



# Advances in biology through agronomy, aquaculture, coastal and environmental sciences

— Volume II —

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Ofelda Peñuelas-Rubio  
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Editors

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**Advances in biology through  
agronomy, aquaculture, coastal and  
environmental sciences**  
**Volume II**



Pantanal Editora

2026

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Catalog sheet

**Cataloging in publication**  
**Prepared by a Librarian Janaina Ramos – CRB-8/9166**

A244

Advances in biology through agronomy, aquaculture, coastal and environmental sciences - Volume II /  
Editors Leandris Argente-Martínez, Ofelda Peñuelas-Rubio, Joe Luis Arias-Moscato. – Nova  
Xavantina-MT: Pantanal, 2026.  
362p. ; il.

Book in PDF format

ISBN 978-65-85756-79-2

DOI <https://doi.org/10.46420/9786585756792>

1. Biology. 2. Agronomy. 3. Aquaculture. 4. Environmental sciences. I. Argente-Martínez, Leandris  
(Editor). II. Peñuelas-Rubio, Ofelda (Editor). III. Arias-Moscato, Joe Luis (Editor). IV. Title.

CDD 570

Index to systematic catalog

I. Biology



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**Advances in Biology through Agronomy, Aquaculture, Coastal and Environmental Sciences, Volume II**, is an e-book that continues the work of the first version (<https://editorapantanal.com.br/ebooks/2023/advances-in-biology-through-agronomy-aquaculture-coastal-and-environmental-sciences/ebook.pdf>), published in 2023 by Leandris Argente-Martínez and Ofelda Peñuelas-Rubio.

Our e-book compiles 25 manuscripts that present scientific results and reviews based on biological aspects. All of them contribute to explaining the responses of living organisms to agricultural, aquaculture, and coastal ecosystems, as well as those facing fragility or threat of climate change. This e-book was edited by Leandris Argente-Martínez, Ofelda Peñuelas-Rubio, and Joe Luis Arias-Moscote, members of the Consolidated Academic Group ITVAYA-CA-3.

We appreciate the contribution of all authors for their careful attention to the editorial committee's recommendations. The review process was double-blind and conducted by internationally renowned researchers.

Special thanks to the members of the BioSecuraNet International Network for Biotechnology and Innovative Strategies for Global Food Security at the National Technological Institute of Mexico.

**The Editors**

|                                                                                                                                                                                    |            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Prologue</b>                                                                                                                                                                    | <b>4</b>   |
| <b>Agronomy</b>                                                                                                                                                                    |            |
| <b>Chapter 1</b>                                                                                                                                                                   | <b>9</b>   |
| The reduction in chemical fertilization combined with PGPM under a controlled deficit irrigation system for maize                                                                  |            |
| <b>Chapter 2</b>                                                                                                                                                                   | <b>22</b>  |
| Effects of sowing date and size on the physical and physiological quality of bread wheat seeds in southern Sonora, Mexico                                                          |            |
| <b>Chapter 3</b>                                                                                                                                                                   | <b>35</b>  |
| Morphophysiological response and yield of tomato ( <i>Solanum lycopersicum</i> L.) to growth regulators and glutamic acid                                                          |            |
| <b>Chapter 4</b>                                                                                                                                                                   | <b>49</b>  |
| Influence of benzoxazinoid metabolites in maize roots interacting with diverse microbes                                                                                            |            |
| <b>Chapter 5</b>                                                                                                                                                                   | <b>64</b>  |
| Comparison of RGB spectrum vegetation indices to estimate agronomic variables in wheat and oats                                                                                    |            |
| <b>Chapter 6</b>                                                                                                                                                                   | <b>74</b>  |
| Alleviation of saline stress in maize and peanut plants induced by <i>Bacillus aryabhattai</i> strain CMAA 1363                                                                    |            |
| <b>Chapter 7</b>                                                                                                                                                                   | <b>92</b>  |
| Bacterial consortia as a sustainable strategy for disease management and productivity improvement in maize                                                                         |            |
| <b>Chapter 8</b>                                                                                                                                                                   | <b>109</b> |
| Agronomic management for oat seed production in the Bajío region, Mexico                                                                                                           |            |
| <b>Chapter 9</b>                                                                                                                                                                   | <b>125</b> |
| Risk factors in loading and unloading operations of agricultural products in land transport units at a company in Veracruz, Mexico                                                 |            |
| <b>Chapter 10</b>                                                                                                                                                                  | <b>145</b> |
| Physicochemical characterization of four varieties of durum wheat ( <i>Triticum durum</i> Desf.) under full irrigation and reduced irrigation conditions                           |            |
| <b>Chapter 11</b>                                                                                                                                                                  | <b>161</b> |
| Antifungal activity of edible chitosan coatings and <i>Coriandrum sativum</i> L. essential oil against <i>Colletotrichum gloeosporioides</i> and their application on mango fruits |            |
| <b>Chapter 12</b>                                                                                                                                                                  | <b>175</b> |
| Agricultural gypsum with micronutrients in citrus cultivation                                                                                                                      |            |
| <b>Chapter 13</b>                                                                                                                                                                  | <b>186</b> |

