https://doi.org/10.15414/agrobiodiversity.2018.2585-8246.292-299

AGROBIODIVERSITY 2018
FOR IMPROVING NUTRITION, HEALTH AND LIFE QUALITY

OPEN ACCESS

PHENOLOGICAL GROWTH STAGES OF CHINESE QUINCE (*PSEUDOCYDONIA SINENSIS* C.K. SCHNEID.): CODIFICATION AND DESCRIPTION ACCORDING TO THE BBCH SCALE

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Received: 20.12. 2018 **Revised: 20. 12. 2018** **Published: 21. 12. 2018**

The aim of the study was the determination of the main phenological growth stages less known species of Chinese quince in the conditions of Slovakia. For the study of the issue, we used 6 individuals produced in the Arboretum Mlyňany (Slovak Republic). The age of them will be estimated approximately 30 years. Experimental data gained in years 2016–2017 in phenological studies of Chinese quince (*Pseudocydonia sinensis* C.K. Schneid.) were utilized to describe phenological growth stages of given species. For the description of phenological growth stages, it was used BBCH Monograph (1997). Phenological observations and time data collection were provided at regular intervals in the text form and photo documentation. Complex phenological growth stages were processed based on the phenological records. Resulting data will be used for the list of descriptors preparation specified for the given species and oriented on the practical utilization in the research, breeding and genetic resources investigation. A feature of the system is that homologous stages of different crops are presented by the same codes.

Keywords: Chinese quince, BBCH-code, growth stage, adaptation

Introduction

Climate change and other adverse global factors in each region also have a significant effect on the cultivation of plant species to ensure food security and the provision of raw materials for other increasing needs for the population. It is, therefore, necessary to gradually introduce and test the adaptation of less-known and less-used plant species for different practical uses in each region. In Slovak conditions, the Chinese quince is being tested for a longer period of time. In order to recognize the adaptation of each species, it is necessary to know, inter alia the phenology of the species. This issue has become the main subject of the presented work.

Pseudocydonia sinensis Schneid. (Chinese quince) belongs to the family Rosaceae Juss., native to eastern Asia in China, and the only one species from *Pseudocydonia* C.K.Schneid. genus

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(USDA, 2013). It is closely related to the East Asian genus *Chaenomeles* Lindl. and to the European genus Cydonia Mill.

Fruit of the *Pseudocydonia sinensis* is yellow colored eatable pomes. It has elliptical (var. *ellipsoidea*) or ovoid (var. *ovoidea*) shape. Fruits are very big, the height of fruit 98.06–124.48 mm, the average diameter of fruit 62.33–88.64 mm, the average weight of the fruit in the range 197.85–466.38 g (Monka et al., 2014).

Fresh fruits of *Pseudocydonia sinensis* are sour and hard, and because of this used in the recycling form. From the fruits can be prepared spreads, marmalades, jams, fruit jellies, candied pulp, sweetened syrups and juices, wine, liqueurs (Monka et al., 2014; Klymenko et al., 2017). Fruits of the Chinese quince are used especially in traditional Chinese medicine as antitussives that central or peripheral suppress a cough. Fruits are used for the treatment of asthma, cold, sore throat, mastitis and tuberculosis in Korea (NPRI, 1998).

The Belgian botanist Charles Morren (1953) introduced the term phenology for the first time in 1853, but the history of phenology background is much older. Modern phenology is the study of the timing of recurring biological events in the animal and plant world, the causes of their timing with regard to biotic and abiotic forces, and the interrelation among phases of the same or different species (Lieth, 1974; Meier et al., 2009). The first known phenological network was installed by him in Sweden in the middle of the 18^{th} century. In his work Philosophia Botanica, he outlined methods for compiling annual plant calendars of leaf opening, flowering, fruiting and leaf fall, together with climatic observations so as to show how areas differ (Schnelle, 1955). Plant development, and thus phenological phases, show great inter-annual variability and also large spatial differences. Individual (e.g. genes, age) and environmental factors (weather and climate conditions in the micro and macro-scale, soil-conditions, water supply, diseases, competition, etc.) influence plants significantly. They can be viewed as integrative measurement devices for the environment. The seasonal cycle of plants, however, is influenced to the greatest extent by temperature, photoperiod and precipitation (Keatley, 2000; Morellato, 2000).

