Mango.org

Research Results Report

First Edition

Table of Contents

Strategies to Avoid Irregular Flowering and Modify the Harvest Period for Export Mangos Through the Use of an Integrated Management Approach

Dr. Maria Hilda Perez Barraza et al – INIFAP

General Objective.

Increase the productivity and quality of export mangos using an integrated management approach that includes pruning, nutrition, and the use of growth regulators that are friendly to the environment and human health.

Internationally, Mexico is the sixth largest mango producer with a production of 2.2 million tons and an area of more than 206 thousand hectares; the average yield is 10.7 t/ha^{-1}. Due to climate change, the mango crop has been highly vulnerable to year-to-year changes, mainly the temperature and humidity that prevail before and during flowering and that lead to irregular flowering. During the 2017-2021 period, research work was carried out to evaluate strategies that would give insights into how to avoid irregular flowering and modify the harvest season in at least three varieties, Ataulfo, Tommy Atkins and Kent, in the states of Nayarit and Colima. The above-mentioned study was sponsored by the National Mango Board (NMB). The results obtained helped to clarify the action of different growth regulators, nutrition, and pruning, on the differentiation of flower buds, flower sprouting, as well as on the harvest season and fruit production. The most outstanding results in the different research activities carried out during this period are presented below.

Climate characterization, its variability, and forecasting system associated with flowering and harvest processes in two mango production areas in Mexico

The states of Nayarit and Colima were characterized from the point of view of climate and with this information the climate forecast system generated tool to predict and or avoid irregular flowering in 'Ataulfo' mango. The query system uses two important inputs for the forecast:

1. The ENSO condition in region 3.4 of the equatorial Pacific Ocean https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/

2. The phenological models of floral development, fruit setting; as well as INIFAP technology for integrated management. By combining these technologies, it is possible to issue an alert on possible future climatic conditions (autumn-winter) to recommend actions to avoid irregular flowering, low fruit set and even to avoid a high incidence of seedless fruits.

Gibberellins and their effect on floral induction and differentiation (reproductive development stage of the apical bud)

In Nayarit, in two consecutive years, the Kent cultivar did not have a favourable response to the application of gibberellins to delay flowering. The third-year gibberellin treatments were evaluated in 'Tommy Atkins' with positive results. Two applications of gibberellic acid (AG3), approximately one month before normal flowering, at a dose of 50 mg/L^{-1}, delayed the period of differentiation, floral sprouting, and harvest, in the latter the delay was 18 days, compared to the control. The trees flowered in 85% of the crown and had a yield of 152 kg/$tree^{-1}$ against 136 kg of the control.

Under Colima conditions and during two years of evaluation, the effect of the application of AG3 was not consistent in 'Tommy Atkins'.

Nitrates and their relationship with bud latency and floral differentiation

Under Nayarit conditions, nitrates did not modify the differentiation of the terminal bud in cultivars 'Ataulfo' and 'Kent' and therefore did not modify flowering

Study of gibberellin inhibitors as an alternative to PBZ, and their effect on the flowering process in mango cultivars

In Nayarit, this work was carried out during the three years of study on 'Tommy Atkins' and in the last year (2020-2021) the Kent cultivar was included.

In **'Tommy Atkins'**, all gibberellin inhibitors prevented irregular flowering by promoting more abundant flowering than control trees. In 2020, calcium prohexadione (P-Ca) 1500 mg stood out, a single application 45 days after pruning with 72% flowering in its crown, and cycocel 1000 mg/L^{-1}, three applications (15, 30

and 45 DAP), with 66% statistically surpassing and equating PBZ (68%).

In the three years of the study, all the treatments with gibberellin inhibitors had a higher yield than the trees without treatment. In the last two years, 2020 and 2021, a single application of P-Ca at a dose of 1500 mg/L^{-1} exceeded the yield of trees with PBZ with 159 and 145 kg/$tree^{-1}$ in 2020 and 2021, respectively, against 123 and 108 kg/$tree^{-1}$ obtained with PBZ. In addition, P-Ca 1500 mg advanced a little more than 50 % of the harvest in 25 days and produced larger fruits equating the effect of PBZ.

In the **Kent** cultivar, with a single year of evaluation (2021) under Nayarit conditions, P-Ca at any of the doses advanced differentiation and flowering in 21 days compared to the control, equating the effect of PBZ. A single application of P-Ca at a dose of 1500 mg L^{-1} equated the yield per tree with 128 kg and 15 days earlier in the harvest, statistically equating the effect of PBZ that had a yield of 132 kg/$tree^{-1}$ and 18 days. early in the harvest.
In Colima, in the Ataulfo cultivar, with three applications of P-Ca in doses of 500 mg/L^{-1} each at 15, 30 and 45 DAP, it was possible to statistically equalize the flowering percentage with respect to PBZ; while, in performance, this same treatment equated and, in some years, surpassed the effect of PBZ.
In Nayarit and Colima there is the possibility of replacing the use of PBZ with calcium prohexadione in its different doses, although the results must be validated.

Effect of pruning and nutrition on the flowering process for mango cultivars

1. Time and intensity of pruning in the flowering and production of 'Ataulfo' mango in Nayarit and Colima. In Nayarit, the results were very consistent when pruning the trees with a 50 cm tip in the early season (immediately after harvest). The flowering percentage was very similar to the trees without pruning, with a three-year average between 75 and 80% in trees with and without pruning, respectively. The flowering obtained gave rise to a higher yield in these treatments. Otherwise, late-severe pruning drastically decreased flowering

and yield; but the intermediate (carried out two months after early pruning), either light or severe, although it reduced flowering and yield compared to treatments with early pruning or without pruning; orchard productivity was better. All pruning treatments will delay the harvest, the greatest delay was obtained with intermediate and late pruning in any of the severity; This resulted in the fruit reaching up to 3 times more in price/kg and obtaining a greater benefit when marketing the fruit. In addition, larger fruits were achieved. To modify the flowering and harvest in Nayarit, intermediate-light pruning may be a better option, by delaying the harvest, achieving larger, healthy fruits and with a better price in the commercialization; however, its validation is necessary. In Colima, the results showed that early light pruning improved yield.

2. Nutritional strategies and comprehensive sustainable management for floral induction and differentiation in 'Ataulfo' mango. In the years of study, it was confirmed that the use of Ascophyllum nodosum marine algae (four fortnightly applications of 2 L ha^{-1}), in addition to balanced fertilization of the soil, either with organic fertilizer such as vermicompost, granulated or water-soluble, as well as with foliar of Ca, B and Zn in pre-flowering, they are a sustainable alternative to increase floral differentiation, yields and fruit quality by up to 25%. Experience indicated that A. nodosum can be combined with amino acids (1 L ha^{-1}) plus cytokinins (1.5 L ha^{-1}), with the additional advantage of a greater number of pollinated fruits (94.9 % compared to 83.7 % in the control) when present favourable inductive climatic conditions.

For the full report: https://www.mango.org/wp-content/uploads/2022/12/Irregular_Flowering.pdf

Nutrition and Fertilization in Mango Literature Review

Dr. Víctor Galán Saúco - Tropical Fruit Consultant - vgalan46@gmail.com

The main objective of this report consists in aiding mango growers in establishing an adequate fertilization program. To accomplish this objective a thorough literature review was complemented with a survey on mango nutrition and sent to mango producers and researchers all over the world, as well as information collected from different important fertilizers companies.

