

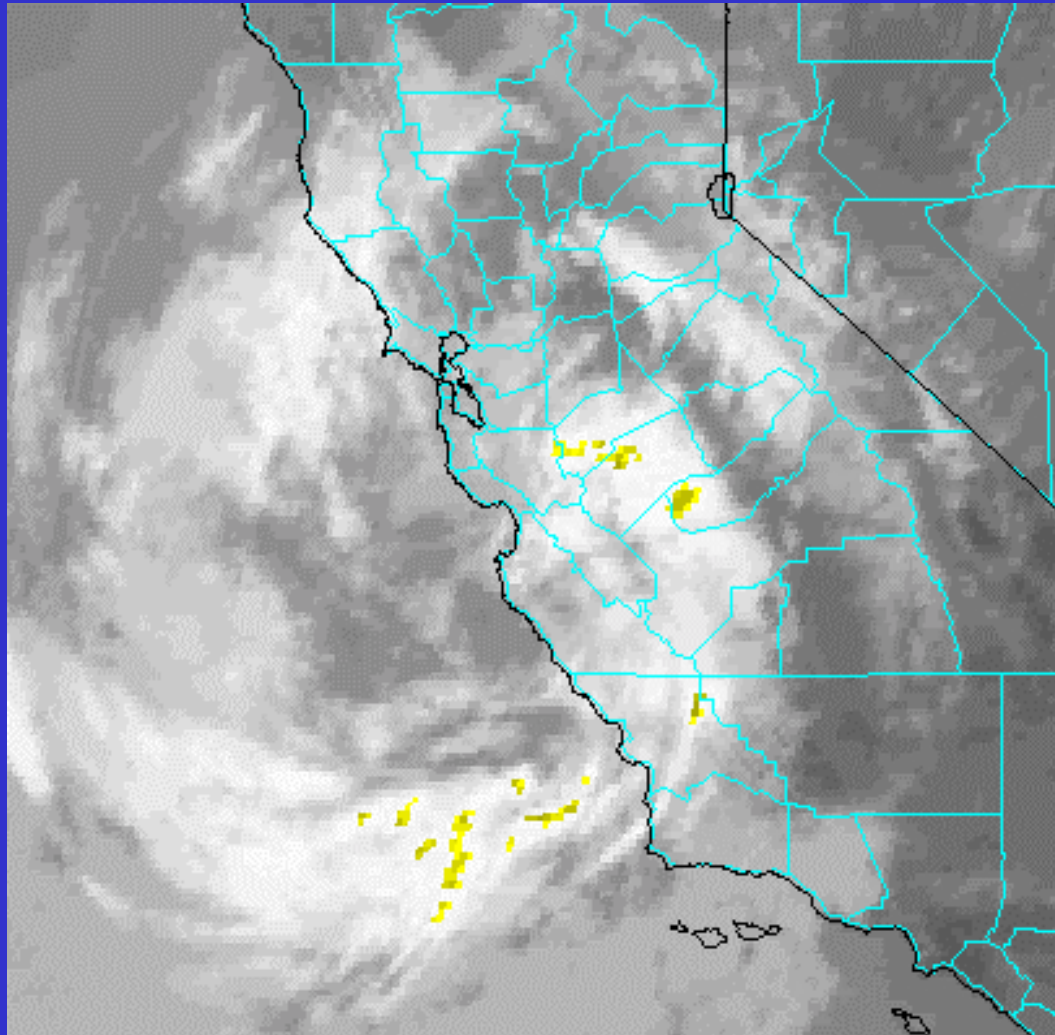
# **The Many Roles of Cover Crops in Organic Crop Production**

**Richard Smith, Farm Advisor  
University of California Cooperative Extension  
Monterey, Santa Cruz and San Benito Counties**

# Background on Cover Crops

- **Cover cropping is an age old agricultural practice that can benefit soils/crops by:**
  - **Increasing nitrogen (N) supply to subsequent crops**
  - **Conserve nutrients (i.e. reducing N leaching)**
  - **Improve soil physical properties**
  - **Reduce soilborne pest pressure**
  - **Reduce soil erosion (water quality benefits)**

# If Cover Crops are So Beneficial, Why are They Not More Commonly Planted



- Direct cost (\$150 to \$200/A)
- Opportunity Costs
- Risk of missing planting schedules
- Dealing with cover crop residue in the spring (wet soils)
- Negative impacts of cover crop use (pests)



**Cereals**



**Legumes**



**Mustards**

**Others**

# Cover Crop Planting Slots

- **Planting Slots**
  - **Winter (Oct. – March)**
  - **Summer**
  - **Fall (Sept. to Oct.)**

# Cover Crop Roles

- **Nutrient input and cycling**
- **Pest management impacts**
- **Soil quality impacts**
- **Water quality impacts**

# 1. Nutrient Input and Cycling of Cover Crops

- **Cereals and mustards are good at scavenging N from the soil. In the Salinas Valley, there are often high levels of residual N in the soil left over from intensive crop production**
- **Legumes have the ability to fix nitrogen. However, in high residual N soils, legume nodulation and N fixation are reduced**

# Nitrogen Content of Cover Crops

Six year Average

<b>Cover Crop</b>	<b>6 year mean</b>
<b>Cereals</b>	<b>131.5</b>
<b>Legumes</b>	<b>145.7*</b>
<b>Cereal/Legume Mix</b>	<b>177.1</b>

\* How much is net fixation is not known

# Scavenging of N - Three Cover Crops

Chualar, 2003

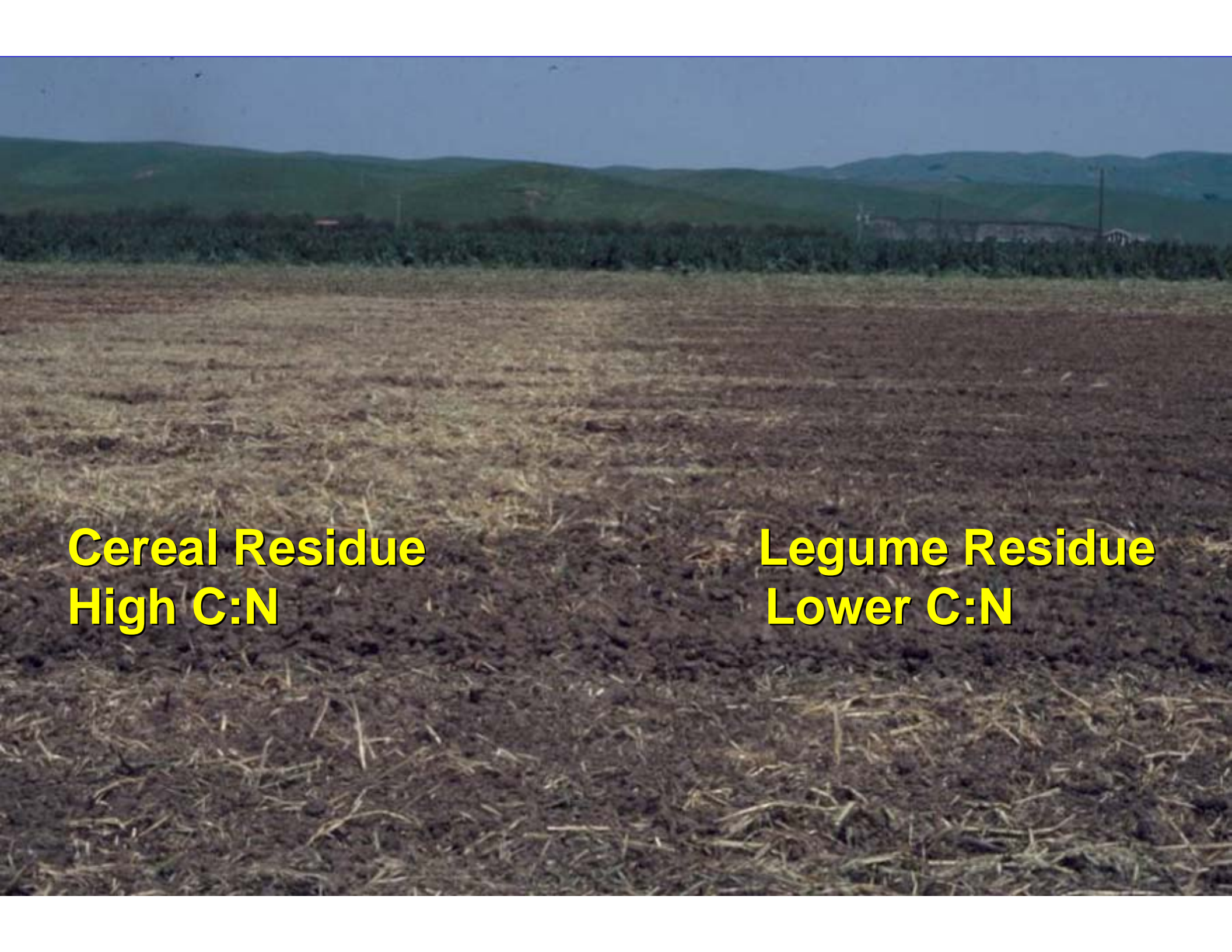
<b>Cover Crops</b>	<b>Biomass T/A</b>	<b>% N in Tops</b>	<b>lbs N/acre in Tops</b>
<b>White Mustard</b>	<b>2.5</b>	<b>3.9</b>	<b>194.8</b>
<b>Indian Mustard</b>	<b>2.2</b>	<b>4.5</b>	<b>199.7</b>
<b>Cereal Rye</b>	<b>3.1</b>	<b>3.3</b>	<b>203.7</b>

