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THE GROWTH SEASON FOLLOWING BBCH SCALE AND THE GDD REQUIREMENT FOR *RUBUS IDAEUS* VAR. 'PROMYK'. DURING THE ADAPTATION PERIOD, PLACED IN THE URBAN GARDEN

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Abstract

*Urban gardening represents high interest within cities due to extended heat waves produced by pronounced climate change. Raspberry has high potential to adapt and develop under urban gardening conditions. The study aimed to assess the adaptation of Rubus idaeus var. 'Promyk' in urban garden from UASVM Cluj-Napoca. The observation on phenotypic features according BBCH (**B**iologische Bundesanstalt, **B**undessortenamt und **CH**emische Industrie) scale was recorded twice a week for the growing season of 2023-2024, together with the range time for each principal growth stage. The corresponding heat units' requirement (GDD-growing degree-days) was computed for each phenophase. Overall, the raspberries presented asynchronous growth and development in the adaptation year. The GDD highlighted differences. Therefore, the plant's development differed at the individual level based on climatic conditions.*

Key words*: adaptation, development, growing degree-days, phenological assessment, raspberry.*

INTRODUCTION

Urban gardens act as incubators for plant growth and development as the climate rises in cities and the heat island effect is increasingly present (Imbroane et al., 2014). Several plants could benefit from and adapt to these changes in this context. These anthropic gardens could sustain multiple interconnected advantages by reducing the negative effects of heat islands, in periods with high temperatures and especially in the summer, through plant evapotranspiration and shade (Wong et al., 2021).

As climate change intensifies, monitoring the impact of climatic factors on crop performance has become a priority in modern agriculture (Croitoru et al., 2020; Rezaei et al., 2023). The ability to ensure optimal environmental conditions directly influences the quality and quantity of potential yields (Bisbis et al., 2018). Key factors such as temperature, photoperiod, soil pH, and moisture must meet the specific needs of each plant species to ensure healthy growth and maximum productivity (Bacelor et al., 2024). Among these factors, temperature emerges as one of the most decisive and restrictive external variables (Raza et al., 2024), significantly shaping the physiological processes that govern plant growth, development, and fruit production (Patel, 2023). Temperature serves as a natural signal for initiating phenological stages (Guesmi et al., 2021). Continuous monitoring of temperature fluctuations is important, as it enables the use of growing degree days (GDD) to measure cumulative heat over time (Miller et al., 2001). These daily records can be transformed into a heat calendar that sustains the prediction of when specific phenological events will occur (Miller et al., 2001). An important indicator is the base temperature (Tb), which represents the minimum temperature required for plants to initiate active growth (Wahid, 2007). This Tb is specific to each species and plays a crucial role in GDD calculations for determining growth dynamics

and developmental stages (Fraisse & Paula-Moraes, 2018).
The raspberry (*Rubus idaeus* L.) is a less demanding crop regarding climatic factors, which has gained increasing popularity in recent years (Brennan et al., 2014). Raspberries thrive in climates characterized by mild winters (Palonen & Buszard, 1997) and moderately dry summers (Swanson et al., 2011), being less sensitive to cold than blackberries (Palonen & Buszard, 1997). However, the crop can be vulnerable to climatic events like freezing winds and early spring frosts, severely affecting growth and fruiting (Waister et al., 1979). Despite these challenges, raspberry cultivation remains widespread due to the fruit's exceptional aroma (Sawicka et al., 2023), rich nutritional profile, and health benefits (Teng et al., 2017). Global raspberry production in 2022 approached almost 950,000 tons, reflecting a growing consumer demand (Ladyzhenskaya et al., 2025). This makes it essential to closely monitor the environmental factors influencing the plant's growth, development, and fruiting potential to ensure quality and sustainability.
Scientific studies reveal that raspberry plants respond differently to climatic variations depending on their variety (Gotame, 2014), with temperature and photoperiod playing a pivotal role in determining growth outcomes (Sønsteby & Heide, 2012). High-temperature stress, for instance, is particularly detrimental, triggering a range of morphological, physiological, and biochemical changes (Guo et al., 2023). The phenological stages of raspberry plants - such as anthesis initiation, flowering (anthesis), and dormancy - are directly influenced by temperature and sunlight exposure (Hodnefjell, 2017). Previous studies have shown that the breaking dormancy, which lasts approximately six weeks (Pruteanu et al., 2024), in red raspberry is triggered by exposure to a Tb of 4°C (Sutherland et al., 2015; Mazzitelli et al., 2007). The phenological stages of budburst and flowering are also highly sensitive to climatic factors and are directly influenced by them (Rusnac, 2021).
To better understand how temperature affects raspberry development, our study aimed to monitor the growth and phenological progression of *Rubus idaeus* L., a promising plant for urban gardening, 'Promyk' primocanes, using the BBCH scale (Meier, 2018). The main study objective was to correlate the plant's growth stages on the BBCH scale with GDD, as the days' interval required to pass from one secondary stage to another, and productivity percentages in the adaptation year. The experiment was conducted in an outdoor urban garden system, highlighting the role of urban agriculture in promoting sustainable urban development and eco-friendly lifestyles. Urban gardens not only offer opportunities for localized food production but also serve as testbeds for innovative agricultural practices, especially in the face of climate variability

