Optimizing N application rates while minimizing the risk of yield losses

Daniel Geisseler
Post-Doctoral Scientist, UC Davis

FREP Conference, Oct. 30, 2014

Overview

- Background
- Optimizing N management step by step
- Implementation in the field

Why adjust N application rate?

- Nitrate in groundwater ⇨ Regulations
- Increase profit by reducing fertilizer costs
- Changed crop management (e.g. irrigation system)

- Yield increase

Why may growers be reluctant to adjust N rate?

- The current nutrient management program works
- High value crops
  - Optimum yield close to maximum yield
  - Major economic consequences when yield is lowered

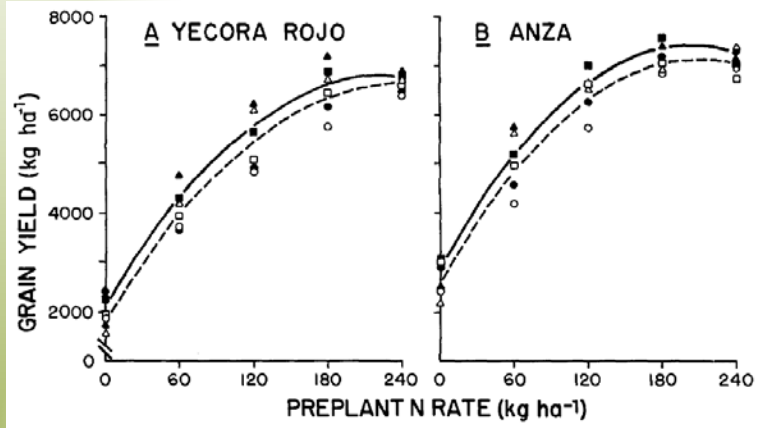
⇨ From an economic point of view, it often makes sense for a grower to add a bit too much N

Step by step optimization

1. Determine optimal N rate based on current research data

Research approaches to determine optimal N rate

N rate trials



Site-specific adjustments when different from research sites:

- Residual soil nitrate
- N in irrigation water
- N mineralization
- Nitrogen use efficiency

N removed at harvest

Crop	N removed (lbs/acre) per 1000 lbs yield
Almonds	68
Pistachio	28
Walnuts	20
Grapevines	1-2

Site-specific data needed to determine N application rate:

- **Nitrogen use efficiency**
- N in irrigation water
- Residual soil nitrate
- N mineralization

Resources: Fertilization guidelines

http://apps.cdfa.ca.gov/frep/docs/guidelines.html

CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE
INSPECTION SERVICES DIVISION

CDFA Home | Inspection Home | Programs | Apply/Register | Laws & Regs | Meetings | Contact Us

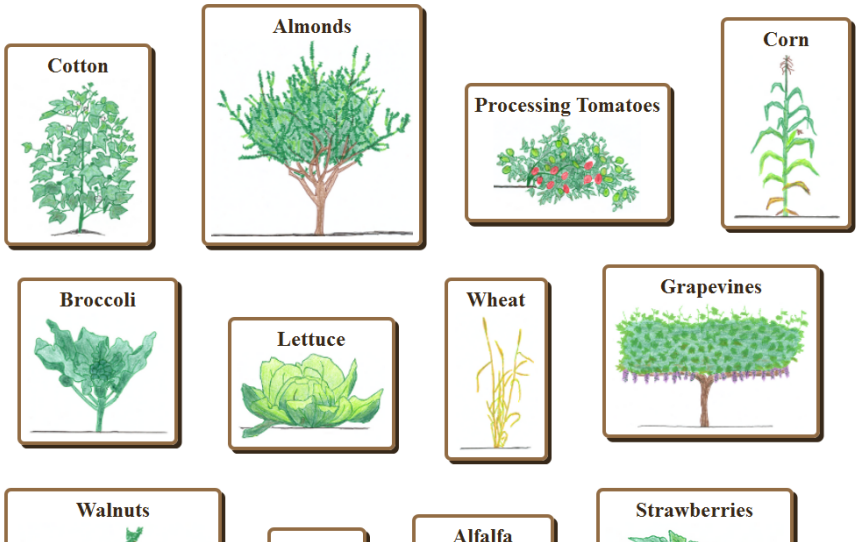
Laws & Regs

CDFA Home > Inspection Services > FFLDRS > FREP > Fertilization Guidelines

Fertilization Guidelines for Major Crops Grown in California

These guidelines are based on research results from studies carried out in California and elsewhere. For an optimal fertilization program, site-specific information on soil type, climate and crop management need also to be take in into account.

After choosing a crop from the list below, detailed information can be accessed by moving the mouse over any shape with the symbol ⓘ.



