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Branches characteristic of growth of the soursop (*Annona muricata* L.) under tropical dry forest conditions

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Abstract

With the purpose of studying the vegetative and reproductive growth of soursop (*Annona muricata* L), an essay was carried out at a commercial farm located at Mara municipality (11º 02’ and 11º 07’ LN and 71º 58’ and 72º 10’LO), Zulia state, Venezuela, for 7 months. Five (5) plants of 7 months old were selected at random, sowed at a sexual propagation, at a sowing distance of 6 m x 6 m. The studied variables were vegetative buds (BV), floral buds (BFL) and occurrence time of these. The experimental design was completely randomized, considering as experimental unit 5 plants as replication and 2 branches per plant. The variable analysis was done following the methodology employed by Costes. BV were of two types: 0 (latent buds), 1 (short buds: 1cm), 2 (intermediate buds: until 5cm) and 3 (long buds: >5 cm) presenting on a sequence way throughout the portable axis. BFL were registered in branches of orders VII and VIII formed in nudes from 3 to 5. The sprouting occurrence agreed to the precipitation season (January – May – July – December). Ramification is acrotonous and growth is plagiotropic.
Key words: Annona muricata L., growth, budding, phenology.

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Introduction

Soursop (*Annona muricata* L.) is a fruit plant that belongs to the Anonaceas family. Species of this family are from Tropical America (17, 18, 33, 42), being the origin of the soursop in Colombia or Brazil (18, 21). This specie is disseminated wildly as it is also sowed at Antilles, the South of Mexico, and Brazil and in the Pacific Islands; it is also cultivated at the South of Florida, Southeast of China, Australia and low and warm lands of the East and West of Africa (17, 18).

In Venezuela this product has been sowed for many years, nowadays in Zulia state there is a surface sowed of 415 hectares (13). In the last years soursop has had an economic importance by its high demand of its fruit, by the fresh consumption and for the industry of ice creams, juices, concentrates, yogurts and nectars (3, 9, 34), there lots of expectation of its importing as frozen pulp (1, 17, 27, 34, 44).

Due to the high demand of this fruit (48), its commercial exploitation is limited by different factors. Among the most important are, the dissemination by seed of plants (21, 22), problems with scarce sprouting (10, 28), deficient handle of the crop (3, 17, 49), high incidence of plagues (4, 7) and illnesses (46), plus the lack of pruning techniques (19, 44).

Consequently, there are few investigations done in this fruit (17, 32), likewise, the technical-scientific information about the handle of the crop is limited (17), and the habit of vegetative (5) and reproductive (5, 6) growth of the plants has even been less studied, as well as occurrence seasons of the different phenophases that happen on each crop's cycle, and its relation with climatic conditions that predominate on the productive areas. That information is considered fundamental for research and development of handling programs on tropical crops (2, 23, 26, 30). Therefore, it was considered important to study the characteristics of branches and the phenology of soursop under a Very Dry Tropical Forest conditions.

Materials and methods

Location of the investigation

The study was done on an experimental farm located at Los Mayales, Mara municipality (11º02' and 11º07' North Latitude and 71º58' and 72º10' West Longitude), Zulia state (35, 38). The investigation was done for 7 months (from April to October, 1997). The area is located on the North-occidental are of Zulia state, inside the highlands of Maracaibo. According to Holdrige, this area corresponds to a very dry Tropical Forest, it presents a bimodal distribution regimen, with irregular rains that oscillates between 500 and 600 mm annually, presenting two peaks of maximum precipitation on May and October, with two minimum in December-January and July-August.

The annual average temperature is 27ºC, the evapotranspiration is 2.500 mm annually and the relative humidity of 70% (38). Soils in general, have a low natural fertility and a pH averaged in 5.5, with a superficial sandy texture or loamy-sandy texture varying in thickness from 0 to 90 cm, on an argillite horizon with a finer loamy-clayey-sandy texture (40). These soils, according to the classification system of soils «Soil Taxonomy» are classified as Aridisols.