MATERIALS AND METHODS

The experiment was installed in the agro-botanical garden of UASVM Cluj-Napoca, thus simulating an urban garden located near km 0 of the city. The selected experimental area was located in the experimental field 46˚45'36''N and 23˚34'27''E of the Plant Physiology Department from the Faculty of Agriculture.
Remounted primocanes of raspberry, *Rubus idaeus* L., 'Promyk', were purchased from the Moara Nursery in Suceava County, Romania. This variety was recently launched on the market after extensive research and crossings in Poland (Orzeł et al., 2023), the fourth largest raspberry producer in the world (Adamczuk et al., 2023). Unlike red raspberry varieties, this one lacks anthocyanins (Adamczuk et al., 2023). A total of 27 rooted raspberry shoots were placed in the field with different nutrition surface areas as follows: high nutrition area (SN_max) with 100 cm between shoots, medium nutrition area (SN_med) with 75 cm between shoots, and low nutrition area (SN_min) with 50 cm between rooted shoots. Raspberry crop monitoring took place between 26.02.2024 and 02.01.2025. All the plants were assessed twice a week, each Monday and Thursday, following the BBCH scale (Meier, 2018). Images of plant growth and development were taken with a 48MP camera. The meteorological data were exported from the Meteomanz database from Romania (http://www.meteomanz.com/), where synoptic observations from the Cluj-Napoca station (15120) were selected. Data by days were

further computed for obtaining GDD (growing degree days) and precipitation amount during the raspberry growth season and principal growth stages. The GDD was calculated with a Tb of 4°C with the formula (Vâtcă et al., 2021):

$$GDD=\sum_{1}^{n}\left(\frac{Tmax+Tmin}{2}\right)-Tb$$

The first step consisted in changing the climatic database respectively the negative values were changed in Tb (4). Then, the GDD formula was applied for each day. After exploring the data base, it was found the period of Eco-dormancy which consisted of six weeks of average temperature above 4°C according to Sutherland et al., 2015, that started from 20.02.2024 with only one day of average temperature of 2°C, value not considered. Eco-dormancy is released when the buds burst in the spring. Endo-dormancy happen in the cold period and values between 1-4°C break this dormancy process. Para-dormancy comes after endo-dormancy with chilling and cold temperatures typically run at 4°C. All raspberry canes were assessed individually in the field and for the climatic database, establishing GDD average and days interval for one secondary stage to another. Therefore, all GDD presented values were calculated from one BBCH secondary stage to another identified in order for the entire vegetation period from a complete database without missing data. The GDD values were then made as average for each variant. Together with GDD, the days for setting into a BBCH and from a BBCH stage to the following were noted from the field observations. These days were used to establish a time range specific for a principal or secondary stage to be achieved. BBCH with one digit is describing principal growth stages and BBCH with two digits represent specific secondary growth stages following the newest growth scale proposed by Meier in 2018.

RESULTS AND DISCUSSIONS

The day's range (Table 1) differed between nutrition area variants and was influenced by the climatic conditions, respectively, the GDD and precipitation amount. A wide range of days were found in the endo-dormancy period, for the leaf development stage, flowering, fruiting, and the beginning of senescence. In the first year of the adaptation period, the raspberry did not produce shoots in SN_min variants and produced only very few in SN_max variants.

Table 1. Registered days interval from one secondary stage to the following

BBCH Code	SN_max	SN_med	SN_min
PGS 0	156-213	131-197	69-169
00	128	128	43-128
03	20-43	1-43	19-27
07	1-10	1-22	3-7
09	7-22	1-4	4-7
PGS 1	39-151	35-206	21-108
10	4-36	7-26	7-28
11	1-3	3-54	4-38
12	1-7	3-54	1-3
13	3-7	3-4	1-18
14	4-21	3-4	3-4
15	1-7	3-18	4-14
16	14-42	3-11	1-3
17	1-7	3-14	
18	7-11	3-4	
19	3-10	4-17	
PGS 2	1-38	26-109	
21	1-38	24-88	
22		1-10	
23		1-11	
PGS 5	17-39	9-36	7-22
51	11-28	3-25	3-4
55	3-4	3-7	3-14
59	3-7	3-4	1-4
PGS 6	6-21	6-21	5-10
60	4-14	1-4	
65	1-3	1-3	1-3
69	1-4	4-14	4-7
PGS 7	11-21	10-31	11-17
75	10-17	7-21	7-10
79	1-4	3-10	4-7
PGS 8	5-11	9-12	5-11
81	1-3	3-4	3-4
85	1-4	3-4	1-3
89	3-4	3-4	1-4
PGS 9	66-214	91-190	53-213
91	21-105	21-53	4-122
93	17-67	14-21	24-52
97	28-42	56-116	25-39

