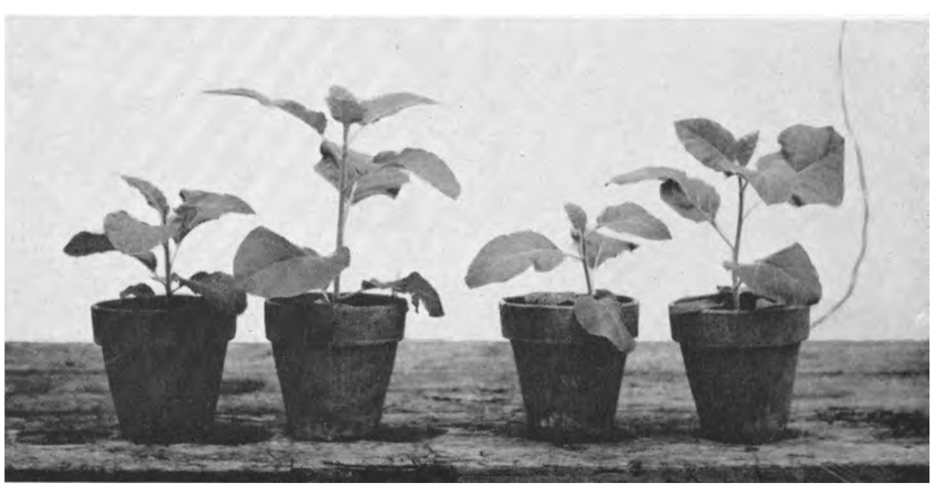
Sunlight in this room varies in intensity from east to west during the day in a compensating manner but no plant growth differences were observed. On September 11, 1959, 12 potted tobacco plants from the greenhouse, selected at the 5-leaf stage for uniformity in size and height, were placed in a row extending from the east wall to the center of the room, with soil surface 9½ feet from the ceiling. The natural day-length was 12 hours and no supplementary light was employed. This time, the glass blocks were oriented to give low intensities at noon.

A similar group of plants was placed in a conventional growth room illuminated with 1000 foot-candles of fluorescent lighting, supplemented with incandescent lights, during a 12-hour day. Temperatures in both locations were kept at 70–73° continuously. Twelve days later the plants were photographed as shown in the illustration above.

No consistent difference in height could be associated with position in the room. The phytotron plants were stockier and appreciably taller, had more and darker green leaves than those under fluorescent light and were similar in appearance to greenhouse plants. In fresh weights, the tops of the 10 best phytotron plants weighed 245 g., while similar fluorescent-lighted plants weighed only 130 g. Considering that much cloudy weather prevailed during this period (two-thirds normal sunlight), this plant test made the use of sunlight appear very favorable under these conditions.

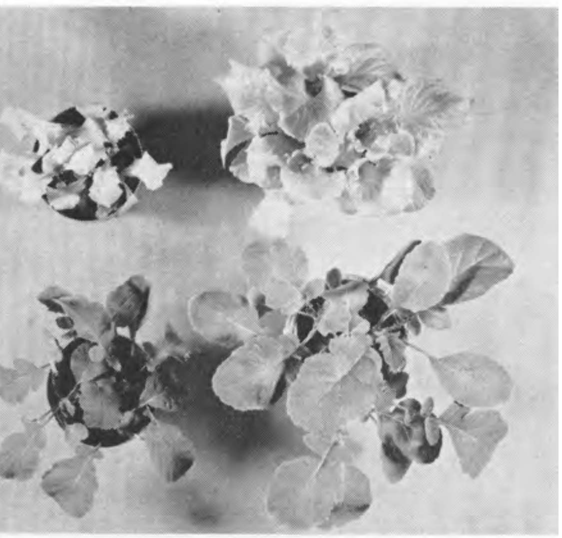
Six species of crop plants were planted on February 14, 1961, in 4-inch pots of soil. The pots were placed on three benches running north and south in the phytotron and 10 feet below the flat, glass-block ceiling. The glass blocks were oriented to give a more uniform sunlight intensity during the day. Incandescent light was blended with sunlight during

Smallest and largest of 12 tobacco plants used in phytotron tests, at 72°F from Sept. 11 to Sept. 23, 1959. The pair of plants to left were grown in phytotron with sunlight and natural daylength. Pair of plants to right were grown in growth room with fluorescent plus incandescent lighting and 12-hour daylength.



