

## Heat unit accumulation and inflorescence and fruit development in 'Ubá' mango trees grown in Visconde do Rio Branco-MG

Lorena Moreira Carvalho Lemos<sup>1</sup>, Luiz Carlos Chamhum Salomão<sup>2</sup>, Dalmo Lopes de Siqueira<sup>2</sup>, Olinto Liparini Pereira<sup>3</sup>, Paulo Roberto Cecon<sup>4</sup>

**Abstract** - There are little information in the scientific literature on flowering and fruiting of 'Ubá' mango trees. These information enables to know the proportion of hermaphrodite flowers in inflorescence, fruit set percentage and developmental stages of the fruit. In this study evaluations on inflorescence and fruit development of the 'Ubá' mango tree (*Mangifera indica* L.) were carried out, as well as the determination of the required number of heat units for full fruit development. Thirty branches whose terminal buds were swollen were selected from five mango trees. With the aid of a camera and a caliper, the panicle and fruit development were evaluated weekly until full fruit development. A digital thermometer was used to record ambient temperatures during fruit development in order to estimate the number of heat units required for complete development of the fruits. Male and hermaphrodite flowers of the panicles were also identified and counted. The developmental cycle of 'Ubá' mango from the beginning of apical bud swelling to commercial harvest of the fruit lasted 168 days in 2011 and 154 days in 2012. The number of hermaphrodite flowers and the percentage of fruit set in the inflorescence in 2011 were 32.3 and 0.066%, respectively; and 122.1 and 0.099% in 2012, respectively. There was accumulation of 3,173 heat units from flower bud swelling to full development of the 'Ubá' mangoes.

**Index terms:** *Mangifera indica* L., heat units, anthesis, phenological phases.

### Acúmulo de unidades térmicas e desenvolvimento da inflorescência e do fruto da mangueira 'Ubá' cultivada em Visconde do Rio Branco-MG

**Resumo** - Há poucas informações na literatura científica sobre florescimento e frutificação da mangueira 'Ubá'. Essas informações permitem conhecer a proporção de flores hermafroditas na inflorescência, a porcentagem de fixação e as fases de desenvolvimento do fruto. Neste trabalho, foram realizadas avaliações do desenvolvimento da inflorescência e do fruto da mangueira 'Ubá' (*Mangifera indica* L.), além da determinação do número de unidades térmicas necessário para o completo desenvolvimento do fruto. Foram selecionados 30 ramos de cinco mangueiras, em estágio de intumescimento da gema terminal. Com o auxílio de câmara fotográfica e paquímetro, avaliou-se semanalmente o desenvolvimento da panícula e do fruto até o completo desenvolvimento do mesmo. Com o auxílio de um termômetro digital, registraram-se as temperaturas ambientes durante o desenvolvimento dos frutos, com o objetivo de estimar o número de unidades térmicas necessárias para o completo desenvolvimento dos mesmos. Foram realizadas ainda a contagem e a identificação do número de flores masculinas e hermafroditas das panículas. O ciclo de desenvolvimento da manga 'Ubá', desde o início do intumescimento da gema apical até à colheita comercial do fruto, teve a duração de 168 dias em 2011 e 154 dias em 2012. O número de flores hermafroditas e a porcentagem de fixação dos frutos na inflorescência no ano de 2011 foram de 32,3 e 0,066%, respectivamente; e em 2012, de 122,1 e 0,099%, respectivamente. Houve acúmulo de 3.173 unidades térmicas a partir do intumescimento da gema floral até ao completo desenvolvimento da manga 'Ubá'.

