Progress in the study of phenology cholupa (*Passiflora maliformis* L.) in producing areas of Colombia

Avances en el estudio de la fenología de la cholupa (*Passiflora maliformis* L.) en áreas productivas de Colombia

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Fruit of cholupa, which was followed phenologically.  
Photo: Z. Molano-Avellaneda

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**Short title:** STUDY OF PHENOLOGY FOR CHOLUPA

**Doi:** [https://doi.org/10.17584/rcch.2020v14i1.11251](https://doi.org/10.17584/rcch.2020v14i1.11251)
Received for publication: 23-02-2020  Accepted for publication: 30-03-2020

Abstract
The cholupa or stone granadilla (*Passiflora maliformis* L.) is one of the eight cultivated species of the genus *Passiflora* L. However, knowledge about the phenological development of this species has not been investigated. This study aimed to assess some aspects of phenology of cholupa growth in vegetative and reproductive phases in the town of Rivera (Colombia). For this, plant phenology during vegetative and reproductive phases of growth was evaluated by weekly measurements of length and number of stem nodes, primary and secondary branches, and longitudinal and transverse fruit diameter in commercial crops. The curves were obtained that describe the dynamics of growth of the main stem and primary and secondary branches and their respective equations by curve fitting technique, which was fitted to sigmoidal-logistic models with high statistical reliability. The time from anthesis to fruit maturity was between 50 and 60 days; the final longitudinal and transverse diameters averaged 54 and 53 mm, respectively. The phenological BBCH scale was established for the major phenological stages (E1: leaf development of the main stem, E3: stem elongation, E5 and E6: appearance and development of floral organs and flowering, and E7: fruit development). These aspects of cholupa development were similar to the ones reported for other *Passiflora* species and are very useful results to define agronomic practices in cultivation and breeding programs.

Additional key words: growth curves; development stages; BBCH; stone granadilla; *Passifloraceae.*

Resumen
La cholupa o stone granadilla (*Passiflora maliformis* L.) es una de las ocho especies cultivadas del género *Passiflora* L. Sin embargo, el conocimiento sobre el desarrollo fenológico de esta especie no se ha investigado. Este estudio tuvo como objetivo evaluar algunos aspectos de la fenología del crecimiento de cholupa en las fases vegetativa y reproductiva en la ciudad de Rivera (Colombia). Para esto, se evaluó la fenología de las plantas durante las fases vegetativas y reproductivas del crecimiento mediante mediciones semanales de la longitud y el número de nudos del tallo, ramas primarias y secundarias, y el diámetro longitudinal y transversal del fruto en cultivos comerciales. Se obtuvieron las curvas que describen la dinámica de crecimiento del
tallo principal y las ramas primarias y secundarias y sus respectivas ecuaciones mediante la técnica de ajuste de curvas, que se ajustó a modelos sigmoidales-logísticos con alta confiabilidad estadística. El tiempo desde la antesis hasta la madurez del fruto fue entre 50 y 60 días; los diámetros longitudinales y transversales finales promediaron 54 y 53 mm, respectivamente. La escala fenológica BBCH se estableció para las principales etapas fenológicas (E1: desarrollo de la hoja del tallo principal, E3: alargamiento del tallo, E5 y E6: apariencia y desarrollo de los órganos florales y floración, y E7: desarrollo del fruto). Estos aspectos del desarrollo de la cholupa fueron similares a los reportados para otras especies de Passiflora y son resultados muy útiles para definir las prácticas agronómicas en los programas de cultivo y reproducción. 

Palabras clave adicionales: curva de crecimiento; estados de desarrollo; BBCH; stone granadilla; Passifloraceae.

