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1.5. Forcing the Termination of Dormancy

Although chilling is required to terminate dormancy, and insufficient chilling is detrimental to subsequent growth and development, temperate-zone crops have been successfully cultivated in tropical countries. Crop management techniques have been manipulated, albeit with mixed results, in an attempt to grow such crops out-with their natural geographical range with exposure to minimum chilling.

1.6.1. Premature Defoliation

Assuming the theories of Tinklin and Schwabe (1970) and Mielke and Dennis (1978), if a growth inhibitor was synthesized and translocated from plant leaves to bud scales then into the bud, thus preventing bud burst, removing the source of the inhibitor would prevent accumulation. Subsequent growth, therefore, would be expected to be advanced.

In tropical countries, temperate-zone crops enter a shallow dormancy that is broken by exposure to stress, in the form of premature defoliation (Dennis, 1987). This technique has been employed to successfully cultivate *Prunus* spp. and *Malus domestica* in Thailand, Venezuela and India, where winter temperatures do not satisfy the chilling requirement (Dennis, 1987). Premature defoliation induced bud burst of *Prunus persica* 'Flordaprince' before any chilling had accumulated, based on the Utah and <7.2°C models, indicating that premature defoliation was the sole cause of bud burst (Lloyd and Firth, 1990). Defoliation of *P. persica* 'Flordagold' and 'Flordaprince' resulted in a decrease in dormancy, although it is unclear what measure of dormancy was utilised (Lloyd and Firth, 1990).

Premature defoliation, however, did not affect bud burst of *P. persica* 'Redhaven' (Crisosto *et al*., 1987), *Actinidia chinensis* 'Hayward' (Snelgar *et al*., 1997), *Olea europaea* 'Ascolano' and 'Manzanillo' (Rallo and Martin, 1991), *Ribes nigrum* 'White Bud' (Westmore, 2004), *R. nigrum* 'Vija' and Klone 8 (Plancher, 1983b). Treatment timing is an important factor however, and Crisosto *et al.* (1987), Westmore (2004) and

Plancher, 1983b) defoliated the respective plants either just before the date of natural senescence, or when leaf fall had begun. Detrimental effects on *R. nigrum* 'Baldwin' flower production were observed after premature defoliation, and the earlier the treatment was applied, the more severe the reaction (Corke and Wilson, 1963). Contrastingly, however, defoliation increased the yield of *P. persica* 'Redhaven' (Crisosoto *et al*., 1987).

1.6.2. Nitrogen Application

Bud burst of *Malus domestica* 'Lord Lambourne' (Delap, 1966), 'Golden Delicious' (Terblanche *et al.*, 1979) and 'Cox's Orange Pippin' (Delap, 1967) was advanced in tropical countries following nitrogen fertlisation. The rate of bud burst and final bud burst were unaffected by nitrogen application (Terblanche *et al*., 1979), however treated plants demonstrated higher fruit set and yields (Delap, 1966). The form of nitrogen may be important - urea and nitrate nitrogen were used in the above experiments, but application of nitram was detrimental to *Prunsus persica* 'Flordaprince' bud burst (George and Nissen, 1992). The timing of application may also be an important factor in the above discrepancies. Autumn application of nitrogen (0.016 $g.l.^{-1}$) advanced bud burst of *M. domestica* 'Cox's Orange Pippin' but spring and summer applications were ineffective (Delap, 1967).

1.6.3. Extended Photoperiodic Regimes

Extended photoperiods (24-hours) have been observed to substitute for insufficient chilling and promote growth and development (Campbell and Sugano, 1975), and have been successfully applied to promote premature bud burst of *Picea abies* (Heide, 1974a), *Ribes nigrum* 'Boskoop Giant' (Hoyle, 1960), *Acer saccharum* (Olmsted, 1961), *Picea sitchensis* (Cannell and Smith, 1983), *Fagus sylvatica*, *Larix decidua* and *Betula pubescens* (Wareing, 1954b). No effect of extended photoperiod was recorded for *Acer pseudoplatanus*, *Robina pseudoacacia* (Wareing, 1954b) and *Cornus alba* (Whalley and Cockshull, 1976), but this may be because the chilling requirements of these species were sufficiently satisfied (Heide, 1993a), or the chilling deficits may have been too large for treatment to overcome.

1.6.4. Application of Dormancy Breaking Chemicals

Dormancy breaking chemicals have been utilized to induce bud burst in several crop species e.g. *Malus domestica* grown in Yemen (Finetto, 1993) and *Prunus armeniaca* grown in Turkey (Kuden and Son, 1997). There are several commercially-available products that are rely either on oil, nutrient or chemical activity to force bud burst. The major drawback in using oils and chemicals, however, is the rigorous and expensive registration process that must be undertaken before application to the crop in the UK is permitted. Application has also been reported to have detrimental effects on the crop; e.g. hydrogen cyanamide can be toxic to flowers and DNOC-oil is phyto-toxic (Erez and Yablowitz, 1997).

GlaxoSmithKline identified the potential for the adjuvant Abacus (active ingredients alkylphenyl hydroxypolyoxyethylene, natural fatty acids and esterified rape seed oil) to be used as a dormancy breaking chemical. The mode of action of Abacus is unknown but it was suggested that when sprayed onto buds it formed a seal, preventing transpiration and resulting in a stress reaction (Mitchell, R., *Pers. Comm.*). Alkylphenyl hydroxypolyoxy-ethylene is a member of the nonylphenol ethoxylate family, and despite the equipment and technology available to chemists, the exact degradation process of this substance process has not been fully identified (Montgomery-Brown and Reinhard, 2003). The first step of degradation of this compound is the loss of ethoxylate (C_2H_40) side groups, which may further degrade to produce ethylene or a similar breakdown product, and may induce bud burst (Jonkers *et al.*, 2001). Regardless of the lack of understanding in this subject area, initial field trials have proved promising.