Experimental material

Seven-month-old soursop plants were used, sowed sexually at a sowing distance of 6m x 6m. A sample of 5 plants chosen at random (16, 25), from a lot of 176 plants, which were uniform in size and handling. For observations and measurements, the canopy of plants was sectioned in two halves, drawing an imaginary line on North-south direction, by the central axis of each plant. Thus, each plant originated an East half (E) and a West half (O), represented by the squared 1 (C1) and squared 2 (C2). On each half a branch was selected at random, through order VI.

Studied variables

The studied variables were: vegetative buds (BV), floral buds (BFL) and season of occurrence. The experimental design was completely randomized, taking as experimental unit five (5) plants and two branches (2) per plant as replication with a cardinal orientation.

The variable analysis was done following the methodology employed by Costes (14), where the axilar production supported by each node was represented using the following scale: 0 buds steady, I short bud (<5cm), 2 medium buds (6 and 19 cm), 3 long buds (>20cm) and 4 floral buds. The event sequences were defined as qualitative variables and were interpreted by comparison methods of sequences and exploratory analysis (14, 15).

The sequence comparison consisted on confronting the event sequences, taking the first sequence as referent point, and the other were used for analysis. The analysis of these were transformed according to four (4) essential substitution operations (s), that means the replacement of an element of the sequence for another one; similarity (m), when elements are identical; insertion (i), when an element appears; and suppression (d) when an element is taken out or eliminated.

The exploratory analysis of sampling sequences lie on the description of the empiric distribution of different symbols of the portable axis, which were grouped according to the intensity, and the node's range, and manifesting the relative frequency of each value according to the type of outcropping. For this analysis, inside each plant (PL1, PL2, PL3, PL4 and PL5) the evaluated branches were delimited and determined on growth units (UC), which are defined as the group of new elements that form on branches, during a continuous growth phase (6, 8).

The phenology was determined through the registers of photoperiods where the vegetative and floral outcropping happened. The frequency when measurements and observations were done was weekly at the moment that the study initiated, and then it was done every fifteen days (25).

The climatologic registers were obtained from the Fruit Center of Zulia state (CORPOZULIA), located at 10º49'15" of latitude, 71º46'20" of longitude and 1m of altitude (36).

Results and discussion

Vegetative buds (BV)

This fruit tree belongs to the architectural model of Troll's characterized by presenting a continuous growth in branches (29). On parental branches of VI order the composition of portable axis were formed by a succession of differentiated areas, characterized by a mix of axilar structures which most of them resulted vegetative (buds). Outcropping and the formation of lateral branches occurred simultaneously with the growth of the portable axis (29); this has been observed in other fruits as well, under greenhouse conditions and on grafted plants (37).

Differences were observed on the production of buds an on the sequence of events analyzing globally axis by squares and by plant,

On figure 1, the distribution (1a) and sequence (1b) of the axilar production is shown in one of axis. In order to visualize clearer the areas and to be able to prove the biological relevance of the model employed, five structure sequences were chosen and measured on a branch located on the squared 1 (C1) and squared (2) of the plant 1, which are presented next:

Sequences in C1

000000000000000000000000000-00020200102-0000000000000-02010001000010

000000000000000000000000000-01020300102-0000000000000-02010001000010

000000000000000000000000000-10203001030-0000000000000-20100010000110

000000000000000000000000000-10203001030-0000000000000-30100021000110

000000000000000000000000000-10203001030-0000000000000-30110021000110

These five sequences exhibit a succession of four differentiated areas, the first one formed by 0; the second by 0, 1, 2 and 3; and the third by 0; and fourth by 0, 1, 2 and 3.

Sequences in C2

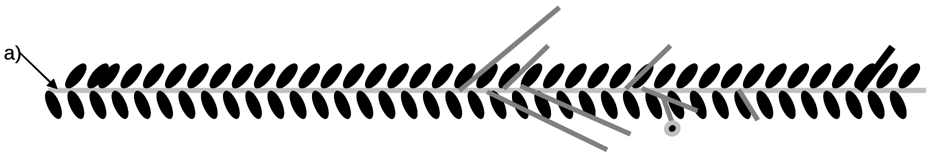
0000000000-30201010101-000000000000000010000000000-20301000020002000