# Release of N from Cover Crops

- **When cover crops are incorporated into the soil, microbes begin to decompose the tissue and the complex forms of nitrogen that they contain (i.e. proteins)**
- **Plant available forms of nitrogen (ammonium and nitrate) are released to the soil through this process**

# Release of N from Cover Crops

- The N content of the cover crop at incorporation is an important consideration whether the cover crop will release N or whether it will be tied up in the microbial biomass (immobilized)
- In general C:N ratios  $> 25$  immobilize nitrogen (i.e. cereals at heading)
- Leaf tissue with higher N content mineralizes quickly, while the stem tissue may take longer to break down



**Cereal Residue**  
**High C:N**

**Legume Residue**  
**Lower C:N**

# Nitrogen Content of the Cover Crop Tops, C:N Ratio and Potential N Mineralization

	<b>Percent N in CC</b>	<b>C:N Ratio</b>
<b>Immobilize Nitrogen</b>	<b>0.5</b>	<b>1:90</b>
	<b>1.0</b>	<b>1:45</b>
	<b>1.5</b>	<b>1:30</b>
<b>May Release N</b>	<b>2.0</b>	<b>1:23</b>
	<b>2.5</b>	<b>1:18</b>
<b>Release N Immediately</b>	<b>3.0</b>	<b>1:15</b>
	<b>3.5</b>	<b>1:13</b>
	<b>4.0</b>	<b>1:11</b>

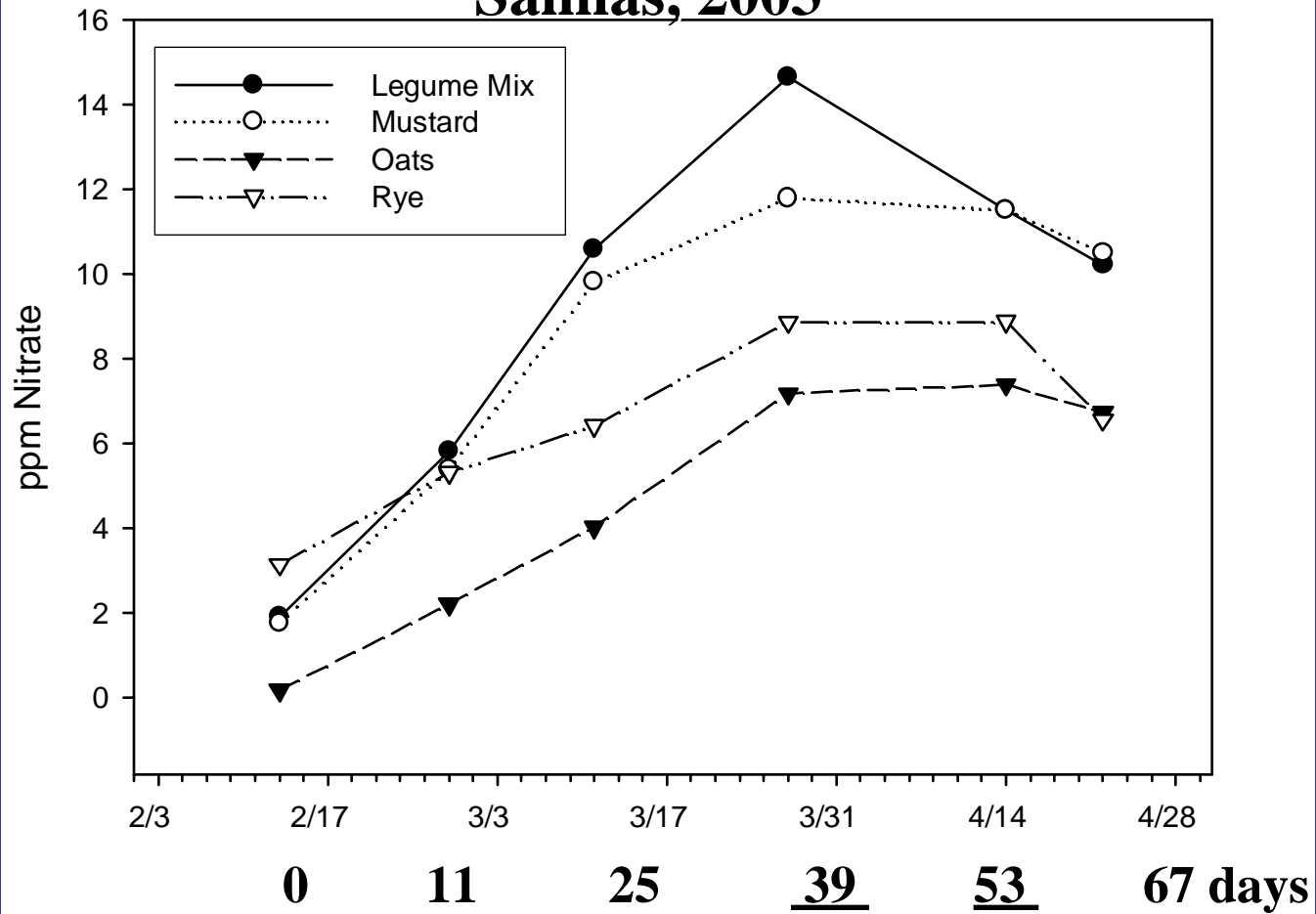
# Release of N from Cover Crops

- **The ideal scenario would be that the release of N from cover crop residue would match the N demand by crops (i.e. fast enough to match crop demand, but not so fast to leach)**

# Cover Crops and Nitrogen Nutrition

- The synchronization of N release from cover crops with the demand by the subsequent cash crop are important for efficient use of cover crop N
- Release of N from cover crops depends upon the cover crop species, stage of growth and soil moisture/temperature conditions upon incorporation

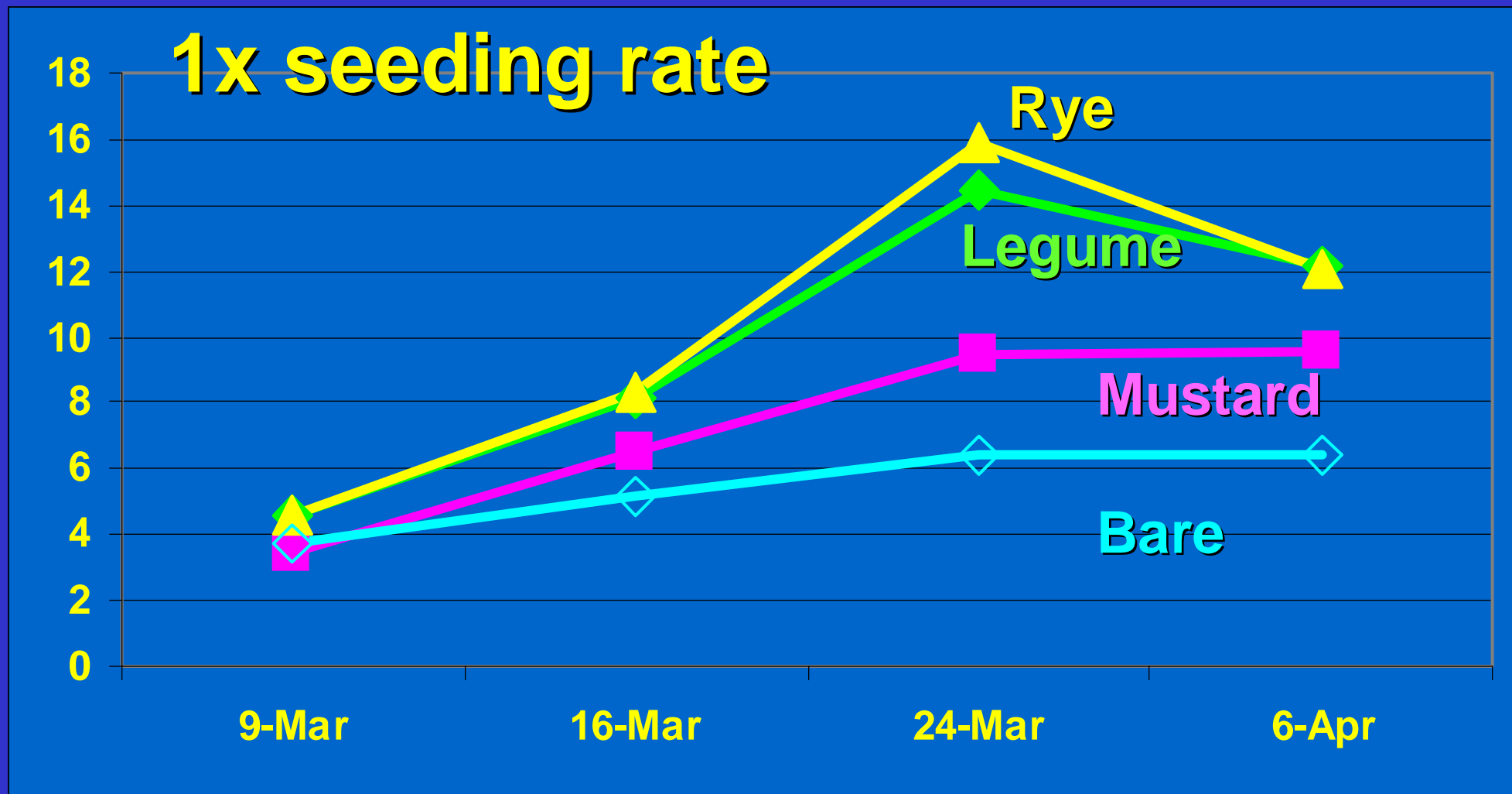
# Nitrate Release from Cover Crops Salinas, 2003\*