The establishment of a correct fertilization p rogram must begin with conducting a soil analysis performed before planting. This will indicate the physicochemical characteristics of the soil where mango is going to be cultivated, a necessary step to setup the initial basal dressing and correction measures. Appropriates values for a soil to be cultivated with mangos are discussed, and general recommendations are given in the **Soil analysis** paragraph. Examples of general fertilizer programs that have been recommended in different countries for mango cultivation for the first year have been provided, and also for adult trees in smaller farms with no access to laboratories (**General recommendations for fertilizing mangos** paragraph).

As indicated in this report, despite its limitations, foliar analysis is the most useful tool for a correct establishment of a mango fertilizer program. A complete review of the values recommended by different authors as well as a discussion about sampling and interpretations techniques, both based on individual values and on the relations between nutrients, is reported in the **Foliar analysis** paragraph. As indicated in the **Nutrient extractions** section, the reposition of macro and micronutrient losses due to crop load, dropped fruits, leaves and branches removed by pruning, as well as those removed by lixiviation, volatilization, soil fixation and runoff is essential for an appropriate mango fertilizer program. It is clear from our review that fertilizer programs differ depending on cultivars and locations (soil and climatic conditions, particularly temperature), cultural practices and age of the tree and, as a consequence, nutrient extraction should be

determined for each mango farm and cultivar. An example of using crop removal to establish a mango fertilization program is given in Annex 4.

The role of macro and micronutrients, their effect in the plant at different moment of the growth cycle and the most appropriate moment for their application was also reviewed. In conclusion, most macronutrients, and particularly nitrogen, should be applied directly to the soils or through fertigation immediately after harvest, except for foliar applications of nitrates to induce flowering. Micronutrients, however, should be applied by foliar sprays mostly during flowering, with the exception of iron that should preferably be applied regularly as chelates through fertigation.

It is also indicated that experiments done in mango comparing organic and inorganic sources of fertilizers have not shown clear differences regarding nutrient absorption and yield; and that organic fertilizers are applied directly to the soil or, in some cases, through fertigation.

The final conclusion of the report is that the many variables involved in mango nutrition and fertilization make it impossible to draw general recommendation for a mango fertilizing program that have to be established by each particular farm. This is true even for each cultivar inside the farm, based in the sound interpretation of soil and foliar analysis and forecasted nutrient extraction. However, guidelines for a correct interpretation of these tools have been given in this report that can serve mango growers for obtaining the maximum productivity for this crop through an adequate fertilizer program.

For the full report, please click here: https://buff.ly/2HUjiDp

Pest and Diseases in Mango (*Mangifera Indica L.*)

J. González-Fernández, J.I. Hormaza - IHSM la Mayora
ihormaza@eelm.csic.es

In this work, we review the most important pests and diseases that affect mango production worldwide as well as the main measures implemented to control them. Pests and diseases are the main factors that can impact sustainable mango fruit production in the tropics and subtropics worldwide. Commercial cultivation of mango, characterized by expansion to new areas, changing crop management, replacement of varieties and increased chemical interventions, has altered significantly the pest and disease community structure in this crop in the different mango producing regions. In addition, climate change is inducing the emergence of new pests and, whereas globalization and trade liberalization have created wide opportunities for mango commercialization growth, at the same time, this can result in faster dispersion of pests and diseases among different mango growing areas if proper sanitary measures are not implemented.

This review covers different topics related to pests and diseases in mango. First, a thorough description of the main pests and diseases that affect mango is provided. Second, the different approaches used in different mango producing countries for chemical and biological control are described. Third, recommendations for appropriate mango management techiques that include integrated pest and disease management, reduction in the use of chemicals and the implementation of a good monitoring and surveillance system to help control the main pests and diseases, are also discussed. Finally, the current knowledge on agrohomeopathy and Korean Natural Farming is analyzed and recommendations on future lines of research to optimize mango pest and disease control are discussed. The fight against mango pests and diseases will require internationally coordinated research, development and innovation efforts to find effective responses and proper management approaches to the extant pests and diseases and be prepared for new threats. This should include the selection of disease and pest tolerant/resistant

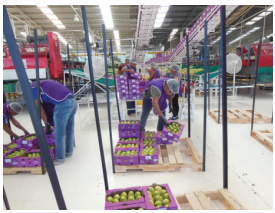
varieties; the development of those varieties has so far been made through conventional breeding and selection programs and empirical selection made by growers, but new biotechnological approaches will surely speed up this process in the future. Ideally, effective mango pest and disease management will involve a holistic combination of management approaches combined with strict quarantine and regulatory measures that should be enforced for fruit and plant materials at entry points of countries in which mango is produced to prevent introduction of new pests and diseases.

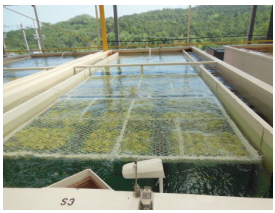
For the full report, please click here: https://buff.ly/2XqTwyP

Diagnosis of the Mango Export Chain From Harvest to Refrigerated Shipping

Dr. Jorge Alberto Osuna Garcia – INIFAP
osuna.jorgealberto@inifap.gob.mx / josunaga2@hotmail.com

Why was the diagnosis of the mango chain for export made? What were the main objectives of this diagnosis?





1. To carry out a diagnosis of the practices that are carried out from the harvest to the refrigerated shipment, including all the practices that are carried out in the packinghouse.

2. To develop a protocol on the best practices that are carried out in the packing house to deliver a mango of excellent quality and that is consistent.

What was done?

- A survey was designed that includes all operations from the harvest to the loading of the truck or container for shipment to the United States. This survey was applied to 19 members of the Mango Export Packers Association (EMEX, A.C.) in Mexico, 4 packers in Guatemala, 1 in Ecuador and 1 in Peru. The survey was carried out in electronic format with specific questions and multiple-choice answers, through the Internet and, when necessary, a few were carried out in person. Some questions were formulated for open response;
- A detailed evaluation was made of the points (Flowering and harvesting, placement of boxes, fruit washing in orchards, fruit washing in packing houses, quarantine hydrothermal treatment, Rest after hydrothermal treatment and refrigeration temperature) that directly or indirectly affect in the initial quality, shelf life and consumption quality of the fresh mango fruit.

What were the most relevant results of the surveys?

- 80% of the interviewees answered that they usually record and monitor the flowering process in their orchards, unfortunately, 100% stated that their main criteria for harvesting is the aspect of size and color of the fruit and only 16% consider counts the appearance of days after flowering (DDF).
- Even though the majority of those surveyed stated that when harvesting they use plastic boxes and that they are placed in the shade and without directly touching the ground, the photographic evidence shows the opposite.

