Nitrogen Management of Lettuce: Field Scale Studies

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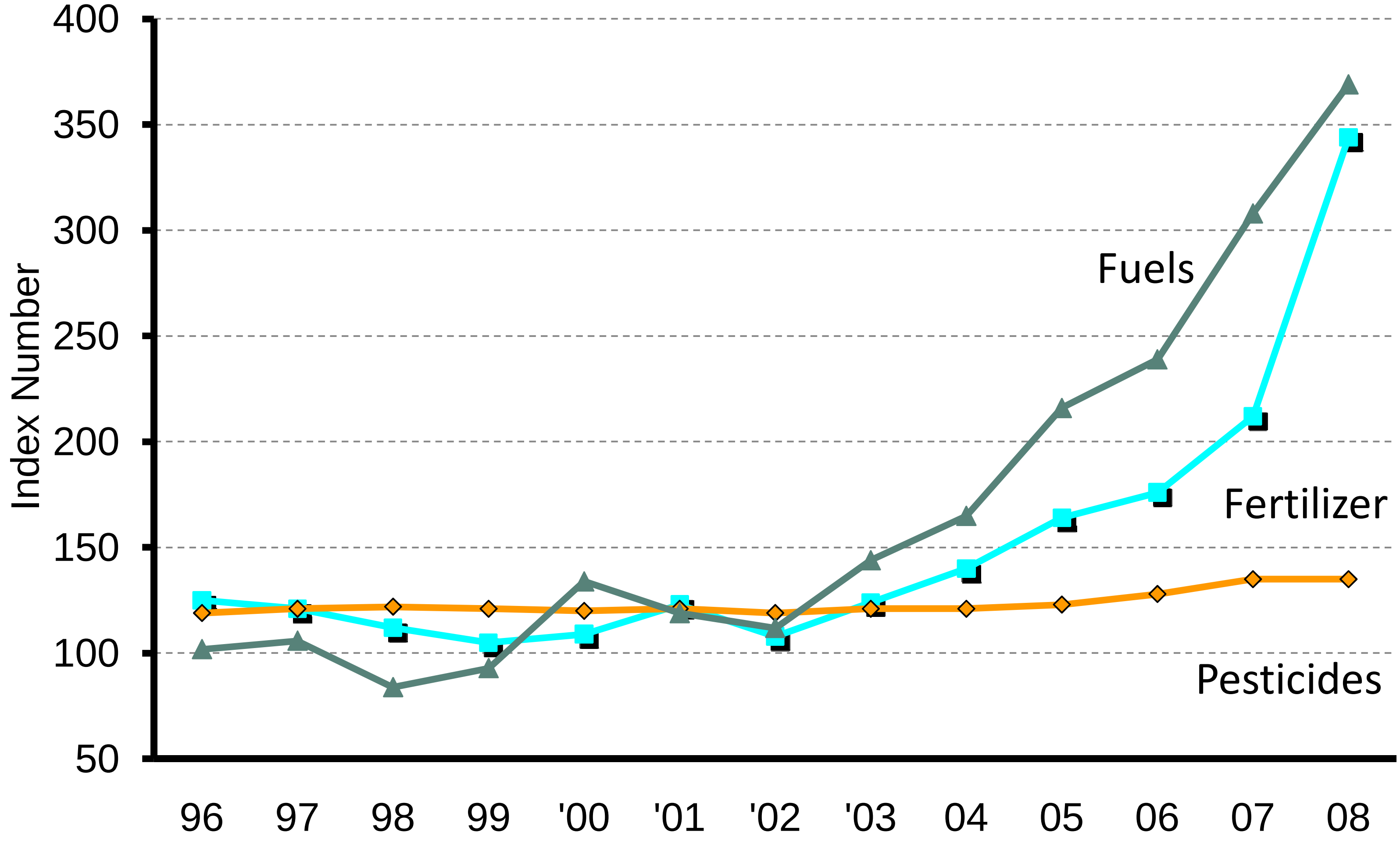
Nitrogen Fertilization