**Termos para Indexação:** *Mangifera indica* L., unidades térmicas, antese, fases fenológicas.

**Corresponding author:**

lsalomao@ufv.br

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<sup>1</sup>Agronomist - DS, Departamento de Fitotecnia, Universidade Federal de Viçosa. Viçosa - MG. E-mail: [lorenamcarvalho@yahoo.com.br](mailto:lorenamcarvalho@yahoo.com.br)

<sup>2</sup>Agronomist - DS, Departamento de Fitotecnia, Universidade Federal de Viçosa. Viçosa -MG. E-mail: [lsalomao@ufv.br](mailto:lsalomao@ufv.br); [siqueira@ufv.br](mailto:siqueira@ufv.br)

<sup>3</sup>Agronomist - DS, Departamento de Fitopatologia, Universidade Federal de Viçosa. Viçosa -MG. E-mail: [oliparini@ufv.br](mailto:oliparini@ufv.br)

<sup>4</sup>Agronomist - DS, Departamento de Estatística, Universidade Federal de Viçosa. Viçosa- MG. E-mail: [cecon@ufv.br](mailto:cecon@ufv.br)

## Introduction

The growth of mango tree (*Mangifera indica* L.) occurs in up to three or four annual vegetative flows, and the stoppage of vegetative growth is necessary for the initiation of flowering and later fruiting and development of the fruits (DAVENPORT, 2009).

The mango tree has inflorescences of panicle type, which develop under the climatic conditions of the Zona da Mata Mineira from terminal buds of mature branches with three to nine months of age, having hermaphrodite and male flowers. The flowers begin the anthesis even before the panicles reach the maximum length, and the anthesis occurs in the morning (RAMÍREZ; DAVENPORT, 2016).

The fruit maturation time, according to Albuquerque et al. (2002), varies among the different producing regions according to the climatic conditions and the time elapsed between the development of the inflorescence and the physiological maturity, which is generally between 100 to 150 days. However, in warmer regions, this period may be less.

The calculation of degrees-days or thermal units (TU) is a simple approach to define each stage of development of the crop and assumes that the development of a plant species is related to the environment and it is controlled from the thermal daily sum required for each stadium. TUs can be determined by summing up all the daily hours in which the plants are in vegetative activity. In practice, average daily temperatures are used for the sum of the Tus, from which the necessary thermal summation is calculated in each phenological phase or in the crop cycle (RENATO et al., 2013). The number of day degrees varies less with environmental changes than the number of days from anthesis to harvest, being more accurate method to estimate the time of harvest.

For the 'Ubá' mango tree cultivated in Visconde do Rio Branco, MG, Silva (2009) observed that 1,565.5 thermal units were required to reach the commercial harvest point (18 weeks after the anthesis - WAA). As for the 'Tommy Atkins' mango cultivated in Petrolina region, Lucena (2006) observed that, in order to reach the commercial harvest point (16 WAA), are necessary 1,939.7 TU. This parallel suggests that under equal environmental conditions the 'Ubá' mango is earlier than the 'Tommy Atkins' mango for the TU accumulation.

The knowledge of the development stages of the inflorescence and the fruit of 'Ubá' mango tree and the number of degrees-days is of great importance for other studies and it is necessary for the producer to be able to determine the right moment for the application of pesticides, fertilizing, crop planning, harvesting, among others.

In view of the above and the lack of information in scientific literature that describes the peculiarities of the flowering and fruiting phases of the 'Ubá' mango tree,

this study aims to characterize the natural development of inflorescences and fruits, and to determine the number of degrees - day required for the complete development of the fruit.

## Material and Methods

The study was carried out at the Experimental Farm Sementeira in Visconde do Rio Branco, MG (21°00'37"S, 42°50'26"W and 352 m altitude) belonging to the Federal University of Viçosa, in mango trees with about 35 years of age in the crops of 2011/2012 and 2012/2013. Five plants were randomly selected, and each one, six branches in the swelling stage of the terminal bud were identified with colored ribbons. From each branch, it was weekly evaluated the development of the panicle and the fruits until the complete development of them. The evaluations took place through photographic records and measurements of the longitudinal and transverse diameters of one fruit per panicle in the plant.

The photographs were obtained with a Sony Cyber-shot 14.1 MP digital camera and were used with auxiliary means to determine the stages of fruit development. The transverse and longitudinal diameters were obtained with the aid of a digital caliper. The experimental design was completely randomized with five replicates (mango trees) and six panicles / fruits per sample unit. The phases of panicle growth and fruiting were established in analogy with Kavati (2004) and the stages of fruit development, according to Lucena (2006).

