



Optimizing Nutrient Management – Tools and Approaches



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**Irrigation and Nutrient Management
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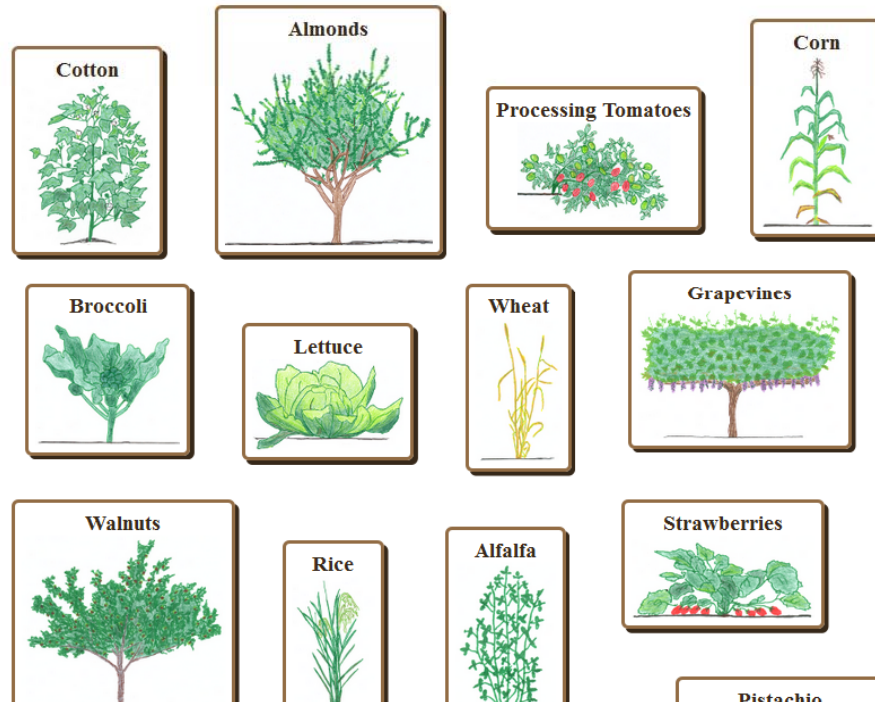
Fertilization guidelines

<http://apps.cdafa.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 ⓘ.



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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](#)



Fertilization guidelines

Lettuce Fertilization Guidelines

Funding provided by:



Pre-Plant

Sowing

Rosette Stage

Head Development

Harvest



Nitrogen (N)

Soil Test ⓘ

Pre-Plant N ⓘ

Starter N ⓘ

Soil Test ⓘ

Leaf Analysis ⓘ

Sidedress N ⓘ

Phosphorus (P₂O₅)

Soil Test ⓘ

Pre-Plant P ⓘ

Starter P ⓘ

Potassium (K₂O)

Acknowledgments ⓘ

Additional Information ⓘ

1. Lettuce Production in California

Sidedress N

Between heading and harvest, N demand of lettuce is high, reaching 3-4 lbs N/acre per day [N13, N32, N33]. During this period, which is generally the last month before harvest, 70-80% of total N is taken up [N21, N30, N33, N41]. A sufficient N supply between heading and harvest is crucial for obtaining a high yield.

Application Rate ⓘ

Specific Fertilization Management ⓘ

Mode of Application ⓘ

Fertilizer Type ⓘ

Time of Application ⓘ

When leaching losses are minimized, the seasonal N application rates for lettuce should not exceed 150-180 lbs/acre for winter and spring production and 100-140 lbs/acre for summer and fall production. However, the required N rate depends on the residual soil nitrate content. Crops produced from late fall through early spring generally require more fertilizer N because the residual soil N content tends to be lower during this period compared to the summer months [N12].

