CDFA/FREP – New Fertigation Book
Final Report
January 2020

A. Project Information

1. Report Type: Final
2. Full Project Title: New Fertigation Book
3. Project Period: July 1, 2015 – December 31, 2019
4. Assigned FREP Grant Agreement: 15-0393-SA
5. Project Leader/Director:

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B. Objectives

1. Improve the understanding of good fertigation practices by practitioners (i.e., farmers, foremen, farm managers). The improved understanding will hopefully result in farmers implementing better irrigation and fertilization practices. Those good practices will improve crop yields while protecting the environment.
2. To meet the primary objective, the old Cal Poly ITRC *Fertigation* book was updated. It previously served as a valuable reference tool for practitioners but was over 20 years old.

C. Abstract

The old ITRC FERTIGATION book was widely used by agronomists in California and was the single most comprehensive book of its nature in the US. With this contract it received a complete overhaul and updating. This new book (completed 2018) was intended to serve as a valuable resource for practitioners (farmers, consultants, vendors) who are involved in applying fertilizers and other chemicals through irrigation systems. Short courses were also held to further spread the knowledge.

The book covers typical subjects such as commercial fertilizer properties, injection equipment, solubility, crop nutrient uptake patterns (lb. vs. stage of growth), achieving good distribution uniformity with different irrigation methods, chemical maintenance of drip systems, and water amendments to improve infiltration rates. The book also includes many special current topics.

D. INTRODUCTION

In California it is very common to apply a large percentage of fertilizers through the irrigation water. There has been a gradual shift from gravity irrigation to drip/micro and sprinkler. Those pressurized irrigation methods now represent about 60% of the acreage in California and are found on most of the intensively grown crops that need excellent fertilizer management.

There are many fertilizer books, and thousands of research articles on fertilizers and plant uptake. However, few of these resources focus on pragmatic chemical applications via irrigation water – especially considering special California conditions. An older ITRC publication of FERTIGATION was an extremely important reference for practitioners in California. But it was over 20 years old and was written at a time when fertigation was in its relative infancy, when organic farming was scarce, and when environmental regulations related to fertilizers were few. Equipment and chemicals have both changed, as well as management practices.

The new FERTIGATION book provides a valuable update that will hopefully serve California well for another 20 years. Short courses have also been held to further disseminate the knowledge.

E. WORK DESCRIPTION

The tasks are seen in the table below, and are mostly self-explanatory

Task	Number	Task Description
Initial Organization	1	Develop Revised Outline
Information Gathering	2a	Review old Fertigation book, define improvements
	2b	Literature and web search
	2c	Interviews with farmers, fertilizer dealers, researchers, etc.
	2d	Collect new information on injectors, costs, etc.
	2e	Examination of codes
	2f	Model the difference between spoonfeeding and occasional injection of N fertilizer
	2g	Develop improved crop-specific recommendations
Book Organization	3	Organization of information
Write book	4a	Writing of texts
	4b	Development of graphics
	4c	Editing
	4d	Completion of book
Outreach activities	5a	Cal Poly Fertigation Class for Beta Testing (28 students April 2017)
	5b	e-mails, advertisements
	5c	Presentations to the California Ag. Irrigation Association
	5d	Fertigation short courses for industry at ITRC (5) and one more
	5e	Further development of teaching aids
Attendance at FREP conferences	6	Attended Fall FREP conferences, Nov. 2016 and Nov 2017 and October 2019
Reporting	7	Quarterly, annual, and final reports. Interpretive summaries provided annually for FREP conferences

The information gathering including conversations and physical visits with most of the fertigation equipment manufacturers, and interviews with a range of San Joaquin Valley and Coastal fertilizer companies. New injection and safety equipment, as well as a proportional injector, were obtained to enhance the Fertigation short courses.

Testing was conducted at Cal Poly with a variety of commercially available organic fertilizer compounds to determine solubility, the ability of material to pass through a filter, and oil content. Label fertilizer concentrations were compared against commercial laboratory analysis of samples taken by ITRC. The results are found in the new Fertigation book.

USDA's RZWQM2 nitrogen leaching model was used to estimate the difference in nitrogen leaching that occurs if fertilizer is spoon-fed or only fertigated occasionally.

Numerous other items were researched or tested before being included in the new book. These ranged from topics such as minimizing fertigated materials from being lost in filter backflush water, to injection of air and oxygen, to the impact of various plant growth stimulations that are injected

into irrigation water. Special attention was given to the topic of proportional injection, and the commercial options were explained with the help of process sketches.

F. Data/Results

Materials. The Fertigation book has been completed and published and is available via the ITRC web site of www.itrc.org. Copies of the new Fertigation book were previously supplied to FREP personnel. The Table of Contents of the Fertigation book is seen below.

