

Phenological Description of Quince (*Cydonia oblonga* Mill.) and Its Relationship with Climatic Changes on the Transylvanian Plateau

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Abstract. This study provides a phenological characterization of quince (*Cydonia oblonga* Mill.) in relation to the dynamics of key climatic factors over three consecutive growing seasons (2020–2022). Phenological observations were carried out under field conditions on two cultivated genotypes, using the standardized BBCH scale to record vegetative and reproductive developmental stages from winter dormancy to senescence. Climatic data, including air temperature, precipitation, and relative humidity, were analyzed to assess their influence on the timing and progression of phenophases. The results revealed marked interannual variability in the phenological calendar of quince, mainly driven by differences in thermal and hydric regimes. Favourable climatic conditions in 2020 and 2022 promoted an earlier onset of vegetative activity, a more compact flowering period, and more uniform fruit development and maturation. In contrast, cooler spring temperatures and episodic water deficits in 2021 delayed early phenophases, prolonged flowering, and resulted in less uniform fruit growth, followed by an accelerated onset of senescence. The BBCH scale proved to be a robust and reliable framework for standardized phenological assessment, enabling precise interannual comparisons and clear correlations between plant development and climatic drivers. These findings highlight the sensitivity of quince phenology to climate variability and emphasize the importance of continuous phenological monitoring to support adaptive orchard management under changing environmental conditions.

Keywords: plant development, temperature, humidity, flowering, BBCH scale

INTRODUCTION

Phenology studies have a wide range of uses, and among them the most important refer to the role as a biological indicator of global and regional weather and climate change (Inouye et al., 2022), reflect the response of plants to biotic and abiotic stress (Baidya et al., 2022), make it possible to evaluate the adaptive characteristics of new cultivars (Weber, 1964). Knowledge of crop phenology is crucial to synchronize correct management practices such as fertilization and irrigation or control of disease, pest, and weed populations in agricultural crops (Şahin et al., 2026). Phenology studies recurrent seasonal natural events, which can indicate changes in ecosystems caused by global warming, so there are numerous studies that analyze the climate impact on plant development (Abu-Asab et al., 2001; Cornelius et al., 2011, Kuldeep Singh 2026; Menzel et al., 2006). Thus, phenological observations are all the more necessary now, when climate change, especially heat and water stress, are becoming more intense, causing an increase in the incidence of disease and pest attacks on cultivated species.

The annual life cycle of quince (*Cydonia oblonga*), as well as of other species in temperate climates, includes a complex of phenological stages of growth and development, represented mainly by: swelling and opening of buds, growth of leaves and shoots, appearance of flowers, flowering, fruiting and senescence, as well as resting periods.

The progression of plant development has been recorded by scalar methods and has been the main concern in numerous studies (Chitu and Paltineanu, 2020; Kumar et al., 2026; Lisandru et al., 2016, Cifuentes-Carvajal et al., 2024). A very common and validated scale is the BBCH (Biologische Bundesanstalt, Bundessortenamt und Chemische Industrie) (Ramírez and Davenport, 2016; Sakar et al., 2019) studied for at least three decades. The first coded system developed for fruit species had preferred uses in plant protection. The BBCH phenological stage coding system is an improved variant of the Zadoks coding system, including mono- and dicotyledonous plants. However, the biggest disadvantage of the initial scales was the use of a common code for the same developmental stages, so an improvement was needed in the BBCH code that ensures uniform coding of similar phenological growth and development stages for plants (Meier et al., 2009). The aim of this study is to characterize the phenological development of quince (*Cydonia oblonga* Mill.) and to determine how climatic factors—especially temperature, precipitation, and humidity—affect the timing and progression of its developmental stages over different growing seasons.

MATERIAL AND METHODS

Orchard location and data collection

Phenological study on quince (*Cydonia oblonga*) on two cultivated genotypes, Aurii and Bereczki in the orchard in Jucu, Cluj county (46°50'32.91" N- 23°48'01.10" E) (fig 1).