\* No crop present

# Cover Crop Mineralization Comparison

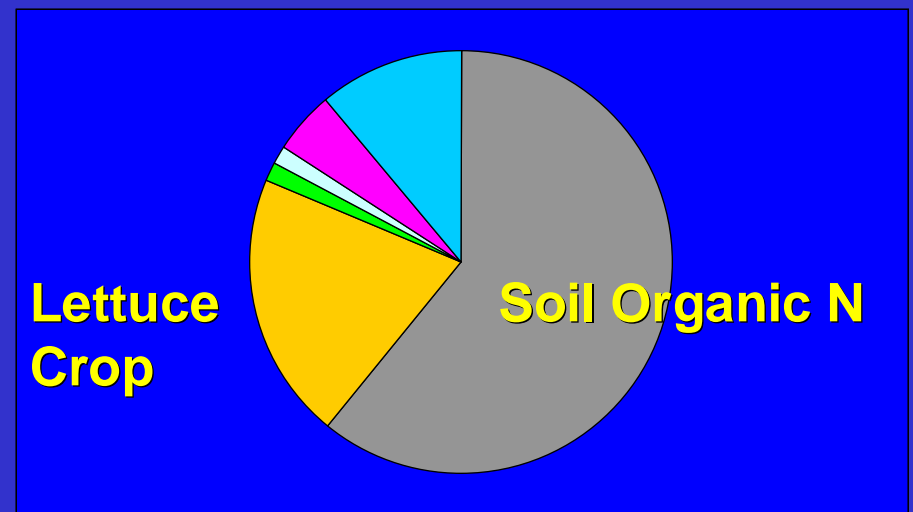
Salinas, 2004



# How Much Cover Crop N is Made Available for Crop Growth

- **Cover crops can contain 100 – 200 lbs N but typically less than half of this is made available to the subsequent crop**

**Cover Crop in Lettuce  
Four months after incorporation**



**Jackson, 2000**

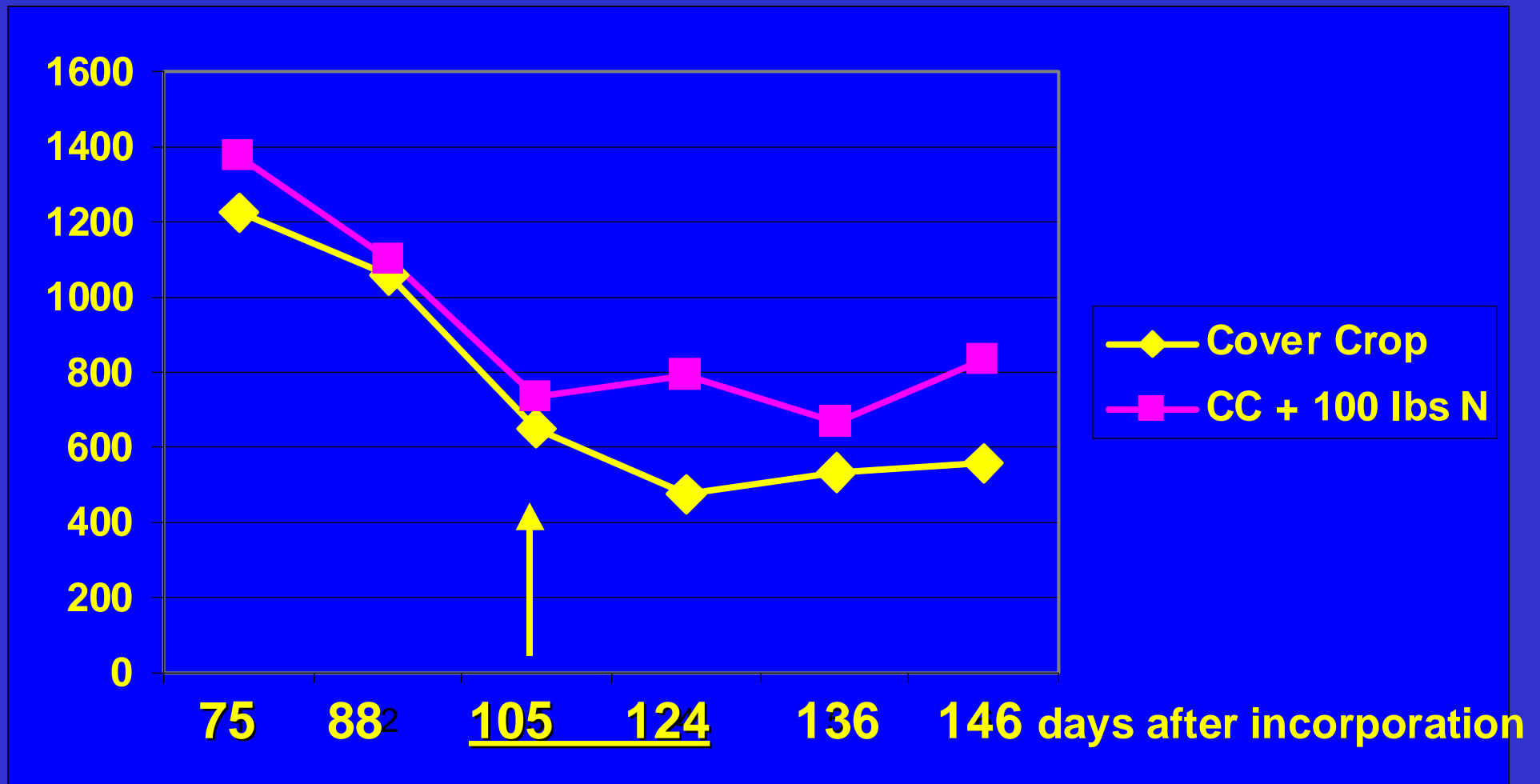
# How Long is Cover Crop N Available for Crop Growth

- **Following the initial burst of mineralization soil N levels return to background levels after 6 – 10 weeks**
- **The longevity of the release of N is a concern for crops that have a growth span of >6 weeks or so**
- **Cover crop N may be sufficient for short term crops (i.e. spinach, radishes), but longer season crops will need supplemental N applications**