Several studies carried out in commercial fields in the Salinas Valley found that when the pre-sidedress soil nitrate-N level is above 20 mg/kg (= 20 ppm), no fertilizer N is necessary [N2, N3, N5, N10, N15]. If the soil nitrate-N concentration is below 20 ppm, only enough N to



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Soil Nitrate Test

Samples are taken from the top foot of the soil profile, which is the major rooting zone for lettuce [N20, N21]. Zones of recently banded fertilizer applications should be avoided so that the N availability is not over-estimated [N11]. For more information on sampling procedure see [Sampling for Soil Nitrate Determination](#).

Young lettuce plants require little N, as approximately 70% of the total N is taken up between heading and harvest [N21, N30, N33, N41]. Therefore, taking a soil sample after thinning, prior to the first in-season N application, and a second 2-3 weeks later provides sufficient information to schedule N applications throughout the season [N13].

Soil Nitrate Quick Test ⓘ

Interpretation of Test Results ⓘ

Additional Information:

LINKS:

1. Lettuce Production in California
(Historic Background, Production Statistics)

1. Vegetable Research and Information Center
2. UC Nutrient Management for Vegetable, Fruit and Nut Crops



A comparison with CropManage

CropManage

Guidelines

Based on the same research

- Site-specific recommendations
- Irrigation, N

- Overview of current knowledge
- N, P, K
- List of literature sources

⇒ Two complementary tools





N uptake and removal

Fertilization Guidelines for Major Crops Grown in California

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

 Cotton	 Almonds	 Processing Tomatoes	 Corn
 Broccoli	 Lettuce	 Wheat	 Grapevines
 Walnuts	 Rice	 Alfalfa	 Strawberries
			 Pistachio

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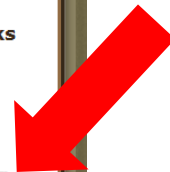
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N uptake and removal

Crops:

Almonds

Broccoli

Corn for Grain

Corn for Silage

Cotton

Grapevines

Lettuce

Pistachio

Rice

Strawberries

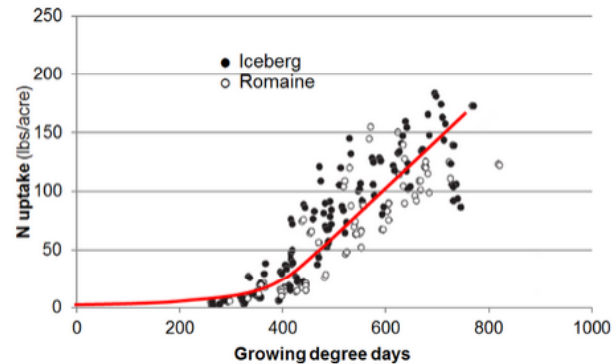
Tomatoes

Walnut

Wheat

Lettuce Nitrogen Uptake and Partitioning

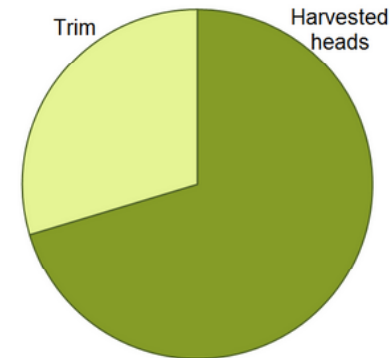
Seasonal N Uptake



Nitrogen uptake was determined by harvesting the aboveground biomass at different times during lettuce development.

Early in the season, lettuce N uptake was low. Between heading and harvest, however, N demand of lettuce was high. During this period, which is generally the last month before harvest, 70-80% of total N was taken up (Bottoms et al., 2012).

Nitrogen Partitioning



Wrapper leaves and not marketable heads may contain 10-40% of the aboveground N (Thompson and Doerge, 1996; Hartz et al., 2000).