In order to gain comparable phenological data, it is necessary to define exactly the phases which are to be observed. The use of the so-called extended BBCH scale (BBCH Monograph, 1997) is recommended, based on Zadok et al. (1974) cereal code is a system for a uniform coding of phenologically similar growth stages of all mono- and dicotyledonous plant species. It is a general scale allowing their application to those plants for which no special scale is available. For the description of the main (longer-lasting) phenological development stages, called principal growth stages, clear and easily recognized external morphological characteristics are used. The secondary growth stages define a short step of development.

Bruns and van Vliet (2003) and Meier (2003) develop the relationship to modern agriculture, they recommend the BBCH system and the traditional meteorology and climatology.

Many researchers used the BBCH-scale for describing the growth stages of different fruit trees, for instance, *Malus domestica* Borkh., *Pyrus communis* L., *Prunus cerasus* L., *Prunus domestica* L., *Prunus persica* Batsch., *Prunus ameriaca* L. (Meier, 1994), *Citrus* spp. (Agustí et al., 1995), *Punica granatum* L. (Melgarejo et al., 1997), *Cydonia oblonga* Mill. (Martínez-Valero

et al., 2001), *Diospyros kaki* L. (García-Carbonell et al., 2001), *Olea europea* L. (Sanz-Cortés et al., 2002), *Actinidia deliciosa* C.F.Liang & A.R.Ferguson (Salinero et al., 2009), *Diospyros virginiana* L. (Grygorieva et al., 2010), *Mespilus germanica* L. (Atay, 2013), *Ziziphus jujuba* Mill. (Hernandez et al., 2015).

The objective of this study was to describe the phenological growth stages of *Pseudocydonia sinensis* genotypes based on the BBCH scale.

Materials and methods

Locating trees and data collection

In a phenological survey of *Pseudocydonia sinensis* were studied genotypes grown in arboretum Mlyňany (Figure 1). Measurements and observations were carried out over two growing seasons (2016–2017), from March to November. Measurements were made two to three times per week between March and June and once per week from June onwards. Representative plants were photographed to describe the phenological growth stages. The phenological growth stages of *Pseudocydonia sinensis* tree were described and defined between winter dormancy and leaf fall using the BBCH General scale.

Figure 1 Chinese quince (*Pseudocydonia sinensis* C.K. Schneid.)

Results and discussion

Pseudocydonia sinensis plants in the conditions of introduction characterized by a full cycle of seasonal growing which indicates that natural and climatic conditions are favorable for growing in this region. Plants are bloom and bear fruits. Chinese quince is promising as fruit, ornamental and medicinal plant and it can be widely grown in the conditions of Slovakia.

For fruit trees, the BBCH-scale uses eight of the 10 principal stages, starting with shoot growth (stage 0) and ending at the initiation of dormancy (stage 9). Three principal growth stages are assigned to vegetative growth, describing the bud development (stage 0), leaf development (stage 1) and shoot growth (stage 3), the latter being shared with flower development (stage 5). Flowering (stage 6), fruit growth (stage 7) and maturity of fruit (stage 8) complete the code.