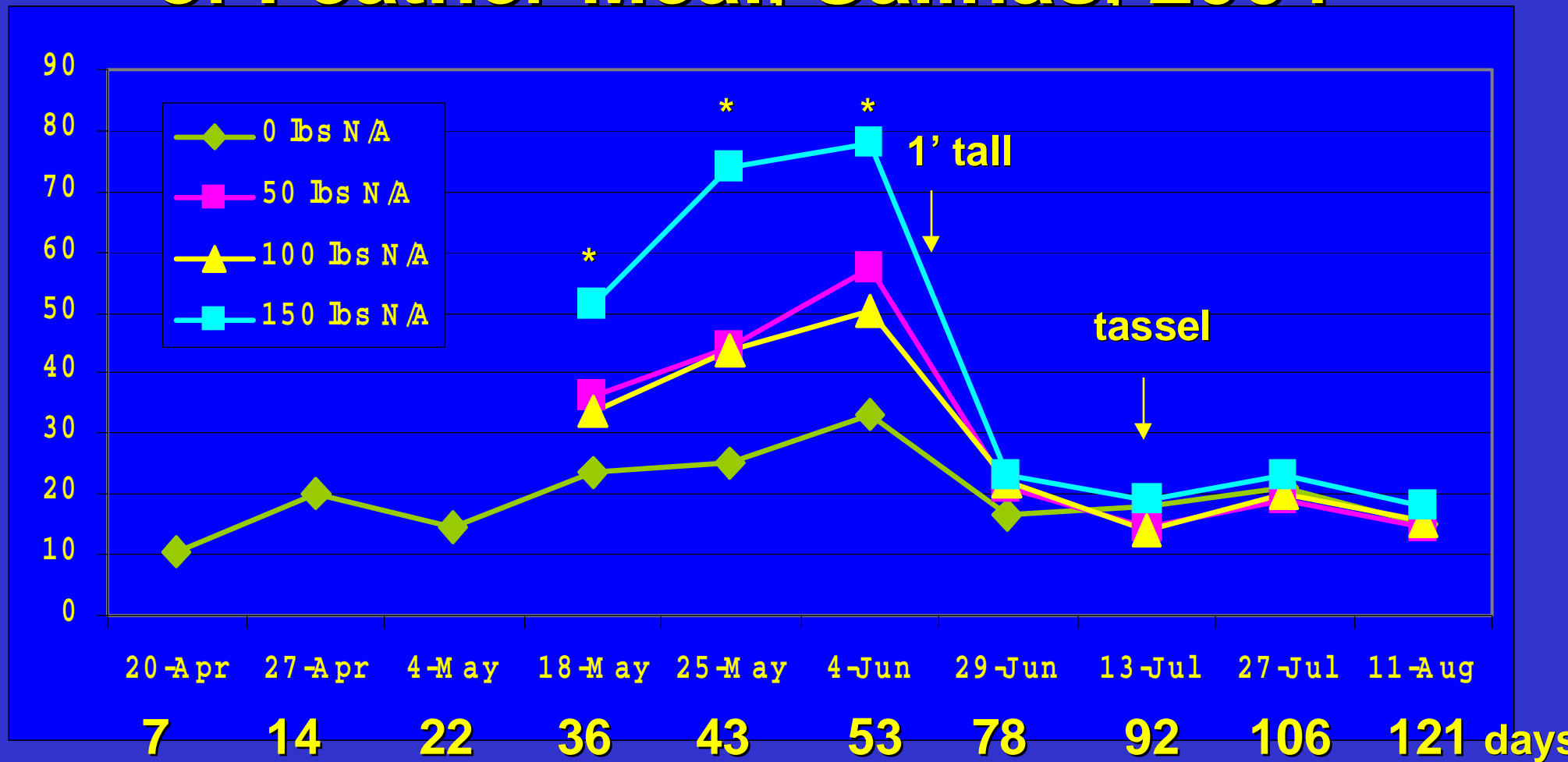
# Nitrogen Release from Cover Crops

- **The difficulty in matching the release characteristics of cover crops with the nitrogen demand of horticultural crops necessitates supplemental fertilization for many crops**
- **The other difficulty is the nature of the crops: shallow rooted, high N demand and quality concerns**