Nitrogen Removed at Harvest

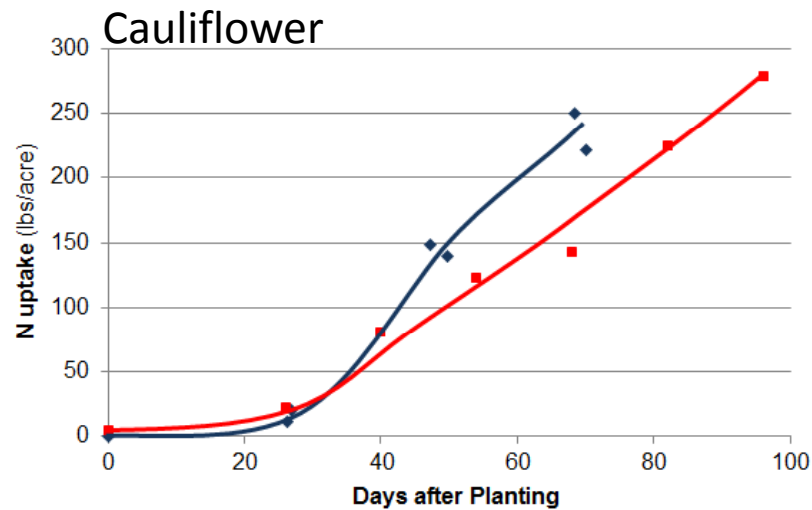
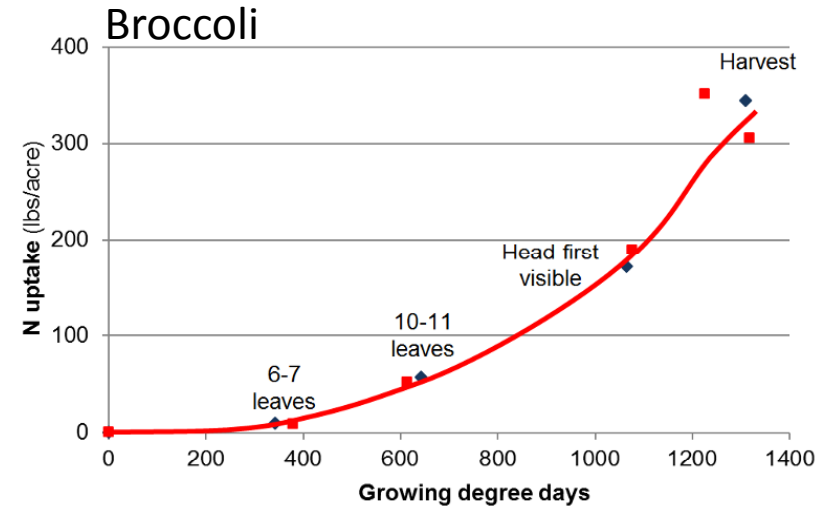
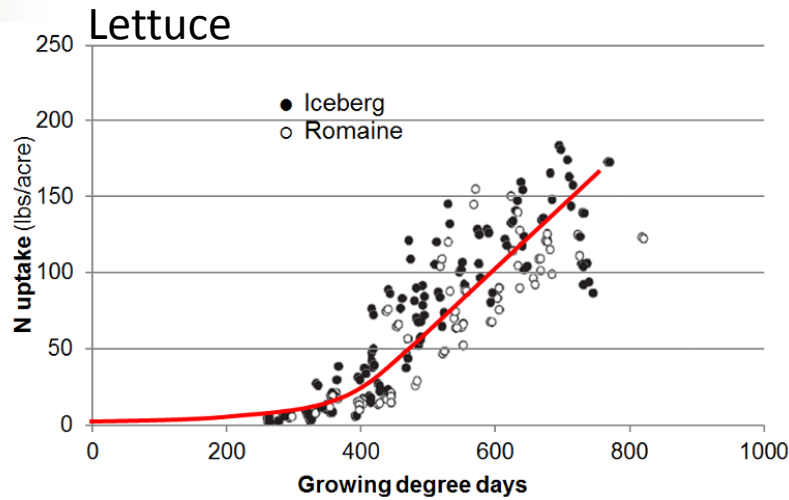
Lettuce yield and N removed at harvest.

