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Portulaca oleracea L.: genotypes phenology and thermal sum in tropical climate

Portulaca oleracea L.: fenologia e soma térmica de genótipos em clima tropical

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ABSTRACT: *Portulaca oleracea* L., known as purslane, is an unconventional food plant rich in nutrients and medicinal properties, with potential for consumption and commercialization. The objective was to describe phenological stages of purslane based on BBCH (*Biologische Bundesantalt, Bundessortenamt and Chemische Industrie*) scale and thermal sum at different times. Evaluations were made from two genotypes, the Golden variety and an access. Plants were observed during six consecutive periods, interspersed every two months. Thermal sum and base temperature were obtained considering the average temperature from seedling emergence to flowering and dispersion of the first capsule in 50% of the plants. The phenological cycle of *Purslane* based on the BBCH scale shows seven main stages, subdivided into secondary stages: germination (0); leaf development on the main branch (1); development of lateral branches (2); development of flower buds (5); flowering (6); seed dispersal (8); and senescence (9). The lower base temperatures (Tb) determined to flowering were 10 to 15 ºC for the variety Golden and access, respectively, since for seed dispersal, Tb was 9 and 13 ºC, respectively. Thermal requirements for Golden variety are 421.3 GD for flowering and 644.2 GD for seed dispersal, while for access they are 239.7 and 407.0 GD, respectively. *Purslane* as a food plant can be produced throughout the year in tropical region and may be best used if harvested until the plants reach 12 or 10 leaves.

Keywords: BBCH Codification. Degree days. Non-conventional food plants. Purslane.

RESUMO: *Portulaca oleracea* L., conhecida como beldroega, é uma planta alimentícia não convencional, rica em nutrientes e propriedades medicinais, com potencial para consumo e comercialização. O objetivo foi descrever estágios fenológicos da beldroega com base na escala BBCH (*Biologische Bundesantalt, Bundessortenamt* e *Chemische Industrie*) e a soma térmica em diferentes épocas do ano. As avaliações foram feitas a partir de dois genótipos, a variedade Golden e um acesso. As plantas foram observadas durante seis períodos consecutivos, intercalados a cada dois meses. A soma térmica e a temperatura base foram obtidas considerando a temperatura média da emergência das plântulas ao florescimento e dispersão da primeira cápsula em 50% das plantas. O ciclo fenológico da beldroega com base na escala BBCH apresenta sete estágios principais, subdivididos em estágios secundários: germinação (0); desenvolvimento foliar no ramo principal (1); desenvolvimento de ramos laterais (2); desenvolvimento de botões de flores (5); floração (6); dispersão de sementes (8); e senescência (9). As menores temperaturas base (Tb) determinadas para o florescimento foram de 10 a 15 ºC para a variedade Golden e acesso, respectivamente, já para a dispersão de sementes, a Tb foi de 9 e 13 ºC, respectivamente. Os requisitos térmicos para a variedade Golden são de 421,3 GD para o florescimento e 644,2 GD para a dispersão de sementes, enquanto que para o acesso são de 239,7 e 407,0 GD, respectivamente. A beldroega pode ser produzida ao longo de todo ano em regiões tropicais e pode ser melhor utilizada se colhida até que as plantas atinjam 10 ou 12 folhas.

Palavras-chave: Beldroega. Codificação BBCH. Graus dia. Plantas alimentícias não convencionais.

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INTRODUCTION

Purslane is an edible succulent plant that belongs to the Portulacaceae family, it is known as an unconventional food plant in Brazil (KINUPP; LORENZI, 2014) and used for medicinal and food purposes in many regions of the world, mainly by traditional populations (KUMAR *et al*., 2021). The species is rich in omega 3 (SIMOPOULOS *et al*., 1992; NEMZER *et al*., 2020); omega 6 (MARTIN *et al*., 2006); beta carotene, vitamins A, C and E and especially contains high levels of antioxidants (SIMOPOULOS *et al*., 1992; SICARI *et al.,* 2018; WANG *et al*., 2021). In addition, purslane is a potential vegetable that can contribute to the prevention of degenerative brain diseases (MONEIM *et al*., 2013); diabetes (LEE *et al*., 2012); ovarian cancer (YOUGUO, 2009) and potential to be consumed as a food ingredient for nutraceutical applications (NEMZER *et al*., 2020).