To determine the sum of the thermal units (degrees-days) from the swelling of the buds to the complete development of the fruits, the experimental area temperatures were recorded every two hours by means of a digital thermometer AZ, model 8829, installed near the orchard. Temperature records during fruit development were made in the 2013/2014 crop, and the calculation of the thermal units (TU) or degrees-days was done considering only the basal temperature, according to Renato et al. (2013), in which:

$$TU = \sum [(T_{\max} + T_{\min})/2] - T_{\text{base}},$$

Where:

TU = thermal units, °C;

$T_{\max}$  = maximum daytime temperature, °C;

$T_{\min}$  = minimum daytime temperature, °C; and

$T_{\text{base}}$  = minimum growth temperature.

The lower or minimum basal temperature for mango tree growth found in the literature is 10°C, given as the temperature below which there is plant growth shutdown (LUCENA, 2006; BARROS et al., 2010).

At the same time, 10 panicles were collected at the stage of maximum floral opening; out of these, the number

of hermaphrodite and male flowers was counted with the aid of a 10x magnifying glass.

The results were analyzed by means of descriptive statistics using the means of each evaluation.

## Results and Discussion

In Figure 1, photographs of the panicles and fruits in development allowed the visual evaluation of these organs.

According to Kavati (2004), the flowering of mango tree can be divided into four distinct stages: swelling of the apical bud (stage 1), panicle elongation (stage 2), panicle growth and flowering (stage 3), and fruiting (stage 4). For the 'Ubá' mango tree developed in the year 2011 the beginning of the floral gem swelling occurred on July 6<sup>th</sup>, 2011 (Figure 1). It was observed that stages 1 and 2 lasted for two and three weeks, respectively. Stage 3; when the lateral branches of the panicle expand and the flowers open it lasted two weeks, and stage 4 lasted 17 weeks. These values differ from those observed for 'Palmer' mango, in which Carvalho et al. (2009) observed for stages 1, 2, 3 and 4, the duration of 1, 3, 2 and 4 weeks, respectively. However, the authors evaluated the fruits only up to the fruitlet ("chumbinho") stage. In Figure 1 it can be observed that between the eighth and tenth weeks after the beginning of the bud swelling there is an intense drop of flowers in the panicle.

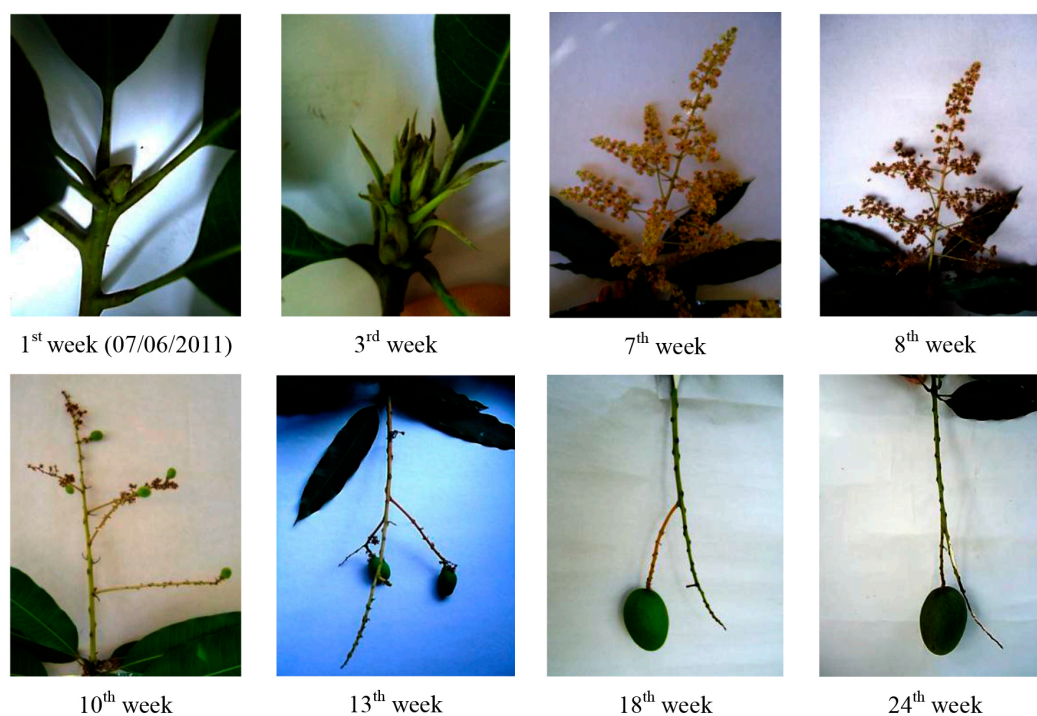
In the year 2012 was also observed the swelling of the apical bud and the elongation phase of the panicle in two and three weeks, respectively. The phases of panicle growth and flowering (stage 3) lasted two weeks, as in the previous year. Phase 4, which is fruiting, took 15 weeks, a

