2nd Edition
FERTIGATION book

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Ph.D., P.E., D.WRE., CID, CAIS, etc, etc.

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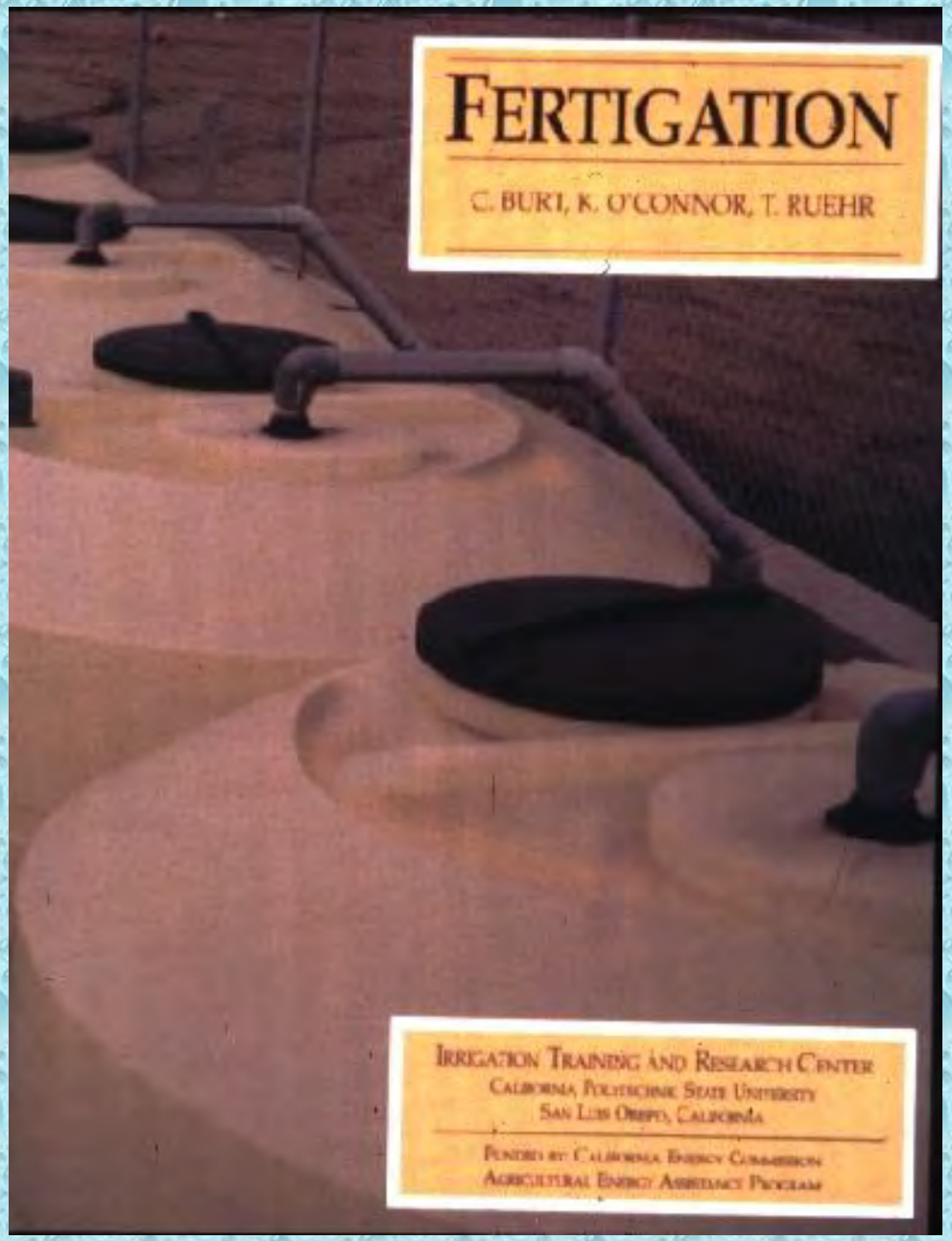
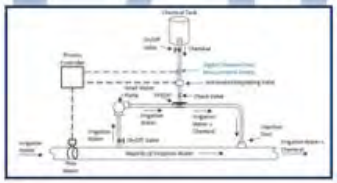
The old Cal Poly ITRC Fertigation book (1998)

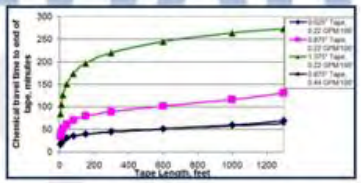


FREP has funded a second edition of the FERTIGATION book

Available early 2018

Fertigation





Second Edition

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with contributions by Monica Holman and first edition co-authors
Dr. Thomas Ruehr and Kris Beal

ITRC
moving water in new directions
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Many of the chapters have the same title, but the content has been significantly updated.

