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# Response of peach tree leaf area to seasonal variation in tropical climate

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**Abstract**

Here, we describe differences in the establishment of the leaf limb area and morphology of peach tree attributed to different seasonal conditions at a high-altitude tropical climate. The cultivars 'Tropic Beauty', 'BRS Kampai' and 'BRS Rubimel' were cultivated in a production area located in Ervália – MG, Brazil. A series of experiments is being carried out in this area since 2016, and the data collection for the present report was carried out in the 2018 productive cycle, when the plants were 4 years old. Fully expanded leaves were collected from 'brindilla' type (with same flushes vegetative growth) branches according to the period of the year. Leaves were collected for two seasons in year, August (first flushes) and December (second flushes) 2018. Three hundred leaves from each cultivar at each season were collected randomly as representative of the canopy in its middle portion. They were separated into ten replicates and evaluated individually for length, width and leaf area. All cultivars exhibited cyclic and significant differences in length, width and leaf area attributed to the environmental conditions, where and when they were developed. Further investigation is needed regarding this differential leaf growth and its impact on the production of peach trees grown in tropical highland regions.

**Keywords:** *Prunus persica* L. Batsch, tropical climate, leaf area, leaf limb.
**Abbreviations:** ABA_Abscisic acid; INMET_Meteorological National Institut; L_length of leaves; LF_ leaf area; MG_Minas Gerais state; RH_relative humidity; Temp_temperature; t $ha^{-1}$_ tons per hectare; "Y" _sistem of conduction of plant; W_width of leaves.

**Introduction**

The production of peach has been expanded to new regions of subtropical and even tropical climate, where were previously considered unsuited for the culture. Some of these new producing areas, such as in the state of Minas Gerais – Brazil, render advantages of commercialization of fruits compared to colder regions. The absence/or lower probability of frosts during the winter in warmer climate areas and dormancy management technologies allows the anticipation of harvest in a period, of which there is a low fruit supply in the market, producing greater profit (Barbosa et al., 2010). However, due to the differentiated climate in these areas, there are plant management problems that can lead to significant changes in the developmental, physiological and anatomical behavior of the plants (Penso et al., 2018).
The development of leaves of peach trees grown in tropical regions is submitted to novel environmental conditions that may associated with physiological and developmental behavior of the plant as a whole, which on the same hand, is different from the expected for traditional cultivation regions (Larbi et al., 2015). An example is the occurrence of "flushes" discontinuous of vegetative growth, which may affect the photosynthetic capacity of the plant, supply of assimilates for fruit production, and reestablishment of reserves and other structures for the subsequent production cycle. Such changes are poorly documented and its evaluation is necessary to provide due support to these crops at new growing sites. It also provides relevant information on crop behavior under current extreme conditions for future climate change scenarios, and possible climate changes and global warming for areas that are now considered traditional.
The objective of this work is to report morphological differences in the formation of the leaf of peach cultivars grown at different seasons throughout the year under high-altitude tropical climate conditions.

**Results and discussion**

There were significant differences in length (*L*), width (*W*) and leaf area (*LF*) between the two evaluated periods for all cultivars (Table 1). The difference in relation to the *LF* was 2.3 times higher in December compared to the August season, in cv. 'Tropic Beauty' (Table 1). Such differences may affect the total photosynthetic capacity and energy availability of plants, since the plasticity in the compensation for smaller leaf area with increased photosynthetic activity is limited. The cv. 'BRS Kampai' presented a smaller difference between the variables of *L*, *W* and *LF* between the periods evaluated, as its vegetative development behavior is more stable to the environment variation (Penso et al., 2018).

It is important to quote that changes in leaf morphology are associated with juvenile-to adult phase transition. There is evidence that, besides hormones, sugars and microRNAs are involved with this event. Similarly, morpho-physiological adjustments to environmental conditions that are important parameters to plant growth are also foreseen (Silva et al., 2019).

