Original Research Article

Anatomic leaf structure of 'Sunrise Solo' and 'Golden THB' papaya plants

ABSTRACT

Papaya (*Carica papaya* L.) stands out as a strong economic driver, being one of the fruit trees that most contribute to the total volume of brazilian production. The description of leaf characteristics allows to understand structures that act in resistance to pathogens, relationships with water resources and photosynthetic of plants, in addition to contributing to genetic improvement programs. However, there are few studies that attempt to describe the leaf anatomy of the different papaya cultivars. Thus, this study aims to describe the main leaf structure of papaya cultivars Sunrise Solo and Golden THB. The leaves were collected in the municipalities of São Mateus and Aracruz, located in the north of the State of Espírito Santo, using transversal and paradermic sections and the usual techniques of plant histology. Both cultivars presented uni-stratified epidermis, followed by palisade chlorophyll parenchyma and lacunous with collateral vascular system. Calcium oxalate druses were more observed in the Sunrise Soil cultivar. The differences between cultivars were in the number of layers of mesophyll tissues.

Keywords: Carica papaya L.; leaf structure; calcium oxalate crystals.

1. INTRODUCTION

Papaya (*Carica papaya* L.) is of great importance within tropical fruit farming, with its cultivation spread across different regions of the world [1]. In Brazil, the total production of papaya in 2018 was 1,060,392 tons with a cultivated area of 78,502,422 ha, highlighting the states of Espírito Santo and Bahia with production of 354,405 and 337,151 tons, respectively, with these two states responsible for more than 65% of all national production [2].

Among the most prominent cultivars in the brazilian production scenario are Sunrise Solo and Golden THB, both belonging to the Solo group and have fruits ranging in size from 350 to 700 g, being Sunrise Solo destined mainly for the national market and Golden THB destined for the market of exports [3].

Despite the notorious importance of papaya for the Brazilian market, there are few studies that seek to describe the leaf anatomy of different cultivars. This description allows to identify structures that act in the resistance to pathogens, contributes to the knowledge about the water relations and photosynthetic capacity of the plants, in addition, these characteristics can be used in programs of genetic improvement and development of new accessions, collaborating with the increase of the production and reducing damage to crops [4] [5].

In this context, the objective of this study was to describe the main characteristics of the leaf structures of 'Sunrise Solo' and 'Golden THB' papaya and to compare these structures between the analyzed cultivars, contributing to the internal morphological knowledge of these cultivars of commercial interest.

2. MATERIAL AND METHODS

For the present study, papaya leaves (*Carica papaya* L.) were collected from cultivars belonging to the Sunrise Solo and Golden THB soil group, fully expanded and without damage from pests or diseases. The leaves were collected in the municipalities of São Mateus and Aracruz, located in the north of the state of Espírito Santo, Brazil. The climate in the region is classified by Köppen as tropical Aw, with a predominance of rain in summer and dry winter [6].

In the laboratory, the samples were fixed in FAA (formaldehyde: acetic acid: 50% ethyl alcohol, in proportions 2:1:18, v/v), according to [7], being transferred after 48 hours to 70% ethanol. The description of leaf structures was performed from transverse and paradermal sections, made manually, in the median region of the leaves with the aid of a steel blade. Subsequently, the sections underwent depigmentation in 25% sodium hypochlorite solution and double staining with 1% safranin and 1% alcian blue [8]. Paradermal sections were stained with 1% safranin and mounted between slide and coverslip with glycerin gelatin.

The laminate was submitted to a descriptive analysis of the characteristics of the leaf structures of Sunrise Solo and Golden THB papaya under a photonic microscope (Leica DM 750) and the illustrations obtained using a photomicroscope (Motic BA 210), with projection of micrometric scales.

3. RESULTS AND DISCUSSION

In frontal view, the epidermal cells of the adaxial surface present straight cell walls (Fig. 1A). The stomata of the cultivars Sunrise Solo and THB are anomocytic, and are present on the abaxial surface of the leaf blade, being classified as hypostomatic (Fig. 1B and Fig. 1C), which gives these cultivars adaptive capacity to conditions of high incidence of radiation. solar energy [9]. For 'THB', anisocytotic stomata were also observed, to a lesser extent (Figure 1D). The stomata occur at the same level as the other epidermal cells (Fig. 1D). The description is in agreement with the works observed by [10], when they described the leaf anatomy of conventional and transgenic papaya. However, [11] [12], described only anomocytic stomata for the species.