INTRODUCTION

La cholupa or stone granadilla (Passiflora maliformis L.) is one of the eight cultivated species of the genus Passiflora such as yellow passion fruit (Ocampo et al., 2015a; Hurtado-Salazar et al., 2020) and sweet granadilla (Ocampo et al., 2015b), and others with agronomic potential (Hurtado-Salazar et al., 2018). This species is native to Northern Ecuador, Colombia, Venezuela and the Antilles, and introduced to Europe as an ornamental plant under a greenhouse. The fruit are characterized by its high content of total phenols (277.00 mg gallic acid equivalent/L fresh weight-FW) and by its total antioxidant activity (1,685.00 μmol Trolox/L FW) (Fischer et al., 2018). The cultivation of the cholupa has become a line of economic and social importance in the department of Huila, Colombia, due to its high profitability and the generation of rural jobs, which can reach 648 wages per hectare for a three-year cycle. Cholupa is grown commercially in 14 municipalities with about 200 ha, Rivera being the main. In Huila, around 1,200 t of fruit were produced in 2018 (Agronet, 2019), of which 10% corresponds to pre or post-harvest losses and 90% is destined for consumption in the regional market as fresh fruit, mainly in the preparation of juices. Production behavior throughout the year is continuous; it presents two marked harvest times: the first from October to January, the last two months being the ones with the highest production and the second from the first week of April to the end of May.
The effect of the physical, chemical and biotic environment on the physiological mechanisms of the plant is known as plant ecophysiology (Larcher, 2003). Cholupa in Colombia is cultivated between 600-1,000 m a.s.l. (Ocampo et al., 2015a), temperatures between 26 and 32°C with rainfall between 1,200 and 1,450 mm, and relative humidity between 60 and 70% and 8-11 h light/d (Fischer et al., 2018). These ecological conditions greatly affect the duration of the phenological stages of the plant (Fischer et al., 2009).

The study of biological events and the causes of their occurrence as a function of biotic and abiotic factors, as well as their relationship between the phases characterized by these events, within one or more species, is known as phenology (Silva et al., 2007). Phenological characterization through stages of the phenophases (vegetative and reproductive) allows greater detail in the description of plant cycle, helping in the prediction of seed collection for seed production and in the conservation and breeding programs of species (Rego et al., 2006). Furthermore, phenological identification of growth stages of mono- and dicotyledonous plant species, the extended BBCH scale has been used, derived from its acronym Biologische Bundesanstalt, Bundessortenamt und Chemical Industry (Meier, 2001). The scale has 10 main stages or longest plant development stages clearly identifiable and visible, starting with the budbreak (stage 0) and ending with the latency period (stage 9); intermediate values include leaf development, buds, flowers, fruit development and subsequent ripening: Secondary stages are also listed from 0 to 9 and related to ordinal or percentage values of development (Mayor, 2011). Another useful tool to identify the physiological behavior of fruit species are the growth curves and development events, which are genetically determined, hormonally regulated and can be modified by the environmental conditions (Garriz et al., 2005). Likewise, they allow to strengthen knowledge about a system (López et al., 2005), evaluate possible management strategies, and make an approach of the potential yield (Cañizares et al., 2003). Among the non-linear models used to characterize growth and/or development as a function of time, the logistic, the exponential, and the monomolecular models stand out (García, 2008; Moreno-Medina et al., 2016; Almanza-Merchán et al., 2017).

Although there is an empirical knowledge of cholupa producers about the duration and the time (in the year) where the most interesting phenological events take place (Ocampo et al., 2015a), these have not been described according to the BBCH scale, neither there is any information on growth and development under this climatic condition. Therefore, the present
study was proposed to identify the main phenological stages and its approximate times of duration in order to generate a guide that allows estimate some growth and development parameters, which contribute to achieve an integrated crop management.