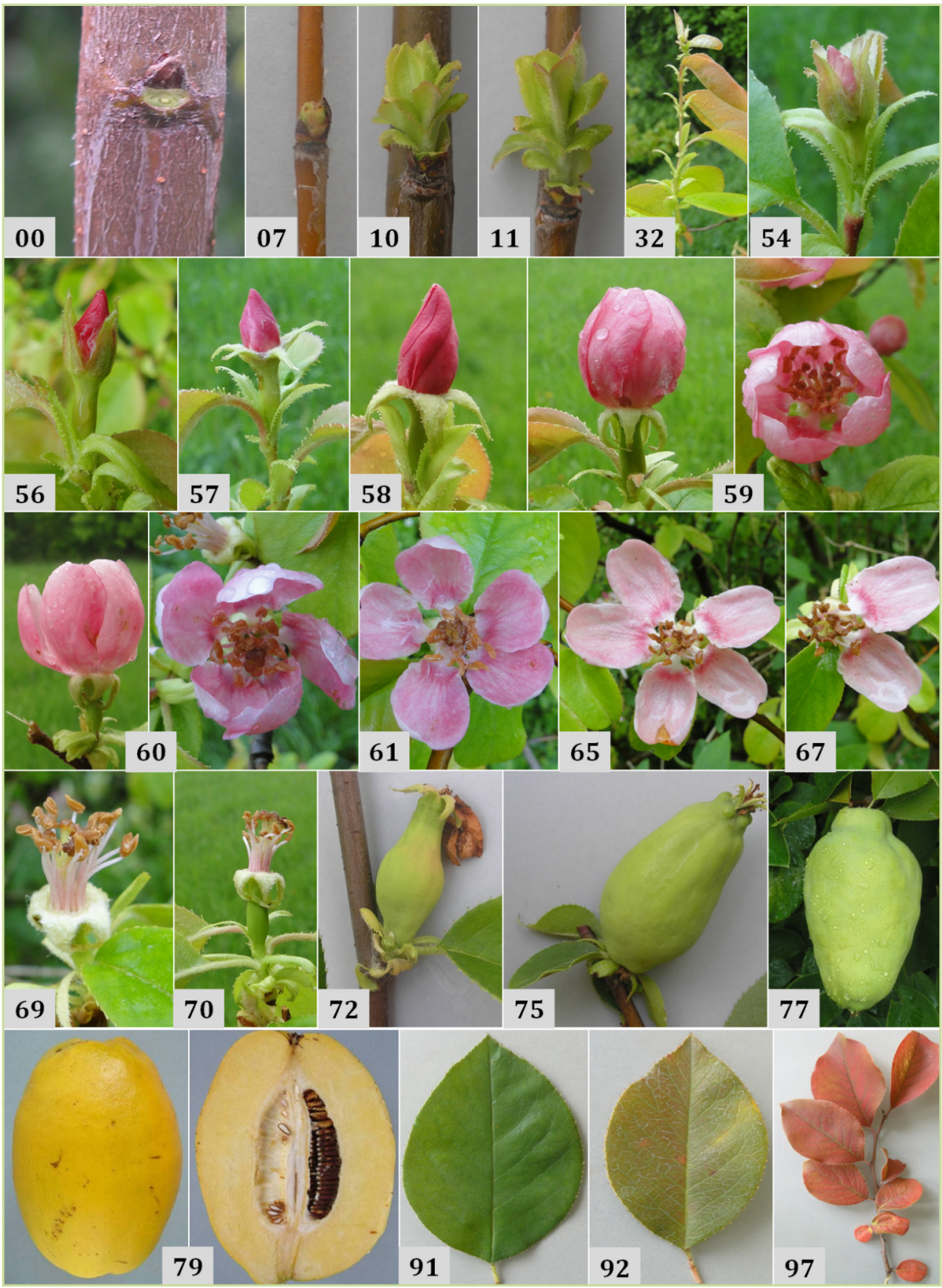

Figure 2 Phenological stages of the Chinese quince (*Pseudocydonia sinensis* C.K. Schneid.) tree

The secondary stages are also numbered from 0 to 9, is related to ordinal or percentile values of growth. Hence, value 1 of the principal stage of growth 6 (flowering) represents 10% of flowers in anthesis and its identification will be 61. Likewise, the value 5 of the principal stage 7 (fruit development) represents fruit at about 50% of the final size and will be defined, therefore, as 75. In other cases, values of secondary stages indicate qualitatively different stages within a given principal phenological stage; thus, within the flowering stage, the beginning of the anthesis (60) and flowers withered state (67) are identified.

Figure and Table 1 show the different phenological stages as well as the phenological codes and duration of *Pseudocydonia sinensis* tree phenology. The pattern of development of individual buds from selected trees generally matched that of all plants even though flowering was dependant on the position and orientation of the branches on the tree. There was no appreciable difference between buds for the duration of the successive phenological stages. The data in this study strictly refer to average values of monitored branches for every single experimental tree.

