Considerations in the Design of Experimental Cold Storage Plants for Perishable Commodities[1]

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Abstract. **We discuss criteria for the design of cold storage facilities for use in research. Factors considered are: determination of the desired accuracy of temperature and relative humidity control, methods of air circulation and fresh air introduction.**

During a recent survey, which included on-site studies in the United States, Canada, England and Holland, design and utility of experimental cold storage facilities for perishable commodities were examined. Researchers were asked for their opinions on preferred designs, desired degree of precision of temp and relative humidity (rh) control, and on methods of air circulation and introduction of fresh air. This information is summarized in this paper, with emphasis on storage rooms used for large-scale experiments. Much of this information may be generally known, but its discussion in this context may emphasize that careful consideration of these factors is necessary before requirements for new experimental cold storage plants are specified.

Theoretically, storage environments can now be accurately controlled. However, this is not often accomplished because sophisticated equipment is expensive, not always reliable, and is difficult to maintain. Moreover, the need for highly controlled conditions has not been well established for most fruits and vegetables. In large-scale storage studies, aimed primarily at providing industry with storage recommendations, very high accuracies neither are needed nor desirable if they can not be economically achieved in commercial cold storages. The following discussion centers on general design criteria for new experimental cold storage facilities.

Temp and relative humidity. The combination of low temp and high rh needed for the storage of most commodities is difficult to maintain in storage rooms. Temp fluctuations in the cold air supply usually range from ± ¼ to ± 1°C. Closer control has been achieved in specially designed chambers. The magnitude of these fluctuations gradually decrease toward the center of the stacks of containers and they decrease further toward the center of each fruit. However, even though the direct effect of small air temp fluctuations on the quality of the commodity in storage rooms may not be easily detected, such small variations have a profound effect on rh. For example, for air at 2°C and 90% rh, a change of ± ½° will result in changes of ± 5% rh. Larger temp fluctuations may result in excessive moisture condensation on the refrigerating coil, which may necessitate frequent defrosting, further increasing the temp fluctuations.

Inadequate insulation may also increase variations in temp and rh. Small experimental storage rooms have large surface to volume ratios, so that heat leakage relative to the volume is greater than in large commercial installations. Therefore, thickness and quality of insulation for small experimental rooms must be increased proportionally; money saved on insulation is injudicious parsimony.

Thus, maintenance of a fairly constant rh is the main reason for minimizing temp fluctuations. However, many researchers believe that variations of less than ± ½°C are impractical to achieve, since initial cost and expense of maintenance of highly sophisticated equipment required for precise control likely overshadow its advantages.

Precise control of rh is difficult to achieve, particularly in high rh – low temp ranges. Some experimental storage facilities lack provision for adding moisture, and humidity is maintained by means of a large refrigerating surface that is only slightly below room temp. However, frequent opening of doors and introduction of fresh air often reduce rh below the desired level. In other experimental rooms moisture is added as steam or mist. Here, fluctuations of 5 to 10% rh or more occur, particularly where moisture addition is controlled by time clocks. Economical humidity sensing devices, with greater precision and more rapid response than presently available are needed. Best results are obtained when moisture is added to the cold air supply, as remotely as possible from the refrigerating surface, but before the air reaches the stacked fruit. If at all possible, moisture should be added some distance from the coil, but ahead of a downward air stream. Here, air velocity is lower than it is close to the coil, and droplets above aerosol size are directed to the floor and not toward the fruit. The humidity sensing element should be located in the return air. Since the air is warmed by field and respiratory heat, as it passes through the produce, the rh decreases where there is no practical means of adding moisture. Therefore, while it is desirable to keep rh at a high and constant level throughout the storage room, achievement of this aim is subject to considerable limitations by the very operation of cooling of stacked produce.

Many researchers tolerate ± 2 to 3% fluctuations in rh. However, in many cases a ± 5% fluctuation is acceptable, but only when rh is 90% or higher.

Air circulation. Air circulation within storage rooms should be sufficient to transfer heat from the produce and minimize variations in environmental conditions. Excess variations in these factors may adversely affect the quality of the stored produce and increase the uncertainty of experimental results. To overcome such variability, experimental material often occupies only a small percentage of the total volume in storages. If large quantities of produce are stored, they must be randomly distributed throughout the room. Although these practices tend to decrease variation (2), they are costly in money and storage space.

Inadequate air circulation and nonuniform air distribution produce stagnant areas. This problem can not be overcome by control instrumentation, but rather by positively directing air flow through and around stacked produce. The specific design of air circulation patterns should be adapted for each produce– package–stacking combination. The additional cost involved in providing positive and reasonably uniform air circulation in experimental storage rooms is relatively

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small and – in the opinion of many researchers – well justified.