- In the recent past, nitrogen fertilizers have been relatively inexpensive and constituted a small proportion of the production budget – 5%
- In 2008 there was a spike in fertilizer prices that increased interest in fertilizer use efficiency

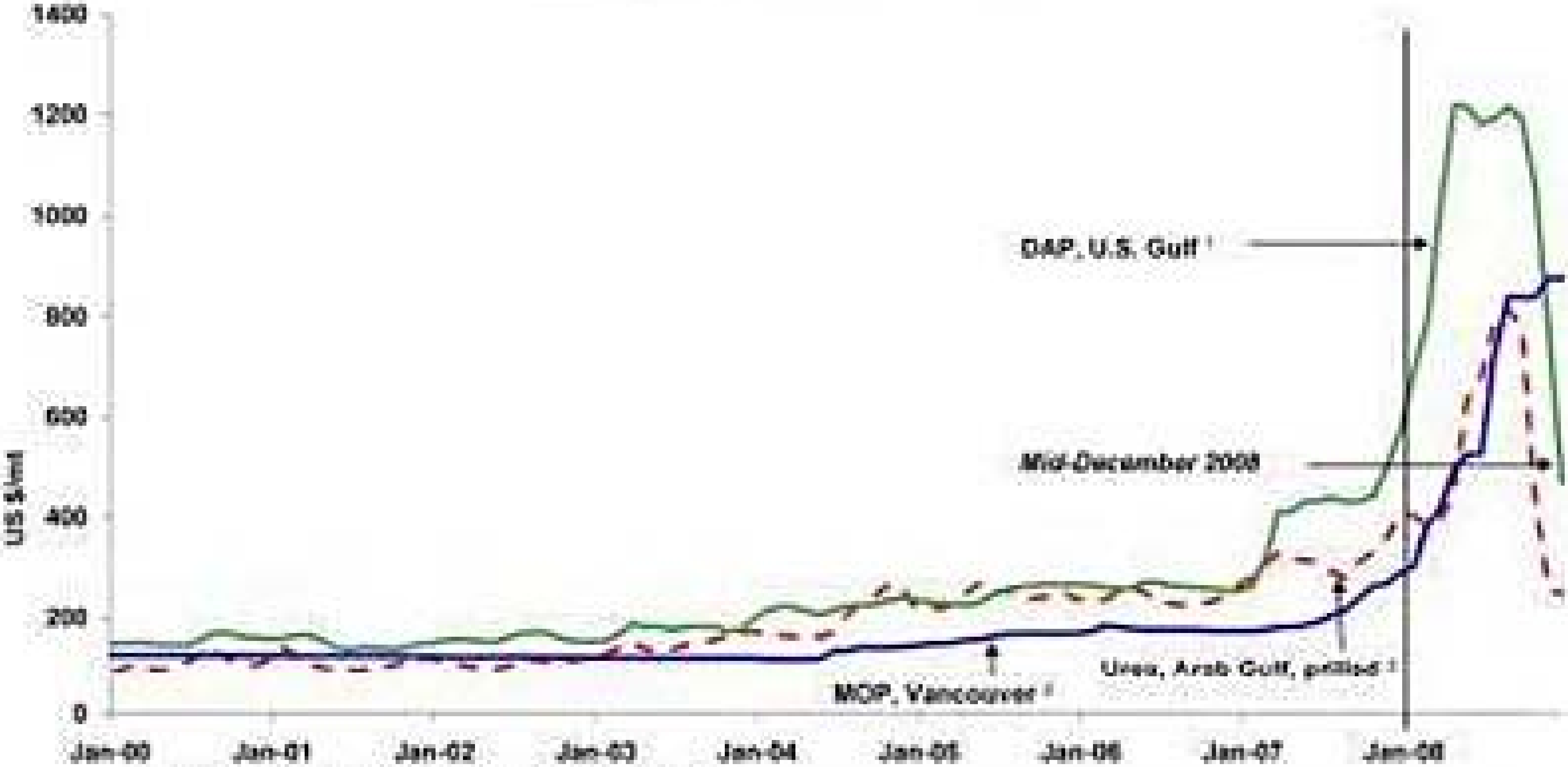
Figure 2. Indexes of prices paid by US farmers 1990-1992 = 100



Source: USDA, National Agricultural Statistical Service.

