Why Can Fertigation Improve Fertilizer Use Efficiency?

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Top-ten Vegetable Crops Grown in FL

Crop	Planted Acres	Value (million US$)	US Rank
Tomato	30,000	382.2	1
Snap bean	28,200	105.6	1
Watermelon	22,500	123.3	1
Cucumber	11,000	66	1
Strawberry	10,800	449.7	2
Bell pepper	13,500	209.7	2
Sweet corn	37,600	160	2
Squash	6,000	30	2
Cabbage	8,500	49.4	3
Potato	29,300	117	11
Total	168,100	1,576	

Source: Vegetables—2015–2016 summary, NASS, USDA.

Statewide Production of Ethnic Vegetables



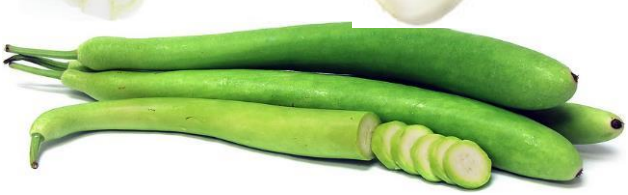








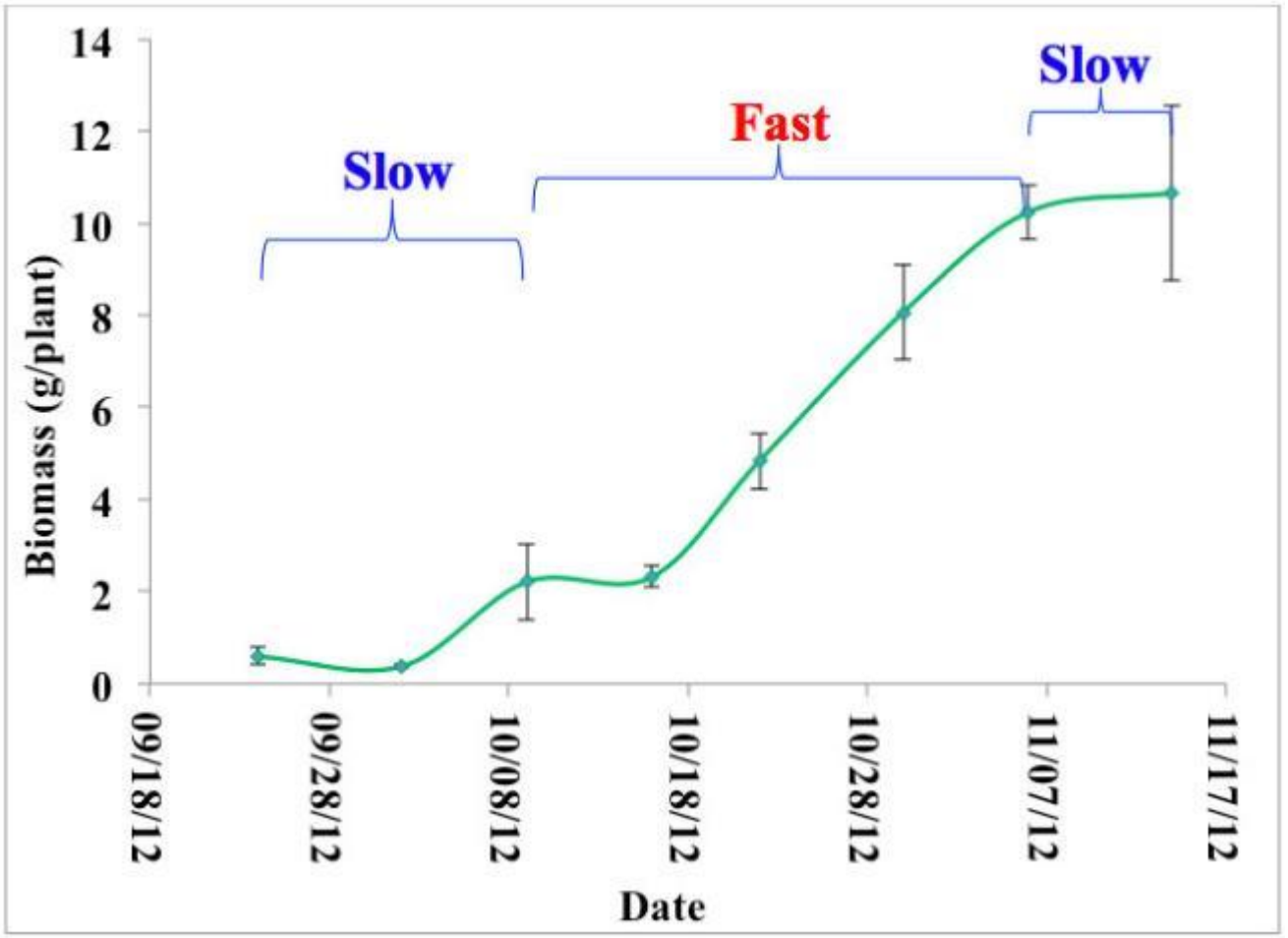





Most Soils in Florida Are Sandy by Nature

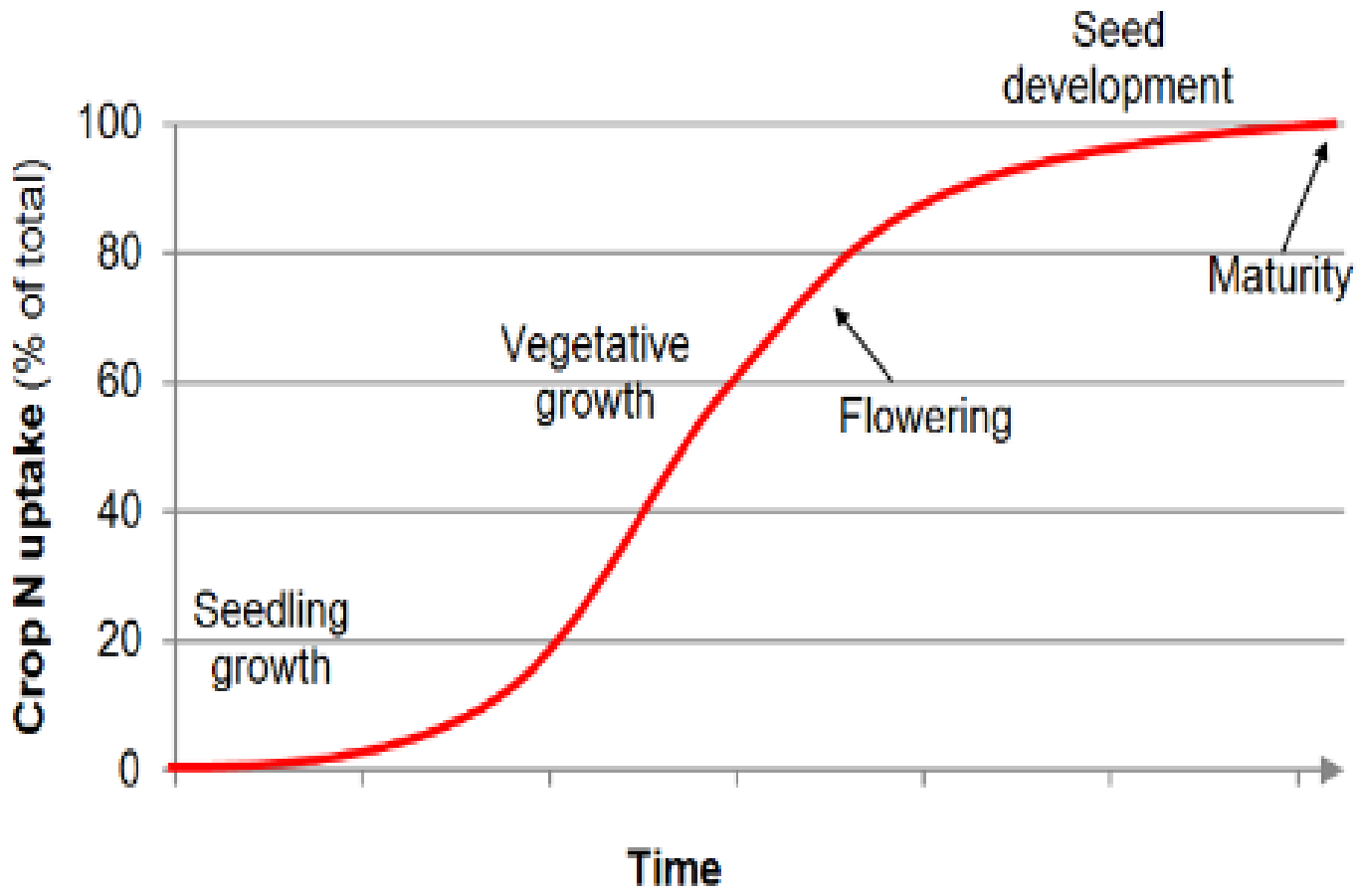
S-shaped Growth Curve of Snap Bean



Growth curve of snap bean (variety: 'Bronco') in fall 2012.
Credit: Guodong Liu, UF/IFAS

https://edis.ifas.ufl.edu/publication/HS1255

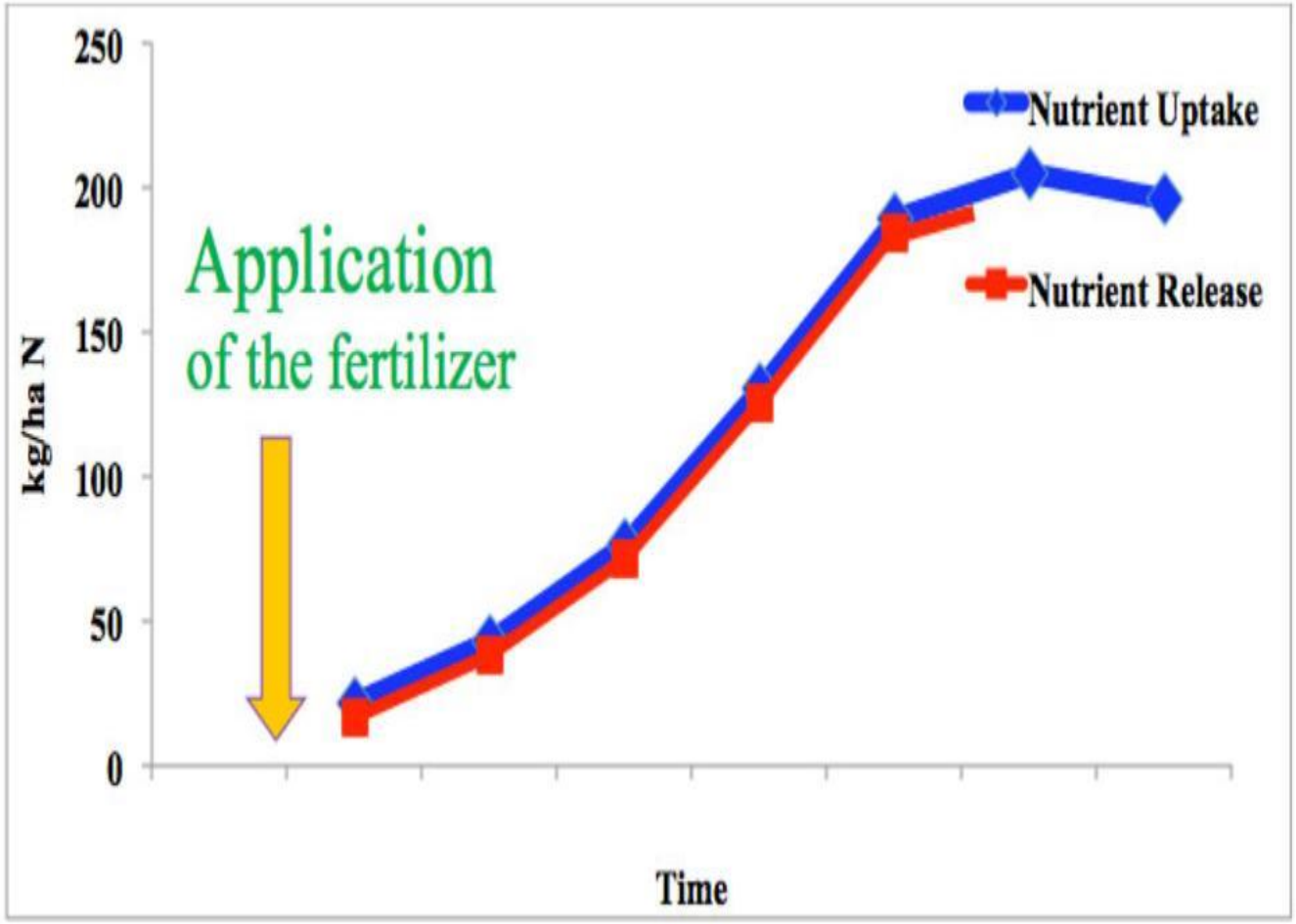
S-shaped N-Uptake Curve



General shape of the N uptake curve for annual crops.