Initial Agronomic Adaptation of *Stevia rebaudiana* Bertoni in the High Mountain Region of Veracruz and Sustainable Management of *Planococcus citri* Using a Neem-Based Bioinsecticide

**Chapter 14** 197

Evaluation of yield components of two F1 maize hybrids under controlled deficit irrigation in a moderately saline vertisol soil in Yaqui Valley, Sonora, Mexico

**Aquaculture**

**Chapter 15** 207

Effects of partially replacing fish meal with mesquite pod meal (*Prosopis juliflora*) on the growth of Nile tilapia (*Oreochromis niloticus*)

**Chapter 16** 220

Consumer preferences and value-added opportunities in the commercialization of *Oreochromis niloticus* in Tenosique, Tabasco, México

**Chapter 17** 228

Partial substitution of pechita (*Prosopis glandulosa*) and alfalfa (*Medicago sativa*) flour with commercial flour in diets for tilapia (*Oreochromis niloticus*) farming

**Chapter 18** 239

Hydrolysate of the alga *Spirulina* influences the proliferation, growth, and development of *Spathiphyllum uxpanapense* in vitro

**Chapter 19** 251

Growth of the wild juvenile common snook *Centropomus undecimalis* in captivity

**Coastal Sciences**

**Chapter 20** 260

Notes on the recreational fishing of snook (*Centropomus* spp.) in the coastal zone of Centla, Tabasco, Mexico

**Chapter 21** 268

Linkage among climatic variation and artisanal fisheries behavior of common snook (*Centropomus undecimalis*) in tropical Atlantic coast

**Environmental Sciences**

**Chapter 22** 277

Fungal-based arsenic bioremediation: linking enzymatic detoxification mechanisms with bioreactor engineering

**Chapter 23** 292

Simplified dynamic modeling for scenario analysis of the anaerobic digestion of fruit and vegetable waste

**Chapter 24** 303

Impact of biofertilizers on wheat (*Triticum aestivum* L.) yield in different environments of the Bajío region of Guanajuato

**Chapter 25** 326

Genomic Reprogramming and Epigenetic Memory: Transforming Somaclonal Variation into a Tool for Climate Resilience

|                                                                                                                                                         |            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>Chapter 26</b>                                                                                                                                       | <b>351</b> |
| Research on the use of rhizobacteria for the biodegradation of herbicides and insecticides in agriculture and their effects on environmental protection |            |
| <b>Index</b>                                                                                                                                            | <b>360</b> |
| <b>About the editors</b>                                                                                                                                | <b>362</b> |

# Evaluation of yield components of two F1 maize hybrids under controlled deficit irrigation in a moderately saline vertisol soil in Yaqui Valley, Sonora, Mexico