Developed in collaboration by

cdfa
FERTILIZER RESEARCH AND EDUCATION PROGRAM FREP
UC DAVIS UNIVERSITY OF CALIFORNIA
Department of LAND, AIR AND WATER RESOURCES

Soil and Plant Tissue Sampling

- Soil Test Sampling Instructions
- Sampling for Soil Nitrate Determination
- Soil Sampling in Orchards
- Plant Tissue Sampling

Additional Resources, Links

- Organized by Topic
- Organized by Source

New! Nitrogen Partitioning and Seasonal Uptake Curves

Resources: Fertilization guidelines

Crop-specific guidelines

Processing Tomatoes Fertilization Guidelines

Funding provided by:

FERTILIZER RESEARCH AND EDUCATION PROGRAM FREP

Preplant | Sowing / Transplanting | Vegetative Growth | Bloom | Early Fruit Set | First Red Fruits

Nitrogen (N)

Soil Test | Leaf Analysis

Preplant N | Starter N | Soil Applied N / Foliar N

Phosphorus (P_2O_5)

Soil Test

Pre-

Potassium (K_2O)

So

Pre-

Acknowledgements

For drip-irrigated processing tomatoes, Hartz and Bottoms[N4] found that a seasonal rate of approximately 175 lbs N/acre is adequate to maximize fruit yields in most soils. Contact your local farm advisor for more information.

Krusekopf and coworkers[N10] carried out a study in the Central Valley in ten furrow irrigated fields. A response to N fertilization was observed in only four fields. In the responsive fields, no significant yield increase with sidedress N application rates above 100 lbs/acre was observed. The total available N in these fields, which included the pre-sidedress nitrate-N in the top 2 feet of the profile and the sidedress N, averaged 170 lbs/acre [N10]. Based on this and other studies, the recommended seasonal N application rate for furrow irrigated tomatoes is 100-150 lbs N/acre [N8].

Soil Applied N / Foliar N

- Application Rate
- Mode of Application
- Fertilizer Type
- Time of Application

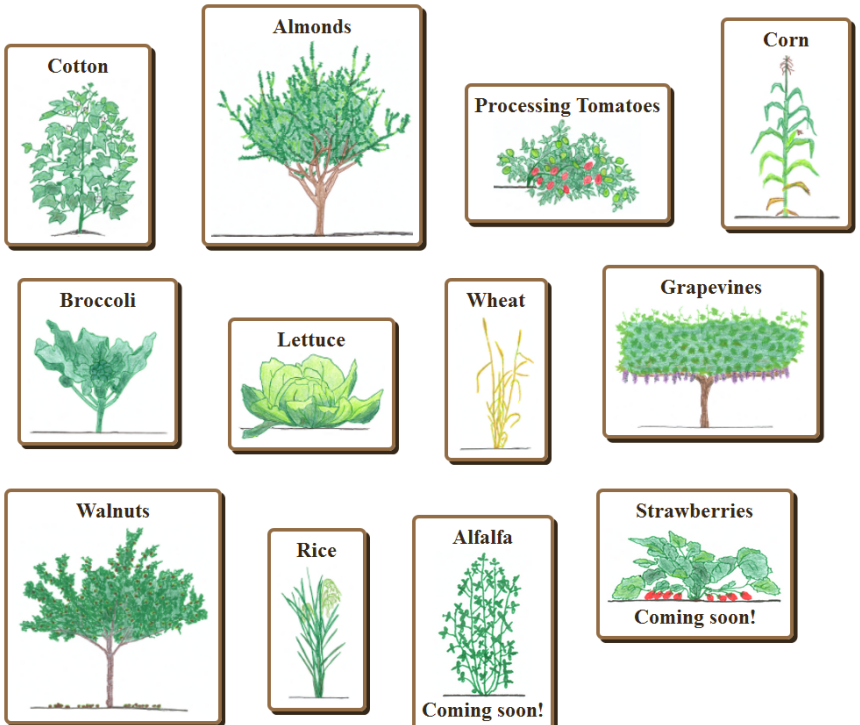
Resources: Fertilization guidelines

http://apps.cdfa.ca.gov/frep/docs/guidelines.html

Fertilization Guidelines for Major Crops Grown in California

These guidelines are based on research results from studies carried out in California and elsewhere. For an optimal fertilization program, site-specific information on soil type, climate and crop management need also to be take in into account.

After choosing a crop from the list below, detailed information can be accessed by moving the mouse over any shape with the symbol ⓘ.