Fresh air introduction. Ventilation with fresh air is often needed to avoid accumulation of undesirable volatiles. Ambient air temp and rh are rarely similar to those inside, so that ½ to 1 or more air changes per hour (based on an empty room volume) make control of temp and rh difficult. Since the effects of volatiles on quality of most stored perishable products have not been established, some rooms may be over-ventilated to avoid the possible risk of damage, whereas others may be under-ventilated since they have no provision for fresh air introduction, other than doors or similar inaccurate methods. These uncertainties suggest that experimental rooms should be designed for controlled ventilation. This can be accurately done by sucking air from the room, measuring its velocity, and adjusting fresh air ports accordingly (1). Fresh air could be filtered and its temp and rh adjusted close to the internal conditions before it is introduced into a room.

Layout of a cold-storage facility. The design of an experimental cold-storage facility of more than a few rooms requires special attention to adjacent work areas. Adequate space should be allocated for accumulation of commodities before storage, for fruit examination and for various laboratory tests. Experience has shown that this area has to be at least 1½ to 2 × the total storage area. This space should be kept at a fairly constant temp to minimize changes inside the rooms and to prevent excessive vapor condensation on cold fruit when doors are opened. About 17°C achieves these purposes, while still providing comfortable working conditions.

Since purely economic factors are not always considered in the design of experimental cold-storage plants, researchers may tend to specify unnecessarily precise conditions in their storage rooms. We have attempted to emphasize that specifications for storage conditions that are not necessarily very precise, but that are adequate, and easy to achieve and maintain, may best serve research on storage intended for commercial application.

Literature Cited

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The Fruiting Nursery: Ultrahigh Density for Evaluation of Blueberry and Peach Seedlings[1]

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Abstract. **Approximately 80% of the seedlings of blueberry (*Vaccinium* spp.) and 55% of peach [*Prunus persica* (L.) Batsch] fruited the 2nd year after seed harvest when grown rapidly at densities of 16 plants/m^2 for blueberry and 8 plants/m^2 for peach. This permits roguing of plants on the basis of fruit characters in the 2nd year from seed harvest (24 months) and evaluation of remaining plants the following year. The fruiting nursery system, based on intensive care of seedlings at ultrahigh densities to achieve rapid growth, is suggested to improve breeding efficiency.**

Fruit breeding programs are frequently limited by difficulties of handling large populations. The expense involved in maintaining large areas of land for long periods of time is often the limiting factor. Seedlings have traditionally been spaced about 5 to 8 times the density of commercial plantings. A slight increase in the density of peach selections has been achieved by topworking older trees but this presents many problems. Topworking requires considerable labor, may contribute to virus spread, and in Florida many topworked limbs have been lost by freezing, wind breakage and other hazards. Pest control and culture of large blocks of seedlings can be costly. Nematodes are a serious problem in Florida and even with pre-plant injection-type fumigation, losses of peach seedlings have reached as much as 25% in 4 years. A fruiting nursery system was initiated in 1966 for blueberries and in 1969 for peaches and nectarines to improve efficiency and reduce costs. The fruiting nursery is based on ultrahigh density and intensive care to achieve rapid seedling growth and early fruiting for screening fruit characters.

Blueberry. Seeds were removed from fruit in a food blender, washed, and stored dry at 7°C from June to October. They were planted in small pots and transplanted to greenhouse flats at 5 cm spacing in December. Plants were 10 to 15 cm high by May when they were transplanted to the fruiting nursery. Normally 2 applications of soluble fertilizer were used between December and May.

The fruiting nursery was fumigated with methyl bromide (50 g/m^2) under plastic 2 to 3 weeks before transplanting, eliminating most weed problems. Plants were set 15 cm in the row with rows 45 cm apart (Fig. 1, top), a density of 16.1/m^2 (Table 1). Thus, 12,000 plants could be accommodated in a 27 x 30 m plot. This is over 30 × the density of previous seedling plantings and over 70 × that used in standard production plantings. Light doses of high N or ammonium sulfate fertilizers were applied every 4 to 6 weeks in summer. A netting cover was used to prevent bird damage. Irrigation was considered for frost control but has not been needed.

Evaluation of the initial population was completed in 2 years from seed

Table 1. Comparative density of peach and blueberry seedlings in the fruiting nursery, seedling orchard and typical commercial orchard.

Crop	Density (plants/m^2)		
	Production orchard[z]	Standard seedling orchard	Fruiting nursery[x]
Peach	0.027	0.14	7.7
Blueberry	0.222	0.55	16.1

[z] Typical spacing for peach = 6.1 x 6.1 m (20 x 20 ft).
" " " blueberry = 1.5 x 3.0 m (5 x 10 ft.).

[y] Typical spacing for peach = 1.5 x 4.6 m (5 x 15 ft).
" " " blueberry = 0.6 x 3.0 m (2 x 10 ft).

[x] Avg spacing for peach = .13 x 1.0 m (0.4 x 3.3 ft).
" " " blueberry = .15 x 0.45 m (0.5 x 1.5 ft).

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