0000000000-30201010101-000000000000000010000000000-20301000020002000

0000000000-30201010101-000000000000000010000000000-20301000020002010

0000000000-30201010000-000000000000000000000000000-20300000030002100

0000000000-30201010000-000000000000000000000000000-20300000030102100



b) 000000000000000000000000000000000202010200000001010000000000010000000010000

Figure 1. Schematic representation of: a) growth units b) Transcription as a sequence. 0: Latent buds 1 Short buds (<5cm), 2: Medium buds (6 and 19 cm), 3 Long buds (>20cm) and 4 Floral buds

These sequences are formed by four areas: the first one formed by 0; the second by 0, 1, 2 and 3; the third by 0 and 1; the fourth by 0, 1, 2 and 3. Even though sequences in C1 and in C3 are similar in the number of areas, these turn to be different in relation to the sequence and type of buds.

In some species of Anonaceas, an interval sprouting has been observed from the distal sectors to the basal, which do not normally sprout, due to the strong competence of the terminal buds (12, 38), but once these disappear the development of axilar buds favors, as happens on the analyzed case. This difference on the apparition of sprouts might depend in some situations, on the competence by photoassimilated and on the metabolites principles of growth (photosynthetic rate and biomass production), hydric stress, leaves' removal, the reproductive capacity of buds and the environmental conditions that favors the development of these (12, 31, 41, 47).

In figures from 2 to 11, growth units are shown (UC) established for branches evaluated by the plant; finding on C1 and C2 of PL1, PL3 and PL4 three UC, in C2 of PL2 two UC, and on C1 and C2 of PL5 a UC. On this analysis the apparition frequency of the buds types was determined by UC, where the type 0 (steady buds) resulted to have the highest frequency in all UC; the other types of buds were observed with a much lower frequency and in some cases did not appear, as happened in UC1 of C1 and C2 of PL1.

The average of steady buds was of 77.56% which indicates the high sprouting capacity of portable branches or parental axis that might be induced by handling practices such as pruning, sprouting and an adequate irrigation. The formation of structures 1, 2, 3 and 4 is proportionally very low and its apparition focuses on rainy seasons; meanwhile, on drought season growth and the ramification stopped. Variation in the number of sections (growth units) of the parental branch might be due to the genetic influence of plants originated by seeds; and on the other hand might be subject to environmental conditions and the crop handling (41, 47).

Floral buds (BFL)

In branches of order VI, floral buds did not register, therefore, BFL were observed in lateral branches of

Extracción de intensidad de características (a)

```
                UC        |           UC               |          UC
Abr 00000002011010-0000000000010000002030100000-00002000000000000000000020
                          |                            |
Jul 00000302011010-0000000000100000002030100000-000020000000000000000020100
                          |                            |
Ago 00000020101010-0000000000000000002030000000-000300000000000000000201000
                          |                            |
Sep 00003020101010-0000000000000000002030000000-000300000000000000000201000
                          |                            |
Oct 00003020101000-0000000000000000002030000000-000301000000000000000201000
```

Frecuencia de nudos (b)

f(0):	0.77	0.91	0.79
f(1):	0.14	0.04	0.08
f(2):	0.04	0.02	0.08
f(3):	0.04	0.02	0.04
f(4):	0.00	0.00	0.00

Figure 2. Exploratory analysis of sample sequence by type of sprout. Intensity extraction of characteristics (a). Nodes frequence (b).

