

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

5,300

Open access books available

132,000

International authors and editors

160M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Mixed Cacti Orchards – A Horticultural Alternative for Mexican Semiarid Tropics

Rodolfo López Gómez^{1*}, Heriberto Martínez López²
and Luis María Suárez Rodríguez¹

¹Universidad Michoacana de San Nicolás de Hidalgo,
Instituto de Investigaciones Químico-Biológicas,
Edificio B-1. Francisco J Mujica S/N Col Felicitas del Rio,

²Centro Interdisciplinario de Investigaciones para el Desarrollo Integral Regional,
Unidad Oaxaca,
México

1. Introduction

One of the most determinant phenomenon in horticulture is the phenology of cultivated species, a factor that is poorly known for cacti. Sexual reproduction in the majority of species belonging to the deciduous tropical forest communities (including some cacti) takes place during the middle or the end of the dry season (Rzedowski, 1978). There is an increasing interest in the fruits of some columnar cacti with economic value in the national and international markets. Such is the case in the state of Oaxaca, México of fruits of *Stenocereus griseus* (Haw) Buxbaum, locally known as “pitaya de mayo,” *S. stellatus* (Pfeiffer) Riccobono, “tunillo” or “pitaya de aguas” and *Escontria chiotilla* (Weber) Rose, “jiotilla,” species which produce fruits of economic relevance for several marginal communities in the state. The fruits of these columnar cacti are consumed fresh or used for making ice cream. The diversity in pulp color is an additional attractive of the fruits of the “pitayas” (*Stenocereus* spp.), which can be red, yellow, orange, purple or colorless, while those of “jiotilla” are invariably of red color. Several works have been made about the nutritional characteristics and diversity of the fruits of these cacti, mainly in their size and color (Ayala & Beltrán, 2007; Benito et al., 1992; Piña, 1977; Beltran et al., 2005; Casas, 2005; Tenango, 2005). The objective of the present work was to observe the phenological behavior of these species in their natural ecosystem, in order to obtain information about differences in their reproductive phenology that could be used for the establishment of mixed cacti orchards in the semiarid tropical lands of Mexico.

2. Materials and methods

A sampling area for phenological data was delimited for each one of the three studied species (Figure 1): 32 plants of “pitaya de mayo” were marked in a rural orchard at Joluxtla,

* Corresponding Author

in the municipality of Cosoltepec, district of Huajuapán de León, Oaxaca, at 1640 m.a.s.l. (Figure 1A); 30 plants of “tunillo” were marked in a rural orchard at Agua del Espino, municipality of La Compañía, district of Ejutla, Oaxaca, at 1420 m.a.s.l. (Figure 1B); and for “jiotilla,” an area of approximately 0.1 ha was delimited located 7 Km S of San Pedro Totolápan, municipality of San Pedro Totolápan, district of Tlacolula, Oaxaca, at 950 m.a.s.l. (Figure 1C) 45 plants were marked.

