Sugar Beet Growth Research

all factors affecting growth of plants now subject to individual study in controlled environment laboratory

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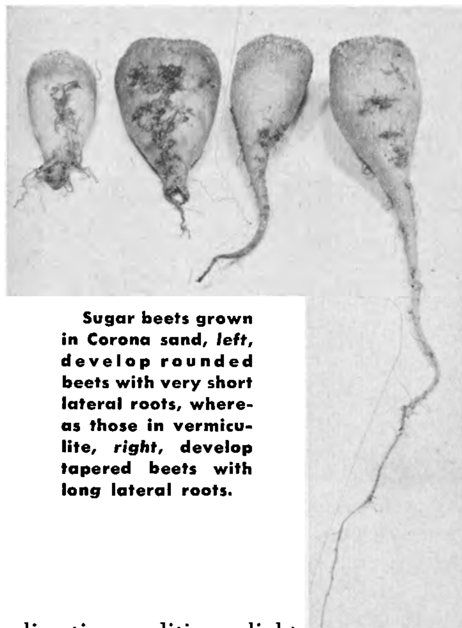
The investigations reported in the following article are being conducted through the cooperation of the California Institute of Technology, the Beet Sugar Development Foundation and the University of California College of Agriculture.

The proper soil temperature at which sugar beet seed should be planted, the approximate number of days required for germination and subsequent emergence of the plants, the effects of day and night temperatures upon the yield and sugar content of beets—these are the objectives of current investigations in controlled environments.



Sugar beets grown in Corona sand, *left*, develop rounded beets with very short lateral roots, whereas those in vermiculite, *right*, develop tapered beets with long lateral roots.

Under field conditions it is impossible to control all environmental factors which affect plant growth. Years may pass before all of the various climatic factors which influence plant growth and behavior would occur naturally. Extensive experiments would have to be conducted year after year under conditions of varying climate, soil fertility, moisture status, plant development and a host of other variables in the hope that eventually a sufficient amount of information may be collected, which when treated statistically, will bring to light the critical factors relating climate to growth. However, upon the completion of the Earhart Plant Research Laboratory at the California Institute of Technology in Pasadena, it became possible, for the first time, to perform experiments continuously throughout the year and to preselect and control independently all conditions influencing plant growth, including nutrition and climatic conditions—light, temperature, humidity, gas content of the air, wind, rain, or fog.

The new laboratory—sometimes called the phytotron—fulfills about the same function in the plant sciences as the cyclotron does in physics. Soil, sand, pots and plant material to be used in the laboratory can be sterilized or fumigated, and further infection is prevented by insect-proofing the greenhouses and outer walls of the building. Mercury vapor tubes permit the growing of plants in fluorescent light. In conjunction with fluorescent lamp illumination the phytotron has complete air conditioning. Regular alternation between day and night temperatures can be synchronized either with a predetermined daily time pattern or with changes in total light and heat radiation. In all greenhouses and light and dark rooms the air moves past the plants at a uniform rate of 33 feet a minute. A wind tunnel has been built in one of the air-conditioned rooms where plants can be subjected to air velocities up to 1,600 feet a minute. In another air-conditioned room, equipped with artificial light panels, slotted steel floor and waterproof electrical outlets, rain and fog can be produced. Two additional rooms can be used for experiments in which the composition of the air may be altered by introducing either ordinary gases or unusual gases, such as radioactive or smog gases.

The completion of this laboratory has fulfilled a long-felt need for equipment

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Night temperature as well as day temperature is important in the growth of sugar beet plants. The plants to the left and in the center were grown at the same day temperature (79°F) but differed only in night temperature (79 and 43° F). The plants in the center and to the right were grown at the same night temperature (43° F) but differed only in day temperature (79 and 68° F).

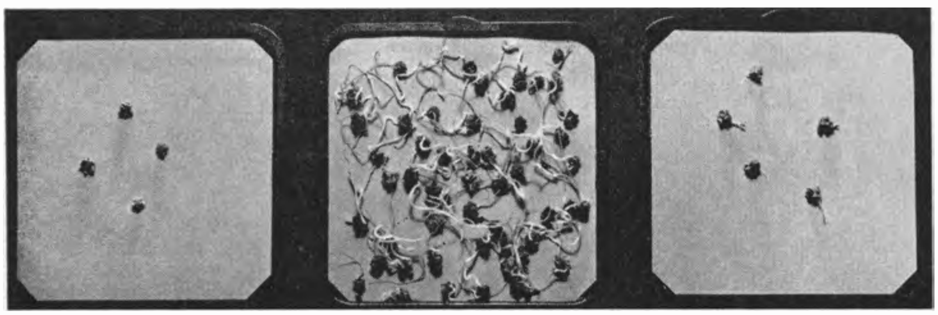
required to gain information on the specific effects of light and temperature on the growth and development of sugar beet plants. That light and temperature have an important effect upon the sugar content of beets has been indicated in field and greenhouse experiments in which all factors but climate were controlled. In these experiments differences in sucrose concentration in beets were observed which could not be interpreted except in relation to the uncontrolled variables associated with climate. By using the facilities of the phytotron, it will now be possible to evaluate the relative importance of climatic factors such as day length, light intensity and day and night temperatures in the production of sugar by beet plants. To date, experiments paving the way toward the consumation of this objective have been completed in relation to the substrate conditions affecting seed germination and beet growth, including root shape and top development. Currently, experiments are in progress to observe the effects of day and night temperatures upon seed germination, plant emergence and beet growth.