Daniel Geisseler and W.R. Horwath, http://geisseler.ucdavis.edu/Guidelines/N_Uptake.html

Ideal Fertilizers Should Synchronize Nutrients with Crop's Nutrient Needs



The ideal fertilizer: the nutrient release is synchronized with the crop's nutrient requirements.
Credit: Adapted from Lammel 2005

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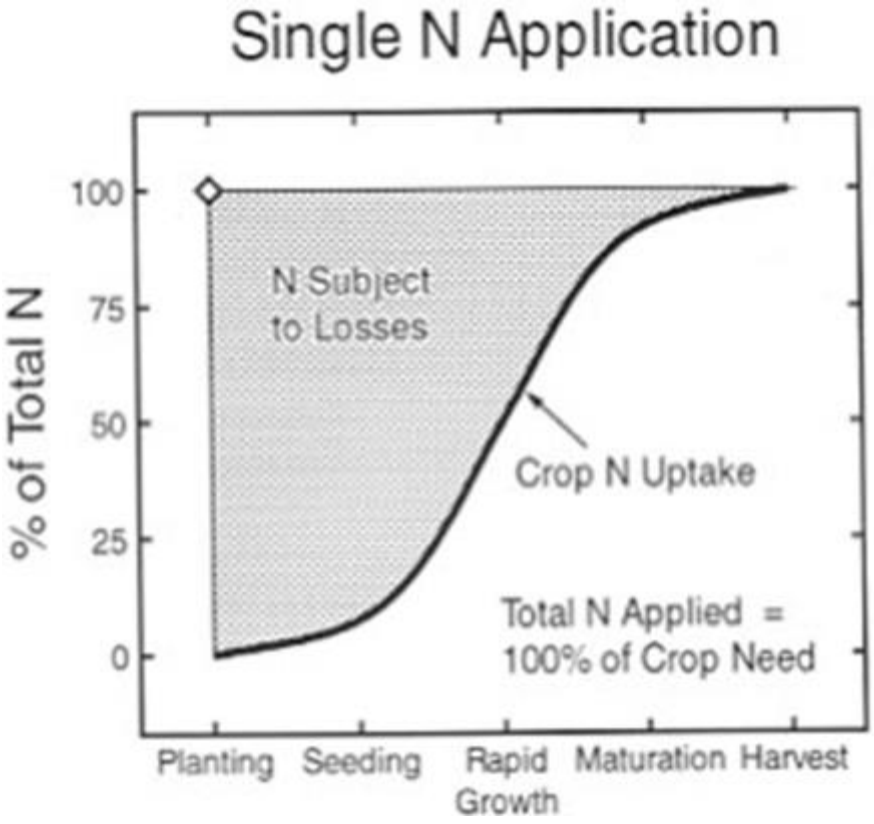
Single N Application vs. N Loss



General estimations of potential N losses occurring when N fertilizer is applied in a single application.
Credit: Waskom, Cardon, and Crookston

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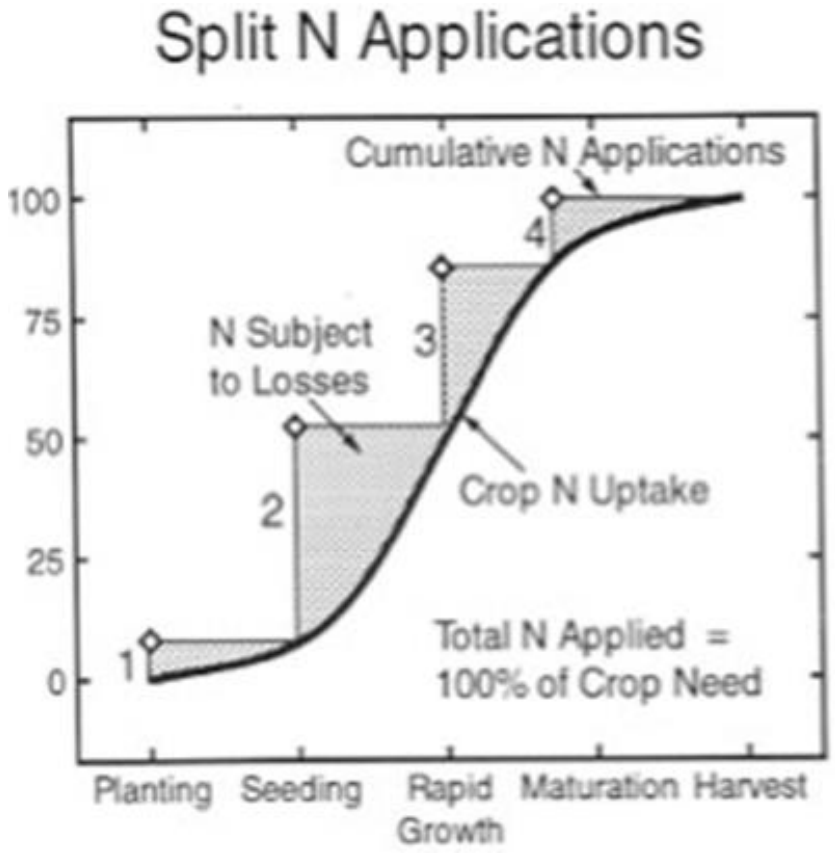
Split N Applications vs. N Loss



General estimations of potential N losses occurring when N fertilizer is applied in split applications.
Credit: Waskom, Cardon, and Crookston

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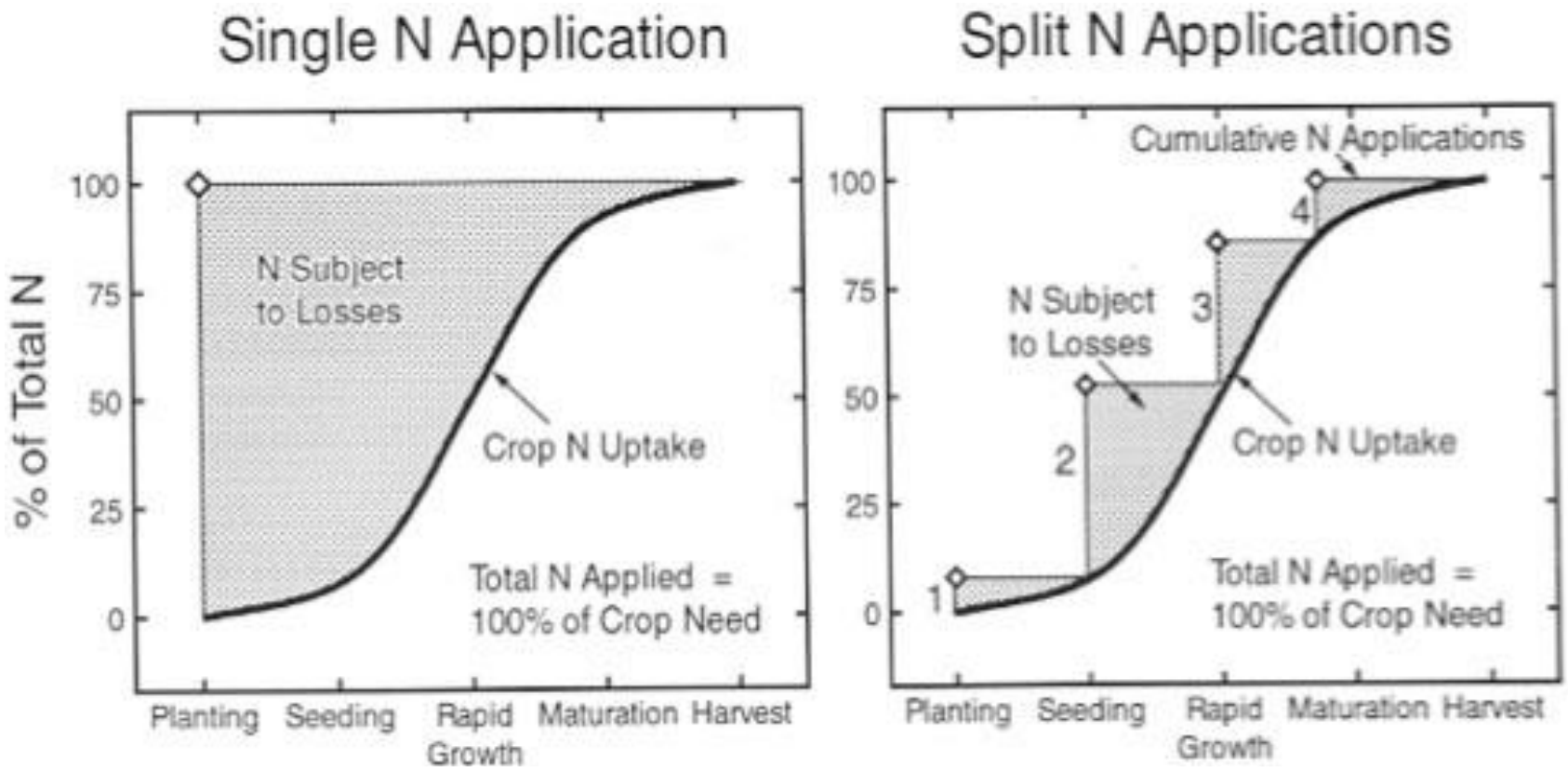
Number of N Applications vs. N Loss



General estimations of potential N losses occurring when N fertilizer is applied in a single application or in split applications.
Credit: Waskom, Cardon, and Crookston

https://edis.ifas.ufl.edu/publication/HS1255

Single P Application vs. P Immobilization

In acidic soil, aluminum, and iron can chemically fix P applied.

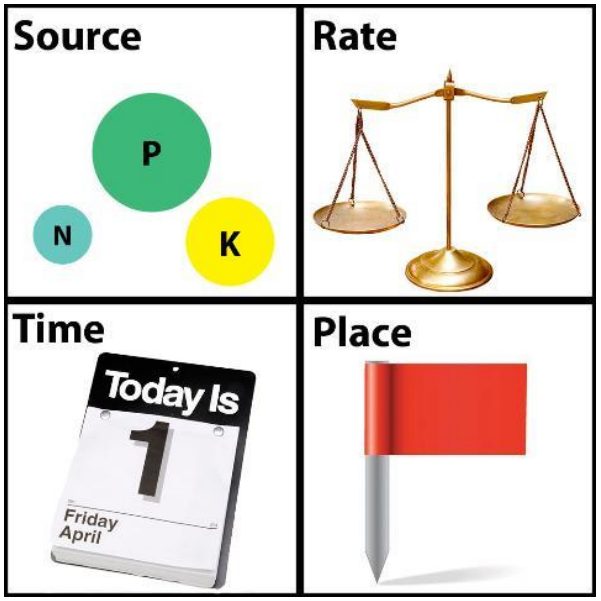
In alkaline soil, calcium and magnesium can tie up P applied.

Single application has to face P fixation and reduces P use efficiency.

How Can We Improve Fertilizer Use Efficiency?

The 4 R's nutrient stewardship is defined as

- *the RIGHT fertilizer source is applied at*
- *the RIGHT rate at*
- *the RIGHT time, and in*
- *the RIGHT place for a crop.*



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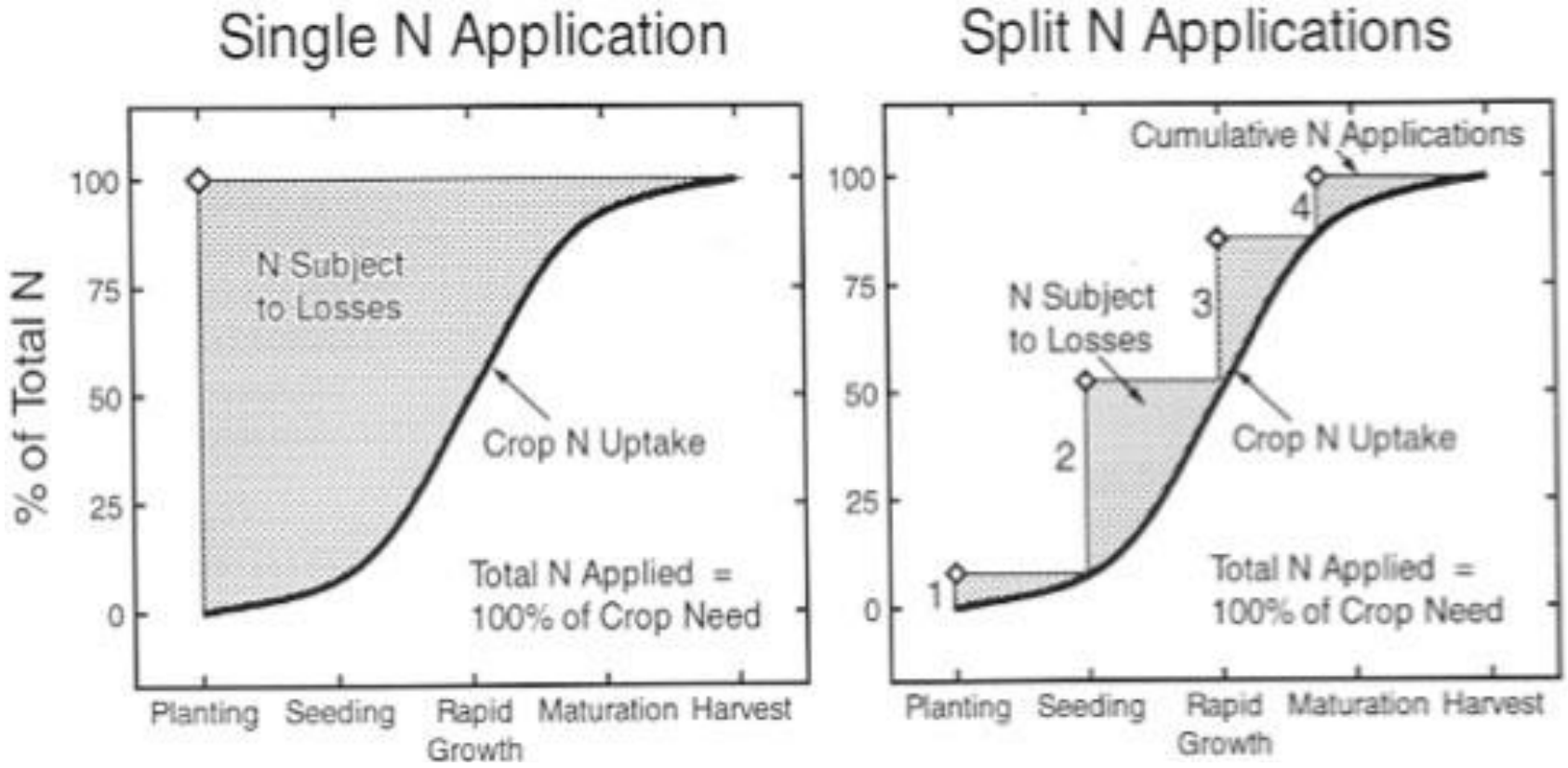
Split Applications Increase Nutrient Use Efficiency