Figure 1. Positioning of the orchard and aspects of the quince orchard (*Cydonia oblonga*) in Jucu, Cluj county

The experimental field was located in the outskirts of Jucu, Cluj county, at an altitude of 310 m, on a slight slope (fig. 1). It covers 3 ha of quinces: 1.7 ha of the Bereczki variety and 1.3 ha of the Aurii variety (both at a distance of 4 x 4 m). Established in the autumn of 2017, the plantation was certified organic.

Biological material

Bereczki – a quince variety, dating back to the Habsburg era, named after the Hungarian pomologist Máté Ereczki (1824-1895). It is a famous quince with large fruits (400-500 g), pyriform, ovoid or irregular, fragrant and juicy, with a lemon-yellow pericarp, covered with grayish-brown fluff before maturity. The pulp is yellowish, crispy, with medium juiciness and few sclereides.

The tree is of high or medium-high vigor, depending on the rootstock, with an inverse pyramidal or globular crown, rustic, with good and constant productivity, being self-fertile and pollinating. It has a high tolerance to frost and specific diseases.

It blooms in April and begins to bear fruit in about 2-3 years after planting, with the harvest period being in September and October. The plant loves the sun and well-drained fertile soils, and the ideal pH is around 6.5.

Aurii - Romanian variety of quince (obtained and approved by ICDP Mărăcineni), clone of Bereczki. Large fruits (300–500 g), pyriform or globuloelongate, slightly irregular with a pericarp from yellowaury to yellow-orange, with characteristic fine fluff, yellowish, crunchy, dense, juicy pulp, with fine sclereides and aromatic, sweet, slightly astringent taste.

The tree has a medium vigor, 3-4 m at maturity, with a globular crown, balanced and relatively easy to maintain, rapid entry into fruit (2-3 years after planting), good and constant productivity, medium tolerance to biotic and abiotic stressors. The flowering period is in April, and ripening is between September and October.

Collecting and processing climate data

The climatic data that were the basis for the analyses were taken from the meteostat website ([The Weather's Record Keeper | Meteostat](https://www.meteostat.net/en/)) using the records of the nearest weather station, namely ANM Cluj-Napoca Meteorological Station (airport area). The values pursued were; maximum and minimum air temperature (°C), relative humidity (%) and precipitation level (mm), and the records used were daily in the calendar interval 01.03-15.11 of each experimental cycle (2020/2021/2022).

Research methods

BBCH SCALE

For fruit trees, the BBCH scale generally uses eight of the ten main stages, starting with the start of the buds in vegetation (stage 0) and ending with the initiation of the latent (stage 9). Three main stages of growth are attributed to vegetative growth, the start of buds in vegetation (stage 0), leaf formation (stage 1) and bud growth (stage 3), the latter being shared with flower development (stage 5). Flowering (stage 6), fruit growth (stage 7), and fruit ripening (stage 8) complete the code. Each of the above stages of development has phenophases coded from 0 to 9, so that the expression of phenophases appears to consist of two digits, the first expressing the stage and the second the phenophase specific to each stage of development.

The measurements and observations were carried out during three growing seasons (2020–2022), from March to November. Field determinations and observations were carried out two to three times a week between March and June and once twice a week from June onwards.

RESULTS AND DISCUSSIONS

Coding the main stages of development in quince

The main stages of the development of quince plants are as follows:

Stage 0: Buds swell and break dormancy, showing the first green tips.

Stage 1: Leaf formation — leaves unfold and extend to create the first canopy.

Stage 3: Growing shoots – covers the extension of new shoots to the final length.

Stage 5: Appearance of inflorescences – describes the swelling and visibility of flowers in the buds.

Stage 6: Flowering – follows the opening of the flowers, from the initial flowering to the fall of the petals.

Stage 7: Fruit Formation and Growth – monitors fruit growth from fixed size to near final size, including natural periods of decline.

Stage 8: Fruit maturity – focuses on ripening, marked by color changes and reaching specific parameters for harvesting.

