Basics of Propagation by Cuttings—Temperature

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Proper control of air and root zone temperatures is critical for rooting of stem cuttings. The optimum air temperature for growing the crop is probably the best for propagation. Bottom heat should be manipulated in two phases, with a higher temperature for root initiation, then a somewhat lower temperature for root growth and development.

INTRODUCTION

Propagators routinely regulate the temperature of both the air and the medium when rooting cuttings. It is clear that as temperatures increase (within limits) cuttings metabolize faster and root better. Improper control of temperature can result in slow rooting, low rooting percentages, poor development of the root system, damage, or death of cuttings. Daily monitoring will alert a propagator if there is a failure in the heating system, especially the source of bottom heat. Aspirated thermometers housed in white (to reflect light) boxes are the most accurate way to assess air temperature. Soil thermometers should be placed at multiple locations within a propagation bed with their temperature sensors at a depth equal to the bottom of the cuttings. A written record of daily temperatures can be used for trouble-shooting and to help a propagator repeat past successes.

AIR TEMPERATURE

Within limits, as temperature rises, plant metabolism, including respiration, increases. Respiration has a temperature coefficient (Q_{10}) of approximately 2. This means that for every 10C (16F) increase in temperature the amount of CO_2 given off doubles. Respiration is necessary for the process of rooting cuttings because it is the method by which plants release energy to support growth. Photosynthesis is also temperature sensitive, but to a lesser degree than respiration. Therefore, as temperature rises, the rate of respiration will tend to increase faster than photosynthesis. This can cause cuttings to lose weight and possibly even die (Kester, 1970). Evans (1951) reported that *Theobroma cacao* (cacao) cuttings placed under low light and high air temperature (32 to 33C or 90 to 91F) showed "starvation symptoms within a week" because of loss of carbohydrates. When the air temperature was lower, (27 to 28C or 81 to 82F), however, cacao cuttings were successfully rooted. Rooting will be slow or success will be limited if temperatures are too low because the cuttings will not be metabolizing at a sufficiently rapid rate for optimum rooting.

The relationship between day and night temperatures is also important. Photosynthesis does not occur in the dark, but respiration continues. Lower night temperatures will slow this respiration, conserving food reserves while higher night temperatures will tend to cause the plant (or cutting) to burn this energy (Preece and Read, 1993).

The relationship between air temperature, and light (for photosynthesis) is important. Howard (1965) reported that under conditions of very low light, *Humulus lupulus* (hop plant) cuttings rooted at 15.5C (60F) had higher root dry weights than those rooted at higher air temperatures. Yue and Margolis (1993) found that as air temperatures rose around *Picea mariana* (black spruce) cuttings, there was an increase in the light compensation point (the level of light at which the CO_2 fixed by photosynthesis equals the amount of CO_2 released by respiration). Black spruce cuttings rooted at 10C (50F) required about one-third the amount of light as cuttings rooted at 30C (86F). This would primarily be a concern if cuttings are rooted under heavy shade.

The system for controlling water loss by the cuttings must be considered along with air temperatures. When leaves and cuttings are illuminated, the leaf temperature generally exceeds air temperature (Loach, 1988); this effect would be negligible if cuttings are rooted under shade. When cuttings are misted, the cooling effect of the water and its subsequent evaporation can reduce leaf temperatures to below that of the air temperature (Loach, 1979, 1988). Evaporative cooling will be greatly reduced if the mist system is enclosed in a plastic tent; in fact it can be warmer within a tent than in the greenhouse that houses the tent (Loach, 1988).

Fog systems are also used to reduce transpiration from cuttings and to lower air temperatures, especially in the summer (Press, 1983; Torn, 1989). Torn (1989) used two layers of 40% white shade cloth and fog to lower the air temperature in his propagation house and combined this with intermittent mist (10 sec/h). He reported that cuttings rooted faster and at higher percentages with this system.