Purslane have potential property that makes an alternatively for cultivation and regular consumption (BOTREL *et al*. 2020), despite being widely distributed throughout the world, there are no studies that establish development patterns of the species, especially in tropical climate regions with high temperatures not supported by many conventional plants. In the central region of Brazil *Purslane* occurs spontaneously in the middle of conventional crops and is treated as an undesirable plant, despite that, *Purslane* is an important food source and should be better used. Knowledge and standardization of the main phenological cycles of the species and development according to the daily temperatures in tropical climate can contribute to better use of purslane. This species may be consumed as a leafy vegetable; the stalks used in the form of pickles and the seeds can be used to bread fabrication (KINUPP; LORENZI, 2014). The early harvest favors greater use of the plant's nutritional compounds (PETROPOULOS *et al*., 2019)

The BBCH (*Biologische Bundesantalt, Bundessortenamt e Chemische Industrie*) scale is applied to the description of various fruit, forest, vegetable, ornamental and weed species, as Japanese tomatoes (ACOSTA-QUEZADA *et al*., 2016); safflower (FLEMMER *et al*., 2014), quinoa (SOSA-ZUNIGA *et al.,* 2017) and forage legumes (ENRIQUEZ-HIDALGO *et al*., 2020). The scale is based on a sequential coding of main and secondary stages (BLEIHOLDER *et al.,* 1991). Each of the main codes is subdivided into ten secondary stages and in case of detailing of secondary stages, an intermediate code can be added to more phenology accurate description.

Temperature is the main factor that interferes on the plant life cycle and determines the start and duration of phenological events (OLIVIER; ANNANDALE, 1998; AHMAD *et al.,* 2021). The relationship between rate of development and temperature can be quantified by models, based on cardinal base (Tb) and maximum (Tmax) temperatures, below or above them, respectively, plant development does not occur. At the optimum temperature (To) development is faster. From the base temperature, the thermal sum in degrees days (GD) is determined to assign a heat value to each day of plant growth and is usually to provide an estimate of the amount of seasonal growth (MILLER *et al.,* 2001). Phenology standardization and daily growth rate of plants can contribute to the plant utilization and introduction of new vegetables, as in *Purslane.* The aim of this study was to propose phenological description of *Purslane* based on the BBCH scale and to establish base temperature and daily thermal sum for the beginning of the principal phenological events of the species.

2 MATERIAL AND METHODS

2.1 SEED COLLECTION AND ACQUISITION, CLIMATIC CHARACTERIZATION OF THE STUDY REGION AND PLANT CULTIVATION

Mature seeds of two genotypes of purslane were used in the experiment, a commercial variety Golden and a frequent spontaneous genotype of occurrence in the Brazil Central region, called as access. The plants were evaluated during the years 2015 and 2016, considering six growing seasons: 1 (Sep/Oct - 2015); 2 (Nov/Dec - 2015); 3 (Jan/Feb - 2016); 4 (Mar/Apr - 2016); 5 (May/Jun - 2016); 6 (Jul/Aug - 2016), where the plants were kept in full sun.

The experiment was carried out in the central region of Brazil, in the state of Mato Grosso in the reference coordinates: latitude of 15º 61 'S, longitude of 56º 10' W and altitude of 145 m. The region's climate according to the Koppen classification is Aw, with a maximum annual temperature of 33 ºC and a minimum of 22 ºC, on average in the last ten years (INMET, 2021). The region has well-defined rainy and dry seasons; in the dry season, temperatures can reach 40 ºC or more and the relative humidity of the air remains close to 20% during the period, based on meteorological data from stations located in the Brazil Central.

The average temperatures during the growing seasons were around 30 °C, except in the 5 and 6 seasons, in the coldest period of the year, where the averages were below 30 °C and the minimum temperatures reached 15 °C. Precipitations were concentrated in the 2nd, 3rd and 4th seasons, in other sowing high temperatures and little precipitation prevailed (Figure 1). Events of temperature, relative air humidity and precipitation were obtained through the database of the Meteorological Institute (INMET, 2021) and the Space Research Institute (INPE, 2021) of the respective meteorological stations located in the central region of Brazil.