period that is lower than that observed in the previous year.

The development period of the panicle varied with the cultivar and was 45 days for 'Keitt'; 50 days to 'Palmer' and 63 days for the 'Espada Vermelha' (SOUZA et al., 2015), being the first flowers open only after 21 days from the beginning of inflorescence development (KAVATI, 2004). Similar results were observed by Lucena et al. (2007) in 'Tommy Atkins' cultivar which reported that it takes 25 days to start the flowering. However, the 'Ubá' mango in 2011 required six weeks for the opening of the first flowers and in 2012, only five weeks.

We observed the occurrence of  $32.3 \pm 19.3$  (1.68%) hermaphrodite flowers and  $1,936.0 \pm 397.2$  (98.32%) male flowers in the year 2011 in the panicle. In 2012 occurred an increase in the proportion of hermaphrodite flowers on  $122.12 \pm 55.10$  (9.39%), whereas the male flowers were  $1,178.3 \pm 320.6$  (90.6%). In general, the percentage of hermaphrodite flowers in the panicle is less than 50% (RAMÍREZ; DAVENPORT, 2016). However, according to Lima Filho et al. (2002) the number of hermaphrodite flowers in mango tree changes from year to year, and depending on the cultivar and the location of the panicle in the plant can vary from 2 to 75%. Greater proportion of hermaphrodite flowers in the panicle could result in higher numbers of fruits and higher productivity. Environmental factors such as temperature, relative air humidity and rainfall, as well as endogenous factors such as tree age, tree inflorescence position and hormones can affect the proportion of hermaphrodite flowers (RAMÍREZ; DAVENPORT, 2016).

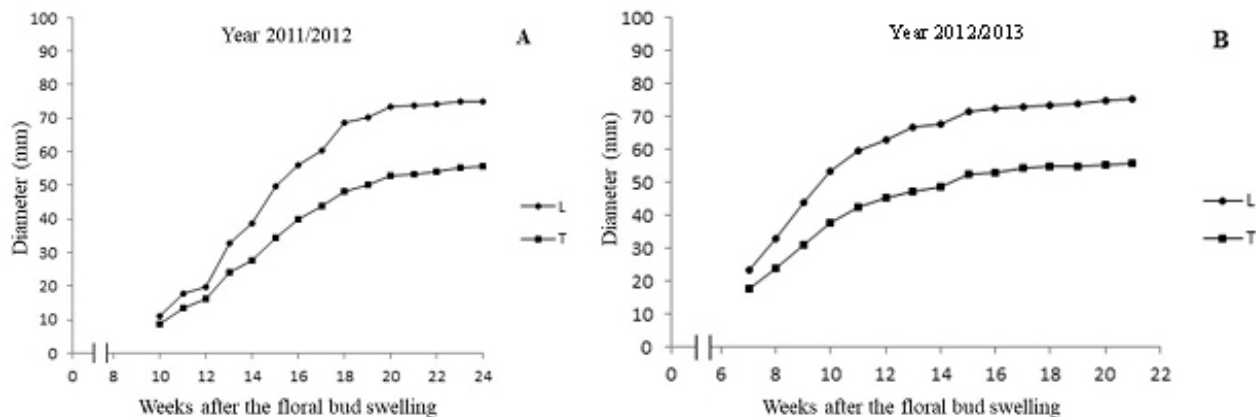
The percentage of fruit fixation in the inflorescences in 2011 was 0.066%, and the apex of flowering occurred