Developed in collaboration by

cdfa

FERTILIZER RESEARCH AND EDUCATION PROGRAM FREP

UC DAVIS
UNIVERSITY OF CALIFORNIA

Department of
LAND, AIR AND WATER RESOURCES

Soil and Plant Tissue Sampling

- Soil Test Sampling Instructions
- Sampling for Soil Nitrate Determination
- Soil Sampling in Orchards
- Plant Tissue Sampling

Additional Resources, Links

- Organized by Topic
- Organized by Source

New! Nitrogen Partitioning and Seasonal Uptake Curves

Resources: Fertilization guidelines

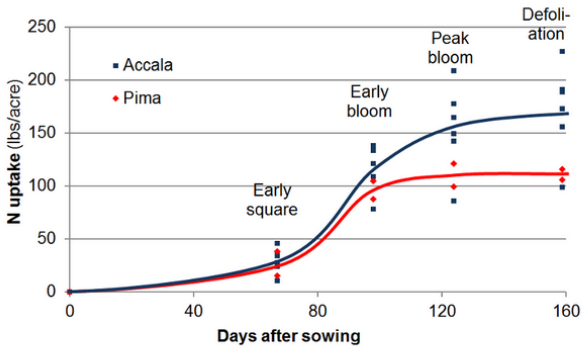
N uptake and removal rates

Crops:

- Almonds
- Broccoli
- Corn for Grain
- Corn for Silage
- Cotton
- Grapevines
- Lettuce
- Pistachio
- Rice
- Strawberries
- Tomatoes
- Walnut
- Wheat

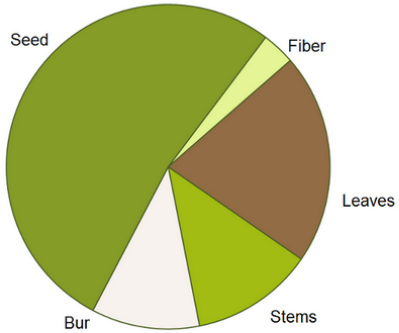
Cotton Nitrogen Uptake and Partitioning

Seasonal N Uptake



Nitrogen uptake of cotton grown in Fresno and Kings County was determined by harvesting the aboveground biomass at different times during cotton development.
Cotton plants took up little N until they reached the early square stage. Most N was taken up between the early square and peak bloom stage (Fritschi et al., 2004).

Nitrogen Partitioning



Measured immediately before defoliation, more than half of the aboveground N of Accala cotton was in the seeds. Nitrogen in the fiber and burs accounted for about 15% (Fritschi et al., 2004).

Nitrogen Removed at Harvest

Cotton yield and N removed at harvest. The N application rate was 150 lbs/acre.

Study location	Years	Lint yield (lbs/acre)	Aboveground N (lbs/acre)	N in seed and lint (lbs/acre)	Source
			Accala Cotton		
Fresno & Kings Counties	1998-2000	1411	172	106	Fritschi et al., 2003; 2004
			Pima Cotton		
Fresno County	1999-2000	1457	113	83	Fritschi et al., 2003; 2004

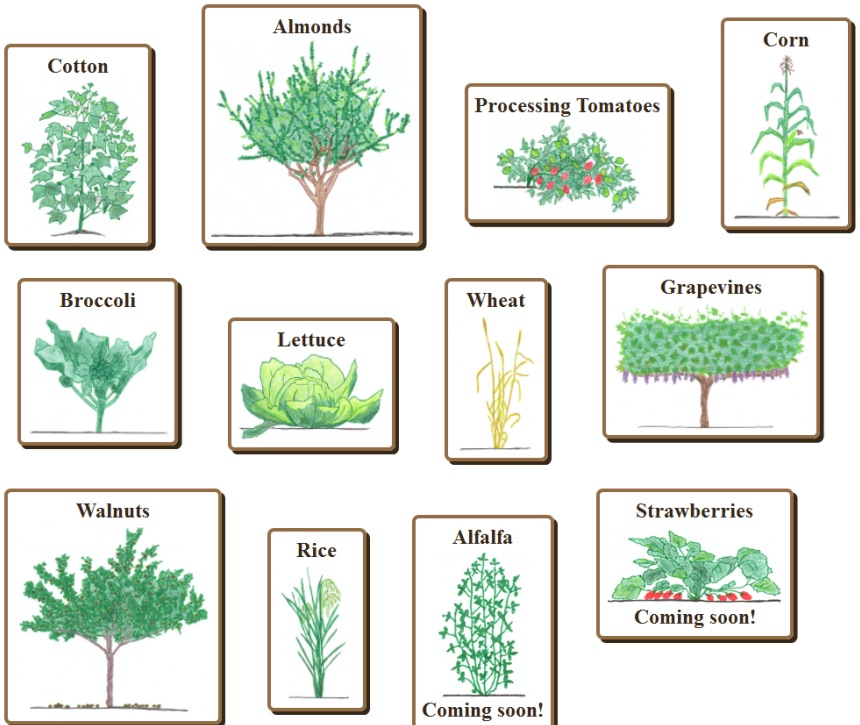
Resources: Fertilization guidelines

Additional resources, links

Fertilization Guidelines for Major Crops Grown in California

These guidelines are based on research results from studies carried out in California and elsewhere. For an optimal fertilization program, site-specific information on soil type, climate and crop management need also to be take in into account.

