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Short communication

Chill unit models for blackcurrant (*Ribes nigrum* L.) cultivars 'Ben Gairn', 'Ben Hope' and 'Ben Tirran'

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ABSTRACT

Temperate-zone crops require a period of winter chilling to terminate dormancy and ensure adequate bud break the following spring. The exact chilling requirement of blackcurrant (*Ribes nigrum*), a commercially important crop in northern Europe, is relatively unknown. Chill unit models have been successfully utilized to determine the optimum chilling temperature of a range of crops, with one chill unit equating to 1 h exposure to the optimum temperature for chill satisfaction. Two-year-old *R. nigrum* plants of the cultivars 'Ben Gairn', 'Ben Hope' and 'Ben Tirran' were exposed to temperatures of −10.1 °C, −3.4 °C, 0.1 °C, 1.5 °C, 2.1 °C, 3.4 °C or 8.9 °C (±0.7 °C) for durations of 0, 2, 4, 6, 8 or 10 weeks and multiple regression analyses used to determine the optimum temperature for chill satisfaction.

In temperate and boreal regions woody plant species avoid low-temperature injury by entering a state of winter dormancy (endodormancy) where growth ceases and metabolic activity is reduced (Lang et al., 1985). It is recognized that chilling temperatures promote the removal of endodormancy in woody plants, although the mechanism involved remains unclear. If the chilling requirement is not fulfilled, plants can suffer from uneven and delayed bud break, reduced shoot vigour, limited anthesis and poor flower development (Campbell and Sugano, 1975). As a consequence, yield of commercial fruit crops can be significantly compromised by inadequate winter chilling. Originally, Richardson et al. (1974) developed a model for predicting dormancy release of *Prunus persica* 'Redhaven' and 'Elberta' (the Utah model). Attempts to apply the Utah model to other crop species met with limited success (Shaltout and Unrath, 1983; Erez and Couvillon, 1987). Recent work has concentrated on constructing models for individual species including *Malus domestica* (Young and Werner, 1985; Del-Real-Laborde et al., 1990); *Fragaria x ananassa* 'Elsanta' (Tehranifar et al., 1998); 'Glasa' and 'Tioga' (Kronenberg et al., 1976); *P. persica* 'Redhaven' (Scalabrelli and Couvillon, 1986; Erez and Couvillon, 1987); *Vaccinium vitis-idea* (Holloway et al., 1983) and *Actinidia deliciosa* 'Tomuri' (Guerriero et al., 1990).

Ribes nigrum is an economically important crop in northern Europe and Australasia and recent research suggested that several important commercial cultivars are not receiving the required chill units (Sunley et al., 2006). It is imperative that the chilling requirement of this crop be determined in order to prevent the future planting of cultivars that will not perform well under the predicted climate change scenarios.

The objective of this research was to determine the chilling requirements of three commercially important *R. nigrum* cultivars. In addition we aimed to develop chill unit models specific for each of the cultivars and test their effectiveness in predicting bud break date in the field compared to existing model systems.

1. Materials and methods

1.1. Year 1

Two-year-old *R. nigrum* 'Ben Gairn', 'Ben Hope' and 'Ben Tirran' were grown outside, subject to natural environmental conditions in 3 L pots (100% peat) prior to experimentation. On 20 December 2002, plants of each cultivar were placed in cold stores at −3.4 °C, 0.1 °C, 1.5 °C, 3.4 °C and 8.9 °C in groups of 25 per store. Excessive tissue desiccation was avoided by wrapping each plant in black polythene. A control group of plants were placed directly into a polythene tunnel maintained at approx.18 °C to avoid further winter chilling. Five plants of each cultivar were removed from each cold store and placed in the polytunnel at 2-week intervals commencing 3 January 2003. Time to first bud break was recorded for each individual plant, thereafter, the number of buds that had burst was recorded three times a week until 16 July 2003. Data were used to calculate chilling requirements.

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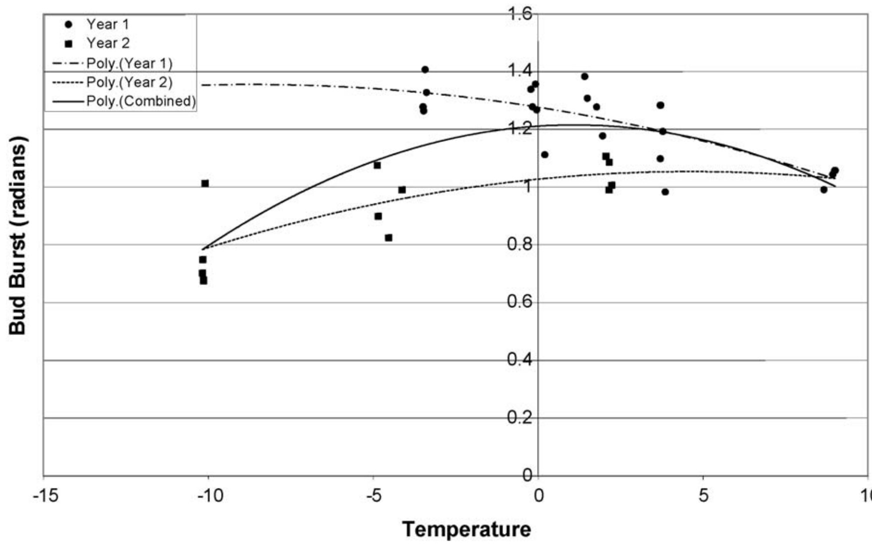