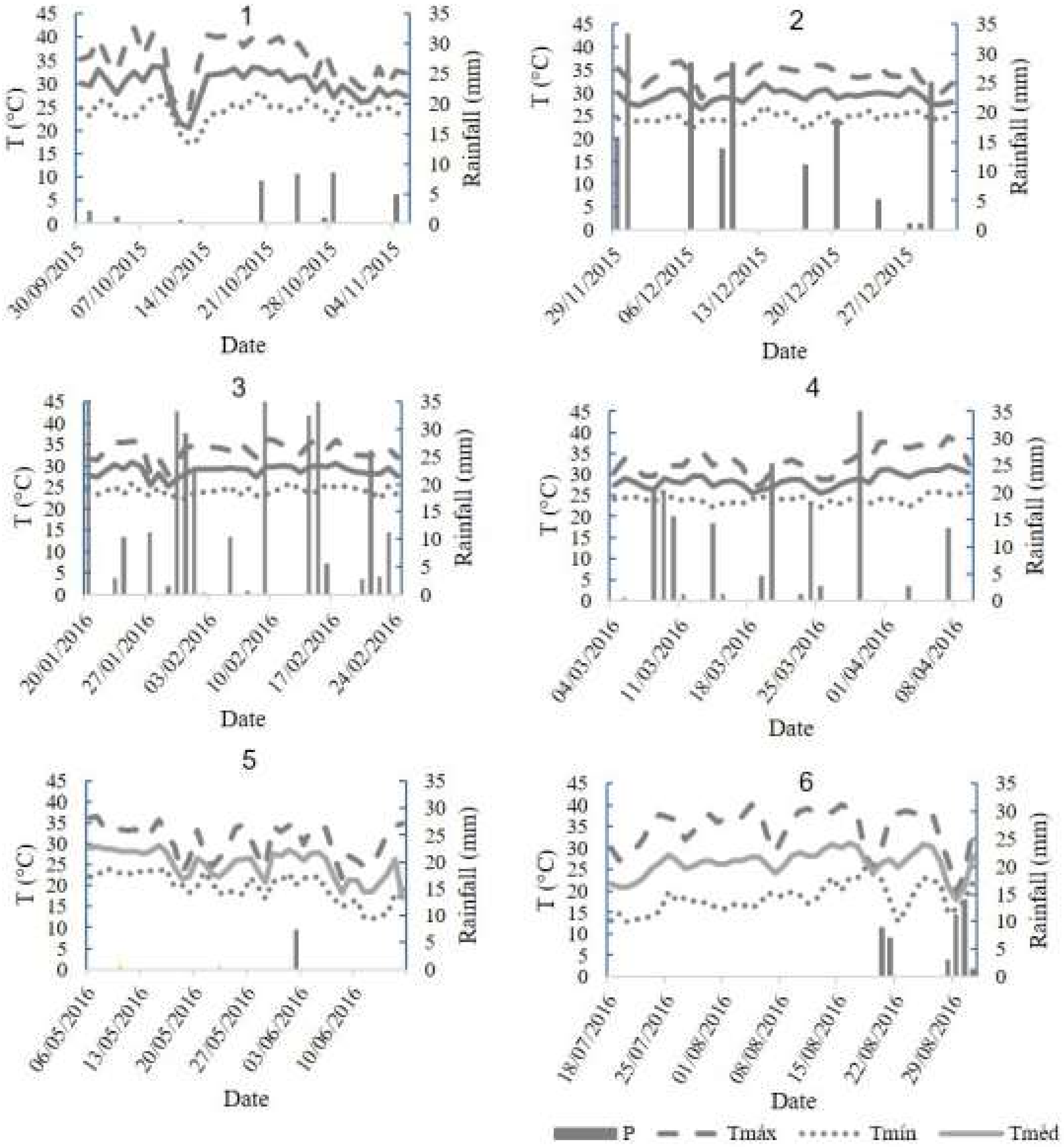

Figure 1. Maximum, medium and minimum temperatures; relative air humidity and daily rainfall for period of grow purslane plants, during the years 2015 and 2016. 1, 2, 3, 4, 5 and 6 correspond to the seasons (Sep / Oct), (Nov / Dec), (Jan / Feb), (Mar / Apr), (May / Jun) and (Jul / Aug), respectively
Fonte: (INMET, 2021; INPE, 2021).

Photoperiod in the region varies according to the seasons, with higher values during late spring, in the months of October and November and in the beginning of summer, in the months of December and January (Figure 2). The photoperiod was obtained by the equation:

$$N= 0.1333 \text{ arccos } (- \text{tg } \delta . \text{ Tg } \phi) \quad \text{(Eq. 1)}$$

$$\delta = 23.45 \text{ sen } [360/365 \text{ (DJ-81)}] \quad \text{(Eq. 2)}$$

Where: N: photoperiod in hours; δ: solar declination, in degrees; ϕ: latitude of the location, in degrees; DJ: Julian day, order number from January 1st.