The leaf bud development stage (BBCH 0) has different GDD requirements depending on the growth nutrition area (Table 2). Raspberry rooted shoots planted 100 cm apart required the lowest GDD. Planting shoots at small and medium distances implied an increase of 36% and 44% compared to those at SN_max in the raspberry's requirement towards GDD for the BBCH 0 stage initiation and evolution. An increase in the planting area was associated with increased GDD required for leaf growth and development (BBCH 1). Thus, SN_max and SN_med seedlings benefited from a 74% and 72% increase compared to SN_min seedlings in the GDD required to initiate and develop the main stage BBCH 1.

Table 2. Principal growth stages (PGS) and corresponding growing degree days (GDD, in °C) for all three nutrition areas tested for raspberry

No	PGS	SN_max	SN_med	SN_min
1	**BBCH 0**	153	220	208
2	**BBCH 1**	1380	1369	795
3	**BBCH 2**	764	133	0
4	**BBCH 5**	431	313	196
5	**BBCH 6**	221	275	122
6	**BBCH 7**	253	311	245
7	**BBCH 8**	195	175	197
8	**BBCH 9**	591	1061	1652

Interestingly, the development of lateral shoots (BBCH 2) was the most sensitive stage to GDD and different nutritional areas (Table 2). While SN_min buds did not enter the main BBCH stage, the requirement towards GDD of SN_max shoots was six times higher than in SN_med. The initiation of the generative stage in raspberry is associated with the appearance of the flower bud (Hodnefjell et al., 2018). It was observed that SN_min raspberries required a reduced GDD value to enter BBCH 5 compared to the other variants. For this stage, the GDD needs for plants from SN_med and SN_max increased with values in the 117-235 GDD range compared to the minimum recorded in SN_min. The plant's evolution on the BBCH scale in main stages 6 and 7 recorded a similar trend. Raspberries from SN_med had the highest GDD requirements. At the opposite pole were the rooted shoots planted at a distance of 50 cm. Fruit ripening (BBCH 8) occurred under similar conditions of GDD for the SN_max and SN_min variants. On the other hand, SN_med required slightly lower GDD compared to the other variants. The onset of plant senescence (BBCH 9) is associated with increases in GDD proportional to a decrease in the nutrition area. The maximum value, recorded at SN_min, was 1.6 times higher than at SN_med and 2.8 times higher than at SN_max.

Eco-dormancy ends when the average temperature is at least 4°C for at least 6 weeks (Sutherland et al., 2015) (Table 3, Figure 1). From the time the raspberry rooted shoots were planted to when they came out of dormancy, it took 128 days. At SN_ max and SN_min, this physiological phenomenon took only 3 weeks with average temperatures above 4ºC to complete bud swelling (BBCH 03). At SN_med, it took more than 6 weeks with average temperatures above 4°C to observe the beginning of bud burst (BBCH 07).

For better data exploration, GDD is scaled as follows: minimum requirements GDD<50, medium requirements GDD between 50-100, high requirements GDD between 100-150, and very high requirements GDD>150.

Only a few BBCH stages were observed with values less than 50 GDD (Table 3, Figure 1).

Only 10% of the 31 BBCH stages studied in SN_max raspberry plants had GDD requirements lower than 50 (BBCH 07, 11, and 55). Similarly, the same percentage of BBCH stages evaluated at SN_med required GDDs less than 50. On the other hand, several BBCH stages (16% of the total) needed reduced GDD in SN_min, including one related to flower bud development (BBCH 51). When raspberry receives the photoperiod signals and temperature requirements are fulfilled, the flower primordia start broadening its apical meristem and elongate (Hodnefjell, 2017).

For SN_max raspberries, 35% of the BBCH stages evaluated required values in the 50-100 GDDs range for initiation and evolution. Planting the rooted shoots in an average nutrition area influenced the evolution of the plants on the BBCH scale and their GDD requirements. Only 29% of the BBCH stages evaluated required GDD in the 50-100 GDD range. Raspberries planted at a distance of 50 cm recorded 32 percent of the assessed

BBCH stages. It was emphasized that, among the BBCH stages monitored, the fruit-ripening stages showed similar requirements to GDD for all variants (BBCH 81, 85, 89).