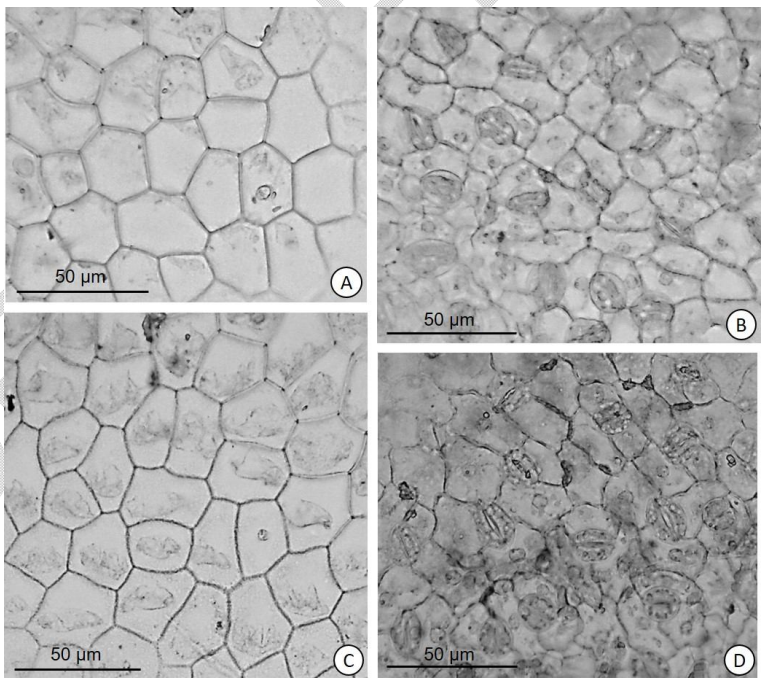

Fig. 1. Front view of the leaf blade of *Carica papaya* L. A- Adaxial face of the cultivar Sunrise Solo. B- Abaxial face of the Sunrise Solo cultivar, anomocytic stomata. C- Adaxial face of the Golden THB cultivar. D- abaxial face of the 'Golden THB' cultivar, anomocytic and anisocytic stomata.

In cross-section, the leaf blade of both cultivars presented unistratified epidermis with quadrangular to rectangular epidermal cells, with those on the abaxial face being clearly smaller (Fig. 2). This similarity may be associated with the kinship between these two cultivars, since the THB cultivar was obtained from the selection of the Golden cultivar, which

comes from a mutation of the Sunrise Solo cultivar, so there is low genetic variability between these cultivars [13] [14] [15]. The dorsiventral mesophyll consists of a single layer of palisade chlorophyll parenchyma and spongy parenchyma layers, 5 to 8 in 'Sunrise Solo' (Fig. 2A) and 7 to 10 in 'Golden THB' (Fig. 2B).

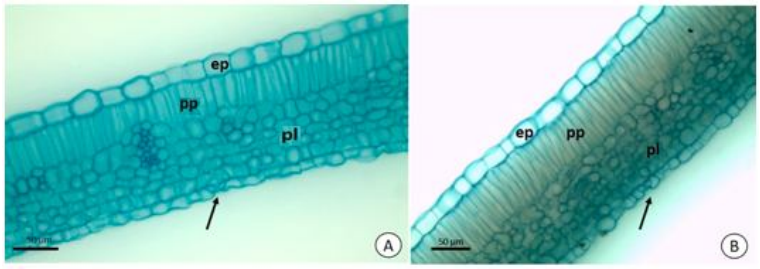

Fig. 2. Cross sections of the leaf blade of *Carica papaya* L. A- Mesophyll of the cultivar Sunrise Solo. B- Mesophyll of the Golden THB cultivar. Seta- stomata, epi- epidermis, pl- spongy parenchyma, pp- palisade parenchyma.

The main vein has a biconvex outline (Fig. 3) and the vascular system of 'Sunrise Solo' and 'Golden THB' are respectively made up of 7 and 10 sparse xylem bundles and phloem cells distributed in groups along the perimeter of the vein (Fig. 3B). These structures, present in the leaves, are associated with adaptive functions to different types of environments, maintaining the functionality of the plant [16]. Note that 'Golden THB' presented a greater number of xylem bundles compared to 'Sunrise Solo' (Fig. 3B and Fig. 3E) this finding is important, as plants that present a greater amount of these structures have greater tolerance to adverse conditions, such as to water stress, as the xylem bundles are specialized in the efficient transport of large amounts of water and mineral salts from the root system [17] [18].