Chapter 1. Introduction
Chapter 2. Safety
Chapter 3. Chemical Injectors
Chapter 4. Proportional Fertigation
Chapter 5. SO_2, Gypsum, and Solids
Chapter 6.Irrigation Principles, Leaching, and Fertilizer Uniformity
Chapter 7.Injection Techniques for Various Irrigation Methods
Chapter 8. Nitrogen Transformations and Processes
Chapter 9. Nitrogen Uptake
Chapter 10. Other Nutrient Processes
Chapter 11. Specific Fertilizers
Chapter 12. Biostimulants
Chapter 13. Organic Fertilizers
Chapter 14. Air and Oxygen Injection
Chapter 15. Plant and Soil Testing
Chapter 16. Specific Crop Requirements
Chapter 17. Sample Fertigation Calculations
Chapter 18. Drip System Maintenance
Chapter 19. Infiltration Problems
Appendix A. Units of Salinity Measurement

I'll briefly cover a few points from the following chapters

Chapter 4. Proportional Fertigation

Chapter 6.Irrigation Principles, Leaching, and Fertilizer Uniformity

Chapter 9. Nitrogen Uptake

Chapter 12. Biostimulants

Chapter 13. Organic Fertilizers

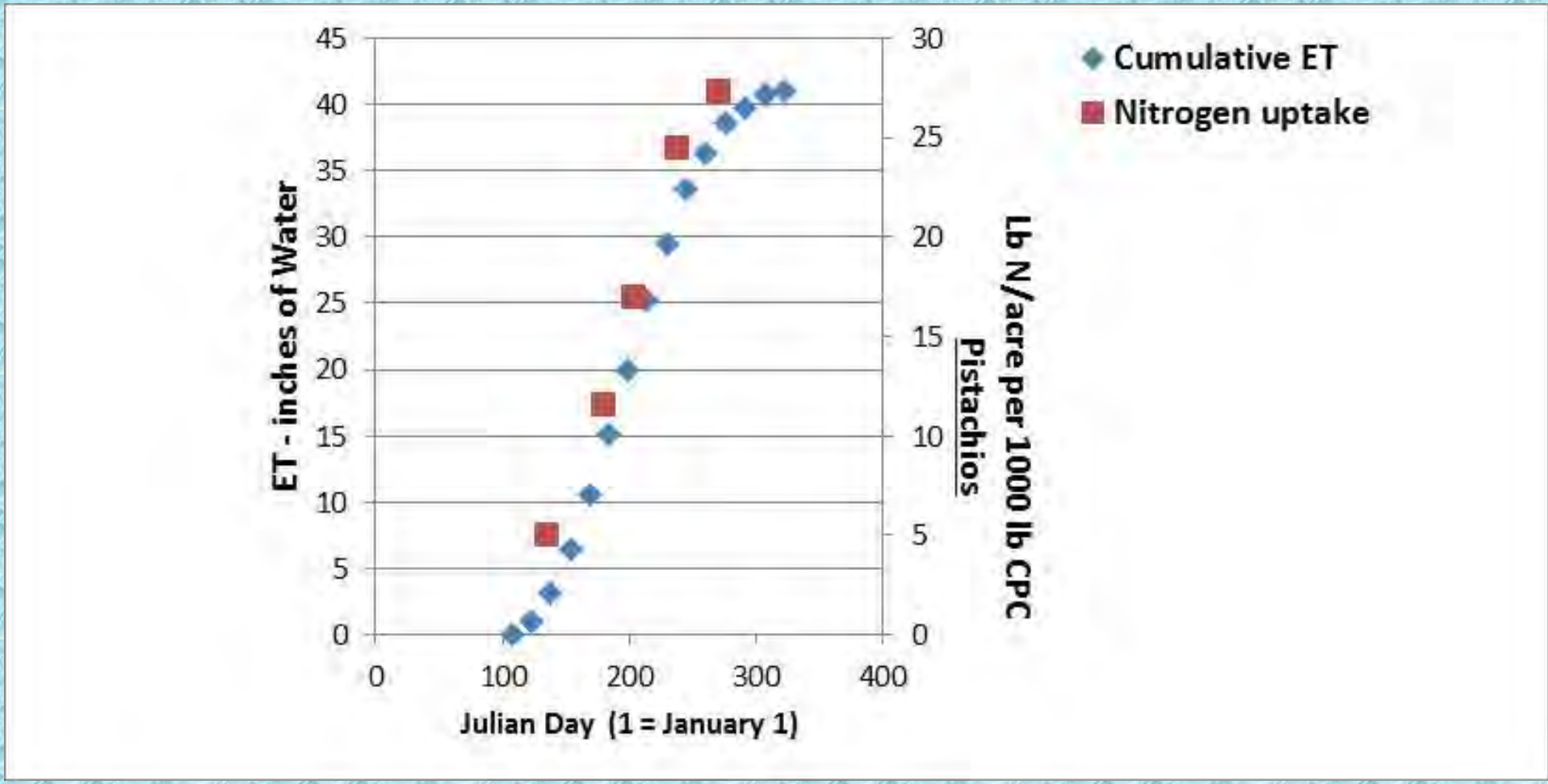
Chapter 14.Air and Oxygen Injection

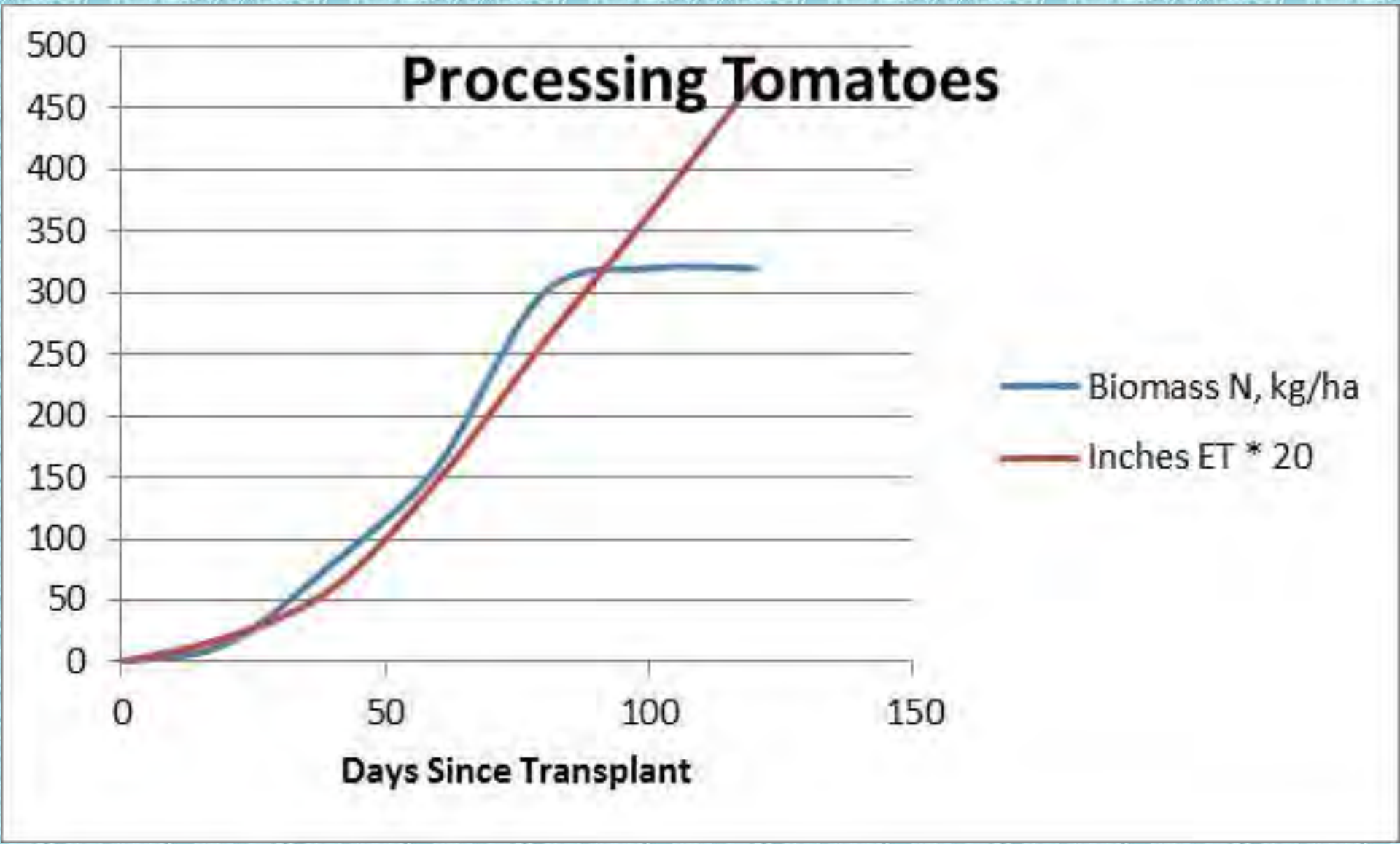
Proportional Fertigation

- Similar to maintaining a pH in the water.
- Injects a constant ppm.
- “PPM” is much more difficult for people to understand than “inject 100 gallons during the irrigation”
- Proportional fertigation automatically adjusts the injection rate as you switch irrigation sets with different sizes/flow rates.