After choosing a crop from the list below, detailed information can be accessed by moving the mouse over any shape with the symbol ⓘ.



Developed in collaboration by

cdfa

FREP Fertilizer Research and Education Program

UC DAVIS
UNIVERSITY OF CALIFORNIA

Department of
LAND, AIR AND WATER RESOURCES

Soil and Plant Tissue Sampling

- Soil Test Sampling Instructions
- Sampling for Soil Nitrate Determination
- Soil Sampling in Orchards
- Plant Tissue Sampling

Additional Resources, Links

- Organized by Topic
- Organized by Source

New! Nitrogen Partitioning and Seasonal Uptake Curves

Step by step optimization

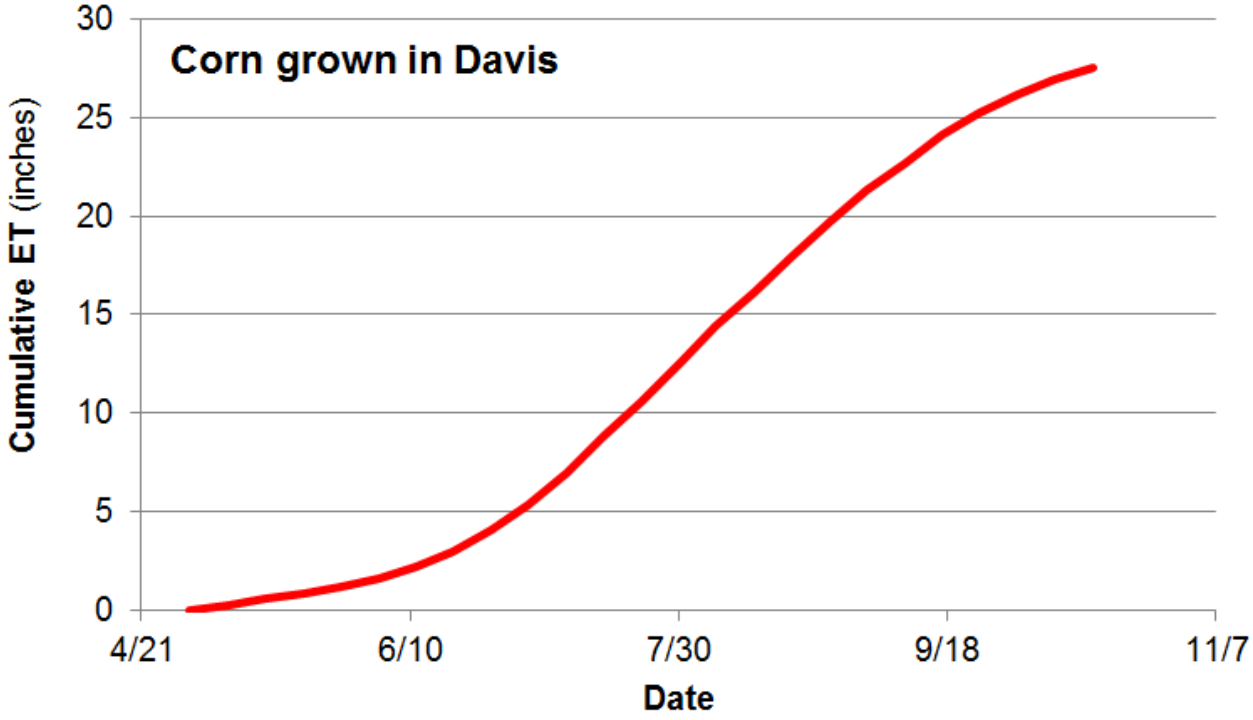
1. Determine optimal N rate
2. **Manage fields with different yield potential separately**

Step by step optimization

1. Determine optimal N rate
2. Manage fields with different yield potential separately
3. **Ensure that irrigation management is efficient**