Under the conditions of the experiment, there was no chilling accumulation, considering the temperature of 7.2 °C, as the ideal temperature for breaking dormancy, elimination of growth inhibitors and biosynthesis of growth promoters (Figure 1 A) (Erez et al., 1979; Citadin et al., 2002).

Temperatures <10 °C and 12 °C were also poorly observed, accounting for only 6 h and 75 h, respectively, until the moment prior to breaking dormancy (Figure 1 A).

There was about 200 h under temperatures <15 °C until the artificial dormancy breaks, although the plant exposition to these temperatures was close to 400 h during the entire study period (Figure 1 A). In addition to allow more chilling accumulation, the other use of dormancy break might be to delay the harvest period, which has been pointed out as one of the main advantages of production in these regions. Temperatures around 15 °C are also pointed out as non-efficient for dormancy breaking (Erez et al., 1979). In addition, it is considered detrimental to dormancy break and to establish a full growth and initial vegetative development that can occur in a staggered way.

There were also several hours with temperatures above 20 °C (Figure 1 B), which are presented as detrimental to the overcoming of dormancy and to the development of reproductive structures, stimulating abortion of flowers and fruits, as well as impairing the initial formation of fruits (Carpenedo et al., 2017).

The occurrence of a number of hours with temperatures between 25-30 °C and even above 30 °C (Figure 1 B), can invalidate the chilling accumulation effect of the buds, but they help in the requirement of heat so that the growth and development of the structures like fruits, shoots and leaves can occur.

The occurrence of high temperatures can lead to an expressive increase in the growth and vegetative development of plants (Penso et al., 2018), considering that there is water availability in the soil and air. This can be observed in the second evaluation period, when there was a combination of high-temperature factors and water availability (Figure 1B, 1C e 1D), vegetative growth, consequently the development of the leaf area (Table 1).

After the breaking of dormancy a significant reduction of the sum of hours with> 90% relative humidity was observed, as well as a high sum of hours with relative humidity below 60% (Figure 1C). This combination may strongly interfere with the establishment of new vegetative growth after dormancy, since conditions of low relative humidity lead to the increase or maintenance of the concentration of abscisic acid (ABA) (Ali-Rachedi et al., 2004).

ABA is one of the main factors responsible for the inhibition of growth under stress conditions and is present in high concentrations during the dormancy period of temperate fruit trees, especially in low water availability or humid conditions (Wang et al., 2016). Again, novel patterns of hormonal balance and developmental signaling (Silva et al., 2019) are expected, since there are considerable changes in plant morphogenesis and environmental conditions, including implications in fruit setting and quality (Silva et al., 2019).

In warmer winter, even the artificial dormancy breaking and the use of complementary irrigation may not be sufficient for a complete elimination of growth inhibitors and biosynthesis of growth promoters. These conditions may lead to serious problems in establishing cell expansion and formation of new vegetative structures and efficient photosynthetic machinery, as occurs in several temperate crops grown in more mild winters (Ali-Rachedi et al., 2004).

The vegetative growth, such as leaf shape, intensity and period of occurrence, can be strongly affected by the environment as it has been observed, but is not documented in regions of the tropical environment. Peach trees cultivated in these regions may present difficulties for promoting and suspension growth, what will account for problems regarding the normal flow of the so-called circadian cycle of plants throughout the year.

**Table 1.** Leaf length (*L*), width (*W*) and area (*LF*) of peach plants evaluated at different seasons in tropical high altitude Ervália – MG, 2018.

| Seasons | Tropic Beauty | | |
|---|---|---|---|
| | *L* | *W* | *LF* |
| | cm | | cm$^2$ |
| August | 11.74 B | 2.27 B | 14.05 B |
| December | 17.11 A | 3.59 A | 32.84 A |
| | BRS Kampai | | |
| | *L* | *W* | *FF* |
| | cm | | cm$^2$ |
| August | 11.79 B | 2.66 B | 19.57 B |
| December | 15.55 A | 3.58 A | 30.87 A |
| | BRS Rubimel | | |
| | *L* | *W* | *LF* |
| | cm | | cm$^2$ |
| August | 11.33 B | 2.80 B | 18.95 B |
| December | 15.59 A | 3.84 A | 33.84 A |

Averages followed by the same letter vertically do not differ from each other by the Tukey test (p<0.05).