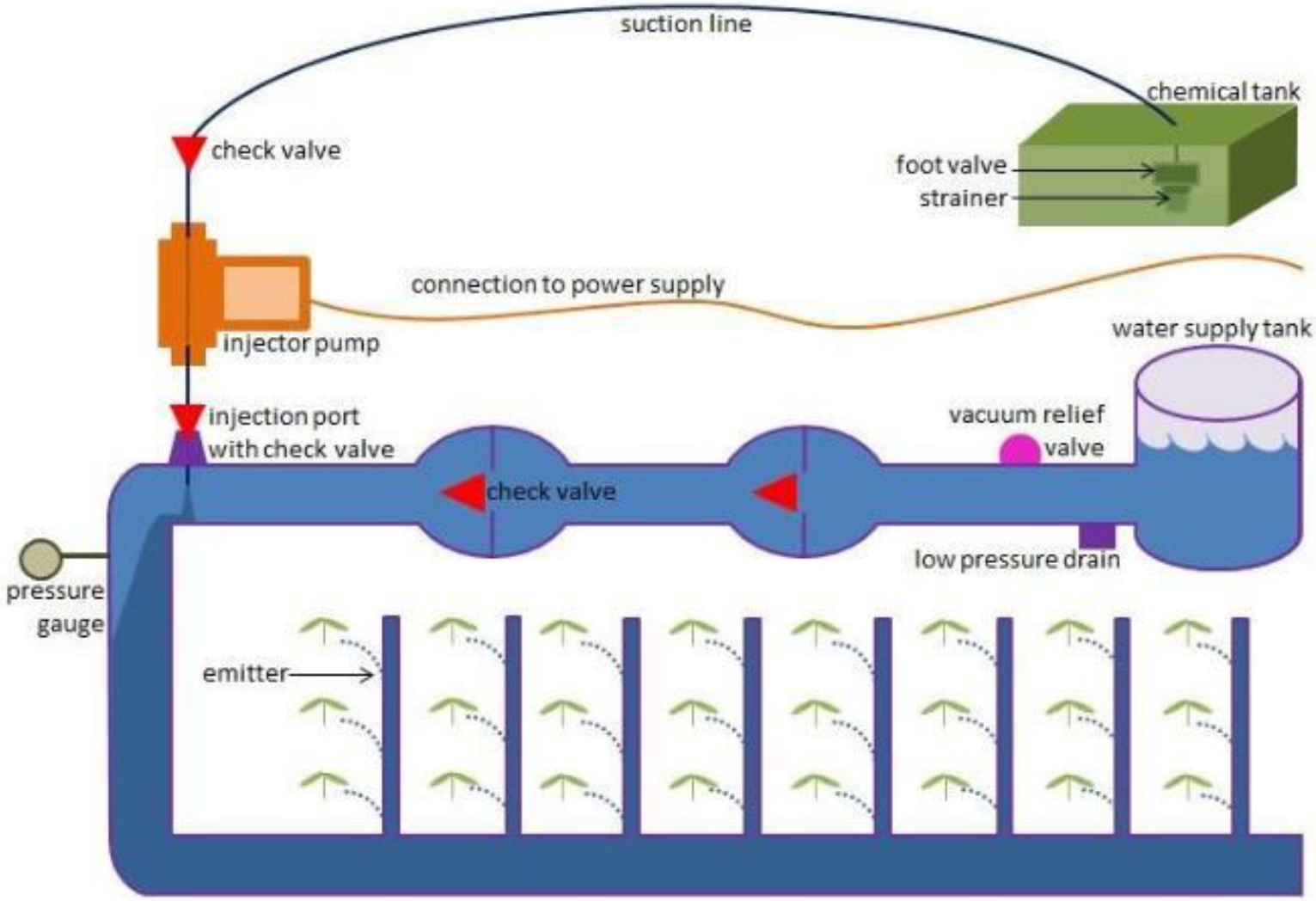
General estimations of potential N losses occurring when N fertilizer is applied in a single application or in split applications.
Credit: Waskom, Cardon, and Crookston

https://edis.ifas.ufl.edu/publication/HS1255

What Is Fertigation?

- **Fertigation** is the process of applying fertilizer to a crop through irrigation.
- A drip, sprinkler, or center pivot irrigation system is needed.

Schematic of Typical Fertigation System



Credit: Mary Dixon and Iain Dixon

https://edis.ifas.ufl.edu/publication/HS1392

Fertigation for Asian Vegetable Production

Fertigation Manifold

In Citra

Fertigation for Watermelon Production

In Live Oak

Fertigation System for Ethnic Vegetable Production

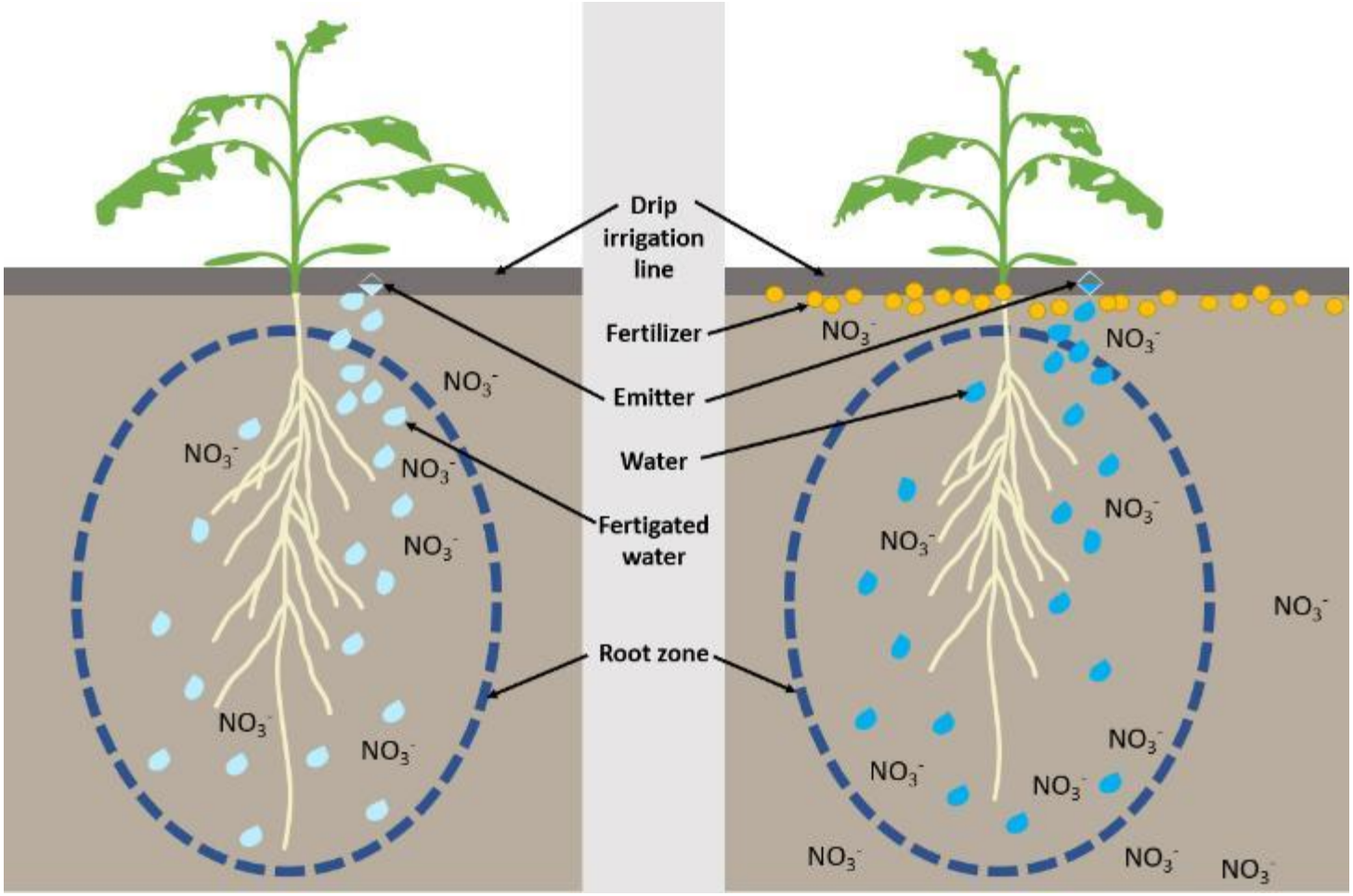
In Elkton

What is Chemigation?

- **Fertigation** and Chemigation are sometimes used interchangeably.
- **Chemigation** is the process of applying a chemical through irrigation.

https://edis.ifas.ufl.edu/publication/WI004

Diagram of Root Zone With Fertigation or Dry Granular Fertilization



Credit: Mary Dixon

https://edis.ifas.ufl.edu/publication/HS1386

Advantages of Fertigation

1. Efficient delivery of nutrients
2. Precise localized application
3. Easy control of application rate and timing
4. Ability to micro dose, feeding plant just enough
5. Reduced leaching of fertilizer into waterbody
6. Greater fertilizer-use efficiency
7. Reduced soil erosion issues
8. Lower application cost

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Disadvantages of Fertigation

1. Only liquid or fully water-soluble fertilizer can be used.
2. It needs to calculate injection rate.
3. If it rains too often, then no irrigation is needed, and it is difficult to fertigate.
4. Emitters/nozzles clogging

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How to Fix Clogging Problems?

Clogged

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Tips to Fix Clogging Problems

- Using clean irrigation water
- Choosing compatible and fully soluble fertilizers
- Acidify irrigation water
- Chlorinate irrigation water
- Three-stage fertigation

1. Starting without fertilizers
2. Applying fertilizer after wetting ground
3. Cleaning the irrigation system

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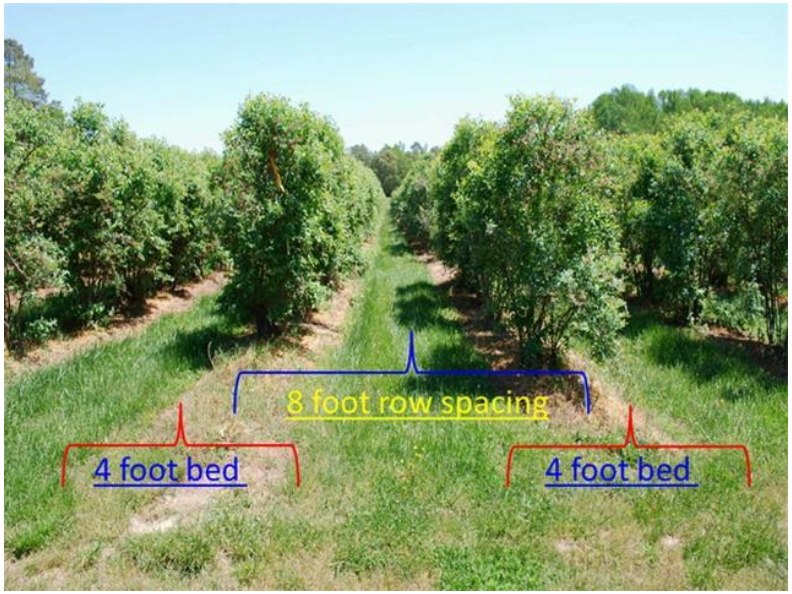
How to Calculate Fertigation Injection Rates?

1. Determine the total amount of N needed for the fertigation event
2. Calculate the total weight of liquid fertilizer needed for fertigation
3. Calculate the number of gallons of liquid N fertilizer
4. Calculate the dilution factor
5. Calculate the injection rate
6. Calculate the injection time



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Practical Example of Fertigation in Drip Irrigation

- **N source:** UAN-32 (32% N, 11.05 lbs/gal N)
- **N rate:** 5 lbs/A N
- **Acreage:** 5 acres--blueberry field
- **Irrigation rate:** 1000gal/min
- **Target N concentration:** 150 ppm
- **To calculate:** Injection rate and time

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Calculations

1. Total N: 5 lb/acre N × 5 acres = 25 lb N
2. Amount of UAN-32: 25 lb N ÷ 0.32 = 78.1 lb UAN-32
3. Volume of UAN-32: 78.1 lb ÷ 11.05 lb/gal = 7.0 gal
4. Dilution factor: 0.32 × 1,000,000 ppm ÷ 150 ppm = 2,133.3
5. Injection rate: 1000 gal/min ÷ 2,133.3 = 0.47 gal/min
6. Injection time: 7.0 gal ÷ 0.47 gal/min = 15 min

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Fertigation Recommendations

Tomato	**Preplant**	**Injected**				
	(lb/A)	**(lb/A/D)**				
Week after transplanting		1-2	3–4	5–11	12	13
N	0–70	1.5	2	2.5	2	1.5
K_2O	0–70	1.5	2	2.5	2	1.5

https://edis.ifas.ufl.edu/publication/CV296

How To Fertigate Potato Vines Via Center Pivots?

What Is Needed?

- An overhead irrigation system
- An injector

When Should Fertigation Start?

- Traditional fertilization practices: 3 applications of dry granular fertilizers

1. Preplant
2. Emergence
3. Tuber initiation

- Fertigation: 4 weekly applications of liquid or fully water-soluble fertilizers, starting from before tuber initiation

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What Is The Fertigation Rate?

Fertigation starting in tuber initiation stage

- 20% to 35% total N and K_2O in 4 to 5 events
- 10 to lb/A per event
- Liquid fertilizer: 8-0-8

Before fertigating potato vines using dry granular fertilizers:

- Preplant: 20% to 25% total N and K_2O
- At emergence: 40% to 55%

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How Is The Fertilizer Concentration in The Irrigation System Calculated (I)?

- **Center pivot size:** 40 acres
- **Irrigation rate:** 600 gal/min
- **Pivot running speed:** 6 or more hours/circle
- **Fertigation N rate:** 10 lb/acre/event
- **Injection rate:** 55 GPH
- **Liquid N fertilizer source:** 8-0-8
- **N content per gallon:** 0.807 lb.

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How Is The Fertilizer Concentration in The Irrigation System Calculated (II)?