MATERIALS AND METHODS

The study was carried out in the municipality of Rivera (02°44'29.4" N, 075°77'19.5" W), province of Huila (Colombia) located at 595 m a.s.l., during the period of December 2014 to December 2015. The curve of fruit growth was carried out on a commercial crop located in the municipality of Campoalegre (2°43'26.9" N, 75°15'50.7" W), located at 788 m a.s.l., with an average temperature of 27°C and a relative humidity of 65%. The plants from 15 d of age established at 4×4 m were evaluated under a trellis system, that consisted of a mesh of 2 m height, on which the different types of crop branches were conducted and fixed. The climate of the region is classified by Köppen as As, dry tropical, with dry summer. For the characterization of meteorological conditions during the experimental period, climatological data, relative humidity (RH, %) and temperature (°C) were obtained from datalogger weather sensors (Onset HOBO UX100-003 humidity and temperature data logger, MicroDAQ, Contoocook, NH) with a frequency of 6 h and an accuracy of 3.5%. The precipitation variable was taken with the climate databases (Wordclim) source.

From the 18 days after planting (DAP) of the selected plants, the following variables were recorded weekly during for 150 DAP: Length (cm) and the number of nodes of the main stem, primary and secondary branches. Subsequently, for the fruit growth curve, ten flowers were marked in anthesis and weekly records were taken of the longitudinal and the transverse diameter of ten fruits per plant until its ripening. For the growth variables considering the plant as the sampling unit. From the variables of each of the samples, growth was modeled using the logistic function (1)

\[
Y = \frac{\alpha}{1 + \text{Exp}(b - c \times X)}
\]

(1)

where \( \alpha \) the upper asymptote, is the maximum magnitude of the variable, \( c \) is the parameter that determines the slope of the curve, and \( b \) is the moment when the maximum growth rate is
achieved and $X$ is the time (Seber and Wild, 1989). Based on these coefficients, obtained by the STATISTIX 9, 2008 software, the growth curves for the plants established in the field were obtained. The BBCH-scale was used to identify the phenological development stages of plants.

RESULTS AND DISCUSSION

Behavior of climatic variables

Regarding the average temperature (Fig. 1A), an irregular behavior was observed with values between 21 and 30°C, with marked peaks for the months of February and March 2015 (39.4 and 37.3°C, respectively). Oscillating trend of relative humidity was observed throughout the months of evaluation; the lowest values in the month of February 2015 (Fig. 1B). During this period, a high rate of vegetative growth of the stem and primary branches was detected.

Differences were observed between daytime and nighttime temperatures with fluctuations of 19.7°C; likewise, at night the RH reached 99.8%, which was a positive condition for the occurrence of diseases, and during the day, it dropped to 32.2% with a difference of 67.7% between the 2 d. It should be noted that this low RH causes dehydration of pollen and stigmatic fluid, reducing the fertilization process and facilitating the flower abortion (Ocampo, 2013; Fischer et al., 2009).

![Figure 1](image-url)
Vegetative phase

During the vegetative phase, the development stages 1 (leaf development) and 3 (main stem elongation) were identified according to the BBCH scale (Meier, 2001). The times are presented in days after planting (DAP) averaging the date on which 50% of the plants reached each stage of development.

In the principal growth stage 1 (Tab. 1) it was possible to identify the secondary stages corresponding to the development of the third leaf (code 13) for day 6 DAP as well as the appearance of the fifth leaf (code 15) at 10 DAP until obtaining nine true leaves (BBCH code 19) for 17 DAP. Since that, the development of new leaves continued and it is possible to observe appearance of the first tendril accompanying leaves, which shows the characteristic climber habit of these species, being one of the parameters that the producers take into account to perform the transplant to the definitive place, in addition to determinate the height of the plant.

The cholupa is characterized as a liana whose growth is continuous, with lateral flowering and basitonic branching (Tovar, 2009). During its development, there is a moment from which lateral shoots begin to appear, in the basal portion, below and above the knot with the first tendril.

