Plastic Chambers for Humidity and Temperature Control in Vegetative Propagation and Growth of Sugar Beets[1]

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The polycross breeding system in use at East Lansing, Michigan, requires selfed seed or a cutting from the original plant for completion of the polycross. Cuttings are also used in genetic studies and physiological studies where genetically uniform plants are needed. Since most seed is produced during the summer, it is expedient to take cuttings at that time. Because of adverse temperature and moisture relations, the rooting of cuttings in the summer is more difficult than at other seasons. A plastic humidity chamber was built in 1955 to alleviate these adverse summer conditions.

Sugar beet breeders are searching for methods to reduce the time required for successive generations. Gaskill (1,2)[3] reported a method "by means of which two successive generations of sugar-beet seed can be produced in 12 months, with approximately 100% flowering." He suggested post-induction temperatures of 60° F or below at night, with the maximum during the day (in the shade) seldom exceeding 80° and then only for very short periods, and with a daily average not exceeding 68°.

The average daily mean temperature at East Lansing exceeds 68° F from June 16 to August 21. Such temperatures necessitate artificial means of cooling to assure successful blooming at the end of the post-induction period. In an accelerated breeding program artificial cooling may be needed between June 16 and August 21, since post-induction would need to be started by April 19 to be safely completed ahead of unseasonable warm weather or delayed at least until September 5. The second part of this paper deals with a plastic chamber for temperature control.

A Plastic Humidity Chamber for Summer Rooting of Sugar Beet Cuttings

A constant-mist humidity chamber, similar to the one built by Sweet and Carlson (4), was constructed in the summer of 1955. The constant mist appeared to have some undesirable features such as excessive leaching of nutrients from the leaves

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[3] Numbers in parentheses refer to literature cited.

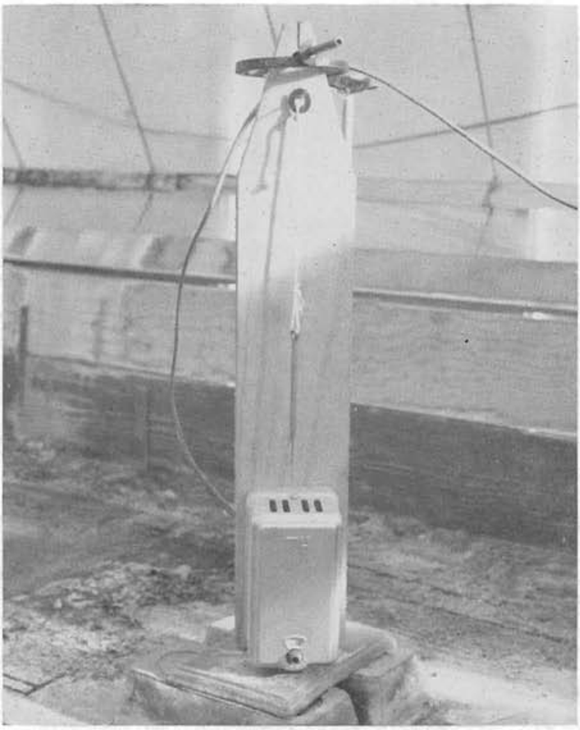

Figure 2.—Pendulum-mounted, portable, humidity-control unit.

humidity-control unit, which energizes the valve when the humidity drops below the setting on the control. The mist nozzles are oil-furnace nozzles rated 0.3 gallon per hour, 80° angle. Six nozzles provide adequate mist in the chamber measuring 3 feet wide, 16 feet long, 19 inches high at the sides, and 28 inches high at the peak.

A 12-inch, three-speed office-type fan was mounted in one end of the chamber to exhaust the air from the chamber. The remaining area around the fan was closed with a piece of galvanized sheet metal (Figure 1). The opposite end of the chamber (air intake) was covered with a plastic film except for the lower 6 inches. A 12-inch board was placed on edge across the bottom, inside the chamber, about 2 inches from the intake end. This type of enclosure at the intake end of the chamber resulted in a more even distribution of the mist within the chamber. The fan and the humidity control were connected to a time clock for daytime operation. With lower temperature and higher humidity at night, it was unnecessary and inadvisable to continue the mist after sundown.

Techniques in Handling Cuttings

The cuttings are taken from the lower side branches of the seedstalk and generally when the plant begins to flower. The cuttings are usually 2 to 3 inches long and include at least one vegetative axillary bud and leaf near the top.

To facilitate transplanting without root damage each cutting is placed in an aluminum foil tube filled with expanded mica. The tubes, $1\frac{1}{4} \times 1\frac{1}{4} \times 6$ inches, are placed in rows in a box having a wire bottom to permit adequate drainage. A $1\frac{1}{4}$-inch spacer between rows functions as a precaution against the spread of diseases.

The cutting boxes may be prepared and watered in advance and taken to the field where cuttings are placed directly into them or larger branches may be labeled, cut from the plants, placed in water, and taken to the laboratory for cutting.

Discussion

Owen's (3) method of making cuttings required plant manipulation to obtain a semi-vegetative seedstalk. This method has merit when an entire reproductive cycle can be devoted to cuttings, and greenhouse space is available during the cooler part of the year. The humidity chamber has made possible the rooting of cuttings from reproductive plants at all seasons. Both seed and cuttings may be obtained in one reproductive cycle.