Stage 9: Senescence and entry into dormancy– which involves discoloration and fall of the leaves, completion of the growth of shoots, thus signaling the beginning of the entry into dormancy.

Phenological characterization of quince (*Cydonia oblonga* Mill.) in correlation with the dynamics of climatic factors specific to the experimental year 2020

The phenology of quince is closely correlated with the thermal and water regime of the vegetation period. The analysis of the variation of precipitation and relative humidity of the minimum and maximum temperatures (fig.2) and the minimum and maximum temperatures (fig.3), respectively, allows to highlight the main phenological stages undergone by quince plants in 2020 and how they are influenced by specific climatic conditions.

Vegetation Initiation and Early Phenological Phases (BBCH 0)

At the beginning of the growing season, corresponding to March, the thermal regime was characterized by minimum temperatures close to the biological activation threshold (0–2 °C) and by progressively increasing maximum temperatures, which frequently exceeded 10 °C (fig. 3). These conditions determined the gradual exit from winter rest and the initiation of physiological processes specific to the swelling and opening phase of the buds. From a water point of view, this stage was supported by relatively frequent rainfall and high atmospheric humidity (fig. 2), which contributed to the restoration of water reserves in the soil.

Leaf formation and active vegetative growth (BBCH 1 and 3)

Between April and May, maximum temperatures often rose to 15–20 °C, with minimums stabilising above 5–7 °C (fig. 3). These thermal and rainfall conditions, along with high humidity (fig. 2), promoted leaf development, shoot initiation, and overall vegetative growth.

Appearance of inflorescences and flowering (BBCH 5 and 6)

During May and early June, the thermal regime was characterised by maximum temperatures near or slightly exceeding 20 °C, with minimum temperatures generally remaining above 8–10 °C (Fig. 3). These conditions were conducive to floral differentiation and opening, supporting a relatively uniform progression of flowering. Concurrently, elevated relative humidity levels and episodes of precipitation (Fig. 2) further contributed to sustaining a microclimate suitable for pollination and fertilisation processes.

Fruit formation and growth and concomitant vegetative growth (BBCH 7 and 3)

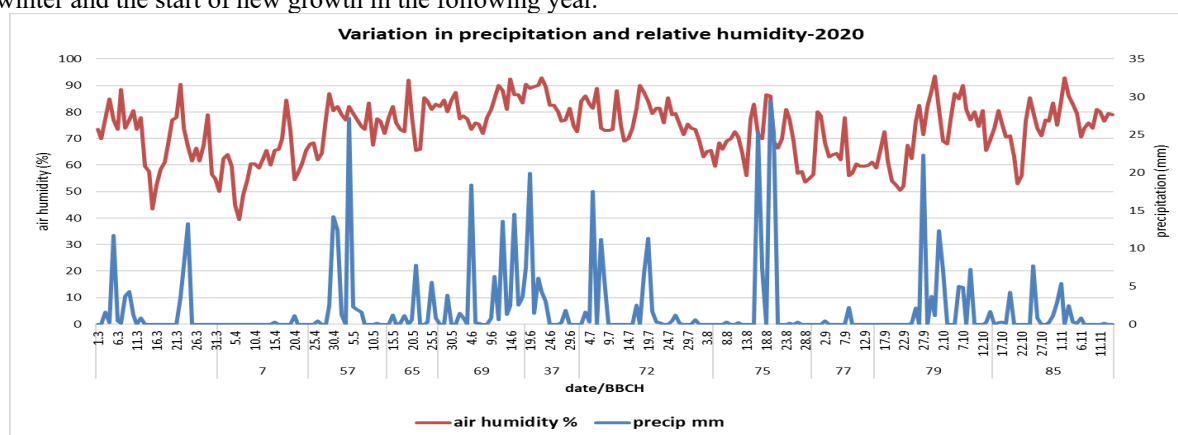
During June and July, maximum temperatures consistently ranged from 24 to 28 °C, while minimum night-time temperatures were typically between 14 and 16 °C (see fig. 3). These conditions fall within the optimal range for fruit development and support robust photosynthetic activity. Concurrently, elevated precipitation levels and increased relative humidity (refer to fig. 2) facilitated vigorous cell division and accelerated fruit growth.