Growth and development of the principal stem

The plant is a climbing semi-perennial vine, with a cylindrical stem, glabrous or finely pubescent, green in color, striated, herbaceous and woody towards the base with up to 12 cm diameter (Ocampo et al., 2015a). At 23 DAP the main stem reached an average of 37.03 cm. From 30 DAP the plants increased the growth rate that at 88 DAP they reached a maximum length of 455 cm with a total of 68 nodes presenting an emission rate of 2.8 nodes per week (Fig. 2) and $R^2$ 0.91 (Tab. 2). Schwartz (2013) stated that the phenological stages are good indicators of plant development rates, and according to Angulo (2003), this behavior can be calculated by knowing the period that lapses since a node appearance until the appearance of the next node. At this time, the pruning was carried out, which consisted of making a cutting. The cut was made at the top of the node, in order to activate lateral buds, with the purpose of stimulating the emission of the primary branches.
Table 1. BBCH scale established for the growth and development of cholupa (*P. maliformis*) in Colombia.

| Phenological growth stages | BBCH | Description | DAP |
|----------------------------|------|-------------|-----|
| Total developed cotyledons | 10   | n.d         |     |
| Development of the first leaf | 11   | n.d         |     |
| Development of the second leaf | 12   | 6           |     |
| Development of the third leaf | 13   | 8           |     |
| Development of the fourth leaf | 14   | 10          |     |
| Development of the fifth leaf | 15   | 12          |     |
| Development of the sixth leaf | 16   | 14          |     |
| Development of the seventh leaf | 17   | 15          |     |
| Development of the eighth leaf | 18   | 17          |     |
| Development of the ninth leaf | 19   | 17          |     |

Principal growth stage 3: main stem development

| | BBCH | Description | DAP |
|----------------------------|------|-------------|-----|
| 10% of maximum length of the main stem | 31   | 25          |     |
| 20% of maximum length of the main stem | 32   | 34          |     |
| 30% of maximum length of the main stem | 33   | 42          |     |
| 40% of maximum length of the main stem | 34   | 47          |     |
| 50% of maximum length of the main stem | 35   | 52          |     |
| 60% of maximum length of the main stem | 36   | 57          |     |
| 70% of maximum length of the main stem | 37   | 66          |     |
| 80% of maximum length of the main stem | 38   | 71          |     |
| The main stem of the plant has reached 90% - 100% of its maximum length. | 39   | 80          |     |

Principal growth stage 5 y 6: inflorescence emergence and flowering

| | BBCH | Description | DAP |
|----------------------------|------|-------------|-----|
| Visible floral button | 51   | 90          |     |
| Floral cartridge with 50% of the characteristic size of the species | 55   | 95          |     |
| Maximum size of the floral cartridge | 58   | 99          |     |
| Beginning of flowering: 10% of flowers are open | 61   | 100         |     |
| Full bloom. 50% of flowers in anthesis | 65   | 108         |     |
| End of flowering: fruit set | 69   | 112         |     |

Principal growth stage 7: development of fruit

| | BBCH | Description | DAP |
|----------------------------|------|-------------|-----|
| Visible fruit | 70   | 114         |     |
| The fruit reaches 10% of the final size | 71   | 117         |     |
| The fruit reaches 20% of the final size | 72   | 121         |     |
| The fruit reaches 30% of the final size | 73   | 126         |     |
| The fruit reaches 40% of the final size | 74   | 132         |     |
| The fruit reaches 50% of the final size | 75   | 140         |     |
| The fruit reaches 60% of the final size | 76   | 150         |     |
| The fruit reaches 75% of the final size. | 77   | 161         |     |
| The fruit reaches 90% of the final size. | 78   | 173         |     |
| Fruit has reached typical form and size | 79   | 180         |     |

DAP = days after planting.
Figure 2. Length (A) and average number of nodes (B) of the main stem of cholupa (P. maliformis) plants.