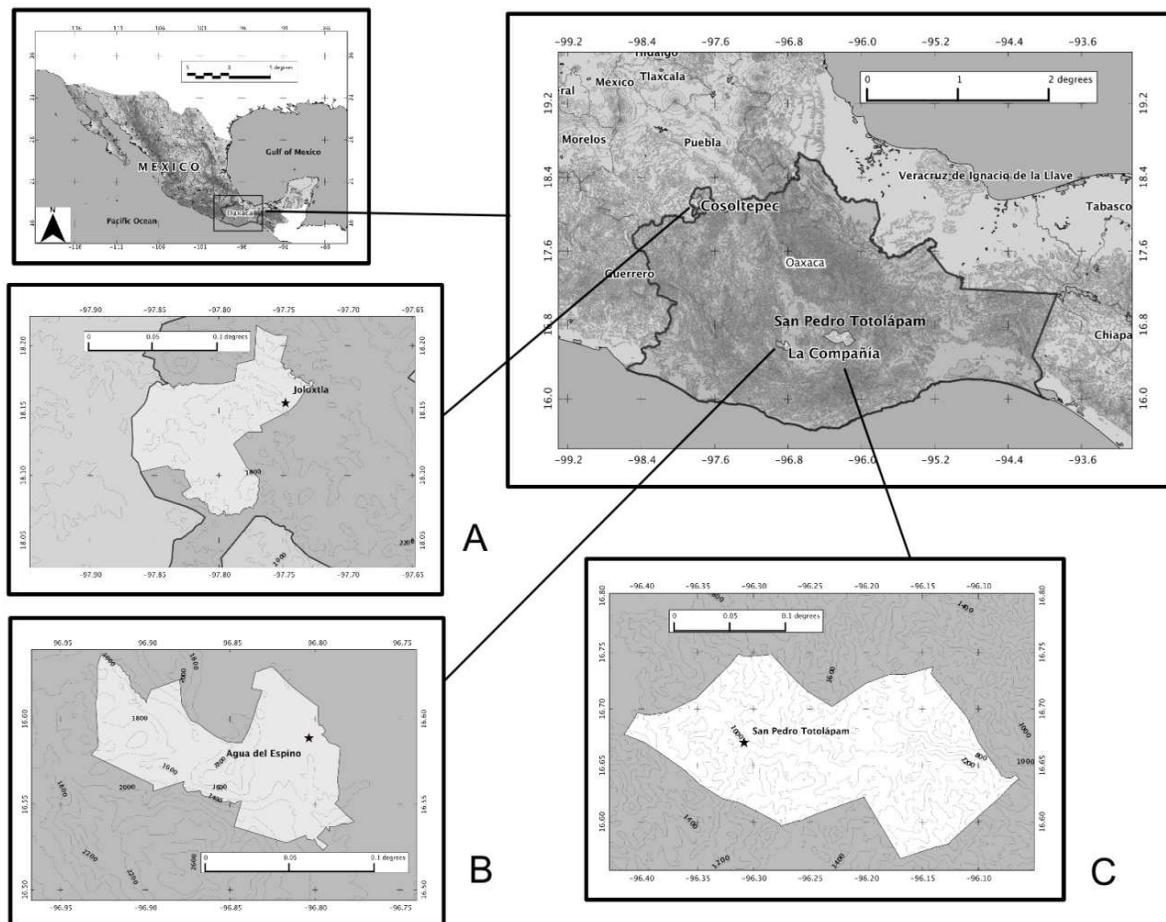


Fig. 1. Localization of study area and sampling sites for phenological data. A. Jolixtla: *Stenocereus griseus*, “pitaya de mayo;” B. Agua del Espino: *Stenocereus stellatus*, “tunillo;” C. San Pedro Totolápan: *Escontria chiotilla*, “jiotilla.”

The sampling areas were visited every 30 days throughout the 2005 year and phenological data were recorded. The phenological stages were defined as following:

- Fl₁.- Buds before anthesis
- Fl₂.- Flowers after anthesis
- Fr₁.- Immature fruits
- Fr₂.- Mature fruits
- Veg.- Vegetative

For the three phenological data sampling areas, ombrothermic diagrams were constructed using the climatic data for the last ten years from the nearest meteorological stations.

3. Results and discussion

The climatic conditions for the three study areas are represent in the ombrothermic diagrams shown in Figures 2A, 2B and 2C. These areas present similar climatic conditions with average temperature between 25-30 °C , a midsummer drought and an average annual precipitation of 600-800 mm.