Fertilizer prices follow fuel prices

Fertilizer Prices
(FOB, bulk)
Monthly Averages
January 2000 - Mid-December 2008



1. Derived from Green Markets. 2. Derived from FMB Weekly.

World fertilizer prices doubled in 2007 and reached all-time highs in April 2008. But prices began dropping dramatically in October and November.
FOB = free on board (average price, with buyer paying freight and insurance, to destination port).
DAP = diammonium phosphate. MOP = muriate of potash.

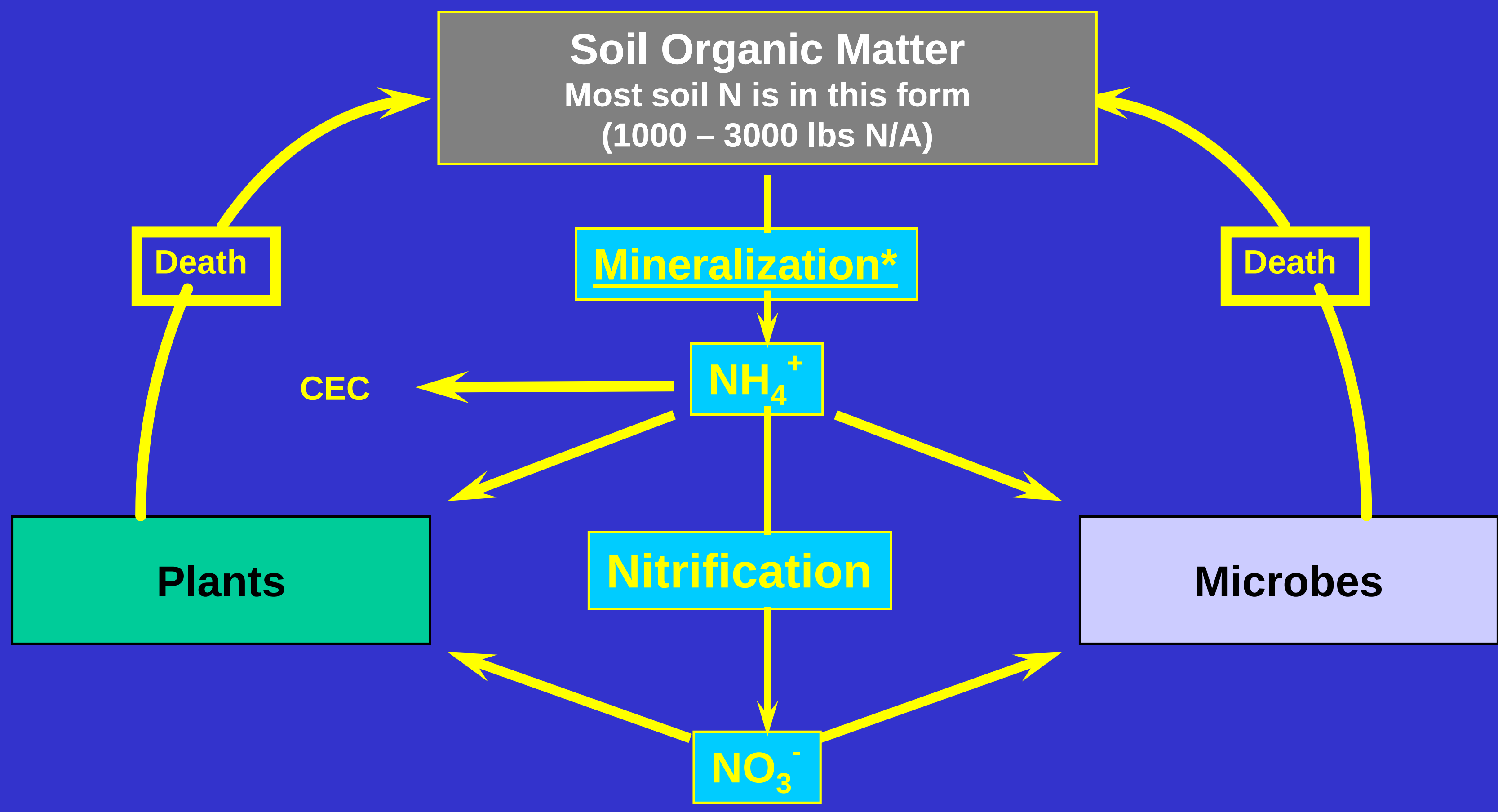
IFDC Graph by IFDC—An International Center for Soil Fertility and Agricultural Development