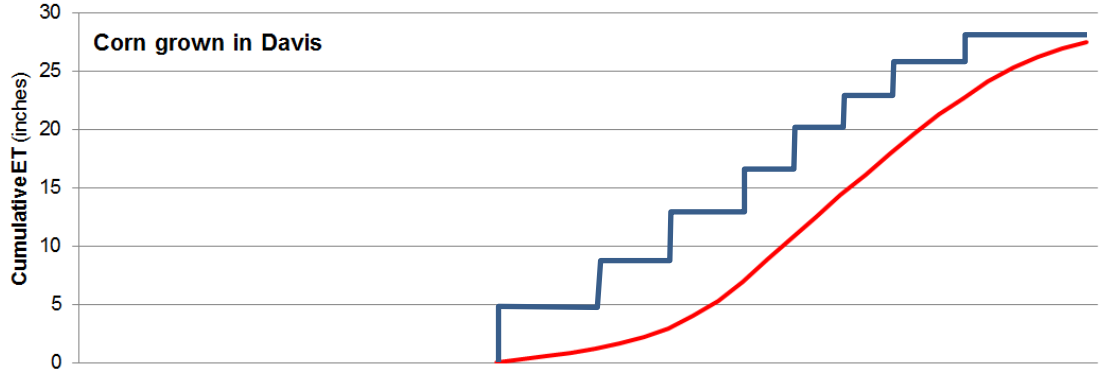
Efficient irrigation water use

- Total amount of water applied
- Time of application

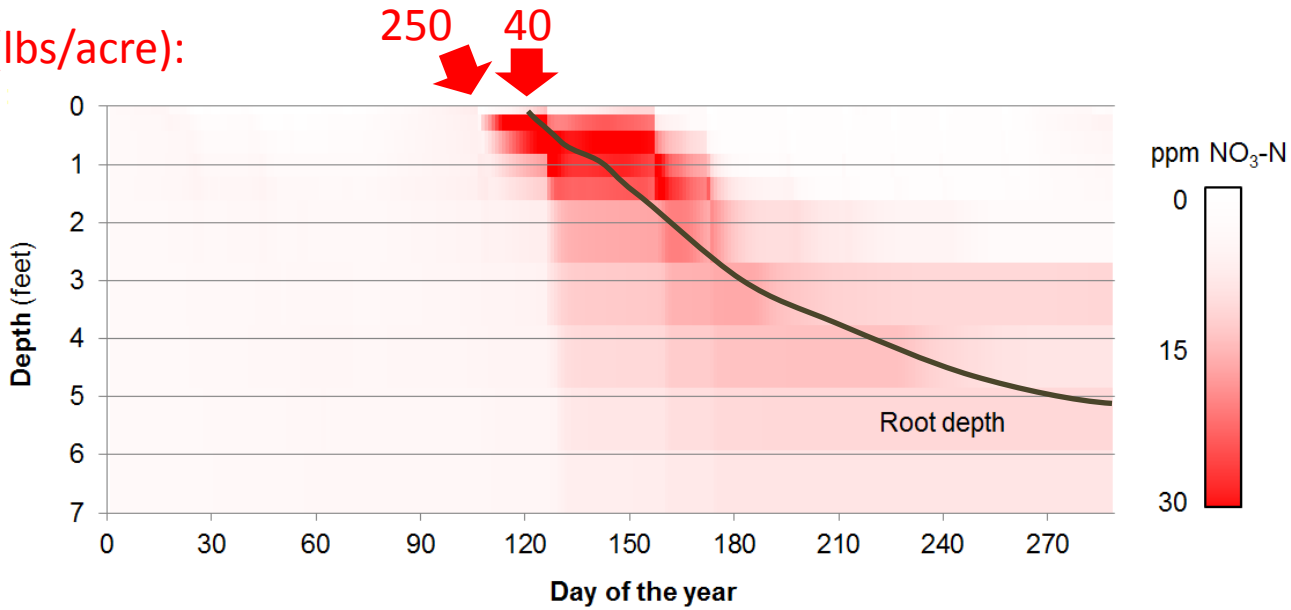


Irrigation management:

Early season excess water



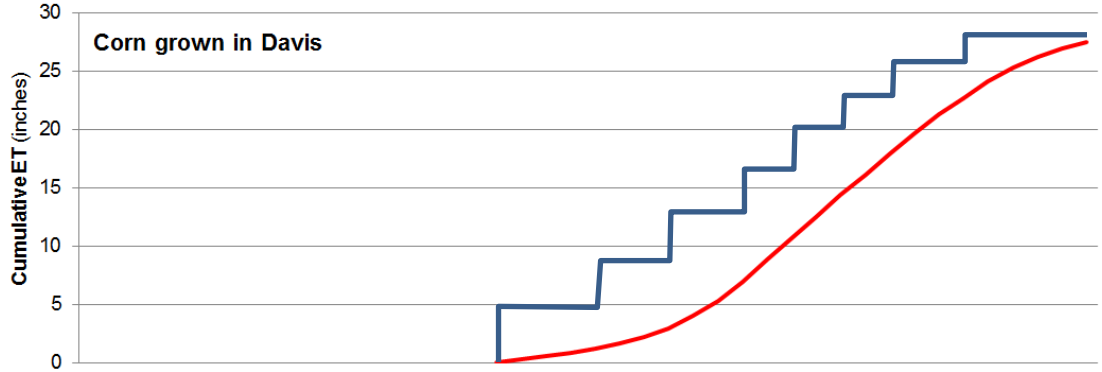
N applications (lbs/acre):