For both SN_max and SN_med, it was observed that 19% of the monitored BBCH stages required values in the range 100-150 GDD (Table 3, Figure 1). The difference between the two variants was represented by the specific stages with these requirements. While two-thirds of these stages analyzed at SN_max supported leaf development, at SN_med, only one-third did, and another third was represented by side shoot development. For raspberries with SN_min, only 10% of the monitored stages had requirements in the same range of GDD values.

Table 3. Principal growth stages of raspberry and corresponding GDD values as a response to different nutritional areas

Code	Stage	SN_max	SN_med	SN_min
Principal growth stage 0: Bud development				
00	Winter dormancy or resting period	387/249	387/249	397
03	End of bud swelling			135
07	Beginning of sprouting or bud breaking	39	191	28
09	Bud shows green tips	114	29	45
Principal growth stage 1: Leaf development (main shoot)				
10	First leaves separated	138	153	143
11	First leaves unfolded	34	287	169
12	2 true leaves, leaf pairs, or whorls unfold	70	289	38
13	3 true leaves, leaf pairs, or whorls unfolded	58	43	265
14	4 true leaves, leaf pairs, or whorls unfolded	132	44	51
15	5 true leaves, leaf pairs, or whorls unfolded	81	117	74
16	6 true leaves, leaf pairs, or whorls unfolded	462	80	54
17	7 true leaves, leaf pairs, or whorls unfolded	137	130	
18	8 true leaves, leaf pairs, or whorls unfolded	157	55	
19	9 or more true leaves, leaf pairs, or whorls unfolded	112	170	
Principal growth stage 2: Formation of side shoots/tillering				
21	First side shoot visible; First tiller visible	764	478	
22	2 side shoots visible; 2 tillers visible		128	
23	3 side shoots visible; 3 tillers visible		138	
Principal growth stage 5: Inflorescence emergence (main shoot) /heading				
51	Inflorescence or flower buds are visible	303	166	46
55	First individual flowers visible (still closed)	50	79	95
59	First flower petals visible (in petalled forms)	77	67	55
Principal growth stage 6: Flowering (main shoot)				
60	First flowers open (sporadically)	101	80	
65	Full flowering: 50% of flowers open, first petals may be fallen	56	52	47
69	End of flowering: fruit set visible	64	143	75
Principal growth stage 7: Development of fruit				
75	50% of fruits have reached final size	197	190	147
79	Nearly all fruits have reached final size	56	122	98
Principal growth stage 8: Ripening or maturity of fruit and seed				
81	Beginning of ripening or fruit colouration	50	61	59
85	Advanced ripening or fruit colouration	73	59	65
89	Fully ripe: fruit shows fully-ripe colour, beginning of fruit abscission	71	54	73
Principal growth stage 9: Senescence, beginning of dormancy				
91	Shoot development completed, foliage still green	286	571	1176
93	Beginning of leaf-fall	254	225	266
97	Plant resting or dormant	52	265	210

Note: SN_max - high nutrition area, SN_med - medium nutrition area, SN_min - low nutrition area

