

Interdisciplinary Pathways to Sustainability

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*Agriculture, Environment,
and Rural Development*

Edited by

Monika Stojanova, Gordan Karaman,
Dragutin A. Djukic and Leka Mandic

**Cambridge
Scholars
Publishing**



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This book first published 2026

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

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ISBN: 978-1-0364-6703-6

ISBN (Ebook): 978-1-0364-6704-3

All papers included in this special edition were originally presented at the 7th International Conference on Modern Trends in Agricultural Production, Rural Development, and Environmental Protection (June 19–20, 2025, Vrnjačka Banja, Serbia), organized by the Balkan Scientific Center of the Russian Academy of Natural Sciences, Belgrade, Serbia. The initial versions of these papers were published in the official Conference Proceedings.

For this edition, all contributions have been substantially revised and expanded, and each manuscript underwent a double-blind peer review process conducted by independent experts. The editorial team, composed of scholars from Serbia, Montenegro, and North Macedonia, selected the papers based on scientific quality, originality, and relevance.

This publication adheres to ethical guidelines: none of the papers have been published elsewhere in the same form, all authors have confirmed the originality of their work, and they have declared no conflicts of interest.

The inclusion of revised versions in this publication has been approved by the Editor and Publisher, in accordance with ethical and copyright standards.

MONITORING PHENOLOGICAL STAGES
IN CULTIVATED CURRANT VARIETIES
(*RIBES* SP.): FIELD OBSERVATIONS
AND VARIATION PATTERNS

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Abstract: *An experiment was conducted over a period of three years to systematically examine patterns of occurrence of periodic life-cycle events or phenological stages (beginning of leaf unfolding, full leaf unfolding, inflorescence emergence, beginning of flowering, full flowering, beginning of berry set and berry ripening) in currant cultivars (*Ribes* sp.). The experiment included nine black currant cultivars, ten red currant cultivars and three white currant cultivars.*

The phenological properties of tested currant cultivars were determined using international descriptors for black currants (CPVO-TP/040/2 – UPOV, 2009), and for red and white currants (CPVO-TP/52/1 – UPOV, 2004). The

tested cultivars showed differences in the phenological traits. Under the agro-environmental conditions of Čačak, black currant cultivars entered earlier into phenological stages compared to red currant and white currant cultivars. The earliest occurrence of phenological events was observed in black currant cultivars 'Čačanska Crna' and 'Tisel', red currant cultivar 'Junifer', and white currant cultivar 'Primus'. On the other hand, almost all phenological stages of the latest were recorded in cultivars 'Titania' (black currant), 'Rovada' (red currant), and 'Weisse aus Juteborg' (white currant), except for the ripening phase, which occurred the latest in 'Ben Lomond' (black currant) and 'Industria' (red currant).

The results indicated that the tested cultivars are suitable for growing under the agroclimatic conditions of Čačak, Western Serbia, given their late entry into the flowering stage as their important characteristic in terms of preventing damage due to late spring frosts.

Keywords: *Black, red and white currant, cultivar, phenological traits*

Introduction

Currants are deciduous, aromatic, and fruit-bearing shrubs that begin yielding fruit in about 3–4 years. They belong to the genus *Ribes* and the family Grossulariaceae. The species *Ribes nigrum* (black currants) and *Ribes rubrum* (red and white currants) are economically important. They are widely cultivated across temperate regions of Europe, Russia, parts of Asia, and, to a lesser extent, North America. Currants rank as the second most important small fruit globally, after strawberries, in terms of production volume. However, currant production in Serbia is negligible despite the demand for this fruit species and the favorable natural conditions for cultivation. Serbia is among the lowest-ranked countries in Europe and worldwide for currant production, with yields ranging from only 100 to 150 tons. Currants are generally grown in home gardens as individual bushes but are rarely produced in orchards in Serbia. The importance of currant growing is mainly based on its early harvest, high and regular yields, and relatively low investment costs in the establishment and maintenance of plantations.

Currants thrive in humid mountainous areas characterized by cool summers, high rainfall, and high humidity levels. They are winter-hardy; however, high summer temperatures and drought during summer can cause problems in currant cultivation and directly affect productivity and fruit quality. Currants require between 800 and 1600 chill hours (accumulated at temperatures between 0°C and 7°C) during winter for optimum fruit production. They can

tolerate winter temperatures below -33°C , and even down to -40°C or lower, especially black currants. For flowering, they require a base temperature of 5°C . According to Mišić (2002), currants are a small fruit crop that enters the growing season earlier than other continental fruit species. The onset and length of phenological stages are genotype-specific and are influenced not only by genetic factors but also by agro-environmental conditions. Different currant cultivars have varying timings for each phenological stage.

Systematic monitoring and examination of the patterns of occurrence of periodic life-cycle events or growth stages in currants involve several key phases, including leaf unfolding, inflorescence emergence, flowering, berry setting, and berry ripening. These stages are particularly affected by factors such as temperature and day length, and their timing can vary among cultivars and growing conditions. Sønsteby et al. (2012) reported that day length and temperature directly impact phenological stages overall, especially flowering, causing currant cultivars to respond differently to climatic variations. Additionally, soil management systems can influence phenological stages through the use of different mulching treatments. Mulching in currant orchards promotes early fruit ripening, increases soil temperature, and consequently results in earlier flowering and fruit ripening (Paunović et al., 2016).

