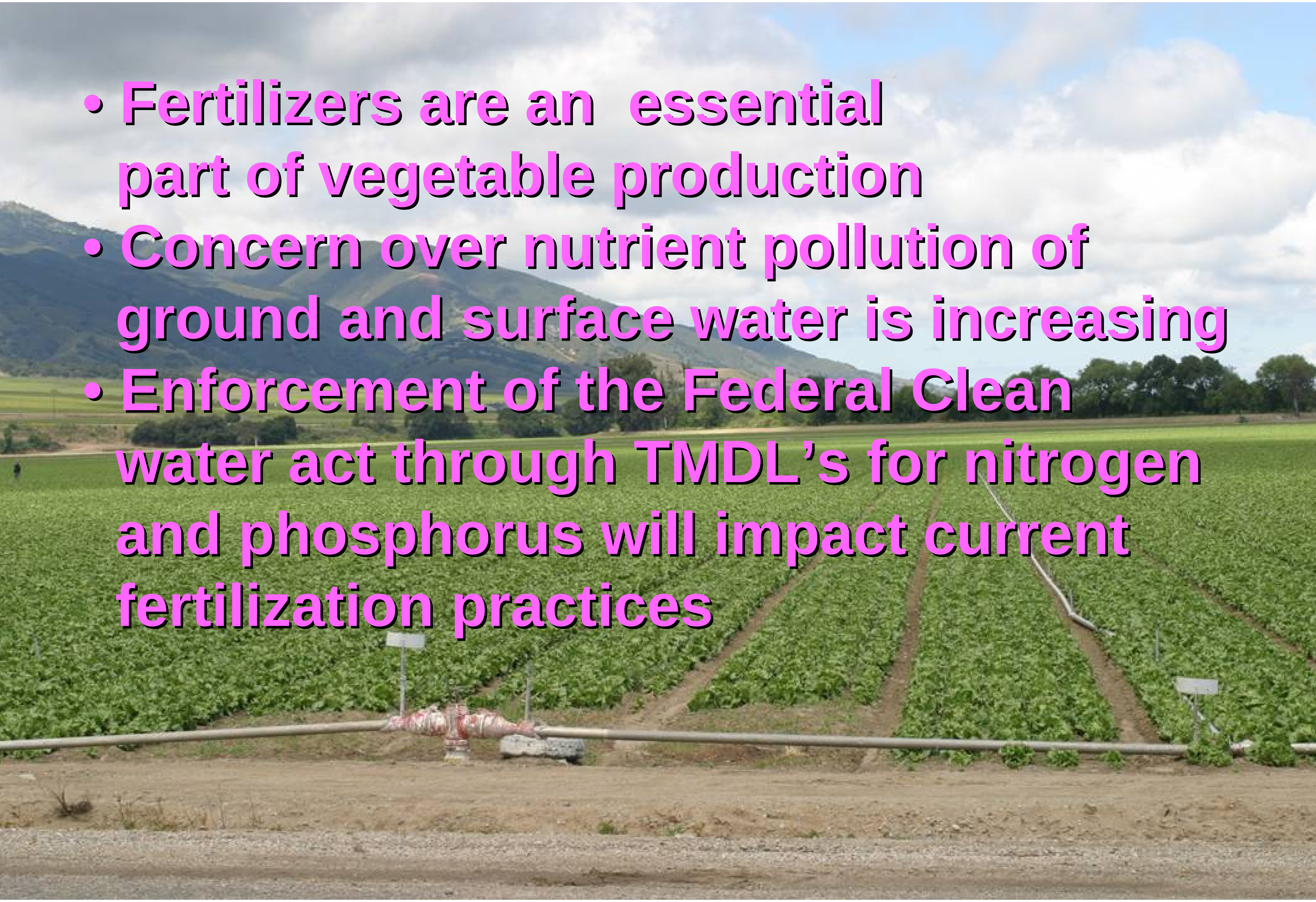
# Nutrient Management for Vegetable Production

**Richard Smith, Farm Advisor**
**Monterey County**

**Farm Water Quality Planning Project**

**UC Cooperative Extension/ USDA Natural Resources Conservation Service**



- **Fertilizers are an essential part of vegetable production**
- **Concern over nutrient pollution of ground and surface water is increasing**
- **Enforcement of the Federal Clean water act through TMDL’s for nitrogen and phosphorus will impact current fertilization practices**

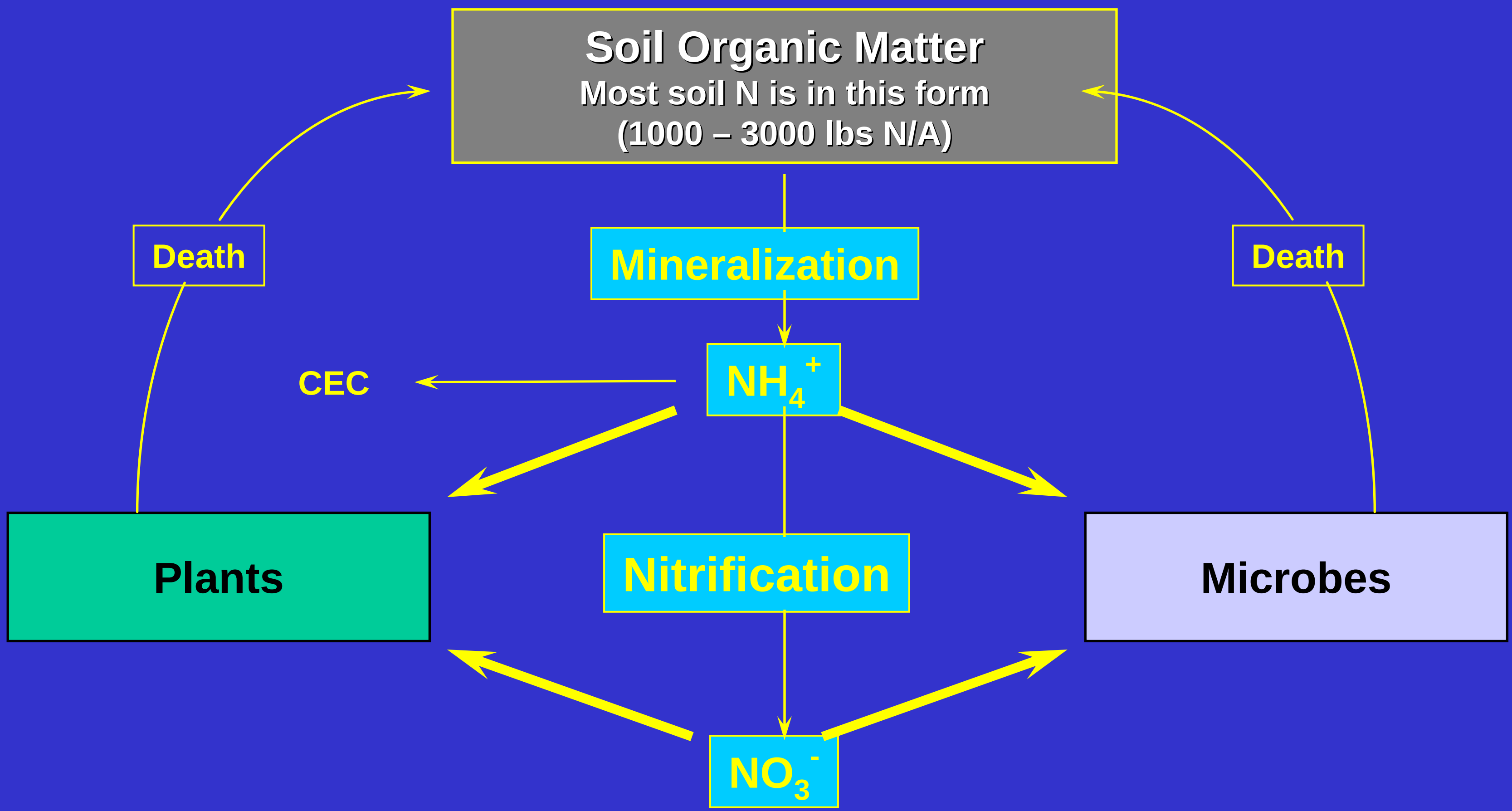
# Nitrogen and Phosphorus are Key Nutrients of Environmental Concern

- They become environmental problems when they move off-site to surface water and groundwater (nitrate)

# Nitrate Contamination

- Nitrate is a key concern because of its ability to cause algal blooms in surface waters, dead zones in Marine environments
- It is of great concern in ground water because of drinking water standards: <45 ppm $NO_3$
- It is becoming increasingly difficult for municipalities to find drinking water from wells that comply with these standards