Study location	Years	Yield (lbs/acre)	Yield (cwt/acre)	Aboveground N (lbs/acre)	Harvested N (lbs/acre)	Source
Salinas Valley	2009-10	36,600	333	135	90 - 100	Bottoms et al., 2012; Hartz et al., 2000





N uptake curves of cool season vegetables





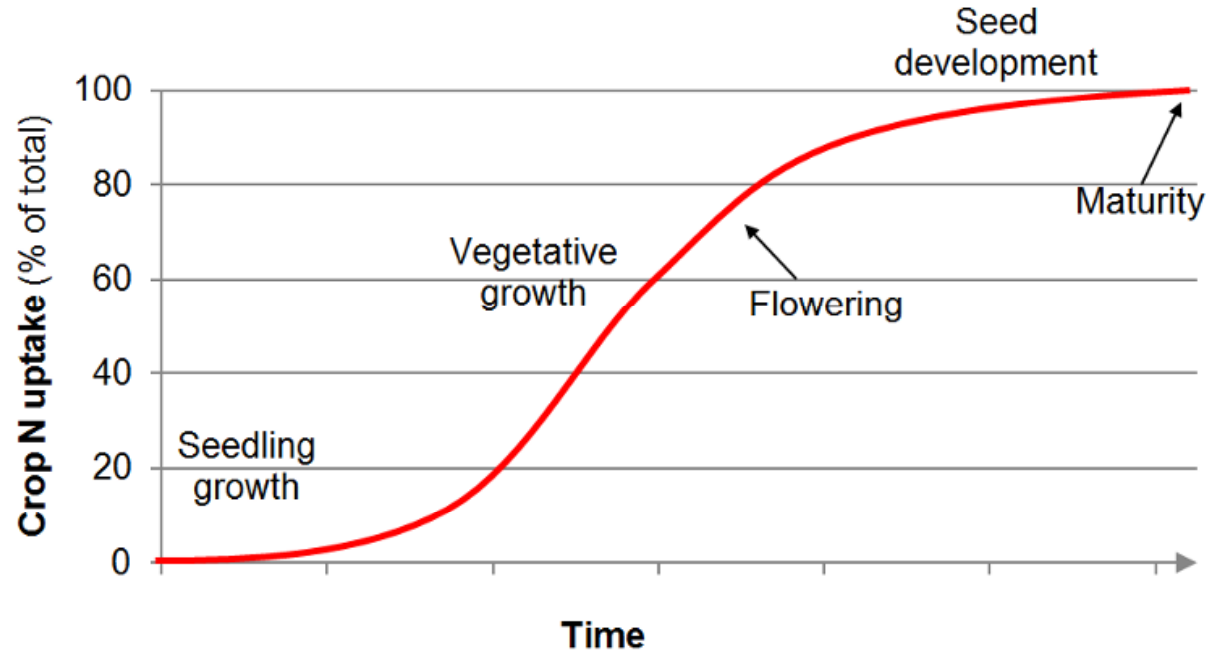
Early growth challenges

- Early N uptake low
 - Often high residual nitrate concentrations
 - Shallow root system
 - Need to provide optimal conditions for growth
- ⇒ Early conditions affect plant development and yield potential
- ⇒ High risk of nitrate leaching