**Figure 1-** Inflorescence and 'Ubá' mango at the beginning of the floral bud swelling (1<sup>st</sup> week), at the beginning of the panicle elongation phase (3<sup>rd</sup> week), at the peak of flowering (7<sup>th</sup> week) and at the fruiting stage (from the 8<sup>th</sup> to the 24<sup>th</sup> week), in Visconde do Rio Branco-MG, in the crop 2011/2012.

in the 7<sup>th</sup> week after the beginning of the bud swelling (Figure 1). In that year it took 24 weeks for the complete development of the fruit; from the 18<sup>th</sup> week after the

anthesis (WAA) the fruit size practically did not change (Figure 2A).



**Figure 2-** Mean values of the longitudinal (L) and transverse (T) diameters of the ‘Ubá’ mango, in Visconde do Rio Branco-MG, in the crops of 2011/2012 and 2012/2013.

In 2012, percentage of fruit fixation in the inflorescences was 0.099%, and in the 6<sup>th</sup> week after the beginning of the bud swelling occurred the peak of flowering. The total development of the fruit was completed in 22 weeks, and already in the 15<sup>th</sup> week after the floral bud swelling the longitudinal and transverse diameters were stabilized (Figure 2B).

Silva (2009), researching ‘Ubá’ mango growth curve, found that the fruits increased in size up to 12 WAA when the length was evaluated, and up to 13 WAA, when considering the transverse diameter; after these periods these characteristics practically remained constant.

The accumulated degree-days values until the end of the fruiting in ‘Ubá’ mango are shown in Table 1. The number of thermal units accumulated until the natural fall or abscission of the fruits from the trees was 3,173°C for 203 days after the bud swelling (DAS). Considering only from anthesis were accumulated 2,630 °C (3,173 °C - 543 °C) until the natural fruits fall from the trees. On the other hand, from the anthesis until the fruits reach the commercial harvesting point it took 17 weeks and 1,897°C accumulated, a value obtained by the difference between the DD accumulated up to the 17<sup>th</sup> week (2,440°C) and those accumulated up to the 6<sup>th</sup> week after the bud swelling (543°C).

For the same cultivar, Silva (2009) observed in the Experimental Farm Sementeira that in the 17<sup>th</sup> week after the anthesis the sum of the thermal units was only 1,459°C. This difference can be explained by probable occurrences of nutritional diseases or deficiencies, variations in temperature and even by the amount of rainfall in each year that can accelerate or delay fruit development.

Table 2 presents the accumulated degree-days values in each phase of the ‘Ubá’ mango development in the 2013/2014 harvest. The number of thermal units required to form the panicle was 543°C (six weeks from the onset of panicle swelling). Then, from the floral opening (anthesis) to the initial fruit growth stage (fruitlet or “chumbinho” stage), the accumulated number of thermal units was 391°C (1<sup>st</sup> to 4<sup>th</sup> WAA); from the end of the fruitlet stage until the fruits reached the marble size were needed 529°C (5<sup>th</sup> to 9<sup>th</sup> WAA). From that point until the end of the egg stage, 846°C (10<sup>th</sup> to 16<sup>th</sup> WAA) and a further 632°C were required to reach the mature fruit stage (commercial harvest point - 17<sup>th</sup> to 21<sup>st</sup> WAA). Finally, the period of fall of the mature fruits from the tree consumed another 231°C (22<sup>nd</sup> to 23<sup>rd</sup> WAA).