The effect of temperature on the germination of sugar beet seed has been of interest for some time to agronomists, geneticists, beet growers and seed testing laboratories.

Generally, the procedures for testing the germination of beet seeds recommend: *1*, maintenance of a temperature of 86° F during the day and 69° F at night; *2*, a constant temperature of either 77° F or 86° F; *3*, room temperature 70° F to 79° F.

The facilities available in the phytotron offer a unique opportunity to ascertain which of these recommendations is essential for a satisfactory estimation of the germination of a particular lot of sugar beet seed. Seeds for these studies were germinated in the dark either with alternating temperatures during each 24-hour period to simulate daily variation in temperature which might occur naturally or at a constant temperature.

The results obtained thus far indicate that temperatures maintained at a low level delay germination, whereas high temperatures are definitely injurious to the seed. Preliminary results indicate too, that at low temperatures, germination is improved by introducing moderately high temperatures during the 24-hour temperature cycle, and at high temperatures, germination is again improved by interruptions with periods of low temperature. From the results of these and other trials, it is hoped that it will be possible to determine the number of degree hours required for germination at each temperature regime. Such information may be of practical value in determining the soil temperatures at which beet seed should be planted and at what time interval germination may be anticipated.



Sugar beet seed germination is delayed at low temperatures and aborted at high temperatures. After 72 hours an average of 4 out of 64 seed balls germinate at 57° F, 52 at 79° F and 5 at 104° F.

In experiments on the influence of temperature on growth taking place after germination, that is, the emergence of beet plants, 32 seed balls were planted in small dishes containing vermiculite. Just as in the germination studies, the effects of constant and alternating temperatures are being studied. The results to be obtained may have the same practical applications as those for the beet seed germination studies.

At the beginning of this research program many decisions concerning experimental techniques had to be made. On the basis of past experience sugar beet seed of the variety United States 22/3 was selected and Phygon XL was adopted as the fungicide for dusting all seeds prior to planting. A culture solution containing all known nutrients necessary for growth was selected as the liquid medium for culturing the beets in pot containers.

Since a decision concerning the solid medium to be used for supporting the plants and for holding the nutrient solution was not clearly indicated from previous experience, a comparison of several new materials along with others of local origin was made. The materials tested included sponge rok of several grades, vermiculite, standard sand, gravel, Hanford sandy loam and Corona sand. Of these materials the latter was at first favored for culturing sugar beets in the present research program.

In testing the various solid media the experiment included a study of the effect of depth of planting.

The different depths employed were one-half inch, three-fourths inch and one inch. The results showed that for all materials the three-fourths inch depth was as good as or preferable to the one-half inch or the one inch planting depth.

For the coarsest grade of sponge rok the one-half inch depth was insufficient to prevent some drying of the seed, while in all instances the one-inch depth delayed emergence considerably.

In addition to the effect of planting depth upon seedling counts, the materials themselves had an effect upon the number of seedlings which emerged. Vermiculite and standard sand gave the highest number of seedlings in these tests. There was less difference for the various materials in the number of seedballs which germinated, but again the highest rates of germination were recorded for the vermiculite and standard sand.

After the beets had grown for eleven weeks, the beet weights and the dry and fresh weights of the tops of the harvested plants again indicated that there was no large difference in favor of any of the solid media or depths of planting, although the vermiculite gave the best yields throughout. The poorest root development by far, however, took place in the Corona sand. Thus Corona sand was eliminated for use in sugar beet experiments, though at first this material had been favored for the proposed program in the phytotron.

Sugar beets planted in pots containing vermiculite were grown in the greenhouse at 73° F under a uniform procedure. When these plants were large enough, they were divided at random into three groups. The first set of pots was placed in the greenhouse at 69° F, another set at 73° F and the final set at 79° F. Thereafter each set of plants was kept in its respective greenhouse for eight hours of each day and at night was moved in units of four pots to dark rooms at temperatures of 36° F to 86° F. At the end of the 16-hour dark period, the pots were returned to their assigned greenhouse day temperatures.

The beets responded quickly to the temperature regimes imposed upon them. The beets that have been given a high night and day temperature are a pale green color and are spindly in appearance. Other beets in the same day temperature, but cooler night temperature, have made better growth and have a good green color. Still cooler night temperatures have reduced the over-all growth of the beet plants. Thus, from these preliminary experiments, it is quite clear that

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lyzes. There are, however, commercial dust mixtures available in which little deterioration of the tetraethyl pyrophosphate occurs within a period of several weeks after they are prepared. Only such products should be used, because to approach satisfactory control practically all the aphids in a treated field must be killed.