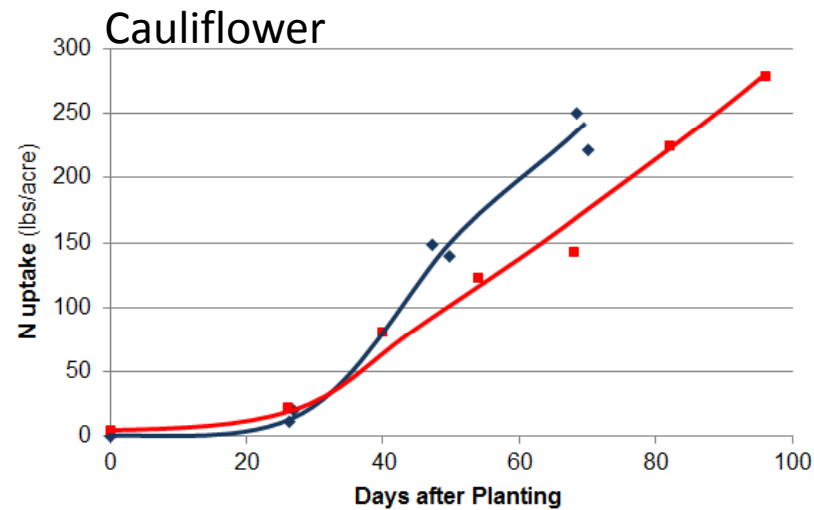
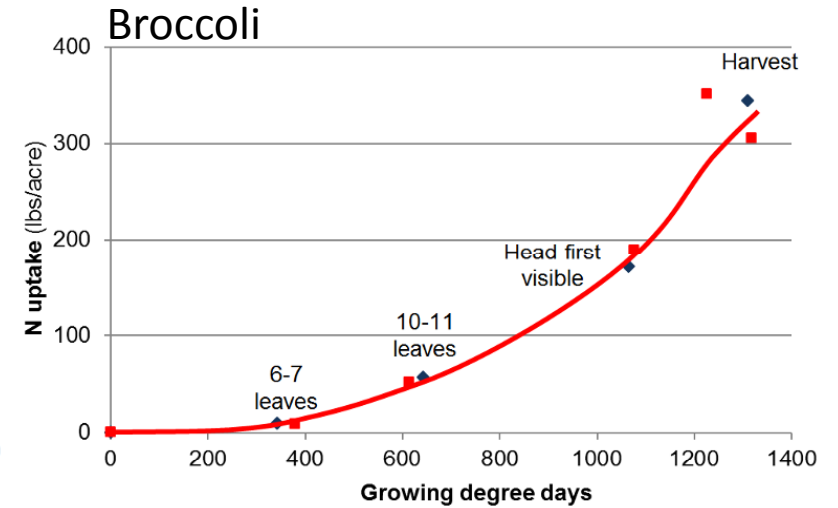
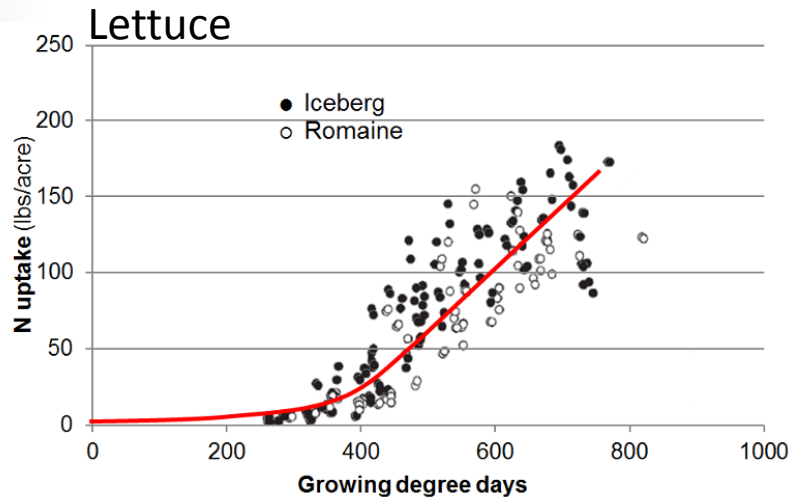