# Nitrogen Cycle



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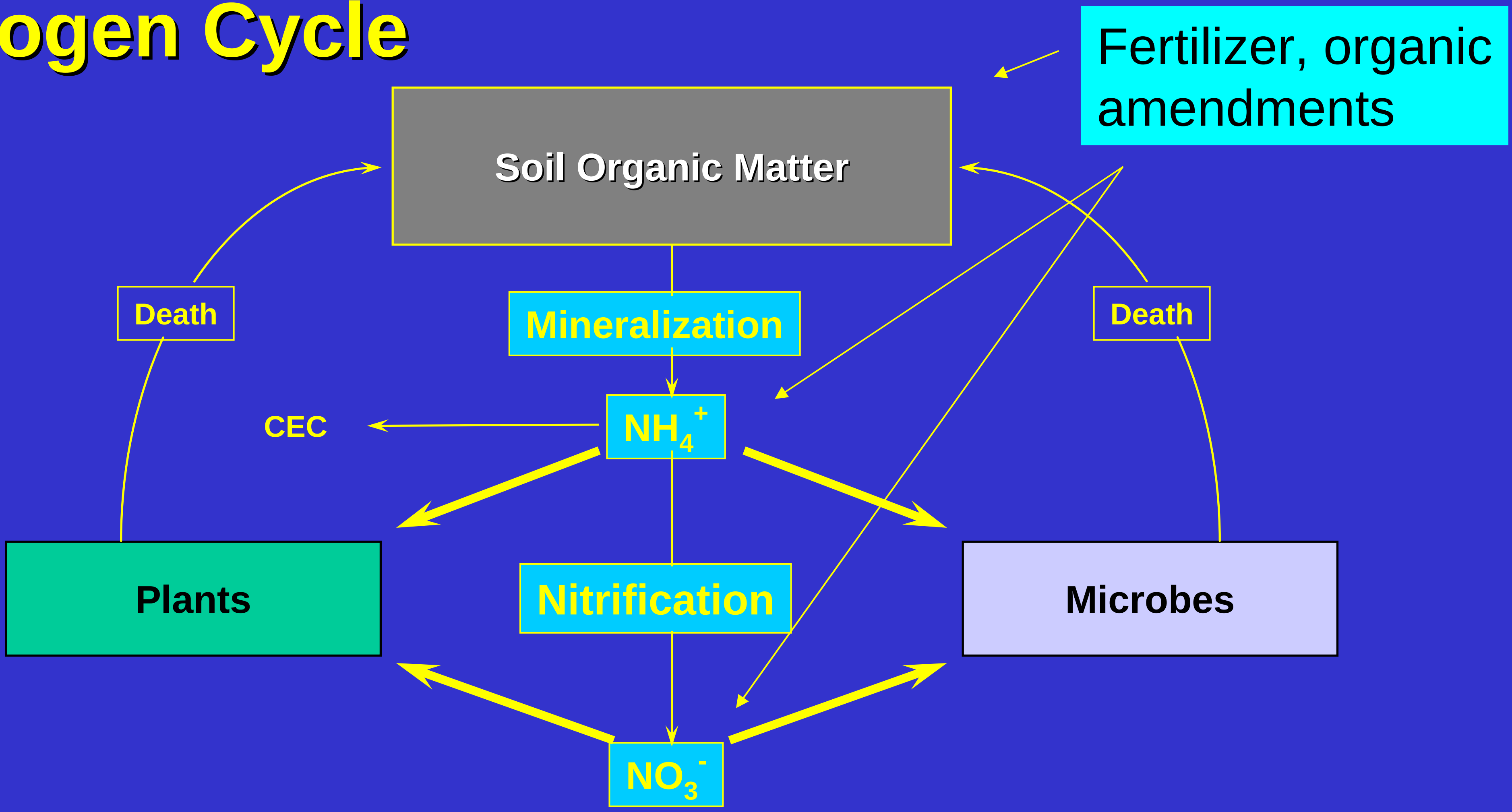

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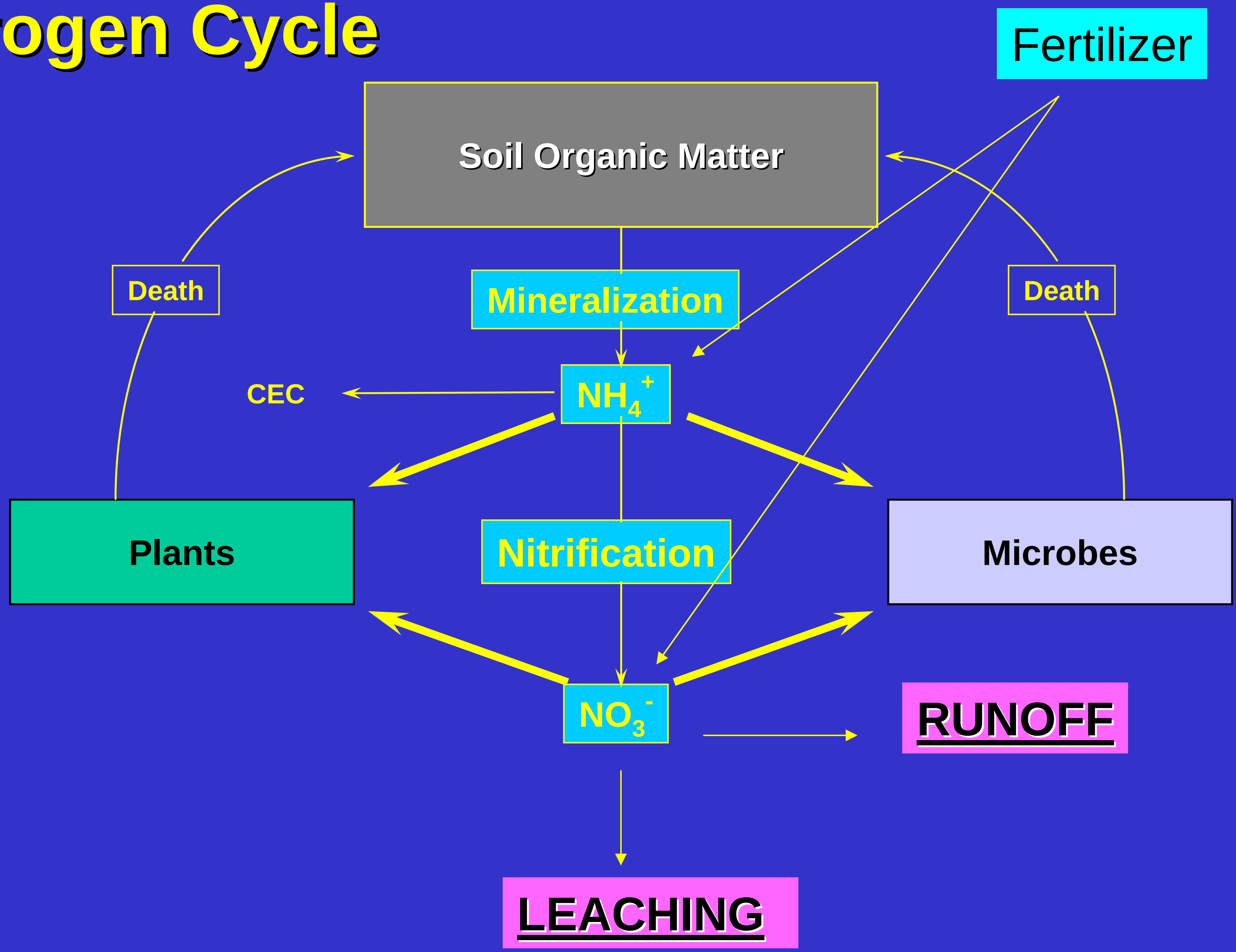


# Nitrogen TMDL

Current levels :

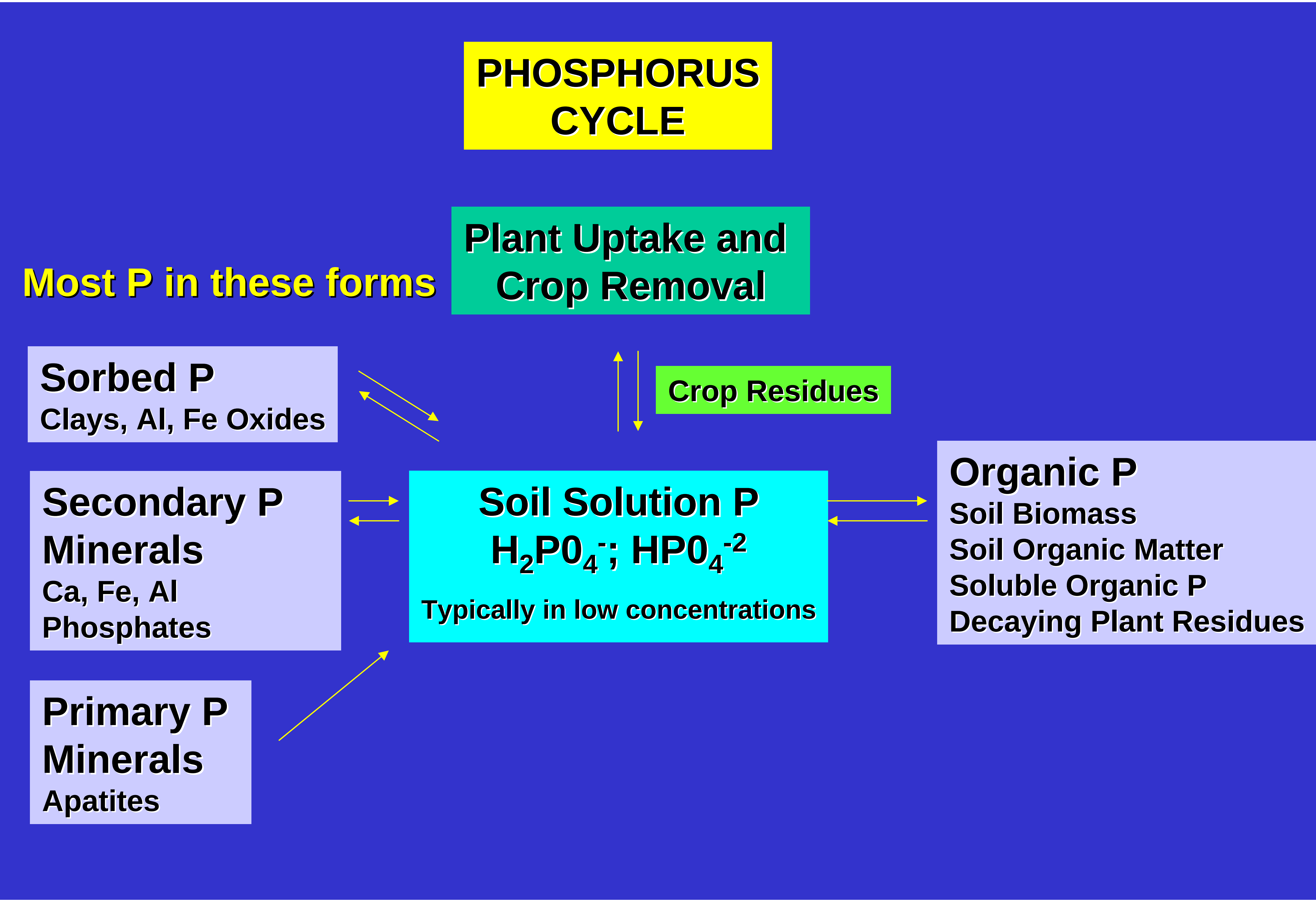
10 PPM total N

Likely TMDL targets :