Fruit ripening (BBCH 8)

August saw the highest temperatures of almost 30 °C, then September brought a gradual cooling (fig. 3). This change, along with uneven rainfall and slightly lower humidity (Fig 2), promoted the shift from fruit growth to ripening, during which dry matter accumulated, fruit color deepened, and organoleptic qualities developed.

Senescence and entry into dormancy (BBCH 9)

During October and November, both minimum and maximum temperatures dropped sharply, often falling below 10–12 °C. This period was also marked by low rainfall but relatively high humidity. These environmental changes gradually slow down plants' physiological functions, break down chlorophyll, and begin the process of senescence. As leaves fall and plants enter dormancy, the annual growth cycle ends, preparing vegetation for winter and the start of new growth in the following year.



regime and increased atmospheric humidity favoring early exit from rest and a relatively rapid transition from BBCH 00 (rest) to BBCH 03–07 (swelling and opening of buds), in 2021 (figs. 4 and 5), lower minimum temperatures and persistent cold episodes in early spring caused a delay in bud activation, with a slower progression through BBCH stages 01–03. As a result, reaching the BBCH 09 stage (appearance of green peaks) occurred later than the previous year

Leaf formation and early vegetative growth (BBCH 1 and 3)

In 2021, lower night-time temperatures and the relative lack of precipitation in the first part of spring led to a slowdown in the rate of leaf formation, with the duration of BBCH stages 10–15 extended. Shoot growth (BBCH 31–33) started later and with a lower intensity in the initial phase (figs 4 and 5).

Appearance of inflorescences and flowering (BBCH 5 and 6)

The climatic conditions in 2020 (figs. 2 and 3) allowed the earlier thermal thresholds necessary for floral differentiation to be reached, which led to a faster evolution through BBCH stages 55–57 (appearance and development of flower buds). The flowering itself (BBCH 60–65) was more compact, with a relatively short duration and good synchronization between individuals. In 2021, the lower temperatures in the pre-flowering period caused a delay in the onset of BBCH 55, and the transition to BBCH 60–65 was more gradual. As a result, flowering was more staggered, with a longer duration until reaching the BBCH 69 stage (complete dropping of the petals).

Fruit formation and growth and concomitant vegetative growth (BBCH 7 and 3)

In 2021, the rainfall deficit in June caused an initial slowdown in the progression through BBCH 71–73, followed by an acceleration of fruit growth after the resumption of rainfall in July (figs. 4 and 5). This alternation led to a more uneven increase and greater variability in the pace of the BBCH stages 75–79.

Fruit ripening (BBCH 8)

In 2020, the high temperatures in August, followed by a progressive cooling in September, favored a relatively early and uniform ripening, with the faster reaching of BBCH 81–85 stages and BBCH 87 physiological maturity (figs. 2 and 3). In 2021, slightly lower temperatures and alternating wet (Fig. 4 and 5) and dry periods delayed the transition to BBCH 81, and maturation was more heterogeneous, with a prolongation of the interval until BBCH 87 was reached.

Senescence and entry into dormancy (BBCH 9)

In 2021, the faster decrease in minimum temperatures and the accentuated rainfall deficit in autumn (figs. 4 and 5) led to the acceleration of senescence processes, with a faster passage through the BBCH 92–97 stages and an earlier entry into rest.

Therefore, the climatic contrast between 2020 and 2021 was clearly reflected in the phenological dynamics of quince, expressed by lags in the BBCH stages. The year 2020 favored a faster and more uniform sequence of phenophases, from BBCH 00 to BBCH 87, while the year 2021 caused a delay of early phenophases, a more staggered flowering (BBCH 60–69), a more variable growth of fruits (BBCH 71–79) and a faster entry into rest (BBCH 91–97). These differences underline the decisive role of the annual thermal and water regime on the phenological calendar of the *Cydonia oblonga* Mill species.