- Only a very small percentage of those surveyed stated that they washed the fruit in the orchard to remove the latex, specifically 40% in the case of 'Ataulfo'. Research results carried out in Nayarit indicated that the latex exuded during the first 30 seconds is the most corrosive and for the latex with the highest exposure, significant differences were detected between varieties, being 'Ataulfo' the most sensitive, 'Haden' and 'Tommy Atkins' moderately susceptible and 'Kent' the most tolerant.
- Regarding the washing of fruit in the packinghouse, the vast majority wash the fruits by spraying with water + detergent + disinfectant recycled from tanks with a maximum capacity of 2,000 liters. The vast majority of packing houses have a single washing line, which means that more than 59% wash between 1,200 and 1,800 field boxes during a single washing cycle.
- The United States requires quarantine hydrothermal treatment (THC) to control fruit flies. 64% of the interviewees indicated that they use starting ramps from 119.5 to 117.5°F and only 32% expressed that they use from 117.4 to 116.0°F. The results reported by Osuna et al. (2015) indicated that the most important factor that influenced external damage and fruit quality during THC was the

treatment temperature (set point). The recommended set point between 115.5 and 116.5 °F showed only light damage while those treated at 117.0 °F showed moderate damage. Therefore, if THC is applied according to the recommendation and protocol, only slight external damage will be observed, maintaining quality and shelf life.

- According to the surveys, a high percentage(76%) of the packers usually rest the fruit (12 to 24 hours) after hydrocooling. Also, 20% of those surveyed stated that they had not hydrocooled, however, they rest the fruit after THC.
- 100% of the surveyed packers stated that they had a cold room and 68% kept their fruit for at least 9 hours in a cold room before shipping the trailer or container, which positively influences the shelf life of the mango fruit. Unfortunately, where serious failures were found was in the temperatures used for cold rooms and/or refrigerated containers, since 52% handle temperatures ≤ 10 °C.

To consider.

1. *The relevant points that most impact the initial quality, shelf life and quality for consumption of fresh mango fruit are the following: a. Flowering and harvest, b. Placing the boxes during harvest, c. Fruit washing in the orchard to prevent latex damage, d. Fruit washing in the packinghouse, e. Quarantine hydrothermal treatment (THC) and Hydrocooling, f. Rest after THC and Hydrocooling and g. Refrigeration temperatures in a cold room and/or transfer;*

2. *A protocol (manual) on the best practices for packing mangoes for export from harvest to the trailer or container was prepared and is available on the NMB website.*

For the full report: **https://www.mango.org/wp-content/uploads/2018/08/Ripening_Degree_Harvest_Shipping_Spn.pdf**

Validation of the Technique of Heat Units to Determine the Optimal Time of Harvest In The Main Mango Varieties For Export

Dr. Jorge Alberto Osuna Garcia – INIFAP
osuna.jorgealberto@inifap.gob.mx / josunaga2@hotmail.com

Understanding the heat units technique

The Heat Units (CU) or degree-days are defined as the time required to complete a particular phenological phase based on the accumulation of heat units from a base temperature. It is a technique that allows us to identify the optimal moment of mango harvest. It is evident that the determination of the optimum moment of ripeness and the maintenance of the sensory properties of the fruit during the different stages after harvesting (handling, marketing, and distribution) is essential to satisfy the needs of the consumer, which will allow them to offer lively fruits. colored, scented and with the right texture.

What parameters did they consider?

The present study was developed over a period of two years: from May 2017 to April 2019.

- **Varieties:** Tommy Atkins and Kent (2017); Ataulfo, Tommy Atkins, Kent, and Keitt (2018).
- **Location:** Commercial orchards of the four varieties in the Municipalities of San Blas and Santiago Ixcuintla, Nayarit and the Municipalities of Rosario and Escuinapa in the South of Sinaloa.

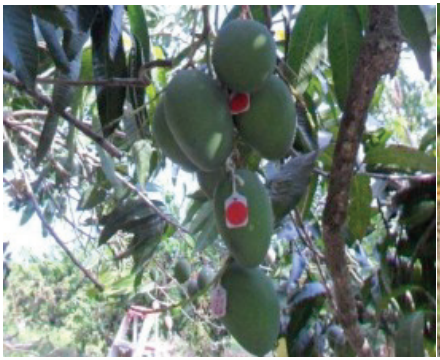
- **Accumulation of Heat Units:** The HOBOS were installed at the beginning of January of each year to monitor flowering, mooring and fruit development from full flower (panicles with at least 50% flowers in anthesis and it is considered the 'zero moment' or the beginning of UC accumulation), until optimum harvest maturity. HOBOS were programmed to record temperature and HR every 30 min.
- **Variables to be measured:** The fruits were measured for length, diameter, weight, and caliber, as well as initial quality at the time of harvest, at the end of the refrigerated transfer simulation (seven days at 12 ± 1 °C; 90 ± 5% HR) and for consumption (after 7-12 days of marketing simulation at 22 ± 2 °C; 75 ± 10% RH). The variables analyzed were dry matter, weight loss, external color, firmness and pulp color, total soluble solids (°Bx) and °Bx/acidity ratio.

Results.

- The validations of all the varieties were established both in Nayarit and in the south of Sinaloa for 2017 and 2018. It was confirmed that the UC required for the optimum harvest time of the Ataulfo and Tommy Atkins mango varieties were 1,600 UC, for Kent from 1,800 UC and for Keitt from 2,100 to 2,200 UC

- The results at harvest describe how the size (regardless of the variety) is affected by the accumulation of UC. The higher the Heat Units, the fruits had a larger caliber. In all varieties, at least 80% of the fruits were of larger caliber. In Sinaloa, the sizes were smaller compared to those of Nayarit due to the scarcity of water.
- The average weight of the fruit varied considerably depending on the place (water availability), the harvest periods and the heat units. In all the varieties considered for this study, the weight of the fruit in the "seasoning" period (higher UC) was higher than in the minimum maturity period. The difference in weight for Ataulfo, Tommy Atkins, Kent, and Keitt was 38.8 g, 20.3 g, 56.3 g, and 87.9 g, respectively. These differences in the average weight of the fruit represent an average of 1.67 additional tons/ha in yield for Nayarit and an additional 1.4 tons/ha for Sinaloa.

- Regarding the content of soluble solids, the UC technique did not show a significant difference for the Ataulfo and Tommy Atkins varieties in relation to the two critical moments of harvest (minimum ripeness and seasoning). The difference was detected only at consumption maturity. For the Kent variety, significant differences were observed from the beginning to consumption maturity between the fruits harvested in both states. At consumption, the fruits harvested at 1,600 UC had 16.3 °Bx, while those harvested at 1,800 UC showed 17.9 °Bx. In Sinaloa the difference was more marked, the fruits harvested at 1,600 UC showed 16.1 °Bx, while those at 1,800 UC reached 18.1 °Bx. For the Keitt variety, significant differences were only detected at consumption maturity between the fruits harvested at 1,800 UC compared to those of 2,100/2,200 UC in both states. At consumption, the fruits harvested in Nayarit at 1,800 UC had 12.1 °Bx, while those harvested at 2,100 UC showed 14.7 °Bx. In Sinaloa it was a very similar situation, the fruits harvested at 1,800 UC showed 14.8 °Bx, while those at 2,200 UC reached 16.8 °Bx.



For the full report: https://www.mango.org/wp-content/uploads/2020/02/Unidades_De_Calor_SPN.pdf

Development and Validation of Techniques to Modify The Production of Parthenocarpic Fruit in Ataulfo Mangos in the States of Nayarit, Chiapas, and Guerrero

Dr. Maria Hilda Perez Barraza – INIFAP - marhil60-02@hotmail.com

General Objective

Increase productivity and improve the quality of *Ataulfo* mango fruit, through the research and validation of techniques related to the use of growth regulators during the flowering, fruit set, and development stages of *Ataulfo* mango fruit in the states of Nayarit, Chiapas, and Guerrero. Additionally, validate the mathematical model under other environmental conditions for the purpose of designing strategies to adapt to future climate variability.