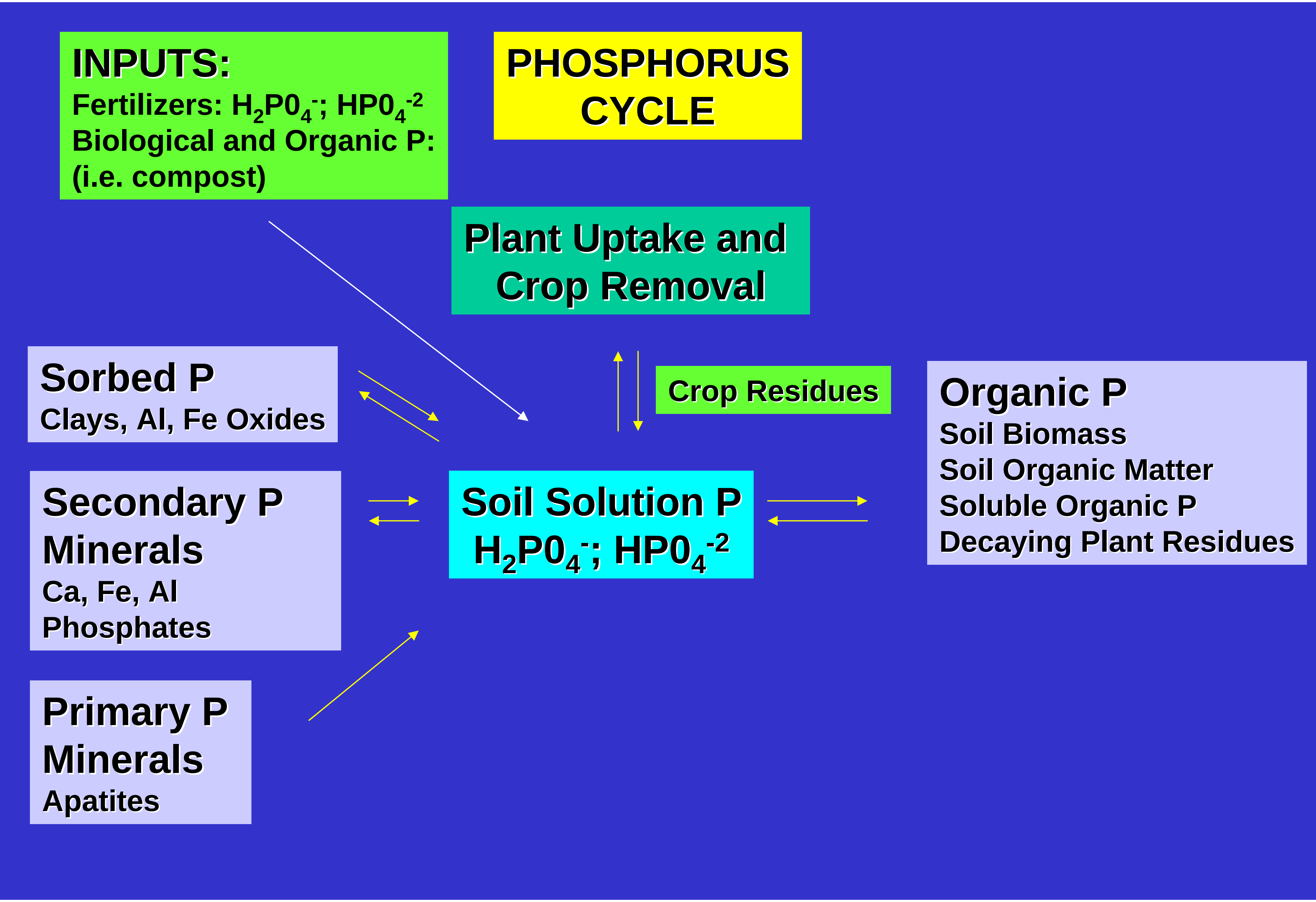
1.2 PPM total N

# Phosphorus

- Phosphorus (P) is essential to all forms of life on earth and has no direct toxic effects to humans or animals.
- Environmental concerns associated with P center on its stimulation of biological activity in water bodies.
- P is normally limiting in most fresh water systems, however P concentrations of as little as 0.02 to 0.10 ppm can stimulate algal growth and cause environmental problems.



PHOSPHORUS CYCLE
Plant Uptake and Crop Removal
Most P in these forms
Crop Residues
Sorbed P
Clays, Al, Fe Oxides
Secondary P Minerals
Ca, Fe, Al Phosphates
Primary P Minerals
Apatites
Soil Solution P
$H_2P0_4^-$; $HP0_4^{-2}$
Typically in low concentrations
Organic P
Soil Biomass
Soil Organic Matter
Soluble Organic P
Decaying Plant Residues


INPUTS:
Fertilizers: $H_2P0_4^-$; $HP0_4^{-2}$
Biological and Organic P:
(i.e. compost)
PHOSPHORUS
CYCLE
Plant Uptake and
Crop Removal
Crop Residues
Sorbed P
Clays, Al, Fe Oxides
Secondary P
Minerals
Ca, Fe, Al
Phosphates
Primary P
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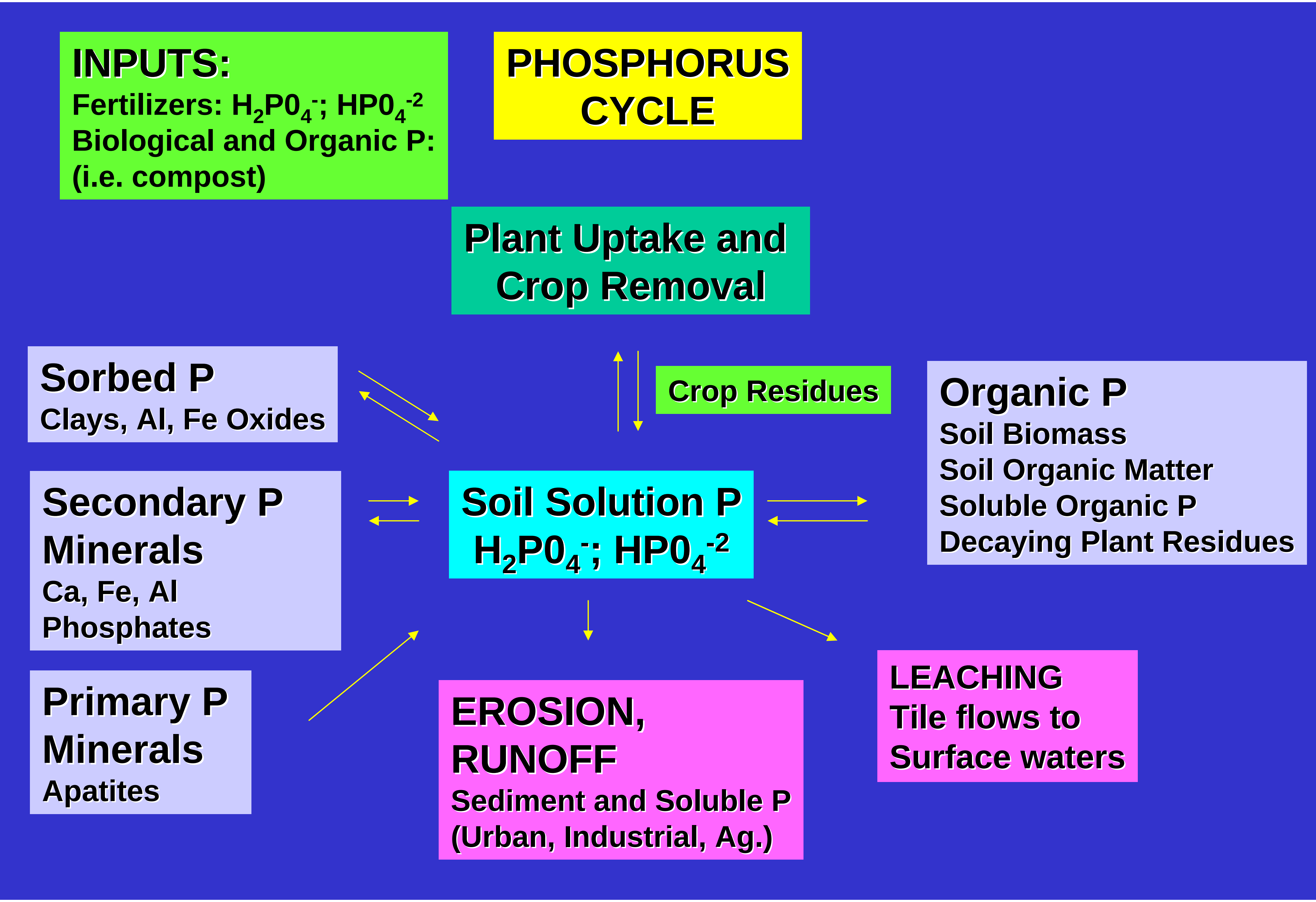
INPUTS:
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$H_2PO_4^-$; $HPO_4^{-2}$
Organic P
Soil Biomass
Soil Organic Matter
Soluble Organic P
Decaying Plant Residues
EROSION, RUNOFF
Sediment and Soluble P
(Urban, Industrial, Ag.)
LEACHING
Tile flows to
Surface waters