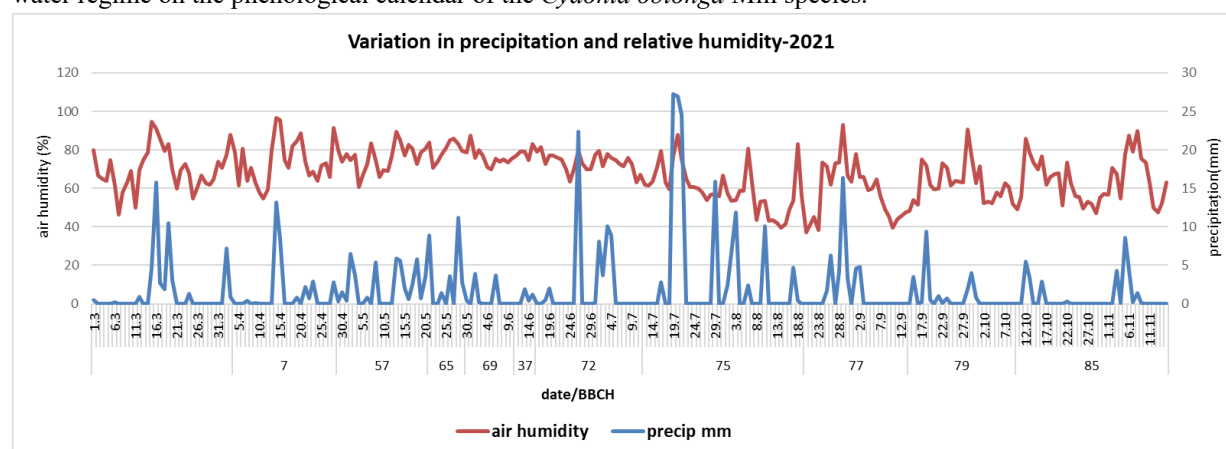


Figure 4. Variation in precipitation and relative humidity in the quince growing season-2021

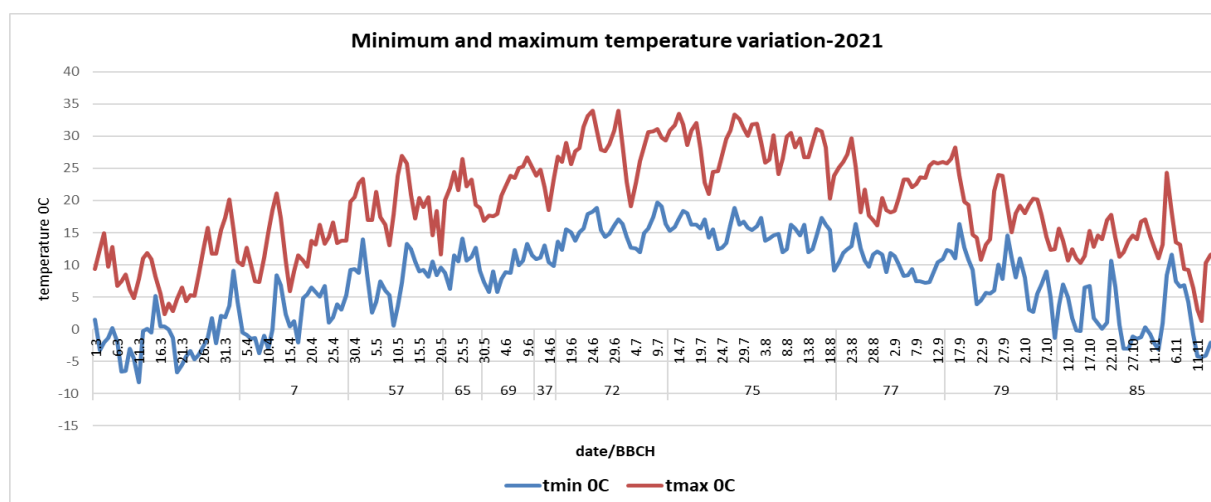


Figure 5. Variation of minimum and maximum temperatures in the quince growing season-2021