Nitrogen Fertilization of Lettuce

- Nitrogen uptake by lettuce is modest:

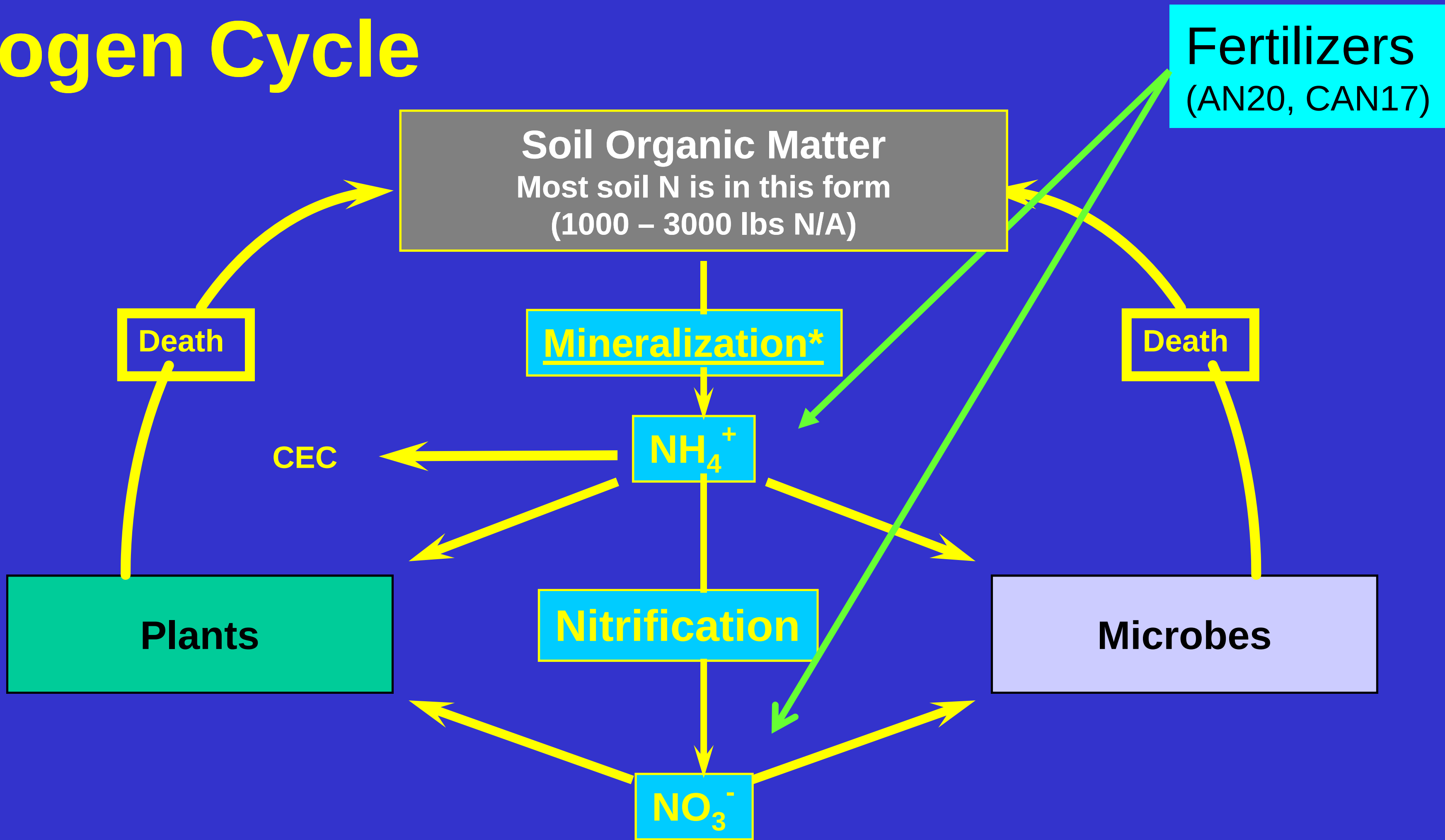
  120 - 140 lbs N/A
- However:
- Lettuce is shallow rooted
- It requires frequent irrigation
- This scenario opens the door to losses of nitrogen in crop production