In recent years, global climate change has exhibited warming trends, especially during winter, which may negatively affect the commercial cultivation of currants. Nikolić and Milivojević (2010) observed that climatic conditions in a particular environment affect planting longevity, productivity, fruit quality, and overall profitability of currant production. Generally, the occurrence of phenological stages in currants is crucial for achieving high yields and good fruit quality.

With this in mind, the purpose of the investigation was to examine the phenological stages of various black, red, and white currant cultivars.

Material and Methods

Plant Material

The research was conducted at the Fruit Research Institute, Čačak, West Serbia, during 2017–2019. The currant orchard was established in the spring of 2011 using two-year-old plants. Currants are grown as bushes at a spacing of 3 m between rows and 1 m in the row. The currant planting is located at 242 m a.s.l. The experiment included nine black currant cultivars ('Ben Lomond', 'Ben Sarek', 'Tsema', 'Titania', 'Čačanska Crna', 'Tisel', 'Tiben', 'Tenah', 'Black

Reward'), ten red currant cultivars ('Losan', 'Redpoll', 'Rovada', 'Detvan', 'Junifer', 'Jonkherr van Tets', 'Industria', 'Red Lake', 'Rondom', 'Rolan') and three white currant cultivars ('Weisse aus Juteborg', 'Primus', 'Blanka'). During the experimental period, standard cultural and cane management practices were employed, and a drip irrigation system was used.

Phenological Observations

The phenological properties of tested currant cultivars were determined using international descriptors for black (CPVO-TP/040/2 – UPOV, 2009), and for red and white (CPVO-TP/52/1 – UPOV, 2004) currant. The following phenological parameters were examined: i) Time of leaf unfolding – recorded as the date of first leaf emergence from the winter bud. Based on the leaf unfolding date, the tested cultivars were classified into early, medium, and late leaf unfolding; ii) Time of inflorescence emergence, i.e. the date of first inflorescence emergence from the generative bud; iii) Time of beginning of flowering – i.e. the moment when 10% of the total number of flowers were open; full flowering – the moment when 90 % of flowers were open. According to their flowering times, the cultivars were classified into early, medium, and late flowering; iv) Time of first berry set – recorded as the date of first berry set, and v) Time of berry ripening, i.e. date of full or harvest maturity of the fruit (harvest date), according to which the cultivars were classified into very early, early, medium, late, and very late ripening.

Results and Discussion

Currants enter the growing season earlier than other continental fruit species; therefore, they require a certain amount of exposure to cold temperatures (800 to 1600 chilling hours) during dormancy to break bud dormancy and initiate spring growth. Seasonal asymmetric warming alters the spring phenology of currants, and winter warming delays floral bud break, depending on the degree of warming during dormancy and the heat accumulation phase in spring (Andersen et al., 2017). Actually, temperature is a major driver of all phenological events, with warmer temperatures generally accelerating development. The various plant species react differently to climatic factors ("phenological interception"), even in different environments phenophases within the same species (Wielgolaski, 2003). According to Roetzer and Chmielewski (2001), the duration of phenological phases is also determined by the sum of active and effective temperatures, and this effect varies among cultivars and plant species. In addition to temperature, many other factors, such as humidity, day length, and growth conditions, influence the phenophase stages

in currant cultivars (Tooke and Battey, 2010). Paunović (2015) recorded that soil management systems including bare fallow, sawdust mulch, and black plastic mulch, also have a significant effect on the occurrence of phenological stages in black currants. In general, different currant cultivars (e.g., black, red, and white) exhibit variations in their phenological development.

The research conducted over the three years involved systematic monitoring and examination of patterns of occurrence of periodic life-cycle events or growth stages in currant cultivars. Data on leaf unfolding and inflorescence emergence dates in the tested cultivars are presented in Table 1. Under the agro-environmental conditions of Serbia, the average first leaf unfolding date was 14 March for black currant, 23 March for red currant and 22 March for white currant. On average, full leaf unfolding occurred 7 days after the date of first leaf unfolding day in black and white currants (21 March and 29 March, respectively) and 8 days in red currants (31 March). The average difference in the date of first leaf unfolding between black and red currants was 9 days, black and white currants 8 days, and between red and white currants 1 day. In terms of full leaf unfolding, the differences were 10 days between black and red currants, 8 days between black and white currants, and 2 days between red and white currants. The studied cultivars differed in the time of first leaf unfolding. The earliest date of the beginning of leaf unfolding and full leaf unfolding were observed in the black currant cultivars 'Čačanska Crna' and 'Tisel', and the latest in 'Titania'. In terms of red and white currants, the earliest date of leaf unfolding and full leaf was in 'Junifer' and 'Primus', while the latest occurred in 'Rovada' and 'Weisse aus Juteborg'. The period between the beginning of leaf unfolding and full leaf unfolding was shortest in the black and red currant cultivars 'Ben Sarek' and 'Redpoll' (5 days on average), and in the white currant cultivars 'Primus' and 'Weisse aus Juteborg' (7 days on average). In contrast, the longest periods were recorded in the black currant cultivars 'Tsema', 'Black Reward' and 'Tenah' (9 days on average), in the red currant cultivar 'Rovada' (10 days on average), and in the white currant cultivar 'Blanka' (8 days on average).

