氣候變遷下溫帶果樹打破休眠低溫量變化分析

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摘　要

臺灣地處亞熱帶氣候區，但因地貌豐富且海拔地勢較高，加上農業科技及技術不斷取得先進的突破，部分地區早已發展多種溫帶水果品項成熟的種植與生產技術，包含梨、柿、桃、梅、葡萄等。近年全臺果樹種植面積已有明顯變化，相較於熱帶或亞熱帶果樹，例如芒果、香蕉、鳳梨等，種植面積多保持持平，少數呈現有上升的趨勢；但溫帶果樹卻相反，種植面積已逐年下降。

氣候變遷影響許多現種植於中低海拔之溫帶果樹打破休眠的過程，雖然溫帶果樹可使用氰胺(Hydrogen cyanamide)或氰胺基化鈣(Calcium cyanamide)，降低果樹休眠所需低溫量(chilling unit, CU)，但目前臺灣對於藥劑施用量與作用時期研究仍屬初期。本研究探討現況及未來氣候變遷情境下，溫帶果樹打破休眠所需低溫量分析，包含現況及未來低溫量增減趨勢與全臺空間分布差異，藉此助益預先發展溫帶果樹因應氣候衝擊的調適作為。

本研究使用國科會「臺灣氣候變遷推估資訊與調適知識平台計畫(The Taiwan Climate Change Projection Information and Adaptation Knowledge Platform, TCCIP)」AR5 HiRAM 動力降尺度氣候推估資料及農業試驗所溫帶果樹類之農地土地覆蓋圖資，進行相對區位 CU 分析。臺中市溫帶果樹屬全臺種植較大宗區域，梨、柿與桃種植面積於臺中市分別佔全臺 68%、72%與 62%，主要種植於和平區、東勢區及新社區。分析結果顯示，目前中低海拔種植區現況(1995-2014 年)平均為 60 CU，於全球暖化程度 2℃ (2034-2053 年)平均為 30 CU，而全球暖化程度 4℃ (2073-2092 年)平均僅剩 9 CU；而高海拔地區現況平均為 841 CU，於世紀中平均為 611 CU，至世紀末也剩餘 364 CU。分析結果顯示，未來相較現況的低溫量明顯減少，可能導致溫帶果樹開花減少、開花不整齊、新梢無法正常生長或果實發育不良等。

未來可進一步應用本研究成果於評估現況相對區位作物於氣候變遷影響下的適栽性，並予以檢視以往慣行的栽培及管理模式在面臨未來暖化情形下是否需進行調整，藉以提前規劃後續品種改良技術研發及栽種區位調整策略，以期逐步規劃及建構地方農業因應種植品種轉換及農業系統轉型之所需調適能力。

關鍵詞：氣候變遷、溫帶果樹、低溫量、農業系統轉型、調適能力

Analysis of Chilling Requirement Variability for Dormancy Release in Temperate Fruit Trees under Climate Change

Abstract

Taiwan is located in a subtropical climate zone. However, due to its diverse topography and higher elevations, along with continuous advancements in agricultural science and technology, some regions have successfully developed mature cultivation and production techniques for various temperate fruits, including pears, persimmons, peaches, plums, and grapes. In recent years, there has been a significant shift in the total area of fruit tree cultivation around Taiwan. Compared to tropical and subtropical fruits such as mangoes, bananas, and pineapples—whose cultivation areas have remained stable with slightly increasing—the cultivation area of temperate fruit trees has shown a steady decline year by year.

Climate change has disrupted the dormancy-breaking process of temperate fruit trees varieties grown in low to mid-elevation areas. Although temperate fruit trees can utilize hydrogen cyanamide or calcium cyanamide to reduce the chilling units (CU) required for dormancy breaking, however, research on application rates and timing in Taiwan is still in the initial stages. This study analyzed the chilling requirements for temperate fruit trees to break dormancy under current and future climate change scenarios, including analysis of trends in chilling accumulation and spatial differences across Taiwan. This study aims to support proactive development of adaptation strategies for temperate fruit crops against climate related impacts.

This study conducted relative location-based CU analyses by using the AR5 HiRAM dynamically downscaled climate projection data from the TCCIP and along with land cover maps of farmland dedicated to temperate fruit trees provided by the Agricultural Research Institute. Taichung City is one of the major regions for temperate fruit cultivation in Taiwan, with pears, persimmons, and peaches accounting for 68%, 72%, and 62% of the nation's total cultivation area, respectively. These fruits are mainly grown in the districts of Heping, Dongshi, and Xinshe. The analysis shows that the current (year 1995-2014) average for mid-to-low altitude planting areas is 60 CU, the average is 30 CU under 2°C scenario of global warming (2034-2053), while at 4°C warming (2073-2092), it drops to 9 CU. Analysis results of high-altitude areas, current average is 841 CU, but decreasing to 611 CU by mid-century and 364 CU by the end of the century, respectively. These findings initial indicate that significant reductions in chilling units compared to the present, which may lead to issues such as reduced flowering, uneven blooming, poor shoot development, or abnormal fruit growth in temperate fruit trees.

The research results can be further applied to planning and building local agriculture

adaptive capacity for crop variety changes and agricultural system transformation, including assessment of the suitability of current crop locations under climate change, reviewing traditional cultivation and management practices for necessary adjustments in warming scenarios, and planning for variety improvement and planting location strategies.

Keywords: Climate change, Temperate fruit trees, Chilling units, Agricultural system transformation, Adaptive capacity