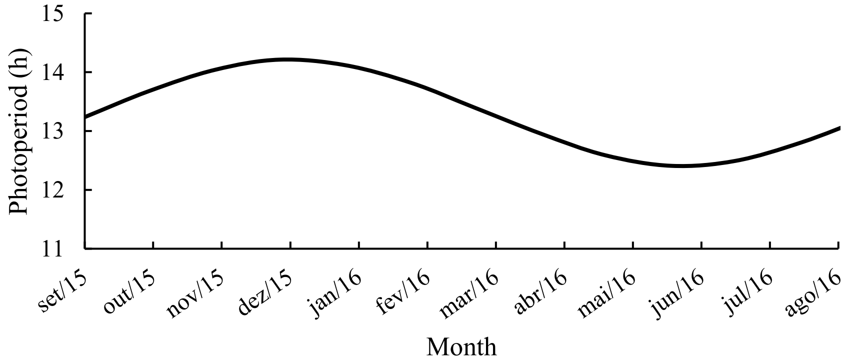

Figure 2. Photoperiod (N) of the central region of Brazil during cultivation period of purslane.

Ten plants of each genotype were arranged in a completely randomized design and grown in pots with a capacity of 5 liters filled with soil, bovine manure, carbonized rice in the proportion of 2: 1: 1 and 5 g L $^{-1}$ of formulated fertilizer (04-14-08). Sowing was consecutive, interspersed every two months and the plants were kept in full sun throughout the experiment. Irrigations were performed daily. Chemical and granulometric analyzes of the substrate were determined by Embrapa (1998) (Table 1).

Table 1. Chemical and granulometric characterization of the substrate used in phenological evaluations of purslane

pH	P	K	Ca	Mg	Al	H	CTC	V	Mo	Sand	Silt	Clay
$CaCl_2$	mg dm^{-3}		cmol$_c$ dm^{-3}					%	g dm^{-3}	g kg^{-1}		
5.0	1021.0	509.0	21.0	7.4	0.0	6.7	36.5	81.5	98.7	690.0	66.0	244.0

MO: Organic matter. CTC: cation exchange capacity; V: base saturation

BBCH scale (MEIER *et al.*, 2009) was applied based on daily observations, written and photographic records of plant phenology and the codification of phenological stages divided into major and subdivisions of secondary and tertiary levels was determined, when necessary.

2 STATISTICAL ANALYSIS

The lower basal temperature (Tb) was determined for both genotypes, using thermal sum method (Ometto, 1981), where basal temperatures between 1 and 18 °C were previously selected. The daily thermal sum was calculated using the following equations:

$$If\ Tb \geq TM \geq Tm \qquad GD = 0; \qquad \text{(Eq. 3)}$$

$$If\ TM \geq Tm \geq Tb \qquad GD = \frac{TM+Tm}{2} - Tb \qquad \text{(Eq. 4)}$$

$$If\ TM \geq Tb \geq Tm \qquad GD = \frac{(TM-Tb)^2}{2(TM-Tm)} \qquad \text{(Eq. 5)}$$

Where, DG: Degrees-day; TM: maximum daily air temperature (° C); Tm: minimum daily air temperature (°C); Tb: lower base temperature (°C).

Subsequently, the base temperature of each genotype corresponded to the lowest standard deviation, according to Arnold (1959), as follows:

$$Sd = Sdd\ /\ (Xt - Tb) \qquad \text{(Eq. 6)}$$

Where, Sd: standard deviation in days; Sdd: standard deviation in degrees days; Xt: medium temperature for all seasons; Tb: base temperature.

The accumulated degree-days for the flowering and seed dispersal stages was calculated in each sowing period, considering the day of the event in at least 50% of the plants. The data were evaluated using Excel software.

3 RESULTS AND DISCUSSION

According to the BBCH scale, the development cycle of *Purslane* was divided into seven main stages, from seed germination (stage 0) to plant senescence (stage 9). Vegetative phase included germination (stage 0), leaf development in the main branch (stage 1) and development of lateral branches (stage 2). Reproductive phase included appearance of flower buds (stage 5), flowering (stage 6) and seed maturity and dispersal (stage 8) (Table 2). Other main stages existing in the coding of the BBCH scale did not apply to purslane.