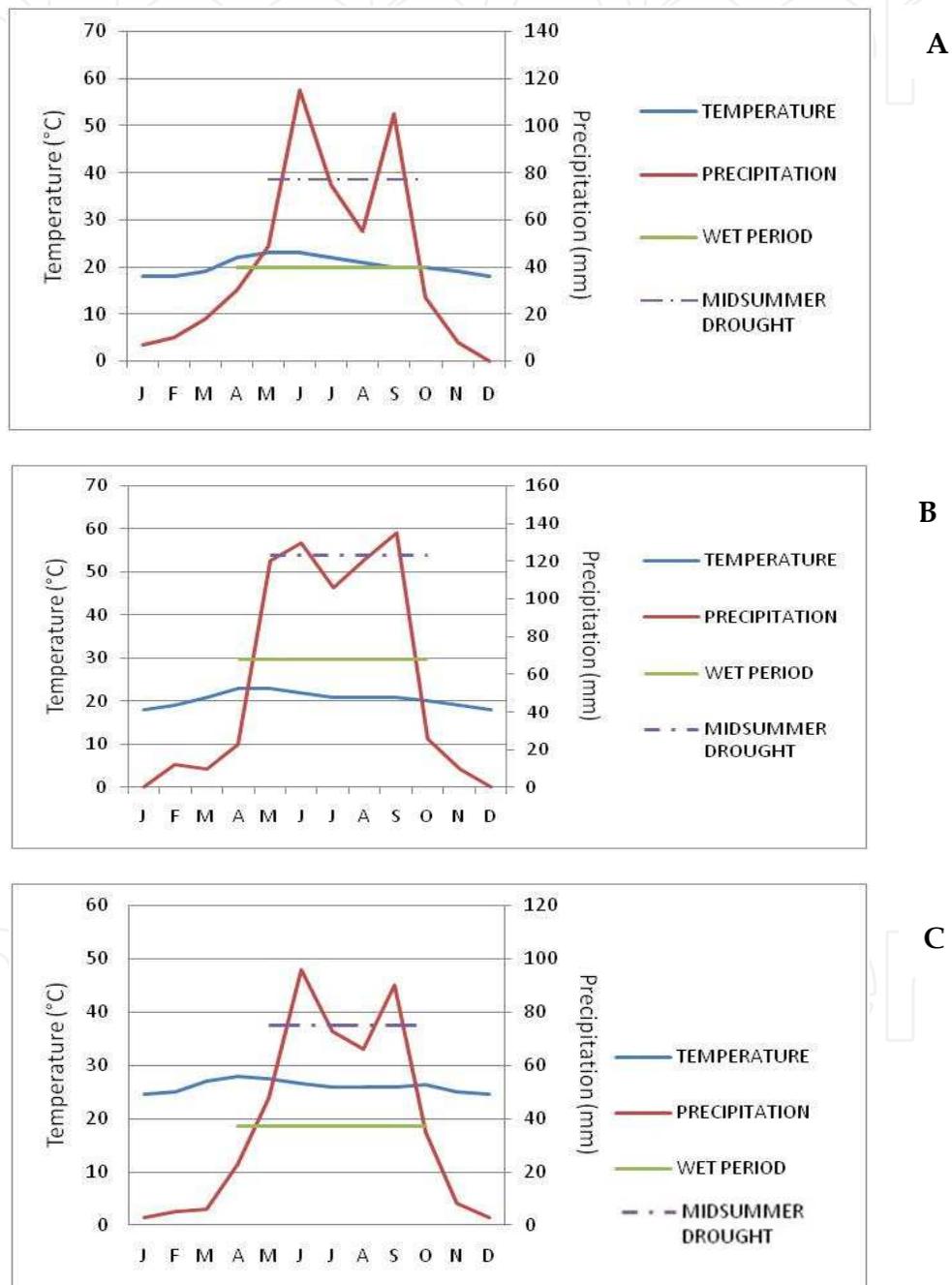


Fig. 2. Ombrothermic diagrams of sampling sites of phenological data of fruit producing columnar cacti; A) Chazumba for “pitaya” B) Ejutla for “tunillo” and C) Totolapan for “jiotilla.”

In the “pitaya” area, 76.6% of the plants were observed to have reproductive structures during the months from January to June (Figure 3) with a maximal of fruit production during May (hence the local name of “pitaya de mayo,” alluding to the month of May). 90% of the plants in reproductive phase produced mature fruits. *Stenocereus griseus* has also been reported to be of economic importance in Colombia, with two fruit production periods associated to rain seasons (Villalobos et al., 2007).