# Nitrate N in Pepper Petioles Following Cover Crop with and without Supplemental Application of Feather Meal

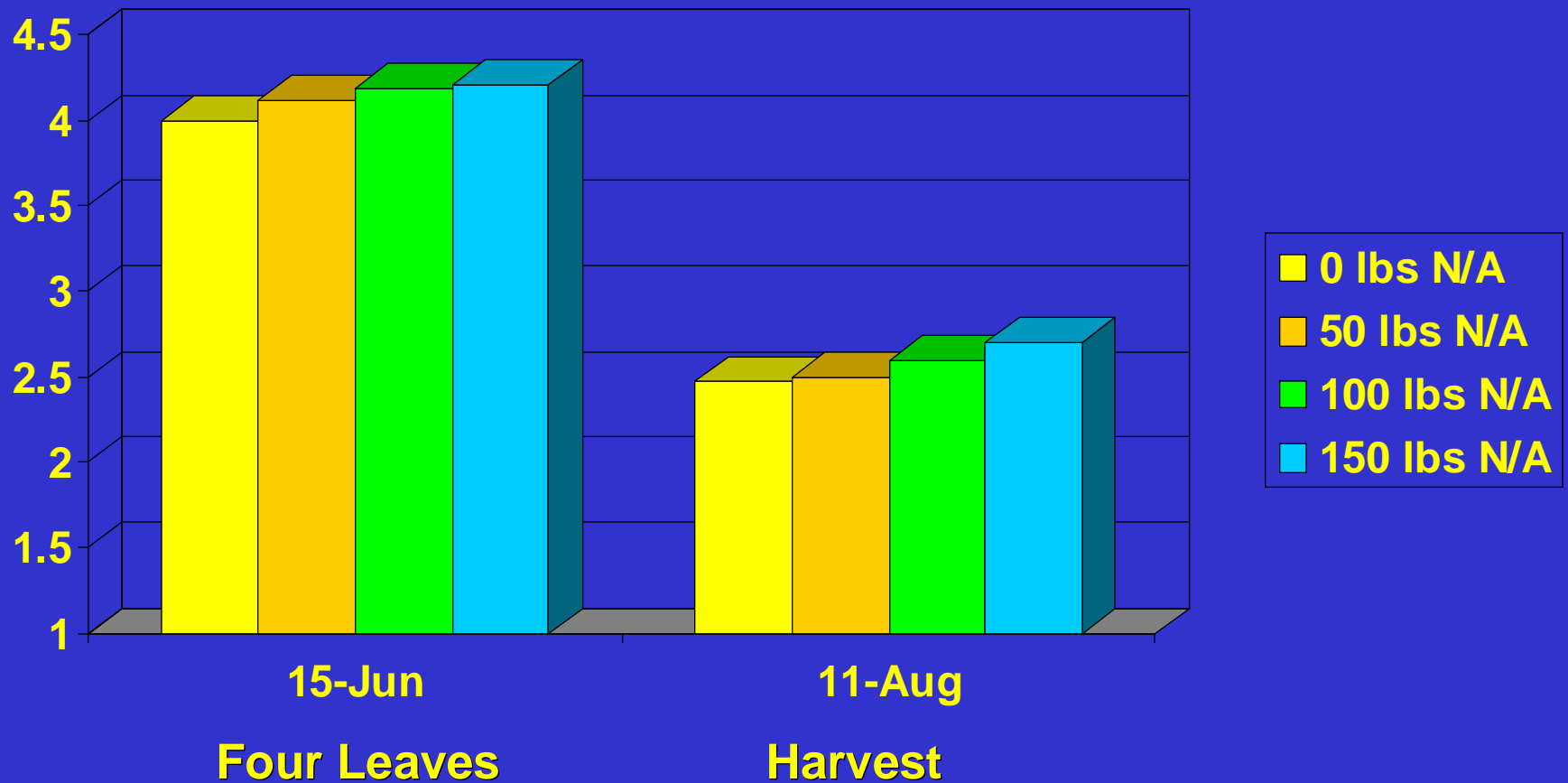


# Nitrate Nitrogen in Soil of Sweet Corn Following Cover Crop and Four Rates of Feather Meal, Salinas, 2004

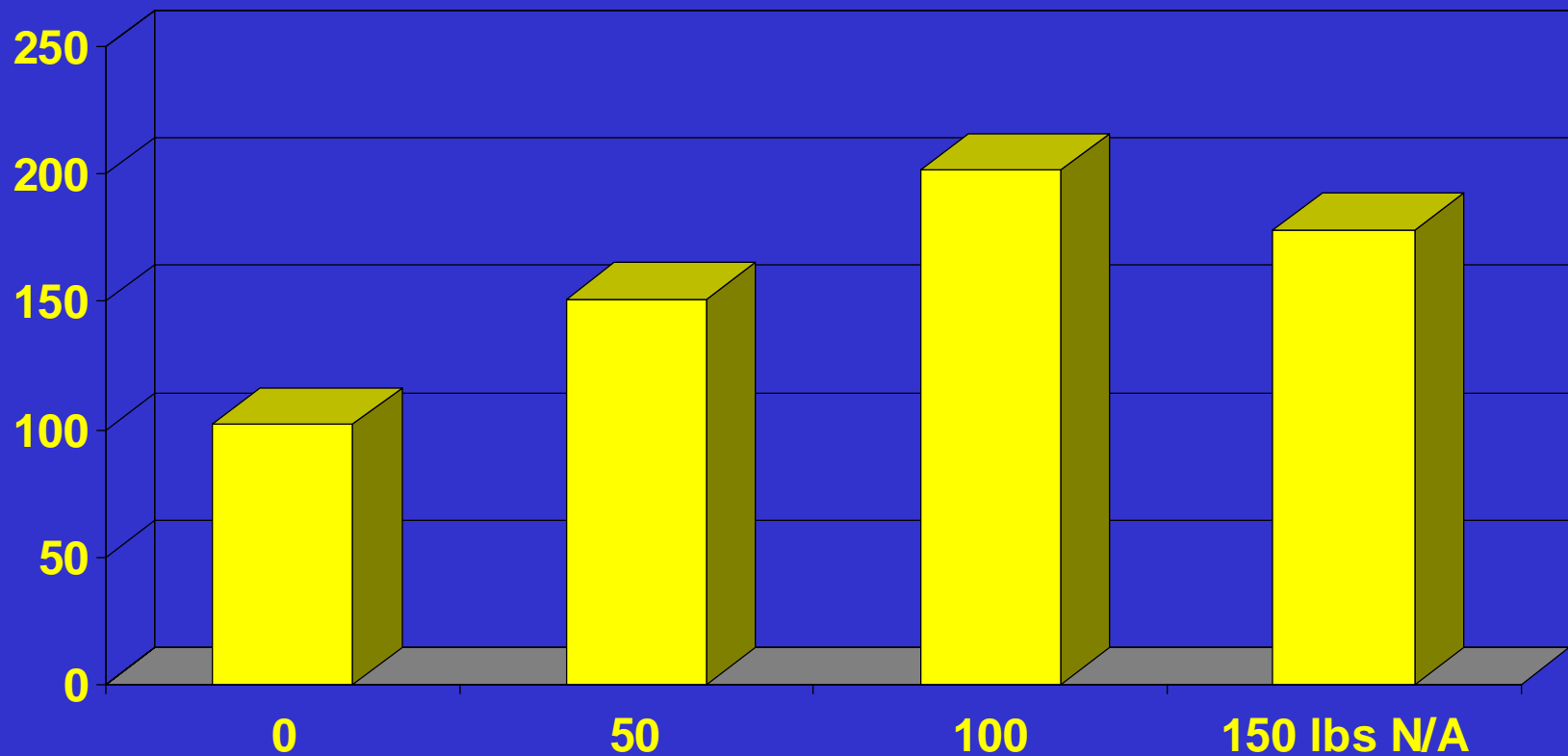


# Total Nitrogen in Corn Tissue

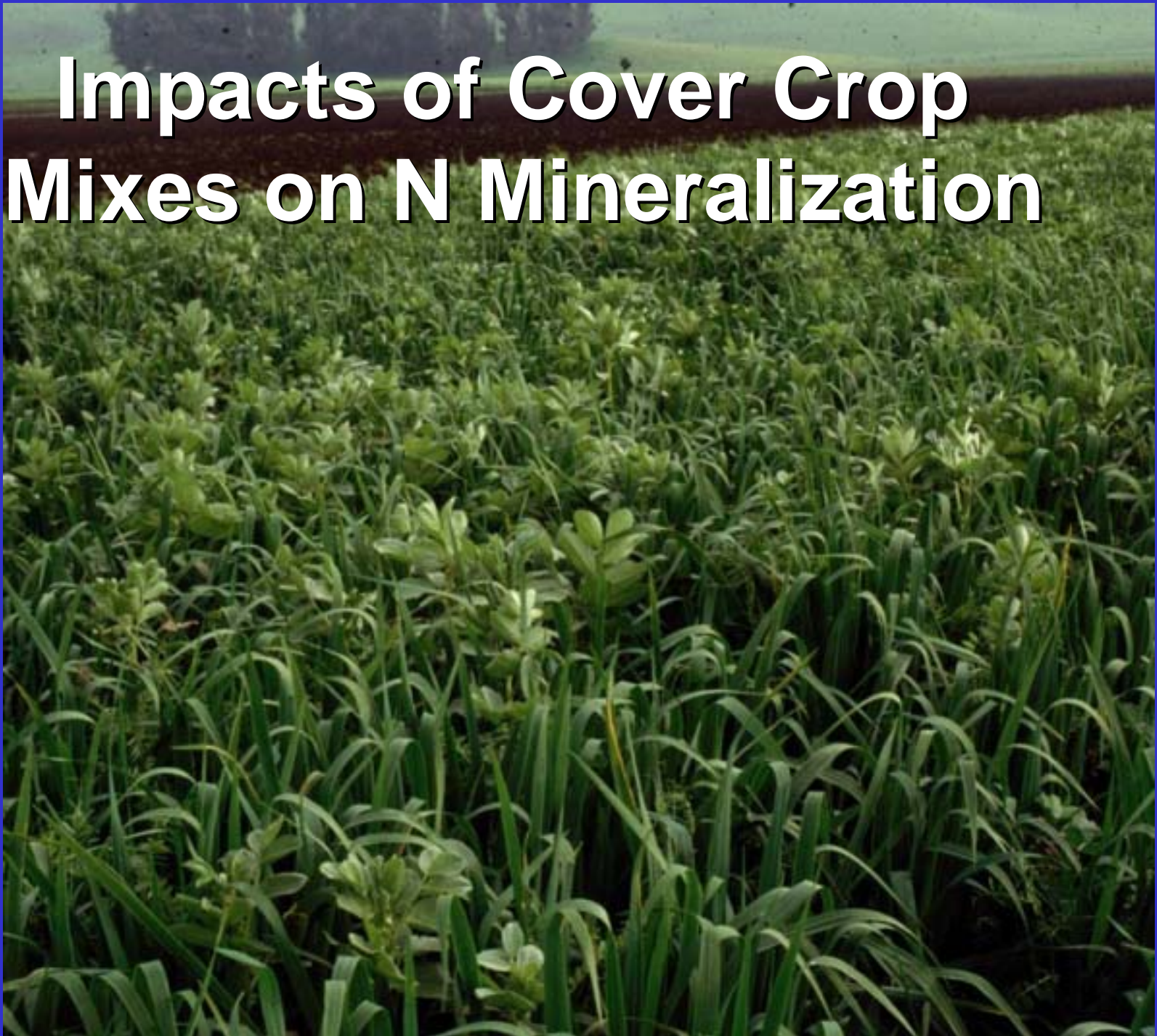
## Two Growth Stages



# Yield of Sweet Corn Fertilizer Rates Following Cover Crop



# Impacts of Cover Crop Mixes on N Mineralization



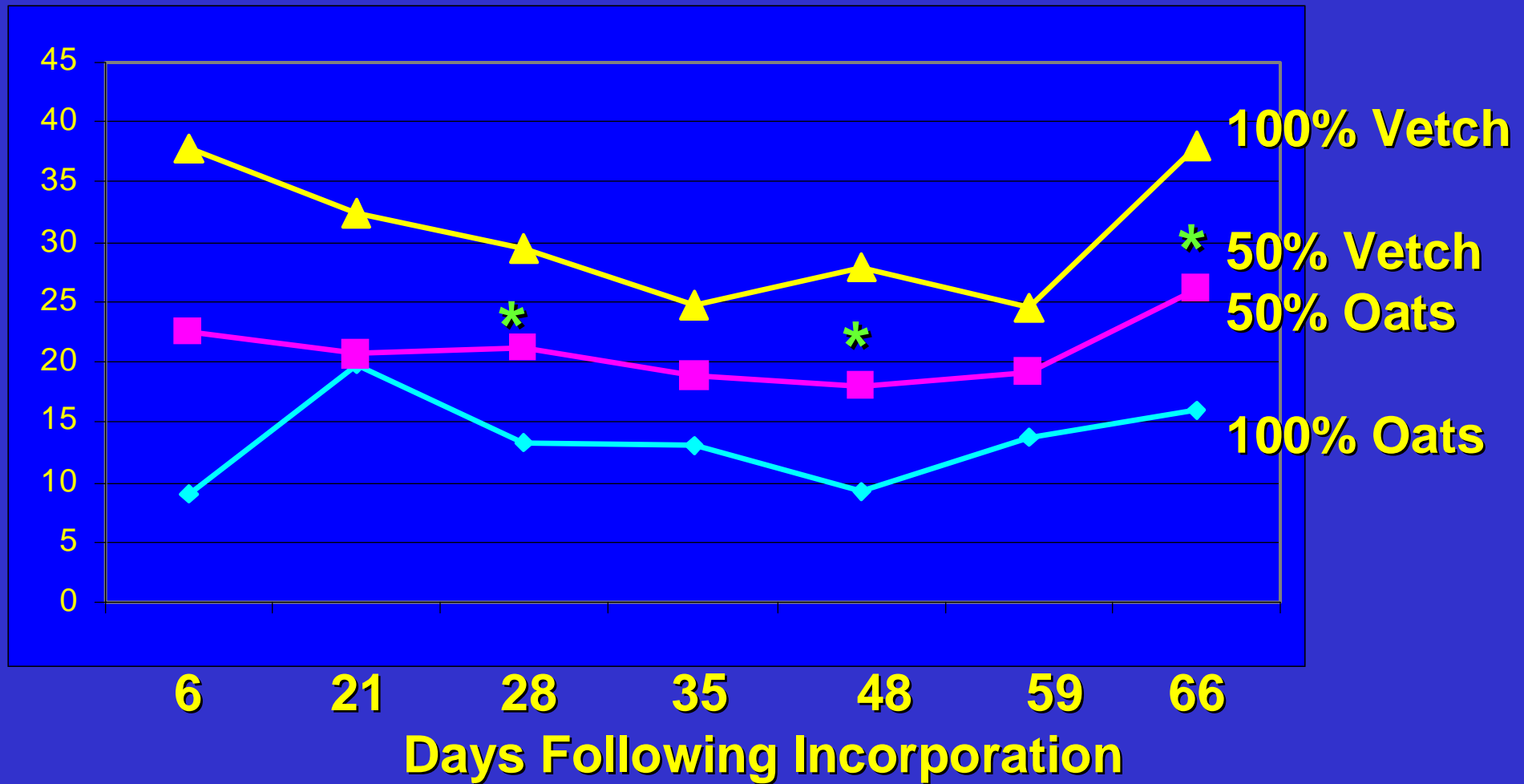
# Biomass and Composition of Oats, Vetch and Mix

Salinas, 2004

<b>Cover Crop Mix</b>	<b>Biomass T/A</b>	<b>Cereal %</b>	<b>Vetch %</b>
<b>100% Oats</b>	<b>5.01</b>	<b>100.0</b>	<b>0.0</b>
<b>50% Oats/50% Vetch</b>	<b>4.50</b>	<b>93.4</b>	<b>1.6</b>
<b>100% Vetch</b>	<b>1.83</b>	<b>0.0</b>	<b>100.0</b>

# Nitrogen Release from Cover Crop Mix

Salinas, 2004



# Summary of Nitrogen Impacts of Cover Crops on Crop Production

- **Cover crops mineralize useful amounts of nitrogen that can be an important source for subsequent crops**
- **For high yield and quality, supplemental applications of N are needed for long-season crops**
- **Over a period of years, as the soil organic matter levels build up from the use of cover crops and compost, the amounts of supplemental nitrogen fertilizer needed for high yields may decline**

## 2. Pest Management Impacts of Cover Crops

- Insects**
- Disease**
- Weeds**

# **Insect Pest Impacts**

- **The impacts of cover crops can be both positive and negative**
- **Cover crops provide habitat that can be useful to beneficial insects, but that also can be useful to pests**
- **Often times these are mute points if the cover crop is grown out of synch with the crop cycle, but can be issues if they are being produced while crops are present or increase the pest population**



**Flea Beetle on Mustard**



**Grain Aphid on Cereal**



**Diamond Back Moth on Mustard**

# Soilborne Disease Impacts

- There is a fair amount of literature regarding the impacts of cover crops on soilborne diseases