Nitrogen Cycle

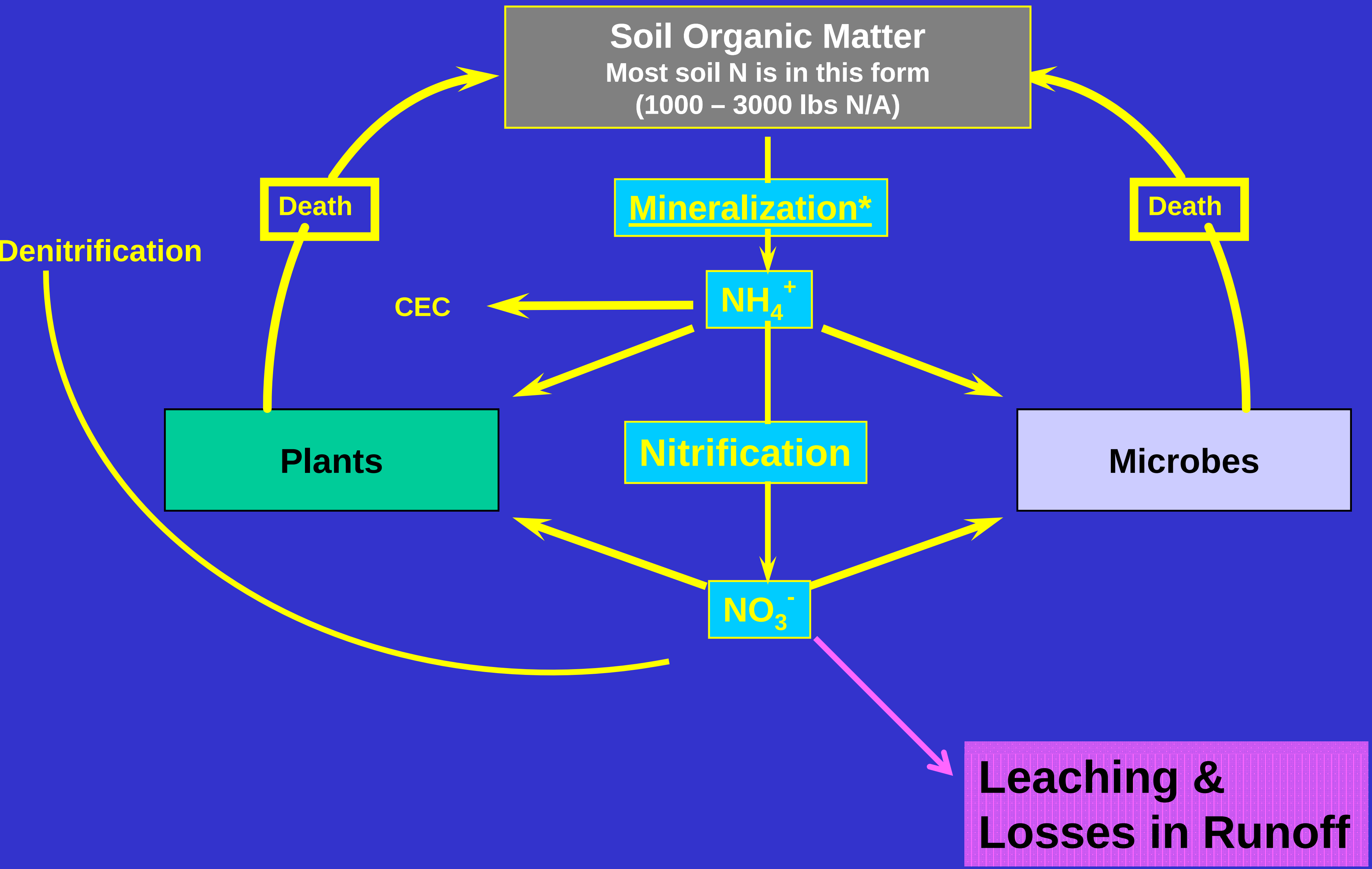


* Mineralization is a key step in making N available for plant growth
It is dependent upon adequate soil temperatures (i.e. > 50 F)