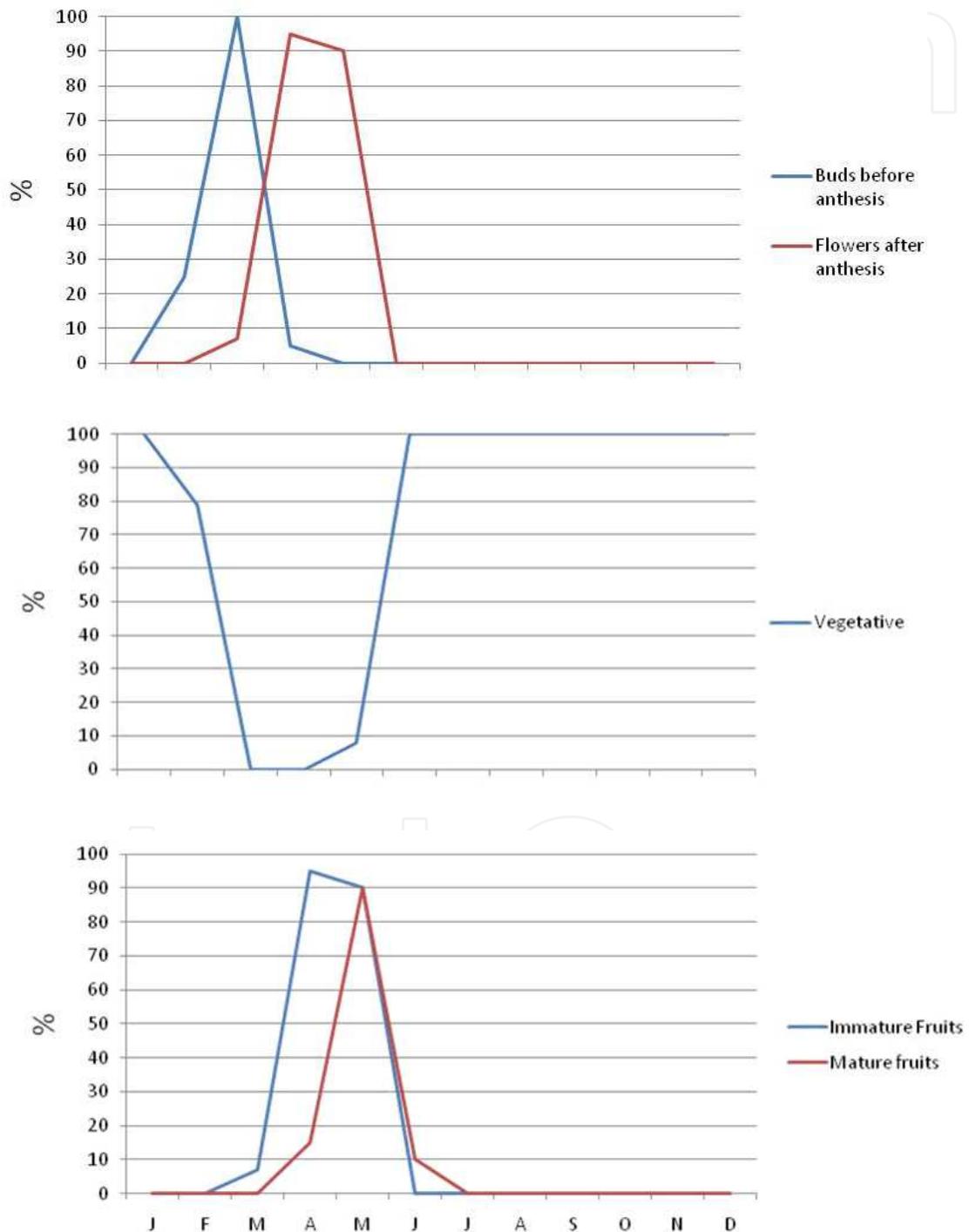


Fig. 3. Phenological diagram for “pitaya” (*Stenocereus griseus*).

