NEW FINDINGS IN THE STORAGE AND SHIPMENT OF UNROOTED CUTTINGS[1]

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Shipment and storage of unrooted cuttings has changed dramatically over the past 10 years. In this time period cutting production has shifted to specialist propagators who are normally located long distances from final growers. Given that this is the case, then one must accept that cuttings are going to be shipped for longer periods without adequate environmental controls.

Production shifts have been noted because of either financial considerations or need to improve the cutting production environment. When plant material is produced in warmer climates, heating costs are reduced and elaborate growing structures are generally not necessary. In addition, labor in most instances is less expensive, especially overseas. A grower can also relocate to an area with limited rainfall which, in many cases, will reduce the severity of foliar diseases, when stock plants are grown outdoors.

With these changes, new problems have surfaced. The major problem is related to postharvest physiology. Unrooted cuttings that are shipped for long periods often show foliar yellowing when received. In addition, cuttings that may appear green can show reduced rooting rates and develop disease problems which are not as serious with directly rooted cuttings.

We, at the University of Illinois, are attempting to understand these shipping problems. Our first priority is defining the shipping environment. Once this is defined, cutting quality can be correlated to specific environmental parameters. Our second objective is to understand why these problems occur on a physiological basis. The experiments presented in this brief paper are part of a 5 year project formulated to understand why any plant material yellows during shipping and/or storage. Based on preliminary experiments a shipping hypoth-

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esis has been formulated. The hypothesis follows this line of reasoning:

1) Unrooted plant material is shipped for long distances, generally without adequate environmental controls.

2) Poor environmental controls close stomates.

3) Once stomates close internal ethylene builds-up.

4) High levels of internal ethylene reduce cutting quality.

Results from 2 experiments will be presented. Each project was designed to verify points in our hypothesis. Data will first be presented defining the shipping environment which will be followed by an examination of stomatal fluctuations during specific handling procedures.

Monitoring the shipping environment was the first step to understanding why cuttings yellow during shipment. It is recommended that unrooted geranium cuttings be stored at 3°C (37°F). In order to examine temperature patterns during shipment a Ryan temperature monitor (available from Ryan Instruments, Inc., P. O Box 599, Kirkland, WA. 98033) was used. This recorder allowed us to obtain a constant record of temperature during the complete shipment period.

Several experiments were conducted that examined packing materials, box types, fungicides, precooling, and the incorporation of ice into boxes. Shipment times varied from 72 to 108 hr. Plant material originated on the Canary Islands and was air-freighted to Munich, Germany; Miami, FL.; Chicago, IL; and finally to Urbana, IL. The data presented in this paper is from a 72 hr shipment with several geranium cultivars. Each box contained 1000 cuttings which were divided into four groups of 250, wrapped in moist newspaper and placed in unsealed plastic bags. All cuttings were treated with a fungicide prior to being shipped in either a cardboard or a styrofoam box. One styrofoam box treatment contained ice. Each box contained a Ryan temperature recorder.

When temperature graphs were examined the cardboard box and styrofoam box without ice showed few differences (Figure 1). Temperature inside the styrofoam box fluctuated, but at a slower rate when compared to the cardboard box. The temperature extremes were similar. The significant finding was that the styrofoam box with ice maintained a cooler temperature for the first 32 hr when compared to the other treatments.

When plant material was evaluated, cuttings from the styrofoam box with ice were greener and showed less foliar decay than the other treatments Results from this work indicate that maintaining lower shipping temperatures for the first

