Using Electrical Conductivity: a Possible Indicator for the Rooting of Cuttings©

H. William Barnes
Lorax Farms, 2319 Evergreen Ave, Warrington, Pennsylvania 18976 U.S.A.

INTRODUCTION

Electrical conductivity (EC) of plant tissues has been examined by horticulturists to elucidate plant developmental status, however, much work needs to be done to make it a practical tool. Whitlow et al. (1992) and Brønnum (1998) are but two of many researchers who have tried to correlate leaf and stem conductivity to specific times of the year. Brønnum (1998) developed a protocol for the timing of harvesting evergreen tree seedlings based upon EC readings.

The theory of electrical conductivity is based upon the idea that plant cell components are largely made up of water-based solutions much of which are composed of mineral nutrients such as nitrogen, calcium, magnesium, iron, phosphorus, sulfur, oxygen, and potassium. Some of these nutrients are further integrated with carbon-based compounds such as sugars, proteins, and amino acids along with a host of more minor chemicals. Since many of the mineral elements are ionic in nature they contribute substantially to the degree of electrical conductivity, much as they would in water extracts of soil.

METHODS

Prunus 'Kanzan' (syn. 'Kwanzan') was selected as the subject of study because previous work by the author (1989) has demonstrated that there is a definite timing factor and that cuttings taken in August have much poor rooting that those taken in June.

For this study cuttings were collected every 10 days from 14 June till 17 July. Cuttings were 6 to 8 nodes long with an average length of 23 cm. Cuttings were wounded basally about 3 to 4 cm on two sides. They were then bundled into groups of 10, weighed, and the wounded ends were submerged in distilled water with a ratio of 20 ml of water per cutting in 1-qt mason jars. Care was taken to insure that each wounded end was beneath the water surface. The jars and cuttings were covered with a plastic bag and placed in the dark for 24 h at 20°C. The cuttings were removed and the electrical conductivity of the resultant supernatant was measured using a Hanna Instruments Agritest hand held combined EC/pH meter (Woonsocket, RI). Results are expressed digitally as $\mu S\ cm^{-1}$, (microseims cm^{-1}). The device automaticaly compensates for temperature differences. The electrical conductivity, EC , for each sample was then tabulated.

The cuttings were reserved along with the first leachate for further processing. A total of 20 cuttings were placed in a pressure cooker and due to the requirements of the pressure cooker an additional 200 ml of distilled water was added to bring the total volume to 600 ml. The pressure cooker was removed to an outdoor burner and the heat brought up. When the pressure cooker ceased steaming and the pressure mechanism engaged a timer was set and the cuttings were pressure cooked for 15 min. After 15 min the heat was discontinued and the unit was allowed to cool. A second EC reading was then taken of the resultant liquid once it reached ambient temperature.

Alternatively, 10 cuttings were separated from their original soak solution and were placed in Ziploc® freezer bags and were frozen for 12 h. They were then removed, crushed while still frozen, recombined with the original supernatant, and allowed to stand for an additional 12 h. At the end of that time period the resultant liquid was filtered and the EC was again measured.

An identical group of 64 cuttings was taken from the original batches and prepared for a rooting trial. Cuttings were wounded and treated with Woods Rooting Compound at l/10 dilution (water). After drying the cuttings were stuck into 2¼-inch pots filled with Economix Perennial Mix. A proprietary formula of peat, bark, peanut hulls, and sand. They were placed on bottom heat at 20°C with mist 15 sec per 15 min. The cuttings were then evaluated after 28 days. Rooting percentage was tabulated.

Other data was obtained by the counting of mature leaves versus developing leaves for each of the sample dates.

EC readings were determined by the formula:

$$\frac{\text{EC I (soak solution) - EC of distilled water}}{\text{EC (destructive method*) - EC of distilled water}}$$

*Destructive method being either pressure cooker or freezer method.

RESULTS

One of the first apparent things over the time period was the change in weight of the samples every 10 days (Fig. 1). The data shows a steady increase in weight of cuttings of the same size over time with a progression of an average weight from 73 g for 10 cuttings to an average of 129 g at the end of the study. This correlates well with changes in leaf morphology (Fig. 2) starting with a 6.4 mature per 3.9 developing leaf combination and terminating at the end of the study with an 11 mature/2 developing leaf combination. While these changes were taking place rooting percentages went from a high of 72% and steadily declined to 22% by the end of the 30-day period (Fig. 3).