Nitrogen Cycle



Nitrogen Cycle



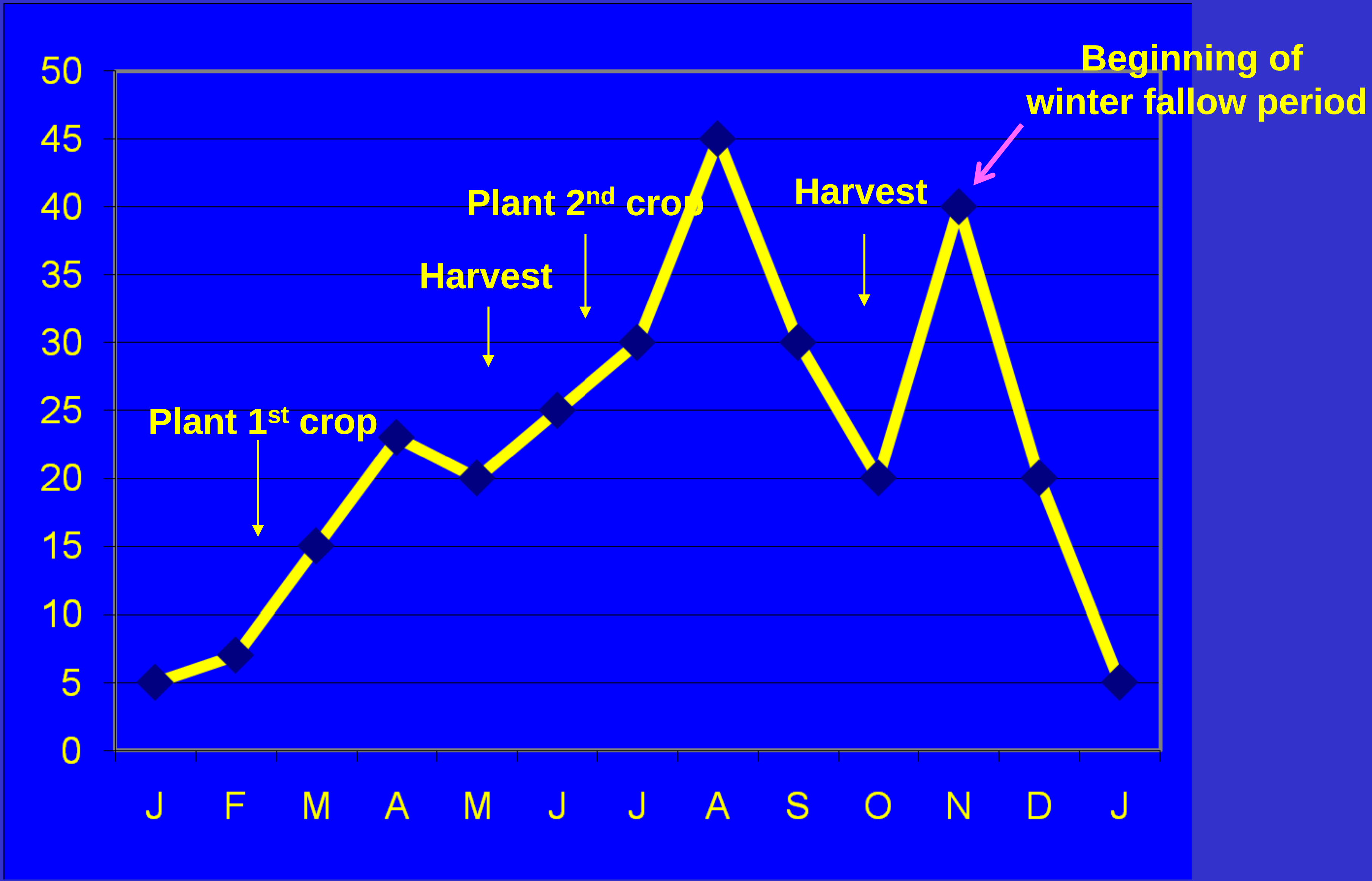
Importance of Nitrate

- Nitrogen from all sources tends to transform to nitrate in warm soils
- As a result, nitrate is the dominant form of available nitrogen in the soil
- It accumulates in quantities that can be easily measured
- Nitrate is beneficial in agricultural soils
- However, large pools of soil nitrate are susceptible to leaching past the root zone of the crop