Table 2. Phenological stages description of purslane according to the BBCH scale

Code	Description
Main stage 0: Seed germination	
00	Dry seed
01	Beginning of seed imbibition
03	Seed imbibition complete
05	Primary root visible output
07	Hypocotyl and cotyledons break integument
09	Emergence of cotyledons
Main stage 1: Leaf development on the main branch	
10	Cotyledons completely open
11	First pair of fully opened true leaves
12	Second pair of fully opened true leaves

13	Third pair of fully opened true leaves
1.	The stadiums continue to ...
16	Six pairs of fully opened true leaves
Main stage 2: Development of lateral branches	
211	First pair of first order lateral branches
212	Second pair of first order lateral branches
213	Third pair of first order lateral branches
214	Fourth pair of first order lateral branches
215	Fifth pair of first order lateral branches
221	First pair of second-order lateral branches
22.	Stadiums continue to ...
229	Nine or more pairs of second-order lateral branches
231	First pair of third-order lateral branches
23.	Stadiums continue to ...
2NX	N pairs of lateral branches X order visible
Main stage 5: Flower bud development	
501	First floral bud at the apex of the main branch
502	Second floral bud at the apex of the main branch
503	Third floral bud at the apex of the main branch
50.	The stadiums continue to ...
509	Nine or more flower buds at the apex of the main branch
511	First floral bud on one of the first order side branches
521	First floral bud on one of the second order side branches
5.	The stadiums continue to ...
551	First floral bud on one of the fifth order lateral branches
Main stage 6: Flowering	
601	First flower opened at the apex of the main branch
602	Second flower open at the apex of the main branch
603	Third flower open at the apex of the main branch [1]
611	First flower opened on one of the first order lateral branches [1]
621	First flower opened on one of the second order lateral branches [1]
6.	The stadiums continue to ...
651	First flower opened on one of the fifth order lateral branches [1]
690	Full flowering; all orders of lateral branches feature at least one open flower [1]
Main stage 8: Seed dispersal	
801	First capsule in the main branch with hard black seeds
802	Second capsule in the main branch with hard black seeds
803	Third capsule in the main branch with hard black seeds
8.	The stadiums continue to ...
809	Nine or more capsules in the main branch with hard black seeds
811	First capsule in one of the first order side branches with hard black seeds
821	First capsule in one of the second order side branches with hard black seeds
8.	The stadiums continue to ...
851	First capsule in one of the fifth order side branches with hard, black seeds
890	Full maturation; all orders of lateral branches have at least one capsule with hard black seeds
Main stage 9: Senescence of plants	
93	30% defoliation of the plant
95	50% defoliation of the plant
97	70% defoliation of the plant
99	100% defoliation of the plant

[1] Solitary purslane flowers open individually, only once; therefore, no more than three flowers were found open at the same time on the same branch.
Source: Meier *et al*. (2009).

3.1 MAIN STAGE 0: SEED GERMINATION

This stage covered the purslane germination, from the dry seed phase to the emergence of cotyledons. Stage 00 or 000 was characterized by seeds still dry (Figure 3A and B); the start of the imbibition comprised stage 01 or 001. Main stage 0 was completed with the exit of the cotyledons from the soil surface (stage 09) which took place one day after sowing (DAS) for Golden and two DAS for access.

Figure 3. Phenological stages of two genotypes (Golden variety and access of spontaneous occurrence in central Brazil) of purslane according to the BBCH scale. A, D, F, H, J, L, O and Q correspond to the Golden variety.

3.2 MAIN STAGE 1: LEAF DEVELOPMENT ON THE MAIN BRANCH

This stage was characterized by development of leaf pairs in the main purslane branch, main stage 1 started with the event of the complete opening of the cotyledons (stage 10) (Figure 3C), which remained persistent throughout the plant cycle. The next secondary stages continued with the development of leaves, always from the base to the plant apex, until between seven and eight pairs of leaves were completed. The first pair of fully expanded true leaves (stage 11) (Figure 3D and E) of the two genotypes occurred between five and eight DAS and the maximum number of leaves in the main branch was between 14 and 16.

3.3 MAIN STAGE 2: DEVELOPMENT OF LATERAL BRANCHES

This stage was determined by the development of lateral branches in the plants and was necessary to use three codes, for better detailing of the secondary stages. In both genotypes, the first order lateral branches always developed in the axils of each leaf present in the main branch, except in the rosette (Figure 3F and G); likewise, the second order of lateral branches appeared in the leaf axils of the first order and so on.