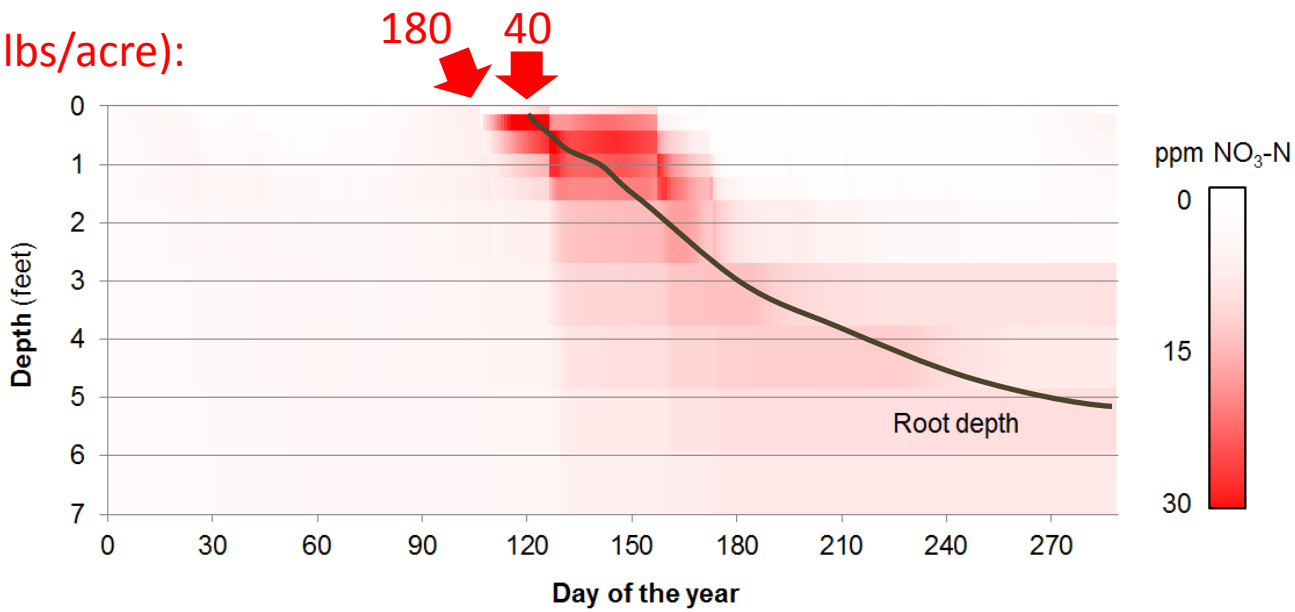
Grain yield: 7,740 lbs/acre

Irrigation management:

Effect of reducing N rate



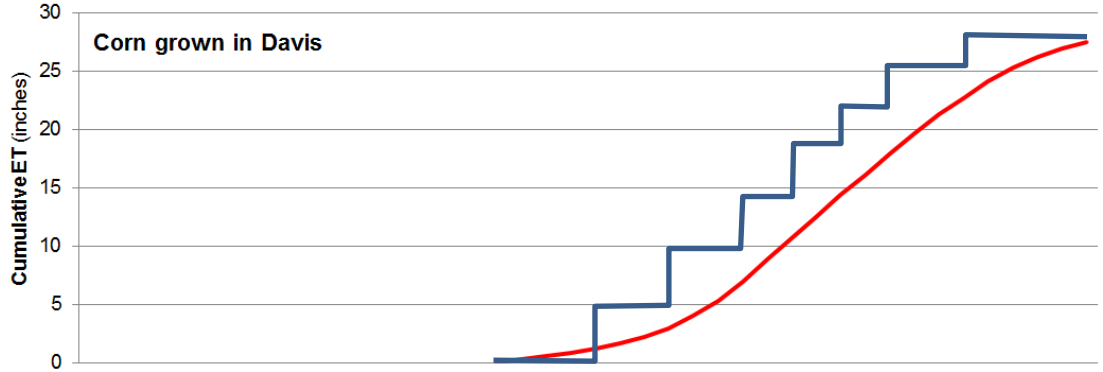
N applications (lbs/acre):