A general N uptake curve



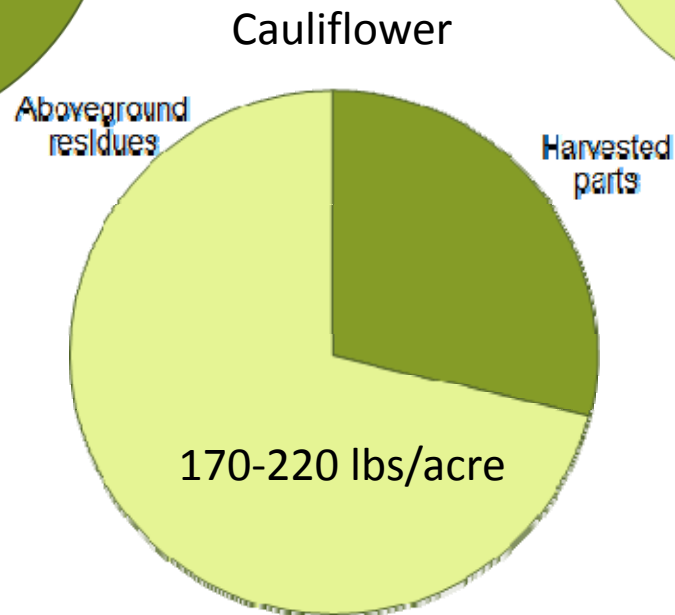
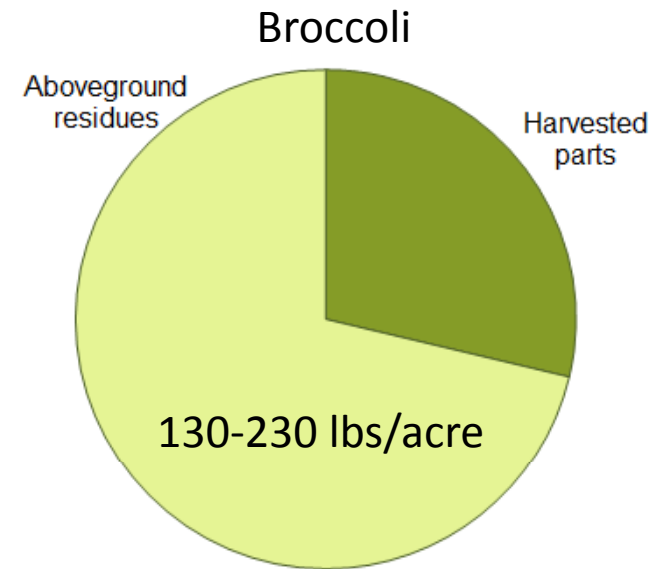
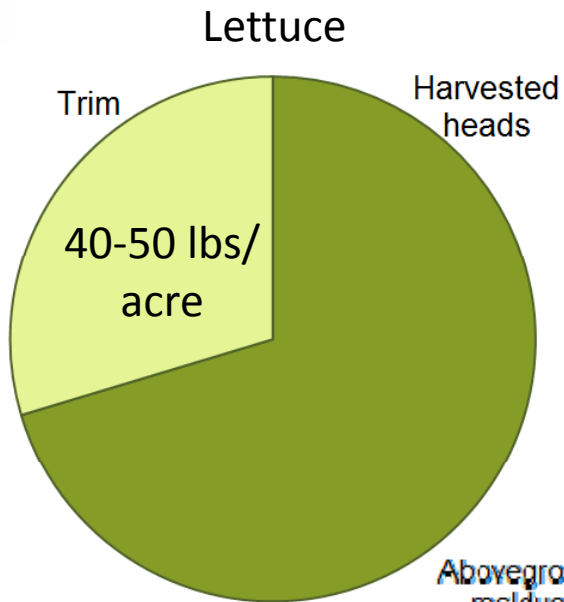


N uptake curves of cool season vegetables





Harvest removal





Step by step optimization

1. Determine optimal N rate based on current research data





Step by step optimization

1. Determine optimal N rate
2. **Manage fields with different yield potential or crop rotation differently**

⇒ **There is no one-size-fits-all nutrient management program**

- Fields differ
- One year differs from the next





Step by step optimization

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





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**





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**





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 to be converted to ammonium first
- Ammonium is temporarily resistant to leaching
- Ammonia and urea temporarily increase soil pH