# Phosphorus TMDL

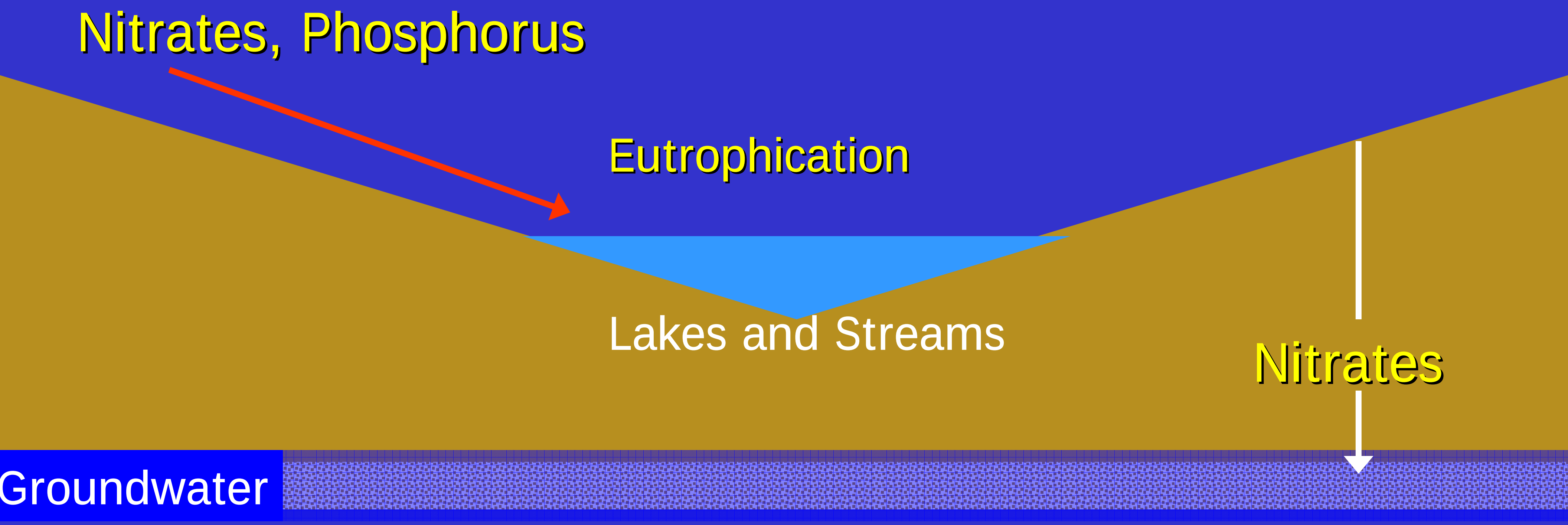
**Current levels :**

**0.5 PPM total P**

**Likely TMDL targets :**

**0.12 PPM total P**

# Problem: Contamination of surrounding water bodies



# Nitrate/Nutrient Impairment
# State Water Quality Control Board
# 303d Listing

| Water Body | Nitrate/Nutrient |
|---|---|
| Gabilan Creek | |
| Alisal Creek | X |
| Blanco Drain | |
| Alisal Slough | X |
| Salinas Reclamation Canal | X |
| Lower Salinas River | X |
| Pajaro River | X |

# Therefore…

## The Nutrient Management Plan

- Management Goals
  - Evaluate current practices
  - Determine crop requirements
  - Manage fertilizer materials and application
  - Maximize irrigation efficiency and uniformity
  - Minimize offsite movement
  - Manage  materials during transport, storage and application
  - Manage livestock and human waste

# The  Farm Water Quality Plan

- N1 – N and P applications as fertilizer,  compost and manure
- N2 – Fertilizers stored and/or mixed at site
- N3 – Fertilizers applied to crops
- N4 – Offsite movement of applied nutrients
- N5 – Septic Systems
- N6 – Livestock and waterbodies
- N7 – Feedlot, loafing areas

# N1: Nutrient Management

## Nitrogen

# Typical Annual Nutrient Balance for Coastal Vegetables

| Nutrient | Input Lbs/A | Removal Lbs/A |
|---|---|---|
| N | 350 | 150 |

# Sources of Nitrogen for Crop Growth

1. Fertilizer
2. Residual soil $NO_3$-N (nitrate pool)
3. In season mineralization of N from soil organic matter including residue from prior crops:

   approximately 30-60 lb N/acre is typically mineralized during 60 days in the summer

4. Irrigation water

# Techniques for Improving Nitrogen Use Efficiency

1. Accounting for crop needs
2. Accounting for residual nitrogen in the soil and adjusting fertilizer applications accordingly (nitrate quick test)
3. Changing fertilization practices (i.e. drip irrigation)
4. Accounting for N in irrigation water
5. Improvements in irrigation efficiency

# 1 - Crop Needs: Nitrogen Fertilization

- **The spring crop typically has relatively higher N fertilizer requirements because soil is lower in N due to leaching of residual soil nitrate in the winter and low soil microbe activity in the winter**

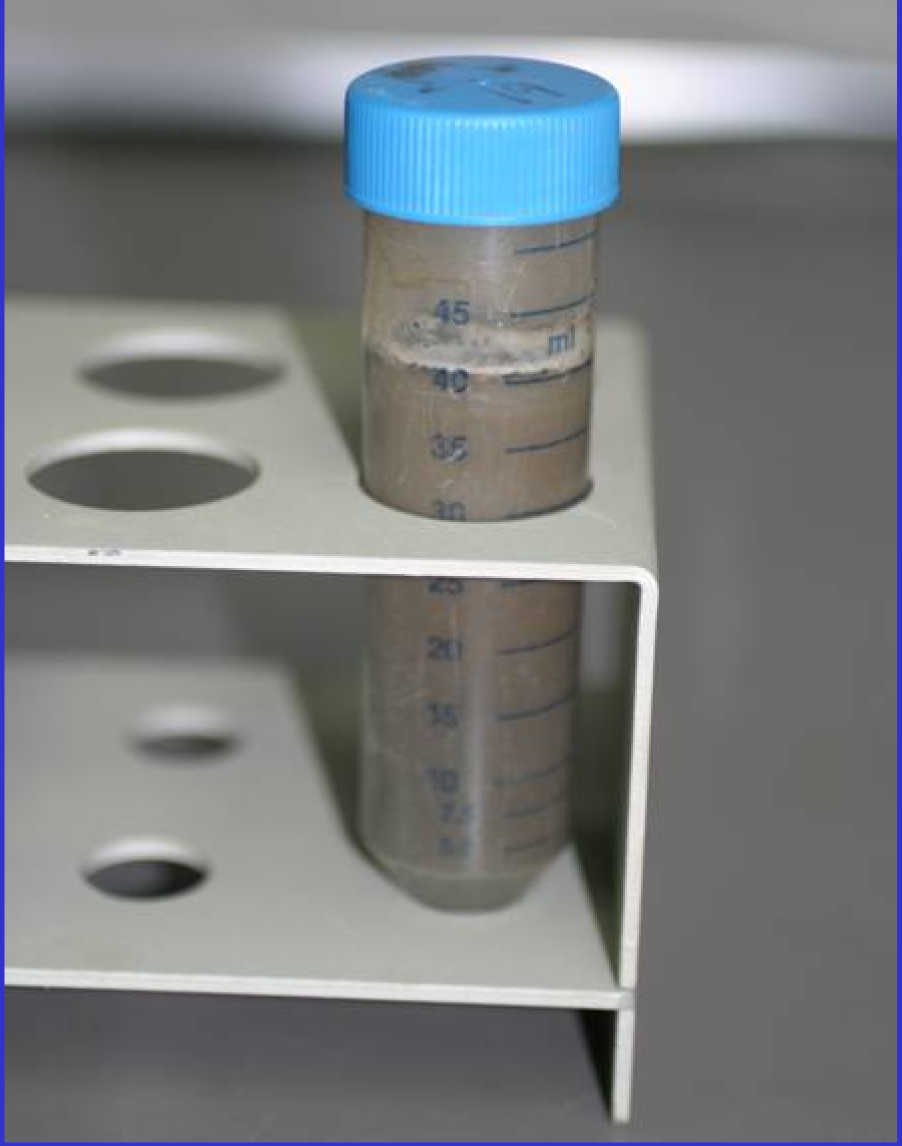
- **N fertilizer requirement for summer crops is less due to N build up from 1) N mineralization, 2) applied fertilizer, 3) N from residues.**