According to the international descriptor for black currants (CPVO-TP/040/2 – UPOV, 2009), based on the time of first leaf unfolding, the cultivars were classified into two groups: i) Medium early (6–10 March): 'Čačanska Crna' and 'Tisel', and ii) Late (after 11 March): 'Ben Lomond', 'Titania', 'Tsema', 'Ben Sarek', 'Tiben', 'Black Reward', and 'Tenah'. Based on the international descriptor for red and white currants (CPVO-TP/52/1 – UPOV, 2004), the tested cultivars were classified as follows: i) Early (up to 15 March): 'Junifer' and 'Detvan'; ii) Medium early (16–20 March): 'Losan', 'Jonkherr van Tets', and 'Primus'; and iii) Late (after 21 March): 'Redpoll',

‘Industria’, ‘Red Lake’, ‘Rovada’, ‘Rondom’, ‘Rolan’, ‘Weisse aus Juteborg’, and ‘Blanka’. The classification of the cultivars in this experiment according to the onset dates for leaf unfolding is partially comparable with the classification provided by Laugale (2007), who classified the examined cultivars of black currants into three groups: early, mid-early, and late, determining that the largest number of cultivars belongs to the mid-early group. Depending on the soil management systems, Paunović (2015) and Paunović et al. (2017) classified black currant cultivars into two groups according to the time of first leaf unfolding (medium-early and late). Also, Djordjević et al. (2012) classified black currants according to the period of leaf unfolding as early (‘Tsema’, ‘Ben Sarek’, and ‘Ben Lomond’), medium-early (‘Čačanska Crna’ and ‘Tenah’), and late (‘Titania’), while red and white currants are classified as early (‘Junifer’ and ‘Jonkherr van Tets’), medium-early (‘Primus’), and late (‘Redpoll’, ‘Rovada’, ‘Rondom’, ‘Rolan’, and ‘Weisse aus Juteborg’).

A comparison of the present data on the time and dynamics of leaf unfolding suggests partial agreement with the results of Djordjević (2012), obtained under the agro-environmental conditions of Serbia, but not with those of Georgiev et al. (2008) in Bulgaria, nor with the findings of Rotundo et al. (1998) in the southern Italian mountains, where currants enter the leaf unfolding stage at the end of March/beginning of April, with black currant cultivars entering this phase a few days earlier than red currant cultivars. Paunović (2015) and Paunović et al. (2017) reported that leaf unfolding development begins between 11 April and 14 April in black currants, and that the earliest occurred in the cultivars ‘Čačanska Crna’ and ‘Tisel’, and the latest in the cultivars ‘Titania’ and ‘Tsema’. Also, Stanisavljević et al. (1999) noted that the black currant cultivar ‘Čačanska Crna’ is characterized by a particularly early entry into the vegetative phase. Following the phenological dynamics of red currant cultivars, Čolić et al. (2007) established that in the territory of Serbia, red currants enter the vegetative period from 28 March to 3 April. Panfilova et al. (2021) reported that the average duration of the period from the beginning of vegetation to the beginning of flowering in red currant cultivars is between 19 and 25 days and the growing season starts from 11 April to 16 April. The present results in red currants can be supported by the findings of Djordjević et al. (2020), who observed that the red currant cultivar ‘Junifer’ has the earliest beginning of vegetation, while the cultivar ‘Rovada’ has the latest.

Table 1. Dates of leaf unfolding and inflorescence emergence in currant cultivars

Cultivars	Beginning of leaf unfolding	Full leaf unfolding	Inflorescence emergence
Ben Lomond	17 March	24 March	9 April
Ben Sarek	13 March	18 March	6 April
Tsema	16 March	25 March	11 April
Titania	19 March	27 March	13 April
Čačanska Crna	10 March	16 March	2 April
Tisel	10 March	17 March	2 April
Tiben	14 March	20 March	7 April
Tenah	16 March	25 March	10 April
Black Reward	13 March	22 March	5 April
Average across black currant cultivars	14 March	21 March	07 April
Losan	19 March	28 March	13 April
Redpoll	24 March	29 March	10 April
Rovada	29 March	8 April	18 April
Detvan	14 March	21 March	7 April
Junifer	13 March	20 March	5 April
Jonkherr van Tets	20 March	26 March	11 April
Industria	26 March	3 April	14 April
Red Lake	25 March	2 April	13 April
Random	28 March	6 April	17 April
Rolan	27 March	4 April	15 April
Average across red currant cultivars	23 March	31 March	12 April
Weisse aus Juteborg	24 March	31 March	16 April
Primus	20 March	27 March	13 April
Blanka	22 March	30 March	14 April
Average across white currant cultivars	22 March	29 March	14 April

Inflorescence emergence occurred on average 17 days after full leaf unfolding in black currant (7 April), 12 days in red currant (12 April), and 16 days in white currant (14 April). The difference in the time of inflorescence emergence was 5 days between black and red currants, 7 days between black and white currants, and 2 days between red and white currants. The earliest inflorescence emergence was observed in the black currant cultivars ‘Čačanska Crna’ and ‘Tisel,’ the red currant cultivar ‘Junifer’, and the white currant cultivar ‘Primus.’ In contrast, the latest emergence was recorded in

‘Titania’ (black currant), ‘Rovada’ (red currant), and ‘Weisse aus Juteborg’ (white currant). The period between full leaf unfolding and inflorescence emergence was shortest for the black currant ‘Black Reward’ (14 days on average), red currant ‘Rovada’ (10 days on average), and white currant ‘Blanka’ (15 days on average). On the other hand, the longest periods were observed in black currant ‘Tiben’ (18 days on average), red currant ‘Detvan’ (17 days on average), and white currant ‘Primus’ (17 days on average).