- **Total N needed:** 10 lb/acre × 40 acre = 400 lbs
- **N delivered:** 55 GPH × 0.807 lb/gal = 44.385 lb/hr
- **Time of fertigation:** 400 lb ÷ 44.385 lb/hr = 9.0 hrs
- **Total water volume:** 600 gal/min × 9 hrs × 60 min/hr = 324,000 gal
- **N concentration :** 400 lb ÷ 324,000 gal × 16 oz/lb = 0.02 (oz/gal)
- **Conversion factor:** 1 oz/gal = 6,236 ppm
- **N concentration:** 0.02 × 6,236 = 123 ppm

https://edis.ifas.ufl.edu/publication/HS1200

Fertigation for Potato Production

Fertigation N distribution in different stages

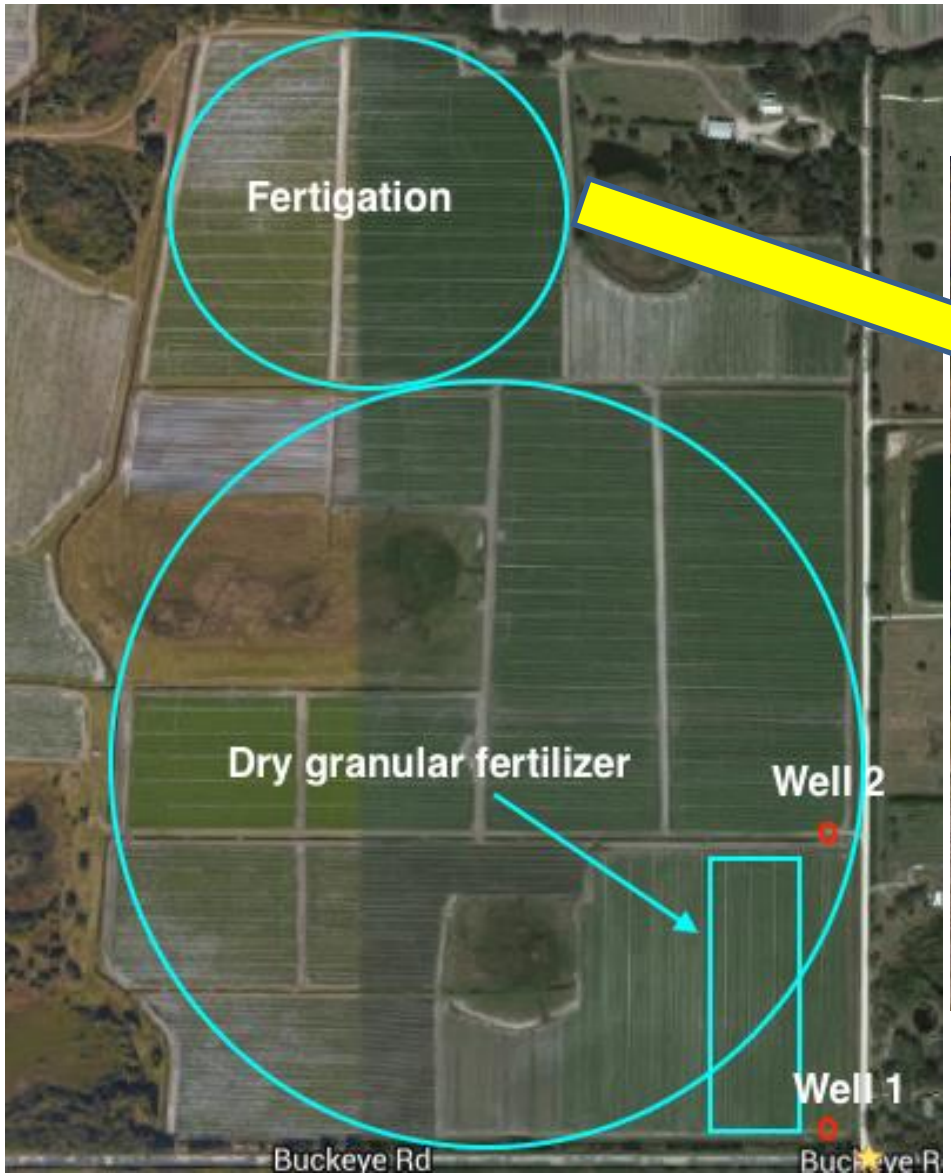
- ***Dry granular fertilization only:***

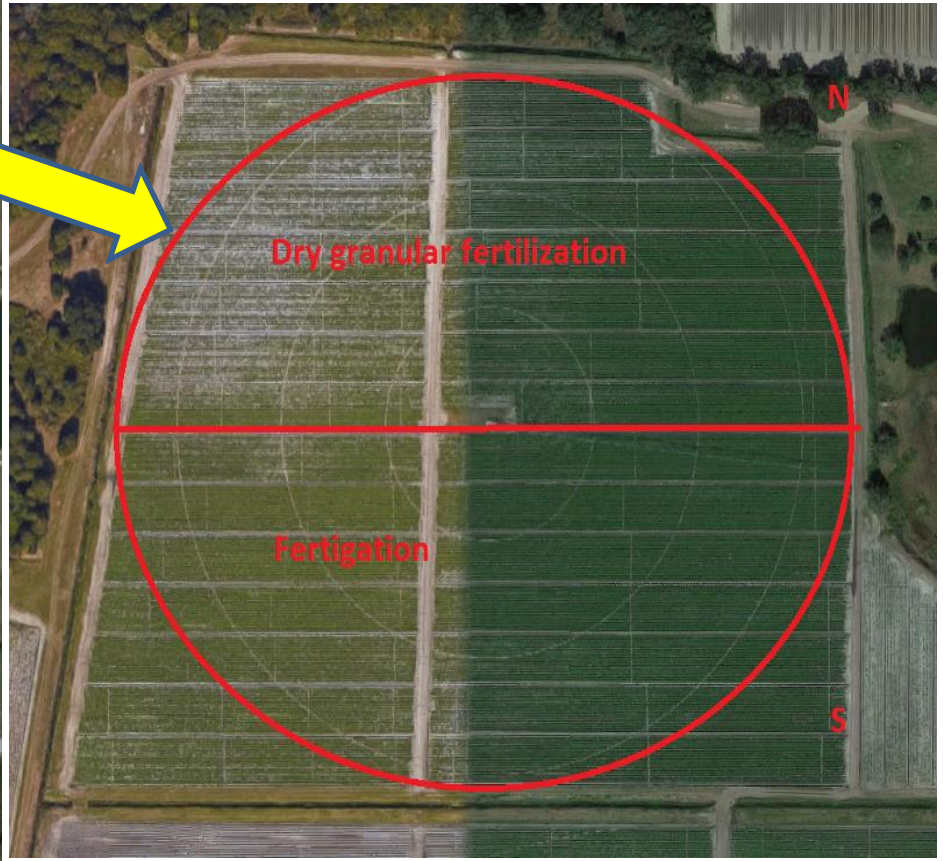
1. 25% pre-plant
2. 50% at emergence
3. 25% at tuber initiation

- ***Fertigation (dry fertilization + fertigation)***

1. 25% pre-plant
2. 50% at emergence
3. 25% at tuber initiation—4 weeks after emergency—5 events: fertigation/week