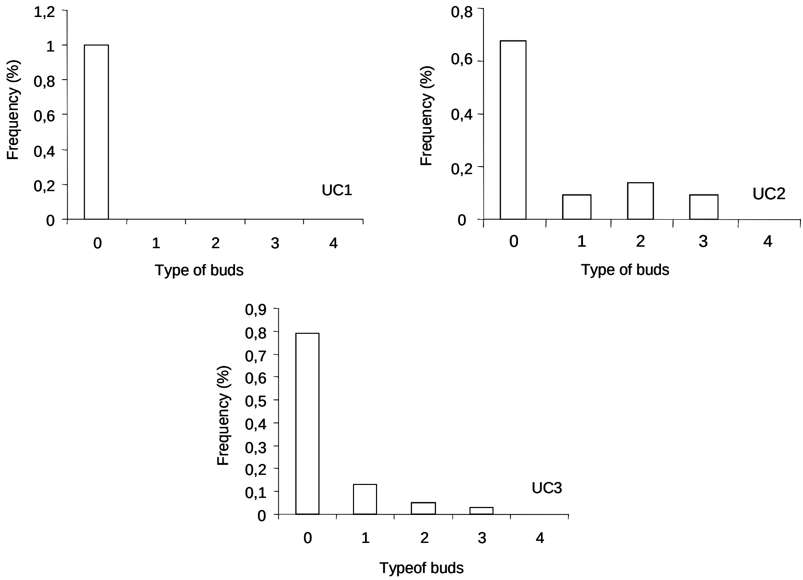


Figure 3. Frequency (%) of formed sprouts (0, 1, 2, 3 and 4) by growth unit (UC1, UC2, UC3) in the portable axis. East squared 1 (C1). 1st Plant (PL1).

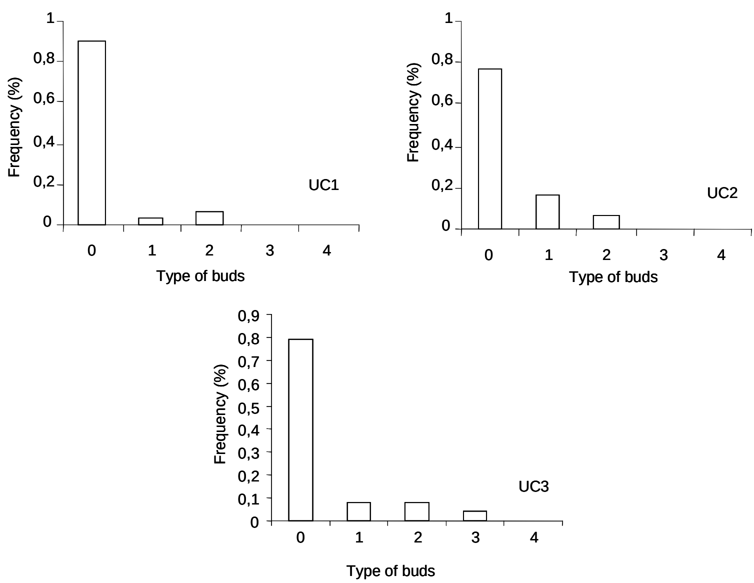


Figure 4. Frequency (%) of formed sprouts (0, 1, 2, 3 and 4) by growth unit (UC1, UC2, UC3) on the portable axis. West squared 2. (C2). 1st plant (PL1).

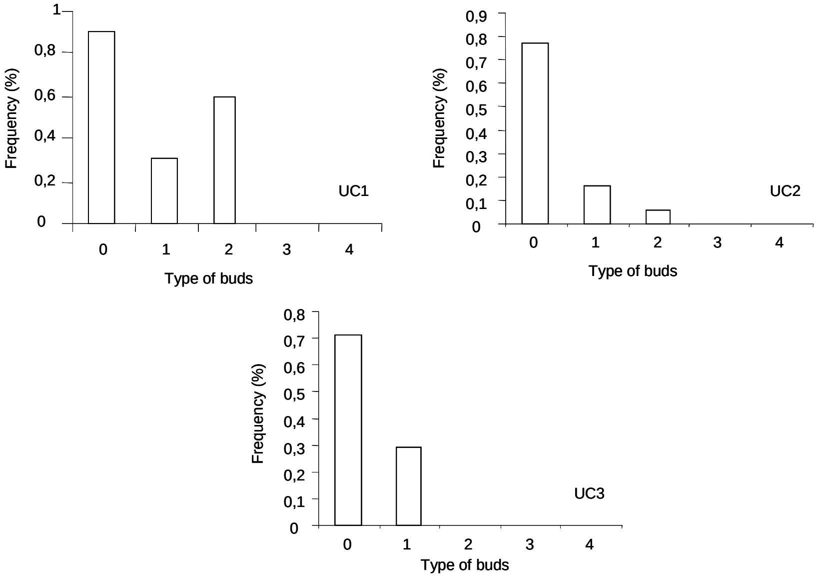


Figure 5. Frequency (%) of formed sprouts (0, 1, 2, 3 and 4) by growth unit (UC1, UC2, UC3) on the protable axis. East squared 1 (C1). 2nd Plant (PL2).

the order VII and VII, originated in the different nodes throughout the portable buds, resulting between nodes 3 and 5 where the highest number formed. In figure 12, frequencies of BFL are shown, where it is observed that this variable is presented during all the evaluation period, but with higher frequency on July, September and October, months where the highest precipitations happened (figure 13), thus agreeing to BV of the parental axis, showing that the type pf growth that characterizes the anonaceas is continuous (11, 29).