Table 2. Dates of flowering, berry set and berry ripening in currant cultivars

Cultivars	Beginning of flowering	Full flowering	Beginning of berry set	Berry ripening
Ben Lomond	15 April	24 April	29 April	28 June
Ben Sarek	11 April	19 April	25 April	21 June
Tsema	16 April	23 April	29 April	25 June
Titania	19 April	26 April	30 April	27 June
Čačanska Crna	8 April	14 April	20 April	19 June
Tisel	9 April	15 April	21 April	19 June
Tiben	16 April	21 April	28 April	23 June
Tenah	17 April	25 April	30 April	24 June
Black Reward	14 April	18 April	25 April	22 June
Average across black currant cultivars	14 April	21 April	26 April	23 June
Losan	18 April	24 April	1 May	21 June
Redpoll	20 April	27 April	3 May	7 July
Rovada	25 April	30 April	8 May	4 July
Detvan	14 April	22 April	27 April	21 June
Junifer	12 April	19 April	25 April	20 June
Jonkherr van Tets	19 April	23 April	30 April	20 June
Industria	20 April	26 April	2 May	11 July
Red Lake	21 April	27 April	3 May	25 June
Random	24 April	30 April	7 May	5 July
Rolan	23 April	29 April	6 May	22 June
Average across red currant cultivars	20 April	26 April	4 May	28 June
Weisse aus Juteborg	24 April	30 April	5 May	27 June
Primus	18 April	25 April	1 May	20 June
Blanka	21 April	26 April	3 May	24 June
Average across white currant cultivars	21 April	27 April	3 May	23 June

The beginning of flowering was 7 days on average after inflorescence emergence in black and white currants (14 April and 21 April, respectively), and 8 days on average in red currants (20 April), while full flowering was 7 days after the beginning of flowering in black currants (21 April), and 6 days in red currants (26 April) and white currants (27 April). Data on flowering dates in the tested cultivars are given in Table 2. The difference in the time of the beginning of flowering was 6 days between black and red currants, 7 days between black and white currants, and 1 day between red and white currants. Conversely, the difference in the time of full flowering was 5 days between black and red currants, 6 days between black and white currants, and 1 day between red and white currants.

Flowering was the earliest in 'Čačanska Crna' and 'Tisel' (black currant), 'Junifer' (red currant), and 'Primus' (white currant), and the latest in 'Titania' (black currant), 'Rovada' (red currant) and 'Weisse aus Juteborg' (white currant). The shortest period between inflorescence emergence and the beginning of flowering in currants was observed in 'Ben Sarek', 'Tsema', 'Losan', and 'Primus', which averaged 5 days, whereas the longest was recorded for black currant 'Tiben' (9 days on average), red currant 'Redpoll' (10 days on average), and white currant 'Weisse aus Juteborg' (8 days on average). The period between the beginning of flowering and full flowering was shortest in black currant 'Black Reward' and red currant 'Jonkherr van Tets' (4 days on average), and in 'Blanka' (5 days on average). In contrast, the longest period was noted for black currant 'Ben Lomond' (9 days on average), red currant 'Detvan' (8 days on average), and white currant 'Primus' (7 days on average).

Based on the international descriptor for black currants (CPVO-TP/040/2 – UPOV, 2009) and for red and white currants (CPVO-TP/52/1 – UPOV, 2004), all cultivars were classified into late flowering cultivars. The analysis of the experimental data on the classification of the tested cultivars according to the time of flowering suggests that the data are partially comparable with the classification provided by Laugale (2007). Madry et al. (2010) classified 'Ben Lomond' into late flowering cultivars, 'Tiben', 'Tisel' and 'Titania' into medium flowering cultivars, and 'Ben Sarek' into early flowering cultivars, whereas Denisow (2004) grouped 'Ben Lomond' and 'Titania' into medium early flowering cultivars. Paunović et al. (2016) and Paunović et al. (2017) reported a similar classification of the flowering time of the tested black currant cultivars, but the difference can be explained by different cultivation systems in the currant plantations and varying climatic conditions. Also, Djordjević et al. (2012) classified black currants according to the period of flowering as early ('Čačanska Crna', 'Tsema', and 'Ben Lomond'), and

medium-early ('Titania', 'Ben Sarek' and, 'Tenah'), while red and white currants are classified as early ('Junifer'), medium-early ('Jonkherr van Tets', 'Primus', 'Weisse aus Juteborg', and 'Rondom'), and late ('Redpoll', 'Rovada', and 'Rolan'). According to the terms of flowering, Panfilova et al. (2021) classified into early, medium-early, medium, and late. These findings are partially in agreement with the present data.