Received: 14/04/2026

Accepted: 06/05/2026

doi 10.46420/9786585756792cap14

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## ABSTRACT

Maize (*Zea mays*) is among the most important cereals worldwide because of its high consumer demand. Through genetic improvement, hybrids with high yields have been obtained compared with those of previous eras, as well as hybrids that are tolerant to damage from certain pests, diseases, salinity, and other biotic and abiotic factors. Currently, salinity is a global problem, particularly in arid and semiarid zones, such as the Yaqui Valley in Sonora, Mexico, where rainfall is quite scarce and the indiscriminate use of chemical fertilizers is prevalent. Therefore, implementing controlled deficit irrigation systems will be the best option or alternative for agricultural producers, not only in the Yaqui Valley but also in other regions with similar climate and soil salinity conditions. From this perspective, the present study was conducted to evaluate the grain yield components of two F1 single-crop hybrids using a split-plot experimental design in Vertisol soil with moderate salinity (3.8 ds/m) under drip irrigation. The results revealed variability in the response of the two hybrids to salinity, with a difference of one ton. The F1 hybrid from treatment 2 (L7 TNM-107-C x L5 TNM-72-P) exhibited the best response, achieving a yield of 14.4 t h<sup>-1</sup>. The yield components ear length, number of rows, and number of grains per row were significantly greater in this hybrid, indicating greater salinity tolerance.

**Keywords:** *Zea mays* L., salinity, deficit irrigation, Vertisol soil, yield components

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## INTRODUCTION

There is a wide variety of maize types, primarily white and yellow kernels, used for human and livestock consumption, respectively. This cereal is among the most important crops produced in Mexico because of its significant contribution to the Mexican diet (Franco; Galindo, 2023). Pigmented maize varieties also exist in Mexico in a considerable area (Preciado-Ortiz et al., 2025). In the Yaqui Valley, maize is considered a second crop option after wheat, which is cultivated on a larger number of hectares (Velázquez et al., 2025). Genetic improvement in maize has progressed considerably in recent years, primarily because of its great economic, social, and cultural importance, and second, because of the efficient development and implementation of various technological innovations that have allowed for physiological and molecular studies that were not possible in previous research (Valenzuela, 2024).

Drought, which is considered an abiotic factor, is currently an alarming problem in Mexico in all aspects of life (Ortega-Marín; González-Rosa, 2024). High temperatures and a lack of rainfall contribute to this problem, affecting almost 50% of Mexico's territory. Currently, 14 states are experiencing this climatic problem most acutely, with the northern states being the most critical. In the states of Chihuahua, Sonora, and Sinaloa (Noperi-Mosqueda et al., 2025).

The implementation of agricultural practices for sustainable agriculture has many benefits, primarily environmental and economic. Specifically, water conservation is highly important in regions with very low rainfall (Sperandio et al., 2026).

Therefore, opting for a drip irrigation system is an excellent alternative for the production of a crop that requires a high-water demand, in this case, maize (Monge-Freile et al., 2025).

Recently, in the Yaqui Valley, studies have been conducted to evaluate the tolerance of maize hybrids to conditions such as drought and salinity. Reduced water availability can affect the concentration of salts in the soil; thus, evaluating the tolerance of local hybrids to salinity in soils with limited water availability can be a sustainable option for increasing yields and contributing to regional food security (Pérez-López et al., 2025). Therefore, the objective of this study was to evaluate the yield components of two F1 single-crossed maize hybrids under controlled drip irrigation conditions in moderately saline Vertisol soil in the Yaqui Valley.

## MATERIALS AND METHODS

### *Study site*

The geographical location of the study area corresponds to the experimental field of the National Technological Institute of Mexico, Valle del Yaqui Campus (Figure 1). The ITVY is located on Calle 600, Block 611, BÁCUM, 85276 San Ignacio Río Muerto, Sonora, at an altitude of 26 meters above sea

level. The climate of the municipality is classified into two types: the area north of the Yaqui River has a very hot and hot dry climate, whereas half of the area south of the river has a temperate dry climate.



**Figure 1.** Image of the site where the trial was established at the National Technological Institute of Mexico, Valle del Yaqui campus, BÁCUM, Sonora, Mexico. Image taken from Google Earth on October 20, 2025.