About 95% of the cuttings made during the summer of 1956 rooted successfully. During the summer of 1957 disease killed many of them. In some cases, entire boxes of cuttings were lost. In contrast, boxes of cuttings free of disease rooted well. Since the summer of 1957, spacers have been used between rows of cuttings to help control the spread of diseases.

A Temperature-Control Chamber for Growing Plants in Daylight

Since both cool temperatures and adequate lighting are necessary for proper seedstalk development, a plastic chamber was cooled in the greenhouse using natural lighting rather than a walk-in, insulated type of cool chamber with adequate artificial lighting.

A polyethylene-plastic chamber (Figure 3) was built over a bench $6\frac{1}{2}$ feet by 24 feet in the greenhouse. A plastic crosswall divided the chamber into two 12-foot sections. In addition, a movable plastic crosswall was provided within each section to permit decreasing its length, if necessary, to get greater cooling.

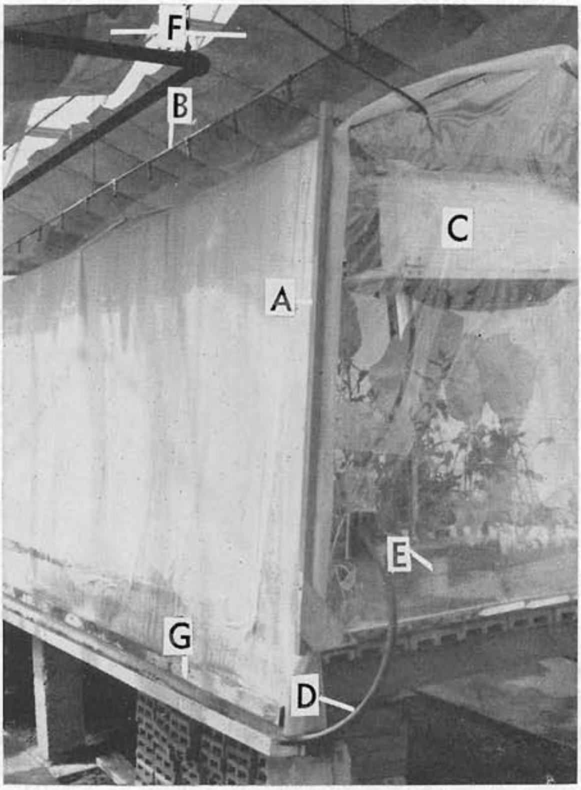

Figure 3.—Temperature-control chamber: (A) Removable end fastener to permit rolling up sides to service plants, (B) overhead mist spray system to wet cheesecloth for evaporational cooling of surface, (C) wall jet unit cooler mounted inside chamber, (D) drain for cooler, (E) thermograph inside chamber, (F) paper over top of chamber to shade from midday sun, and (G) drain for run-off water from mist system.

A 1½-horsepower condensing unit was connected to two wall-jet unit coolers, one in each section, to provide the main source of cooling. Separate thermostats, provided for each section, were connected in such a way that each section was completely independent in operation. The coils of the condensing unit were mounted outside the greenhouse and a fine mist of water was directed over the coils during the hottest part of the summer.

To effect a greater differential between the temperature inside and outside the chamber during the heat of the day, the following cooling devices were used: shading from the sun, evaporational cooling, and forced ventilation. The greenhouse was whitewashed and in addition a paper canopy was constructed to shade the chamber from the midday sun. For evaporational cooling, mist nozzles suspended over the peak of the chamber supplied water to cheesecloth covering the outer surface. Exhaust fans on one side of the greenhouse and open vents on the opposite side increased evaporational cooling and removed some of the excess heat within the greenhouse. A 35 to 40° F temperature differential could be maintained by employing all the cooling devices simultaneously. This provided adequate temperature control to avoid reversal of photothermal induction in sugar beets. During late fall and winter, shading, evaporational cooling, and forced ventilation were not necessary to maintain temperature control. Since the coils of the condensing unit were mounted outside the greenhouse, they were covered in sub-zero weather to prevent the gas in them from liquifying too rapidly.

During July and August, when outdoor light intensities ranged from 6,000 to 7,600-foot candles, intensities inside the chamber averaged approximately 600-foot candles. To aid in maintaining the photothermal induction in the plants, 10 hours of supplemental night lighting (100-watt incandescent) was used in each section.

Male-sterile hybrid progenies were brought to flower by the use of this chamber in the summer of 1957. These progenies, with a prior photothermal induction period of 80 days, were placed in the chamber July 19 and removed September 6. They were indexed for male-sterile anthers. The first yellow-anthered plants were rogued on August 1. The first complete indexing of a progeny was accomplished on September 27. Most progenies were 90% indexed by mid-November and the remainder by late December. The delay in blooming may be partially attributed to the lack of supplemental night lighting during October.

The chamber has been used successfully for controlled temperatures in a physiological experiment and also to induce sugar beets photothermally at 48° F with natural lighting during the day and artificial lighting at night.

Summary

The plastic humidity chamber makes possible the rooting of cuttings from seed-producing plants, saving time and plant manipulations. Also, cuttings can be made in the summer when greenhouse space is not at a premium. Although this chamber was designed for summer use it works equally well at all seasons.

The construction and use of a plastic chamber for temperature control with natural lighting in the greenhouse are discussed.

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