Objectives & Rationale

Apple trees, that do not fulfil their winter chill requirement, undergo inadequate dormancy release resulting in poor bud break with irregular and delayed flowering that impact negatively on fruit production. Under mild winter conditions the application of rest breaking agents (RBA) is standard practise to artificially release dormancy and synchronise bud break to ensure sustainable and profitable apple production. However, RBA can be harmful and may result in phytotoxic damage if not applied optimally, a good understanding of the physiological status of the buds is necessary to mitigate this risk and develop new RBA. The main aim of this study was to compare the dormant apple buds from Elgin (insufficient winter chill) and the Koue Bokkeveld (sufficient winter chill) in terms of their respiration rate, lipid composition and abscisic acid metabolism. Results were also compared after buds received a HCo treatment.

Methods

Numerous trials were conducted, the word limitation doesn't allow for a detailed description of the methodology. Please refer to dissertation for detail.

Key Results and Discussion

Apple buds exposed to sufficient chill showed an early dormancy entrance, high maximum dormancy level and an early release, while buds from the milder area generally showed atypical dormancy behaviour. During winter, the total respiration rate and the rate of the main respiratory pathways (tricarboxylic acid cycle (TCA) and cytochrome C (CYT)) were reduced with the decline in temperature. Their levels increased again in the cold area at the beginning of spring to provide energy for growth resumption. In contrast, the main respiration levels remained low in the warm area and the pentose phosphate pathway (PPP) and alternative pathway (ALT) tested higher suggesting an attempt by the plant to compensate for the deficiency in energy production. The HCo treatment induced hypoxia in the buds and immediately decreased the total respiration as well as the main respiratory pathways (TCA and CYT). After this initial response the treated buds showed a significant increase in respiration and reached high levels towards bud break. This increase was absent in the untreated buds from the mild winter climate, these buds maintained higher PPP and ALT pathways. Temperature also affected the lipid composition in the buds towards the onset of spring. Warmer winters reduced the desaturase process preventing the desaturation of linoleic acid to linolenic acid. Lower free phospholipids and higher free sterols content were detected in the warmer area and is thought to reduce the membrane fluidity and permeability hampering growth resumption in spring. The HCo treated buds showed results similar to buds that received sufficient winter chill. It is suggested that the use of HCo targets similar pathways and mechanisms as the natural accumulation of sufficient chill when inducing growth resumption. The ABA concentration were found to decrease in buds irrespective of winter chill although the catabolism of ABA was slower in the warm area, resulting in an incomplete breakdown.

Conclusion and Recommendation

This study provided evidence that the lack of winter chill changes the physiological landscape of the bud tissue in such a way that energy production via respiration is limited, membrane lipid composition is altered, and the catabolism of growth inhibiting hormones are compromised. These factors can all contribute to a lack in growth resumption resulting in prolonged dormancy symptoms. When HCo is used as a rest breaking agent, it acts similar to sufficient winter chill by enhancing the main respiration pathways and stimulated the production of polyunsaturated fatty acid, which in turn, provides more fluid and permeable membranes that increase energy production needed for bud break. Results from this study provide evidence that future development of artificial ways to target these same systems may improve apple cultivation in marginal production areas.