a capacitance sensor-automated propagation system. In order to avoid damaging native plants, we took minimal cuttings from two wild sources, a private property source and we obtained some cuttings from a grower collaborator. There was an interaction between the effects of light and soil moisture. However, the plants with the largest roots were grown at a DLI of 14.4 $mol \cdot m^{-2} \cdot d^{-1}$ and Θ of 0.30 or 0.35 $L \cdot L^{-1}$. We also observed that the source of cuttings had an impact on survival. Cuttings taken from the source that was in the greatest amount of light had the lowest survival (26.7%) compared to cuttings taken from stock plants that were growing in partial shade (65% and 81.7%).

Specified Source(s) of Funding: Maine Agriculture Center

(222) Sub-mist Is an Effective Alternative to Overhead Mist for the Propagation of Coleus By Stem Cuttings

Bryan J. Peterson*
University of Maine, Orono, ME

Olivia Sanchez
University of Maine, Orono, ME

Stephanie Burnett
University of Maine, Orono, ME

Darren J. Hayes
University of Maine, Orono, ME

Overhead mist facilitates the propagation of tender cuttings from a variety of taxa by preventing transpirational water loss. Despite its success, drawbacks to overhead mist include the application of large volumes of water, potentially unsanitary conditions, irregular misting coverage, and leaching of foliar nutrients. We explored the feasibility of three alternatives to overhead mist that might avoid these problems by applying moisture exclusively from below. These included 1) a sub-mist aeroponic system configured to provide intermittent mist only to the rooting zone, 2) a sub-irrigation system that provided water via capillary action through perlite from a reservoir maintained below the base of each cutting, and 3) a sub-fog aeroponic system (Nutramist) that was configured to provide constant fog only to the rooting zone. To initiate each system, we wetted perlite or filled reservoirs using either water or quarter-strength Hoagland solution. Each combination of system and fertilizer was replicated three times. A total of 240 herbaceous stem cuttings of coleus (*Solenostemon scutellarioides* 'Wizard Mix') were inserted into the systems for 21 days with 50% shading. Cuttings in the sub-mist system produced measures of rooting superior to those in the other systems. They produced more than three times as many roots as cuttings in the overhead mist system, with roots more than six times the length. Root dry weights averaged 28 mg for cuttings in the sub-mist system, compared with only 3.5 mg among cuttings receiving overhead mist. The sub-fog and sub-irrigation systems produced results broadly comparable to the overhead mist. Fertilizer did not consistently improve rooting measures across the systems. Although we observed few root hairs on cuttings rooted using sub-mist, they transplanted well into a soilless substrate and quickly produced new root growth. The sub-mist system used less than one-fifth the water used by the sub-irrigation system, and less than one-fiftieth the water used by the sub-fog system. In comparison, a single overhead mist nozzle operating for 10 seconds released approximately one-third of the total water lost through transpiration from each sub-mist system over the entire experiment. Our results show that sub-mist systems merit further evaluation for propagation of plants by leafy stem cuttings. Potential advantages of propagation by sub-mist include low water usage, high sanitation, low potential for nutrient leaching, fast rooting, and rapid and non-invasive evaluation of rooting. The reason for improved rooting in the sub-mist system is unclear, and warrants further investigation.

Specified Source(s) of Funding: Maine Agricultural Center (Horticulture Research Grant)

(223) The Effect of Cutting Position Relative to Cotyledon on Survival Rate, Axillary Sprouts, Adventitious Root Formation, and Regrowth of Grafted Pepper Seedlings

Mahmoud Mohammad Ahmed Soltan*
The Ohio State University-OARDC, Wooster, OH

Matthew Kleinhenz
The Ohio State University-OARDC, Wooster, OH

Producing grafted vegetable plants is complicated or made untenable by adventitious roots erupting from the scion axillary sprouts developing on the rootstock. Removing both unwanted organs is labor intensive but necessary in fruit production because their presence has several undesirable effects. Still, chemical-mediated removal of axillary sprouts is challenging because offsite movement of the chemical (e.g., to roots via stem flow) may damage the root system. The goal of this experiment was to document the effects of rootstock and scion seedling cutting position—above or below the cotyledon—on plant survival and regrowth, and axillary sprout and adventitious root formation. Seedlings of 'Early Sunsation' were used as the scion and rootstock when grafted to four other varieties ('Jalapeño M', 'Cayenne Large Thick', 'Hungarian Hot Wax' and 'Thai Hot') using the splice-tube method. Seedlings were cut either immediately above or below the cotyledons and plants representing three combinations of cut position were prepared: 1) scion epicotyl/rootstock hypocotyl; 2) scion epicotyl/rootstock epicotyl; and 3) scion hypocotyl/rootstock hypocotyl. Twenty newly-grafted plants representing each of the eight variety and three cut-position combinations (24 treatments; 480 plants total) were arranged in a completely randomized design within a standard healing chamber in a climate-controlled greenhouse room at the OSU-OARDC in Wooster, OH. Plant survival rate and regrowth rates were recorded 15 days after grafting using destructive and non-destructive measures; adventitious root and axillary sprout development were also scored. The experiment was repeated twice June–September 2015. Survival and plant data were unaffected by variety combination and interactions involving variety combination and cut position were not significant. Percent survival (79%) was significantly lower among plants

prepared with the scion hypo-/rootstock hypocotyl combination but it did not differ between the two other combinations, averaging 93%. Axillary sprouts developed in nearly 76% of plants with the scion epi-/rootstock epicotyl combination but not in any other combination. Similarly, adventitious roots developed in plants with the scion hypo-rootstock hypocotyl combination but not in any other combination. Plant fresh and dry weights were greater when both the scion and rootstock were cut at the epicotyl and similar in the other cut position combinations. Grafted plant leaf area calculated by WinCam from digital images was unaffected by cut position treatment. Additional related research is underway and involves seedlings representing the scion hypocotyl/rootstock epicotyl cut position combination.