The present data on the time and dynamics of the beginning of flowering and full flowering suggest their partial compliance with the results of Djordjević et al. (2022) for all tested black currant cultivars grown under agroenvironmental conditions of Serbia and Pedersen (2008) in Denmark, who found that the 'Čačanska Crna' cultivar stands out for its earliest flowering initiation and earliest entry into full flowering. Also, Paunović et al. (2016) reported that the 'Čačanska Crna' and 'Tisel' cultivars showed the earliest onset of flowering and full flowering, and the latest were cultivars 'Ben Lomond' and 'Tsema' under different soil management systems, which is consistent with previous research on black currants. Generally, Nikolić and Milivojević (2010) noted that flowering is dependent on cultivar and weather conditions (altitude, aspect, and temperature); the warmer the weather during the flowering period, the shorter the length of flowering, and vice versa. In terms of red currants, which survive well in cold areas, Wielgolaski (1999) found that the time of flowering and development accelerates with high temperatures, particularly during the night in the early period of flowering, but increased precipitation, while the incoming radiation is less important. According to Wielgolaski (2003), red currants flower very early (mean 10 May) in the oceanic district, significantly earlier than in the middle and inner lowland districts, where temperatures, even in May, are generally lower than they are closer to the ocean. This may indicate that the flower development of the currant starts at a low basic or threshold temperature and thus has an early starting date. In the environmental conditions of Serbia, Vulić et al. (2012) recorded that the red currant cultivar 'Junifer' enters the flowering phenological phase first, and the cultivar 'Rovada' enters it last, while Djordjević et al. (2020) found that 'Junifer' has the earliest beginning time of flowering, and 'Rolan' has the latest. In general, the experimental results on flowering time in currant cultivars are not comparable with those of numerous studies conducted under the conditions of Poland (Pluta and Zurawicz, 2008; Pluta et al., 2008), Denmark (Pedersen, 2010; Pedersen and Andersen, 2012), Estonia (Kaldmae et al., 2013), and Italy (Rotundo et al., 1998). The differences are due to colder climates and higher altitudes, as well as to the later occurrence of the growing season and, hence, later flowering in these studies.

Berry set occurred 5 days on average after full flowering in black currants (26 April), 8 days in red currants (4 May), and 6 days in white currants (3 May). On the other hand, berry ripening started 58 days on average after berry set in black currants (23 June), 55 days in red currants (28 June), and 51 days in white currants (23 June). Data on the onset dates of berry set and berry ripening in the tested cultivars are presented in Table 2. The difference in the dates of the beginning of berry set was 8 days between black and red currants, 7 days between black and white currants, and 1 day between red and white currants. Conversely, the difference in the time of berry ripening was 5 days between black and white currants, and red and white currants, while there was no difference between black and white currants. 'Čačanska Crna' (black currant), 'Junifer' (red currant), and 'Primus' (white currant) had the earliest berry set and berry ripening dates, and 'Titania' (black currant), 'Rovada' (red currant) and 'Weisse aus Juteborg' (white currant) had the latest. The period between full flowering and berry set was the shortest in the black currant 'Titania' (4 days on average), followed by the red currant 'Detvan' and white currant 'Weisse aus Juteborg' (5 days on average). In contrast, the longest period was observed in the black currants 'Tiben' and 'Tisel' (7 days on average), the red currant 'Rovada' (8 days on average), and the white currant 'Blanka' (6 days on average). The period between berry set and berry ripening was shortest for the black currant 'Tenah' (55 days on average), the red currant 'Rolan' (47 days on average), and the white currant 'Primus' (50 days on average). The longest period was in the black currant 'Ben Lomond' (60 days on average), the red currant 'Rovada' (67 days on average), and the white currant 'Weisse aus Juteborg' (53 days on average). Under the environmental conditions of Serbia, the berry set date observed in this study is not comparable with the results of Djordjević (2012) and Vulić et al. (2012), but it is within the berry ripening range reported by these authors.

According to berry ripening time (CPVO-TP/040/2 – UPOV, 2009), the tested cultivars were designated into three groups: i) Early (15–20 June): 'Tisel' and 'Čačanska Crna'; ii) Medium (21–25 June): 'Ben Sarek', 'Tsema', 'Titania', 'Tiben', 'Tenah', and 'Black Reward'; and 3. Late (26–30 June): 'Ben Lomond' and 'Titania'. Based on the international descriptor for berry ripening time in red and white currants (CPVO-TP/52/1 – UPOV, 2004), the tested cultivars were classified as follows: i) Medium early (15–25 June): 'Losan', 'Detvan', 'Junifer', 'Jonkherr van Tets', 'Red Lake', 'Rolan', 'Primus', and 'Blanka'; ii) Late (26–30 June): 'Weisse aus Juteborg'; and iii) Very late (from 1 July): 'Redpoll', 'Industria', 'Rovada', and 'Rondom'. The classification according to berry ripening time is generally consistent with those made by Laugale (2007) and Pluta and Zurawicz (2008), but it does not correspond to the classification presented