Variations are observed in some of the phases according to the evaluation year (Figure 1 and Tables 1 and 2), which are probably due to variations in temperature and rainfall incidence between the years.

Mosqueda-Vázquez and Ireta-Ojeda (1993) found 434.7 thermal units for the development of ‘Manila’ mango inflorescence, but worked with a base temperature (Tbase) of 12°C. For the ‘Tommy Atkins’ mango, cultivated in Petrolina, it was observed that at 112 DAA with base temperature of 10°C the sum of the thermal units was 1,939.7 necessary for the commercial harvest point of this cultivar (LUCENA, 2006).

**Table 1** –Developmental phases of the panicle and the fruit and thermal units accumulated weekly from the floral bud swelling to the complete development of the 'Ubá' tree in Visconde do Rio Branco, MG, in the harvest of 2013/2014.

Phases	DAS <sup>1</sup>	SAS <sup>2</sup>	WAA <sup>3</sup>	Thermal units accumulated (°C)
Floral bud swelling	7	1		95
	14	2		182
Growth and elongation of the panicle	21	3		276
	28	4		378
	35	5		477
	42	6		543
Floral opening and falling flowers	49	7	1	623
	56	8	2	714
Fruit in the fruitlet or "chumbinho" stage	63	9	3	828
	70	10	4	935
Fruit in the marble stage	77	11	5	1,029
	84	12	6	1,138
	91	13	7	1,250
	98	14	8	1,348
	105	15	9	1,464
Fruit in the egg stage	112	16	10	1,587
	119	17	11	1,689
	126	18	12	1,804
	133	19	13	1,932
	140	20	14	2,061
	147	21	15	2,188
	154	22	16	2,310
Fruit at the commercial harvesting point	161	23	17	2,440
	168	24	18	2,573
	175	25	19	2,699
	182	26	20	2,818
	189	27	21	2,942
From ripe fruit until abscission	196	28	22	3,065
	203	29	23	3,173

\*: <sup>1</sup> Days after the beginning of the floral bud swelling. <sup>2</sup> Weeks after the beginning of the floral bud swelling. <sup>3</sup> Weeks after the anthesis.

**Table 2** - Thermal units (UT) at each stage of panicle and fruit development and the accumulated totals (ATU) from the beginning of the floral bud swelling to the abscission of the 'Ubá' mango, in Visconde do Rio Branco, MG, in the crop of 2013/2014.

Phenological Phases (panicle development)	TU <sup>3</sup> (°C)	ATU <sup>4</sup> (°C)	Phenological Phases (fruit development)	TU <sup>3</sup> (°C)	ATU <sup>4</sup> (°C)
Panicle swelling <sup>1</sup>	182	182	Floral opening and falling flowers <sup>2</sup>	171	171
Beginning of panicle growth <sup>1</sup>	196	378	Fruitlet stage <sup>2</sup>	221	392
Panicle elongation <sup>1</sup>	165	543	Marble stadium <sup>2</sup>	529	921
			Egg stage <sup>2</sup>	846	1,767
			Commercial harvesting point <sup>2</sup>	632	2,399
			From ripening until abscission <sup>2</sup>	231	2,630

\*: <sup>1</sup>From the beginning of the floral bud swelling. <sup>2</sup>From the anthesis. <sup>3</sup> Thermal units. <sup>4</sup>Accumulated thermal units.

## Conclusions

The development of 'Ubá' mango from anthesis to fruit harvest was characterized for two consecutive years in the municipality of Visconde do Rio Branco, MG. The cycle duration was 22 to 24 weeks with the accumulation of 2,630 thermal units. The inflorescence of 'Ubá' mango presented from 90.6 to 98.32% of male flowers and 1.68 to 9.39% of hermaphrodite flowers. The percentage of flowers fixed to fruits did not reach 0.1%.

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## References

ALBUQUERQUE, J.A.S.de; MEDINA, V.D.; MOUCO, M.A.do C. Indução floral. In: GENU, P.J.de C.; PINTO, C.A.de Q. (Ed.). **A cultura da mangueira**. Brasília: Embrapa Informação Tecnológica, 2002. p.259-276.