Fertigation from 2016-2019





Credit: Alan Jones

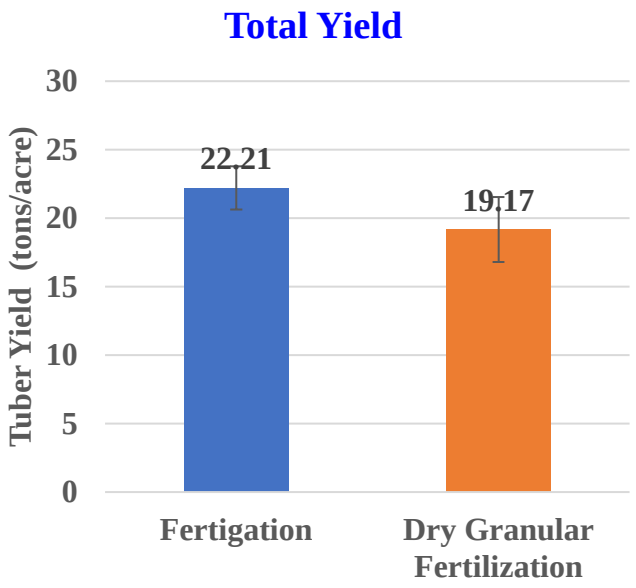
Fertigation

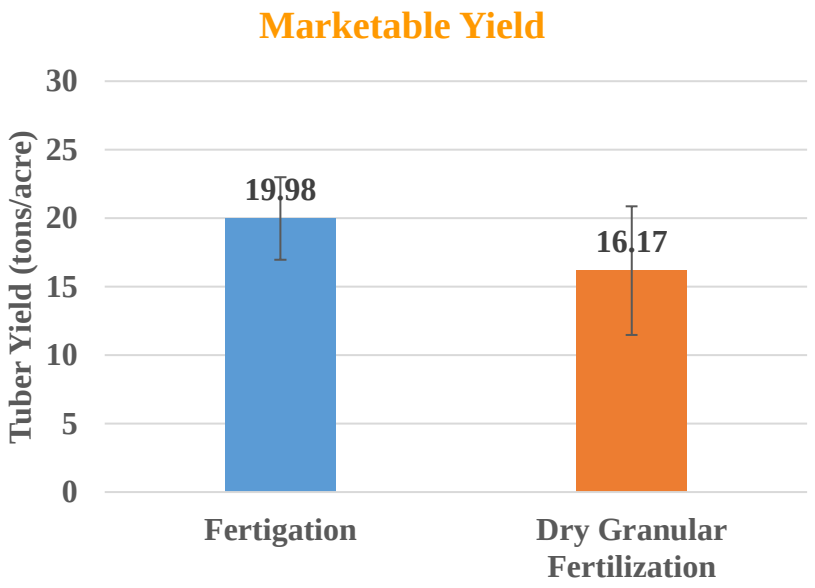
Dry granular fertilization

Tuber Yield

‘Atlantic’, 2015-2016

Fertigation and granular fertilization used the same amount of NPK

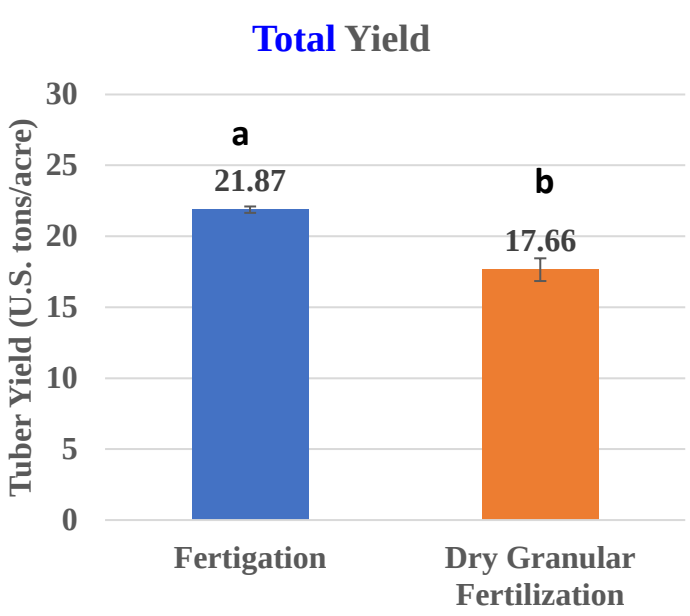


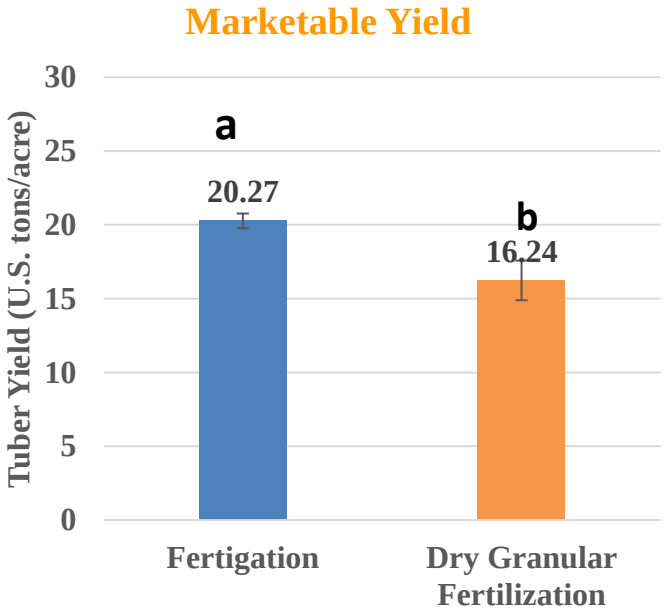


Yield increase: 116% 100% 124% 100%

‘Red LaSoda’, 2016-2017

Fertigation and granular fertilization used the same amount of NPK

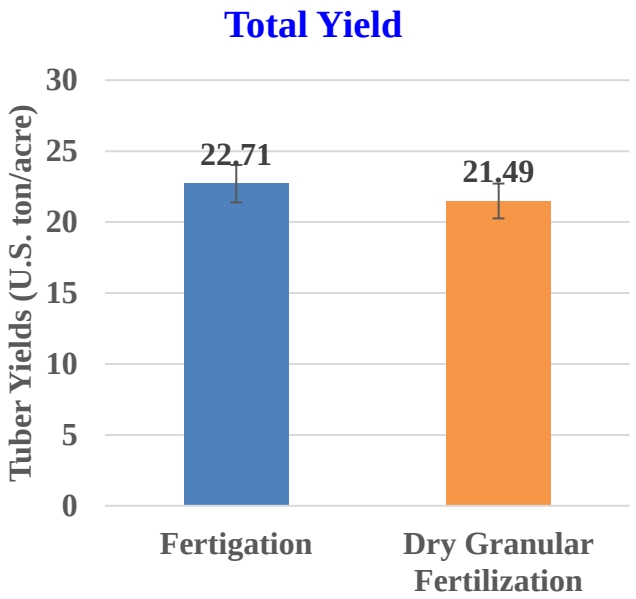


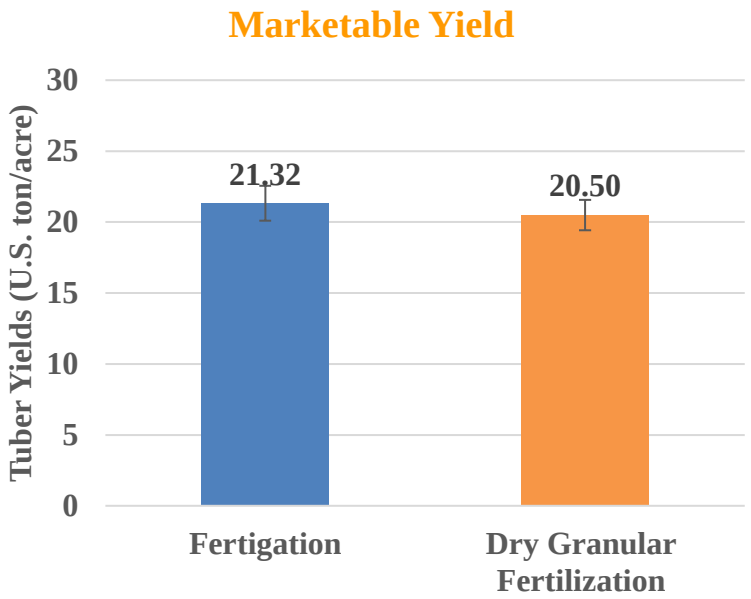


Yield increase: 124% 100% 125% 100%

‘Algeria’, 2017-2018

Fertigation used 70% N of that the control used





Yield increase: 106% 100% 104% 100%

External Quality

Growing Season And Cultivar	Treatment	External Quality Issues (% of total tuber yield)				
		Green Skin	Growth Cracks	Misshapen	Rotten & misc.	Total Culls
Season 1 ‘Atlantic’	Fertigation	0.68	0.14	0.86	0.27	1.95
	Dry Granular Fertilization	1.51	1.10	1.25	0.83	4.69
Season 2 ‘Red LaSoda’	Fertigation	1.2	1.2	0.2	0.1	2.7
	Dry Granular Fertilization	1.5	0.3	0.9	0.4	3.1
Season 3 ‘Algeria’	Fertigation	0.35	0.00	1.69	0.59	2.62
	Dry Granular Fertilization	0.33	0.00	0.47	0.76	1.56

Internal Quality

Growing Season And Cultivar	Treatment	Internal Quality Issues (% of total tubers)				
		Hollow Heart	Brown Center	Corky Ring Spot	Internal Heart Necrosis	Total
Season 1 ‘Atlantic’	Fertigation	2.5	0	0	0	2.5
	Dry Granular Fertilization	1.25	0	0	0	1.25
Season 2 ‘Red LaSoda’	Fertigation	1.25	1.25	1.25	0	3.75
	Dry Granular Fertilization	3.75	1.25	0	0	5.00
Season 3 ‘Algeria’	Fertigation	0	0	0	0	0
	Dry Granular Fertilization	0	0	0	0	0

Average Specific Gravity

Growing Season and Cultivar	Treatment	Specific Gravity
Season 1 ‘Atlantic’	Fertigation	1.077
	Dry Granular Fertilization	1.071
Season 2 ‘Red LaSoda’	Fertigation	1.060
	Dry Granular Fertilization	1.066
Season 3 ‘Algeria’	Fertigation	1.070
	Dry Granular Fertilization	1.072

Summary of Fertigation Study

Fertigation produced more tubers even with less fertilizer applied:

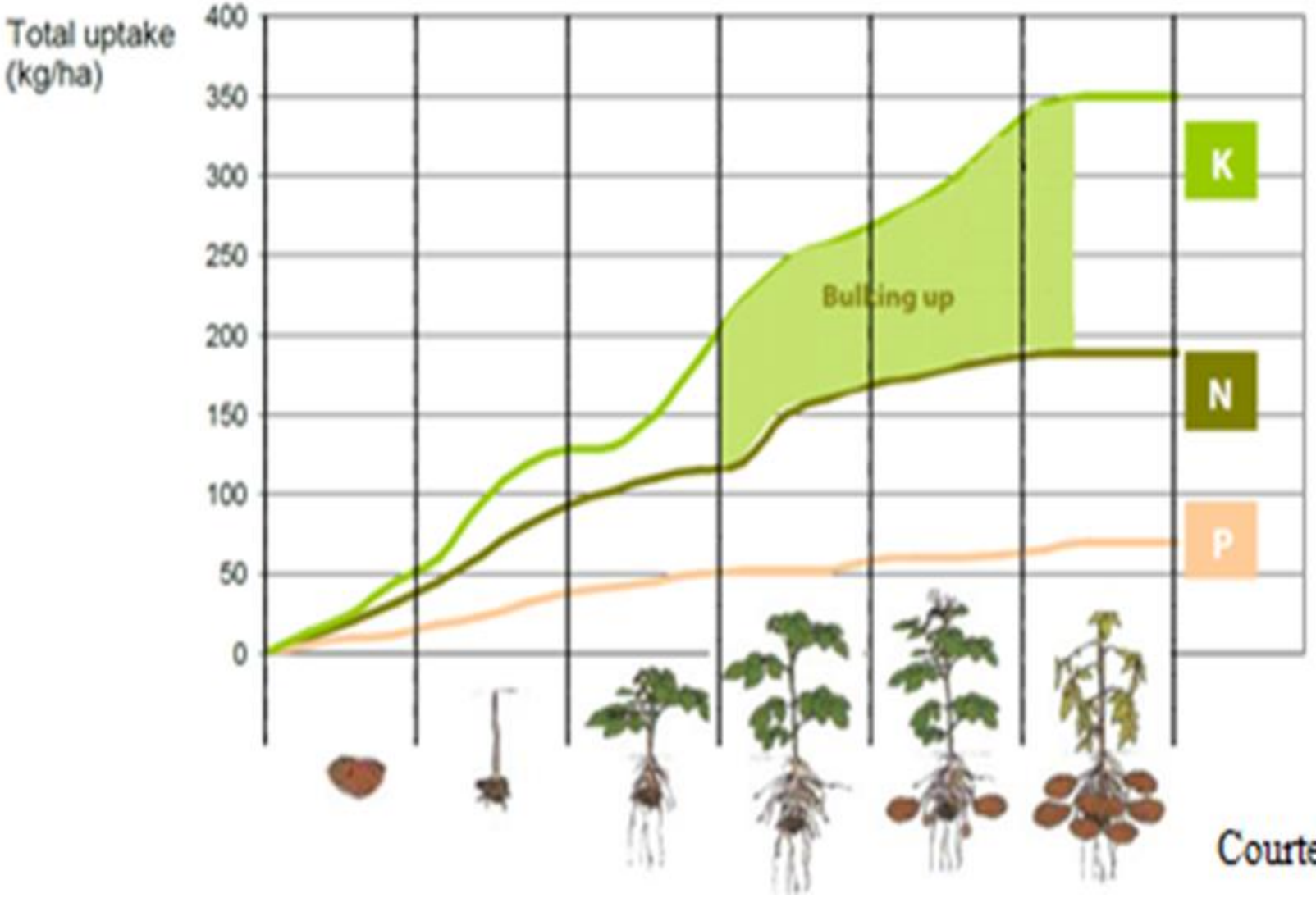
Yield:	Total	Marketable
2015-2016:	16%	24%
2016-2017:	24%	25%
2017-2018:	6% (70% N)	4%

Fertigation saves water and nutrients.

Increased yield also indicated that fertigation had greater water use efficiency than dry fertilization.

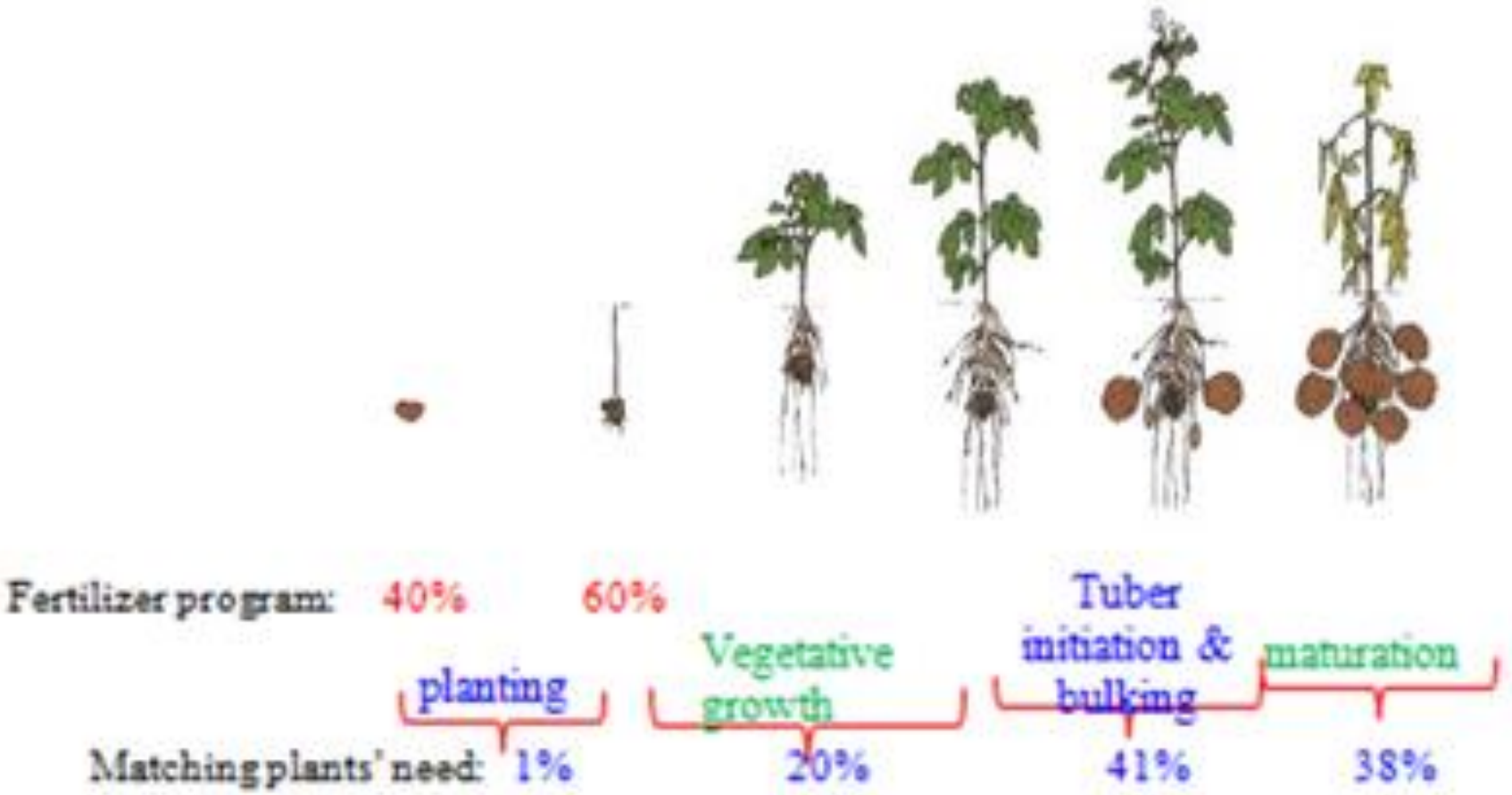
Why can fertigation improve fertilizer use efficiency?

Uptake of NPK by Potato Vines



Courtesy of Haifa

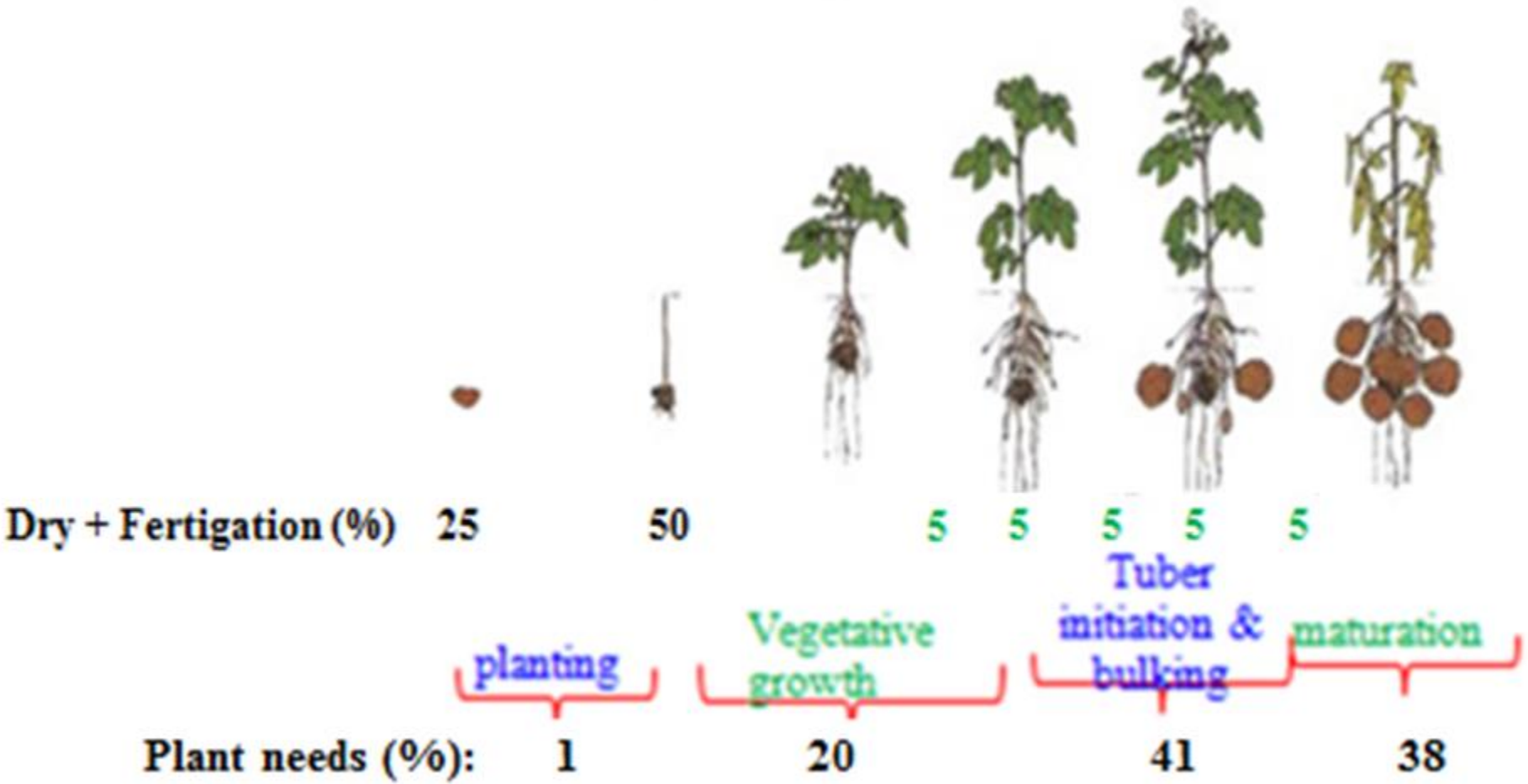
Dry Fertilizer Program



Courtesy of Haifa

Fertigation Program:

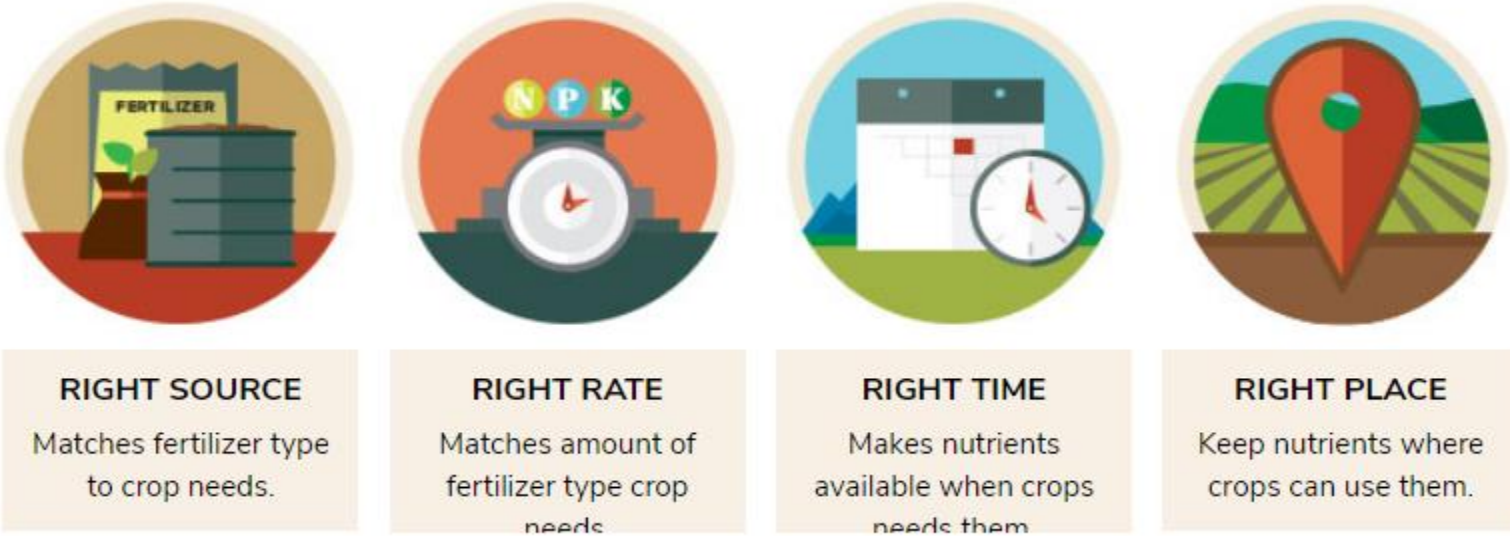
Synchronizing N Supply and N Demand



4R Nutrient Stewardship

The 4R concept incorporates the:

- **Right fertilizer source** at the
- **Right rate**, at the
- **Right time** and in the
- **Right place**



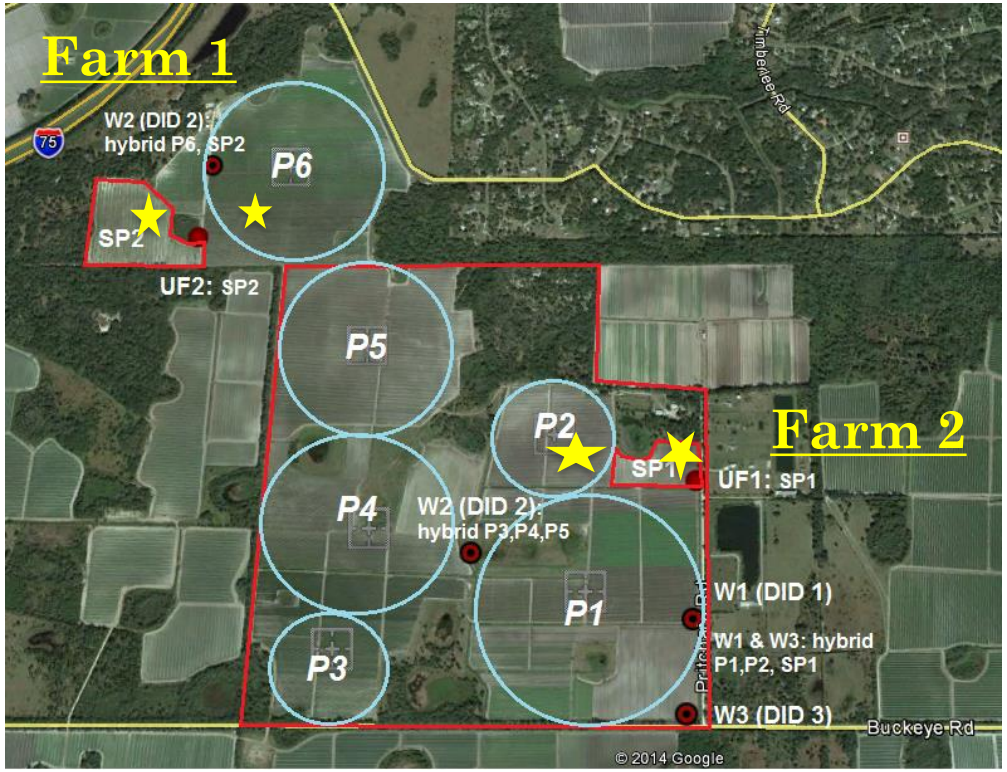
Fertigation Also Saves Water

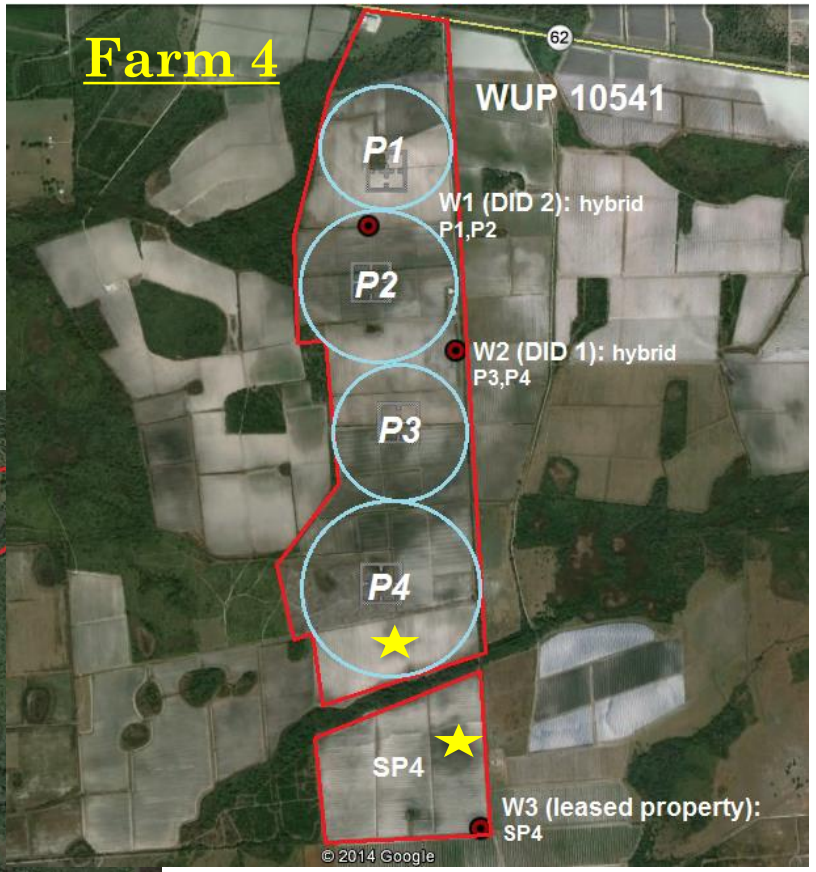
Flow meters

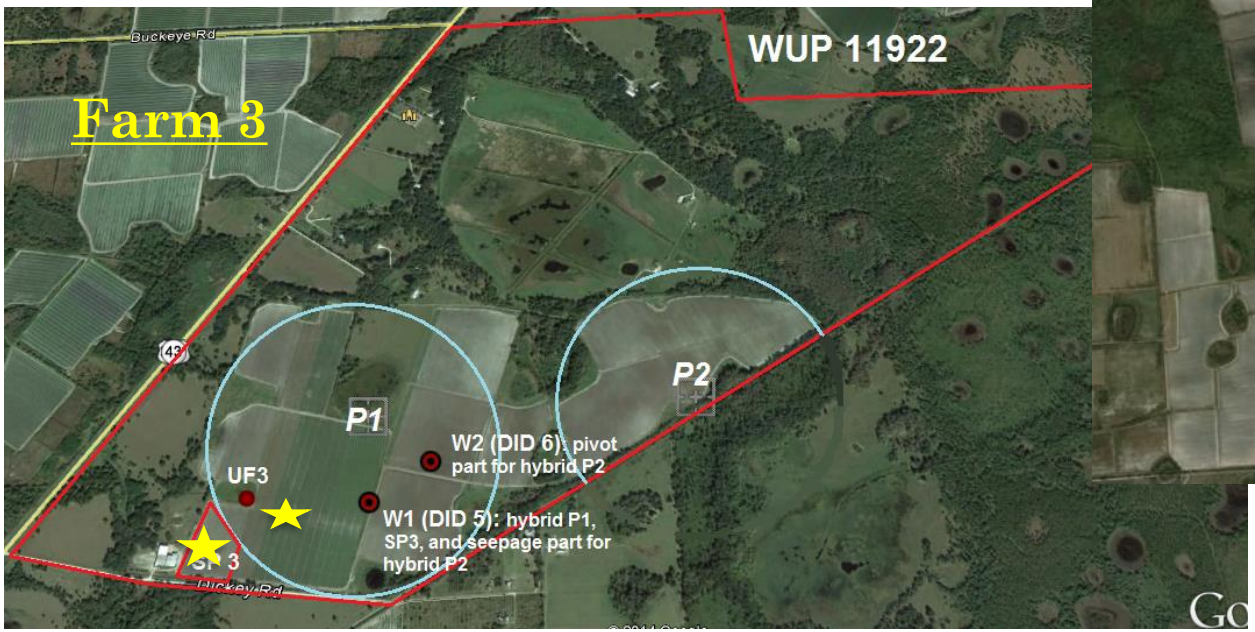
Seepage (SP) *vs.* Center Pivot (CP)