The sprouting process of this crop, is apparently related to sprout, that grows simultaneously to the parental branch (VI order), agreeing

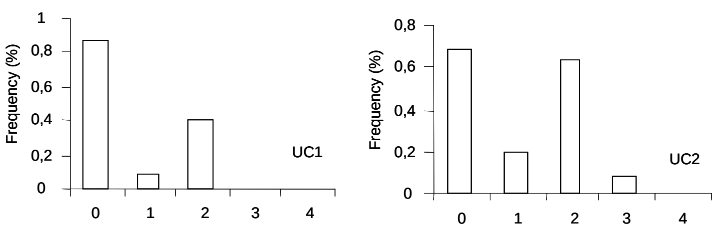


Figure 6. Frequency (%) of formed sprouts (0, 1, 2, 3 and 4) by growth unit (UC1, UC2) on the portable axis. West squared 2 (C2). 2nd plant (PL2).

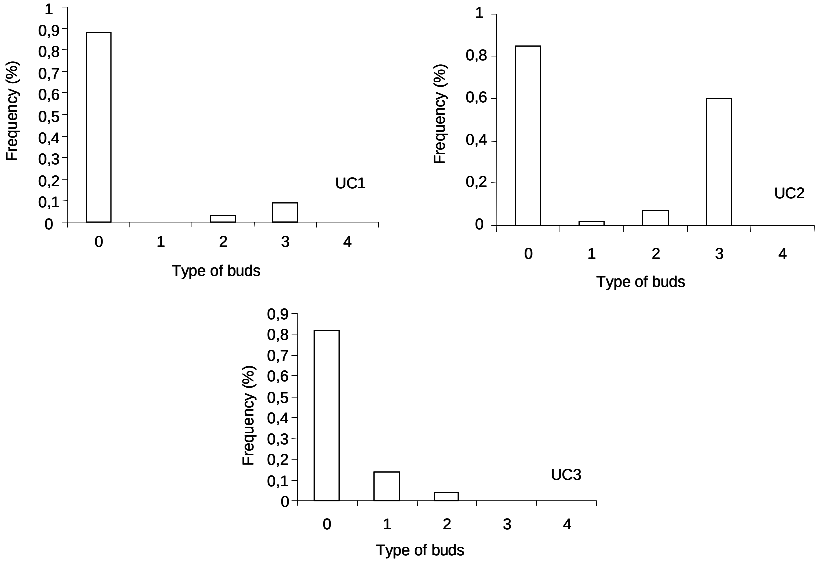


Figure 7. Frequence (%) of formed sprouts (0, 1, 2, 3 and 4) by growth unit (UC1, UC2, UC3) on the portable axis. East squared 1 (C1). 3rd plant.