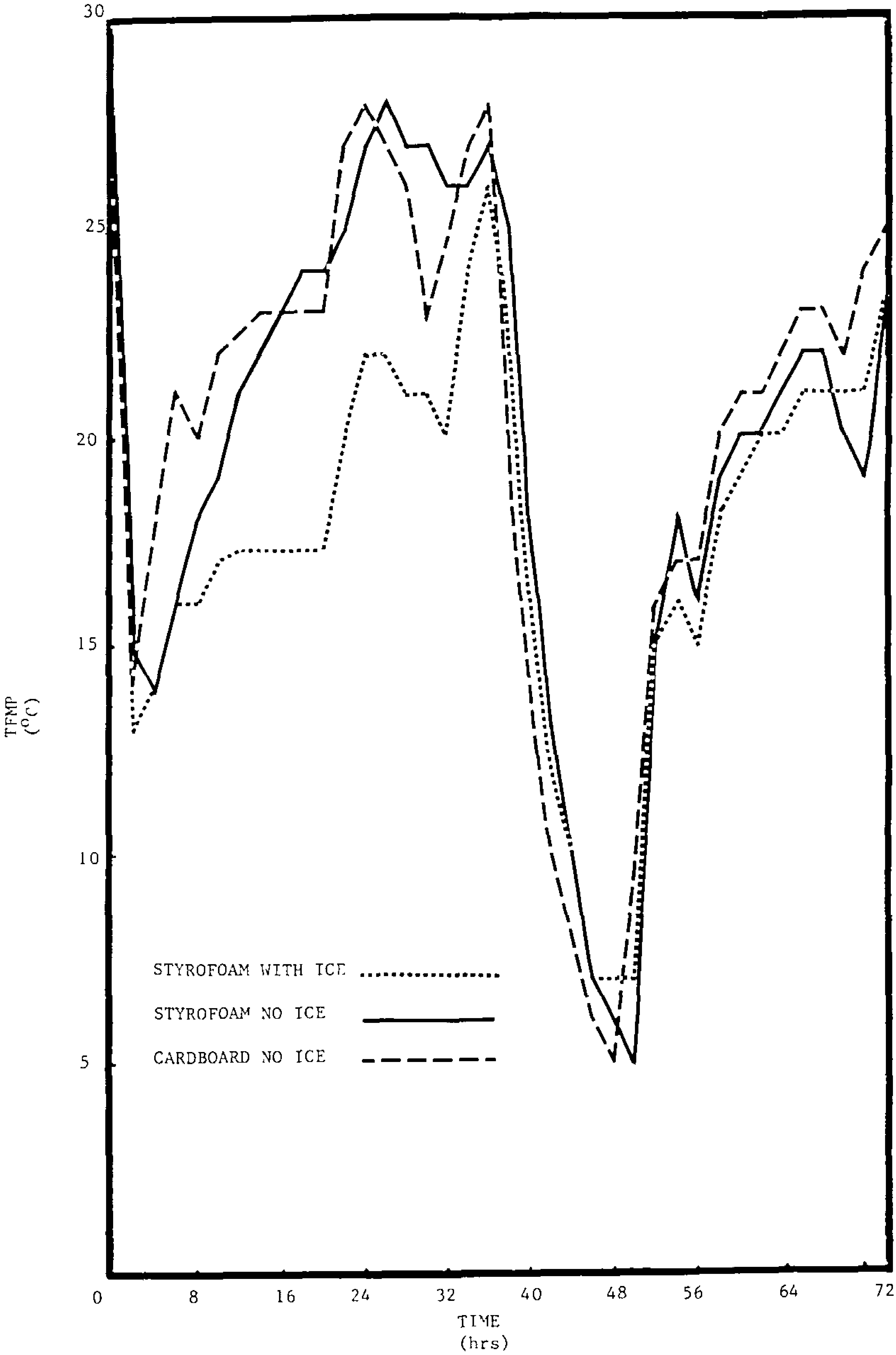

Figure 1. Internal box temperatures during shipment of unrooted geranium cuttings in styrofoam and cardboard from the Canary Islands to Urbana, Illinois

24 to 36 hr can signficantly improve the quality of unrooted cuttings even if temperatures substantially exceed recommendations later on during handling procedures.

Another interesting finding was that the cuttings from the styrofoam box without ice appeared to be in better condition than those from the cardboard box. One advantage of using a styrofoam box is that it is air tight. The natural respiratory activity of the cuttings increased carbon dioxide to levels high enough to inhibit ethylene action. Ethylene is one of many factors that can cause leaves to yellow and eventually die. From the previous work, it become evident that commercial cuttings do not receive adequate temperature control during shipment.

The second phase of the total project was to understand why temperature fluctuations reduced cutting quality. Work was then initiated in the areas of stomatal conductivity and internal ethylene levels.

Stomates are pores in leaf tissue that provide the main pathway for gas exchange between the external environment and that within the leaf. When literature in this area was reviewed, it became obvious that factors which cause stomates to open and close are similar to those encountered during shipping and/or storage.