Phenological characterization of quince (Cydonia oblonga Mill.) in correlation with the dynamics of climatic factors specific to the experimental year 2022 and compared to 2020 and 2021

The comparative analysis of the thermal and water regime specific to the experimental year 2022 (figs. 6 and 7) compared to 2020 and 2021 respectively shows that 2022 had a distinct climatic profile, characterized by warmer spring, high rainfall in May–June, followed by warmer and wetter episodes in the second part of summer. This climatic context specifically influenced the sequence and rhythm of BBCH phenophases in quinces.

Starting in vegetation (BBCH 0)

In 2022, the average temperatures in March and early April were higher than in 2021 and comparable or slightly higher than in 2020 (fig. 7). This thermal regime favored a faster exit from rest and an accelerated progression through the BBCH 01–03 phenophases (bud swelling). By comparison, in 2022 versus 2021, the start in vegetation was significantly earlier, without prolonged stagnation in BBCH 01–03, and compared to 2020 the dynamics were similar or slightly faster, due to the more constant average temperatures.

Leaf formation and early vegetative growth (BBCH 1 and 3)

The more stable thermal regime in April 2022 and the relatively good availability of water (figs. 6 and 7) favoured a rapid leaf unfolding, with an efficient transition from BBCH 10 to BBCH 19, compared to 2021, when low night-time temperatures prolonged BBCH 10–15, in 2022 this stage was shorter and more uniform. And compared to 2020, the evolution was comparable, but with a slight acceleration due to the higher temperatures in April. Also, in 2022, the high temperatures in May–June, associated with sufficient rainfall (figs. 6 and 7), supported intense vegetative growth, with a rapid progression through BBCH 31–33 and the early reaching of BBCH 37–39. Compared to 2021, the growth of shoots was not slowed down by water deficit, and compared to 2020 the dynamics were similar, but with a slight intensification in the first part of the summer.

Appearance of inflorescences and flowering (BBCH 5 and 6)

The warm spring of 2022 favored early floral differentiation, with a rapid progression through BBCH 55–57, compared to 2021, when BBCH 55 was delayed, in 2022 this phenophase was brought forward by a few days, and compared to 2020, the appearance of inflorescences was slightly earlier. In 2022, high daytime temperatures and relatively constant atmospheric humidity determined a relatively compact flowering, with a rapid succession from BBCH 60 to BBCH 69, so that compared to 2021 the flowering was less staggered and shorter in duration.

Fruit formation and growth and concomitant vegetative growth (BBCH 7 and 3)

In 2022, the availability of water in May–June, followed by high temperatures in July–August (fig. 6 and 7), favored a sustained and relatively uniform growth of fruits, with an efficient progression through BBCH 71–74 (cell division) and BBCH 75–79 (cell expansion), compared to 2021, when the rainfall deficit in June slowed