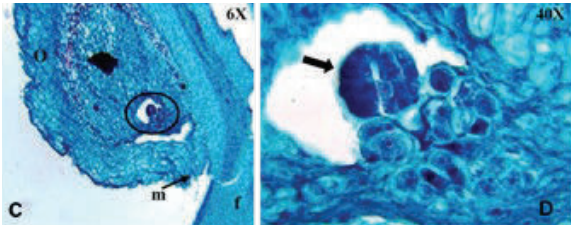
Validation of mathematical model and its relationship to the development of inflorescence and the production of parthenocarpic fruit

Temperatures associated with floral development allowed for highly predictive mathematical modeling to be carried out in the three states. These were generated based on the aggregated number of cold days. The models will lead to the creation of forecasting and early warning systems for extreme temperature events that could affect their development.

With regard to fruit production, in Nayarit, the largest production of parthenocarpic fruit occurred during the second flowering flush. This was related to the period in which petal fall occurred (E 13) and fruit set (E 14), as well as the presence of minimum temperatures below 15°C and greater than 35 °C during that phase.

Climate conditions present during the floral development of *Ataulfo* fruit in Nayarit, Guerrero and Chiapas contrasted between them, therefore, the issue of parthenocarpic fruit for this cultivar was not caused by a fixed temperature threshold.

Studies on pollination, fertilization, and fruit set in Ataulfo mangos: Floral biology



Regulators that were applied during full flowering (cytocinines) produced an effect on fertilization and fruit set; additionally, fruit was retained until the moment of harvest. Similar results were obtained when the regulators (cytocinines + gibberellins) were applied after full flowering. The conclusion was that the application of TDZ + AG3 15 after full flowering improved fruit set, as well as pollinated and parthenocarpic fruit, which were outcomes that provided the basis for the study on the effect of these regulators on production and fruits size on both pollinated and seedless fruit.

At Site 1 the largest production of pollinated fruit was obtained from *Ataulfo* trees with pheromones, although it was found to be statistically equal to the production of the *Ataulfo* farm with no pollinators or pheromones. At this site, none of the orchards produced parthenocarpic fruit, which can probably be attributed to the advanced flowering achieved through the application of PBZ in all of these farms that produce *Ataulfo* mangos.
Site 2. The largest production of pollinated fruit occurred on the Ataulfo + pheromones farm and the lowest production occurred in Ataulfo combined with Haden and pheromones.
These results indicate that, at both sites, regardless of whether the pollinator was near or intermixed with the Ataulfo, there was no improvement in the production of pollinated fruit, but the application of pheromones at both sites contributed to a higher yield.

Aborted embryos were found from the initial development stages of the fruit (4 – 5 mm in length) through the full development stage of the fruit (4 – 5 cm in length). Aborted embryos found at different developmental stages of the fruit are an indication that pollination and fertilization took place, but the embryos were

damaged by temperatures lower than 15 °C and higher than 35 °C that were present from E13 through E14, making these fruit stenospermocarpic, a form of parthenocarpy in which pollination and fertilization occurs, but the recently fertilized embryo is aborted.

Validation of techniques created to increase the fruit set and size of parthenocarpic fruit in Ataulfo mangos.

Results in Nayarit

The results obtained during the experimental phase in terms of the increase in size of the parthenocarpic fruit (weight, length, and diameter) were corroborated with the application of regulators during its commercial phase, and they also favored the production of pollinated fruit.

Both technologies increased the size of the parthenocarpic fruit, as well as that of the regular fruit, though the technology based on the mixture of TDZ + AG3 at a dose of 50 mg/L^{-1} of water for each regulator with four applications starting at fruit set every 15 days yielded better results.

Results in Chiapas

Four applications of the treatment mix TDZ+AG3 at the indicated doses and the scheduled applications every 15 days starting at full flowering on *Ataulfo* mango trees in Soconusco, Chiapas increased the growth of parthenocarpic fruit above the official size considered as the standard 118 g in the Official Federal Register (DOF). An average yield of 5.3 tons per hectare was achieved, which is acceptable from an economic standpoint in the Soconusco, Chiapas region, and is also an indication that there was an increase in the production of fruit with seed.

For the full report: https://www.mango.org/wp-content/uploads/2020/02/Frutos_partenocarpicos_Resumen_Ejecutivo-1.pdf

Use of Biopesticides for the Handling of Anthracnose (*Colletotrichum Gloeosporioides*) on Mango for Export - Phase I

Dr. Rafael Gomez Jaimes – INIFAP - farrag9@hotmail.com

What is anthracnose and how does it affect the mango?

Anthracnose caused by ***Colletotrichum gloeosporioides*** (fungus) is one of the most serious mango diseases. It is found in all mango-producing areas in the world and is the most important disease in climates with high rainfall and humidity. In Nayarit, Mexico, for example, anthracnose is the most important mango disease due to its high incidence and severity, since it produces large losses from flowering to post-harvest, drastically reducing the production and quality of the fruit, which significantly affects exports to destination markets.

Understanding management techniques and/or control of anthracnose

1. **In vitro tests of biological effectiveness of natural ingredients with fungicidal activity**
   - *Mango fruits with anthracnose symptoms were collected in commercial orchards in the municipalities of Santiago Ixcuintla, Compostela, San Blas and Tepic, Nayarit, Mexico.*
   - *Isolates of C. gloeosporioides from the main mango-producing areas in Nayarit were made. Subsequently, the strains with the highest speed of sporulation and growth of the mycelium of the fungus were selected.*

2. **In vitro tests of biological effectiveness of biopesticide formulations**
   - *Active ingredients with biofungicide activity were used, with which formulations were made, and the sporicidal effectiveness against virulent strains of C. gloeosporioides that showed higher speed of sporulation and growth of the fungus mycelium was determined.*
   - *The percentage reduction in spore germination was estimated as an evaluation variable. The estimate was made by counting 100 spores in the bright field of the microscope.*

3. **Application of biopesticides in mango orchards of the "Ataulfo" variety - Field phase (January to May 2017)**
   - *Three experiments were established in commercial mango orchards of the "Ataulfo" variety in the last week of January and the second week of February 2017. Two orchards were located in the town of Las Palmas, in 7-year-old trees. The other orchard was located in the town of Guadalupe, with 9-year-old trees.*
   - *The applications were made every 15 days, with a total of 8 applications from flowering to harvest.*
   - *The evaluations (two) were carried out to determine the incidence of anthracnose in panicles and fruits.*

4. **Application of biopesticides in mango orchards of the "Ataulfo" variety - Field phase (January to June 2018)**
   - *Two experiments were established in commercial mango orchards of the "Ataulfo" variety in the last week of January and the first week of February 2018. The two orchards were in the Ejido de la Palma, with 8-year-old trees.*
   - *The applications of the biopesticide formulations were made every 15 days, with a total of 10 applications from flowering to harvest.*
   - *The evaluations (two) were carried out to determine the incidence of anthracnose in fruits between 3 and 10 cm in length (pre-harvest fruits) and in physiological maturity (fruits close to harvest).*