Golden variety developed up to the first pair of lateral branches of third order (stage 231), while plants of the access to the first pair of lateral branches of fifth order (stage 251). The first pair of lateral branches always occurred from the buds located in the axils of the persistent cotyledons (stage 211). This stage occurred in parallel with stage 5, where flower buds production was verified even before the second order of lateral branches developed.

3.4 MAIN STAGE 5: DEVELOPMENT OF FLOWER BUDS

This stage was characterized by development of flower buds on the main branch and in each order of lateral branches, where beginning occurred at the moment when the first floral bud was seen at the apex of the main branch (stage 501) (Figure 3H and I) and continued with the development of some floral buds in this branch and then in the lateral branches, until the last order.

In purslane appearance of flower buds, flowering and seed maturity and dispersal has always occurred first in the main branch and proceeded, neatly, in the lateral branches. The plants presented first floral bud when minimum number of leaves in the main branch was 12 for Golden and 10 for access; the number days required for the beginning of stage 5 varied from 17 to 22 and 13 to 19 DAS for Golden and access, respectively.

For both genotypes, phenological phases were fast in all periods, with no marked differences between them. For Golden, the beginning of flowering varied from 17 to 22 days, with a more time to flowering in the last two seasons, during the months of May/Jun and Jul/Aug, coinciding with the smaller temperatures and shortest photoperiod. For access, this period varied from 13 to 19 days and increased time to flowering also in the last two seasons.

3.5 MAIN STAGE 6: FLOWERING

The beginning of the main stage 6 was determined with anthesis of the first flower in the apex of the main branch (stage 601) (Figure 3J and K), occurred in an orderly manner, first in the main branch and then in the lateral branches, from the apex to the base of the plants (Figure 3L), until full flowering. The species presented open sessile and solitary yellow flowers for both genotypes in all orders of lateral branches (Fig 3M).

In warmer seasons, the flowers were visited by bees of the genera *Megachilidae*, *Halictidae* and *Apidae*; anthesis always occurred in the morning, between 8:00 and 9:00 am local time, after the incidence of light on the plants and remained open for about two hours. Each flower opened only once and on cloudy days there was no anthesis. In conditions of milder daily temperatures and cloudy days, as in the time of May/Jun, the plants only open the flowers until conditions of light and temperature were favorable (ICHIMURA; SUTO, 1998).

3.6 MAIN STAGE 8: SEED DISPERSAL

Stage 8 started with the first capsule dispersed at the apex of the main branch (stage 801) (Figure 3N). Seeds were ready for dispersion between 11 and 17 and between 9 and 13 days after anthesis for Golden variety and access, respectively; and between 30 and 45 and 26 and 35 DAS for genotypes 1 and 2, respectively. In general, there was greater production of capsules in the main and lateral branches of the two genotypes in the periods of Nov/Dec - 2015 and Jan/Feb - 2016, a period in which the length of the day was longer (Figure 2) and the average temperatures of 28ºC. The seeds in the dispersion phase were hard and had a black color in the moment which the capsules showed an abscission region (Figure 3O). Golden seeds presented 1.1 ± 0.3 mm in diameter while access seeds presented 0.7 ± 0.2 mm. The average number of seeds per capsule for Golden and access was 73 (between 20 and 118) and 100 (between 65 and 115), respectively.

3.6 MAIN STAGE 9: SENESCENCE OF PLANTS

The main stage 9 for purslane was determined based on the defoliation levels of the plant, starting at 30% (stage 93), proceeding up to 50, 70% (Figure 3P) and ending when the plants showed total defoliation (stage 99) (Figure 3Q). In this study, after the dispersion of the capsules, the plants entered in senescence, characterized by the yellowing of the leaves and defoliation of all branches, the end of the cycle occurred from the end of senescence.

The species purslane is efficiently propagated sexually, due to the large number of seeds produced individually by the plants, a single individual can produce more than 10,000 seeds. Despite this, recent studies have shown the ease of multiplication of the species also by cuttings (ALAM *et al*., 2014), which can contribute to obtaining vegetative parts, a desirable characteristic in the sale of leafy vegetables.

For better use, the species can be harvested before flowering, in the main stage 6. The speed with which the plant reaches the flowering stage is not a desirable characteristic for a vegetable, since the plants start from that moment to invest in seed production, however, *Purslane* has not stopped the development of lateral branches after stage 5.