Lettuce, left, peas, right.

Radishes above, lettuce and radishes below.



Sugar beets, top, and spinach, bottom, in photo below.

DRY WEIGHTS OF PHYTOTRON- VS. GREENHOUSE-GROWN PLANTS AFTER 5 WEEKS GROWTH
(grams per plant)

	Phytotron					Green-house	Ratio of growth rates
	West Bench	Center Bench	East Bench	Total	Average among benches		
Barley	2.07	1.78	1.63	5.48	1.83	0.72	2.54
Lettuce	1.20	1.23	1.02	3.45	1.15	0.34	3.39
Pea	1.39	0.93	1.27	3.59	1.20	0.48	2.50
Radish	3.10	3.04	3.04	9.18	3.06	0.90	3.40
Spinach	1.30	1.37	0.73	3.40	1.13	0.39	2.90
Sugar Beet	1.44	0.96	1.09	3.49	1.16	0.32	3.63
Average							3.06

the day by photo-cell control to provide a minimum of 1250 foot-candles for a 16-hour day.

This light was provided by 36, 1500-watt, clear, incandescent, tungsten-filament lamps (*Bulb PS-52, Class C, Filament C-7A*) without reflectors. They were arranged inside the room around the periphery of the roof so that admission of sunlight would not be appreciably obstructed.

Midday maximum intensities varied from 1350 to 1950 foot-candles (on most days nearer 1700) during 8 hours. Day temperature was 60° and night temperature 55°. The soil surface was 42 inches from the floor. Barley (California Mariout), lettuce (Black-seeded Simpson), pea (Little Marble), radish (Scarlet Globe), spinach (Giant Thick-Leaved Noble), and sugar beet (U.S. 75, Lot 103) were distributed over the area of the room. Relative humidity was maintained above 70 per cent. By February 19, all seedlings had emerged. When all lights were on, the soil temperature reached 80° in clay pots. By wrapping pots in aluminum foil the soil temperature was reduced to 75°.

Twelve days after emergence the plants all looked well, especially the pea plants. The temperature conditions were chosen especially for peas. Radishes were of edible size three weeks after planting. At three and one-half weeks, all plants were repotted into 6-inch pots. Peas had buds, barley had heads in the boot stage, and radishes were in bloom. At four and one-half weeks from planting, peas had pods and barley heads were well-filled. At five weeks, plants were harvested and both fresh and dry weights were observed for one to three pots on each bench.

Similar plants had been grown in a conventional glass greenhouse coated with whitewash, but temperatures were too high—even at this early time of the year when it did not get lower than 70° at night and peaked near 90° in midday. Total sunlight on a weekly basis during this period was average for the first two weeks and 90 per cent of average the last three weeks. The sixth-week quantity was 60 per cent of normal and values from the seventh to tenth weeks were again normal. Maximum intensities in the greenhouse were about 4000 foot-candles (directly at the sun) and 2500 foot-candles, measured horizontally.

Several plants each of peas, lettuce, spinach, and sugar beets were transplanted individually into 5-gallon cans and left under the same phytotron conditions to develop in sunlight without supplementary light. At six weeks, peas were at the edible stage. At 10 weeks, the lettuce heads were large and well-developed, as were the beet and spinach plants.

Photographs

The photographs show comparisons of plants in the phytotron, right, and greenhouse, left, at the end of the third week from planting. In all cases, development of phytotron plants was far ahead. The table shows comparison of dry weights at the end of five weeks. The greenhouse plants in no case equaled the least weight of the phytotron group and the average ratio was strikingly favorable to the phytotron. These growth differences are prob-

Barley

ably due in large part to temperature and total irradiation differences. The favorable growth of the phytotron plants shows that if the air temperature is controlled, no obvious adverse effects follow the application of large quantities of infrared radiation from incandescent lamps (equivalent to 77 per cent of direct summer sunshine in intensity and extending over more time than sunlight).

In the phytotron, about two-thirds of the total light reaching the plants was from the incandescent lights, which extended the day length, the remaining one-third being from the sun. About 15 per cent of total outdoor sunlight reached the plants. The table above summarizes the relationships of visible light to infrared, or heat radiation for the entire experiment. These plants received the equivalent of about one-half the total outdoor light (quantity per day). Much more efficient designs of phytotron are now being planned to utilize sunlight more fully and incandescent light more efficiently.