Adjusted EC Readings determined by the above formula showed some differences between the pressure cooker method and the freezer method. In general as the time of the year changes from June to July the EC readings go up and then decline towards the end of July. The freezer method showed a similar trend except for the last reading, which suddenly increased. This disparity could be the result of a mechanical difference between the destructive capabilities of the two methods. Specifically the freezer method may release substances that are not affected by the pressure cooker method. It should be noted that Whitlow et al. (1992) used an autoclave as a destructive method and the autoclave most resembles that of the pressure cooker. Figures 4 and 5 show the results of these tests.

DISCUSSION

The results suggest several things are occurring at the same time. Leaf morphology is rapidly changing with an accompanying increase in weight for a standard sample of 10 cuttings with the same average length. At the same time the cellular constituents are also changing and this is clearly shown by the EC ratings. It is possible that the appearance of an aberration in the freezer method really is a valid change and that a new set of conditions is being manifested in the plant tissues. By comparing the rooting percentage with the EC ratings it becomes clear that as the EC ratings increase and then decline there is a steady drop in the rooting ability of

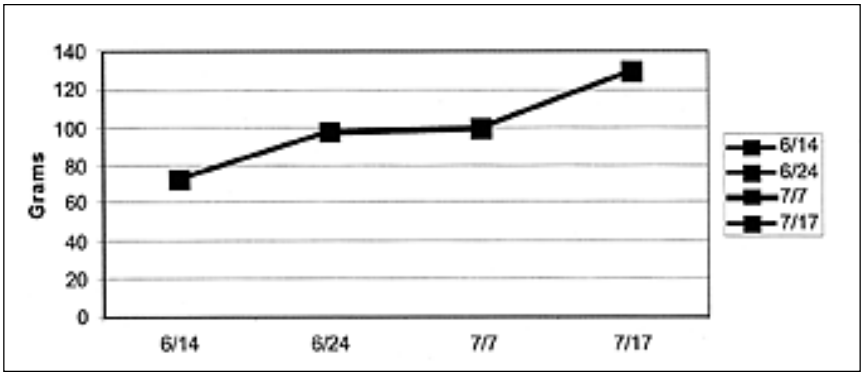

Figure 1. Weight Changes of 10 cuttings vs time

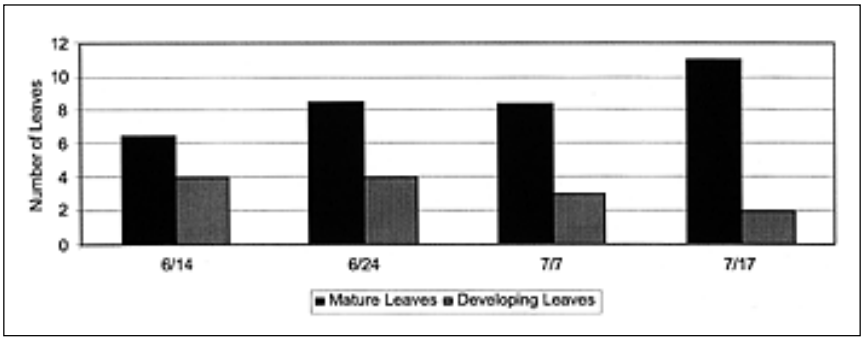

Figure 2. Changes in leaf morphology over time

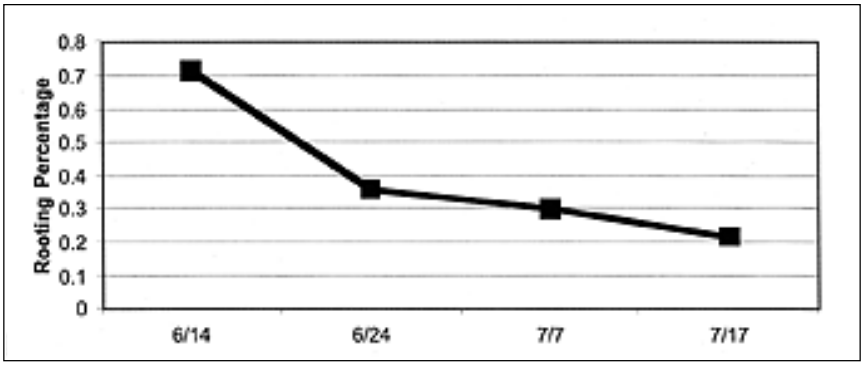

Figure 3. *Prunus serrulata* 'Kansan' rooting percentage over time

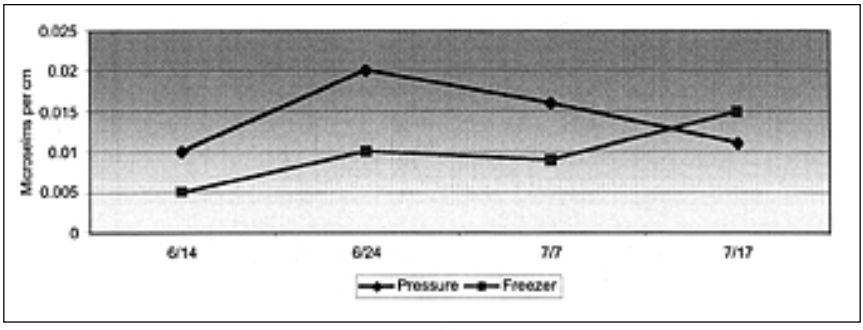

Figure 4. Ec readings of pressuer cooker and freezer leachate

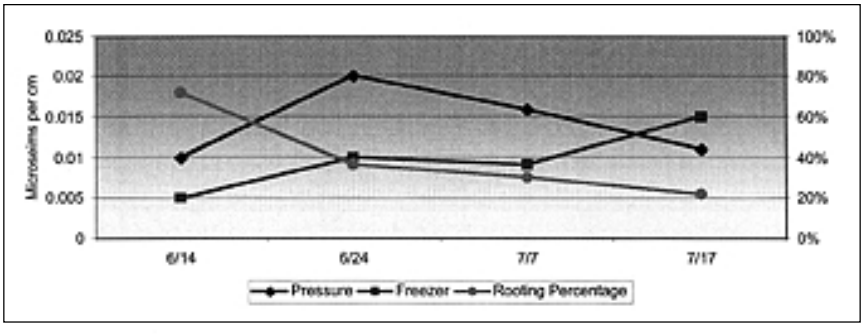

Figure 5. Ec readings overlayed with Rooting Percentage

the cutting. The data from the freezer method seems to indicate that an adjusted ratio of 0.005 µS cm^{-1} is adequate for rooting but as it increases to 0.0098 this rooting potential goes down. The pressure cooker method mimics the freezer readings with a decrease in rooting as the EC reading increase. In both cases the rooting potential declines after an EC threshold is reached.