Ethylene is one compound within a plant that passes outside through the stomates. Ethylene is also known to cause leaf yellowing and is produced in greater quantities at higher temperatures. If stomates close during shipping (low stomatal conductivity), then no gas exchange can occur and ethylene builds up inside the leaf. If our hypothesis is correct, then cutting quality will be reduced.

Three simulated shipping experiments were conducted to examine how stomates react to various shipping environments. The first experiment examined differences between two geranium cultivars, 'Sincerity', a good shipper, and 'Salmon Irene' a poor shipper. The second study involved storing 'Sincerity' cuttings at three constant temperatures 3, 10, and 27°C (37, 50 and 81°F) for 72 hr. The last experiment was conducted at 3°C in the absence, or presence, of light

In each study, terminal cuttings were taken from stock plants grown at the University of Illinois, treated with Daconil and placed in loosely sealed opaque plastic bags for 72-hr periods. Stomatal conductivity was measured using a Li-Cor steady state porometer at the temperature cuttings were stored. Stomatal conductivity data is from the upperside of the lowest leaf on the cutting and is the average of several replications.

'Sincerity' cuttings exhibited higher rates of stomatal conductivity when compared to 'Salmon Irene' for the first 24 hr of monitoring (Figure 2). After 48 hr of dark storage, no differences in stomatal conductivity were detected. In several instances, internal levels of ethylene were monitored. Regardless of treatment, ethylene was always extractable from 'Salmon Irene' cuttings, but not from 'Sincerity'.