Table 1 Some of the primary and secondary phenological growth stages of Chinese quince (*Pseudocydonia sinensis* C.K. Schneid.) genotypes according to BBCH scale

Scale	Characteristics
	Principal growth stage 0: Bud development
00	Winter bud: the bud is dark brown, completely closed and very small (3-5 mm) in size.
01	Beginning of leaf bud swelling: buds visibly swollen, bud scales elongated, with light coloured patches.
03	End of leaf bud swelling: bud scales light coloured with some parts densely covered by hairs.
07	Beginning of bud break: first green leaf tips just visible.
09	Green leaf tips about 5 mm above bud scales
	Principal growth stage 1: Leaf development
10	Green leaf tips 10 mm above the bud scales; first leaves separating
11	First leaves unfolded (others still unfolding)
15	More leaves unfolded, but not yet at full size
19	First leaves fully expanded
	Principal growth stage 3: Shoot development
31	Beginning of shoot growth: axes of developing shoots visible; about 10% of final length
32	Shoots about 20% of final length
35	Shoots about 30% of final length
39	Shoots about 90% of final length
	Principal growth stage 5: Inflorescence emergence
51	Inflorescence buds swelling: calyx becomes visible; formed by five closed sepals protecting flower structure
53	Bud burst: scales begin to separate; beginning of peduncle elongation

Table 1

Scale	Characteristics
	Principal growth stage 5: Inflorescence emergence
54	Mouse-ear stage: green leaf tips 10 mm above bud scales; first leaves separating
55	Flowers still closed; sepals begin to separate
56	Flower petals elongating
57	Sepals open; petal tips visible; flowers with pink petals, still closed
59	Calyx opening: Sepals start opening showing the flower bud; apical leaf development
	Principal growth stage 6: Flowering
60	First flowers open
61	Beginning of flowering: about 10% of flowers open; anthers become visible; pollination begins
65	Full flowering: at least 50% of flowers open, first petals falling
67	Flowers fading: fecundation takes place; petals, stamens and pistils wither; petals fall
69	End of flowering: all petals fallen
	Principal growth stage 7: Fruit development
71	Fruit set: beginning of ovary growth; green ovary surrounded by dying petal crown, petals begin to fall; beginning of fruit let abscission; fruit fall after flowering
72	Immature fruit: fruit increases in size due to cell division (fruit size up to 20 mm)
73	Second fruit fall
75	Fruit about half of final size
76	Fruit about 60% of final size
77	Fruit about 70% of final size; light green fruit
79	Fruit growth: fruit reaches its final volume
	Principal growth stage 8: Maturity of fruit and seed
81	Maturation of the fruit: Change of color from green to light yellow; fruit gives off a pleasant aroma
87	Fruit ripe for picking; increase in color intensity
	Principal growth stage 9: Senescence. Beginning of dormancy
91	Shoot growth completed; terminal bud developed; foliage still fully green
92	Leaves begin to discolour
95	50% of leaves discoloured
97	Leaves fully discoloured
99	Winter rest period

Note: Description of the phenological growth stage of *Cydonia oblonga* and *Mespilus germanica* (Martínez-Valero et al., 2001; Atay, 2013)

In order to gain comparable phenological data, it is necessary to define exactly the phases which are to be observed. The use of the so-called extended BBCH scale (Meier, 1997) is recommended, based on Zadok et al. (1974) cereal code is a system for a uniform coding of phenologically similar growth stages of all mono- and dicotyledonous plant species.

Martínez-Valero et al. (2001) developed for the *Cydonia oblonga* and Atay (2013) for the *Mespilus germanica* description of phenological growth stages using the BBCH system and we have used it in the study of *Pseudocydonia sinensis*.

Conclusions

Chinese quince (*Pseudocydonia sinensis*) phenological development is described here for the first time using the BBCH scale. The use of extended BBCH scale for *Pseudocydonia sinensis* is important for successful implementation of orchard management practices including disease and pest control, a survey of genetic resources and further research purposes. The fruit species is potentially useful as a source of fruit for practical using in the food industry for the preparing of many products. Their biochemical composition provides great prospects for use as a raw material for therapeutic and pharmaceutical purposes, the development of biopesticides and cosmetic products. Trees can also be used in the landscaping and thus improve the environment. Therefore, this species is the perspective type for the practical use in Slovakia as well.

Acknowledgement

This article was prepared with active participation of researchers from AgroBio*Net* international network for implementation of the international program "Agro-biodiversity to improve nutrition, health and quality of life" within the project "Promotion of innovative technologies of special natural products for a healthy diet of people" (ITEBIO ITMS 26220220115) at the Excellent Center for the conservation and use of agricultural biodiversity at the Faculty of Agrobiology and food resources Slovak agricultural university. Co-author O. Grygorieva is grateful to Slovak Agricultural University in Nitra and the Ministry of Education, Science, Research and Sport of the Slovak Republic for providing a scholarship for the research internship, during which the received the results and knowledge presented in this paper.

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