Nitrogen Losses

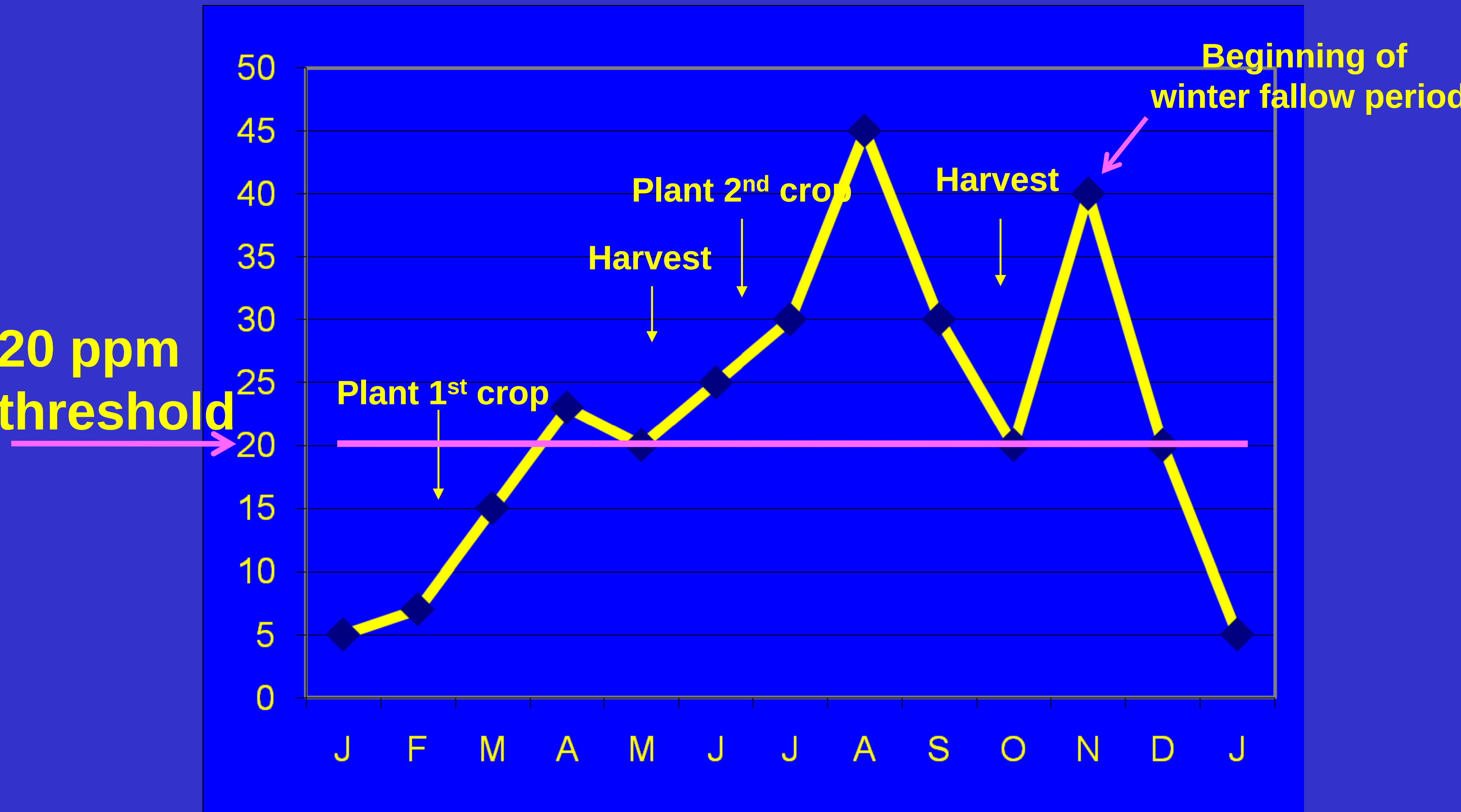
- However, losses to ground or surface waters is a pollutant
- Causes eutrophication of surface waters
- Reduces the use of groundwater for municipal water (drinking water standard is <45 ppm NO_3)
- Nitrate losses are of great concern to many groups (Regional Water Board, Marine Sanctuary, Municipalities, etc)

