Workshop Papers and Authors

Presiding: A.M. Shirazi

Standardizing Methods for Evaluating the Chilling Requirements to Break Dormancy in Seeds and Buds (Including Geophytes): Introduction to the Workshop

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Impact of Temperature on Seed Dormancy

Robert L. Geneve

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F.G. Dennis, Jr.

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Many plants and/or organs require chilling to break their dormancy (Coville, 1920; Doorenbos, 1953; Nienstaedt, 1967). Generally, the optimum temperature is between 0° and 10 °C (Coville, 1920; Doorenbos, 1953; Nienstaedt, 1967). Temperatures required may be continuous, sequential or alternating. The establishment of appropriate protocols for breaking dormancy will permit comparisons between laboratories and produce more effective treatments for commercial use.

Romberger (1963) has identified three phases of dormancy: 1) correlative inhibition, 2) rest, and 3) quiescence. Correlative inhibition occurs when buds do not grow because of inhibitory effects caused by apical dominance or lateral dominance (Samish 1954). This period has also been referred to as "Summer Dormancy" (Doorenbos, 1953). The rest phase, also called "Winter Dormancy" (Doorenbos, 1953), occurs when a bud does not grow because of the effects of an internal factor within the bud (Doorenbos, 1953). Quiescence, "Imposed Dormancy" (Doorenbos, 1953), refers to the condition when bud growth is inhibited because of unfavorable environmental conditions (Samish, 1954). Lang (1987) referred to these three phases of dormancy as "Ecodormancy" (correla-

tive inhibition), "Endodormancy" (rest), and "Paradormancy" (quiescence).

The termination of the endodormancy (rest) period in temperate plant organs of various species requires a period of chilling (Coville, 1920; Doorenbos, 1953; Nienstaedt, 1967). The duration of the chilling period and the temperature required to overcome endodormancy (rest) are genetically controlled (Bennett, 1950; Nakasu et al., 1982; Nooden and Weber, 1978; Samish, 1954; Sherman et al., 1977). The prerequisite of the chilling period for the termination of endodormancy (rest) was first observed by Knight (1801) and subsequently studied by many researchers (Chandler et al., 1937; Coville, 1920; Molish, 1908). The effective chilling period ranges from 250 to 1000 hours (Samish, 1954; Vegis, 1964). Erez and Lavee (1971) indicated in peach trees, 5 °C is the optimum temperature to satisfy the chilling requirement. Fluctuating temperature has been proposed to be more effective in satisfying the chilling requirements of deciduous fruit trees (Erez et al., 1979; Lyr et al., 1970; Samish and Lavee, 1962). However, Lavender and Cleary (1974) found that fluctuating temperatures under natural conditions were less effective in overcoming chilling requirements than a constant temperature in many coniferous species. In addition, chilling requirements may vary with age for a given plant species (Nienstaedt, 1966) and variation within species also occurs (Sharik and Barnes, 1976). Scalabrelli and Couvillon (1986) found that terminal

buds required less chilling temperatures than the lateral buds of 'Redhaven' peach. Long photoperiods may partially compensate for the chilling requirement in many plant species (Garber, 1983; Nienstaedt, 1966; Olmsted, 1951). They postulated that low temperature and photoperiod are not entirely independent since long daylengths could partially compensate for insufficient chilling. A continuous 24-h photoperiod can break dormancy in many plant species (Downs and Borthwick, 1956; Kawase, 1961; Wareing, 1956), while a continuous dark photoperiod will cause budbreak of trees only after their chilling requirements have been satisfied (Wareing, 1956).

Artificial breaking of endodormancy (rest) period has been practiced since the early 1900s (Doorenbos, 1953). Early methods used to force spring-flowering shrubs were: injury (Jost, 1893), acetylene (Johanssen, 1896), ether (Johanssen, 1900), electric current (Bos, 1907), and warm water bath (Molisch, 1908, 1909). Dormancy-breaking treatments were also used on temperate fruit trees grown in warm regions of the world which lacked sufficient chilling temperature to overcome rest naturally (Black, 1952). The amount and time of application of dormancy breaking agents, depends on the stage of physiological growth and genetic makeup of the plants (Erez, 1987; Fuchigami and Nee, 1987). Black (1952) indicated that most dormancy-breaking treatments should be applied at the sublethal (near-lethal) levels in order to be effective.

Erez and Lavee (1974) and Fuchigami and Nee (1987) hypothesized that any treatment applied at near-lethal dosages will break rest. Near-lethal stresses from different sources, e.g., chemicals, heat, freeze, light, drought, injury, anaesthetics, toxic substances, and anoxia are all capable of inducing budbreak (Doorenbos, 1953). However, is it not known whether all stresses utilize the same mechanisms.

Near-lethal heat stress was first reported to be effective in overcoming rest by Molisch (1908, 1909). He placed the dormant shoots of various species in a water bath at 40 to 50 °C. Subsequently, researchers have reported that heat stress (43–55 °C) was effective in overcoming rest in several plant species (Bennett, 1950; Huang and Powell, 1981; Nee, 1986; Shirazi and Fuchigami 1995; Shulman, 1982; Tanino et al., 1989). The finding that, in general, Near Lethal stresses are capable of breaking bud dormancy may explain why chilling models used to predict the development of dormancy do not prove to be satisfactory in some environments (Shirazi and Fuchigami, 1995). Consideration must be given to any predisposition of plant organs to near-lethal (sub-lethal) stresses and/or any factors, e.g., long photoperiods, which contribute to compensation of chilling temperatures and affect the chilling temperature requirements.

The articles on seed dormancy by Geneve (2003), on geophytes by Dole (2003), and on bud dormancy by Dennis (2003) provide invaluable information on chilling temperatures and problems with standardization for breaking endodormancy (rest). In spite of the problems with standardizing chilling temperatures in seed and bud (including geophytes), when asked what temperature could be an optimum chilling temperature, dormancy researchers agreed that 5 ± 1 °C was satisfactory. These workshop papers will provide insightful input for future contributions to dormancy research.

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