Fig. 1. The effect of chilling temperatures on bud burst of *Ribes nigrum* 'Ben Gairn' (Δ represents Year 1 data, □ represents Year 2 data). Poly. (Year 1) $y = -0.001x^2 - 0.018x + 1.276$, $R^2 = 0.587$, Poly. (Year 2) $y = -0.001x^2 + 0.011x + 1.027$, $R^2 = 0.544$, Poly. (Combined) $y = -0.003x^2 + 0.007x + 1.211$, $R^2 = 0.501$.

1.2. Year 2

On 20 December 2003, 60 plants of each cultivar were chosen at random and placed in three cold stores at −10.1 °C, −4.3 °C and 2.1 °C. Control plants were moved to the heated polythene tunnel used previously for forcing after 2, 4, 6 and 10 weeks. Five plants of each cultivar were removed from each cold store on each occasion. Temperature and bud break data were recorded until 15 July 2004.

1.3. Chill unit model development

Results were subjected to analysis of variance (ANOVA) using Genstat V to determine the significance of difference between chilling durations and chilling temperatures. Data sets were transformed to radians using radian = $\sin^{-1}(\sqrt{p})$ where p = proportion = percentage bud break/100.

Multiple regression analysis was performed to determine the relationship between chilling duration, chilling temperature and proportion bud break. Hours of chilling were converted to chill units and multiple regression analyses were performed to determine the relationship between percentage bud break and D, T, D^2, T^2 and $D \times T$, where D = chilling duration and T = chilling temperature, as described by Mahmood et al. (2000). Data obtained from Year 1 were used to create the model GSK/Fraser (1) data obtained from Year 2 were combined with the original data to create the model GSK/Fraser (2).

1.4. Validation of experimental data

Hourly temperature was recorded from October to April in commercial *R. nigrum* fields in Thetford, Norfolk, UK in 2002/2003 and 2003/2004 and in Ledbury, Hereford, UK in 2003/2004. From 1 January, a minimum of two budsticks were cut from selected bushes of all three cultivars at 4-day intervals and placed in buckets of water in a 20 ± 2 °C forcing environment with natural photoperiod. When 75% bud break was achieved in all budsticks, the chilling requirement was concluded to have been

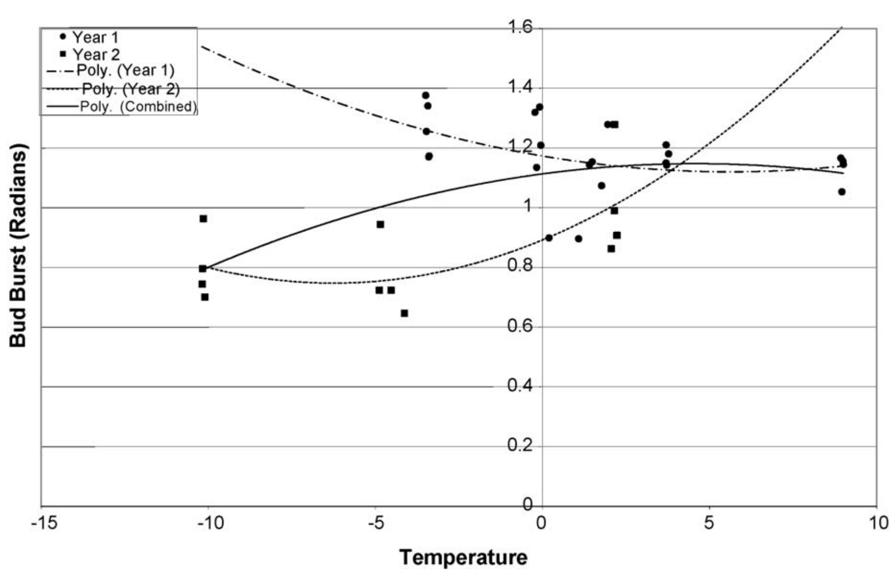

Fig. 2. The effect of chilling temperatures on bud burst of *Ribes nigrum* 'Ben Hope' (Δ represents Year 1 data, □ represents Year 2 data). Poly. (Year 1) $y = 0.001x^2 - 0.018x + 1.173$, $R^2 = 0.163$, Poly. (Year 2) $y = 0.003x^2 + 0.046x + 0.891$, $R^2 = 0.421$, Poly. (Combined) $y = -0.001x^2 + 0.015x + 1.113$, $R^2 = 0.279$.