It would be nice if the proportion of (N/GPM) needed, stayed constant for awhile.

Fairly constant ratio of N needed, per gallon of water ET for Pistachios

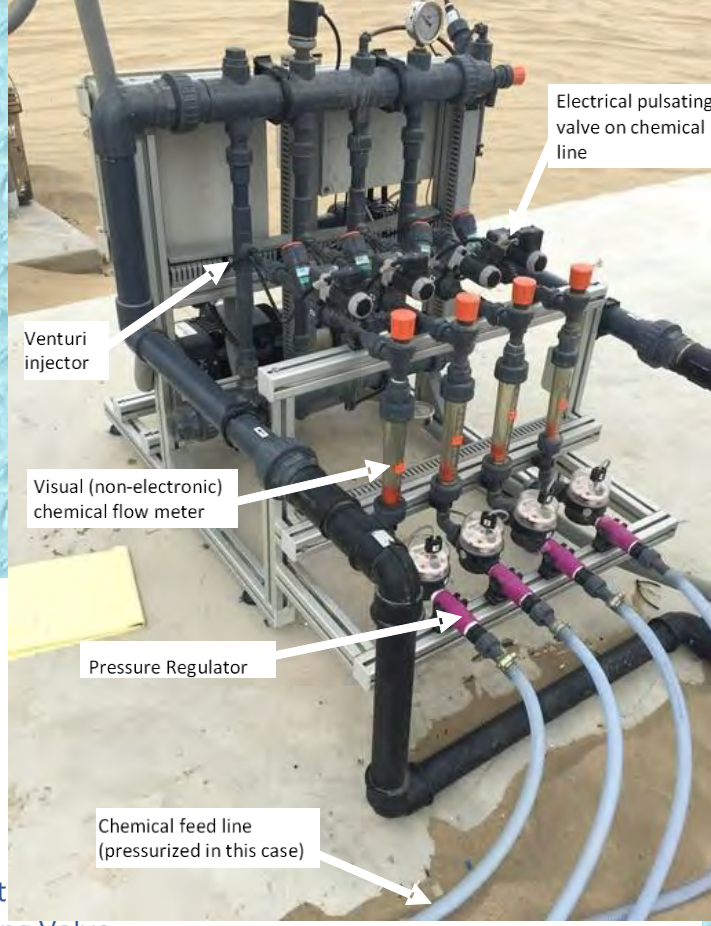



Processing Tomatoes
500
450
400
350
300
250
200
150
100
50
0
0
50
100
150
Days Since Transplant
Biomass N, kg/ha
Inches ET * 20

A fundamental assumption with proportional fertigation is that a farmer will also "spoonfeed" – in other words, always inject during irrigation.

Two types of hardware are commonly used for proportional injection in agriculture.

The chemical flow is first “calibrated” and then if 50% is wanted, a valve pulses on 50% of the time.