Table 2. Equation of growth parameters of cholupa (P. maliformis) plants.

| Parameter                          | Equation                                                                 | Pseudo $R^2$ |
|------------------------------------|--------------------------------------------------------------------------|--------------|
| Length of the main stem            | $Y = \frac{615.66}{1 + \exp(3.5987 - 0.0525 \times DAP)}$               | 0.9165       |
| Number of nodes of the main stem   | $Y = \frac{153.38}{1 + \exp(2.8092 - 0.0327 \times DAP)}$               | 0.9181       |
| Length of the primary branches     | $Y = \frac{225.35}{1 + \exp(5.6968 - 0.1621 \times DAP)}$               | 0.8921       |
| Number of nodes of the primary branches | $Y = \frac{42.45815}{1 + \exp(2.7818 - 0.0899 \times DPA)}$     | 0.884        |
| Length of the secondary branches   | $Y = \frac{143.8392}{1 + \exp(2.7323 - 0.1934 \times DDP)}$             | 0.8137       |
| Number of nodes of the secondary branches | $Y = \frac{29.92532}{1 + \exp(1.79061 - 0.1115 \times DPA)}$ | 0.73         |
| Longitudinal diameter of the fruit | $Y = \frac{54.069}{1 + \exp(2.2440 - 0.4571 \times DDA)}$               | 0.8752       |
| Transverse diameter of the fruit   | $Y = \frac{54.361}{1 + \exp(2.8669 - 0.4888 \times DDA)}$               | 0.870        |
Growth and development of primary branches

The branches can reach up to 30 m in length, with knots and internodes of the which originates a lower bud, two linear provisions stipulated (orange), a leaf and a tendril that serve the plant to adhere to its support (Ocampo et al., 2015a). According to the typical behavior of passion flower crops, the growth of lateral shoots is a successive one, meaning that primary branches of vegetative type are generated from the main stem; after that, the secondary branches originate from nodes of the primary branches, which in the first production cycle make up the group called “loaders or producers” along with some tertiary branches, so these must be thicker to support the weight of the reproductive structures that would be fruits. The trends of the curves obtained for the length of the primary branching correspond to sigmoid curves characterized by a very rapid growth phase due to the budding response of the vegetative buds after the emergence (Fig. 3).

![Figure 3. Length (A) and Average number of nodes (B) of the primary branches of cholupa (P. maliformis) plants.](image)

The maximum length of the primary branches (214 cm) was achieved near the day 57 after pruning, as well as the greater number of nodes (35) in the period evaluated, with an emission rate of 0.86 nodes per day. After the emergence of the primary branches, the re-sprouting of secondary (and tertiary branches begins, since physiologically, every time there is a branch bud, the anterior buds break their dormancy.
Growth and development of secondary branches

The length and number of nodes of the secondary branches adjusted to the logistic model of three parameters over time, the highest average value was obtained with 138.4 cm reaching its maximum length approximately on 30 DAP (Fig. 4). The maximum number of nodes was achieved at 25-30 DAP (Fig. 4B), the final number of nodes was 30. Thus, the rate of emission of nodes in the secondary branches in the initial phase (6-14 DAP) was 12 nodes per day, decreasing progressively, until reaching 0.9. This condition could be due to the presence of thrips (Neohydatothrips sp.) that caused damage to the terminal shoots that retarded the branches growth but not the emission of nodes, resulting in branches with shorter internodes compared with healthy branches (longer internodes) (Santos et al., 2012).

![Figure 4. Length (A) and average number of nodes (B) of the secondary branches of cholupa (Passiflora maliformis L.) plants.](image)

The description of the stage 39 with the elongation of the main stem (Tab. 1), the maximum length of the main stem was 4.0 m considering that the tutored system has an average height of 2 m and the grower allows the growth of the stem for 2 m after reaching the wiring before making the emergence and stimulate the primary branches growth. Ten percent of the growth of the main stem of cholupa was reached at 25 DAP on average for the measured plants, 50% at 52 DAP and, finally, 100% was obtained at approximately 80 DAP. The leaves are inserted on the stem using the petiole of 2.3 to 8.5 cm in length with two subsesile glands (eventually two pairs) located below half. The peduncle can measure from 3 to 9.5 cm in length and at its apex three bracts are
located (cap) greens that they resemble leaves 5 to 8 cm long and 2.5 to 5 cm long wide, which serve as protection to the flower and fruit in their stages of development (Ocampo et al., 2015a) (Fig. 5).