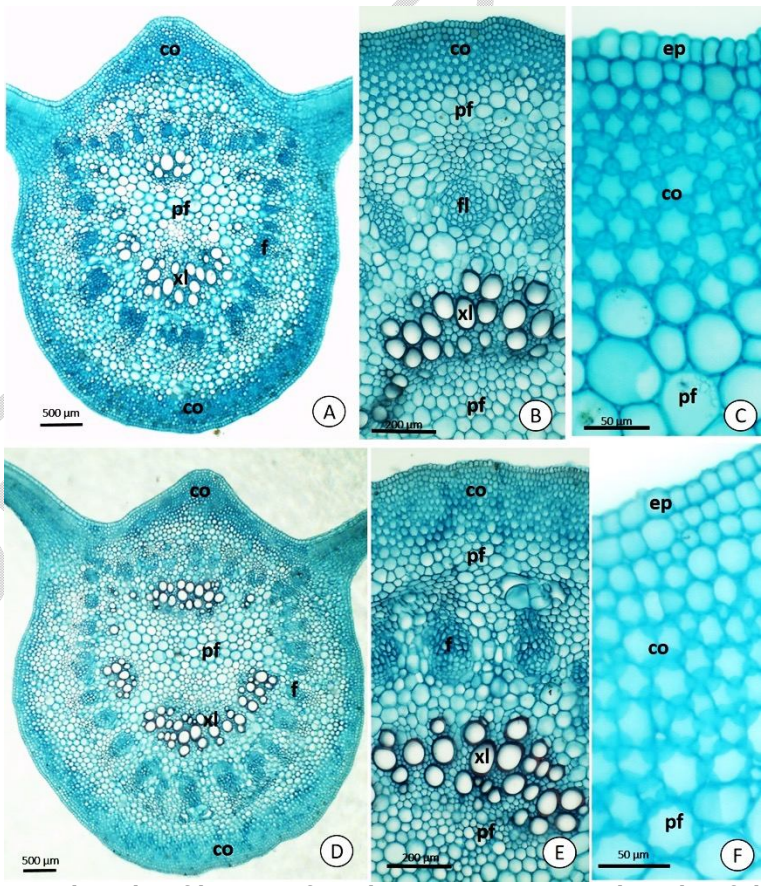

Fig. 3. Cross sections of the main vein of leaves of *Carica papaya* L. A- Main vein of the cultivar Sunrise Solo. B- Vascular bundles of the Sunrise Solo cultivar. C- Angular collenchyma on the abaxial surface of the cultivar Sunrise Solo. D- Main vein of the Golden THB cultivar. E- Vascular bundles of the Golden THB cultivar. F- Angular collenchyma on the abaxial surface of the Golden THB cultivar. ep- epidermis, co-collenchyma, pf- fundamental parenchyma, xl- xylem, fl-phloem.

In the counting of the cells of the tissues that make up the main rib, three count regions were separated, namely: right lateral, median and left lateral of the rib. In this respective order, the number of cell layers that make up the collenchymatic, fundamental parenchyma and filling parenchyma tissues was described. Therefore, in the main vein of 'Sunrise solo' below the abaxial epidermis, 5, 6, 3 layers of collenchyma cells were observed (Fig. 3B and Fig. 3C), followed by fundamental parenchyma composed of 6, 10, 6 layers of cells. (Fig. 3A and Fig. 3B). The vascular bundles were separated by 10, 12, 10 layers of parenchyma filling cells (Fig. 3A) and on the abaxial surface there were 4, 11, 5 layers of collenchyma cells and 4, 10, 3 layers of parenchyma lacunose chlorophyll (Fig. 3A).

In the main vein of 'Golden THB' below the abaxial epidermis, 3, 11, 5 layers of collenchymal cells were observed (Fig. 3F) followed by 9, 12, 7 layers of fundamental parenchyma (Fig. 3D and Fig. 3E). The xylem bundles are separated by 17, 20, 13 layers of infill parenchyma (Fig. 3D). Below the adaxial epidermis, 9, 19, 10 layers of spongy collenchyma were found, followed by 2, 12, 3 layers of fundamental parenchyma (Fig. 3D).

Most parenchyma cells, including chlorenchyma, which is the place where high concentrations of chloroplasts are stored, this relates to the photosynthetic capacity of the plant, greater layers allow greater effectiveness in the absorption of CO_2, with less stomatal opening and saving of water resources soil [19]. It is possible to observe greater development of this tissue in ´Golden THB´ plants, suggesting that this cultivar has greater efficiency in the photosynthetic mechanism. In practice, this may reflect in greater yield gains, since under ideal conditions, the Sunrise Solo cultivar has an average yield of 85 t/ha [20] and the THB cultivar has an estimated average yield of 91 t/ha [21].

Calcium oxalate crystals in the form of druses are found in the spongy parenchyma, where the proportion of crystals varied between cultivars, where Golden THB presented a low amount of crystals, while in Sunrise Solo plants the concentration was high, and these structures were found in the collenchyma, fundamental, palisade and spongy parenchyma (Fig. 3F). According to [22], there is a possible accumulation of calcium oxalate crystals in the latex of papaya, which is related to the protection of the plant from the attack of pathogens Papaya meleira virus (PMeV) that involves signaling pathways that are triggered or that culminate in an increase in the levels of H_2O_2 and calcium oxalate acting against the virus.