BARROS, M.P.; ZANETTI, V.B.; FRAGA, C.I.M.; NINCE, P.C.C.; CAMPELO JR., J.H.; LOBO, F.A. Unidades fototérmicas e temperatura-base inferior de frutos de mangueira Alfa na baixada cuiabana. **Revista Brasileira de Fruticultura**, Jaboticabal, v.32, n.2, p.479-485, 2010.

CARVALHO, L.M.; LEMOS, J.P.; VIECCELLI, J.C.; BRANDÃO, F.M.; SIQUEIRA, D.L. de. Desenvolvimento da inflorescência da mangueira 'Palmer' em Viçosa-MG. In: ENCONTRO LATINO AMERICANO DE INICIAÇÃO CIENTÍFICA, 13.; ENCONTRO LATINO AMERICANO DE PÓS-GRADUAÇÃO, 9., 2009, São José dos Campos, **Anais...** São José dos Campos: UNIVAP, 2009.

DAVENPORT, T.L. Reproductive physiology. In: LITZ, R.E. (Ed.). **The mango: botany, production and uses**. Homestead: CABI, 2009, p.97-169.

KAVATI, R. Manejo da parte aérea da mangueira. In: ROZANE, D.E.; DAREZZO, R.J.; AGUIAR, R.L.; AGUILERA, G.H.A.; ZAMBOLIM, L. **Manga: produção integrada, industrialização e comercialização**. Viçosa: UFV, 2004. p.303-320.

LIMA-FILHO, J.M.P.; ASSIS, J.S.; TEIXEIRA, A.H. de C.; CUNHA, G.A.P.; CASTRO NETO, M.T. Ecofisiologia. In: GENU, P.J. de C.; PINTO, A.C. de Q. **A cultura da mangueira**. Brasília: Embrapa Informação Tecnológica, 2002. p.37-50.

LUCENA, E.M.P. de; ASSIS, J.S. de; ALVES, R.E.; SILVA, V.C.M. da; ENÉAS FILHO, J. Alterações físicas e químicas durante o desenvolvimento de mangas 'Tommy Atkins' no Vale do São Francisco, Petrolina-PE. **Revista Brasileira de Fruticultura**, Jaboticabal, v.29, n.1, p.96-101, 2007.

- LUCENA, E.M.P. **Desenvolvimento e maturidade fisiológica de manga 'Tommy Atkins' no Vale do São Francisco**. 2006. 152 f. Tese (Doutorado em Fitotecnia)- Universidade Federal do Ceará, Fortaleza, 2006.
- MOSQUEDA-VÁZQUEZ, R.; IRETA-OJEDA, A. Degree-days and base temperatures required for inflorescence and fruit development in mango 'Manila'. **Acta Horticulturae**, Leuven, v.24, n.341, p.232-237, 1993.
- RAMÍREZ, F.; DAVENPORT, T.L. Mango (*Mangifera indica* L.) pollination: a review. **Scientia Horticulturae**, New York, v.203, p.158-168, 2016.
- RENATO, N.S.; SILVA, J.B.L.; SEDIYAMA, G.C.; PEREIRA, E.G. Influência dos métodos para cálculo de graus-dia em condições de aumento de temperatura para as culturas de milho e feijão. **Revista Brasileira de Meteorologia**, Rio de Janeiro, v.28, n.4, p.382-388, 2013.
- SILVA, D.F.P. **Desenvolvimento e controle do amadurecimento da Manga 'Ubá'**. 2009. 97 f. Tese (Doutorado em Fitotecnia) - Universidade Federal de Viçosa, Viçosa, 2009.
- SOUZA, J.M.A.; LEONEL, S.; MODESTO, J.H.; FERRAZ, R.A.; GONÇALVES, B.H.L. Phenological cycles, thermal time and growth curves of mango fruit cultivars in subtropical conditions. **British Journal of Applied Science & Technology**, London, v.9, n.1, p.100-107, 2015.