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Harmonisation of phenology stages and selected cherry cultivars as bioindicators for climate change

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Abstract

Perennial fruit crops phenology such as cherry is an ideal bio-indicator of climate change due to their long-lasting features, in particular, dates of flower opening and full bloom. This implies i) the use of several generations of cherry trees/orchards and ii) the use of the same original cherry cultivars, which existed as bearing trees and were replanted after the orchard had been grubbed. A comparison of available definitions of phenological stages in cherry previously used independently throughout Europe showed overlaps and shortcomings; hence, harmonisation was reached in this respect in the COST Cherry FA 1104 working group 2 (cherry phenology and climate change) based largely on the acceptance of the BBCH scale. This contribution presents the agreed phenology stages in both visual and wording evidence. Similarly, this contribution presents the agreed cultivars to be monitored in future for phenology and climate change effects for harmonisation. For sweet cherry, this EU-wide harmonisation includes 'Burlat', 'Cristobalina' and 'Rita' as early, 'Stella' and 'Van' as medium flowering and 'Sweetheart', 'Regina' and 'Bigarreau Noire de Meched/Germersdorfer' for late flowering cultivars for climate change effects. For sour cherry, this harmonisation resulted in 'Meteor korai' and 'Anglaise Hative' for early flowering, 'Chrisana Pandy' and 'Erdibotermo' for medium flowering and 'Schattemorelle', 'Iiva, Ujfehrtoifurtos (Balaton)' for late flowering.

Keywords: cherry (*Prunus avium* L., *Prunus cerasus*), climate change, flowering, global warming, low chill, phenology, sustainable horticulture

INTRODUCTION

Cherry is an ideal candidate for climate change studies (Luedeling et al., 2013a,b), since distinct phenological stages were defined decades ago (Baggiolini, 1952; Lichou, 1990; Meier et al., 1994) and have been recorded by simple means like filing cards for a long time as part of phenology research in the 1970s before computers and climate change emerged. In the 1990s, these records were often classified as old-fashioned research and no longer continued or research sites closed down or re-located. At the few locations where the records were maintained, it was important that the records continued on the same original cherry cultivars to show any long-term changes in both climate and phenology. In addition, these cultivars are often used as reference in breeding and evaluation programs, thus maintaining observation campaigns. Four phenological definitions or scales have been used to assess cherry flowering in Europe since the 1970s (Fleckinger, Baggiolini, 1952; Lichou, 1990; Meier et al., 1994). The combination of such historic meteorological and phenological data from the same site are now considered a valuable tool and treasure in assessing the impacts of climate change on a local scale.

The objective of this work was to harmonise terminology for phenological stages and provide a guideline for future European phenology records in cherry and beyond.

MATERIAL AND METHODS

Phenological data on filing cards included calendar dates of first flower opening (BBCH

61), full bloom (BBCH 65 or F1040 DD), harvest (BBCH 81) and leaf drop (BBCH 95) as well as late frost and consequent yield loss for a range of cherry cultivars, using only fruit bearing trees at the time. BBCH stages harmonisation for observation, together with reference cultivars for sweet and sour cherries were agreed within the meeting held by the COST Cherry FA 1104 working group 2 (cherry phenology and climate change) in Ullensvang (April 2014).

RESULTS AND DISCUSSION

Harmonisation of phenology stages in cherry

Figure 1a-f shows the descriptions for the agreed phenology stages for cherry, largely based on the BBCH scale (Meier et al., 1994).

	BBCH	Description			
	61	Beginning of flowering: about 10% of flowers open	Début de la floraison : environ 10% des fleurs sont ouvertes	Comienzo de la floración: aproximadamente el 10% de las flores están abiertas	Blühbe-ginn; 10% der Blüten offen
	65	Full flowering: at least 50% of flowers open, first petals falling	Pleine floraison: au minimum 50% des fleurs épanouies, les premiers pétales tombent	Plena floración: por lo menos 50% de las flores están abiertas, los primeros pétalos caen	Vollblüte; 50% der Blüten offen
	67	Flowers fading: majority of petals fallen	La floraison s'achève, la plupart des pétales sont tombés	Se termina la floración, la mayoría de los pétalos han caído	Abgehende Blüte, mei-sten Blü-tenblätter abgefallen
	69	End of flowering: all petals fallen	Fin de floraison: tous les pétales sont tombés	Final de floración: todos los pétalos se han caído	Blühende, alle Blü-tenblätter abgefallen
	72	Green ovary surrounded by dying sepal crown, sepals beginning to fall	Ovaire vert entouré de sépales fanés, les premiers sépales tombent	Ovario verde rodeado de una corona de sépalos marchitos, los primeros sépalos caen	Grüner Fru-chtknoten von abster-benden Kel-chblattkranz umgeben
	85	Maturity base on colouring	Maturité évaluée par la couleur	Maduración basada en el color del fruto	Fortgeschritt ene Frucht-ausfärbung
	92	Senescence: Leaves begin to discolour, at least 10% of yellow leaves	Sénescence : début de décoloration des feuilles, au moins 10% de feuilles jaunes	Senescencia: Inicio de la decoloración de las hojas, por lo menos 10% de hojas amarillas	Beginn der Laubblatt-verfärbung

Figure 1. Developmental stages for cherry (©Hélène Christmann, INRA).

Table 1. Phenology harmonisation for future flowering records of sweet/sour cherry (Meier et al., 1994).

Category	Meier scale	Definition	Criterion
BBCH 61	Blühbeginn	Beginning of flowering	10% of flowers open
BBCH 65	Vollblüte	Full bloom	50% flowers open
BBCH 67	Blühende	End of flowering	90% flowers open
BBCH 72	Steinhärtung		Pit hardening
BBCH 85	Fruchtreife	Fruit maturity	
BBCH 92	Blattfall	Senescence	10% of leaves yellow

Harmonisation of cherry cultivars to be monitored in the EU for climate change effects

A major result and outcome of the EU COST Cherry FA 1104 WG 2 (Cherry phenology and climate change) meeting was the acceptance of one universal scale for all European countries (Table 1) and agreed standard cultivars (Table 2) for phenology monitoring. Cultivars were selected on the basis of early, medium and late flowering and most widely grown throughout Europe.

Table 2. Phenology harmonisation for future flowering records of sweet and sour cherry.

Category	Sweet cherry flowering	Sour cherry flowering
Early flowering	Burlat, Christobalina, Rita	Meteor korai, Anglaise Hative
Medium flowering	Stella, Van	Chrisana Pandy, Erdibotermo
Late flowering	Sweetheart, Regina, Noire de Meched/Germersdorfer	Schattenmorelle, Iiva, Ujfehrtoifurtos (Balaton)

The BBCH-scale is a scale used to identify the phenological development stages of a plant. A series of BBCH-scales have been developed for a range of crop species. Phenological development stages of plants are used in a number of scientific disciplines (crop physiology, phytopathology, entomology and plant breeding) and in the agriculture industry (timing of pesticide application, fertilisation, agricultural insurance). The BBCH-scale uses a decimal code system, which is divided into principal and secondary growth stages, and is based on the cereal code system (Zadoks scale) . BBCH officially stands for "Biologische Bundesanstalt, Bundessortenamt und CHemische industrie.

CONCLUSIONS

The experts of the EU COST Cherry agreed to use the detailed and more precise German BBCH throughout Europe in the future for cherry flower monitoring and provide detailed descriptions in all European languages plus pictorial digital evidence in this chapter of this *Acta Horticulturae*. Continued data acquisition throughout Europe will support the development of predictive models for assessing the effects of climate change on cherry phenology but also as useful tools for breeding strategies.

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