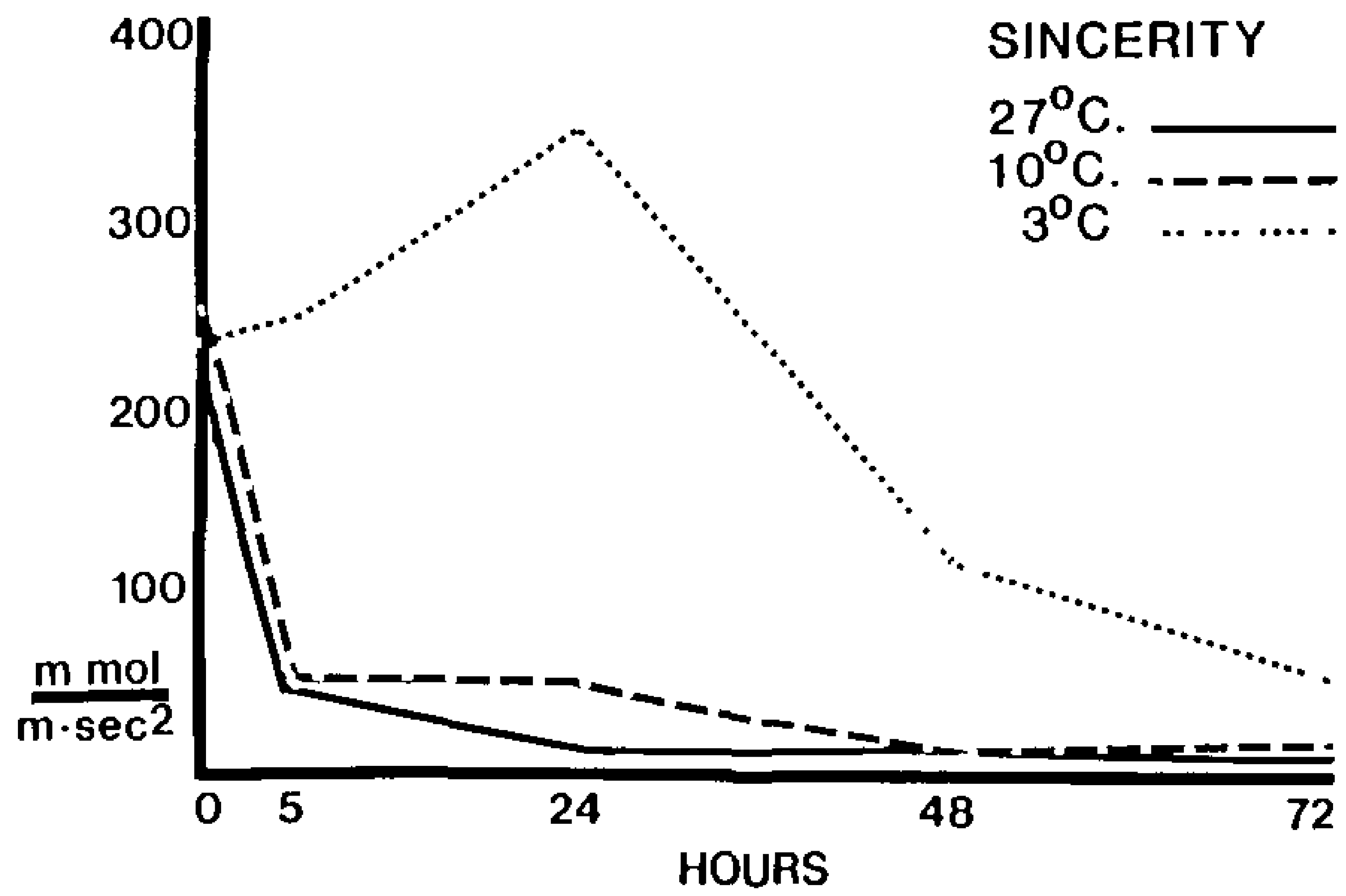

Figure 2. Stomatal conductivity levels from leaves of unrooted cuttings of 'Sincerity' geranium during 72 hr of dark storage at 3, 10, and 27°C

In order to determine if proper temperature storage allowed for greater stomatal conductivity, cuttings were stored at the proper 3°C, a reasonable temperature of 10°C, and an unacceptable 27°C. 'Sincerity' cuttings stored at 3°C showed higher rates of stomatal conductivity when compared to similar cuttings stored at 10 or 27°C (Figure 3). These differences were maintained during the entire 72-hr period. In addition, 'Sincerity' cuttings stored in the light showed higher rates of stomatal conductivity when compared to cuttings in the dark (Figure 4).

These results indicate that conditions during commercial shipment of unrooted geranium cuttings lead to reduced stomatal conductivity. A lack of light and improper shipping temperatures, which are encountered during shipping all proved to be factors that decrease stomatal opening and can led to poor quality cuttings.

Findings from these two series of experiments have aided in our understanding of why cuttings yellow during shipment. Once quality is lost, it is nearly impossible to regain. Therefore, it is the shipper's responsibility to establish improved handling practices, even if it means an added expense. Work is in progress identifying the factor that causes stomates to close, as well as in the area of post-shipment treatments to regreen cuttings.