5. Biological effectiveness of biopesticides on anthracnose in postharvest fruits (2017 season)
   - *22 treatments (biopesticides) and one witness (control) were used. Five concentrations per treatment (250, 500, 1000, 2500 and 5000 ppm) were used, and each concentration had a control.*
   - *The incidence and severity of the disease were evaluated.*

6. **Biological effectiveness of biopesticides on anthracnose in postharvest fruits (2018 season)**
   - *10 treatments (biopesticides) and a witness (control) were used. Five concentrations per treatment (250, 500, 1000, 2500 and 5000 ppm) were used, and each concentration had a control.*
   - *The incidence and severity of the disease were evaluated.*

Results

- The active ingredients that showed higher sporicidal activity and mycelium growth inhibition were orange essential oil, cinnamon essential oil, wintergreen oil, coniferous monoterpenes, geraniol, citral, thymol, rosemary extract, eugenol, pepper extract and menthol. On the other hand, the ingredients that showed greater effectiveness were copper, clove extract plus copper at a concentration of 10,000 ppm, laurel plus copper at 10,000 ppm, oregano at 10,000 ppm, copper plus oregano at 10,000 ppm, governor at 10,000 ppm, gobernadora plus copper in both in the two concentrations and gobernadora plus oregano at 10,000 ppm.
- Most of the treatments tested reduced spore germination at some of the concentrations, however, there were differences in effectiveness between treatments. In control spores, spore germination was not inhibited.
- The results of the vapplication of biopesticides in the field phase (2017) showed that in all the evaluated treatments (in the three plots) no symptoms of anthracnose were observed in panicles. The fruits treated with Trifloxystrobin, copper gluconate and phosphites (5 + 5 mL/L) and gobernadora extract, citral, thymol and eugenol (2.5 mL/L) showed the lowest incidence of anthracnose. Trifloxystrobin completely inhibited the

growth of anthracnose during the first evaluation, while the fruits of the control trees presented an incidence rate of 13% to over 40%. The same behaviors were recorded during the second evaluation. None of the biopesticide formulations completely inhibited the incidence of anthracnose.

- The results of biopesticide application in the field phase (2018) showed that none of the biopesticide formulations completely inhibited the incidence of anthracnose. The fungicidal activity of the biopesticides was by contact, and due to the low residuality, the control effect was short, thus affecting the efficiency regarding the disease. Reducing the application intervals from 15 to 7 days would cause a more significant and prolonged reduction in the incidence of the fungus.
- The results of the biological effectiveness of the biopesticide during the 2017 season showed that none of the biopesticide formulations completely inhibited the incidence of anthracnose. All the products tested, including the chemical fungicides, acted by contact and not systemically. However, there were organic treatments (in certain concentrations) that turned out to be more efficient in the management and control of anthracnose than Trifloxystrobin and copper.
- The results of the biological effectiveness of the biopesticide during the 2018 season showed that none of the biopesticide formulations completely inhibited the incidence of anthracnose. The organic treatments with greater biological effectiveness obtained in the experiment could be an alternative to eliminate anthracnose spores in mango fruits in postharvest treatments, with equal or greater biological effectiveness than chemical fungicides.

To consider.

- Formulations made with essential oils such as citral, geraniol, eugenol and thymol can induce phytotoxicity in fruits when applied in high doses.
- No product totally inhibited the incidence and severity of anthracnose. The results suggest that all the products tested acted by contact, that is, they eliminated the fungus when they came into direct contact with the products. Reducing the application intervals from 15 to 7 days would cause a more significant and prolonged reduction in the incidence of the fungus.

- The organic treatments with greater biological effectiveness obtained in the experiment could be an alternative to eliminate anthracnose spores in mango fruits in postharvest treatments, with equal or greater biological effectiveness than Trifloxystrobin, and much more effective than Copper.
- The use of organic products with fungicidal action, such as those tested in this study, could be an alternative to chemical fungicides for the management of anthracnose in postharvest mangoes, since they offer biological effectiveness on the pathogen, and since they degrade rapidly, they do not there are risks of pesticide residues; in addition, whose ingredients of which they are constituted do not offer health risks.

For the full report: https://www.mango.org/wp-content/uploads/2019/06/Antracnosis_Final_Spn.pdf

Use of Biopesticides for the Handling of Anthracnose (*Colletotrichum Gloeosporioides*) on Mango for Export – Phase II

Dr. Rafael Gomez Jaimes – INIFAP - farrag9@hotmail.com

Objectives

1. Prepare formulations of biopesticides with greater control effect on C. gloeosporioides in postharvest fruits.
2. Determine the doses and immersion time of biopesticide formulations for the control of anthracnose in postharvest fruits.
3. Carry out biological effectiveness tests of biopesticides on fruits of the mango varieties "Ataulfo, Keitt, Kent and Tommy Atkins".
4. Obtain the doses and immersion time of biopesticide formulations with greater biological effectiveness for the control of anthracnose in postharvest fruits.

YEAR 1: Biological effectiveness of biopesticides for the control of anthracnose in mango fruits "Ataulfo, Keitt, Kent and Tommy Atkins

- The chemical fungicide Azoxystrobin in its two concentrations (500 and 1000 ppm) and the biopesticide formulations in their different concentrations, had no effect in stopping the incidence and severity (diameter of the lesion) of anthracnose in wounds. Therefore, it is concluded that none of the treatments, including the chemical fungicide, stop the infection process completely once the pathogen is already inside the fruit.
- The formulations that showed the lowest incidence of anthracnose in fruits of the four varieties (Ataúlfo, Kent, Keit and Tommy) were F1 (Peracetic acid (30%) + Hydrogen Peroxide (30%) + Acetic acid (10%)), F2 (Peracetic Acid (35%) + Hydrogen Peroxide (15%) + Acetic Acid (10%) + Chitosan (40%)) and F5 (Hydrogen Peroxide (50%) + Acetic Acid (15%) + Peracetic acid (15%)).
- The formulations that showed the shortest length in diameter of the anthracnose lesion in fruits of the four varieties were F1 (Peracetic acid (30%) + Hydrogen Peroxide (30%) +

Acetic acid (10%)), F2 (Peracetic Acid (35%) + Hydrogen Peroxide (15%) + Acetic Acid (10%) + Chitosan (40%)) and F3 (Hydrogen Peroxide (30%) + Peracetic Acid (15%) + Acetic Acid (10 %)).