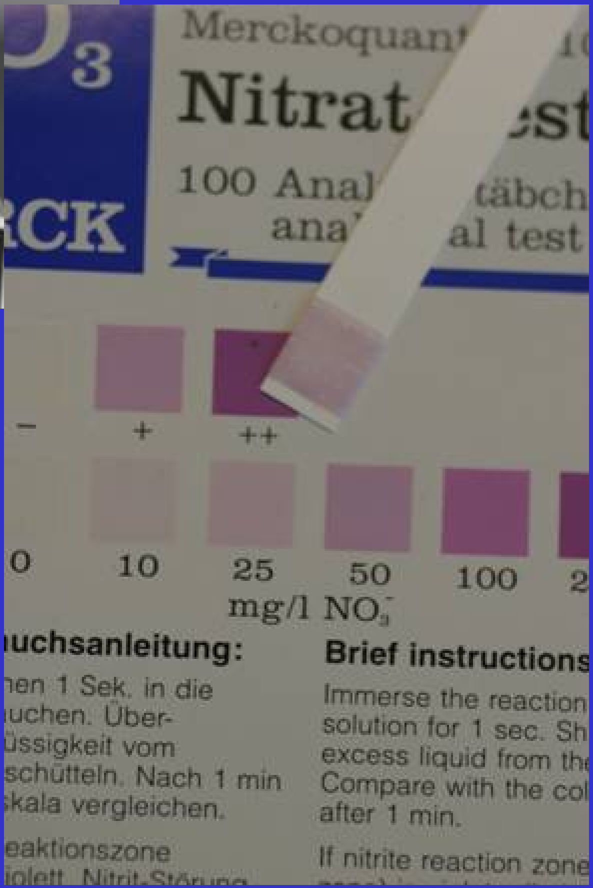
# Crop Needs:
# Total Seasonal Application of Nitrogen/A
# Conventional Fertilization

| Crop | Winter/Spring | Summer/Fall |
| --- | --- | --- |
| Broccoli | 180 - 240 | 150 - 180 |
| Lettuce | 150 - 180 | 100 - 150 |

# 2 - Accounting for Residual Soil Nitrogen:

## Presidedress Nitrate Quick Test



# Accounting for Residual Soil Nitrogen
## Soil Nitrogen Testing

- Residual nitrogen in the soil acts just like fertilizer nitrogen
- Levels of 20 ppm or greater of soil nitrate is sufficient to maintain maximum growth rates for several weeks or more in typical field conditions (= 80 lbs N/A).
- In-season soil $NO_3$-N testing provides a convenient way to determine short-term need for sidedressed N application.

# Presidedress Soil Nitrate Quick Test

- This test is done prior to a sidedress application
- Whenever soil $NO_3$-N is above 20 ppm sidedress N application reduced
- Further testing can be done to as often as necessary to ensure that adequate soil NO3-N level is maintained.
- However, this test had the biggest impact on the first sidedress of the 2nd (summer) crop

# Yield: Presidedress Nitrogen Quick Test Summary of 11 Trials

| | 24s | Total Boxes | Bulk Lbs/A |
|---|---|---|---|
| Grower | 836 | 905 | 32,750 |
| PSNT | 842 | 900 | 32,250 |

Hartz, 2000

# Presidedress Nitrogen Quick Test
# Summary of 11 Trials

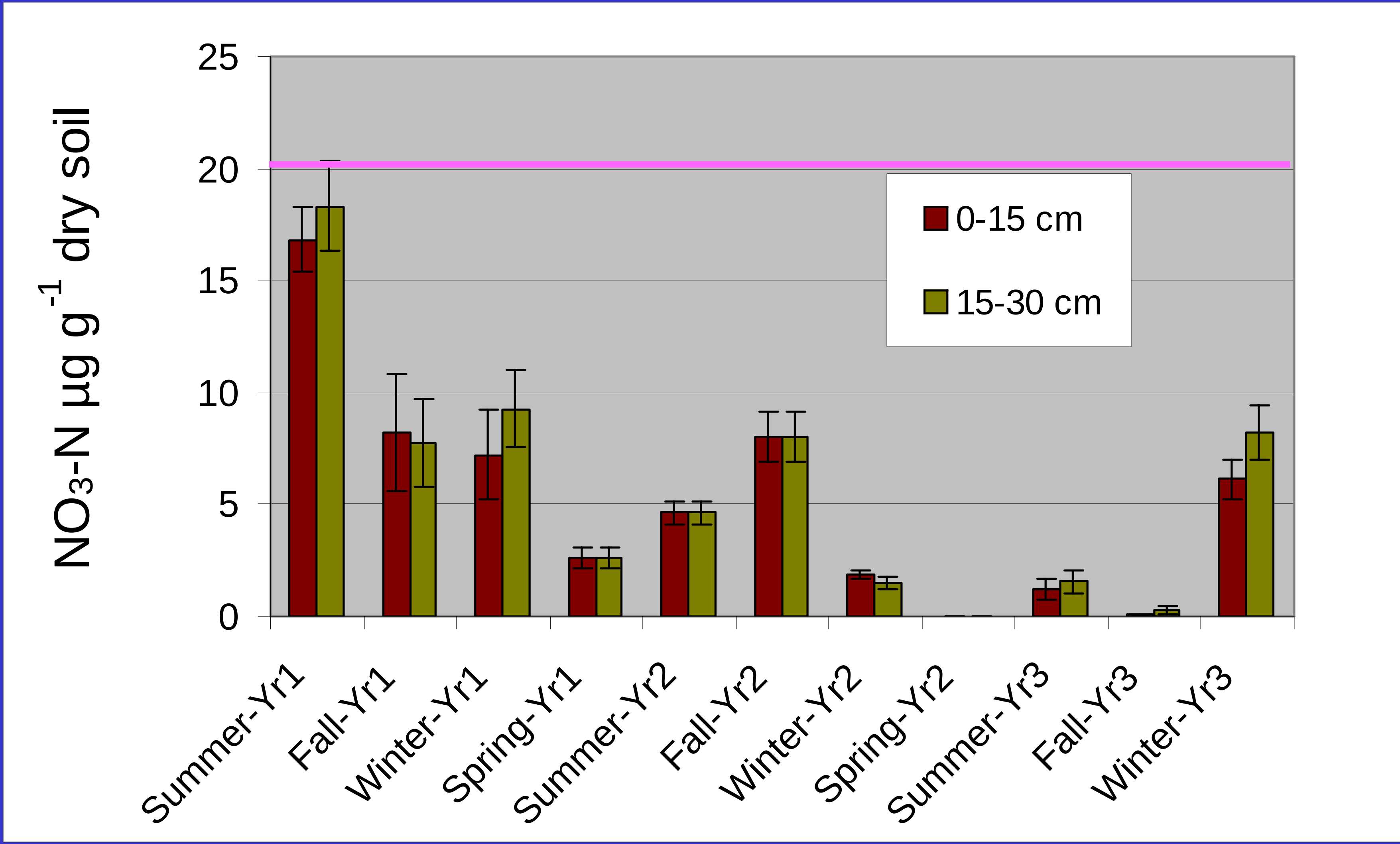
| | Side dress N applied | Total N applied | Total N in crop |
|---|---|---|---|
| Grower | 189 | 247 | 117 |
| PSNT | 77 | 135 | 111 |

Hartz, 2000

# Note on Nitrogen Fertilization of Organic Vegetables Systems

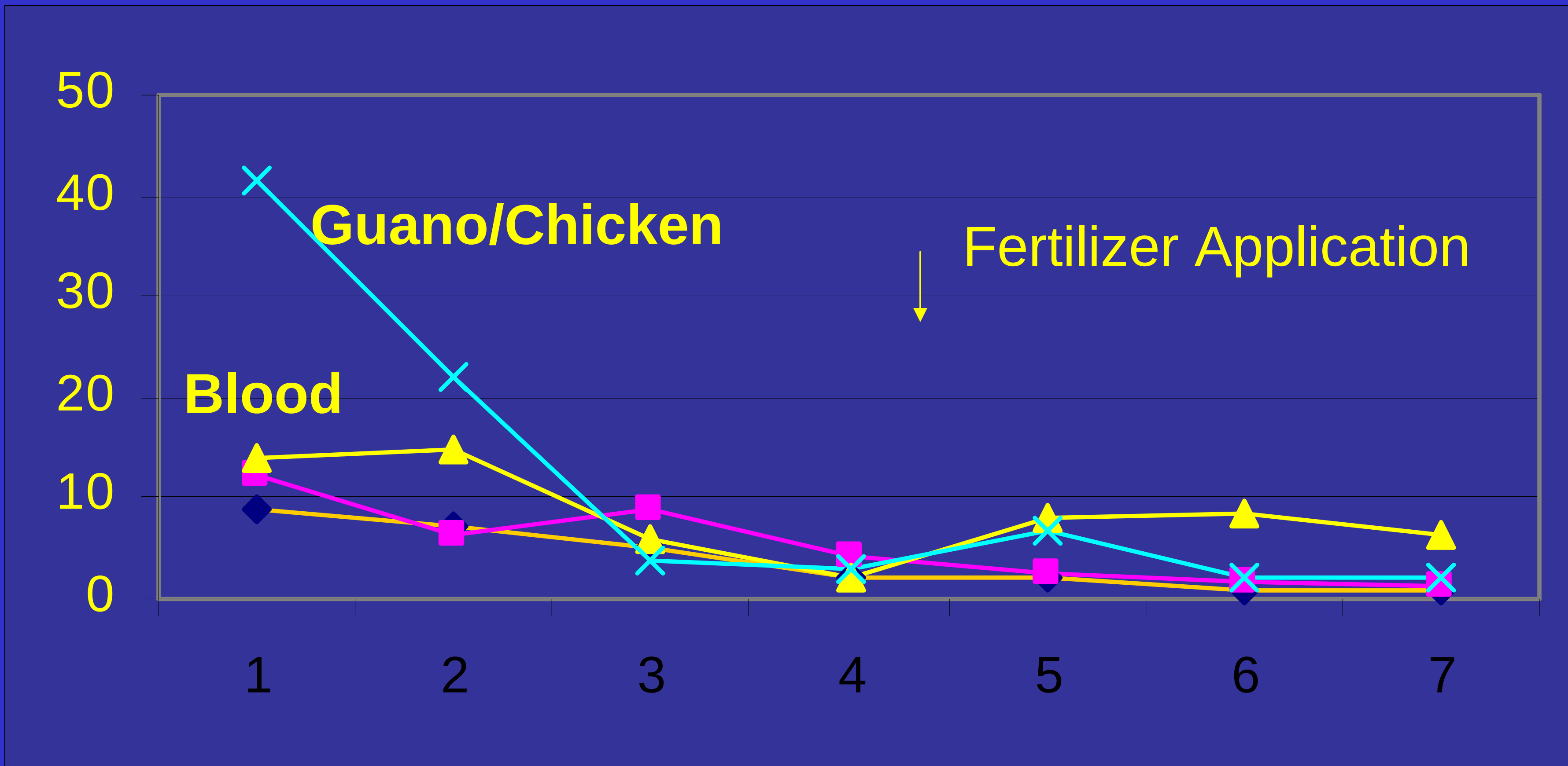
- Nitrate-nitrogen in organic systems is typically at lower levels than in conventional systems
- The presidedress nitrate quick test typically is not useful due to low pools of nitrate in the soil