- mustard cover crops are currently being investigated in the Salinas Valley for their impact on *Sclerotinia minor*
  - Krishna will discuss

**A key concern of cover crops is that they do not build up soilborne diseases such as Sclerotinia which then can attack the cash crop**



**Sclerotinia on Vetch**

<b>Cover Crop</b>	<b>Disease on Cover Crop %</b>	<b>Disease of Subsequent Crop %</b>
<b>Lana Vetch</b>	<b>22.9</b>	<b>27.3</b>
<b>Purple Vetch</b>	<b>18.1</b>	<b>21.9</b>
<b>A.W. Pea</b>	<b>33.4</b>	<b>30.1</b>
<b>Fava Bean</b>	<b>0.3</b>	<b>13.5</b>
<b>Romaine Lettuce</b>	<b>89.5</b>	<b>24.4</b>
<b>Barley</b>	<b>0.0</b>	<b>14.6</b>
<b>Fallow</b>	<b>----</b>	<b>15.2</b>

**Koike et al., 1996**

# Weed Impacts

- **During the cover crop growth cycle they can allow weeds to grow and set seed**
  - Eric will discuss
- **Following the cover crop growth cycle, mustard cover crops have been shown in the literature to reduce weed pressure to some extent in subsequent crops**

# 2004 Mustard Cover Crop Trials



# On-Farm Weed Evaluations

<b>Cover Crop Treatment</b>	<b>% Viability of Weed Seeds - Bags</b>	<b>Emergence of Sow Thistle</b>	<b>Emergence of Purslane</b>	<b>Emergence of Knot Weed</b>	<b>Total Weed Emergence</b>
<b>Mustard CC</b>	<b>97.7</b>	<b>12.0</b>	<b>13.7</b>	<b>0.0</b>	<b>54.4</b>
<b>Bare Fallow</b>	<b>96.1</b>	<b>7.8</b>	<b>0.0</b>	<b>6.6</b>	<b>15.9</b>

# Research Station Weed Evaluations

Cover Crop Treatment	April 2003 Indian Mustard Spinach	Aug 2003 White Mustard Spinach*	May 2004 White Mustard Broccoli*	Aug 2004 Indian Mustard Broccoli	Average of four trials: Total Weeds/4ft <sup>2</sup>
Mustard CC	71.3	29.2	29.1	57.3	46.7
Bare Fallow	86.8	50.0	104.8	100.3	85.5

\* Reductions in stand were observed

### **3. Soil Quality Impacts of Cover Crops**

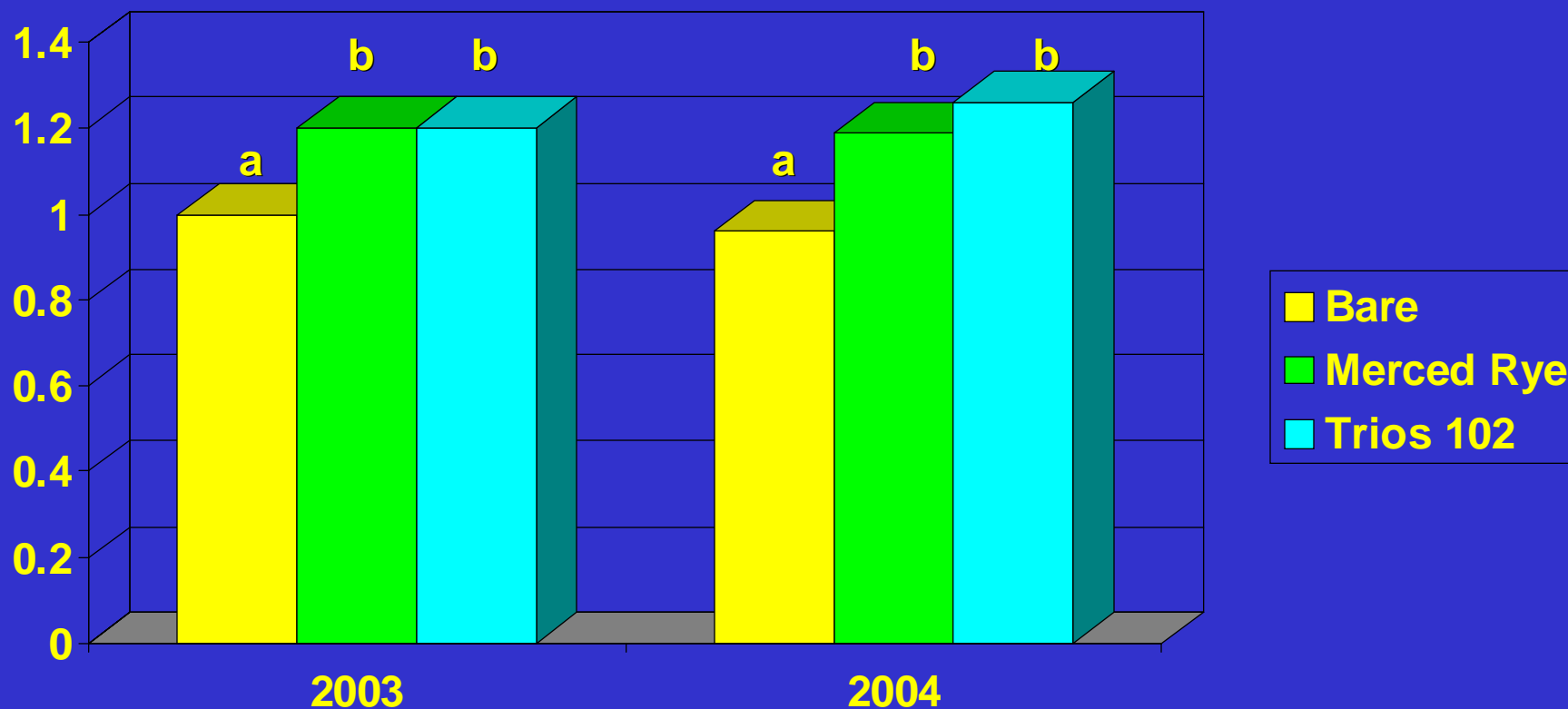
- Additions of organic amendments to agricultural soils is important because they are key to improving the quality of soils for crop production**
- Cover crops are an economical method of adding organic matter to soils, but composts, manures and crop residues are also other sources**