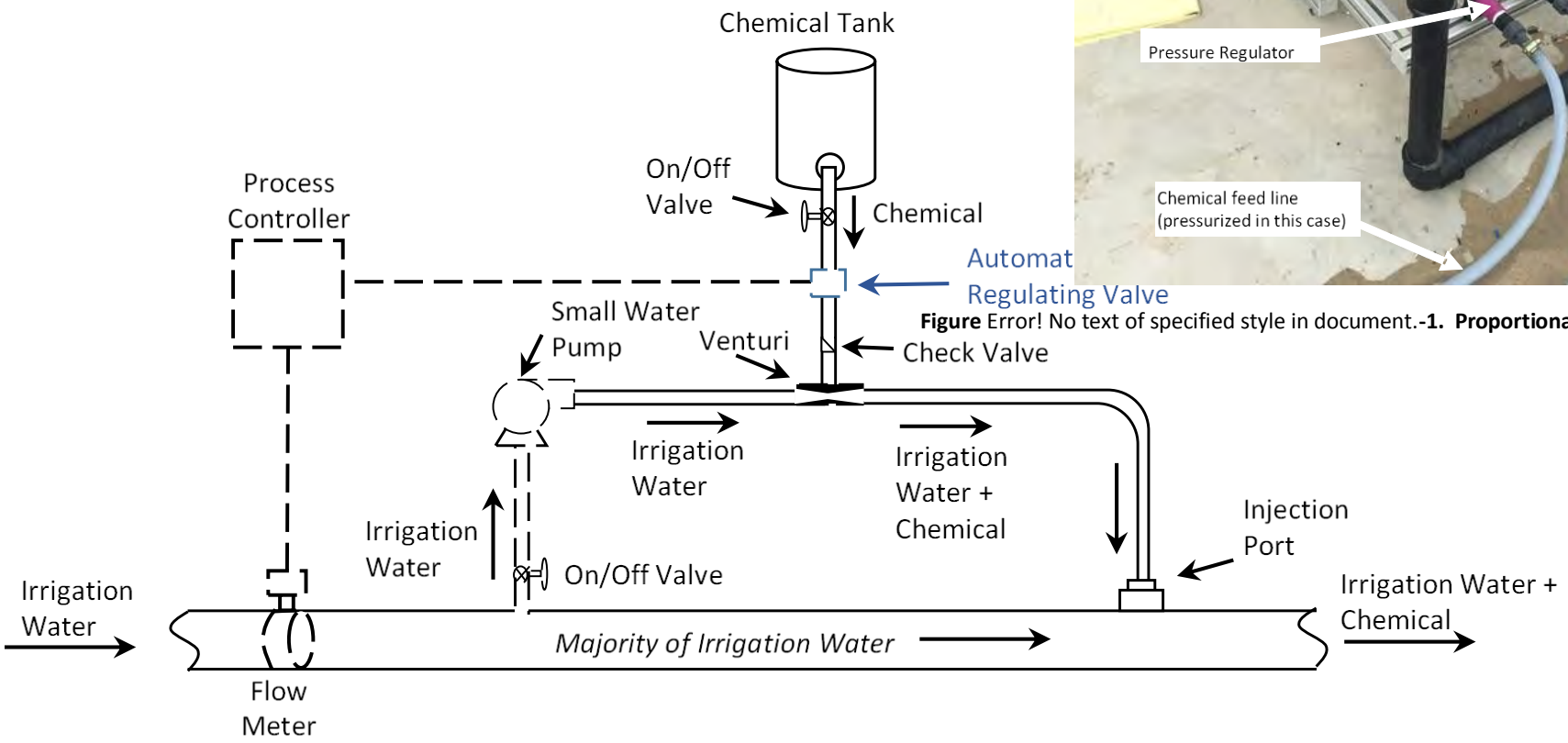
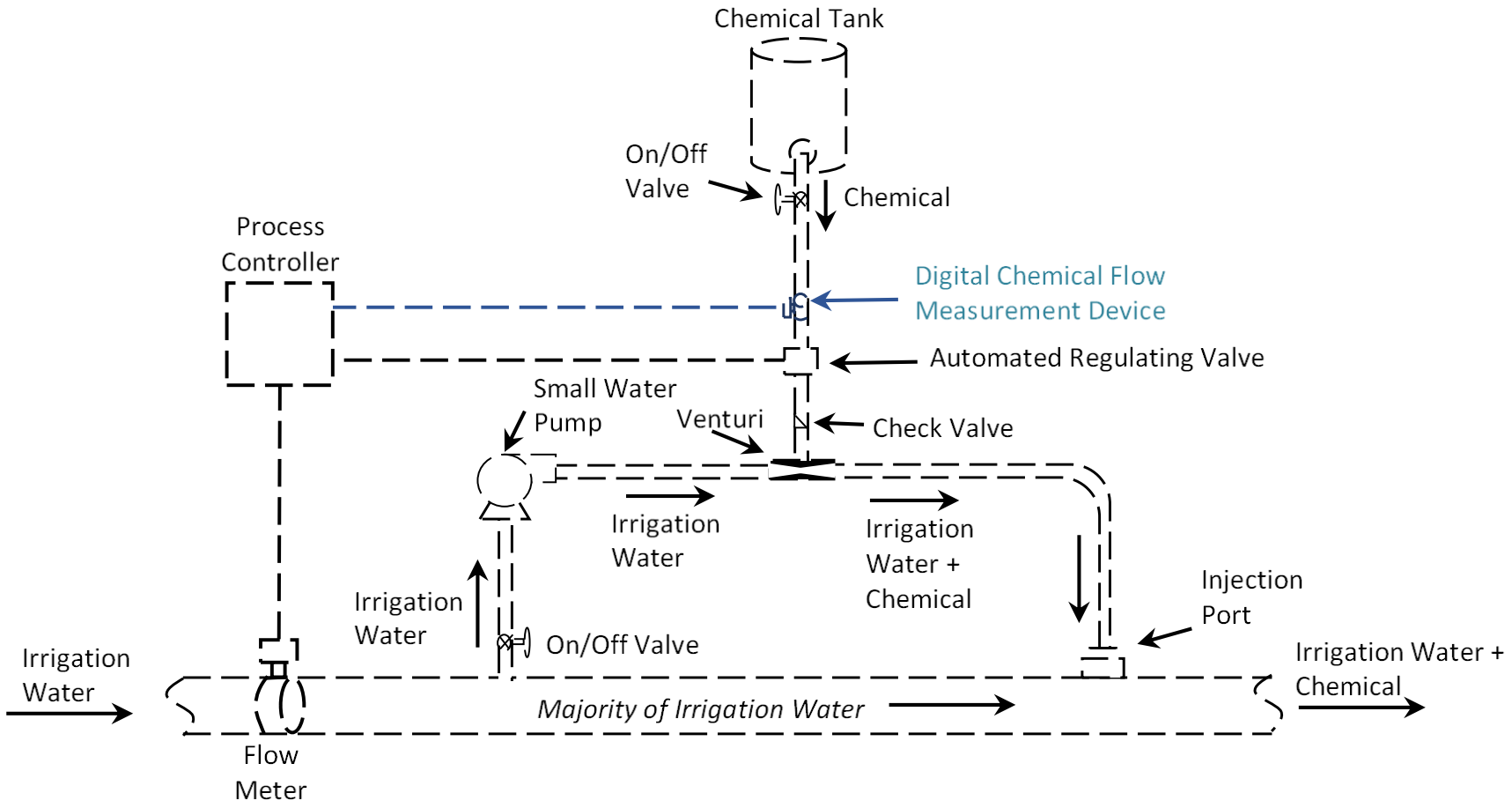