Effect of DDT

It has been generally recognized that applications of DDT to melons on many occasions have resulted in an increase in the aphid population. However, it is desirable that a program be developed in which DDT can be used because it is so effective against *Diabrotica* beetles and the melon leafhopper, *Empoasca abrupta* De Long. Both of these insects are very destructive to melons and if not controlled may greatly injure the crop. During 1948 and 1949 extensive investigations were conducted and it was found that under some conditions DDT can be applied without resulting in a severe loss from aphids. On numerous occasions the environmental balance was not adversely affected. It is certain, however, that the amount of DDT used should be held to a minimum and treatments should be properly and thoroughly applied so that both the *Diabrotica* beetles and the leafhopper are nearly eliminated from the field. However, in order to guard against complications frequent applications of DDT to control these insects should be avoided. During the early stages of growth a material such as cryolite should be used to control *Diabrotica* beetles. Later when the leafhopper population develops to a level to justify control, an application of DDT can be made. It was found that 30 pounds of a 3% dust or a spray containing approximately two pounds of 50% wettable powder per acre will adequately control the leafhopper as well as any *Diabrotica* beetles present. Such a practice need not result in a serious dislocation of the environmental balance. During the 1949 season insect population trends were followed in a number of fields that received a DDT treatment. Subsequent to treatment in fields at Brentwood, Contra Costa County, and at Woodland, Yolo County, there was an increase in the aphid population, followed rather closely by an increase in the predator population. Although the aphid population showed evidence of becoming destructive the threat failed to develop because of the rapid rise in the predator population. The end result was almost perfect biological control. Of the predators present ladybird beetles appeared to be the most important. They were able to establish themselves in the fields rather shortly after the DDT was applied. For example, at Brentwood a 3% DDT dust was applied on July 25th and yet four weeks later the predator population had risen to a sufficiently high level to clearly indicate that it was going to suppress the aphid population. Another example was encountered at Woodland where a melon field was treated with a DDT spray on July 27th. No aphids were observed in a survey conducted on August 5th, but a survey one week later revealed the beginning of an infestation, which gradually increased until September 2d. At this time there were localized areas of severe infestation, but these spots were heavily populated with predators and the aphid population was practically destroyed within the next 10 days. The above illustrations clearly demonstrate that predators are able to establish themselves in a field within a relatively short time after it has been treated with DDT.

The rapid rate at which the predator population increases under favorable conditions is truly remarkable, and if the host population has reached a fairly high level just before it is suppressed the predators are present in great abundance. However, once the aphid is controlled there is a tendency for a rapid dispersal of the predators, and they largely leave the field. Where it is evident that natural enemies are in a position to control the aphid, applications of insecticides that are likely to destroy the environmental balance should be avoided, if this is at all possible.

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JUICE

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Potassium in juice was increased by the fertilization with potassium.

At Riverside, the application of potassium in the fertilizer caused a significant decrease in the calcium content of the juice. The application of phosphorus also reduced the calcium. When phosphorus and potassium were applied together, the decrease in calcium content of the juice was highly significant. The application of manure likewise reduced the calcium content, and high nitrogen from calcium nitrate failed to increase the calcium content. At Claremont, these treatments caused no significant differences in the calcium concentration in the juice.

Correlations

It was found in the Riverside and Claremont experiments: *1,* that a negative correlation existed between the phosphorus content and the acid content of the juice; *2,* that a positive correlation existed between the potassium content and the total acid content of the juice; *3,* that a positive correlation existed between the phosphorus content of the juice and the percentage of juice of the whole fruit; and *4,* that the ascorbic acid content of the juice was negatively correlated with the concentration of phosphorus in the juice.

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FREEZE

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tively large percentage of the freeze injured fruits. The weather conditions were also such that the concentration of soluble solids in the juice did not become so high and the acids did not get so low as in most years.

Young, immature, freeze-injured citrus fruits make a more nearly complete recovery than mature or nearly mature fruits. Under southern California conditions therefore, Valencia oranges, immature lemons and Marsh grapefruit have a better chance to recover than Navel oranges which are usually mature at the time of the low temperatures.

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The detailed results of this investigation will appear in the near future in the form of a University of California Bulletin.

SUGAR BEET

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night temperatures, as well as day temperatures, must be considered in growing a crop of sugar beets successfully at a high nutrient level.

At harvest the beets in this experiment will be analyzed for their sugar content and perhaps the results of the sugar analyses will be as startling as the differences observed in the growth of the beet plants themselves.

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The Earhart Plant Research Laboratory where this project is being conducted is under the direction of Professor F. W. Went at the California Institute of Technology in Pasadena.