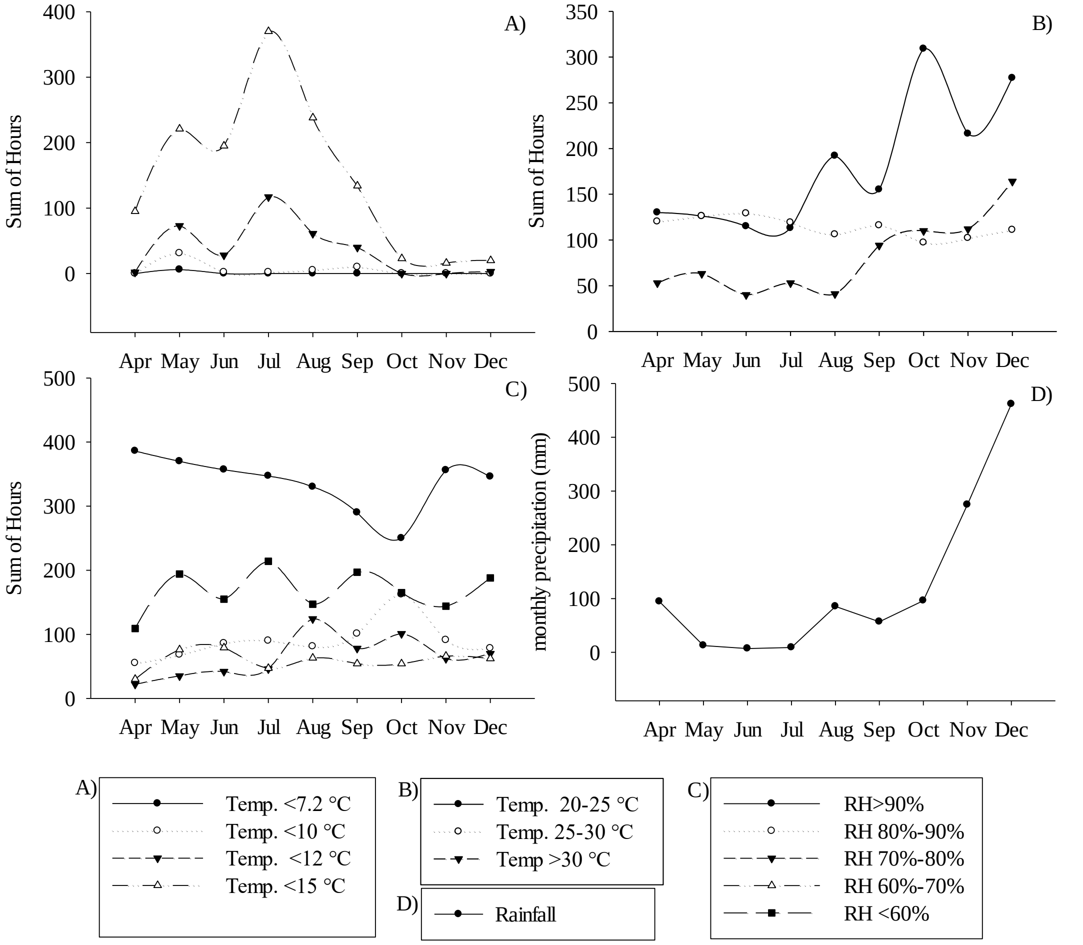


**Fig 1.** Sum of hours of ambient conditions relative to low-temperature ranges (A), Warm-temperatures (B), conditions of relative humidity (C), rainfall (D), between April and December of 2018.