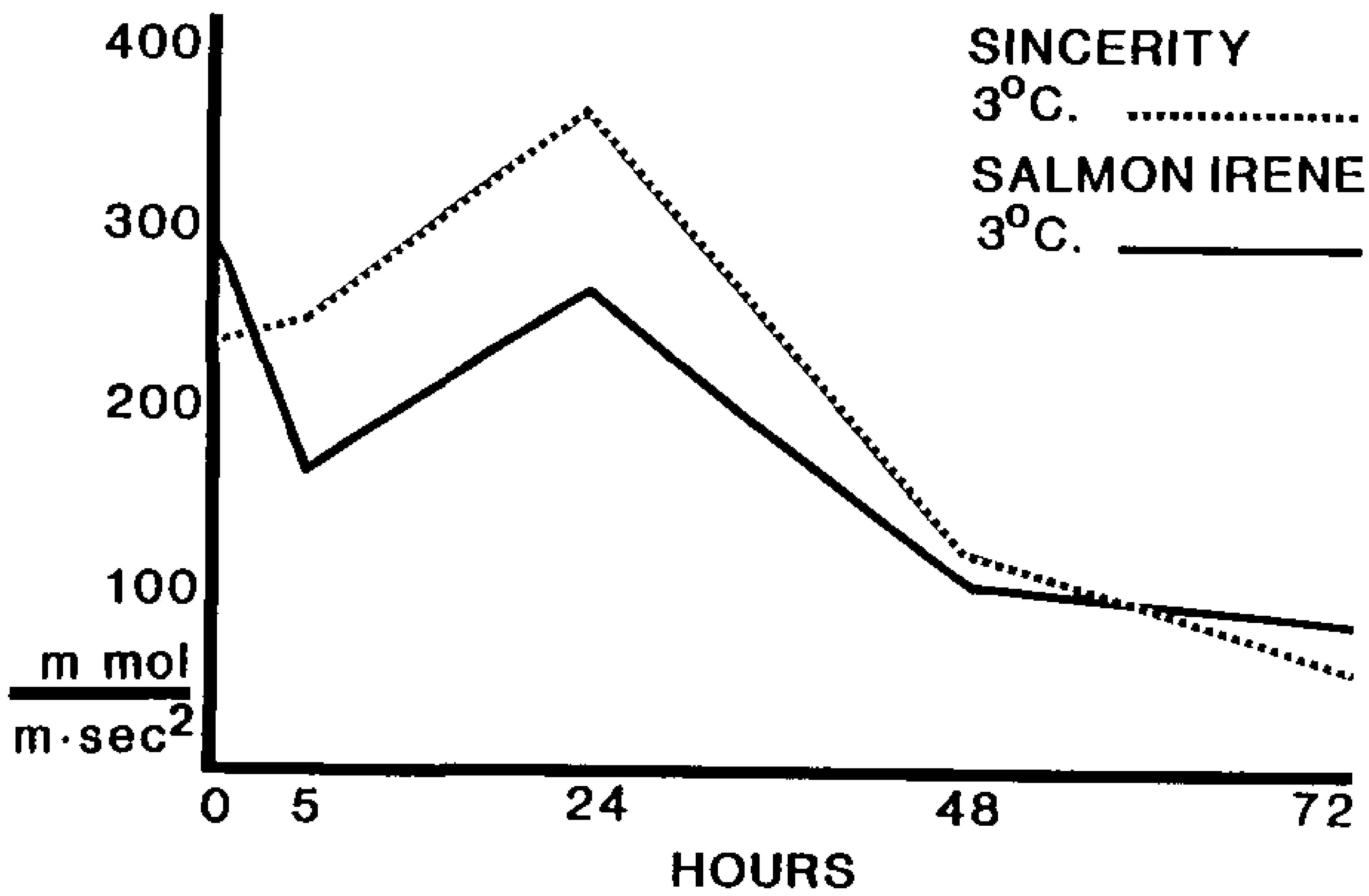

Figure 3. Varietal comparison of stomatal conductivity levels from leaves of unrooted cuttings of two geranium cvs., Sincerity, and Salmon Irene, during 72 hr of dark storage at 3°C