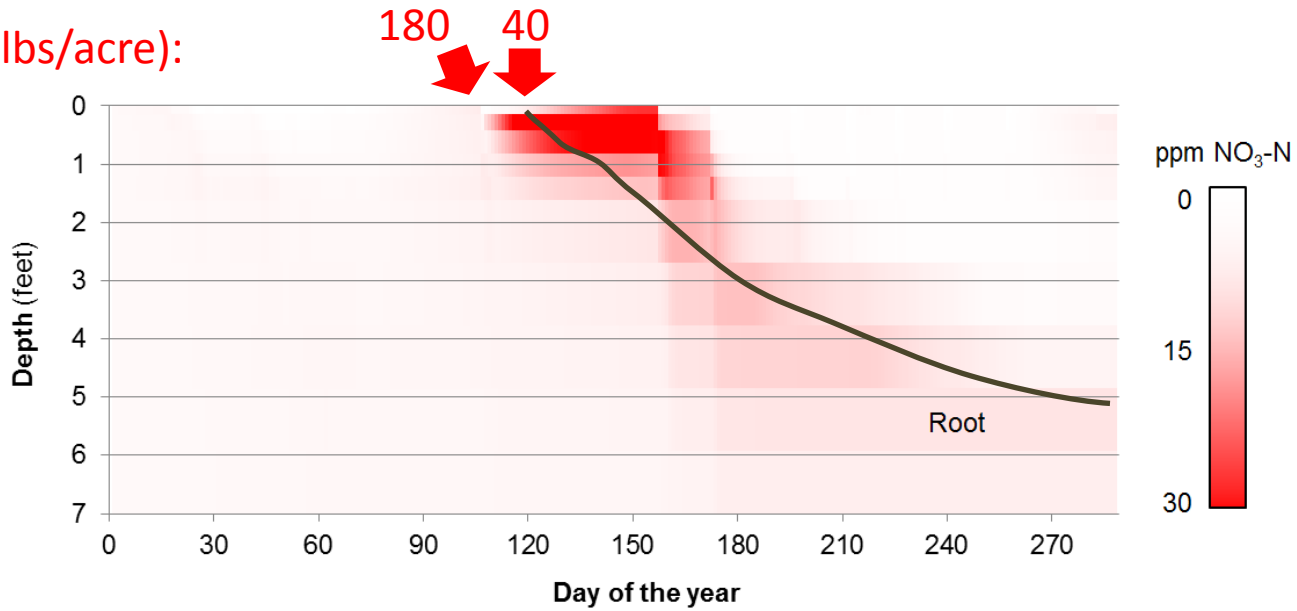
Grain yield: 7,210 lbs/acre (-10%)

Irrigation management:

Optimal irrigation timing



N applications (lbs/acre):