by Mišić (2002), Stanisavljević et al. (2002) and Nikolić and Milivojević (2010), who classified ‘Čačanska Crna’ as medium early ripening and ‘Ben Lomond’ and ‘Ben Sarek’ as early ripening cultivars. A similar classification of berry ripening dates in black currants as early (‘Tisel’, ‘Čačanska Crna’), medium-early (‘Ben Sarek’, ‘Titania’, ‘Tiben’) and late ripening (‘Ben Lomond’) was recorded by Paunović (2015) and Paunović et al. (2016) under different soil maintenance conditions in currant orchards and varying weather conditions. Djordjević et al. (2012) classified black currants according to the period of berry ripening time as early (‘Titania’ and ‘Ben Sarek’), medium-early (‘Čačanska Crna’, ‘Tsema’, and ‘Tenah’) and late (‘Ben Lomond’), while red and white currants are classified as very early (‘Junifer’ and ‘Jonkherr van Tets’), early (‘Weisse aus Juteborg’), medium early (‘Rondom’ and ‘Rolan’ and ‘Primus’), late (‘Rovada’) and very late (‘Redpoll’), which was not confirmed in the present study. Djordjević et al. (2014) also reported that the classification of cultivars with similar geographic origins and pedigrees into different groups confirms the wide variability detected in the studied currant cultivars. Similar findings have been reported by Pluta et al. (2012) and Madry et al. (2010) regarding black currants. According to the terms of maturation periods, Panfilova et al. (2021) classified red currant cultivars into early, medium-early, medium and late, and recorded that the cultivar ‘Jonkherr van Tets’ is a medium-early cultivar.

The present results regarding ripening time can be supported by the findings of Djordjević et al. (2022), who reported similar berry ripening times in black currant cultivars under the conditions of Serbia. Namely, Djordjević et al. (2014) showed that cluster analysis (CA) and principal component analysis (PCA) provided an adequate grouping of cultivars into two groups: one consisting of black currant cultivars and the second group comprising the red and white currant cultivars, indicating phenotypic and, thus, genotypic heterogeneity of the studied cultivars. Paunović (2015) and Paunović et al. (2016) recorded that, depending on the soil management systems, the earliest berry set and berry ripening time were in the cultivars ‘Čačanska Crna’ and ‘Tisel’, and the latest was in the cultivar ‘Ben Lomond’, and the period between the beginning of berry set and berry ripening was from 62 to 69 days. Additionally, Sasnauskas et al. (2012) in Lithuania and Moyer et al. (2002) in Oregon, USA, determined similar berry ripening times in black currants. Pedersen (2010) noted that berries of red currant cultivars grown under the same agro-climatic conditions in Denmark ripened later than those of black currant cultivars. According to Brennan (1996), Mišić (2002), and Estrella et al. (2007), the period for berry growth and development is a length of 70 to 93 days, depending on weather

conditions. In the area of East Sarajevo, Trapara and Radović (2023) noted that the number of days between flowering and berry ripening in red currants was 51 days, and in black currants, it was 62 days. Generally, research findings on the time of black currant berry ripening in many foreign studies (Kawecki et al., 2006; Pluta et al., 2007; 2008; Pedersen and Andersen, 2012; Kaldmae et al., 2013) are not comparable with the results of the present three-year experiment conducted under temperate continental climate conditions. The differences in phenological stages may be attributed to colder regions in other studies, leading to a late onset of the growing season and, hence, a late fruit harvest. By monitoring the phenological characteristics of red currant cultivars over fifteen years in Slovak conditions, Štastný et al. (2002) concluded that their fruits generally ripen, on average, on 2 July, with variations from 24 June to 13 July, while under German conditions, they ripen, on average, on 4 July, with variations from 24 June to 16 July. In Denmark, Toldam-Andersen and Jensen (2004) found that the ripening phase of red and white currant fruits begins in the second half of July and lasts about 15 days, while Dalman (1999) noted that in Finland, cultivars ripen by mid-July, i.e., 'Jonkherr van Tets' ripens early, and 'Rondom' ripens late. Also, in Bulgaria, Georgiev et al. (2008) recorded that the cultivar 'Jonkherr van Tets' had the earliest berry ripening, on average, on 24 June, while the latest was the cultivar 'Rovada', about three weeks later. Estrella et al. (2007) determined that the harvest of red currant fruits begins, on average, on 9 July. Studying the period between the start of blooming and ripening, Čolić et al. (2007) in their two-year research on five cultivars of red currant, state a period of 64 to 70 days between these phenological phases in the area of Serbia and recorded that red currant fruits generally ripened from 8 June to 24 June, with an average of 17 June. Djordjević et al. (2020) reported that the red currant cultivar 'Junifer' has the earliest ripening time, from 9 to 20 June, and the cultivar 'Rovada' the latest, from 29 June to 6 July. In general, according to Djordjević et al. (2014), black currants 'Ben Lomond' and 'Tsema', red currant 'Junifer', and white currant 'Primus' showed the best characteristics under the environmental conditions of Serbia and therefore seem promising for growth in Serbian, or similar, agro-ecological conditions. Panfilova et al. (2021) reported that the average duration of the period of the studied red currant cultivars, from the beginning of bud break to full fruiting, varied from 75 days for early and medium-early cultivars to 91 days for late cultivars, while the period from the beginning of flowering to the beginning of ripening of berries was 50–61 days, and from the beginning of ripening to full maturity of berries was 6–7 days. In the same authors, the beginning of flowering occurs in red currants from 26 April to 1 May, while the date

of full berry ripening depends on the date of the beginning of ripening of the cultivar and high temperatures and begins from 26 June to 14 July. The experimental results on berry ripening in red currants are comparable to those of numerous aforementioned studies.

Conclusion

The tested cultivars are suitable for growing under the agroclimatic conditions of Čačak, Western Serbia, given the delayed onset of the growing season in general and flowering stage in particular, which is an important characteristic due to which late spring frost damage is avoided.

Knowledge of the phenology of currant as a fruit species that demonstrates an early entry into the growing season and flowering is of particular importance when choosing an appropriate location for a currant planting and, accordingly, when making a proper choice of cultivars.