Plants can be classified as cool-season crops, intermediate-season crops, or warm-season crops (Preece and Read, 1993). With respect to rooting cuttings, the best procedure is to use the same air temperature that optimizes growth of that species. For most species, this is in the range of 18 to 32C (64 to 90F) during the day and about 5C (10F) lower during the night (Hartmann et al., 1990).

ROOT ZONE TEMPERATURE

It is easier to control the temperature of the rooting medium than the air temperature. Propagators have been aware of the importance of bottom heat for more than 100 years (Bailey, 1896). Bailey felt that an important reason for using bottom heat was to speed rooting of cuttings and to increase root growth before shoot growth began. However, Hartmann et al. (1990) caution that excessive root growth in leafless hardwood cuttings can deplete carbohydrate reserves needed for bud outgrowth.

Root initiation involves the formation of root primordia and is largely dependent on cell division. Root development (elongation) is dependent on both cell division and cell elongation. Within a temperature range, root development increases as temperatures rise. Burholt and Van't Hof (1971) showed that *Helianthus annuus* (sunflower) roots elongated faster at progressively higher root zone temperatures from 10 to 25C (50 to 77F). However, at temperatures above 25C, roots elongated at a much slower rate and at the highest temperature tested (38C or 100F) root growth virtually ceased.

Dykeman (1976) reported that root initiation and root development have different temperature optima based on experiments with cuttings of *Dendranthema* × *grandiflorum* (chrysanthemum) and *Forsythia* × *intermedia*. At higher temperatures (up to 30C (86F)), more roots initiated and emergence through the stem was faster than at lower temperatures. Root development was improved if root zone temperatures were reduced after emergence. Dykeman (1976) recommended that the optimum root zone temperatures for root initiation was 30C (86F) and for root development was 20C (68F). This system of using a higher temperature for root initiation than root development should be modified for each particular species regarding the timing at each temperature and the optimum temperature for each phase of rooting.

There are some interesting relationships between auxin applications and root zone temperature. Carpenter and Cornell (1992), working with *Hibiscus rosa-sinesis*, showed that the amount of indolebutyric acid (IBA) required to elicit 100% rooting decreased as root zone temperature increased. Higher temperatures did not completely replace the benefits of auxin in this study.

A negative aspect of increasing the temperature of the rooting medium can be increased disease. As the rooting medium temperature increased from 15 to 25C (57 to 77F) the incidence of leaf, bud, and stem rots increased on cuttings of hybrid rhododendrons (*Rhododendron* spp.), even though they had been drenched regularly with Captan fungicide after placement in the rooting medium (Whalley and Loach, 1977). Disease outbreaks can be reduced through strict sanitation procedures in the propagation area. If sanitation does not solve the problem, it may be necessary to treat the stock plants with fungicides and/or dilute liquid chlorine bleach one or two days prior to taking cuttings.

CONCLUSIONS

Clearly both air and root zone temperatures have major effects on rooting of cuttings. Higher temperatures will increase respiration of the cuttings, depleting stored reserves, and reduce rooting. If temperatures are low and metabolism is too slow, rooting may be slow with percentages below desired levels. Optimal air temperature will vary depending if cuttings are rooted under sun, shade, humidity tent, mist, or fog. Root zone temperature can be controlled thermostatically through recirculating water systems, heating pads, or heating cables. To obtain the best rooting in the shortest time, it is probably best to maintain the same air temperature that results in optimal growth of the species. A high root zone temperature should be maintained until roots begin to emerge then the temperature should be lowered for best root development.

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RAY BLEW: What work have you done with white shade cloth?

JOHN PREECE: I have done none, however, I see more and more growers using it.

BRUCE BRIGGS: We use the white poly with our tissue cultured plants in the summer. It keeps the air cooler. Harvey Tempelton, who was an engineer and published in past Proceedings, published many principles that we are using today. It would be valuable reading to go back and review his work. Dr. Dinkle also published work on temperature and his work is also worth reviewing.

DICK BUR: We did a white vs. black shade cloth comparison in a nursery and found no significant difference when the same percentage of shade was used.