# Soil Nitrate in Organic Vegetable Production 2001 - 2003




Jackson, 2005

# Nitrate-Nitrogen in the Soil over Season
# Organic Broccoli Fertilizer Trial
## Watsonville, 2001



# 3 - Fertilization Practice: Drip Irrigation Impact on Nitrogen Fertilization of Lettuce

| Irrigation System | Winter/Spring Lbs N/A | Summer/Fall Lbs N/A |
|---|---|---|
| Conventional | 150 - 180 | 100 - 150 |
| Drip | 120 - 130 | <120 |

* Total N content in the tops of lettuce is 110 – 120 lbs N/A and about 15% more is in the roots. As a general rule, it should be possible to reduce fertilization of lettuce by 30% in drip irrigation.

# 4 - Nitrogen in the Irrigation Water

- 0.052 x PPM $NO_3$ = lbs N/acre inch
- 0.62 x PPM $NO_3$ = lbs N/acre foot
- water <45 ppm $NO_3$ can be ignored but waters >65 ppm $NO_3$ can contribute significant N to the crop
- For instance: 65 ppm x 0.052 x 15 inches = 50 lbs N in the water

# 5 - Irrigation management is A Key Technique to Improving Nitrogen Use Efficiency

- Application uniformity reduces nitrogen losses to leaching retention and improves nitrogen use efficiency

# N1: Phosphorus Management

# Techniques for Improving Phosphorus Use Efficiency

- Make phosphorus fertilizer applications based on the soil test values (Olsen Extractable Phosphorus Test)

# Critical Phosphorus Levels in Soil

| Olsen P Soil Test Value | Crop Type |
|---|---|
| 10 - 15 | Most Row Crops |
| 20 | Warm Season Vegetables |
| 35 – 40*<br>55 (lettuce) | Cool Season Vegetables |

* Recently revised for lettuce

# Phosphorus Status of Salinas Valley Soils

| Soil Test Range (ppm P) | Number of Fields |
|---|---|
| < 40 | 9 |
| 40 - 80 | 27 |
| 80 - 120 | 16 |
| > 120 | 8 |
| average | 70 ppm* |

* Pre Agricultural soil P less than 30 ppm

# Organic Production and Soil P Levels

- Organic farms can have high P as well
- 6 organic farms sampled and the soil P levels ranged from 33 – 196 ppm Olsen P
- Compost typically contains 0.3-0.5% P and can add 6-10 lbs P/ton

# Common $P_2O_5$ application rates in the Salinas Valley:

## Typical application rate:

- 40 – 80 lbs $P_2O_5$/A; average = 70 lbs
- 70 lbs $P_2O_5$ = <u>31 lbs of P</u>
- Lettuce typically removes <u>10 – 15 lbs P/A</u>
- Application rates in excess of removal (i.e. <u>15 lbs</u>) may account for the build up (or loading) of P levels in Salinas Valley soils over time

$P = P_2O_5 \times 0.44$

# Response of Cool Season Vegetables to Phosphorus Fertilizer

- **Tim Hartz examined the response of lettuce to Phosphorus fertilization on 12 sites in the Salinas Valley in 2002-2003.**
- **They found only one site (54 ppm P) that responded to Phosphorus fertilization**

# Response of Cool Season Vegetables to Phosphorus Fertilizer

- This data indicated that fertilization with P may be justified on sites with <55 ppm P
- This is especially true of the cool times of the year (i.e. December to March)
- Fertilization of sites with high phosphorus values in the warm time of the season is unnecessary

# Suggested Practice that May Improve Phosphorus Use Efficiency

- Make fertilization decisions based on soil P levels
- Make at-planting applications of P that are equal to amounts being removed by the crop

# Head Lettuce Phosphorus Trial[1]

## Chualar, 2005

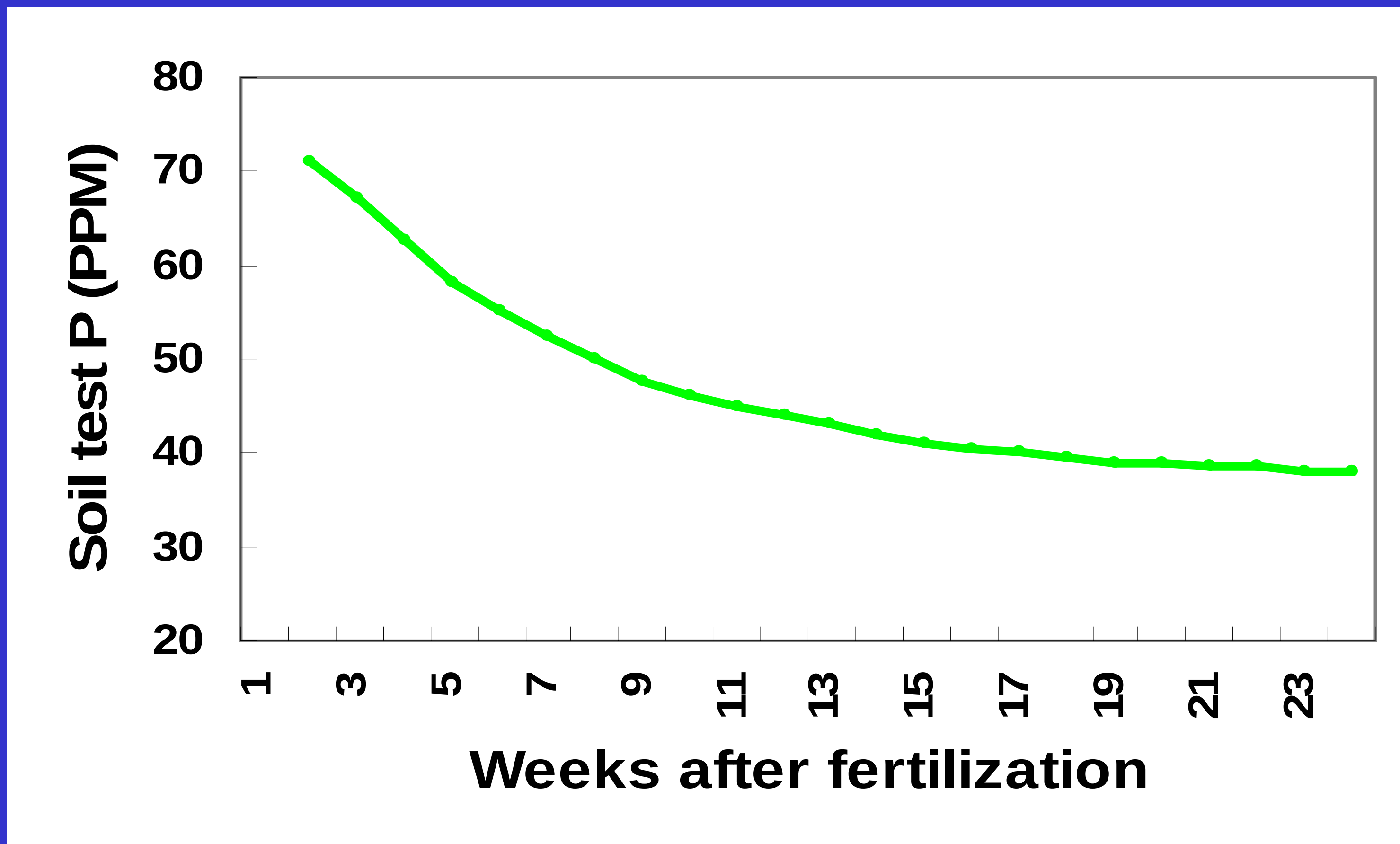
| Treatment and Lbs $P_2 0_5$/A | | Mean Head Weight | Yield Tons/A |
|---|---|---|---|
| Untreated | 0 lbs[2] | 1.09 | 29.6 |
| Field application<br>400 lbs Triple 15 preplant | 60 lbs | 1.04 | 28.9 |
| Actagro 7-21-0 | 20 lbs | 1.18 | 32.9 |
| Ortho Phos 12-58-0 | 20 lbs | 1.10 | 30.3 |
| 10-34-0 | 20 lbs | 1.20 | 32.7 |
| 7-7-0-7 | 20 lbs | 1.17 | 32.2 |