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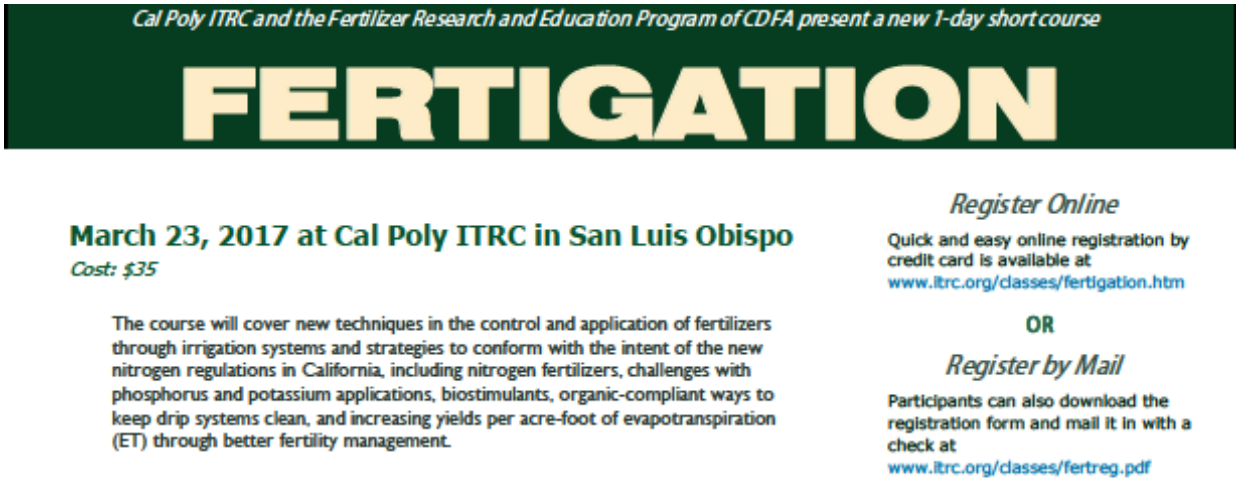
b. One day short courses were held at Cal Poly ITRC. The attendances and dates are provided in the table below.

Date	Duration (Days)	Consultant	Govt	University	Farmer	Equip or Chem Sales	Total
12-Aug-19	1	10	2		23	1	36
13-Aug-18	1	5	1	2	10	9	27
5-Mar-18	1	4	2		9	6	21
7-Aug-17	1	11	4	1	13	6	35
23-Mar-17	1	7	4	1	24	8	44
						Total:	**163**

The short courses were advertised on the ITRC web site, via an extensive e-mail list that ITRC has, through the FREP web site, and with ads placed in the following publications:

CSA News
Irrigation Today
News Harvest
IA Times
CAPCA Applicator Alerts
Western Farm Press
Ag Alert

The three formats for advertising are seen below.




FERTIGATION
Education
for the 21st Century
ITRC and the California Department of Agriculture's (CDFA) Fertilizer Research and Education Program (FREP) are proud to announce updates to our educational offerings for fertigation!
◆ Second edition of popular *Fertigation* book
◆ Updated short courses and classes
Fertigation
Second Edition
Learn more at
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ITRC
moving water in new directions
IRRIGATION TRAINING & RESEARCH CENTER
California Polytechnic State University
San Luis Obispo


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California Polytechnic State University,
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FERTIGATION
Education for the 21st Century
ITRC and the California Department of Agriculture's Fertilizer Research & Education Program present:
◆ Second edition of *Fertigation* book
◆ Updated short courses and classes
Learn more at www.itrc.org/fertigation

An example syllabus is provided below:

Fertigation

Irrigation Training and Research Center (ITRC)
BioResource and Agricultural Engineering Department
Cal Poly State University
San Luis Obispo, CA 93407

Co-sponsored by the FREP program of CDFA
August 13, 2018
Instructors: Drs. Charles Burt and Franklin Gaudi

TIME	ACTIVITY
07:45	Registration
08:00	Introduction
	- Individual introductions by participants, chemicals injected
08:10	**General overview (Chap 1, 2)**
	- Explanation of Chemigation vs. Fertigation
	- Energy requirements
	- Safety
08:40	Break
08:50	**Chemical Injection (Chap 3 & 5)**
09:40	Break
09:50	**Proportional Fertigation (Chap 4)**
10:20	**Irrigation Principles (Chap 6)**
11:00	Break
11:10	**Irrigation Systems (Chap 7)**
12:00	**Lunch**
12:45	**Equipment - outside** (*Dr. Gaudi*)
	- Injector designs
	- Filter backflush recycling
	- SO2 generator
	- Calibration
	- Use of venturi devices
2:15	Break
2:30	**Nitrogen transformations, processes, and regulations (Chap 8, 9)**
3:30	Break
3:40	**Other Nutrient Processes and Specific Fertilizers (Chap 10, 11)**
4:20	Break
4:30	**Bio Stimulants, Oxygen and Air, and Organic Fertilizers (Chap 12, 13, 14)**
5:00	Adjourn

b. (Continued).

