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Historical and future winter chill for temperate fruit and nut trees in Afghanistan

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Abstract

Temperate fruit trees require exposure to chill and heat conditions to overcome the dormant period in winter and resume growth in spring. Rising temperatures due to climate change have already impacted winter chill accumulation in horticulturally vital growing regions worldwide. Afghanistan's intra-regional differences make the country favorable for producing a wide range of fruits and nuts, which constitute approximately 30% of the country's total export earnings. However, expected future temperature increases may be detrimental to the trees' ability to fulfill their chilling requirements. To quantify this risk, we computed and mapped historical and future chill accumulation in Afghanistan. For this purpose, we used long-term daily temperature data from 1980 to 2020 for 51 hydrometeorological stations across the country. Based on the temperature data, we produced four future Shared Socioeconomic Pathway (SSP) scenarios (SSP126, SSP245, SSP370, and SSP585) for five General Circulation Models (GCMs) from the Coupled Model Intercomparison Project Phase 6 (CMIP 6). We used the RMAWGEN weather generator to produce 100 synthetic realisations of weather records for historical (1980, 1990, 2000, 2010, and 2020) and future conditions (2035-2065 and 2070-2100). We quantified winter chill using the Dynamic Model. Additionally, we computed Safe Winter Chill (SWC), which is defined as the level of chill that is expected to be exceeded in 90 % of years. We found that SWC has decreased in the low-lying regions mainly in the eastern, southern, and parts of the northern regions, and is projected to further decrease in the future. This reveals a possible future chill risk for high chill-requiring cultivars of different fruit and nut species, including apricot, peach, plum, pistachio and almond, in these regions. In contrast, we recorded an increase in SWC in the northern and central regions, marking these regions as potentially favorable for high-chill species in the future. Our findings support fruit and nut growers in Afghanistan in adapting their orchards to match species' and cultivars' chill requirements with the expected future winter chill.

Keywords: Chill accumulation, chill risk, dormancy, dynamic model, fruit trees, spatial interpolation

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