# Soil Quality Impacts of Cover Crops

- **Cover crops are important in providing a rotation for cash crops**
- **This is particularly important in areas such as the Salinas Valley where land rents restrict effective crop rotation practices**
- **Cover crops supply carbon to the soil that is lost from intensive tillage**

# Impact of Cover Crops on Organic Matter Content

Vineyard Floor Study, Greenfield



# Comparison of Organic vs Conventional Soils

## Salinas, 2003

Soil Type	Management	Organic Matter Percent	Total Soil Nitrogen Percent
Clay Loam	Organic	2.24	0.17
Clay Loam	Conventional	1.78	0.14
Loam	Organic	1.74	0.14
Loam	Conventional	1.37	0.11
Sandy Loam	Organic	1.31	0.12
Sandy Loam	Conventional	0.66	0.06

# Cover Crop Impact on Lettuce Yield

<b>Cover Crop Treatment</b>	<b>Uncut heads per 600'</b>	<b>Lettuce Yield Lbs/32 heads</b>
<b>Merced Rye</b>	<b>190</b>	<b>46.9</b>
<b>Broccoli CC</b>	<b>219</b>	<b>46.9</b>
<b>White Mustard</b>	<b>222</b>	<b>45.6</b>
<b>Indian Mustard</b>	<b>186</b>	<b>49.0</b>
<b>Bare Fallow</b>	<b>367</b>	<b>42.2</b>

# Soil Quality Impacts of Cover Crops

- **These examples of increased soil organic matter with the use of cover crops and high organic matter inputs have tremendous implications for soil quality**
  - To be discussed by Willie and Susanne

## **4. Water Quality Impacts of Cover Crops**

- **Sediment and nutrient TMDLs are issues that growers need to address**
- **Organic production can have these problems**
- **Cover crops are one way to address these issues**

# Phosphorus Status of Salinas Valley Soils

<b>Soil Test Range (ppm P)</b>	<b>Number of Fields</b>
<b>&lt; 40</b>	<b>9</b>
<b>40 - 80</b>	<b>27</b>
<b>80 - 120</b>	<b>16</b>
<b>&gt; 120</b>	<b>8</b>
<b>average</b>	<b>70 ppm</b>

# Organic Production and Soil P Levels

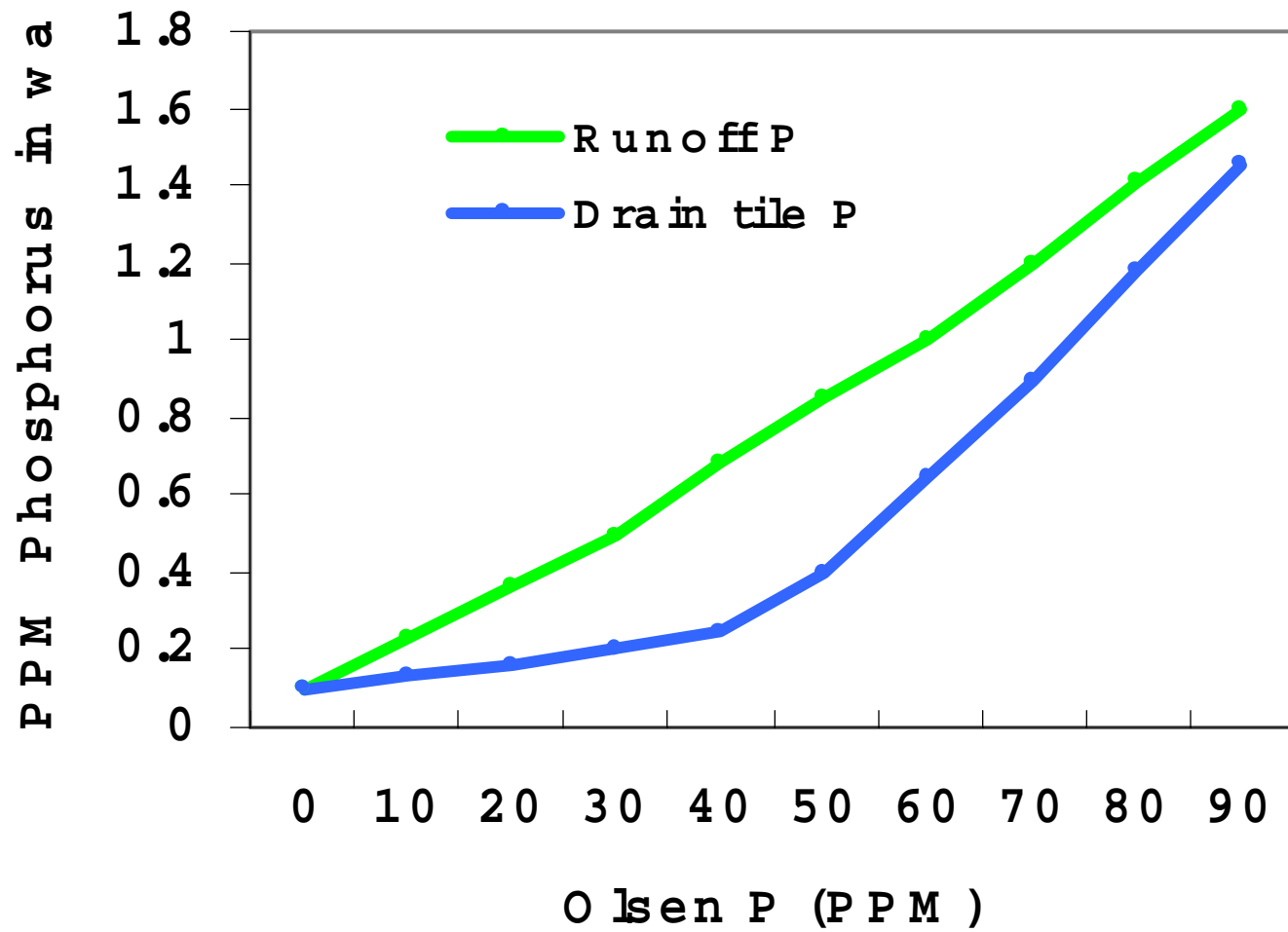
- 6 organic farms sampled and the soil P levels ranged from 33 – 196 ppm Olsen P
- Organic farms can have high P and watching the amount of P that is added with soil amendments will be increasingly important

# Typical Compost Analysis

<b>N</b>	<b>C:N</b>	<b>P</b>	<b>K</b>	<b>Ca</b>
<b>1-2</b>	<b>10</b>	<b>0.3-0.5</b>	<b>1-2</b>	<b>2-3</b>
<b>Lbs/Ton of Compost</b>				
<b>20-40</b>		<b>6-10</b>	<b>20-40</b>	<b>40-60</b>