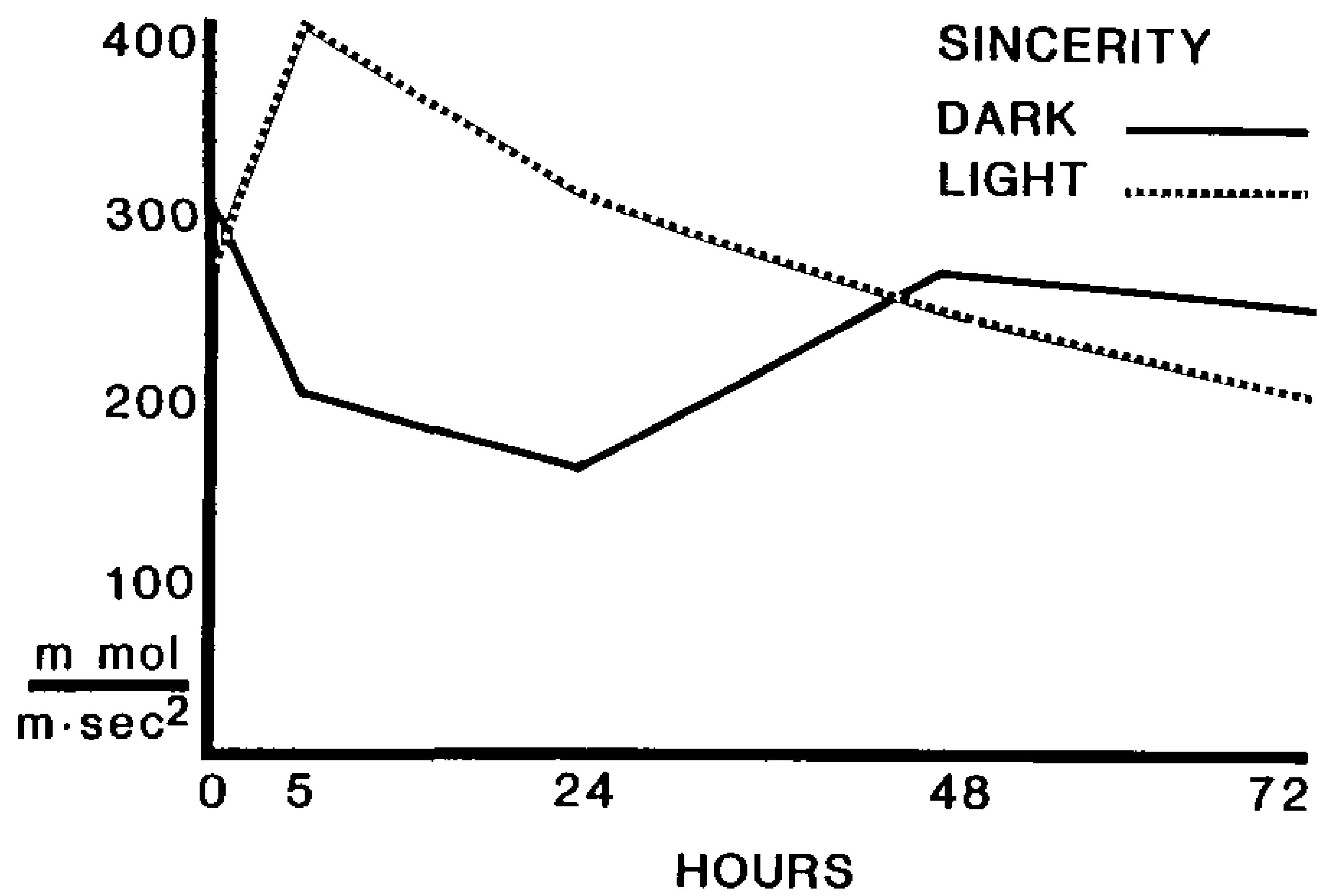

Figure 4. Stomatal conductivity levels from leaves on unrooted cuttings of 'Sincerity' geranium during 72 hr of light or dark storage at 3°C

VOICE: I wonder why you did not reduce the number of cuttings as a first step, because anytime you get yellowing it is because cuttings are packed together and high heat aggrevates the problem.

BARRY EISENBERG: I did not have time to report on all of our experiments. Regardless of how many cuttings put in the box the key is cooling them down. I did not have time to present the information on the gas atmosphere in the styrofoam boxes. Those boxes are air-tight and, after 96 hr, the CO_2

is up to 6 to 8%, O_2 is down to 10%, and there is a little ethylene. One of the benefits of the tight boxes, we feel, is the high CO_2, which should reduce respiration.

Tuesday Evening, December 11, 1984

Dave Beattie moderated the Educational Program. The following paper by Dave Williams was part of that program.

USE OF A SPRAY PATTERNATOR TO DEMONSTRATE LOW-PRESSURE PESTICIDE APPLICATION

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The selection of the proper pesticide to control a known pest is only the first step in implementing a spray program. It is essential that the pesticide be applied properly to insure that the desired pest control will occur in an efficient manner without waste or environmental contamination. More pesticides are applied with low-pressure sprayers than with any other kind of equipment. These sprayers apply chemicals to control weeds, insects, and diseases in field, nursery, vegetable and fruit crops, and turf. Tractor-mounted, pull-type, and self-propelled sprayers are available in many models; however, these may not be available to the classroom teacher or be too cumbersome to use for demonstration purposes. The use of a portable spray patternator allows the instructor to demonstrate the concepts of proper pesticide application in a limited area. The spray patternator, due to its portability, is also useful for extension meetings.

All low-pressure sprayers have several basic components: a pump, a tank, an agitation system, a flow-control assembly, and a distribution system. Spray pressures range from almost 0 to about 200 psi and application rates can vary from 10 to over 100 gal/A.

The spray patternator can be used to demonstrate the effects of pressure, boom height, nozzle placement, and nozzle type on spray patterns. The use of a strobe light behind the spray pattern illuminates the pattern so that it can be easily seen by the audience. Plans for the construction of a portable spray patternator are available from the author.