- The chemical fungicide Azoxystrobin showed control efficiencies greater than 90% at concentrations of 500 and 1000 ppm, in 1, 5 and 10 min of immersion, in the four varieties evaluated (Ataúlfo, Kent, Keit and Tommy).
- All the biopesticide formulations showed biological effectiveness of control against anthracnose in mango. The control efficacy depended on the variety, concentration and immersion time.
- It was observed that some formulations had biological effectiveness against anthracnose above 90% at concentrations of 2000 or 3000 ppm, and one minute of immersion. However, the highest control efficiencies were observed at concentrations of 4000, 5000 and 10000 ppm, in immersion times of 5 and 10 minutes.
- The highest effectiveness for the control of anthracnose in "Ataúlfo" mango was recorded by the formulation F3 (Hydrogen Peroxide (30%) + Peacetic Acid (15%) + Acetic Acid (10%)), which showed efficiencies of 84, 91 and 96% from 4000, 5000 and 10000 ppm, respectively.
- I the effectiveness for the control of anthracnose in the variety "Kent", it was observed that the formulations F1 (Peracetic Acid (30%) + Hydrogen Peroxide (30%) + Acetic Acid (10%)) and F5 (Peroxide Hydrogen (50%) + Acetic acid (15%) + Peracetic acid (15%)), were the most constant in the control, which were in the range of 87 and 96% efficacy. Although the rest of the formulations showed control efficiencies above 90% in at least one of their concentrations and/or immersion times.
- In the effectiveness for the control of anthracnose in mango "Keit", it was determined that the formulations F1 (Peracetic Acid (30%) + Hydrogen Peroxide (30%) + Acetic Acid (10%)), F5 (Peroxide of Hydrogen (50%) + Acetic Acid (15%) + Peracetic Acid (15%)) and F3 (Hydrogen Peroxide (30%) + Peracetic Acid (15%) + Acetic Acid (10%)) showed greater effectiveness, the which were mostly above 90% control efficacy. However, the rest of the formulations also showed control efficiencies above 90% in at least one of their concentrations and/or immersion times.

- For the control of anthracnose in “Tommy” mango, it was observed that four formulations showed the highest effectiveness, which was above 90% of control efficacy. These formulations in order from highest to lowest effectiveness were F1 (Peracetic Acid (30%) + Hydrogen Peroxide (30%) + Acetic Acid (10%)), F2 (Peracetic Acid (35%) + Hydrogen Peroxide (15%)) + Acetic acid (10%) + Chitosan (40%)), F4 (Peracetic acid (30%) + Hydrogen Peroxide (10%) + Extract of governor (Larrea tridentata) (50%) + Thymol (3%)) and F3 (Hydrogen Peroxide (30%) + Peracetic Acid (15%) + Acetic Acid (10%)).

YEAR 2: Effect of biopesticides on the quality of mango fruits “Ataulfo, Keitt, Kent and Tommy Atkins

- The chemical fungicide Azoxystrobin in its two concentrations (500 and 1000 ppm) and the biopesticide formulations in five concentrations (2000, 3000, 4000, 5000 and 10000 ppm), in the three immersion times (1, 5 and 10 min), showed similar behaviors in quality variables (total soluble solids, color, firmness and weight loss), percentage of dry matter and incidence of diseases and physical appearance of the fruit, in mango fruits of the varieties “Ataulfo, Tommy Atkins , Kent and Keitt ” in postharvest.
- Total soluble solids (° Brix): The fruits treated with the biopesticide formulations (F1, F2, F3, F4 and F5) and the fungicide Azoxystrobin, showed TSS contents similar to the control fruits in the four varieties of mango evaluated. No treatment effects were observed at the different concentrations and immersion times on the TSS content.
- Pulp color (Hue): The fruits treated with the biopesticide formulations (F1, F2, F3, F4 and F5) and the fungicide Azoxystrobin, showed similar yellow tones to the control fruits in the four varieties of mango evaluated. No treatment effects were observed at the different concentrations and immersion times in the pulp color.
- Weight loss: The fruits treated with the biopesticide formulations (F1, F2, F3, F4 and F5) and the fungicide Azoxystrobin, did not present significant weight loss between treatments and also with respect to the control in the four mango varieties evaluated. No treatment effects were observed on weight loss at the different concentrations and immersion times.

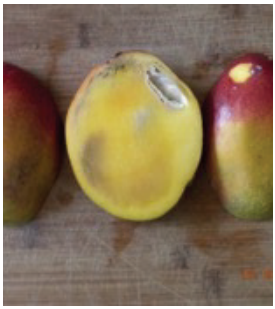
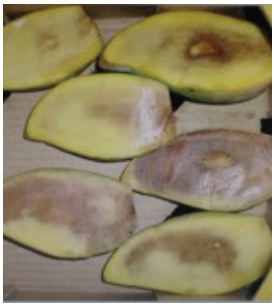
- Percentage of dry matter: The fruits treated with the formulations of biopesticides (F1, F2, F3, F4 and F5) and the fungicide Azoxystrobin, obtained percentages of dry matter similar to the control fruits in the four varieties of mango evaluated. No treatment effects were observed at the different concentrations and immersion times on the percentage of dry matter.
- Incidence of diseases and physical damage in the fruit: The fruits treated with the formulations of biopesticides (F1, F2, F3, F4 and F5) and the fungicide Azoxystrobin, did not show physical alterations in the epidermis or pulp of the fruits in the four varieties of mango evaluated. It was determined that the application of the five biopesticide formulations and the chemical fungicide Azoxystrobin did not induce phytotoxicity damage in fruits at the different concentrations and immersion times tested.

For the full report: **https://www.mango.org/wp-content/uploads/2022/03/USE-OF-BIOPESTICIDES-POSTHARVEST-FINAL-REPORT.pdf**

Mango Internal Discoloration (Cutting Black) in Mango

Dr. Jeffrey Brecht et al – University of Florida | jkbrecht@ufl.edu

What is cutting black?

The Cutting Black is considered as a physiological disorder of internal decomposition that develops in the mango during the ripening phase. It is a difficult disorder to detect unless the fruit is cut. It is characterized by black spots on the pulp and can even affect the seed. Cutting Black can cause up to 30% crop loss depending on the variety. These losses not only have a direct impact on the producers and their planting systems, but also on the entire marketing and distribution chain of the fruit (local and export markets).

Therefore, it is very important to ensure that the mango pre and postharvest management strategies are adequate.

Understanding Cutting Black.

There is very little information about the causes of this disorder and therefore about the measures to prevent or manage it. For this reason, a study was developed to determine the causes of the Cutting Black during the period from 2013 to 2017 in Peru and Ecuador. This study was conducted by a multidisciplinary team from the University of Florida which evaluated different factors that could influence the development of this disorder. Among the factors considered were climatic factors, cultural practices such as the nutrient ratio, specifically the calcium/nitrogen ratio, insufficient micronutrient content (in the soil, leaf, and fruit) and the use of plant growth regulators. In terms of postharvest, the

state of maturity of the fruit at the time of harvest, transport, and cold storage at temperatures below those recommended, and exposure to hot water quarantine treatment were considered.

What was done?

- Through a survey directed at producers, packers and importers, an attempt was made to collect information on climatic conditions and on current pre- and post-harvest cultural practices to see if there was any relationship with the appearance of the disorder. Producers reported incidence rates of up to 50%.
- Four (4) pre-harvest treatments were made in the field to study the behavior of the disorder and evaluate the relationship between nitrogen and calcium: high concentration of N with medium concentration of Ca (Treatment 1), high concentration of N with low concentration of Ca (Treatment 2), low N with high Ca (treatment 3), and low N with low Ca. With these treatments the researchers wanted to test whether mangoes had a predisposition to the development of the disorder. This predisposition seems to be closely related to some critical moment in the fruit ripening process due to a calcium deficiency or an excess of nitrogen.
- The concentrations of micronutrients (Fe, Zn, Cu, Mn, B) in the fruits, in the leaves and in the soil were also analyzed to see what possible impacts these nutrients have with the appearance of the disorder in mango.
- Postharvest experiments were done to see if the disease came from the treatment given to the fruits after harvesting. The factors studied were the effect of the treatment with hot water, the cold storage temperature, and the degree of maturity (stage 1, stage 2 and stage 3) at harvest. For this, four (4) treatments were implemented: to let them mature outdoors (24°C) and without applying hot water (treatment 1); without application of hot water, store in a cold room at 10°C for three (3) weeks and then leave to mature in the open air (treatment 2); With hot water and leave to mature in the open air (treatment 3); With hot water, store in a cold room at 10°C for three (3) weeks and then leave to mature in the open air. These treatments were carried out on fruits harvested at different stages of maturation.