This variation in the vegetative period and the beginning of the reproductive period may be due to the mainly temperature conditions during the seasons (Figure 1), as in *Arabidopsis thaliana*, which is induced to flowering when the temperature rises moderately from 23 ºC to 27 ºC, regardless of the photoperiod (BALASUBRAMANIAN *et al*., 2006). However, small photoperiodic variation may have contributed to the smaller vegetative period in the seasons of Nov/Dec and Jan/Feb, in this case, a more detailed investigation is needed.

Anthesis did not occur in May/Jun, possibly because the days were mild, with an average of 22 ºC during the flowering period and there were many days with cloudiness, purslane does not blooms on cloudy days and temperatures below 21 ºC.

Regarding plant senescence, there was a proliferation of the fungus *Wilsoniana portulacae* (DC.) Thines. in the plants of both genotypes in all growing seasons, especially in the period from November to February, when greater rainfall was recorded, this may have influenced the defoliation of the plants. The phytopathogen has already been reported to cause damage in purslane plants (VRANDEČIĆ *et al*., 2011; HAQ *et al*., 2015; NAGARAJU; MANOHARACHARY, 2018), however, efficient forms of control are not described. The phytopathogen was responsible for causing pustule-like infections, with a powdery aspect and consequent leaf fall, leading the plants to total defoliation (VRANDEČIĆ *et al*., 2011; HAQ *et al*., 2015).

The species *Albugo candida,* as well as *W. portulacae,* belongs to the family Albuginaceae and is known to cause serious damage in cruciferous. According to Verma *et al*.

(2015), the optimum temperature for the development of an *A. candida* breed is 21 ºC. However, it can develop up to 29ºC. In view of this, the average temperatures close to 27 ºC during Nov/Dec seasons in 2015, Jan/Feb and Mar/Apr in 2016 and the higher relative humidity may have favored infection *W. portulacae*, as well as in *A. candida*.

In this study, therefore, after capsules dispersion, the plants went into senescence and death of most plants was not verified. Zimmerman (1976) reported that purslane goes through a stage of declining growth, characterized by the standstill of development, after the formation of the fifth order of lateral branch and seed maturity. This phase can last up to four months under controlled conditions of temperature and lower luminosity, in a greenhouse, right after this phase, the plants can to present new buds (ZIMMERMAN, 1976).

Base temperature (Tb) determined for Golden variety and access was 10 and 15 ºC, respectively, to complete the flowering phase. Since the seed dispersion phase, Tb was 9 and 13 °C respectively. Golden variety showed lower Tb, characteristic possibly consistent with the story of life cycle in other regions, unlike access, with highest Tb, being spontaneous in the central region of Brazil, where high temperatures prevail. For bitter grass, a spontaneous tropical species that has a C4 cycle, as well as purslane access, the base temperature determined was also 15ºC (VASCONCELOS *et al*., 2012). For grasses of the genus *Pennisetum*and *Cynodon*, Tb was 15 and 12 º C, respectively (NOVA *et al.,* 2007). For non-spontaneous species, as a corn tropical accessions, base temperature varied from 7.1 to 13 °C, next to the purslane limits (ARISTA-CORTES *et al.,* 2018).

The beginning and duration of the vegetative, flowering, seed dispersal and senescence cycles of the plants varied according to the planting date (Figure 4), where the two genotypes showed similarities regarding to the duration of the cycles.