4. CONCLUSION

According to the anatomical analyses, it is concluded that the Sunrise Solo and Golden THB cultivars differ from each other in the number of tissue layers and in the proportion of oxalate crystals in drusen forms, with Sunrise Solo standing out with the highest proportion. of these structures.

REFERENCES

1. Souza JMA, Ataíde EM, Silva MS. Post-harvest quality and correlation between physical and chemical characteristics of mamoeiro fruits commercialized in Serra Talhada - PE. Magistra. 2014; 26:554-560.

2. Brazilian Institute of Geography and Statistics – IBGE. Municipal agricultural production: Area planted or intended for colheita, covered area, quantity produced, average yield and value of the production of temporary and permanent washing. 2018. Available at <http:/www.sidra.ibge.gov.br>. Access on March 19, 2020.

3. Serrano LAL, Cattaneo LF. The cultivation of mamoeiro in Brazil. Brazilian Magazine of Fruit Growing. 2010; 32:657-959.

4. Campostrini E, Glenn DM. Ecophysiology of papaya: a review. Brazilian Journal of Plant Physiology. 2007; 19:413-424.

5. Ferreira MGR, Nogueira AE, Damião Filho CF. Leaf morphology of Theobroma grandiflorum Schum. Rural Science. 2008; 38:530-533.

6. Alvares CA, Stape JL, Sentelhas PC, Gonçalves JLM, Sparovek G. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift. 2014; 22:711-728.

7. Johansen DA. Plant Microtechnique. Mc Graw Hill, New York. 1940.

8. Luque R, Sousa HC, Kraus JE. Roeser's (1972) staining methods - modified - and Kropp's (1972) aiming at the substitution of astra blue for alcion blue 8GS or 8GX. Brazilian Botanical Act. nineteen ninety six; 10.

9. Fahn A. Plant anatomy. Madrid: Pyramid. 1985.

10. Leal-Costa MV, Munhoz M, Meissner Filho PE, Reinert F, Tavares ES. Leaf anatomy of transgenic and non-transgenic plants of Carica papaya L. (Caricaceae). Brazilian Botanical Act. 2010; 24:595-597.

11. Fisher JB. The vegetative and reproductive structure of papaya (Carica papaya). lyonia. 1980; 1:191-208.

12. Shai A, Allan P, Gilliland M, Savage MJ. Anatomy and ultrastructure of Carica papaya leaves. South African Journal of Botany. 1986; 52: 372-378.

13. Santos SP. Morphoanatomical and genetic aspects in relation to the germination of mammary seed. 88 f. Thesis (PhD in Genetics and Melhorament) - State University of the North Fluminense Darcy Ribeiro, Campos dos Goytacazes. 2009.

14. Birth AL. Mamoeiro genetic improvement: new hybrids for the North of Espírito Santo. 2014. 105f. Dissertation (Master in Tropical Agriculture) - Federal University of Espírito Santo, North University Center of Espírito Santo, São Mateus. 2014.

15. Alves DI, Noia LR, Lopes JC, Mengarda LHG. Physiological quality of suckling pigs subjected to osmotic stress. Biosphere Encyclopedia. 2015; 11:1624-1635.

16. Castro EM, Pereira FJ, Paiva R. Plant histology: structure and function of vegetative organs. Lavras: UFLA Publisher. 2009.

17. Melo GM, Cunha PC, Pereira JAF, Willadino L, Ulisses C. Anatomical alterations in leaves and roots of Jatropha curcas L. cultivated under saline stress. Agronomic Science Magazine. 2011; 42: 670-674.

18. Taiz L, Zeiger E, Moller IM, Murphy A. Plant physiology and development. 6. ed. Porto Alegre: Artmed. 2017.

19. Arantes SD, Chaves IS, Pinto JEBP, Alvarenga AA, Castro EM, Alves E, Cerri Neto B, Lavanhole DF, Silva FRN, Ferreira TR, Arantes LO, Oliveira VS, Schimildt ER. Limbo structure and essential oil theory in Piper aduncum L. under the influence of photoselective diseases. International Journal of Development Research. 2019; 10: 30197-30202.

20. Feltrin Seeds. Mamão Sunrise Solo segment: Solo. 2010. Available at: <https://www.sementesfeltrin.com.br/_uploads/pdf/InfoTecnicaP_233.pdf>. Access in: April 07, 2020.

21. Feltrin Seeds. (2009). Mamão THB segment: Solo. 2009. Available at: <https://www.sementesfeltrin.com.br/_uploads/pdf/InfoTecnicaP_231.pdf>. Access in: April 07, 2020.

22. Rodrigues SP, Cunha M, Ventura JA, Fernandes PMB. Effects of the Papaya meleira virus on papaya latex structure and composition. Plant cell reports. 2009; 28:861-871.