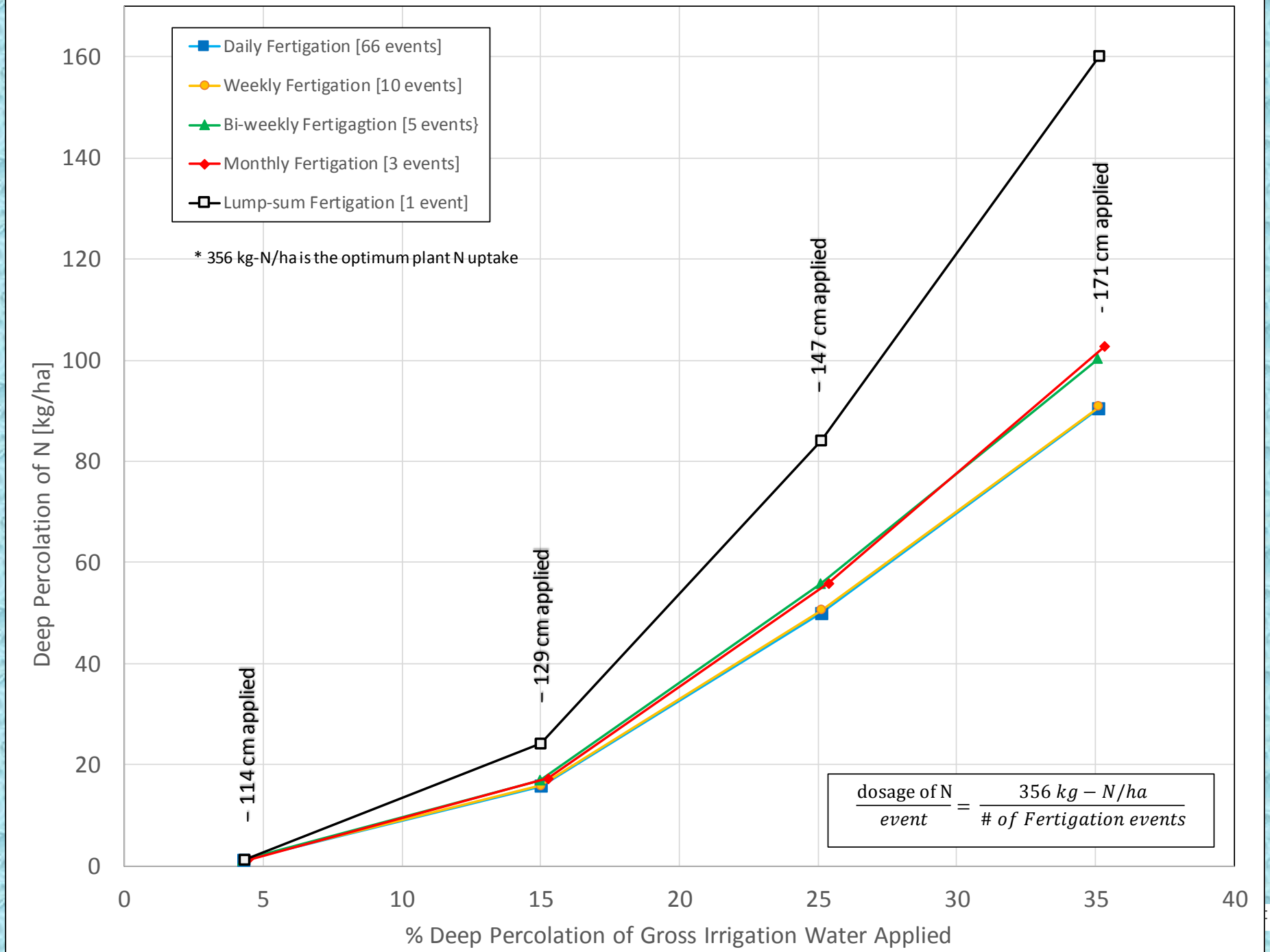
Figure Error! No text of specified style in document.**-1. Proportional injector for ce**