ACKNOWLEDGMENTS: This study was funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, Contract No 451-03-136/2025-03/200215 and Contract No. 451-03-136/2025-03/200011.

References

- Andersen, U.B., Kjaer, K.H., Erban, A., Alpers, J., Hinch, D.K., Kopka, J., Zuther, E., Pagter M. (2017): Impact of seasonal warming on overwintering and spring phenology of blackcurrant. *Environmental and Experimental Botany*, 140, 96-109.
- Brennan, R.M. (1996). Currants and gooseberries. In: *Fruit Breeding. Vine and Small Fruits Crops*, Janick J. & Moore J. N. (eds). John Wiley and Sons, Inc, New York, 2, 191-295.
- Dalman, P. (1999): Evaluation of red currant cultivars in Finland. *Acta Horticulturae*, 505, 319-322.
- Djordjević, S.B. (2012). Production, nutritional and anti-oxidative properties of currant cultivars (*Ribes* cv.). *Doctoral dissertation, University of Belgrade, Faculty of Agriculture*, 56-63.
- Djordjević, S.B., Rakonjac, V., Fotirić Akšić, M., Šavikin K. & Vulić, T. (2014). Pomological and biochemical characterization of European currant berry (*Ribes* sp.) cultivars. *Scientia Horticulturae*, 165, 156-162.
- Djordjević, S.B., Djurović, B.D. Zec, D.G., Meland, O.M. & Fotirić Akšić, M.M. (2020). Effects of shoot age on biological and chemical properties

- of red currant (*Ribes rubrum* L.) cultivars. *Folia Horticulturae*, 32(2), 291–305.
- Djordjević, B., Djurović, D., Zec, G., Dabić Zagorac, D., Natić, M., Meland, M. & Fotirić Akšić, M. (2022). Does shoot age influence biological and chemical properties in black currant (*Ribes nigrum* L.) cultivars? *Plants*, 11, 866.
- Denisow, B. (2004). The influence of artificial wind blow on the pollination and fructification of blackcurrant (*Ribes nigrum*) cultivars. *Acta Scientiarum Polonorum, Hortorum Cultus*, 3(1), 89-96.
- Estrella, N., Sparks, T.H. & Menzel, A. (2007). Trends and temperature response in the phenology of crops in Germany. *Global Change Biology*, 13, 1737-1747.
- Georgiev, D., Dinkova, H. & Georgieva, M. (2008). Study of newly introduced cultivars of black and red currant. *Proceedings of International Scientific Conference „Sustainable Fruit Growing: From Plant To Product”*, Latvia, 44-53.
- Kaldmae, H., Kikas, A., Arus, L. & Libek, A. (2013). Genotype and microclimate conditions influence ripening pattern and quality of blackcurrant (*Ribes nigrum* L.) fruit. *Zemdirbyste Agriculture*, 100, 164-174.
- Kawecki, Z., Bieniek, A., Kopytowski, J. & Siksnianas, T. (2006). Preliminary assessment of productivity and fruit quality of Lithuanian and Ukrainian cultivars of blackcurrant under the climatic conditions of Olsztyn. *Journal of Fruit and Ornamental Plant Research*, 14, 75-80.
- Laugale, V. (2007). Evaluation of black currant collection in Pure horticultural research station, Latvia. *Scientific works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture*, 26, 93-101.
- Mišić, D.P. (2002). Breeding of fruit crops. *Parthenon, Belgrade*, pp. 397-408.
- Madry, W., Pluta, S., Siczko, L. & Studnicki, M. (2010). Phenotypic diversity in a sample of blackcurrant (*Ribes nigrum* L.) cultivars maintained in the Fruit Breeding Department at the Research Institute of Pomology and Floriculture in Skierniewice, Poland. *Journal of Fruit Ornamental Plant Research*, 18(2), 23-37.
- Moyer, A.R., Hummer, E.K., Finn, E.C., Frei, B. & Wrolstad, E.R. (2002). Antioxidant compounds in diverse *Ribes* and *Rubus* germplasm. *Acta Horticulturae*, 585(2), 501-505.
- Nikolić, M. & Milivojević, J. (2010). Small fruit crops. Production technology. *Scientific Pomological Society of Serbia, Belgrade*, 355-362.
- Paunović, S.M. (2015). Effect of soil maintenance systems on biological and productive properties of black currant (*Ribes nigrum* L.) cultivars. *Doctoral dissertation, University of Belgrade, Faculty of Agriculture*, 1-273.