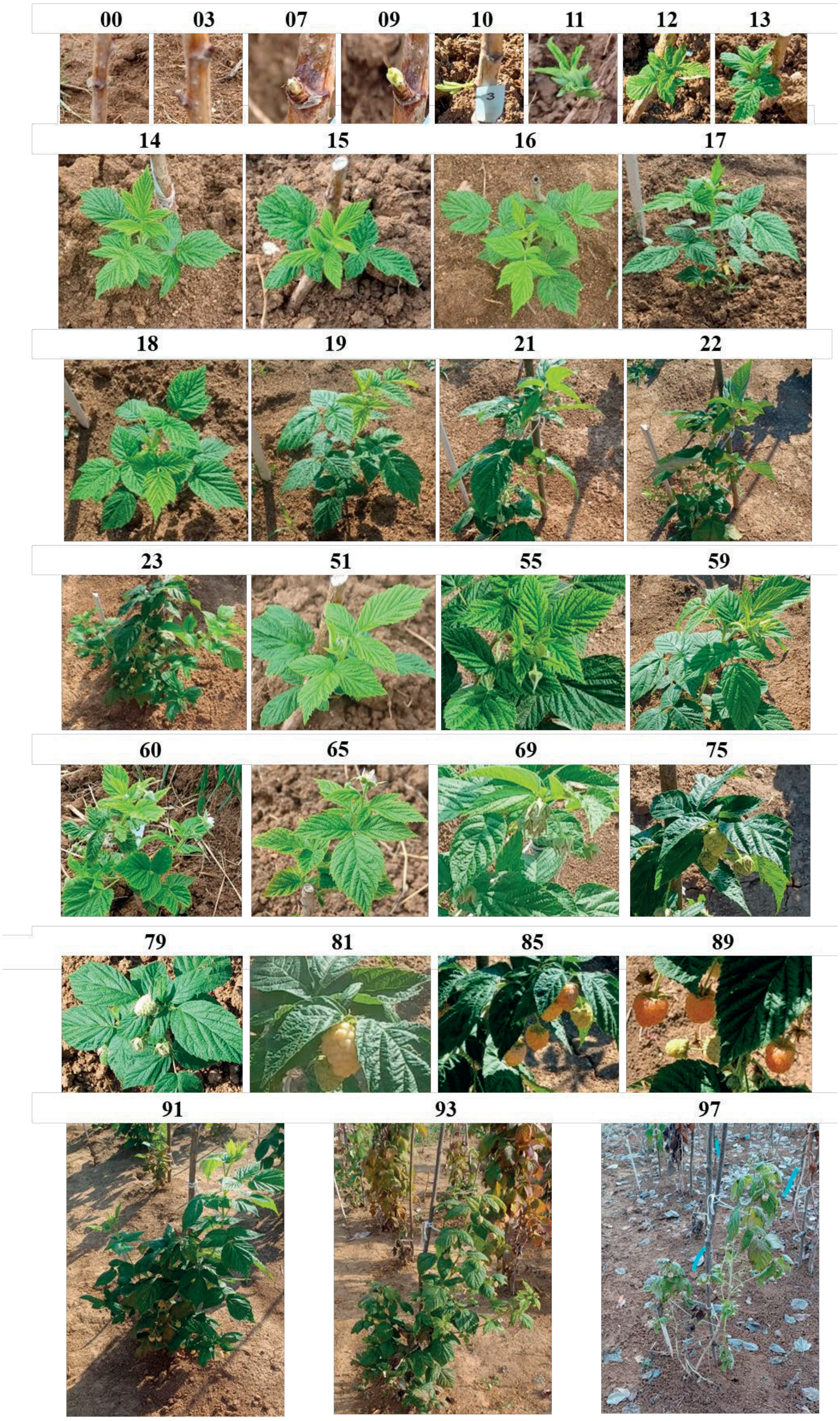

Figure 1. BBCH growth stages at primocanes of raspberry *Rubus idaeus* L., 'Promyk' entire growth period

The experiment also outlined other interesting GDD requirements related to the initiation of BBCH stages and their corresponding GDDs. Such requirements were observed at five large BBCH stages: BBCH 1, 2, 5, 7, and 9, along with 5 BBCH sub-stages related to leaf growth and development, with very high GDD requirements.

The stages from the first unfolded leaf (BBCH 11) to the third unfolded leaf (BBCH 13) required a very high GDD input with values ranging from 169-189 for the minimum and medium nutrition surface (Table 3, Figure 1). On the other hand, the SN_max raspberries also had high GDD requirements for initiating the BBCH 16 stage. Thus, for this variant, the appearance of the sixth unfolded leaf was conditioned by a GDD value higher than the average of the range required for the initiation of BBCH 11, 12, and 13 in the other two variants. Another interesting aspect emerged in all variants for the BBCH 19 stage. The raspberry grown in SN_min did not develop more than six leaves until the appearance of the flower bud (BBCH 51), which means that the plants skipped some growth stages. The other two variants had different requirements for GDD to enter BBCH 19, with a value 1.5 times higher for SN_med than for SN_max. The onset of side shoots was a BBCH step with major requirements for GDD. SN_min did not allow the stumps to develop side shoots, and SN_med had a 1.6-times lower requirement than the large value of growing days that SN_max stumps required. Raspberry developed multiple shoots in SN_med and only a few in SN_max.

Floral bud emergence was triggered under unexpected GDD conditions, with increases in the minimum required value for SN_mic, of 3.6 for SN_med and 6.7 for SN_max. This shows that floral bud emergence fluctuates and has different GDD requirements depending on the growth nutrition area.

Fruit growth to 50% of its final size (BBCH 75) had similar GDD requirements when plants had SN_max and SN_med, whereas SN_min shoots had a 25% decrease in GDD compared to the value recorded at SN_max.