- 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

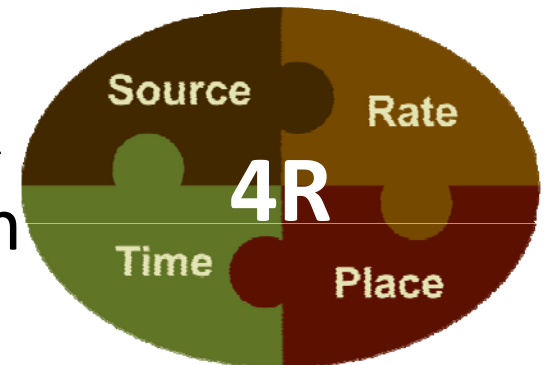




Step by step optimization

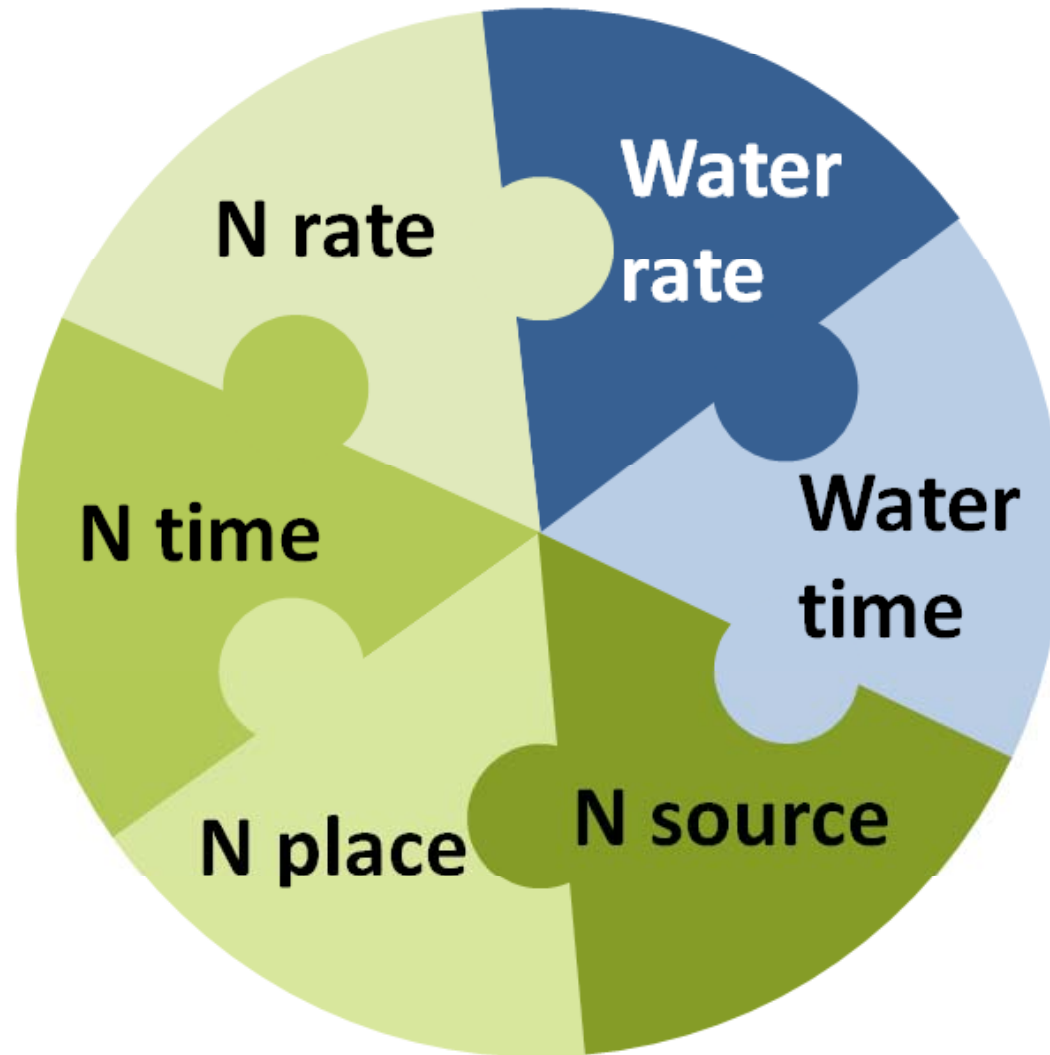
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3. Ensure that irrigation management is efficient
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6. Choose appropriate fertilizer type

⇒ With these adjustments, the risk of yield losses is minimized when N rate is adjusted





The 6 Rs of N management in irrigated agriculture





When changing the nutrient management program ...

- 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
 - If possible, test new fertilizer practices in smaller plots