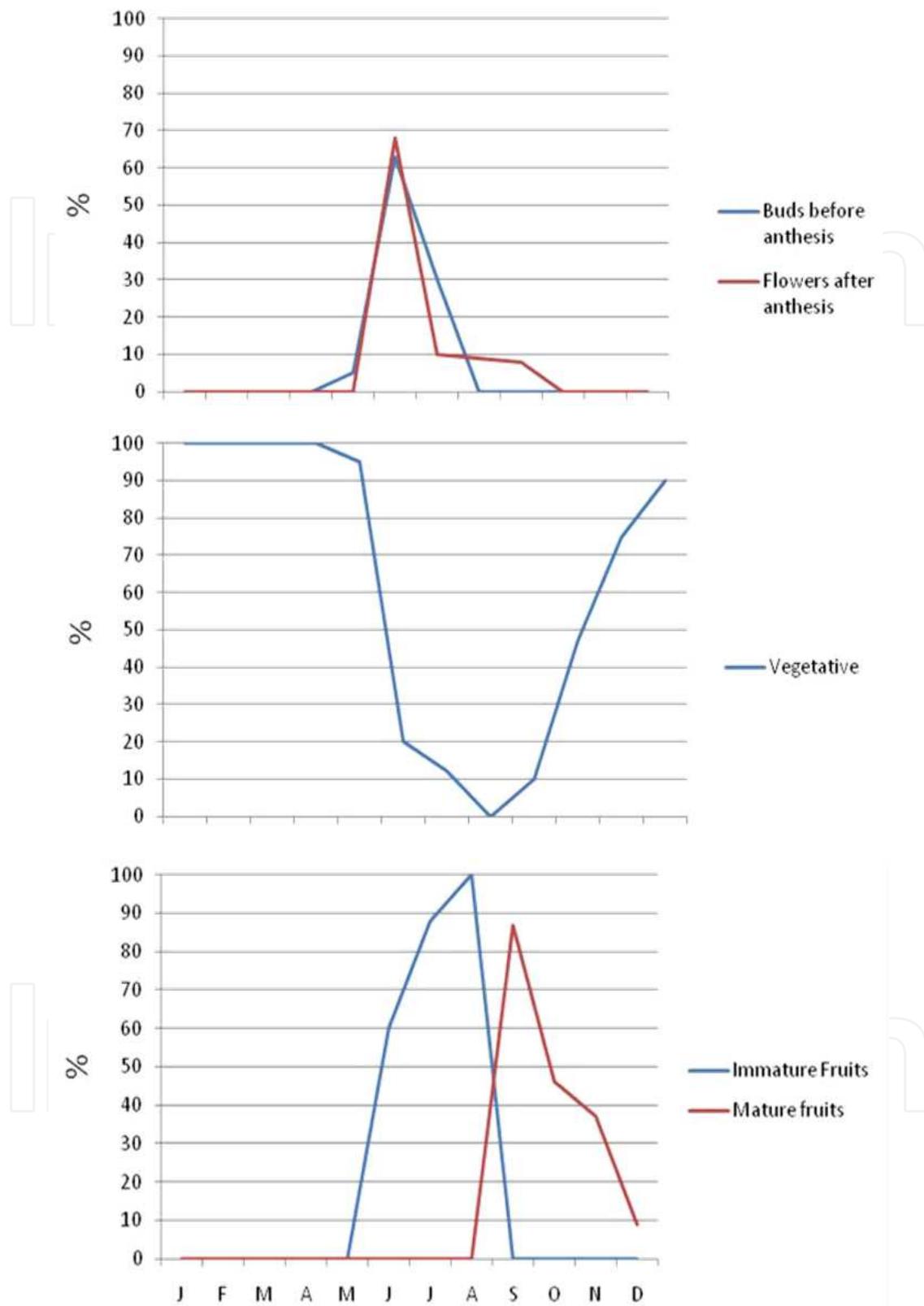


Fig. 4. Phenological diagram for “tunillo” (*Stenocereus stellatus*)

The phenological behavior of “tunillo” (*Stenocereus stellatus*) is represented in Figure 4. The reproductive period of this species is from May to October and mature fruits are present

during the time period from June to September, i.e., during the rainy season. A relationship between precipitation and fruit growth has been reported for this species (García-Suárez et al., 2007). The phenology of *Escontria chiotilla* differs from that of *Stenocereus queretaroensis*, which is phenologically more similar to *S. griseus* ("pitaya de mayo") (Pimienta et al., 1994). The majority (80%) of the monitored plants of tunillo presented fruits. The fruits are only produced in the apical part of the stems. Some observations in *Stenocereus stellaus* shown that cultivated populations have more branches and fruit production than wild populations (Casas et al., 1999)