Water table indicator

4 Commercial Farms

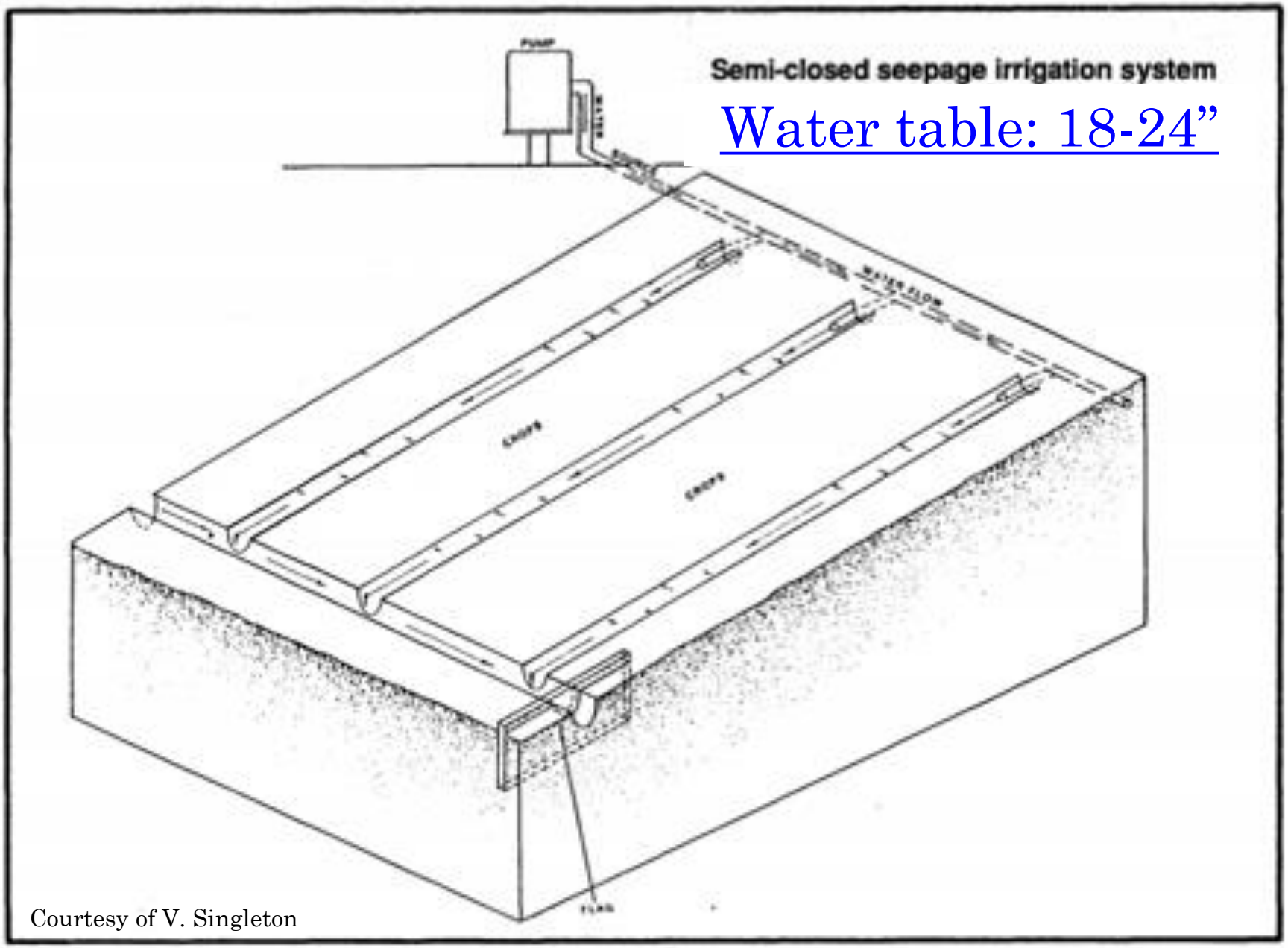






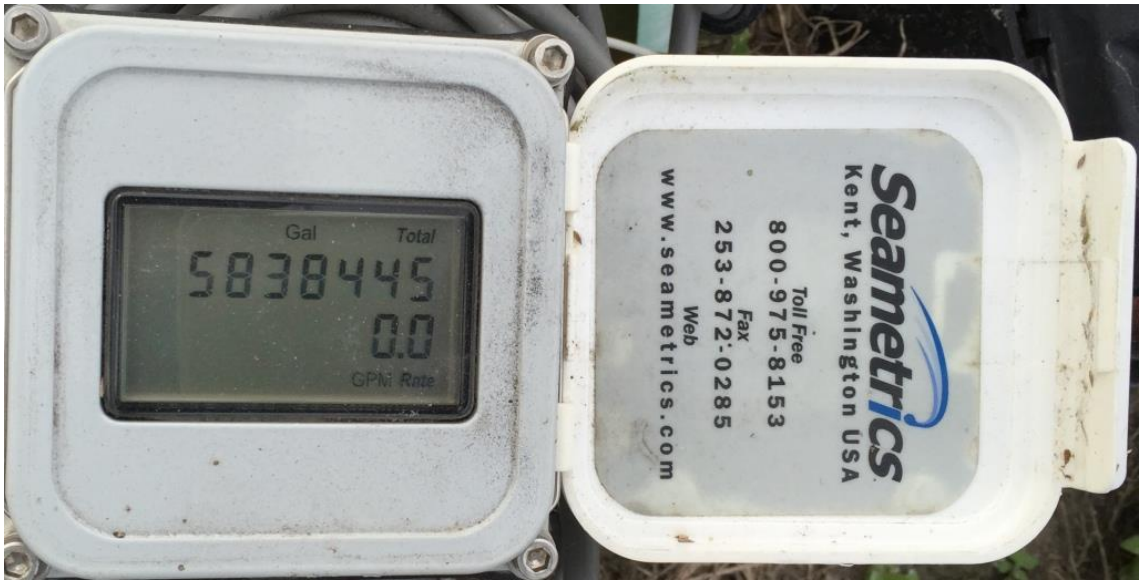
Credit: Alan Jones

Seepage: *20” (12.0~29.6”) water*

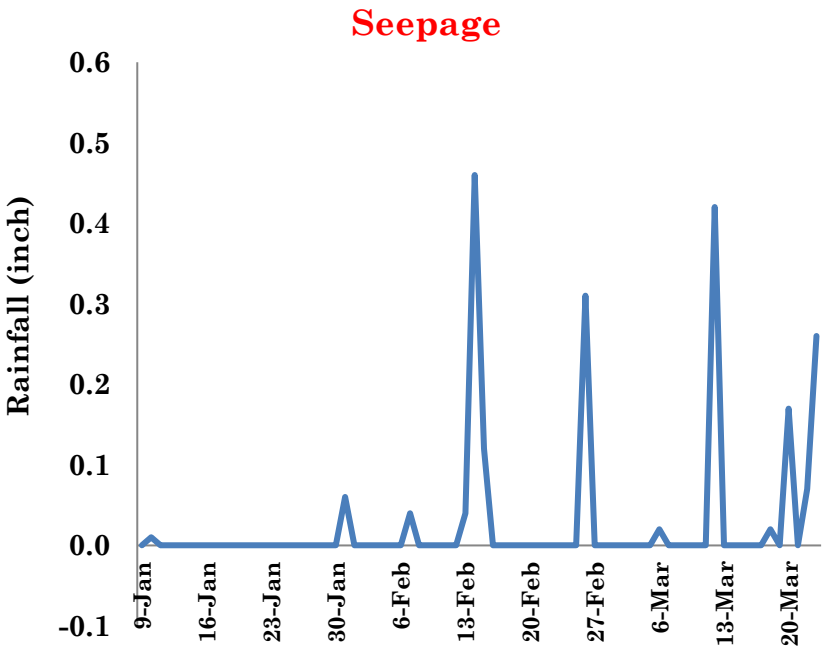


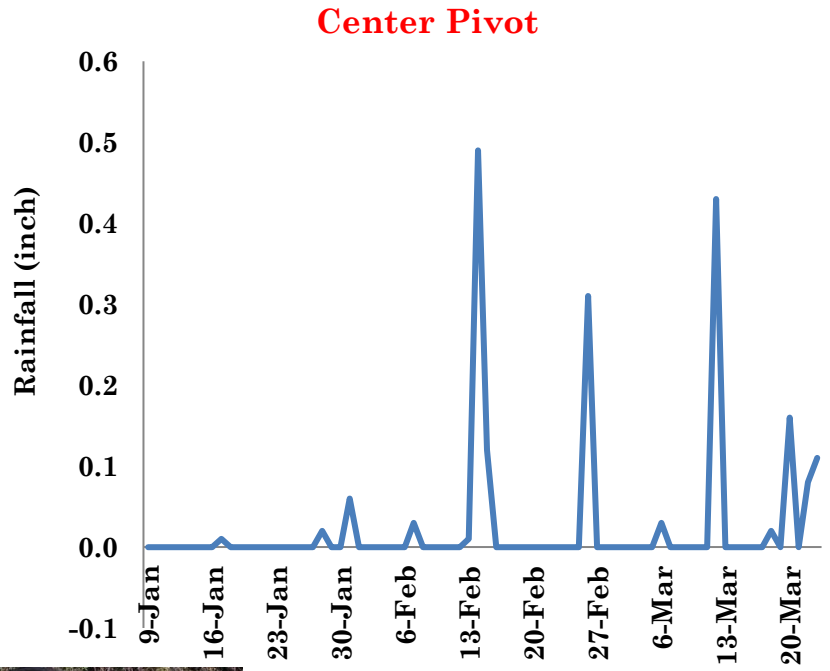
Water usage


0
100
200
300
400
500
600
700
800
900
GALLONS
WATER SPECIALTIES
McCROMETER, INC.
HEMET, CA
POLY-2

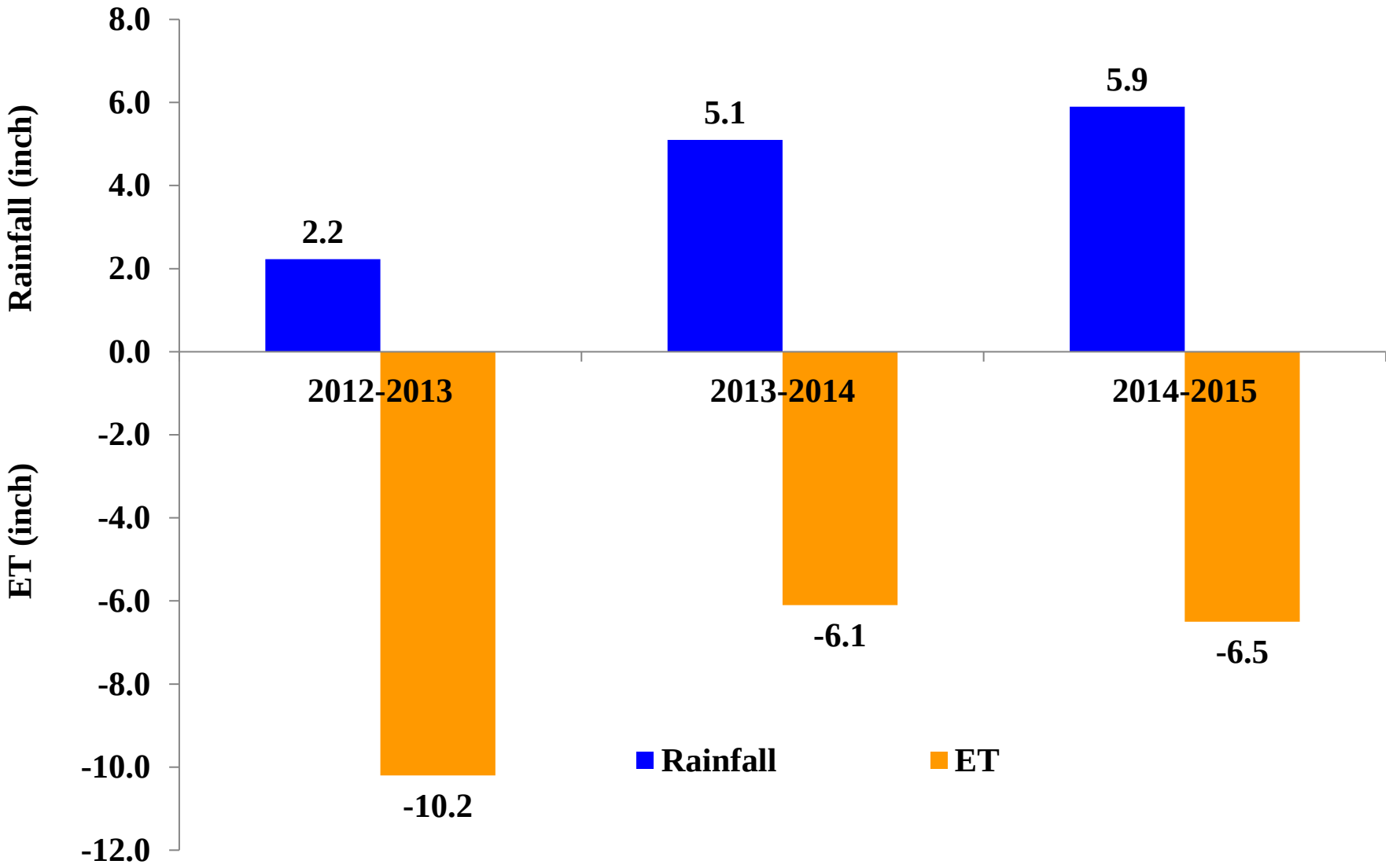

Gal
Total
5838445
0.0
GPM Rate
Seametrics
Kent, Washington USA
Toll Free
800-975-8153
Fax
253-872-0285
Web
www.seametrics.com

Rainfall

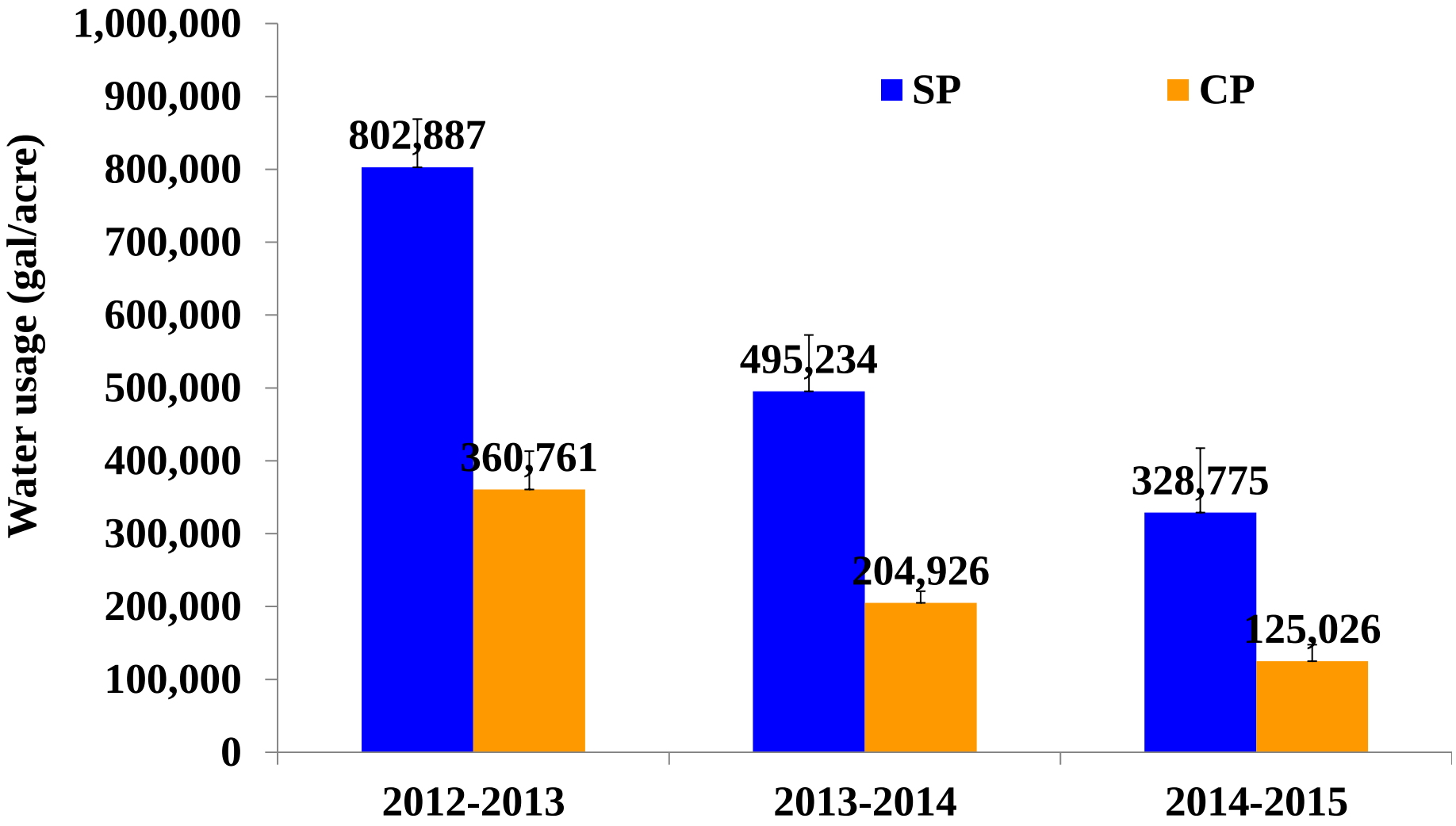

Seepage
Rainfall (inch)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
9-Jan
16-Jan
23-Jan
30-Jan
6-Feb
13-Feb
20-Feb
27-Feb
6-Mar
13-Mar
20-Mar