Figure 5. Principal growth stage 3: main stem development in cholupa (*P. maliformis*) plants. 5a) Stage 19, development of the ninth leaf. 5b) Stage 34, 40% of maximum length of the main stem. 5c) Stage 33, 70% of maximum length of the main stem. 5d) Stage 39, the main stem of the plant has reached 90% - 100% of its maximum length.
Reproductive phase

In the *Passiflora* species family as in cholupa, a stage of completely vegetative growth (juvenile phase of crop development) occur with subsequent annual cycles of growth, where vegetative and reproductive stages occur simultaneously or slightly overlapping (Melgarejo *et al.*, 2015). This fact is related to the indeterminate growth habit of the crop and the origin and adaptation to the environments in which it currently grows. The apex of growth, of all the branches of a plant, is potentially apt to form floral primordium at the level of each node. The reproductive phase begins with appearance of flower buds and ends with the ripening fruits, in which the fruit has developed characteristics of appearance and texture and is related to physicochemical changes of the pulp as flavor and aroma. The stage 5 and 6: appearance and development of the floral organ and flowering (Fig. 6 and Tab. 1), this process was evaluated in the secondary branches of the crop because it was the first cycle of production. The stages were identified from the emergence of the floral bud (stage 51), which is known as a floral cartridge until it reaches its maximum size (stage 58), where all parts of the flower are fully developed and the process of floral opening begins. The flower is generally lonely or rarely in pairs, pendular, pentamera, hermaphrodite, showy and with a pleasant aroma, with a length of 4.5 to 6.5 cm and a width of 4 to 5 cm. These are provided with five petals and five sepals, lanceolate, reflexed, colored white and deep inside mottled red-purple (Ocampo *et al.*, 2015a) (Fig. 6).
Figure 6. Principal growth stage 5 y 6: inflorescence emergence and flowering in cholupa (P. maliformis) plants. 5a) Stage 5. Stage 51: Visible floral Button. 5b) Stage 58, maximum size of the floral cartridge. d) Stage 6. Stage 61, Beginning of flowering: 10% of flowers are open and stage 65, full bloom. 50% of flowers in anthesis.

It was also established the full flowering (stage 65) and the end of flowering or fruit set (stage 69). It should be noted that, in cholupa crop, the process of floral opening, pollination and following flower closure takes place in 12 h and the fruit set is estimated at approximately 2 days after anthesis (DAA).

The beginning of flowering is not uniform because the plants are originated from seeds and the specie is allogamous (Tovar, 2009). The flowering begins with appearance of flowers on the lateral and basal branches. The flower, one per leaf axilla, is ephemeral and the anthesis takes only 12 h (Tovar, 2009). The first flowers in anthesis were observed at 108-110 DAP and at 180 DAP the first ripe fruits were received. However, a high abortion of flowers was observed before the anthesis, which was manifested by the presence of vain structures between the apex and the flowers. After this event, a new fall of flowers can be explained by natural abortion, excess humidity and/or lack of pollination, which turns into a decrease of production, since it has been indicated that 67% of the production and fruit quality depend on the pollinators that decrease their activity at that time (Tovar, 2009).

The BBCH codes with their respective description for the stage 7: fruit formation (Fig. 7 and Tab. 1), in this study, it was determined that 117 DAP, which is equivalent to a fruit between 7-10% of the final size and the following BBCH stages refer to the fruit growth (stages 71-78), where its appreciated that 50% of the fruit size is reached in the 140 DAP, 75% of the size is achieved by day 161 DAP, 90% by day 180 DAP and finally the maximum size on average is
given 185 DAP. The fruit, when entering maturation did not have a color change, so that abscission above the bracts that support it is used as an indicator of maturity.