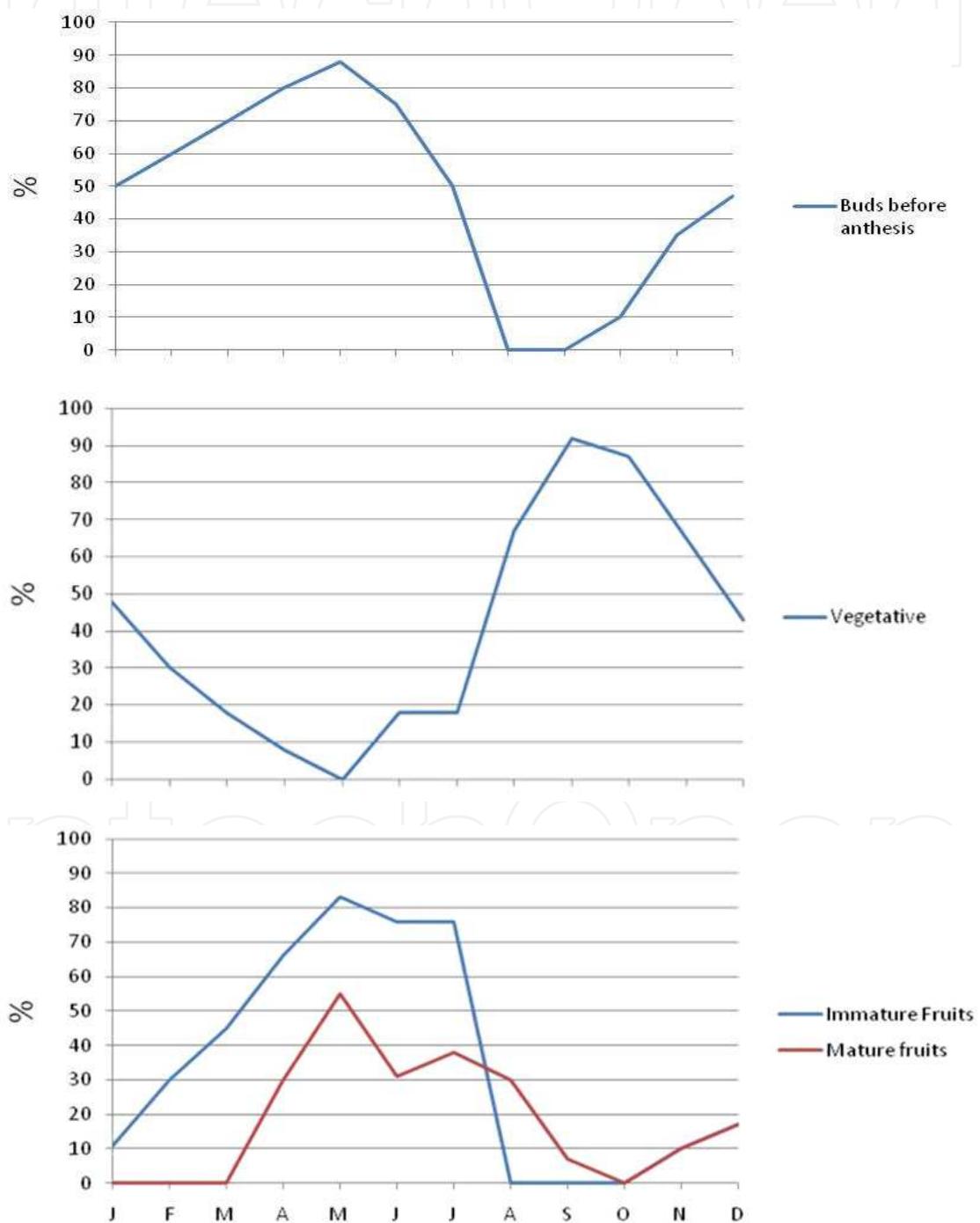


Fig. 5. Phenological diagram for "jiotilla" (*Escontria chiotilla*).

The fruits of “jiotilla” (*Escontria chiotilla*) were produced between January and September and during the time of monitoring only 25.8% of the plants presented reproductive structures, of which 80% produced mature fruits (Figure 5). However, we observed that the majority of marked plants (74.2%) did not bear reproductive structures. This could be the consequence of the presence of many immature plants in the monitored wild population.

Our results suggest that “pitaya” and “jiotilla” have a reproductive period that is similar to the majority of the plants of the tropical deciduous forest, i.e. in the middle or at the end of the dry season, which corresponds to the short day (SD) period. The difference in the reproductive period of the tunillo could be the consequence of a response to either the rainy season or to long days (LD) occurring during the rainy season. Due to the morphological characteristics of cacti flowers, their pollination is carried out by insects or by bats (Osborn, 1988). In the case of *Stenocereus stellatus*, the pollination is principally accomplished by bats and flower anthesis is nocturnal (Casas et al., 1999). These characteristics led us to believe that reproduction of these species could be related to the existence or high activity period of their pollinators. “Jiotilla's” flowers also undergo anthesis during the night.

Our observations show that the studied species respond to climatic conditions in different ways, given that despite growing in similar climatic conditions as seen in the similarity of the ombrothermic diagrams (Fig. 2), their phenological responses are different. Bullock & Solis (1990) state that most elements of the tropical deciduous forest reproduce during the wet season, and that there is a relation between phenology and water availability as is suggested by the flowering of some species during atypical rainfall events in December or January.

Assuming that humidity may be determinant for fruit development in cacti, the pitaya and the jiotilla appear to store water in their stems (Gibson & Novel, 1986) during the rainy season to be used for filling of fruits after the end of the dry season. A bimodal reproductive behavior has been reported for *Stenocereus griseus* (pitaya) in Colombia (Villalobos et al., 2007; Bustamante & Búrquez 2005), suggesting the effect of latitude in the phenology of that specie.

In the case of tunillo (*Stenocereus stellatus*), we observed that water availability determines the change to a reproductive phenological state. García-Suárez et al., (2007) demonstrated a correlation exists between fruit development and the wet season. In arid ecosystems most plants respond to precipitation. The pulse-reserve model addresses the response of individual plants to precipitation and predicts that there are “biologically important” rain events that stimulate plant growth and reproduction (Ogle & Reynolds, 2004).

These two phenological behaviors suggest differences in the flowering-fructification genetic programs of these cacti in response to light (Valverde et al., 2004)

Adequate fruit development depends on a successful pollination. Although the flowers of cacti are hermaphrodite, most species display genetic self-incompatibility so fruit setting is largely dependent on pollinating insects or bats (Bustamante & Búrquez, 2005). In the case

of the studied species, with flowers having nocturnal anthesis, bats have been reported to be the main pollinators (Casas et al., 1999; Nassar et al., 1997). The presence of common pollinators for the three studied species strengthens our proposal.

Although the environmental factors determining the phenology of the studied species may not be established based on the data herein presented, and that the phenology of cacti may respond to light too, day length in particular, or to a combination of environmental factors (De la Barrera et al., 2009), it is possible to use phenological behavior for the establishment of orchards with elements of the native plant communities that allow for the sustainable development of marginal rural communities inhabiting the semiarid tropical regions of our country. From a commercial point of view and based on the results of the present work, we propose the establishment of “mixed orchards” using the three studied cacti species taking advantage of their phenological behavior and climatic conditions. Actually, some regions have been proposed for the use of only one of these species in rural orchards (Piña, 1997; Pimienta et al., 1994; Sánchez-Cortéz, 2011). Figure 6 represents the F₂ phenophase for the three studied species; and as can be seen in the graph, marketable fruits were found to be present throughout an 8 month period. If we add that the physicochemical behavior of the fruits of the studied species is known to be similar (Benito et al., 1992), evidence is found supporting that, by establishing mixed orchards of these columnar cacti, local producers in the study area could harvest a sufficient amount of fruit to sustain a diversified agroindustry for the production of processed commodities such as jams, juices, ice cream and colorants, in addition to the marketing of fresh fruit.