Beta testing and improvement of both the short course and book were conducted via two 1-unit Fertigation classes offered to Cal Poly students as an elective. The Spring 2017 class had 28 students; the Spring 2019 class had 16 students.

The project was advertised at the Fall FREP/WPHA conferences in November of 2016 and 2017, and Oct. 2019. Dr. Gaudi provided a 30-minute presentation in 2019.

The book and short course were also announced and described at two annual California Agricultural Irrigation Dealership meetings. Dr. Gaudi, in his position as a member of the Certification Board of The Irrigation Association, has encouraged The Irrigation Association to begin a certification program in Fertigation.

c. Impact Measurement

For each of the short courses, participants were asked to fill out a one-page class evaluation. These were reviewed by the instructors to determine what topics were most interesting, points that were clear or confusing, and to improve the next short course. The most common recommendation was to have a 2-day course. However, this is always a gamble because many people cannot take 2 days from work.

Not everyone completes the class evaluation form, and they were only collected for 4 of the 5 short courses. The following table provides a summary of some key answers.

How did you hear about this course?							
e-mail	Work	Online	Flier-mail	Friend	Familiar with ITRC Classes	FREP	Ag Show in Tulare
12	30	20	6	5	6	2	1

How would you rate this course?						
Excellent	V. Good	Good	Average	Just Fair	Poor	Horrible
48	29	15	1	2	0	0

How well did you understand the content of this course?						
Excellent	V. Good	Good	Average	Just Fair	Poor	Horrible
30	30	30	2	5	0	0

Would you recommend this short course to others?		
Yes	No	Maybe
89	1	2

G. Discussion and Conclusions

The objective of providing a much improved and updated Fertigation book was met. The short courses were also developed and provided as promised in the proposal.

The primary challenges were:

1. Obtaining information on, and samples of, commercial organic fertilizers. The vendors seemed to have little interest in providing solid information, or in having their compounds examined.

2. Advertising. This is always a challenge. Eventually ITRC paid for advertisements in a variety of professional/farming publications.

H. Project Impacts

The impacts are of course difficult to quantify beyond listing the number of attendees in short courses (163) and Cal Poly Fertigation class students (44) that used the new materials. But an examination of the types of attendees indicates that there is a large multiplier effect. This is because of the large number of equipment manufacturer/vendor attendees, as well as consultants. Some of California's largest farms sent attendees. Only 13 of the 163 short course attendees were government employees.

FREP is interested in contributing toward advancing the environmentally safe and agronomically sound use of fertilizing materials. The new book is perhaps the most pragmatic source of information for this topic. It explicitly addresses concepts of leaching, how leaching occurs with various irrigation systems, the concepts of irrigation system distribution uniformity, the linkage between irrigation water management and nitrogen leaching, and the challenges with determining and obtaining the correct A/R (Applied/Removed) nitrogen ratio.

It is anticipated that this new book will serve as a primary source of information for farmers and consultants who want to achieve high efficiencies with their fertilizer applications.

I. Outreach Activities

This was not a research project, so this section was covered in the earlier section F.

J. Factsheet/Database Template

Please see the final page.

K. Copy of the Product/Result

Copies of the new Fertigation book were provided to FREP personnel earlier.

Section J

1. Project Title: New Fertigation Book
2. FREP Grant Agreement: 15-0393-SA
3. Project Leader/Director:

   Dr. Charles Burt
   Irrigation Training & Research Center (ITRC)
   Cal Poly State University
   San Luis Obispo, CA 93407-0730
4. Project Period: July 1, 2015 – December 31, 2019
5. Location: Statewide
6. County: Statewide
7. Highlights:
   - A completely updated, 265 page book on Fertigation specifically designed for California is available via http://www.itrc.org/publications.htm
   - Short courses on Fertigation are available. Find the schedule at http://www.itrc.org/classes.htm
   - Important topics include the A/R nitrogen ratio, fertilizer compounds, plant requirements, injection equipment and safety, organic fertilizers, and much more.
   - Proportional fertigation and required equipment are discussed in detail.

8-10. Introduction, Methods/Management, and Findings