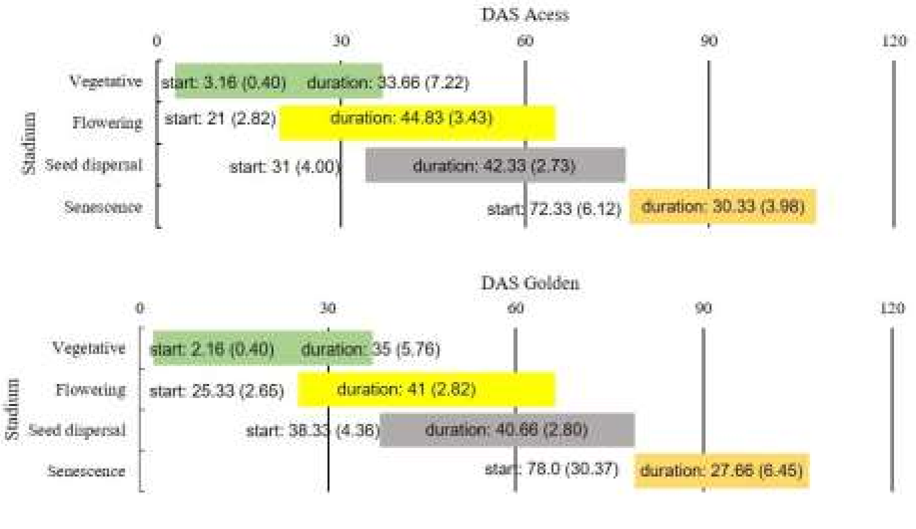

Figure 4. Graphical representation of the beginning and duration of the main phenological events of the Golden variety and the access of purslane. cultivated in central Brazil. DAS: days after sowing; values in parentheses represent standard deviations.

The thermal sum for the beginning of flowering of the Golden variety varied from 421.3 and 489.8 GD and for the accession from 239.7 and 270.2 GD, whereas the thermal sum to achieve seed dispersion was between 644.2 and 770.4 and 407.0 and 485.4 GD, respectively (Table 3).

Table 3. Observation period, number days related to the period (N) and accumulated thermal sum (ΣGD) for plants of Golden variety and accession of purslane growing during 2015 and 2016 in central Brazil

Genotype	Time	Initial date	Final date	Number days	∑GD
			Flowering		
Golden	1	30/09/2015	24/10/2015	24	489.8
	2	29/11/2015	21/12/2015	22	421.3
	3	20/01/2016	13/02/2016	24	451.2
	4	04/03/2016	29/03/2016	25	444.4
	5	06/05/2016	03/06/2016	28	455.2
	6	18/07/2016	16/08/2016	29	482.6
			Seed dispersal		
	1	30/09/2015	05/11/2016	37	745.0
	2	29/11/2015	31/12/2016	33	644.2
	3	20/01/2016	24/02/2016	36	696.4
	4	04/03/2016	09/04/2016	37	705.8
	5	06/05/2016	16/06/2016	42	664.4
	6	18/07/2016	31/08/2016	45	770.4
			Flowering		
Access	1	30/09/2015	20/10/2015	20	270.1
	2	29/11/2015	17/12/2015	18	239.7
	3	20/01/2016	08/02/2016	19	245.9
	4	04/03/2016	24/03/2016	20	243.3
	5	06/05/2016	30/05/2016	24	251.6
	6	18/07/2016	12/08/2016	25	270.2
			Seed dispersal		
	1	30/09/2015	28/10/2016	29	466.7
	2	29/11/2015	25/12/2016	27	407.0
	3	20/01/2016	17/02/2016	29	433.0
	4	04/03/2016	01/04/2016	29	404.4
	5	06/05/2016	09/06/2016	35	421.1
	6	18/07/2016	23/08/2016	37	485.4

Both number days and thermal sum accumulated for purslane plants were lower in the second season, coinciding with the period of greatest photoperiod (Figure 2). In this work, it was observed that the duration of the main phenological phases in purslane can be related not only to the temperature, in which, there may be a shorter duration of the stages in periods of greater photoperiod.

The minimum number of leaves required for purslane plants flowering was 12 for commercial variety and 10 leaves for spontaneous plants. Most plants have a juvenile stage that prevents floral induction until a certain stage of development is reached, which allows the plant to have sufficient resources to be able to support the flower and the fruits (JACKSON, 2009). In many plants this period may be associated with phenotypic and genotypic characteristics

(JACKSON, 2009; WINGLER, 2018). The juvenile phase in purslane can have a very short duration, until enough leaves are reached. In this context, a form of utilization of purslane plants as a food plant is the cultivation throughout the year in tropical regions, with large-scale sowing and harvest before flowering, until that the plants reach 12 or 10 leaves. However, our study allows to the choice of species management, according to the cultivation purpose.

4 FINAL CONSIDERATIONS

The phenological cycle of purslane based on the BBCH scale involves seven main stages, subdivided into secondary stages, they are: germination (0); leaf development on the main branch (1); lateral branches formation (2); appearance of flower buds (5); flowering (6); seeds dispersal (8) and senescence of plants (9).

The lower basal temperatures determined by thermal sum method for phase that precedes flowering in purslane plants are 10 and 15 ºC for Golden variety and the access, respectively; to reach seed dispersal, the plants present temperature base of 9 and 13 ºC, respectively. Thermal requirements for Golden variety and access are 457.46 and 253.49 GD for anthesis and 704.39 and 436.30 GD for seed maturity, respectively.

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