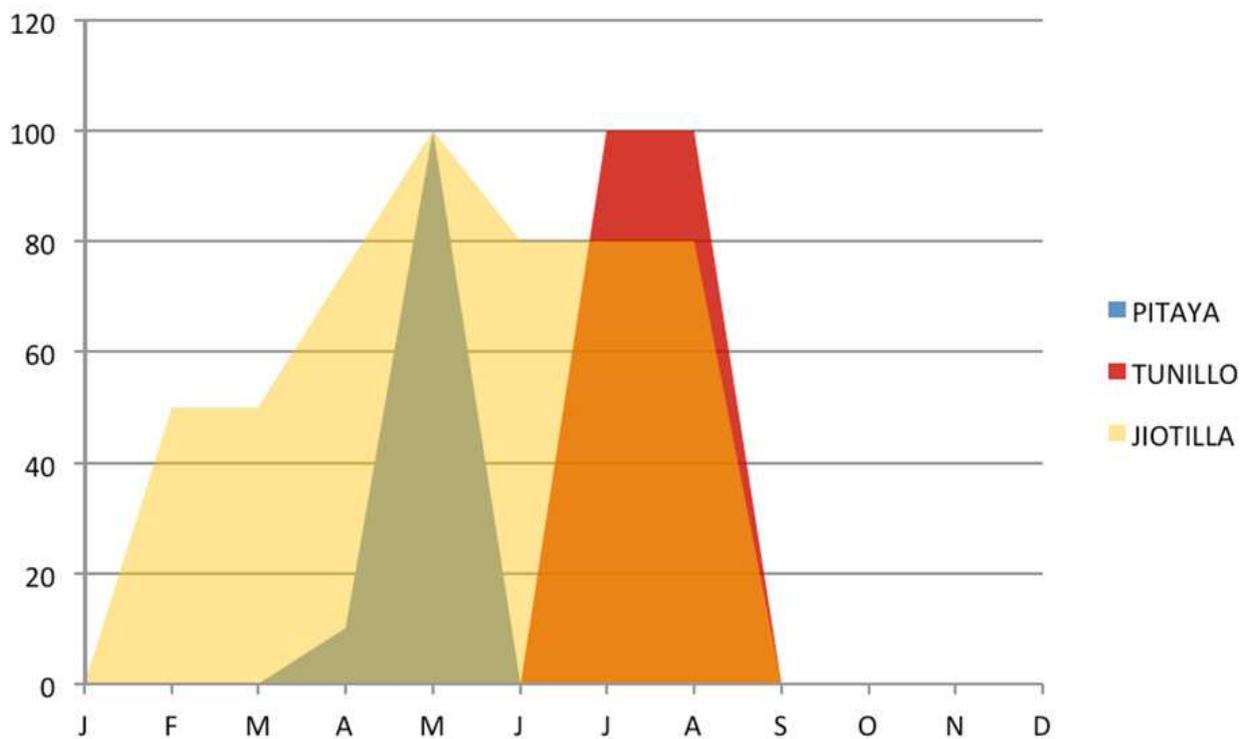


Fig. 6. Annual fruit production periods of “pitaya,” “tunillo,” and “jiotilla.”

