Sugar Beets and Climate

effects of night and day temperature and day length on beet growth and sugar production investigated

Albert Ulrich

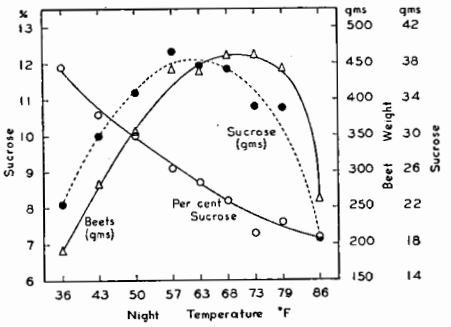
The importance of climate on the raising of a bumper crop of sugar beets is being studied in controlled climate experiments in the laboratory.

The experiments proved that a general relationship exists between night temperature, beet growth and sugar production.

As shown in the accompanying diagram, the beet root weight increases rapidly with rise of night temperature from 36° F. Maximal weights of beet roots are obtained between night tempertures of 57° F and 79° F. At 86° F the beet weights decrease sharply.

The sucrose concentrations of the beet roots grown at different night temperatures form an entirely different pattern. The highest sucrose concentration is found in beets grown at the lowest night temperature. As the night temperatures are increased the sucrose concentrations of the beets decrease gradually from a high value of 12% sucrose at 36° F to a low value of 7% at 86° F.

The total amount of sucrose produced per beet follows much the same pattern as the beet root weights. Of commercial and scientific interest is the fact that the maximum amount of sucrose is produced at a lower night temperature than the maximum beet root growth.



Relationship of night temperature to per cent sucrose, beet root weight and sucrose produced. Each point represents an average value obtained from 12 sugar beet plants grown at a given night temperature but with four of the 12 beets grown at a day temperature of 68° F, four at 73° F and four at 79° F. Day periods in sunlight were from 8 a.m. to 4 p.m. and the night periods from 4 p.m. to 8 a.m.

Day Temperatures

When the results of the experiment are grouped according to day temperatures tested, the beet root weights at 68° F, 73° F and 79° F have respective average values of 307, 392 and 413 grams per beet. Thus the relatively small increases in day temperature produced an average increase in beet root weight of 31%. The sucrose concentrations of the same beets were 9.20%, 9.16% and 8.52% at the respective day temperatures of 68° F, 73° F and 79° F. These increases in beet root weight and decreases in sucrose concentration, while relatively small, are in accord with those observed for night temperature changes. The day temperature increases, however, did not change significantly the total amount of sucrose stored by the beet plants, since the increases in beet root weight were canceled by the decreases in sucrose concentration.

Day Length

The amount of light received by beet plants greatly influences the beet root weight as was shown by comparing plants in a day period limited to eight hours of sunlight with plants in natural day length, 10 to 14 hours a day. The beet roots for normal day length doubled in size without changing the weight of the tops or increasing greatly the sucrose concentrations of the beet roots.

Apparently, for reasons as yet unknown, the first photosynthetic products of beet plants are used for the development of tops and fibrous roots. If the sugar produced exceeds the amount required for development of tops and fibrous roots, the excess is diverted to storage root growth. Evidently the plants receiving more than eight hours of sunlight operate much as a modern factory does when the working day is extended from eight hours to 16 or 24 hours. Under the longer day lengths the beet root and sucrose weights of the plants doubled, but the sucrose concentration increased only slightly. The plants which were subjected to eight hours of daylight had a sucrose concentration of 8.5% as compared to 9.5% for plants receiving 14 hours of sunlight at the time of harvest.

In the experiments conducted thus far, the beets failed to reach a sucrose concentration generally found in commercially grown beets. Apparently, in the presence of an abundant supply of water and plant nutrients, the beet plants, both tops and roots, grew rapidly, utilizing the sucrose synthesized as it was produced by the plants. Under these conditions a high sucrose accumulation in the beet root is prevented as long as favorable conditions

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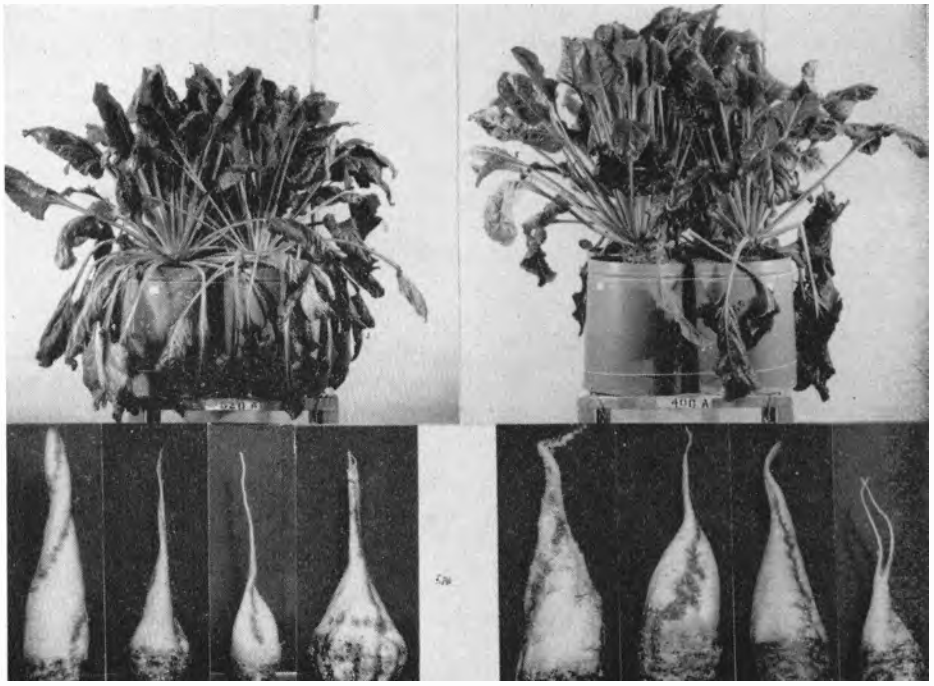