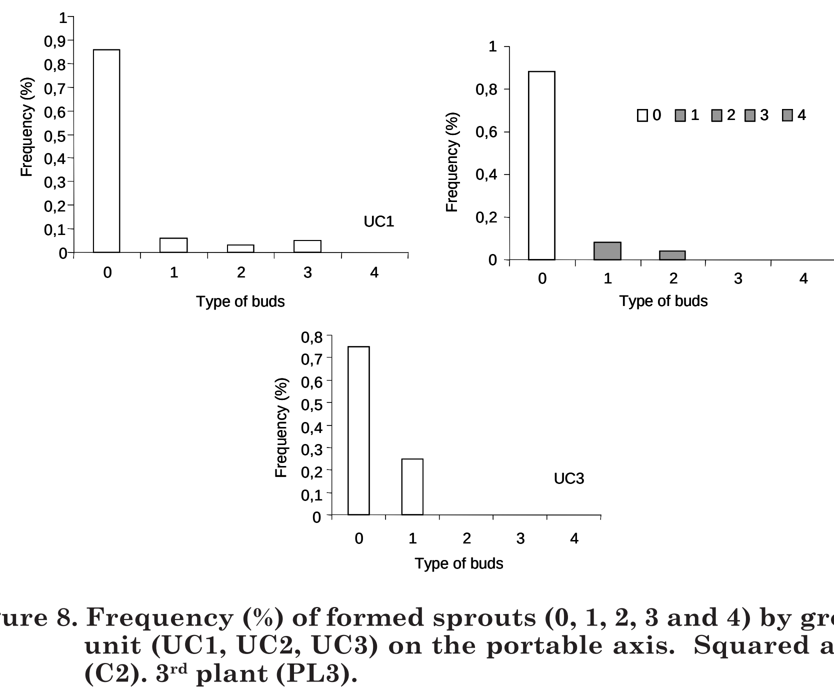


Figure 8. Frequency (%) of formed sprouts (0, 1, 2, 3 and 4) by growth unit (UC1, UC2, UC3) on the portable axis. Squared axis 2 (C2). 3rd plant (PL3).

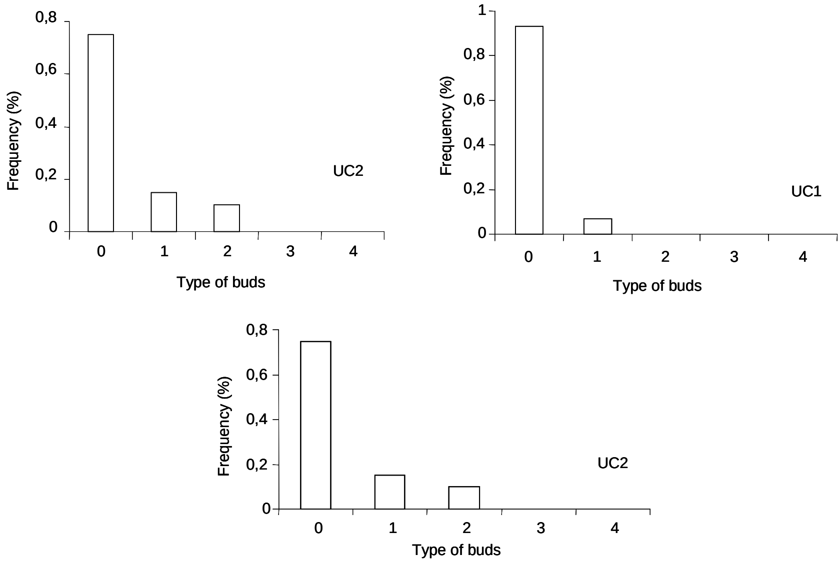


Figure 9. Frequence (%) of formed sprouts (0, 1, 2, 3 and 4) by growth unit (UC1, UC2, UC3) on the protable axis. East squared 1 (C1). 4th plant (PL4).

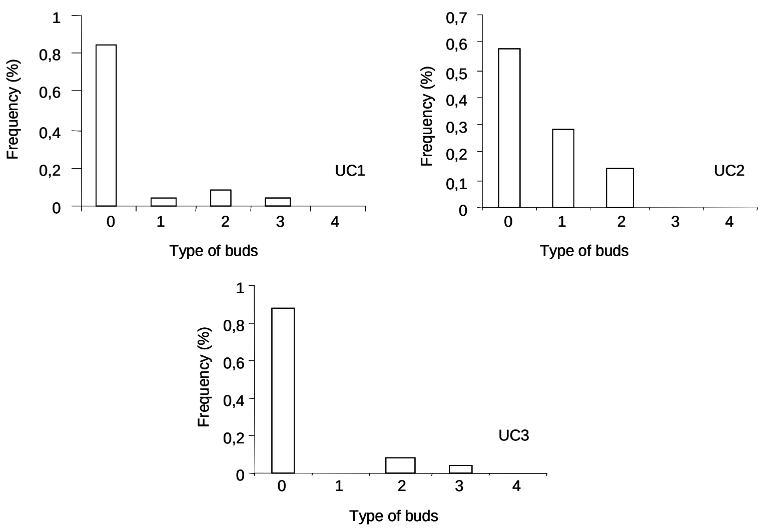


Figure 10. Frequency (%) of formed sprouts (0, 1, 2, 3 and 4) by growth unit (UC1, UC2, UC3) on the portable axis. West squared 2 (C2). 4th plant (PL4).