2nd type - Recommended



Switching topics –

LEACHING of Nitrates


Daily Fertigation [66 events]
Weekly Fertigation [10 events]
Bi-weekly Fertigagtion [5 events}
Monthly Fertigation [3 events]
Lump-sum Fertigation [1 event]
* 356 kg-N/ha is the optimum plant N uptake
– 114 cm applied
– 129 cm applied
– 147 cm applied
- 171 cm applied
dosage of N / event = 356 kg − N/ha / # of Fertigation events
Deep Percolation of N [kg/ha]
% Deep Percolation of Gross Irrigation Water Applied
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30
35
40

Bottom line of modeling results on Nitrate LEACHING (not plant response):

1. The big gorilla is deep percolation of water (irrigation or rain).

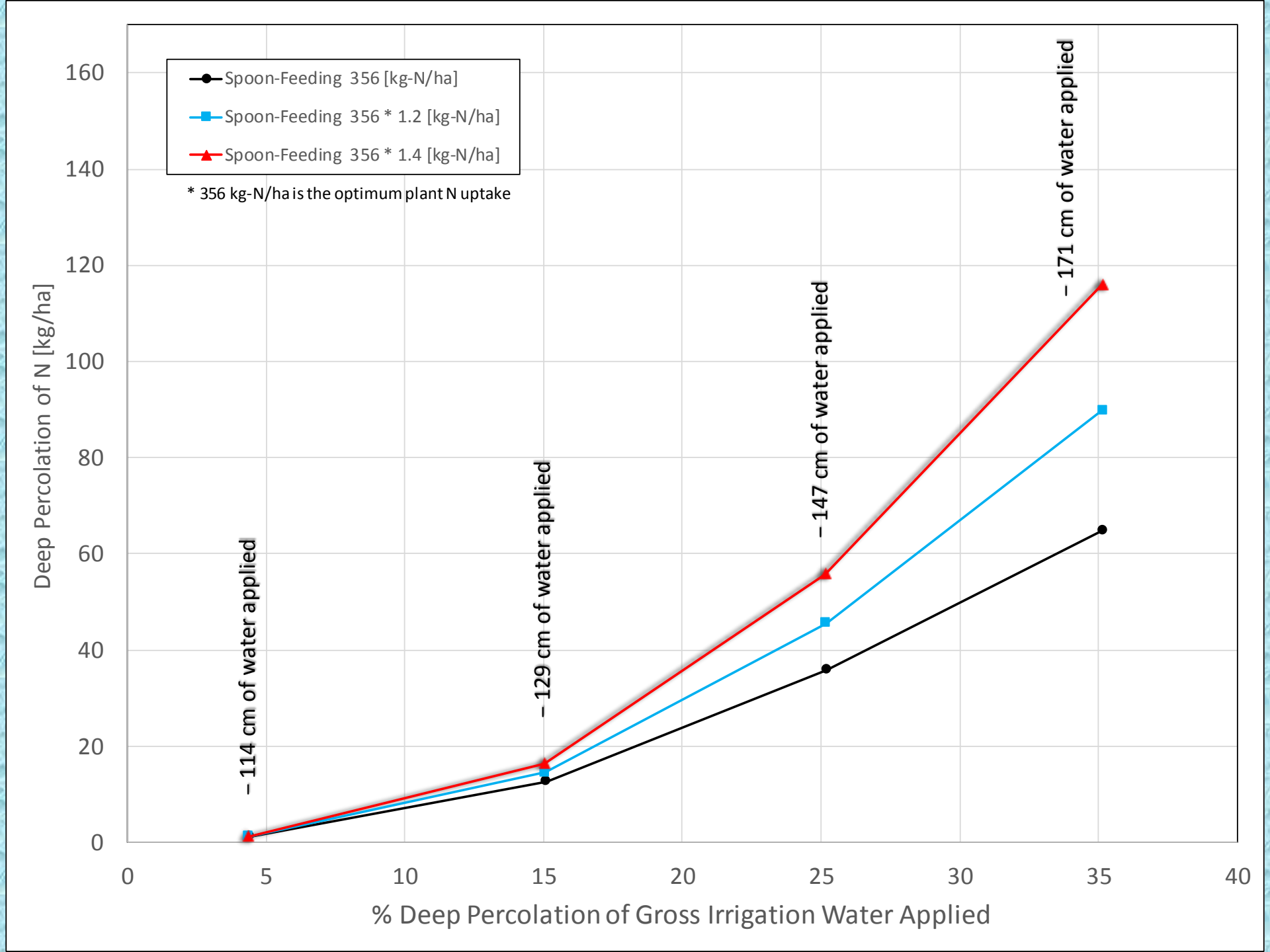
2. Fertilizing only one time isn't real smart.