### *Plant Material*

In this study, two F<sub>1</sub> single-cross hybrids that exhibited the best agronomic characteristics were used. These were obtained from 72 crosses in a diallelic design of 9 pure lines from the National Technological Institute of Mexico, Roque Campus, Celaya, Guanajuato, Mexico.

**Table 1.** shows the characteristics of the 4 pure lines that were crossed in the diallelic design using Griffing's Method I, which generated the 2 single-cross hybrids under study.

| Line                 | Level of inbreeding | Origin of the lines           | Source material |
|----------------------|---------------------|-------------------------------|-----------------|
| <b>L3 TNM-111-DK</b> | S <sub>9</sub>      | Pob. F <sub>2</sub> (DK2042)  | Bayer           |
| <b>L5 TNM – 72-P</b> | S <sub>9</sub>      | Pob. F <sub>2</sub> (P3030 W) | Corteva         |
| <b>L6 6-P</b>        | S <sub>9</sub>      | Pob. F <sub>2</sub> P3030 W)  | Corteva         |
| <b>L7 TNM-107-C</b>  | S <sub>9</sub>      | Pob. F <sub>2</sub> (CAIMAN)  | Bayer           |

The two F<sub>1</sub> single hybrids evaluated in this study for treatments 1 and 2 were as follows: Treatment 1. L3 TNM-111-DK x L6-6-P; Treatment 2. L7 TNM-107-C x L5 TNM-72-P

### ***Variability in Environmental Conditions at the Experimental Site***

During crop development, climatic variables such as soil temperature were monitored using a TRUPER laser temperature meter. The maximum and minimum ambient temperatures and relative humidity were also monitored using a multiparameter temperature and relative humidity meter. Rainfall was recorded, with zero values for most months of the evaluation—only 0.5 mm in January. The soil moisture percentage was monitored with a tensiometer; the moisture content was maintained at 100% after irrigation and decreased to 75% at the time of the next irrigation. The relative humidity values ranged from 46% to 56%, indicating a dry climate in the region.

### ***Experimental Design and Treatments***

The experimental design used was a split-plot design with three replications and two F1 single hybrids that constituted the treatments; these consisted of the two F1 hybrids used. The experimental plot consisted of 4 rows per treatment, with a length of 12 m and 0.80 m spacing between rows and a spacing between plants of 10 cm, for a population of 1440 plants per treatment.

### ***Evaluated variables***

The agronomic variables of the grain yield components were evaluated. To evaluate these four variables, 10 ears of maize were randomly selected for each treatment. The number of rows per ear (NRE, unit), number of grains per ear (NGE, unit), ear length (EL in cm), and ear diameter (ED in cm) were determined. The latter two variables were measured using a TRUPER brand measuring tape and a TRUPER brand digital caliper, respectively.

### ***Statistical analysis***

For the statistical analysis of the data obtained from each treatment, the theoretical t distribution (Gosset, 1917) was used for the variables of the grain yield components at a significance level of 0.05%. The data were processed using the professional statistical package STATISTICA version 14.0 for Windows.

## **RESULTS AND DISCULTS**

### ***Variability in climatic conditions at the experimental site during crop development.***

According to the monitoring of climatological variables during crop development, as shown in Figure 2, differences in occurrence between the evaluation months and a considerable correlation between these variables can be observed. The maximum temperature reached 38°C, and the minimum temperature was 10°C, which affected the relative humidity; the higher the temperature was, the lower the relative humidity.

It can also be observed that only rainfall during the crop cycle occurred in January, which coincided with the lowest temperature and highest relative humidity. From this perspective, the results of the present study allow us to corroborate that these arid and semiarid agricultural zones with very scarce rainfall encourage us to implement irrigation techniques for greater water use efficiency, such as controlled deficit irrigation (Franco-Luesma et al., 2025).

Similarly, the soil temperature increases according to the ambient temperature.