Under vegetative growing conditions in tropical regions, tree growth may occur in the form of "vegetative growth flushes", which may vary in number of occurrence, intensity and duration, according to the time of year, or to environmental/hormonal stimulus received by plants like what occurs in other plant species such as mangoes and avocado trees (Yeshitela et al., 2004; Salazar-García et al., 2006).

The occurrence of these “flushes” may alter the establishment of the total leaf area and also of the individual leaf area of the leaves. In addition, this new “vegetative growth flushes” may lead to a reduction of accumulated reserves in previous flows. These accumulated reserves that could be used for the formation of other organs, such as the formation of productive buds for the next cycle, are spent in establishing new vegetative growth and their posterior organs, which depending on their intensity and time of occurrence may not provide sufficient accumulation and the same magnitude of reserves for a subsequent new productive cycle.

There are, therefore, seasonal differences in the formation, differentiation and establishment of the leaf blade of peach leaves cultivated in a tropical environment of altitude, what not occurs in traditional producing areas. Accordingly, these differences may be associated with differences in fruit setting and quality that are observed in these new frontiers for peach production, but a lot more research is needed on this particular area of reproductive development. Further comprehension of the reported vegetative growth flushes are demanded on its occurrence, duration, intensity and its effects on the establishment of the leaf area of peach plants grown in tropical high altitude.

## Materials and Methods

The peach cultivars ‘Tropic Beauty’, ‘BRS Kampai’ and ‘BRS Rubimel’ were used in a commercial orchard located in Ervália county, State of Minas Gerais, Brazil, at 20° 52'02'' S, 42° 38'41'' W, altitude 780 m. The orchard is located in a region with a Cwa climate type.

Four-year-old plants, grafted on the "Okinawa" rootstock, conducted in the "Y" system, spaced 2.5 x 5.0 m between plants and rows, respectively, were evaluated. The plants were imposed to three prunings during the year. The first was fruit pruning, held on May 2018. The second was carried out right after the harvest (which has been studied as an alternative for the emission of new productive branches for the next productive cycle, due to a first unbalanced growth flow in the region) carried out until the first week of October 2018. The third was performed in December 2018 to control the excess vigor of the plants.

In the second week of May, artificial dormancy breakage was performed using hydrogenated cyanamide (Dormex®) plus mineral oil at a dose of 0.8: 1 (v:v), as well as the use of complementary irrigation (drip irrigation) for periods of low precipitation.

Leaves were collected in two seasons (August and December) of 2018, considering the treatments. The first one was carried out on August 20, 2018 (period of formation of the endocarp), and the second collection took place on December 5, 2018 (period of intense vegetative growth).

Three hundred fully expanded and matures leaves (standard coloring) were sampled for each cultivar, following standard culture staining criteria.

The leaves were separated into ten replicates containing thirty leaves each, leaving only the leaf limb, which was evaluated individually for its length (*L*) and width (*W*), using graduated ruler (cm), and its leaf area (*LF*) using leaf area integrator Licor ®, model LI – 3100 C ($cm^2$). The data were submitted to analysis of variance and comparison of means by Tukey's test ($p < 0.05$) using statistical software GENES (Cruz, 2013).

The temperature and relative humidity data were collected using a datalogger, while the precipitation was monitored based on the data from the Meteorological Nacional Institut – INMET (Viçosa, MG, Brazil) meteorological station. These data were used to count hours with temperature ranges: <7.2 °C; <10 °C; <12 °C; <15 °C; between 20-25 °C; 25-30 °C; >30 °C. The relative air humidity was recorded the sum of hours ranges: >90%; between 80-90%; between 70-80%; between 60-70%; <60%.

**Conclusions**

Here, we emphasize that there are significant differences on morphogenesis of peach tree leaves that are attributed to the environmental conditions and the respective interaction of the genetic background of the cultivated genotypes.

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