(224) Deep Simple Morphophysiological Dormancy in Seeds of *Epimedium koreanum* Nakai native to Korea

Yong Ha Rhie
Korea University, Seoul, Korea, Republic of

Seung Youn Lee*
Useful Plant Resources Center, Korea National Arboretum, Korea Forest Service, Yangpyeong, Korea, Republic of

Han Choi
Useful Plant Resources Center, Korea National Arboretum, Korea Forest Service, Yangpyeong, Korea, Republic of

Sun Hee Ryu
Useful Plant Resources Center, Korea National Arboretum, Korea Forest Service, Yangpyeong, Korea, Republic of

Jeong Ho Lee
Useful Plant Resources Center, Korea National Arboretum, Korea Forest Service, Yangpyeong, Korea, Republic of

Ki Cheol Lee
Useful Plant Resources Center, Korea National Arboretum, Korea Forest Service, Yangpyeong, Korea, Republic of

The Berberidaceae is a family reported to have morphological dormancy (MD) or morphophysiological dormancy (MPD) with underdeveloped embryos. There are few reports on seed dormancy and germination in *Epimedium koreanum* Nakai. This research was performed to determine the type of dormancy for seeds of *E. koreanum* and its dormancy-breaking requirements. Seeds were collected on 5 June 2015, from plants growing in the Korea National Arboretum. Phenology of embryo growth, germination, and seedling emergence in field condition was observed. The effects of temperature sequences and GA_3 treatment on dormancy break and germination were evaluated. Seeds had underdeveloped embryos that were below 10% of the length of fully matured seeds. In phenology study, the embryos grew very little from June to early September, while rapid growth of the embryos was observed from late September to late November. Embryo growth was completed from late November until early December. Seeds sown on the field soil started to germinate from February, and most seedlings were observed on late March. In laboratory experiments, embryos grew rapidly when the seeds were moved from 25 °C/15 °C to 15 °C/6 °C (day/night). However, the embryos in constant temperatures (25 °C) grew very little. Most of the seeds germinated in only warm followed by cold temperature sequence. Therefore, it seems that warm followed by cold temperature sequence is essential for dormancy break and germination in the seeds. GA_3 treatment increased embryo growth in the seeds, but none of them germinated at 20 °C. Based on these results, seed dormancy of *E. koreanum* can be broken through warm followed by cold temperature sequence and classified as having deep simple morphophysiological dormancy (MPD)

(225) Perigynia Removal Improved Germination in Two Native Sedge Species

Randy S. Nelson
North Dakota State University, Fargo, ND

Aaron L. Daigh
North Dakota State University, Fargo, ND

Esther E. McGinnis*
North Dakota State University, Fargo, ND

Sedges (*Carex* spp.) are used in wetland restoration projects and rain gardens because of their tolerance of fluctuating water levels. For larger projects, achene propagation is the most economical. Physiological dormancy is frequently reported in sedges and can be overcome by cold, moist stratification or after-ripening. Even when physiological dormancy is relieved, germination may still take several weeks. Removing the perigynium (perigynia, plural), a bladder–like sac that adheres to the pericarp of the achene, has decreased germination time and increased percent germination of some sedges. A growth chamber experiment was conducted to evaluate perigynia removal of four sedges native to the north central United States. Yellow fox sedge (*C. annectens* Bicknell), porcupine sedge (*C. hystericina* Muhl. Ex Willd), plains oval sedge (*C. brevior* Mack) and palm sedge (*Carex muskingumensis* Schwein) achenes were collected, cleaned and after-ripened. Achenes with and without pergynia were placed into petri dishes with moistened filter paper and grown for four weeks under 12-hours of cool, white fluorescent light, with alternating 27 °C, 10-hour days/15 °C, 10-hour nights with a 2-hour transition period between temperatures. Experimental design was a completely random design with four replicates. A species by perigynia interaction occurred. Removing perigynia significantly increased the germination percentage of yellow fox sedge from 40% to 62% and porcupine sedge from 79% to 98%. Perigynia removal did not significantly increase percent germination of palm sedge or plains oval sedge. Time to 50% germination was reduced for yellow fox sedge and porcupine sedge but not palm sedge or plains oval sedge. Perigynia removal is an effective strategy to increase percent germination and reduce time needed to achieve 50% germination of yellow fox sedge and porcupine sedge.

(226) Collecting Time Affected Immature Seed Germination of *Kalmia latifolia* L. Hybrids

He Li*
University of Georgia, Athens, GA