Whitlow et al. (1992) suggests that an 80% drying of leaf tissue before being subjected to the testing procedure results in more electrolytes being released for measurement. Perhaps this is a good idea, but it increases the complexity of the measurement process, which might make it prohibitive for the average nurseryman to accomplish.

It should be made clear that utilization of these methods is in an experimental stage and that much needs to be explored in order to fully implement these procedures as a standard practice.

The timing of the rooting of cuttings is at times difficult. For example, work by Mitsch (1975) with *Cryptomeria japonica* shows fair rooting in January and February, then poor rooting until October and November, followed by a rapid decline in December. When he looked at *Juniperus squamata* 'Blue Star' there were three peaks for good rooting of cuttings. January to February, being fair, July and August very good, and finally a third successful period stretching from Oct. to Dec. Obviously the changes in plant tissues are related to a number of factors, none the least are day length, general environment, water, and fertilizer relations and a host of circumstances that are not readily identifiable. Since all of these factors and more

can vary considerably from one year to the next, propagators are faced with a myriad of challenges to identify proper rooting times.

For the EC methods to have a place in our toolbox several things have to be accomplished. One is a realization that there are limits to its use due to environmental extremes. Two, it is not important to use these techniques for all plants and that the bulk of plant species do not require this elaborate testing — *Forsythia* and *Ligustrum* being but two examples. However, plants such as *Amelanchier laevis, Syringa vulgaris* hybrids, *Chionanthus, Fraxinus, Hamamelis* family, and others that are notoriously difficult to root might provide justification for adopting these methods to establish a set of standards that could be utilized after a 3- to 4-year period of gathering data.

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