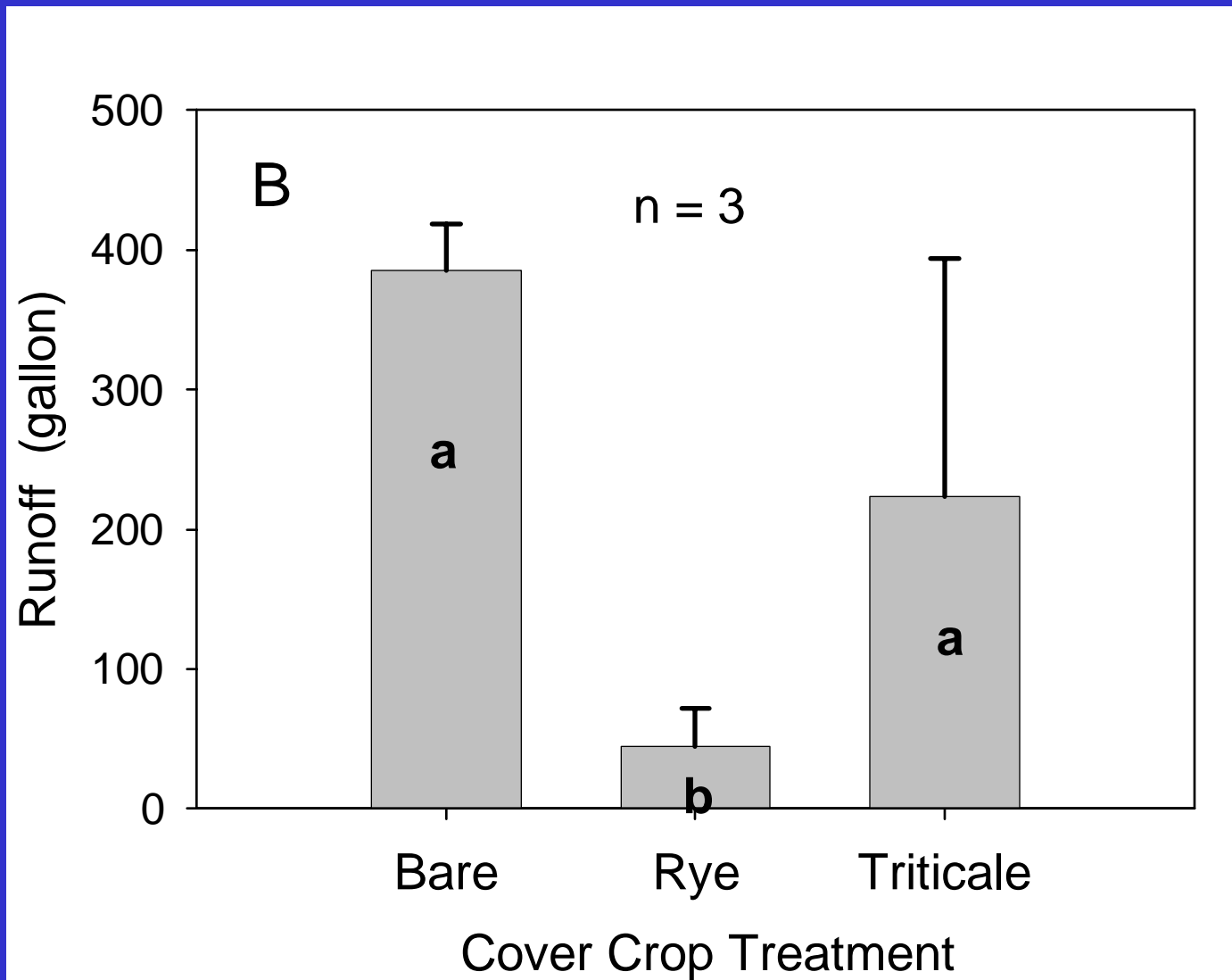
# Loading of Phosphorous

- **Lettuce only removes 10 – 15 lbs P per crop**
- **Depending upon the amount of compost that is added, it could add further amounts of P to the soil and “load” the soil with P that may have water quality impacts**



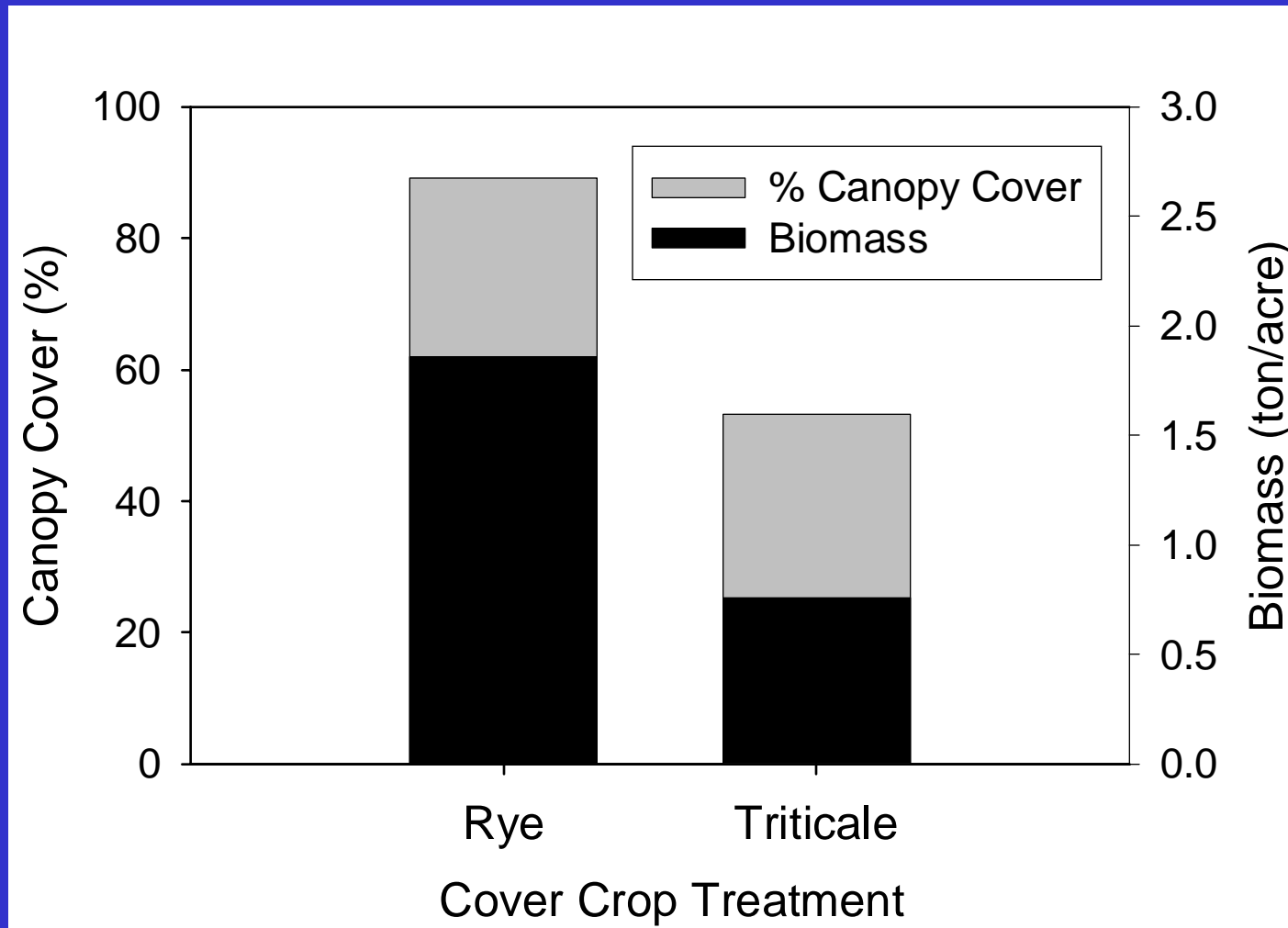
Hartz, 2002

# Impact of Cover Crops on Runoff Greenfield, 2003



# Possible Explanation Why Rye Had Less Runoff than Triticale

Greenfield, 2003





**Rye Cover  
Cropped  
Plot**

**Bare Plot**

# Impact of Fall-Grown Cover Crops on Nitrate Leaching



Anion Resin Bags installed following cover crop incorporation



**Resin Bag placed  
90 cm deep**

# Cover Crop Impact on Nitrate Leaching

Treatment	mg N03-N in resin bag
<b>Bare Fallow</b>	<b>12.2</b>
<b>Broccoli</b>	<b>12.4</b>
<b>White Mustard</b>	<b>4.0</b>
<b>Indian Mustard</b>	<b>2.2</b>
<b>Cereal Rye</b>	<b>4.3</b>

# 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**
- **Others**
  - **Conservation tillage – used in cotton**
  - **Minimum tillage – Louise Jackson's system**
  - **Low residue winter cover crops – an experimental concept**

# Conservation Tillage



**Cover Cropped  
residue on  
soil surface**

**Bare**



**Planting into  
Residue**



**Minimum  
tillage  
incorporation  
of cover  
crops**



**Low residue  
cover crop-  
killed early  
in the life  
cycle and  
left to  
decompose  
prior to spring  
planting**





## **Summary:**

- \* Cover crops have many important roles in the Salinas Valley**
- \* The challenge is to examine ways to increase their usage on high rent ground**