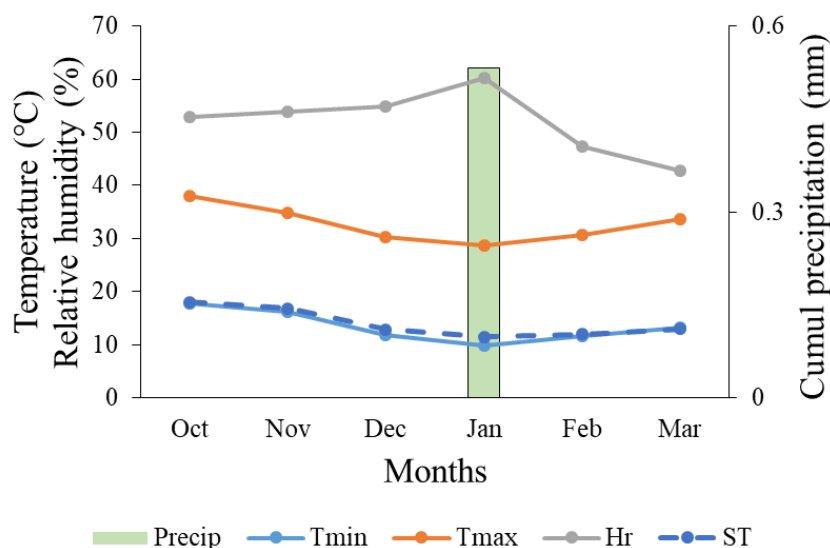


**Figure 2.** Variability in climatological conditions at the experimental site during the crop cycle from October to March 2025–2026.

#### *Agronomic variables of grain yield components.*

The overall average results for the grain yield components of the hybrids under study are shown in Figure 3. Ear length (EL) for both treatments was 19.95 and 21.25 cm, respectively, with significant differences between them. Ear diameter (ED), at 5.5 and 5.23 cm, did not significantly differ. The number of rows per ear (NRE), 15.6 and 14.6, did significantly differ, as did the number of kernels per row.

**Table 2.** Grain yield components in the treatments (EL: ear length; ED: ear diameter; NRE: number of rows per ear; NGE: number of grains per ear; t value: calculated Student's t value; p probability).

| Treatments | Yield components variables |          |            |            |
|------------|----------------------------|----------|------------|------------|
|            | EL (cm)                    | ED (cm)  | NRE (unit) | NGE (unit) |
| T1         | 19.95                      | 5.5      | 15.6*      | 31.20      |
| T2         | 21.25*                     | 5.23     | 14.6       | 33.60*     |
| t-value    | 1.23421                    | -1.27621 | -0.97435   | 1.1832     |
| p          | 0.023299                   | 0.54096  | 0.0072027  | 0.0251940  |

\* represents a significant difference according to Student's t test.

It is essential for maize breeding programs to select homogeneous materials with high yields and stable morphological and agronomic attributes. These attributes contribute to good genetic adaptability and high grain yield (Ponce-Encinas et al., 2022).

Furthermore, considering that these hybrids have not yet been genetically improved, they present very satisfactory values compared with others already on the market as a production alternative for farmers.

With respect to grain yield (Figure 3), significant differences were found between the two hybrids evaluated under this controlled deficit irrigation scheme, which contributed to grain yield. The significant differences in yield and most of the components between these two genetic materials indicate differences in their tolerance to soil salinity. The F1 hybrid of treatment 2 (L7 TNM-107-C X L5 TNM-72-P), which achieved a yield of  $14.4 \text{ t ha}^{-1}$ , was superior to that of treatment 1 (L3 TNM-111-DK X L6-6-P), whose yield was  $13.4 \text{ t ha}^{-1}$ .