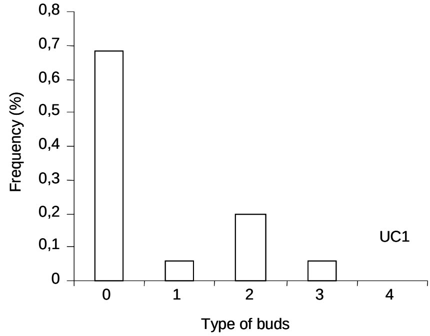


Figure 11. Frequency (%) of formed sprouts (0, 1, 2, 3 and 4) by growth unit (UC1) on the portable axis. East squared 1 (C1). 5th plant (PL5).

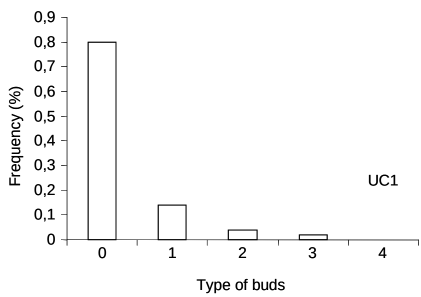
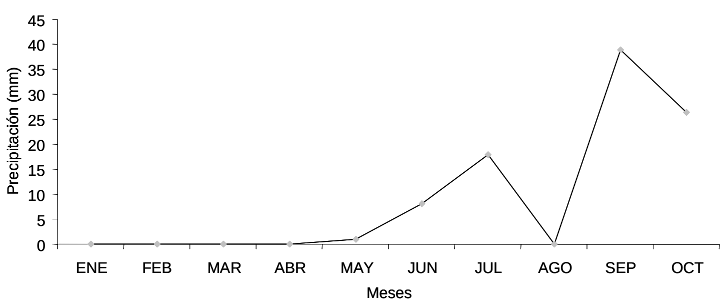


Figure 12. Frequency (%) of formed sprouts (0, 1, 2, 3 and 4) by growth unit (UC1) on the portable axis. West squared 2 (C2). 5th plant (PL5).



Source: M.A.R.N.R – Zulia city. Division of Environmental Information: Fruit Center

Figure 13. Precipitation distribution (mm) on Mara municipality. January-October. 1997.

Figura 14. Fenología del guanábano (*Annona muricata* L.) bajo las condiciones edafoclimaticas del municipio Mara, estado Zulia

these results to those reported in soursop, under weather and soil conditions of La Mesa of the Cundinamarca Department, Colombia (43). On the other hand, in anonaceas as in Chirimoya tree, the sprouting process that occurs simultaneously to sprout has been determined (11), as was observed in this research.

Phenology

In figure 14, is shown in a scheme the phenological behavior of soursop under the climatic and soil conditions at Mara, Zulia state. The axilar production of sprouts on the portable axis was observed with more frequency during August and September, while during May and July none change was registered on measurements, thus in this period buds were considered on a steady status; however, the highest sprouting frequency was observed on September. The vegetative sprouting as well as the reproductive appeared on rainy months. In general, soursop trees tend to sprout and to have fruits during all year, specially when are adults; however, in this case, there were defined seasons. A similar fact has been observed on the Valle del Cauca, in Colombia (19, 20), where predominates a weather with a bimodal precipitation distribution where two sprouting peaks are presented between June and August, with a less intense sprouting in December (19).

Conclusions

In branches with the order VI, sprouting was mostly vegetative, with a high proportion of steady buds (77.56%), in relation to other types of buds.

The reproductive sprouting was located on axis with the VII and VII order happening these on nodes 3 and 5 of these axis.

The vegetative sprouting occurred from July to September and sprouting from September to October, months when highest precipitations were observed.

Recommendation

To do the research in the greenhouse in order to establish the occurrence prediction models of the studied events, that would allow to characterize and to distinguish the behavior of soursop materials from an early development stage, with the purpose of forming the most adequate plant structure.

To study the characteristics of soursop branches on plants obtained by sexual and asexual propagation.

To do the study during two continuous cycles of production.

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