Based on the synthesis of all the observations during the experimentation (Figure 2), the first developmental stage - the leaf plants stage (BBCH 1) - started simultaneously for raspberries that received maximum and minimum surface nutrition. However, in SN_min, the buds stage lasted the longest. As for raspberries planted in a medium nutrient area, they entered BBCH 0 the latest, and the evolution of the stage was very short. The first leaf initiation occurred simultaneously for SN_max and SN_min, but contrary to the evolution observed at BBCH 0, this time, for plants that benefited from SN_max, the period was longer.

The SN_med raspberries showed a similar appearance to the BBCH 0, where they initiated the latest stage (Figure 2). Only SN_med and SN_max plants developed side shoots (BBCH 2), but the stage evolution showed major differences between the two variants. While raspberries planted in a SN_max developed side shoots only at the end of July, those planted in a SN_med required more time to initiate and evolve the main BBCH 2 stage. This stage occurred during all three decades of September and partially overlapped with the main stages of fruit growth and development in SN_med plants. The duration of the BBCH 5 period increased with the increase in the nutrient area. Flower bud emergence and development (BBCH 5) captures interesting aspects in the three tested variants (Figure 2).

The raspberry growth and development evolution for all three nutrient surfaces (Figure 2) showed similar ratios of the BBCH 5 stage with stages 6 and 7. However, notable differences were only observed for the BBCH 8 stage. Stages 5, 6, and 7 start only three, two, and one decade earlier than BBCH 8 at SN_max, and at SN_min, stage 8 starts after the end of BBCH 5. The most interesting aspect was outlined at SN_max, where the BBCH 8 stage ends earlier than 5, 6, 7, emphasizing that either the flowers were not fully developed, the fruits were aborted, or they stopped growing at some point. The decrease in nutritive surface area hastened the entry of plants into senescence, at SN_min noticeably shortening the period of activity. The time of entry into dormancy was the same for all three variants, i.e., at the end of December.

At the maximum nutrition area (SN_max), endo-dormancy runs from the second decade (D2) of October and continues until the second decade (D2 of February) (Figure 2). Para-dormancy extended from D2 of February to D1 of March. The main growth stage, bud development (BBCH 0), started from D2 of March and ended in D3 of April. Leaf development on the main shoot (BBCH 1) started in D1 of April and ended in D1 of August. The lateral shoots (BBCH 2) were visible in D3 in July. The start of floral emergence (BBCH 5) in the area of maximum nutrition began in D1 of May and ended in D2 of September. Other studies declared that marginal low temperature and short day conditions from September determined a reduction of floral induction (Woznicki et al., 2016). On the main shoot, flowering (BBCH 6) started in D2 of May and finished in D3 of September. Fruit development (BBCH 7) started in D2 of June and finished in D1 of October. Fruit ripening (BBCH 8) started in D2 of June and was completed in D2 of August. Raspberry fruit set began in D1 of September and ended in D3 of December.

On the average nutrient surface (SN_med), endo-dormancy runs from D2 of October to D2 of February (Figure 2). Para-dormancy started in February and went from D2 to D1 in March. Shoot development (BBCH 0) began and ends in the last decade (D3) of April. Leaf development on the main shoot (BBCH 1) began in April in D3 and it was completed in D1 of July.