- Paunović, S.M., Nikolić, M., Miletić, R., Tomić, J., Karaklajić-Stajić, Ž., Milinković, M. & Pešaković, M. (2016). Effect of soil maintenance systems on phenological traits of black currant (*Ribes nigrum*) cultivars. *Acta Horticulturae*, 1139, 571-574.
- Paunović, S.M., Nikolić, M., Miletić, R., Milinković, M., Karaklajić-Stajić, Ž., Tomić, J. & Pešaković, M. (2017). Occurrence of phenological stages in black currant (*Ribes nigrum* L.) cultivars as dependent on soil management systems. *Journal of Mountain Agriculture on the Balkans*, 20(5), 168-185.
- Panfilova, O., Tsoy, M., Golyaeva, O., Knyazev, S. & Karpukhin, M. (2021). Agrometeorological and morpho-physiological studies of the response of red currant to abiotic stresses. *Agronomy*, 11, 1522.
- Pedersen, H. L. (2008). Juice quality and yield capacity of black currant cultivars in Denmark. *Acta Horticulturae*, 777, 510-516.
- Pedersen, H.L. (2010). Black and red currant cultivars for organic production. *Eco-fruit.14th International Conference on Organic Fruit-Growing, Universität Hohenheim*, 212–217.
- Pedersen, L.H. & Andersen, L. (2012). Black and red currant cultivars for organic production. *15th International Conference on Organic Fruit-Growing Proceedings to the Conference, Hohenheim, Germany*, 215-220.
- Pluta, S., Zurawicz, E., Broniarek-Niemiec, A. & Markowski, J. (2007). Production and processing value of new blackcurrant cultivars and breeding clones in central Poland. *Scientific works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture*, 26, 309-317.
- Pluta, S., Zurawicz, E., Krawiec, A. & Salamon, Z. (2008). Evaluation of the suitability of Polish blackcurrant cultivars for commercial cultivation. *Journal of Fruit Ornamental Plant Research*, 16, 153-166.
- Pluta, S. & Zurawicz, E. (2008). Suitability of the new Polish blackcurrant cultivars for mechanical fruit harvesting. *Proceedings of International Scientific Conference „Sustainable Fruit Growing: From Plant To Product”, Latvia*, 213–220.
- Pluta, S., Madry, W. & Siczko, L. (2012). Phenotypic diversity for agronomic traits in a collection of blackcurrant (*Ribes nigrum* L.) cultivars evaluated in Poland. *Scientia Horticulturae*, 145, 136-144.
- Rotundo, A., Bounous, G., Benvenuti, S., Vampa, G., Melegari, M. & Soragni, F. (1998). Quality and yield of *Ribes* and *Rubus* cultivars grown in Southern Italy hilly locations. *Phytotherapy Research*, 12, 135-137.
- Roetzer, T., & Chmielewski, F.M. (2001). Phenological maps of Europe. *Climate Research*, 18, 249-257.

- Sasnauskas, A., Siksnianas, T., Stanys V. & Bobinas, Č. (2012). Evaluation of agronomical characters of blackcurrant cultivars and selections in Lithuania. *Acta Horticulturae*, 946, 189-194.
- Stanisavljević, M., Tesović, M. & Pavlović, K. (1999). New small fruit cultivars from Cacak: 2. the new black currant (*Ribes nigrum* L.) cultivar 'Cacanska Crna'. *Acta Horticulturae*, 505, 297-302.
- Stanisavljević, M., Rakićević, M., Mitrović, O. & Gavrilović-Damjanović, J. (2002). Biological-pomological properties of some blackcurrant cultivars and selections. *Acta Horticulturae*, 585, 231-235.
- Sønsteby, A., Opstad N. & Heide, O.M. (2012). Effects of summer temperature on growth and flowering in six black currant cultivars (*Ribes nigrum* L.). *Journal of Horticultural Science and Biotechnology*, 87, 157-164.
- Toldam-Andersen, T.B. & Jensen, S.L. (2004). Evaluation of red and white currant cultivars (*Ribes rubrum* L.) in the genebank collection at Pometet. *Acta Horticulturae*, 649, 315-318.
- Trapara, M. & Radović, M. (2023). Pomological properties of red (*Ribes rubrum* Roxb) and black currents (*Ribes nigrum* L.) in the area of East Sarajevo. *Annals of Agronomy*, 47(1), 89-96.
- Tooke, F. & Battey, N.H. (2010). Temperate flowering phenology. *Journal of Experimental Botany*, 61, 2853-2862.
- UPOV (2004). Protocol for distinctness, uniformity and stability tests. Red and white currant (*Ribes sylvestre* (Lam.) Mert & W.D.J. Koch, *Ribes niveum* Lindl.).
- UPOV (2009). Protocol for distinctness, uniformity and stability tests. Blackcurrant (*Ribes nigrum* L.).
- Vulić, T., Đorđević, B., Ruml, M., Đurović, D., Fotirić, M., Radivojević, D. & Oparnica, Č. (2012). Flowering dynamic and susceptibility of the flowers of black currant (*Ribes nigrum* L.) and red currant (*Ribes rubrum* L.) to spring frost. *Acta Horticulturae*, 946, 373-377.
- Wielgolaski, F.E. (1999). Starting dates and basic temperatures in phenological observations of plants. *International Journal of Biometeorology*, 42, 158-168.
- Wielgolaski, FE. (2003). Climatic factors governing plant phenological phases along a Norwegian fjord. *International Journal of Biometeorology*, 47(4), 213-220.
- Čolić, S., Zec, G., Marinković, D. & Janković, Z. (2007). Fenološko pomološke karakteristike crvene ribizle u uslovima Pančevačkog rita. *Zbornik naučnih radova XXII Savetovanja „Unapređenje proizvodnje voća i grožđa”*, 13(5), 65-69.

Štastný, P., Luknárová, V., Tekušová, M., Dittmann, E., Bissolli, P., Kreis, A. & Müller-Westermeier, G. (2002). Evaluation of phenological data for climatological purposes in Slovakia and Germany. *XIV. Česko-slovenská bioklimatologická konference, Lednice na Moravě*, 610-618.