3. There isn't a lot of difference between daily and weekly fertigation.

The previous slide showed the same total N applied for all cases.

How about if more N is applied than is needed?

(this is also a no-brainer)


Spoon-Feeding 356 [kg-N/ha]
Spoon-Feeding 356 * 1.2 [kg-N/ha]
Spoon-Feeding 356 * 1.4 [kg-N/ha]
* 356 kg-N/ha is the optimum plant N uptake
– 114 cm of water applied
– 129 cm of water applied
– 147 cm of water applied
– 171 cm of water applied
Deep Percolation of N [kg/ha]
% Deep Percolation of Gross Irrigation Water Applied
0
20
40
60
80
100
120
140
160
0
5
10
15
20
25
30
35
40

The basics of reducing N leaching are just that – real basic in concept:

1. Use good irrigation scheduling.
2. Match N applications with needs.
3. You don't need to have daily spoon-feeding for LEACHING efficiency.

A simple design for applying the correct dosage per SET.

But what about when sets change?

This is OK if you only irrigate a few times/week. Is that best for plants, and for avoiding deep percolation?

So we all understand that fertilization with N should “meet the plant needs”.

But what exactly does that mean?

I suppose you have seen the revised Ag Order

SECOND DRAFT 10/10/17

STATE OF CALIFORNIA

STATE WATER RESOURCES CONTROL BOARD

ORDER WQ 2018-

Key to the 2nd Ag Order is the ratio of (Applied/Removed)

$$A/R = \frac{\text{Nitrogen Applied}}{(\text{Nitrogen removed via harvest}) + (\text{Nitrogen sequestered in the permanent wood of perennial crops})}$$

There is a lot to learn about improved N management.

For example:

University of California guidelines for cotton fertilization are found on the California Dept. of Food and Agriculture website https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Cotton.html.

Recommended fertilizer level: 115 lb N/acre

Removed N fertilizer: (44 lb N/ton) × (2860 lb)/(2000 lb/acre) = 62.9 lb N/acre

In other words, “standard” UC fertilizer recommendations for 2 bale cotton would result in an A/R ratio of:

A/R ratio = (115 lb)/(62.9 lb) = 1.8

Next subject – Organic fertilizers

For fertigation, there can be serious problems with emitter plugging with many organic formulations.

Oils

Particulates

Table Error! No text of specified style in document.**-1. Comparison of liquid organic fertilizers**

Sample ID	Label Grade N-P-K	Post-Agitation Observations		Post-Dilution Observations		150 Mesh Sieve Test
		Color	Consistency	Fluid Separation	% Volume of Floating Oil Layer	% Retained by Filter
6	2.5-2.5-1.5	Dark Brown	Very thick, with dense foam that stuck to the side of bucket	Uniform throughout with some foam left on side of cylinder	None	76%
7	2.5-2.5-4.5	Dark Brown	Thin, with white bubbles. Bubbles did not stick to sides.	Uniform throughout with nothing left on side of cylinder.	None	65%
8	2.5-7.0-3.0	Light Brown	Thin, with no bubbles or foam. Small silty clouds.	15 mL of light tan solids formed at bottom of cylinder.	None	0%
9	3.0-3.0-3.0	Tan	White foam. Some stuck to bucket sides.	3 distinct layers. Dark solids formed in the bottom 100 mL.	25%	78%
15	4.0-2.0-1.0	Very Dark Brown	Thin with clumps at bottom of jug.	Uniform throughout with nothing left on side of cylinder.	None	60%
16	2.5-2.0-1.0	Very Dark Brown	Thinner than #15 without any clumps at bottom of jug.	Uniform throughout with nothing left on side of cylinder.	None	60%
17	1.5-3.0-0.2	Light Brown	White foam. Some stuck to bucket sides.	2 distinct layers. Dark solids formed in the bottom 100 mL.	38%	10%
19	5.0-1.0-1.0	Brown	Very thick, with dense foam that stuck to the side of bucket.	3 distinct layers. Light solids formed in the bottom 115 mL.	13%	38%
20	2.0-0.5-0.3	Light Brown	Medium thickness with thin bubbles.	3 distinct layers. Light solids formed in the bottom 115 mL.	22%	50%

Plugging prevention with organic fertigation

- Special emitters

- Special chemicals (approved) to kill bacteria

- Emphasis on soil-applied N for the major % of the annual needs (w/ nitrification inhibitors)

That's a glimpse of the types of content found in the 2nd edition of the Fertigation book