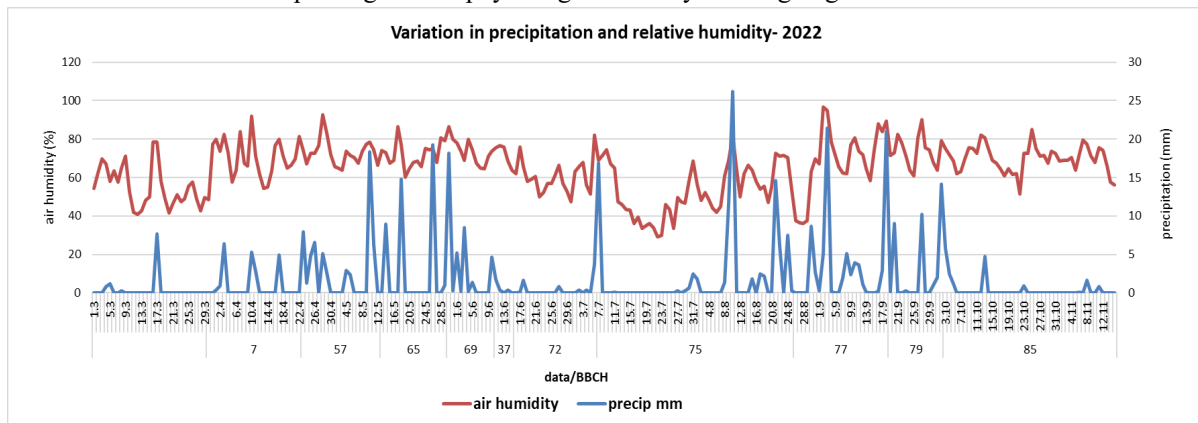
BBCH 71–73, And compared to 2020, fruit growth was comparable, but slightly more intense in the second part of summer.

Fruit ripening (BBCH 8)

The high temperatures in August 2022 (fig. 7), associated with episodes of precipitation (fig. 6), favored a relatively rapid maturation, with the efficient achievement of BBCH 81–85 and the physiological maturity of BBCH 87, compared to 2021 the maturation was earlier and more uniform, and compared to 2020 the process was similar, perhaps slightly faster.

Senescence and entry into dormancy (BBCH 9)

The autumn of 2022 was characterized by a more gradual decrease in temperatures compared to 2021, which allowed a moderate prolongation of physiological activity before going to rest.



identification of eight principal BBCH stages across different climatic regions further confirms the ecological plasticity of *Cydonia oblonga* and the robustness of BBCH-based phenological models.

Moreover, the phenological responses observed in quince closely resemble patterns reported for other temperate pome fruit species. Long-term studies on apple and pear have demonstrated that early phenophases are particularly responsive to temperature increases, advancing more rapidly than later developmental stages (Chitu and Păltineanu, 2020). A comparable sensitivity of early BBCH stages was observed in the present study, where interannual differences in spring temperatures strongly influenced the timing of vegetation onset and flowering. Overall, these similarities reinforce the relevance of standardized BBCH phenology as a reliable tool for assessing climate-driven variability in fruit tree development and for supporting adaptive orchard management strategies.

CONCLUSIONS

The phenological development of quince (*Cydonia oblonga* Mill.) was strongly influenced by interannual climatic variability, particularly air temperature and precipitation regimes specific to the Transylvanian plateau. The comparative analysis of the 2020–2022 growing seasons demonstrated that both the timing and duration of BBCH phenological stages respond sensitively to fluctuations in thermal and hydric conditions. Early-season temperature patterns proved especially decisive for the initiation and progression of vegetative and reproductive phases.

Favourable climatic conditions in 2020 and 2022 promoted a more rapid and uniform phenological progression, characterized by earlier bud break, relatively compact flowering, and more homogeneous fruit development and maturation. In contrast, the cooler spring temperatures and episodic water deficits recorded in 2021 delayed early phenophases, prolonged flowering, and resulted in a less uniform fruit growth pattern, followed by an accelerated onset of senescence. These differences highlight the vulnerability of quince phenology to combined thermal and hydric stress, particularly during early developmental stages.

The study also identified varietal differences: Aurii entered the vegetation period 3–4 days earlier than Bereczki, reaching the transition from dormancy (BBCH 00) to the appearance of green tips (BBCH 09) sooner. At the interannual level, both varieties started vegetation earlier in the warmer springs of 2020 and 2022 than in 2021, when this phase was delayed.

The application of the BBCH scale proved to be a robust and effective framework for standardized phenological characterization of quince. Its use enabled precise interannual comparisons and facilitated the objective linkage between phenological responses and climatic drivers. Overall, the results underline the importance of continuous phenological monitoring using standardized BBCH coding to support adaptive orchard management and to mitigate climate-related risks under increasingly variable environmental conditions.

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