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Climate change shifts almond bloom dates in Afghanistan

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Abstract

Climate change affects the spring phenology of temperate fruit and nut trees worldwide, leading to uneven bud break and reduced fruit yield in many growing regions. Almond trees, including the cultivars grown in Afghanistan, are affected by these changes. Afghanistan cultivates more than 50 almond varieties, with an annual export value of approximately USD 40 million in 2024, according to official statistics. However, exports remain below their potential due to various challenges across the value chain. One of these challenges is the warming climate, which affects almond phenology and yield.

In this study, we explored and projected blooming patterns of 51 almond cultivars using long-term temperature data (1980 to 2023) and phenology records (2011 to 2023). We generated two historical scenarios (1980 and 2020) and projected future bloom timings for 2050 and 2085 under three Shared Socioeconomic Pathway (SSP) scenarios (SSP126, SSP245, and SSP585) using 15 General Circulation Models. We applied the PhenoFlex phenology modelling framework for bloom predictions to understand the response of cultivars to warming climates. The model effectively captured the observed bloom patterns, with a Root Mean Square Error of Prediction of below four days for all cultivars. Compared to 1980, bloom dates advanced by approximately two weeks by 2020. Future projections indicate further advances of up to 16 days for most cultivars, while some cultivars exhibited bloom delays of up to 12 days. Strong shifts in bloom dates of >7 days were observed for a subset of 25 % of total predictions, particularly by 2085 for intermediate and pessimistic climate change scenarios. These findings highlight the ongoing and future shifts in almond phenology, underscoring the need for adaptive strategies to sustain production and exports.

Keywords: Almond phenology, bloom projection, bloom shift, climate change, PhenoFlex framework

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