Results

- In the ports of entry to the United States, up to 30% of the mangoes belonging to the "Tommy Atkins" variety, up to 10% in "Ataulfo" and up to 7% in "Kent" showed symptoms of the disorder. It seems that the climate directly influences the development of the Cutting Black since the incidences vary from season to season.
- In Peru, too much nitrogen-based fertilizer was applied, and not enough calcium-based fertilizer was applied (researchers said this is very common in mango plantations around the world). The contribution of N and Ca through the treatments did not favor any change in the concentrations both in the soil and in the mangos (fruits and leaves).
- Micronutrient applications had no effect on the behavior of the disorder. More time is needed to see a change in the dynamics of nutrients in the soil. In the fruit as well as in the leaves, the concentrations of the micronutrients were not significant and therefore had no effect on the incidence of the disorder.
- According to the data from the study, everything seems to indicate that the development of the Cutting Black is favored mainly by postharvest treatment, above all, stress due to excessive cold (temperature). In general, Cutting Black appears in mangos that have been subjected to refrigeration treatment (10 °C) for several days in a row. The temperature threshold for storing mangos of the "Ataulfo" variety must not be less than 12.5 °C. Below this temperature, the mango begins to suffer cold damage, which leads to the disorder. A properly done hot water treatment does not affect the handle and does not favor Cutting Black. Stage 2 of maturation seems to be the most appropriate to prevent the incidence of the disorder. However, the data collected referring to the different stages of maturation were not significant.

How to combat the Cutting Black?

1. Reduce the contribution of nitrogen to the soil for plants and increase calcium. It seems that excess nitrogen obstructs the absorption of calcium. Which in turn favors the development of the disorder. According to the study data, reducing the nitrogen supply between 25 to 50% would increase the availability of calcium.
2. Harvest only when the mango is physiologically ripe.
3. Avoid exposing the mangoes to temperatures below 10 °C, especially if they are varieties such as “Ataulfo” or “Honey” which is one of the varieties most susceptible to cold damage.
4. Ensure containers have good ventilation [Fresh air exchange not below 45 CFM (76 CMH)].
5. Organize well so that the fruits spend as little time as possible in the containers. Choose the fastest and most efficient routes.

For the full report: https://www.mango.org/wp-content/uploads/2019/07/Mango_Internal_Discoloration_ENG.pdf

Past and Present Irrigation Strategies Evaluated in Mango (A Literature Review)

Dr. Adolfo G Levin – Northern R&D | adolfolevin@gmail.com

Why is it necessary to implement irrigation strategies in mangos?

The amount of fresh water available for agricultural use is declining around the world. Climate change augurs a future increase in aridity and in the frequency of extreme phenomena, such as reduced rainfall, increasing periods of drought and high temperatures, in many regions of the world. This results in a growing demand for irrigation water, which can cause many serious socioeconomic problems, reducing crop yields, limiting crop sustainability, and increasing the cost of irrigation water. Therefore, the adoption of water saving strategies in agriculture is increasingly critical.

Why was a literature review done on this topic?

Studies on the use of irrigation water and strategies evaluated in mango have covered an important number of regions of the world. However, the number of studies carried out on mangos in relation to the needs for water and fertilizer under prevailing growing conditions in the main producing countries (Mexico, Brazil, Peru, Guatemala, Nicaragua, Ecuador, and Haiti) that export mangos to United States of America (USA) is quite limited.

How was this literature review done?

- All available information on irrigation strategies evaluated in mangoes in the past and recently, both globally and in the main countries of export to the US market, was collected and reviewed.
- Past and/or new irrigation strategies were recommended that may be relevant for evaluation in some of the main exporting countries.

Results

1. ***Irrigation strategies used for mango***

   In recent years, it has become clear that maintaining a slight plant water deficit can improve carbohydrate partitioning for reproductive structures such as fruits and also control excessive vegetative growth (Chalmers et al., 1981). Adoption of this deficit requires keeping water levels within a narrow tolerance range in order to get the most out of it on the one hand and avoid excess water stress that will result in decreased crop production and/or quality on the other side. So the different irrigation strategies found in the scientific literature were:

   a) Irrigation deficit [DI – for its acronym in English (Deficit Irrigation)]
   - Sustained Controlled Deficit Irrigation (SDI): the application of water at a constant deficit during the dry season, or on a supplemental basis if irrigation occurs only for a short period, eg during the rainy season.
   - Controlled deficit irrigation (RDI): Varying the water deficit according to the different phenological stages of the fruit.

   b) Partial drying of the root zone (PRD): This method consists of dividing the water applications from one side of the mango tree to the other side, with an alternation of drying of the root zone for constant timese.

2. ***The impact of irrigation strategies on some productive parameters:***
   - The impact of irrigation on fruit weight appears to be more dramatic in the final stage of fruit growth (FFG) (cell expansion), rather than the first phenological stage of fruit growth (MFG) (cell division).
   - In general, the irrigation applied during the periods of fruit set and MFG has promoted a greater retention of fruits that was later reflected in the harvest.
   - Mango produces its crop mainly on the vegetative growth of the previous year (or season). Deficit irrigation practices can significantly reduce vegetative growth. However, it has been shown according to the literature that there may be a positive impact of controlled deficit irrigation strategies on yield, and because of water use efficiency (WUE)..

- Rotation in production can be a major problem in mango production, especially in subtropical regions. Several studies have shown that yield in mango trees is affected by the irrigation regime. However, there are few, if any, long-term studies (five or more seasons) that have evaluated the impact of different irrigation regimes on the rotation of production in mango.

3. *Mango Fertilization.*

The nutrient demand of mango, expressed as the accumulated quantity of the elements found in different plant organs, varies according to factors such as genotype, soil, climate, use of irrigation, water quality, phytosanitary status, etc. Tropical soils, characteristic of many mango growing areas around the world, are often highly acidic and this can prevent adequate mango nutrition and, consequently, commercial production.

- A greater effect can be generated with the mixture of conventional formulations together with organic compounds (for this purpose, chicken manure has been highlighted as more efficient for the category of organic compounds).s)
- The time and frequencies of the total annual application vary according to whether the crop is rainfed or irrigated. The literature recommends a maximum nutrient contribution (N-P-K) of up to 50 kg N ha^{-1}, 80 kg P ha^{-1} and 80 kg K ha^{-1}, for a rainfed crop with a high expected yield. For an irrigated crop these figures increase to 120 kg N ha^{-1}, 150 kg P ha^{-1} and 250 kg K ha^{-1}.

In addition

- Due to the different existing varieties of mango, management practices for both cultivation and water, and soil conditions, it has not been possible to create a widely applicable irrigation protocol to date. That may be since most of the studies have not passed two years. Considering the different realities of mango producers, especially in the countries that export this fruit to the US, would allow the creation of experiments whose objectives would be to better understand the issue of irrigation.
- The secondary effects of some of the irrigation treatments, mainly deficit irrigation, may have bee overlooked in such a

short period of time, especially in studies that were carried out on heavy soils.