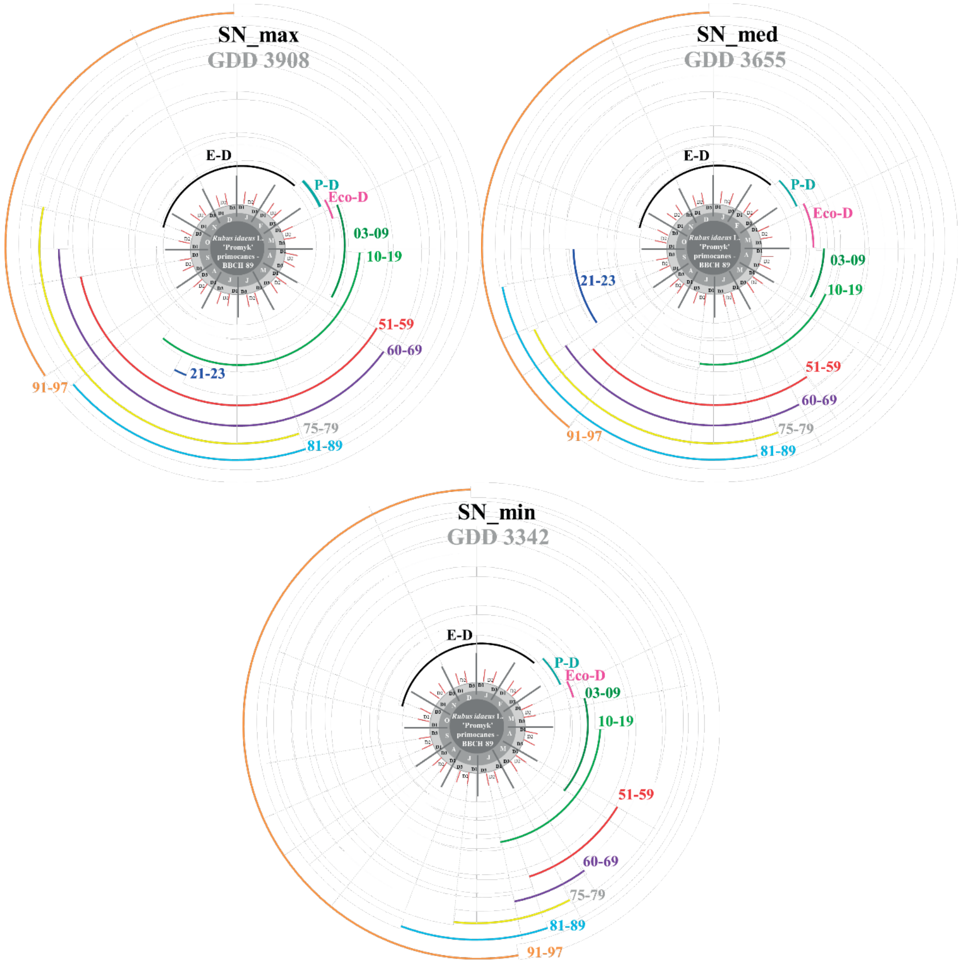

Figure 2. BBCH secondary stages are identified, and the overall growth period depends on the nutrition area

Lateral shoots (BBCH 2) formed between D1 and D3 in September. The BBCH 5 started on D3 of May and ended on D2 of August. Flowering (BBCH 6), on the main shoot, in the minimum nutrition area, started in D1 of June and finished in D3 of August. This results are in accordance with other studies with different temperature and how low temperature can influence the days to anthesis (Woznicki et al., 2016). In a minimum nutrition area, the plants could benefit from higher temperatures, therefore the flowering happens faster and does not last.

BBCH 7, fruit development, started in D2 of June and finished in D1 of September. Fruit ripening (BBCH 8) started in D3 of June and finished in D2 of September. The senescence of raspberry rooted shoots (BBCH 9) occurred between D2 of August and D3 of December. At the minimum nutritive area (SN_min), from the climatic database it was found that endo-dormancy occurred between D2 of October and D2 of February. Para-dormancy started in D2 of February and ended in D1 of March (Figure 2). Shoot development (BBCH 0) took longer, beginning in D2 of March and ending in D1 of May (Figure 2). Leaf development (BBCH 1) started in D1 of April and ended in D2 of June. In the minimum nutrition area, lateral shoot formation (BBCH 2) did not occur. The start of floral emergence (BBCH 5) began in D1 of May and ended in D1 of June. BBCH 6, flowering on the main shoot, began in D3 of May and ended in D2 of June. Fruit development (BBCH 7) started in the D1 of June and ended in the D1 of July. Fruit maturity (BBCH 8) started in D2 of June and ended in D2 of July. The senescence period for raspberry rooted shoots (BBCH 9) was between D3 of June and D3 of December. The leaves started to fall from the end of June at the plants from minimum nutrition area.

The precipitation sums highlighted higher values in the dormancy period in November D2 and lowest in the second decade of October (Figure 3). During the growth period from the raspberry vegetation season, a higher amount of precipitation was registered in June D2 when the fruits developed, fruit maturity was reached, and ripening happened.

Regarding the timing of fruit harvest, the end of main stage 8 and secondary stage BBCH 89, respectively, was staggered differently depending on the nutritional surface available for cutting development (Figure 4).

In the 'Promyk' raspberry planted in the urban garden with a high-nutrition area, the fruit harvest period was carried out over 12 decades with two breaks between July D3-August D1 and October D2.

The fruit harvest began in the second decade of June and lasted until the first decade of November, with a maximum percentage of 37% in D1 of July (Figure 4).

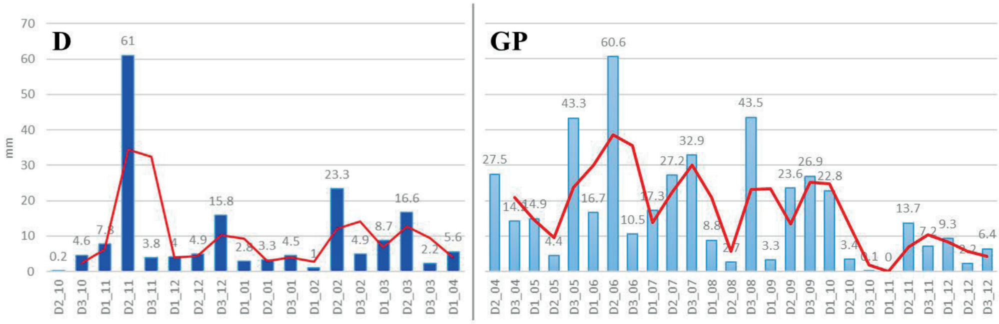

Figure 3. Precipitation amount in the dormancy period (D) and in the active growth period (GP) of raspberry for every decade D1-D3 from all months assessed, the red line represents the moving average trendline