1 - Planted April 25 & soil P = 29.5; 2 – $P_2O_5$

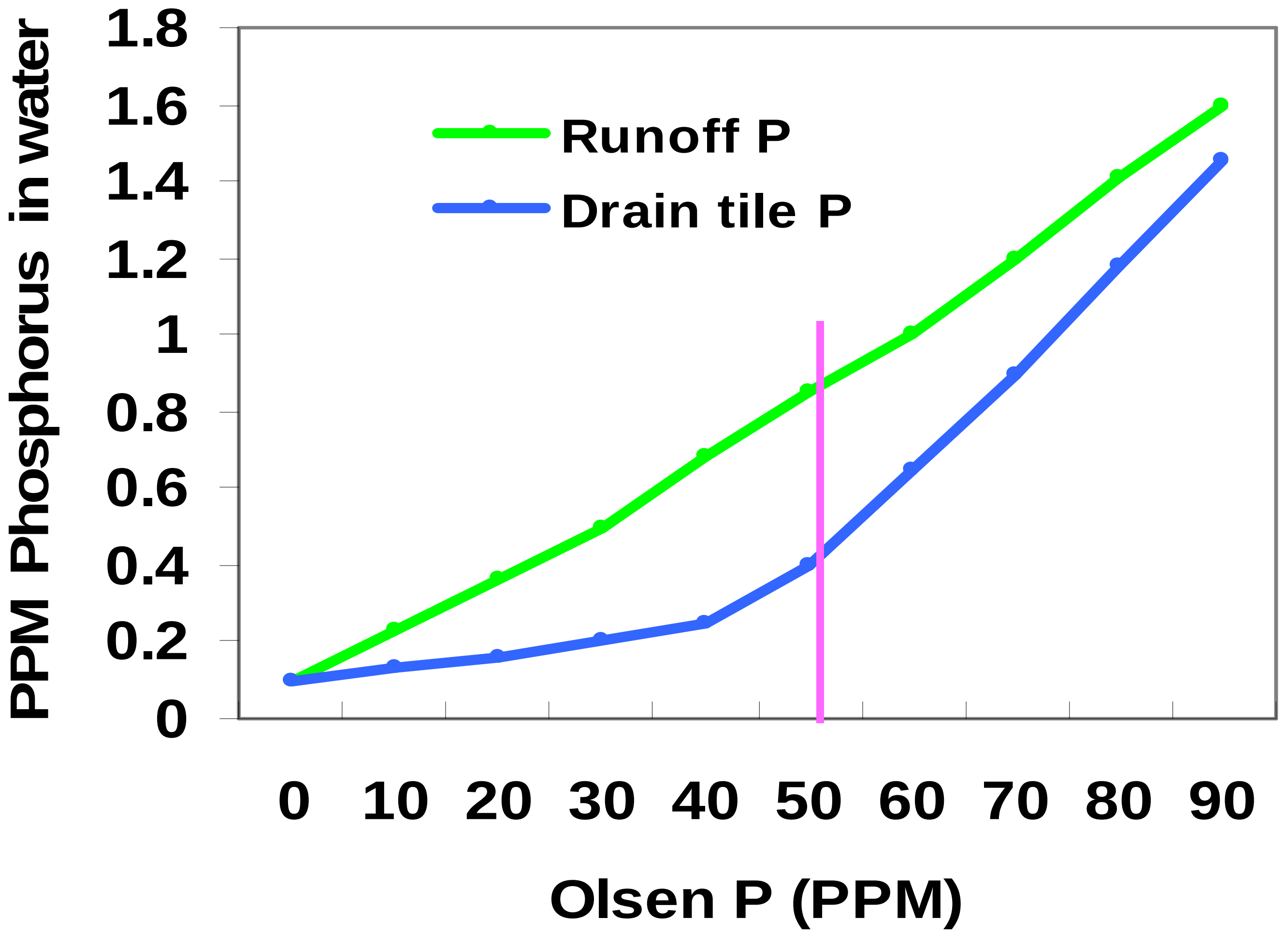
# Suggested Practice that May Improve Phosphorus Use Efficiency

- This trial indicates that there is an advantage to applying low rates of phosphorus as a banded application at planting
- This can help to improve the efficiency of the application to reduce the loading of phosphorus in Salinas Valley Soils

# Timing of application of P makes a difference :




@ 77 $^oF$ at field capacity



PPM Phosphorus in water
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Runoff P
Drain tile P
0
10
20
30
40
50
60
70
80
90
Olsen P (PPM)


Hartz, 2002

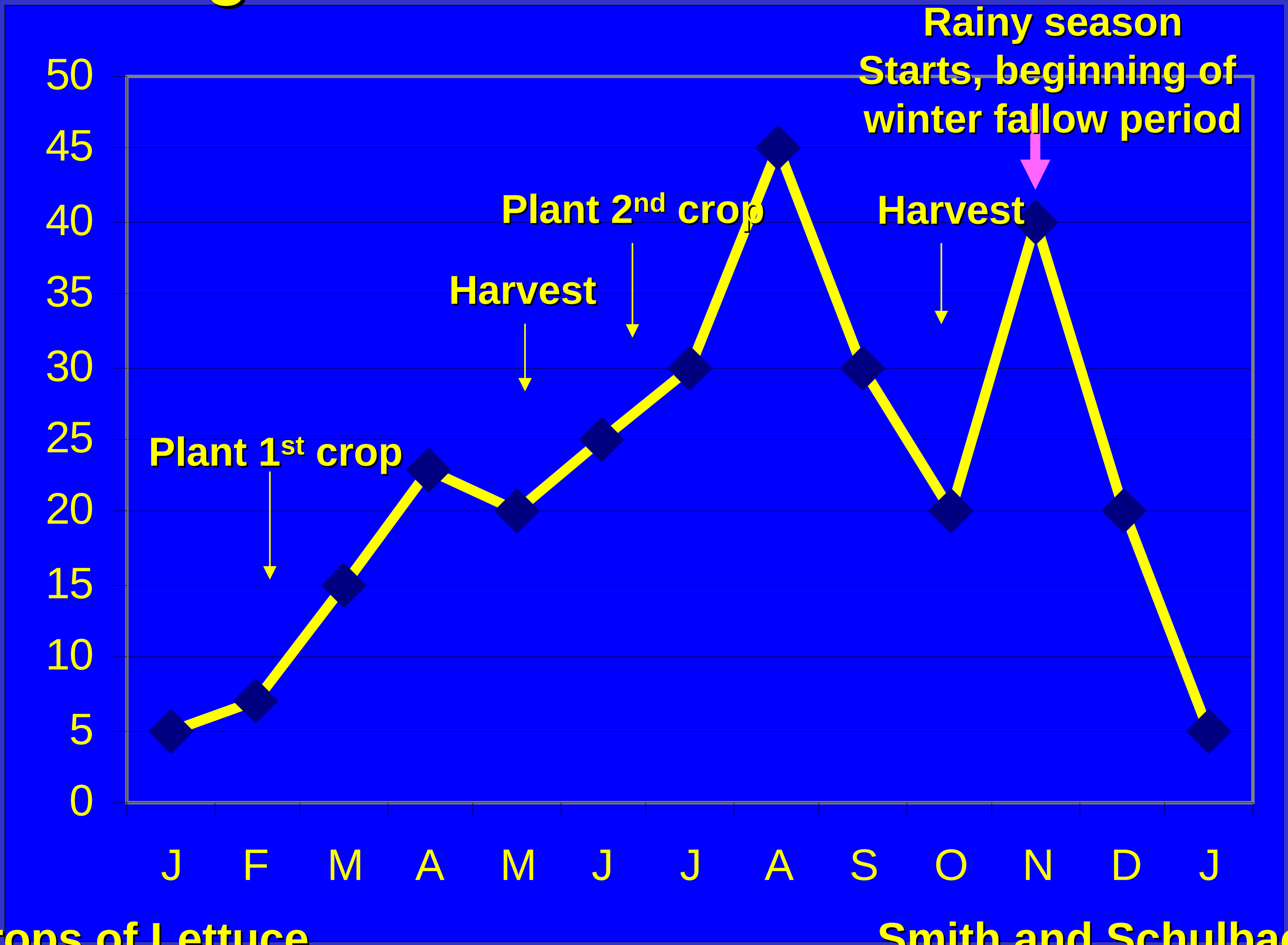
# N4: Potential for Offsite Movement of Nitrogen and Phosphorus