Center Pivot
Rainfall (inch)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
9-Jan
16-Jan
23-Jan
30-Jan
6-Feb
13-Feb
20-Feb
27-Feb
6-Mar
13-Mar
20-Mar

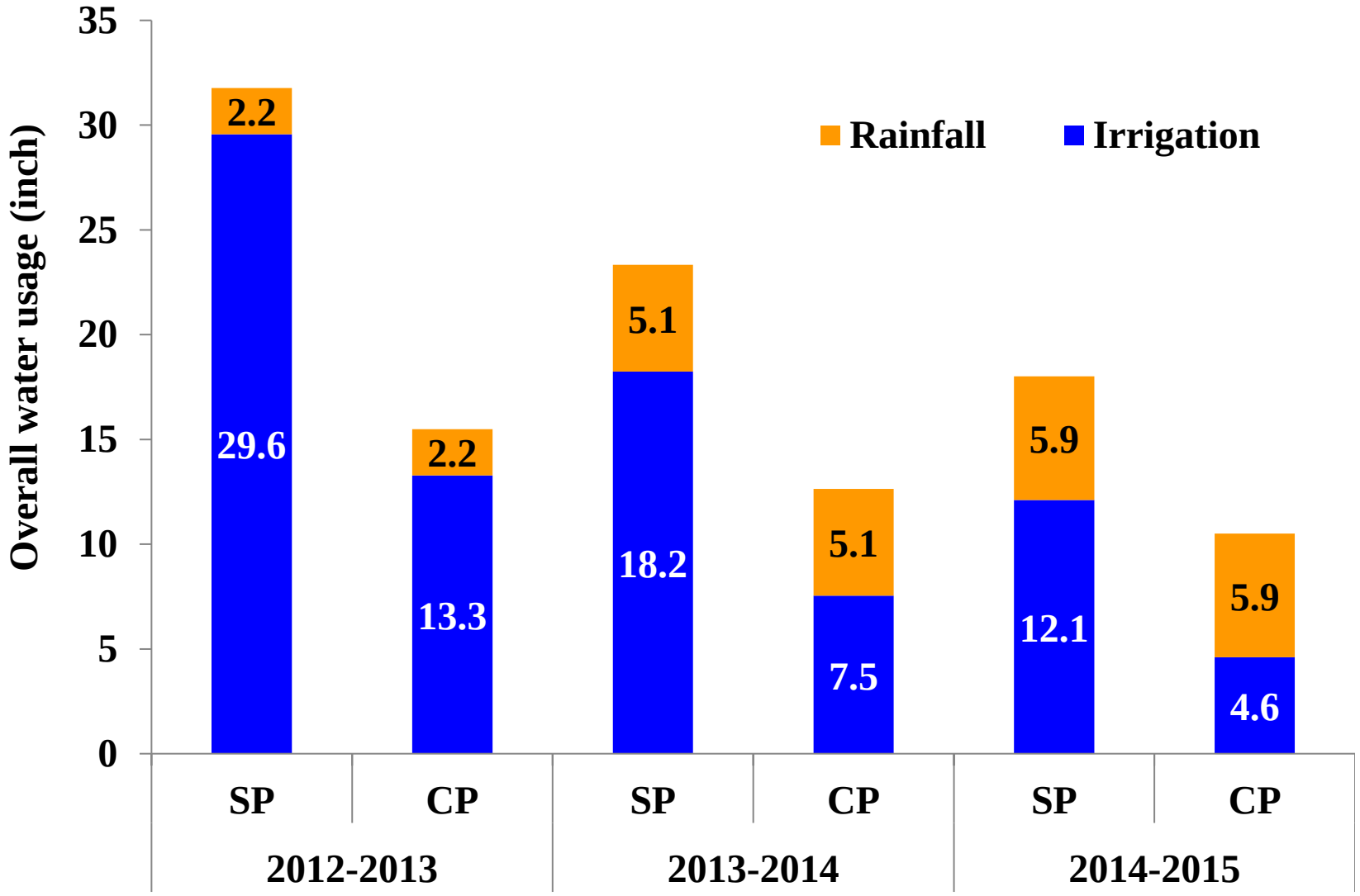
Rainfall and Evapotranspiration (ET)



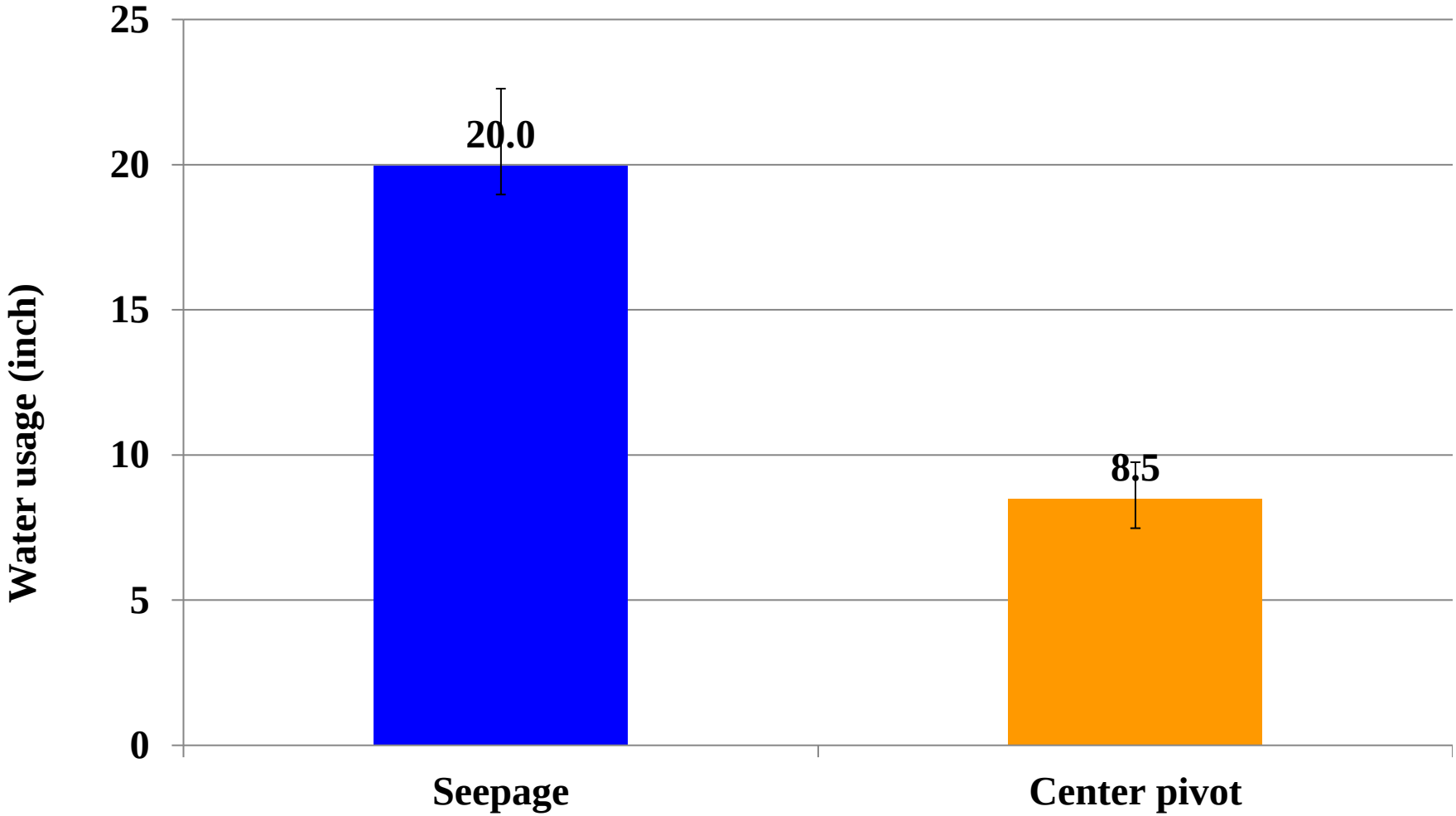
Irrigation Water Usage



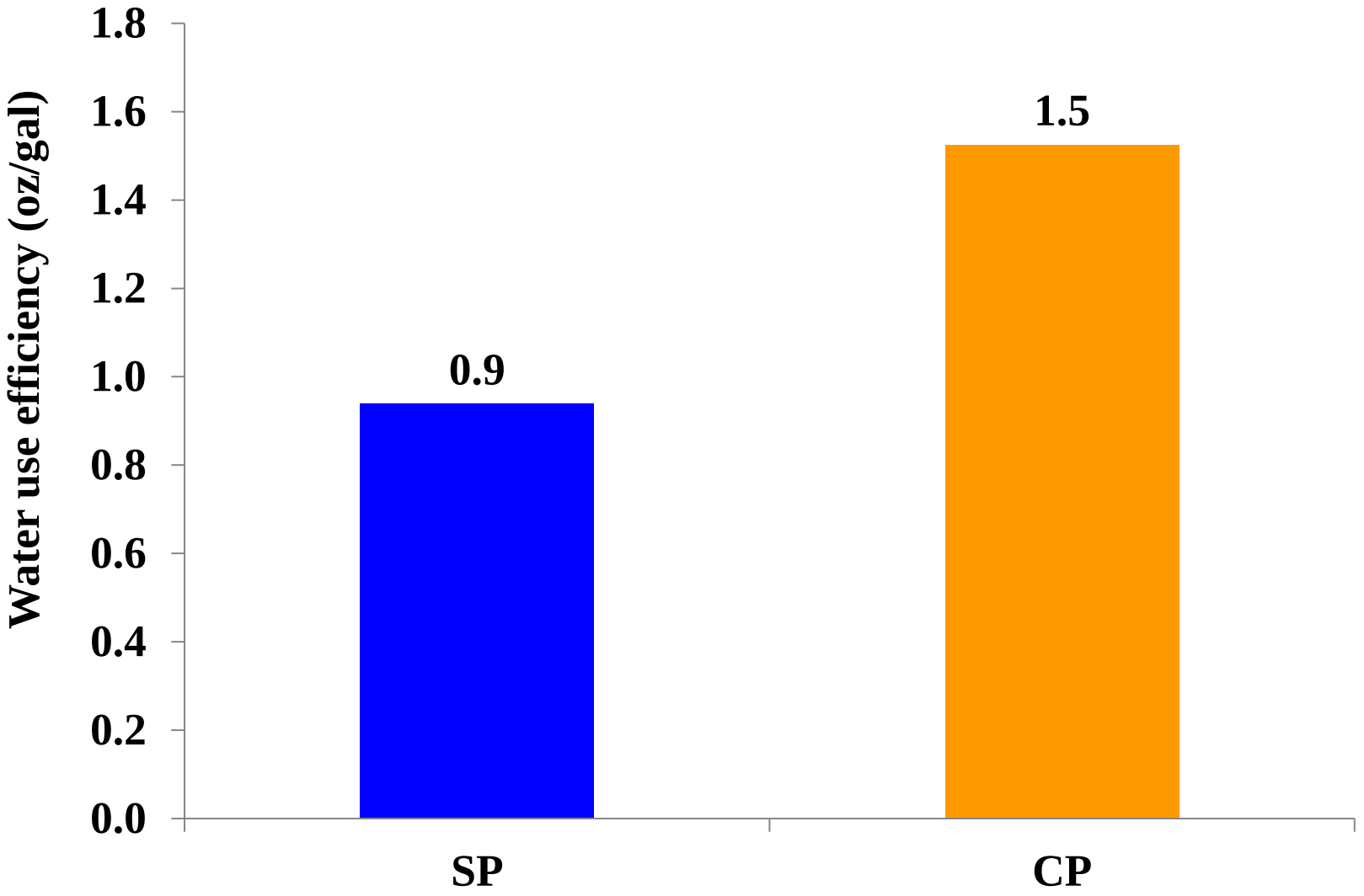
Overall Water Usage



Average Water Usage



Water Use Efficiency



Water Savings

$$WS(\%) = \frac{WU_{SP} - WU_{CP}}{WU_{SP}} \times 100$$

Water Savings on the Farms:
3.23 billion gal since 2012!

Year	Acreage	Total water savings Gallons
Season 1	890	393,492,331
Season 2	1282	372,175,341
Season 3	1002	204,156,117
Total	**3174**	**969,823,789**

Conclusions

Fertigation can

- Provide nutrients at the right rate, at the right time, and in the right place, therefore
- Synchronize nutrients with crop needs
- Increase tuber yield by 15%-25%
- Save irrigation water by 58%

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Thank You!

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