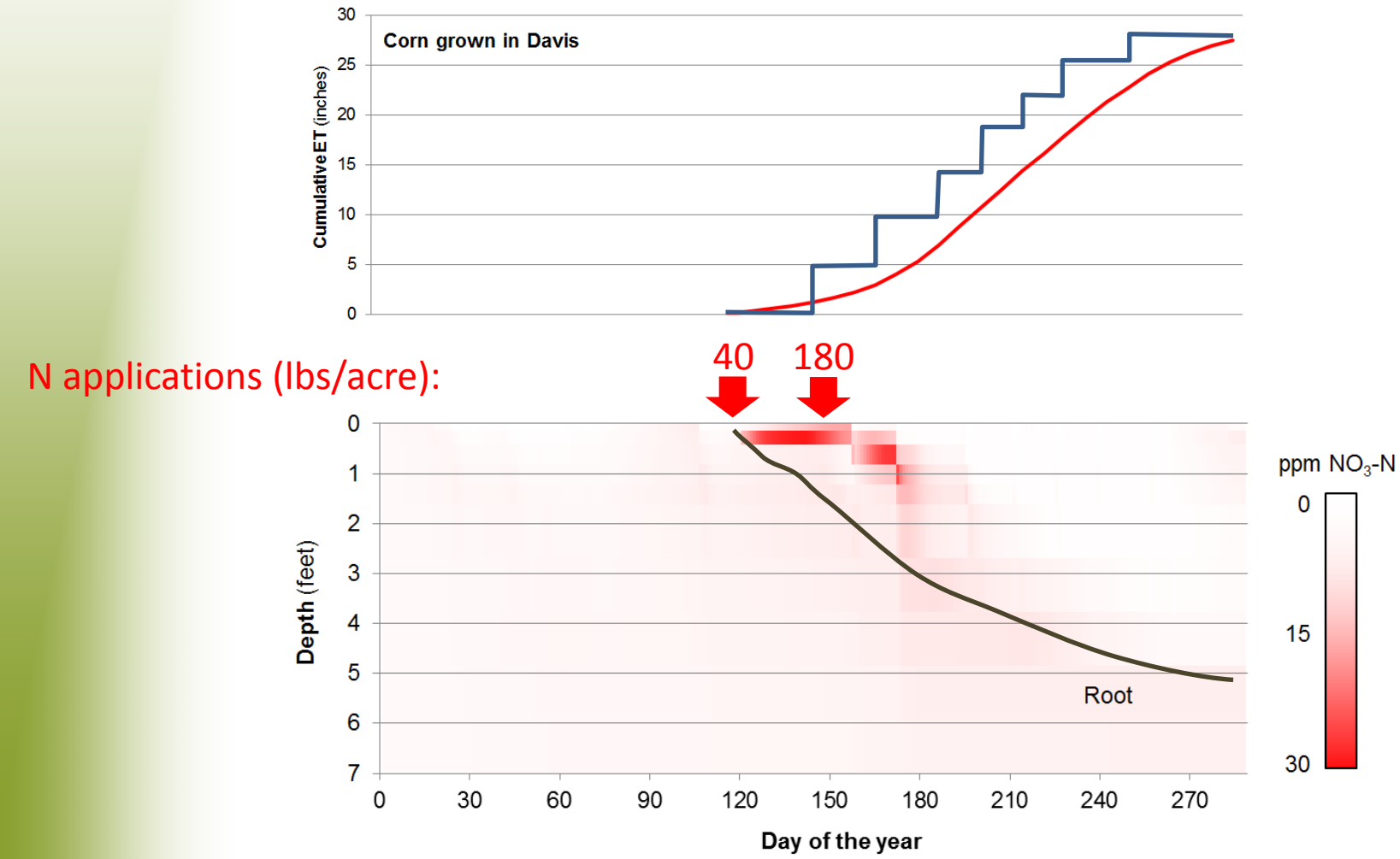


Grain yield: 8,930 lbs/acre (+15%)

Step by step optimization

1. Determine optimal N rate
2. Manage fields with different yield potential separately
3. Ensure that irrigation management is efficient
4. **Synchronize N applications with crop N uptake**

Optimal timing of water application and sidedress N



Grain yield: 9,130 lbs/acre (+18%)

Step by step optimization

1. Determine optimal N rate
2. Manage fields with different yield potential separately
3. Ensure that irrigation management is efficient
4. Synchronize N applications with crop N uptake
5. **Place fertilizer where roots have access and where losses are minimized**

Fertilizer placement

- Urea or ammonium fertilizers need to be incorporated or watered in to minimize ammonia losses
- Band applications are more effective than broadcast applications, especially early in the season
- Apply fertilizer so that N remains in the wetting zone of the irrigation system
- When fertigating with drip or sprinkler systems, apply fertilizer in the middle section of an irrigation
- Efficiency of water-run applications depends on water distribution

Step by step optimization

1. Determine optimal N rate
2. Manage fields with different yield potential separately
3. Ensure that irrigation management is efficient
4. Synchronize N applications with crop N uptake
5. Optimize fertilizer placement
6. **Choose appropriate fertilizer type**

Appropriate fertilizer type

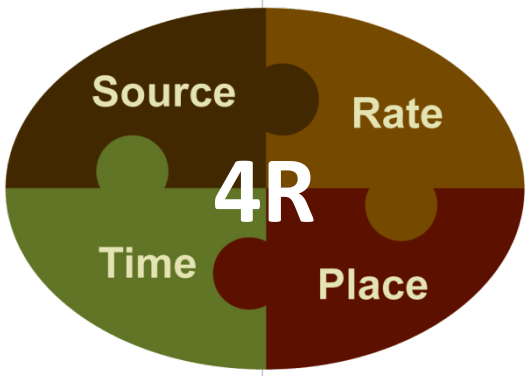
- Urea, ammonium and nitrate are all readily available N sources

- Urea needs t o be converted to ammonium first
- Ammonium is temporarily resistant to leaching
- Ammonia and urea temporarily increase soil pH
- No nitrate to rice
- Controlled release fertilizer may be beneficial when fertilizer needs to be applied far in advance of crop uptake
- N release of controlled release fertilizer needs to match N uptake pattern

Step by step optimization

1. Determine optimal N rate
2. Manage fields with different yield potential separately
3. Ensure that irrigation management is efficient
4. Synchronize N applications with crop N uptake
5. Optimize fertilizer placement
6. Choose appropriate fertilizer type

⇨ With these adjustments, the risk of yield losses is minimized when N rate is adjused



Implementation in the field

- Start with small plots within a field
  - Big enough to harvest plots with regular equipment
- When establishing small plots is not possible, chose several fields with similar characteristics and yield potential. Test new approach in one of these fields.
- Monitor the field
  - Take residual soil nitrate into account
  - Take soil or plant tissue samples during the season
  - Continue more intensive sampling protocol for another year or two
- Proceed in small steps
  - If the potential reduction in N application rate is big, approach the optimal rate in several steps over 2-3 years

Thank you!

- Funding: FREP
- Feedback on an earlier version:
  - Stu Pettygrove
  - Tim Hartz
  - Will Horwath
  - Gene Miyao