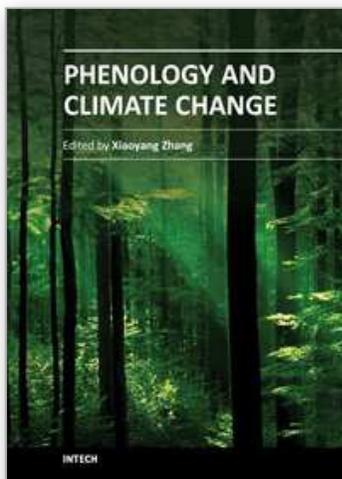
4. References

- Ayala K., Beltrán M.C. 2007. Caracterización de frutos de Pitaya *Stenocereus griseus* H. IX Congreso de Ciencia de los Alimentos y V Foro de Ciencia y Tecnología de Alimentos. Memorias 244-251.
- Beltran O.M.C., Oliva C.T.G., Gallardo V.T. 2005. La pitaya *Stenocereus stellatus*, como alimento funcional. www.alfa-editores.com/alimentaria/Noviembre
- Benito B.P., López G.R., Chávez S.L. 1992. Biología y Aprovechamiento de los frutos de tres cactáceas *Stenocereus griseus* (Haw, Buxbaum), *Stenocereus stellatus* (Pfeiffer, Riccobono), *Escontria chiotilla* (Weber, Rose). Cuadernos de Investigación. CIIDIR-Oaxaca. Instituto Politécnico Nacional.
- Bullock S.H. & Solis-Magallanes A. 1990. Phenology of canopy trees of a tropical deciduous forest in México. *Biotropica* 22(1): 22-35.
- Bustamante E. & Búrquez A. 2005. Fenología y biología reproductiva de las cactáceas columnares. *Cactáceas y Suculentas Mexicanas* 50(3): 68-88
- Casas A., Valiente-Banuet A., Rojas-Martínez A., Dávila P. 1999. Reproductive biology and the process of domestication of the columnar cactus *Stenocereus stellatus* in central Mexico. *American Journal of Botany* 86(4): 534-542.
- Casas A. 2005. El manejo tradicional de una especie puede incrementar la diversidad biológica: el caso xoconochtlí. *Biodiversitas* No 60: 2-6
- De la Barrera E., Pimienta-Barrios E., Schondube J.E. 2009. Reproductive Ecophysiology In: *Perspectives in Biophysical Plant Ecophysiology: A Tribute to Park S. Nobel*, pp. 301-335 Universidad Nacional Autónoma de México. México
- García-Suárez F., Carreto-Montoya L., Cárdenas-Navarro R., Díaz-Pérez J.C., López-Gómez R. 2007. Pitaya (*Stenocereus stellatus*) fruit growth is associated to wet season in Mexican dry tropic. *Pyton* 76: 19-26.
- Gibson A.C. & Novel P.S. 1986. *The cactus primer*. Harvard University Press. Cambridge Massachusetts. USA.
- Nassar J.M., Ramírez N., Linares O. 1997. Comparative pollination biology of Venezuelan columnar cacti and the role of nectar-feeding bats in their sexual reproduction. *American Journal of Botany* 84(8): 918-927.
- Ogle K. & Reynolds J.F. 2004. Plant responses to precipitation in desert ecosystems: integrating functional types, pulses, thresholds, and delays. *Oecologia* 141: 282-294.
- Pimienta-Barrios E. & Nobel P.S. 1994. Pitaya (*Stenocereus* spp., Cactaceae): An ancient and modern fruit crop of Mexico. *Economic Botany* 48(1): 76-83.
- Piña L.I. 1977. Pitayas y otras Cactáceas afines del estado de Oaxaca. *Cactáceas y Suculentas Mexicanas* XXII: 3-14.
- Sánchez-Cortés H. 2011. El cultivo de la pitaya de agosto (*Stenocereus stellatus*) en los municipios de Tlaxiataquilla y Xochihuehetlán, Gro. *Desarrollo Sostenible de Zonas Indígenas*. Maestría Tecnológica. www.biblio.colpos.mx:8080/jspui/handle/10521/291
- Villalobos S., Vargas O., Melo S. 2007. Uso, manejo y conservación de “yosú” *Stenocereus griseus* (Cactaceae), en la alta guajira colombiana. *Acta Biol. Colombiana* 12(1): 99-112.

Tenango C.E. 2005. Germinación de escontria chiotilla (Rose) Cactaceae. Tesis profesional. Universidad Autonoma Metropolitana Unidad Ixtapalapa.

IntechOpen

IntechOpen



Phenology and Climate Change

Edited by Dr. Xiaoyang Zhang

ISBN 978-953-51-0336-3

Hard cover, 320 pages

Publisher InTech

Published online 21, March, 2012

Published in print edition March, 2012

Phenology, a study of animal and plant life cycle, is one of the most obvious and direct phenomena on our planet. The timing of phenological events provides vital information for climate change investigation, natural resource management, carbon sequence analysis, and crop and forest growth monitoring. This book summarizes recent progresses in the understanding of seasonal variation in animals and plants and its correlations to climate variables. With the contributions of phenological scientists worldwide, this book is subdivided into sixteen chapters and sorted in four parts: animal life cycle, plant seasonality, phenology in fruit plants, and remote sensing phenology. The chapters of this book offer a broad overview of phenology observations and climate impacts. Hopefully this book will stimulate further developments in relation to phenology monitoring, modeling and predicting.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Rodolfo López Gómez, Heriberto Martínez López and Luis María Suárez Rodríguez (2012). Mixed Cacti Orchards – A Horticultural Alternative for Mexican Semiarid Tropics, Phenology and Climate Change, Dr. Xiaoyang Zhang (Ed.), ISBN: 978-953-51-0336-3, InTech, Available from:

<http://www.intechopen.com/books/phenology-and-climate-change/cacti-mixed-orchards-an-horticultural-alternative-for-mexican-semiarid-tropics>

INTECH
open science | open minds

InTech Europe

University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China

Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

© 2012 The Author(s). Licensee IntechOpen. This is an open access article distributed under the terms of the [Creative Commons Attribution 3.0 License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

IntechOpen

IntechOpen