- Water
- Eroding soil
- Wind

# Techniques to Maintain Nitrogen in the Crop System

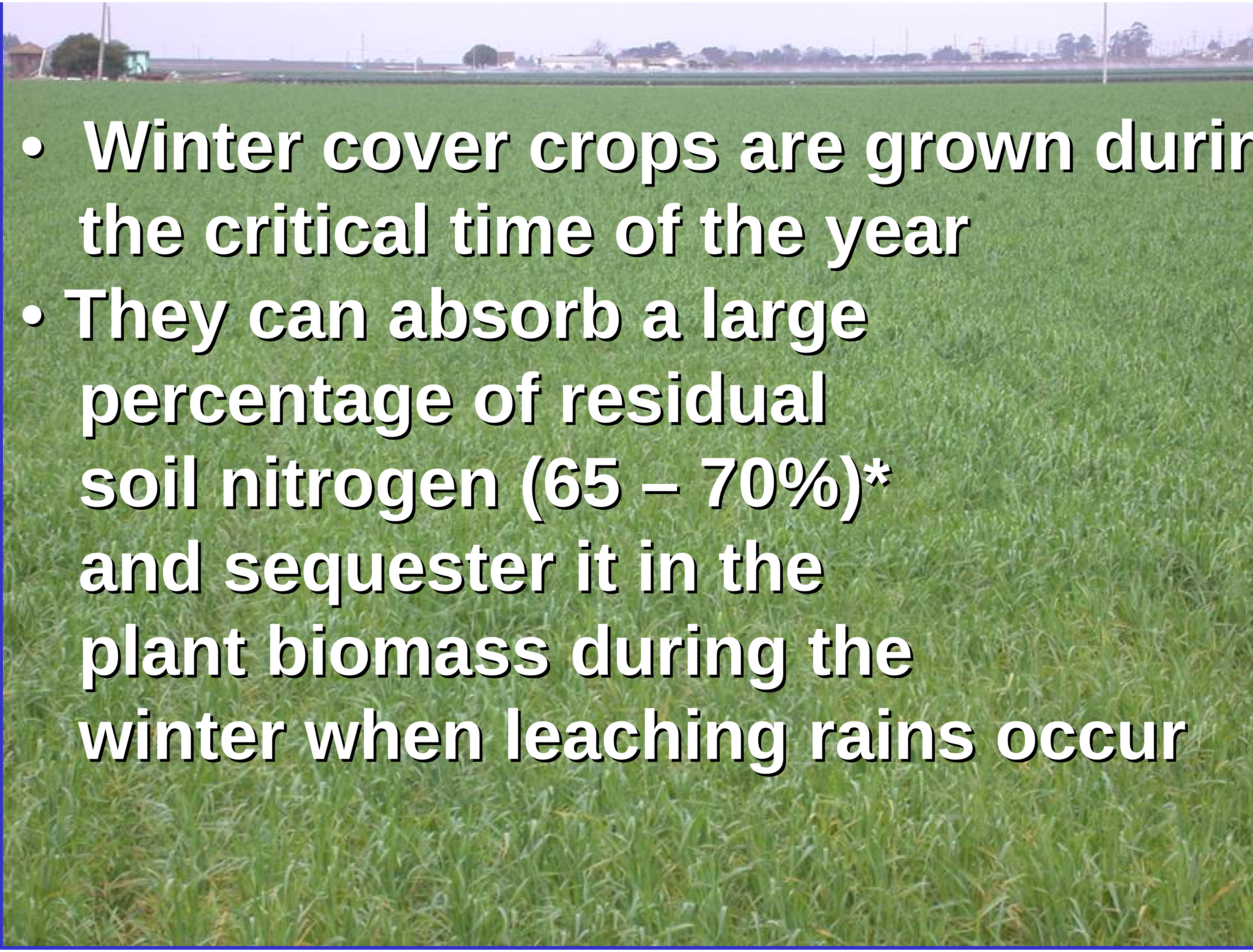
- Winter Cover Crops – reduce runoff & sediment load
- Vegetative Buffer Strips
- Sediment collection ponds

# Typical Soil Nitrate-N Levels in Soil Over Growing Season* in Conventional Production




* Two crops of Lettuce

Smith and Schulbach, 1996


• Winter cover crops are grown during the critical time of the year
• They can absorb a large percentage of residual soil nitrogen (65 – 70%)* and sequester it in the plant biomass during the winter when leaching rains occur

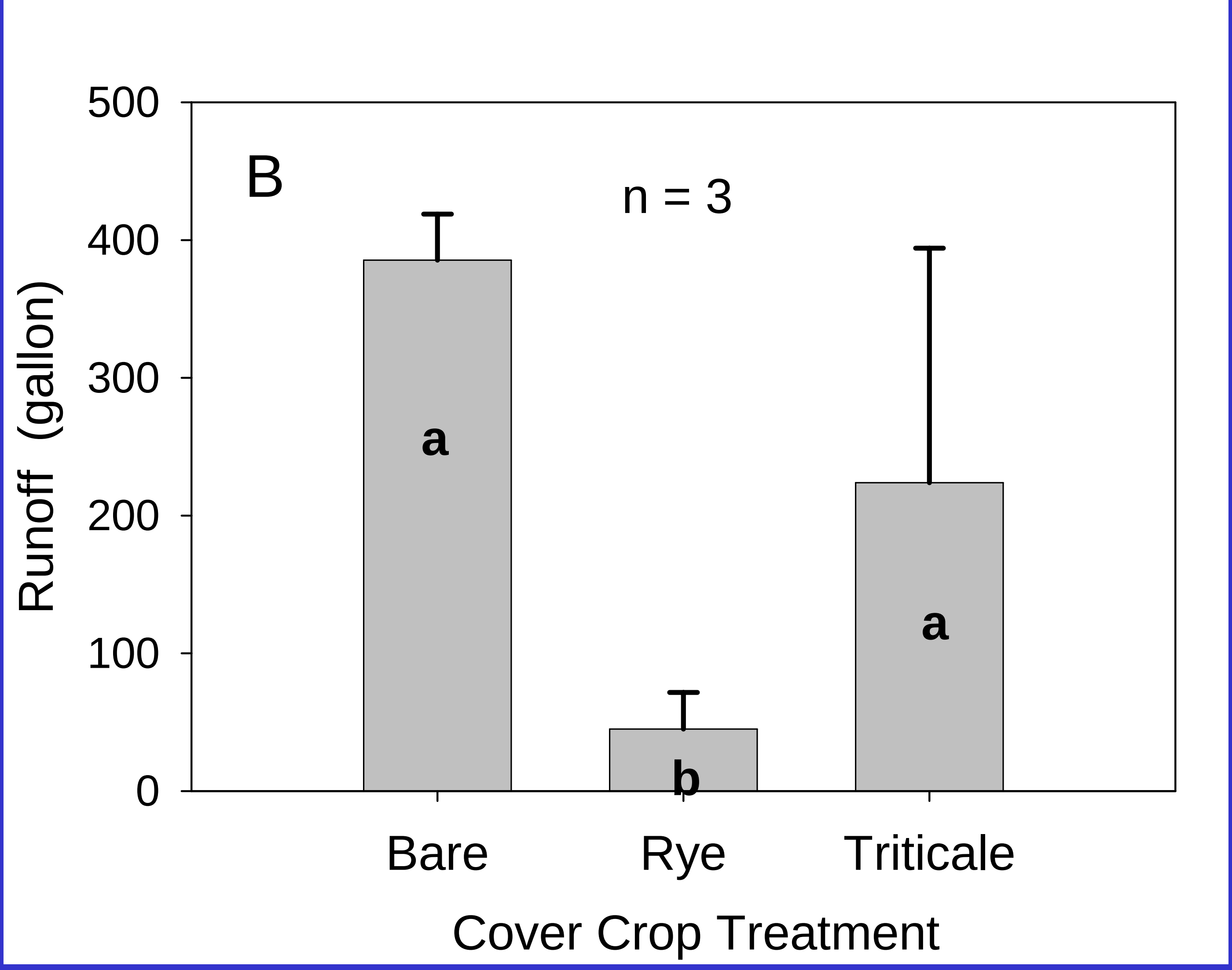
# Nitrate-Nitrogen Captured in Resin Bags (@ 3 ft) Following 2 Month Rainy Period*

## January 2004

| Cover Crop Treatment | Kg/Ha |
|---|---|
| Cereal Rye ‘Merced’ | 15.6 |
| White Mustard ‘Ida Gold’ | 14.1 |
| Indian Mustard ‘ISCI 61’ | 7.6 |
| Bare Fallow | 43.0 |

* 4.7 inches precipitation

# Cover Crops Reduce the Quantity of Runoff



# Cover Crops Improve the Quality of the Runoff Water


**Rye Cover Cropped Plot**

**Bare Plot**

# Cover Crop Systems to Improve Water Quality

- Traditional winter cover crop – has significant limitations in the Salinas Valley
- Fall cover crops – has increased due to the use of mustards
- Other Ideas?

# Summary of the Use of Cover Crops to Reduce Water Quality Issues

- Cover crops can reduce nitrate leaching, sediment and nutrient loads in runoff, can trap residual nitrogen and help to build up organic matter in the soil
- We need to explore ways to use them to make them user friendly and reduce their impact on production schedules

# Summary: Nitrogen & Phosphorus Management

- **What can we do?**
  1. Determine crop requirement
  2. Account of soil residual N and soil P levels and adjust fertilization practices accordingly
  3. Use the most efficient fertilization and irrigation practices
  4. Minimize leaching and runoff

# For Further Information

- Contact our office (University of California Cooperative Extension), NRCS or RCD
- Upcoming UCCE Winter Meetings:
  - Annual Irrigation and Nutrient Management Meeting
    - February 20, 2007

      Agricultural Center

      1432 Abbott Street, Salinas