![Figure 7. Principal growth stage 7: Fruit development in cholupa (P. maliformis) plants. 7a) Stage 70, visible fruit. 7b) Stage 71, The fruit reaches 10% of the final size. 7c) Stage 74, the fruit reaches 30% of the final size. 7d) Stage 74, the fruit reaches 40% of the final size. 7e) Stage 77, the fruit reaches 75% of the final size. 7f) Stage 79, fruit has reached typical form and size.](image-url)
Growth and development of fruits

The fruit is a berry in shape spherical or ovoid, with a shell (pericarp) consistency extremely hard (eventually soft), smooth and waxy, about 3.0 to 4.5 mm thick and with a white mesocarp (Ocampo et al., 2015a). Among the factors that determine development and final fruit size, Cavichioli et al. (2006) references the genetic characteristics, temperature, number of flowers per plant and fruits in development; while the techniques of the grower could directly influence its final size are irrigation, fertilization and pruning.

The variables analyzed showed a simple sigmoidal growth pattern (Fig. 8), result of the analysis from the weight or size fruit as a function of time (Hunt, 2003). The simple sigmoid pattern is consistent with was found in passion fruit (Arjona et al., 1991) and in gulupa (Lederman and Gazit, 1993). For each variable, the model with the best adjust was chosen according to a more homogeneous distribution of the residuals, a highest coefficient of determination for prediction ($R^2$, Tab. 2), and a lowest mean square error.

![Figure 8. Growth curves adjusted to a logistic model with three parameters of a) Longitudinal and b) transverse diameter of the cholupa fruit in Campoalegre, Huila.](image)

The evolution of the longitudinal diameter was adjusted to the logistic model with three parameters, with $R^2$ of 0.87, with a simple sigmoid growth pattern (Fig. 5A). Accelerated growth was observed until 15 DAA, where it tended to stabilize; behavior similar to that found in gulupa by Flórez et al. (2012), in passion fruit by Gómez et al. (1999), and in sweet granadilla by García (2008). The longitudinal diameter presented values very close to the transverse diameter (54 and
53 mm, respectively), which differs from what was observed by García (2008) in sweet granadilla and reflects the characteristic spherical shape of cholupa fruit.

The increment of the transverse diameter of fruits was described with the logistic model with three parameters, with $R^2$ of 0.91 (Fig. 5B) and presented a behavior like as yellow passion fruit by Villanueva et al. (1999). In related species, the exponential phase occurs between 7 and 15 DAA depending on the environment where the fruits grew; the growth rate decreases from this time and tends to be almost constant after 20 d.

Based on the model adjusted to the fruit growth, it is possible to predict that the harvest can be programmed 50 or 60 d after flowering, since the longitudinal and transverse diameters tended to stabilize. The values estimated by the model explain each one of the variables in relation to the field observations, and therefore, properly interpret the physiological processes taking place in the fruit in each of its stages.

CONCLUSIONS

The vegetative and reproductive development phases of cholupa plants established in the province of Huila were described for the first time using the phenological BBCH scale.

The growth pattern of the cholupa is a simple sigmoid type with three phases, which may vary slightly depending on the environmental conditions, relative humidity and precipitation.

The logistic model showed a good fit to describe the growth of the fruits under the specific conditions of the municipality of Campoalegre. These models can be used to schedule crop labors as well as to predict the harvest time.

Acknowledgments

The authors wish to thank the Huila Governorate through the Huila Technology Corridor under the Project "Development and implementation of new technologies for the cultivation of cholupa (Passiflora maliformis) as a contribution to the strengthening of fruit growing in the department of Huila" between the years 2014 and 2015 and the Passiflora Technology Development Center Corporation of Colombia - CEPASS for supporting this study. The thanks are extended to the growers and students involved in the field work.
Conflict of interests: The manuscript was prepared and reviewed with the participation of the authors, who declare that there exists no conflict of interest that puts at risk the validity of the presented results.

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