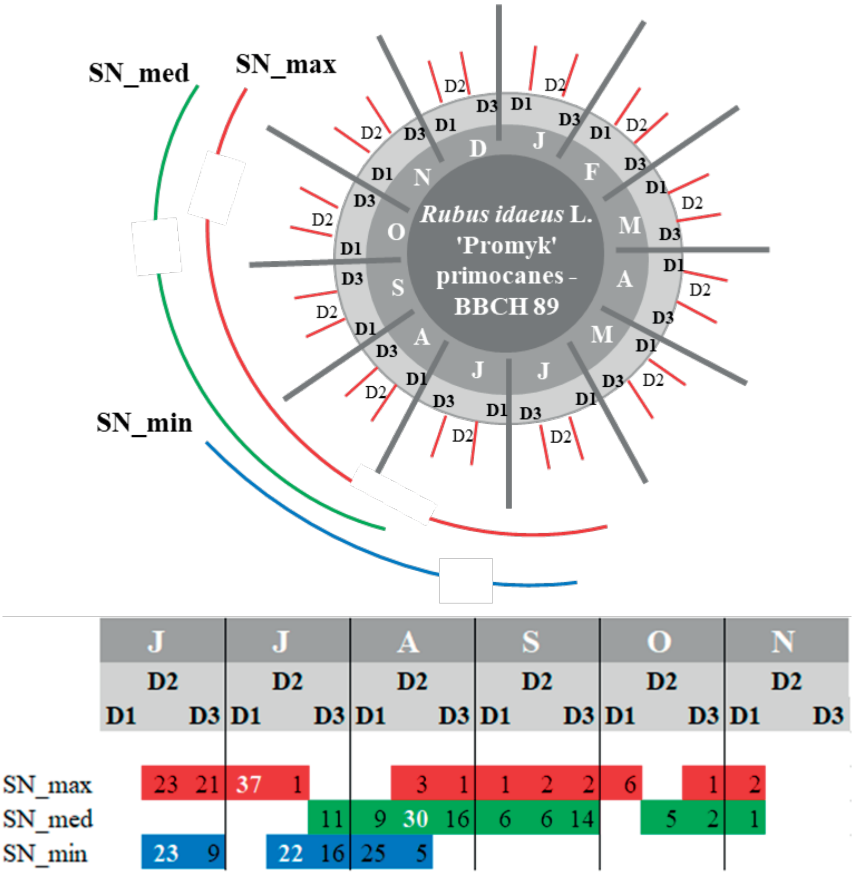

Figure 4. Productivity percentages of ripened fruits BBCH 89 in each decade of the entire vegetation period dependent of the nutrition area. Nutrition area was set as SN_max - Maximum, SN_med - Average or medium and SN_min -Minimum

On an average nutrition surface, fruit harvesting was carried out over 10 decades (Figure 4). The beginning of the BBCH 89 stage was observed in July D3 with a maximum harvest value of 30% in August D2 and an interruption during the first decade of October. The ending of fruit harvesting was recorded in the first decade of November and was similar to that in the variant with maximum nutrition surface.

A minimum nutrition surface accelerated the ripening and harvesting period, and this stage was fully achieved over six decades. Fruits started to be harvested similarly to those on a maximum nutrition surface in June D2, with 23%, very close to July D2, with 22%, and ended in August D2 (Figure 4).

CONCLUSIONS

The development of phenological principal and secondary growth stages depend greatly on temperature and precipitation conditions.

The nutrition area produced a specific dynamic of raspberry growth and development. The vegetation period for the raspberry grown in an average nutrition area was the most efficient at a medium GDD. During the entire growth vegetation season, the GDD was proportional to the plant nutrition area; higher GDD was registered for SN_max and lower at SN_min.

After the first year of experiments, it could be recommended to plant at a maximum nutrition area of 100 cm between plants for faster raspberry fruit appearance and ripening.

Raspberry planted at a 75 cm nutrition area provide in the first vegetation year continuous harvesting in time and optimal physiological development. These results would be updated with the next years trends to establish the reason of this results, if the plants were stressed or if this recommendation stand for the stakeholders.

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