Effects of day length on beet growth. The beets on the left were grown in sunlight limited to 8-hour periods (8 a.m. to 4 p.m.) at 73° F followed by 16-hour periods in the dark at 63° F. The beets on the right were grown at the some temperatures as those on the left but were allowed to receive the full period of sunlight normal to Pasadena, which amounted to 10 hours in January to 14 hours in May. The additional sunlight doubled the size of the beet roots without appreciably increasing their sucrose concentration or the size of the tops.

Deciduous Character of Pepper

tiny fruited form is crossed with non-deciduous variety to get easy-to-pick pepper for commercial use

Paul G. Smith

Deciduous ripe fruit character in peppers, which allows the fruit to be picked while the stem remains on the plant, was inherited in a cross of a tiny fruited Chili Piquin with large but non-deciduous varieties.

Virtually all varieties of the common cultivated pepper, *Capsicum annuum*, are non-deciduous: the ripe fruit adhers tightly to the calyx, so that the calyx and most or all of the stem remain attached to the fruit when picked. Because of the high labor costs in removing the stems from the pods, most of the cayenne or red pepper, paprika and chili powder manufactured in the United States is made from non-stemmed pods. The presence of this woody tissue in the ground powder is economically unavoidable but it lowers the quality and color of the product.

Among a large number of Mexican varieties a tiny fruited wild form called Chili Piquin—Ac. 635—was found to have fruit which separated readily from the calyx when ripe. The fruits are easily picked, while the stem remains on the plant. This character promises to be of value in the problem of economical removal of the stem tissue.

This deciduous fruit character was found in three other wild pepper varieties Ac. 907, 908, and Ac. 957. All four varieties have fruit not over one half inch long. The deciduous character is not found in any of the larger fruited cultivated varieties.

To determine the inheritance of this character and to incorporate it into varieties suitable for commercial use, Chili Piquin was crossed with the non-deciduous Mexican Chili variety. The crossbreds of the first generation—F_1—was selfed, backcrossed to each parent, and outcrossed to California Chili, which is also non-deciduous.

The results show that the deciduous character in *C. annuum* is inherited as a single dominant gene.

In the segregating populations there are definite differences among deciduous plants in the tightness of the fruit to the stem. Many, including the Chili Piquin parent, have fruit which fall at a light touch, while others require some pull. The latter condition is of more value in breeding because of the danger of fruit dropping as a result of wind or other plant disturbances if the fruits are too easily separated from the stems.

Limited evidence indicate that the deciduous character is dominant in several other species of *Capsicum* which are rarely seen in this country. In the following crosses involving both allels, *C. frutescens* × *C. frutescens*—Tabasco × Ac. 902—*C. frutescens* × *C. annuum*—Tabasco × Long Red Cayenne—*C. frutescens* × *C. pendulum*—Tabasco × Ac. 911—and *C. chacoense* × *C. annuum*—Ac. 689 × Long Red Cayenne—all crossbreds of the first generation were deciduous.

The fruit of Chili Piquin, *upper left*, is dwarfed by its cultivated relatives, Floral Gem, *lower left*, Long Red Cayenne, *center*, and Mexican Chili, *right*.

All these other species are very difficult to hybridize with the cultivated pepper, so that Chili Piquin and the other wild forms closely related to it remain the best source of the deciduous gene.

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The above progress report is based on Research Project No. 906.

CLIMATE

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of growth prevail. Only when the utilization of sucrose is decreased without curtailing sucrose synthesis—such as when beets become nitrogen deficient—that the beet root will accumulate sucrose to a high concentration. Other mechanisms for effecting sucrose accumulation may also occur in the beet plant, and one of the objectives of future experimentation will be to find them. A better understanding of the factors affecting sugar beet growth may have an important bearing on the effectiveness of the beet sugar industry to maintain its competitive position in the years to come.

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The above progress report is based on Research Project No. 1157 which is being carried out in co-operation with the Earhart Plant Research Laboratory, California Institute of Technology in Pasadena.

Effects of night temperature on beet growth. The beets from left to right were grown in sunlight for eight hours (8 a.m. to 4 p.m.) at 73° F followed by dark periods of 16 hours at 36° F, 50° F, 63° F, 73° F and 86° F. The highest sucrose concentration was found at the lowest night temperature while the highest root weights and sucrose yields were observed for the intermediate night temperatures. The beets in these experiments were grown in vermiculite and watered daily with a complete nutrient solution.