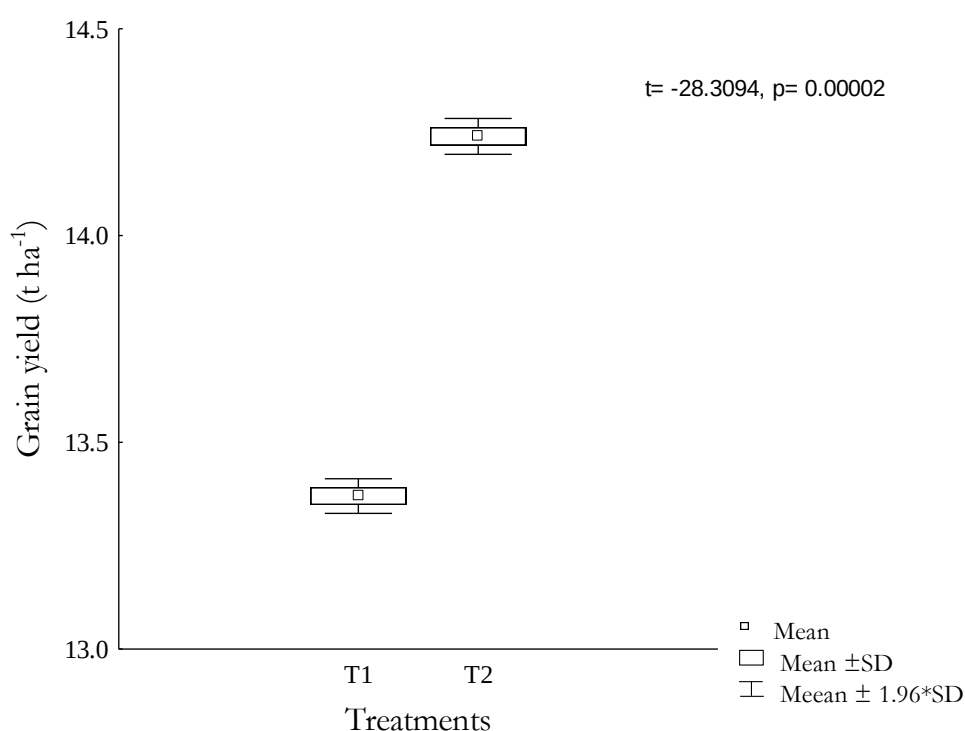


**Figure 3.** Grain yield in  $\text{t ha}^{-1}$  of the two hybrids evaluated.

The tolerance of maize to salinity is becoming a vital element of study because salt damage affects plant development (Li et al., 2023). This is due to the importance of maize cultivation for human and animal consumption and the need to increase production on the basis of the increasing population density in Mexico (Sobrino, 2024).

The salinity in the Yaqui Valley is known to increase significantly each year (Dévora-Isiordia, 2016). Therefore, obtaining local genetic materials that can tolerate these conditions is highly economically important.

The use of drip irrigation systems improve water availability (Solano et al., 2021), making it an economically viable option for increasing water use efficiency in semiarid regions (Díaz et al., 2008; Ortiz-Díaz et al., 2025). This study provides evidence of the work being performed at the local level in northwestern Mexico, particularly in the Yaqui Valley, to help mitigate the effects of salinity on the development and productivity of crops such as maize and to contribute to regional and national food security.

## CONCLUSIONS

The results demonstrated variability in the response of the two hybrids to salinity conditions, with a difference of one ton. The F1 hybrid from treatment 2 (L7 TNM-107-C x L5 TNM-72-P) showed the best response, achieving a yield of 14.4 t ha<sup>-1</sup>.

The yield components ear length (EL), number of rows per ear (NRE), and number of grains per row (NGE) were significantly greater in this hybrid, indicating greater salinity tolerance.

A key conclusion of this study is that when water resources are used efficiently—in this specific case, with controlled drip irrigation—and when the level of fertilization is much lower than that typically recommended in technological packages, the grain yield is 1.0 t<sup>-1</sup> greater than that achieved with flood irrigation.

## ACKNOWLEDGEMENTS

To the BioSecuraNet International Network—International Network for Biotechnology and Innovative Strategies for Global Food Security.