Some recommendations for research topics

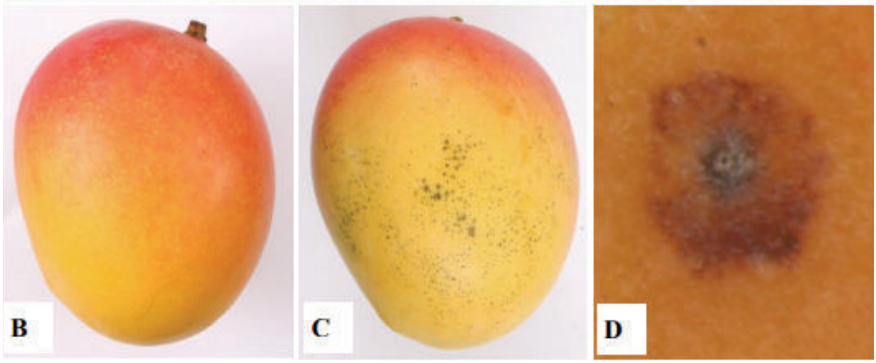
- Long-term response of mango (at least four cycles) to different amounts of water, including deficit irrigation, on vegetative growth and associated yield at each phenological stage in an environment without effective rainfall during the production season and its impact on the post-harvest behavior of the fruit, mainly in cultivars exported to the United States. (Qualitative research)
- Irrigation practices necessary to support optimal fruit number after the use of growth regulators or other flowering treatments for major mango cultivars exported to the United States under different soil conditions. (Qualitative research)
- Impact of irrigation with different water qualities on production parameters such as number of fruits, fruit size distribution, fruit quality (chemical product), total yield, vegetative growth, postharvest behavior, alternation in production under different soil conditions and weather. (Qualitative research)
- Short, medium and long-term impact of different irrigation methods (gravity, sprinkler and drip irrigation) in different soil conditions on the production and post-harvest behavior of different cultivars. (Qualitative research)

For the full report: https://www.mango.org/wp-content/uploads/2019/07/Past_and-_present_-Irrigation_Strategies_in_Mango_ENG.pdf

Lenticels Damage on Mango (Tommy Atkins) From Guatemala

Dr. Rolando Cifuentes V. & Ing. Luis Andrés Arévalo –
Universidad del Valle de Guatemala

Where are the lenticels on the mango?



Source: Nguyen, Tuan Minh – The University of Queensland (B- healthy fruit; C- fruit with lenticel damage; D- magnified view of a lenticel damage)

Lenticels are macropores present on the surface of the handle. Lenticel Damage (LD) is a biological process that manifests as dark tissues around lenticels. Tissue discoloration is a symptomatic defense mechanism against stress. Lenticel damage reduces the quality of the visual appearance of the skin of the fruit, making it unfit for sale. This represents a huge problem with many socioeconomic implications for the mango industry in Guatemala. Several jobs coming from the mango industry is helping with the rural development of communities. It is important to understand in more detail what lenticel damage is to prevent or mitigate its possible negative impacts.
daño de las lenticelas (DL).

What were the main objectives of this study in Guatemala?

- Evaluate the impacts that the (K+Mg)/Ca relationship may have on the absorption and accumulation of nutrients and how much it contributes to lenticel damage.

- Determine the effects of the application of certain micronutrients on the damage of lenticels.
- Determine the effect of soil moisture during harvest and after post-harvest processes on lenticel damage.
- Determine the effect of air temperature and relative humidity on the development of lenticel related problems during harvest and after postharvest processes.
- Check the effect of NaOH (sodium hydroxide) in the post-harvest processes of packing plants

What was done?

Of the mango-producing regions in Guatemala, four departments were selected: Zacapa, Escuintla, Suchitepéquez, and Retalhuleu. In each department, representative farms (Mariola farm, Entre Ríos farm, Mangles farm and San Cayetano farm respectively) were chosen to implement the study in such a way that the results would reflect the proposed objectives. Thus, on these farms, the following were measured: the contribution of air temperature and humidity to the LD process, the lenticel damage index based on a pre-established scale ranging from zero (0) to three (3), three being the highest value with more than 25 % of the surface of the fruit with damaged lenticels; the development of the fruits from flowering to harvest; Cold storage time, relationship between certain nutrients within the fruit (peel, pulp, seed shell and seed), nitrogen applied during the experiment and the sequence of nutrient accumulation, and the effect of sodium hydroxide on the process of washing the fruit after harvesting it.

Results

- The values of the (K+Mg)/Ca ratio were lower in the departments of Zacapa and Retalhuleu. This seems to indicate that the departments of Suchitepéquez and Escuintla have lower Ca availability. There is a relationship between the LD index and the (K+Mg)/Ca ratio. In the departments of Zacapa, Escuintla and Suchitepéquez, the higher (K+Mg)/Ca, the lower the LD index. However, in Retalhuleu, the availability of Ca did not help to prevent LD. N application had no effect on lenticel damage. The distribution of nutrients within the fruit was: 10 % (peel), 80 % (pulp), 3 % (seed peel), 7 % (seed) based on fresh biomass and 15 % (peel), 68 % (pulp), 5% (seed shell), 12% (seed) based on dry biomass.

- The idea that the application of micronutrients could prove to be a remedy for LD was partially verified. The study data showed that applying B, Fe, K together with Mn mitigates the problem to some extent. However, further study is needed to further determine the role of micronutrients.
- The water holding capacity of the soil was also an important factor in determining the problem. The data showed that on the Entre Ríos farm, the DL was lower in the plot with the lowest water retention capacity. However, on the Mangles farm, the index was higher in plots with greater water retention capacity.
- According to the study and various sources in the literature on the subject, lenticel damage is mainly caused by the following: handling of mango fruit trees, postharvest handling, and climatic factors (air temperature and relative humidity). . On average, the DL index in Entre Ríos and San Cayetano was around 2.5 after 1 week of refrigeration and 2.7 after 2 weeks. However, we denote a lower average index in Mangles and Mariola of 1.5 after one week of refrigeration and 1.6 after 2 weeks. Globally, there were no differences in the values of the LD index regarding cold storage time. Depending on farm management conditions, the rate of lenticel damage can increase dramatically with hot water treatment.
- The repetitive use of NaOH during washing and before hydrothermal treatment favored an increase in the lenticel damage index. However, no damage was detected in the peel of the fruit despite the chemical constitution of sodium hydroxide.

How to prevent Lenticel Damage?

1. Wash mangoes immediately after harvesting using water or/ and sodium hydroxide solution for a minimum of 30 seconds.
2. Do not leave the mangoes on the ground after harvest, it does not matter if they have shade or not. The longer it is left on the farm, the more likely it will be to find damaged lenticels.
3. Treatment with hot water and washing with NaOH (sodium hydroxide) work best if the fruits have been lifted immediately after harvest and the latex has been removed.
4. Reduce (do not dump) irrigation during harvest to allow time for the soil to dry out.

5. Do not harvest during rainy days. In case it rained the night before, wait a few hours until you perceive that both the fruits and the leaves are dry.
6. Use boxes to take the fruits to the packing plant. Place paper around and on top of the fruits.
7. Reduce as much as possible the time that the fruits are stored cold.

www.mango.org