LIGHT-INFRARED RELATIONSHIPS

During First 5 Weeks (Feb. 15 to March 21)

Ratios of Solar to Incandescent Radiation at Plant Level

Total radiant energy	1st 3 weeks	1st 5 weeks
Light	0.48	0.55
Infrared	0.094	0.11

Ratios during daily intensity maxima on clear days (up to 8 hours duration):

	Minimum ratio	Maximum ratio
Light	0.33	3.0 and higher
Infrared	0.065	0.58 and higher

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F. P. Zscheile is Professor of Agronomy, University of California, Davis; H. R. Drever is Laboratory Technician II in Botany, U.C., Davis; B. R. Houston is Professor of Plant Pathology and Dean of the Graduate Division, U.C., Davis.

BRIEFS

short reports on current agricultural research

EUROPEAN ALFALFA AND RED CLOVER

During the past growing season, the Department of Agronomy has had under test 16 varieties of alfalfa and 36 varieties of red clover from western Europe. The purpose of these trials is to determine their seed producing capabilities under California conditions. Agriculturalists from western Europe who have traveled in California have been favorably impressed with the yields and quality of seed produced under California conditions. This has often been in sharp contrast with results in many parts of Europe where frequent rains reduce yields and damage quality.

These trials were conducted in cooperation with both private and government officials in Europe as well as in the U. S. Varieties which show favorable seed producing ability would be increased under specific arrangements with the breeder or European governmental officials and in most cases would be produced for export purposes only.

Tests have shown wide variation in seed producing capabilities. In general, red clover varieties from northern Europe have been unsatisfactory while some from central or southern Europe have produced good seed yields. European alfalfa varieties also show large differences in seed yields.—*Maurice L. Peterson and Luther G. Jones, Dept. of Agronomy, University of California, Davis.*

ELECTRON MICROSCOPY AIDS PHYSIOLOGICAL STUDIES

Changes in cell structure caused by boron deficiency can be observed in great detail by electron microscopy. In contrast to the light microscope, which magnifies up to about 1500×, the electron microscope commonly magnifies from 1000× to 50,000×, with even higher magnification possible.

Research at Davis on tomato roots and leaves shows that boron deficiency profoundly affects the mitochondria, those parts of the cell in which respiration is centered. Other cell membranous systems such as the endoplasmic reticulum are shown to be much altered by boron nutrition, but proplastids and chloroplasts are relatively little affected. Effects of boron on cell wall formation are also revealed. Under deficiency the inner surface of the walls is much more irregular than normal, suggesting a relationship to carbohydrate metabolism. Such observations at the fine structural level of organization contribute to a more complete picture of the effects of deficiency of an essential element. Information of this type gives further clues to the function of boron in the plant and aids in the diagnosis of mineral deficiency disorders.

Other phenomena of special interest to vegetable production, such as fruit ripening, the action of growth regulators, and compatibility problems in the production of hybrid seed, should all be given closer scrutiny by use of the electron microscope.—*Arthur R. Spurr, Department of Vegetable Crops, University of California, Davis.*

CROP, SOIL RESPONSE TO WATER APPLICATION

The application of irrigation water to agricultural soils, whether by surface flooding or sprinkling, may adversely affect the structure of the surface soil. If this is the case, the distribution of water and nutrients in the soil and consequently the uptake of nutrients by plants and plant growth may be affected by the method of water application.

To investigate the magnitude of these effects a study has been initiated at the West Side Field Station on Panoche Clay Loam soil. Water is applied to row crops on a given schedule by furrow irrigation and by sprinkler irrigation using two different water application rates for the sprinklers (0.1 and 0.2 inch per hour). During the irrigation season, analyses of water stable aggregates, bulk density, and modulus of rupture are made on soil samples taken from the bottom of the furrow and the bed. Nitrate concentration of these surface soils is also determined. Complete analysis is made of plant tissue samples taken before each irrigation and before harvest. Crop yields will be obtained at the end of the season for each method of irrigation.

Preliminary studies in 1960 show that infiltration of water in the soil was significantly greater for the sprinkled plots, both in rate and total water infiltered up to 200 minutes. After 200 minutes time the rate of infiltration was not affected by the method of water application, but the total depth of water infiltered to 600 minutes was greater for the sprinkled plots.—*A. W. Fry, Assistant Engineer, Department of Irrigation, University of California, Davis.*