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**A**

Alfalfa, 256, 258, 261  
 anaerobic digestion, 324, 325, 326, 330, 331  
 Anthracnose, 184, 189  
 Aquaculture, 280, 281  
*Arachis hypogea*, 76  
 Arsenic, 307, 309, 311, 316

**B**

Benzoxazinoids, 58  
 Biomass yield, 9, 16, 17  
 Bioreactor, 310, 316  
 bioremediation., 394  
 Borlaug, 25, 27, 28, 29, 30

**C**

calcium prohexadione, 36, 38, 41, 42, 43, 44  
 Centla, 289, 290, 291, 292, 293, 294  
*Centropomus undecimalis*, 297, 298, 299, 303, 304

**Ch**

Chitosan, 184, 185, 191  
 Chlorophyll content, 15, 16

**C**

consortia, 94, 95, 97, 99, 100, 101, 103, 104  
*Coriandrum sativum* L., 184, 185, 186, 190, 191, 194  
 CPUE, 289, 291, 292, 294  
 cytokinins, 36, 38, 40, 41, 42, 43, 44, 46

**D**

Dates, 116, 122, 133, 139, 146  
 Degradation, 392  
 Detoxification, 310, 311

**E**

ENSO, 297, 298, 300

**F**

Fertilization, 339  
 fish, 232, 233, 234, 237, 239, 240, 242  
 fruit and vegetable waste, 324, 325, 331

**G**

Gluten, 172, 175  
 Grain quality, 174  
 Growth, 260

**H**

hybrids, 222, 223, 224, 225, 226, 227, 228  
 Hydrolyzed extract, 273  
 Hypopótamo, 13, 18

**I**

*In vitro* culture, 269  
 irrigation, 222, 223, 225, 226, 227, 228

**L**

Locations, 344

**M**

maize, 50, 51, 53, 54, 55, 56, 57, 222, 223, 225, 227, 228  
 Maize, 94, 95, 97, 98, 99  
 Mango, 188  
 mesquite, 232, 233, 234, 238, 240, 241, 242  
 Mesquite, 256, 258, 261, 262  
 Microbial, 99, 101, 104  
 Morphometric analysis, 289, 293  
 morphophysiological, 36, 37, 38, 45, 46

**N**

NDVI, 9, 10, 12, 14, 15, 18  
 nile tilapia, 232  
 NOM-017-PESC-1994, 289, 290, 291, 293, 294

**O**

Oat, 67

*Oreochromis niloticus*, 232, 233, 234, 241, 242, 246, 247

## P

paclobutrazol, 36, 38, 40, 41, 42, 43, 44, 45, 46, 47

Pantanos de Centla, 290

Particle size, 324

physiological quality, 22, 23, 24, 29, 31

Planting, 115, 116, 119, 122, 123, 131, 133, 135, 139, 140

*Prosopis juliflora*, 232, 233, 234, 238, 240

Protein content, 171

## R

Recreational fishing, 289

Reduced irrigation, 167, 178, 179

RGB, 65, 66, 68, 69, 70

Rheological properties, 175

## S

S/I ratios, 324, 328, 329, 330, 331

saline, 222, 223

SDS sedimentation, 171, 176

size, 22, 23, 24, 25, 26, 27, 28, 29, 31

*Spirulina* sp, 267, 269, 270, 276

substrate-to-inoculum, 324, 325, 329, 331

## T

Tabasco, 289, 290, 291, 292, 294, 297, 298, 299, 300, 301, 302, 303, 304

Tilapia, 260

tomato, 36, 37, 38, 40, 42, 43, 44, 45

**Treatments**, 339, 341, 343, 344, 349, 351, 352

## V

Varieties, 119, 122, 123, 136, 139, 141

Vegetation indices, 65, 69

VFAs, 325, 326, 328, 331

volatile fatty acids, 325, 326

## W

Water stress, 173

Weight, 116, 118, 119, 122, 123, 133, 135, 136, 139, 140, 141

wheat, 22, 23, 24, 25, 26, 27, 28, 29, 31

Wheat, 67

Wild juveniles, 283

## Y

yield, 22, 24, 25, 27, 28, 29, 31

Yield, 116, 118, 119, 120, 122, 123, 125, 133, 135, 136, 137, 139, 140, 141, 143, 343, 345, 351, 352

## Z

*Zea mays*, 75, 76, 77, 85, 222

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9786585756792



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Estrategias Innovadoras  
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**Pantanal Editora**

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