Average Nitrate-Nitrogen Levels Measured in Soil Over Growing Season (two crops of lettuce)



Smith and Schulbach, 1996

Average Nitrate-Nitrogen Levels Measured in Soil Over Growing Season (two crops of lettuce)



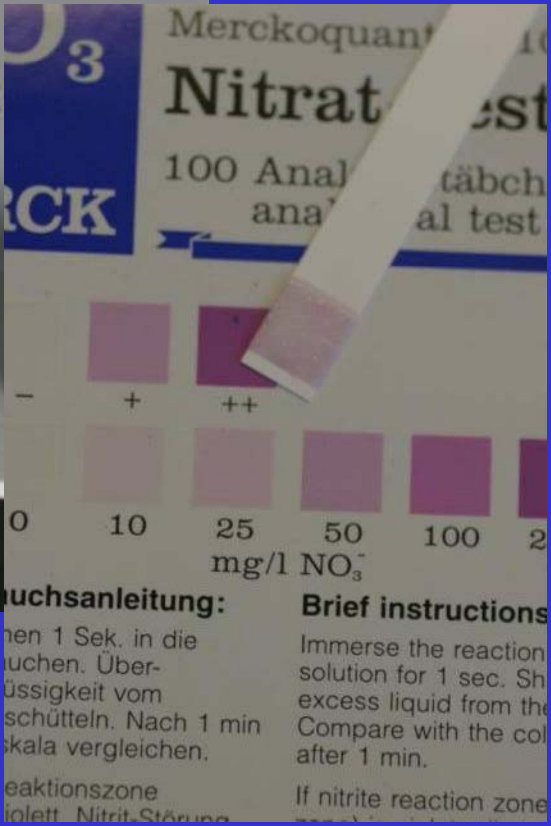
Smith and Schulbach, 1996

Techniques to Increase Nitrate Utilization by Crops

- Fertilizer management
  - Split applications, etc…
- Irrigation management
- Drip irrigation
  - spoon feed N
  - manage water carefully
- Slow release fertilizers
- Nitrification inhibitors
- Soil/plant tissue testing

Soil Tests

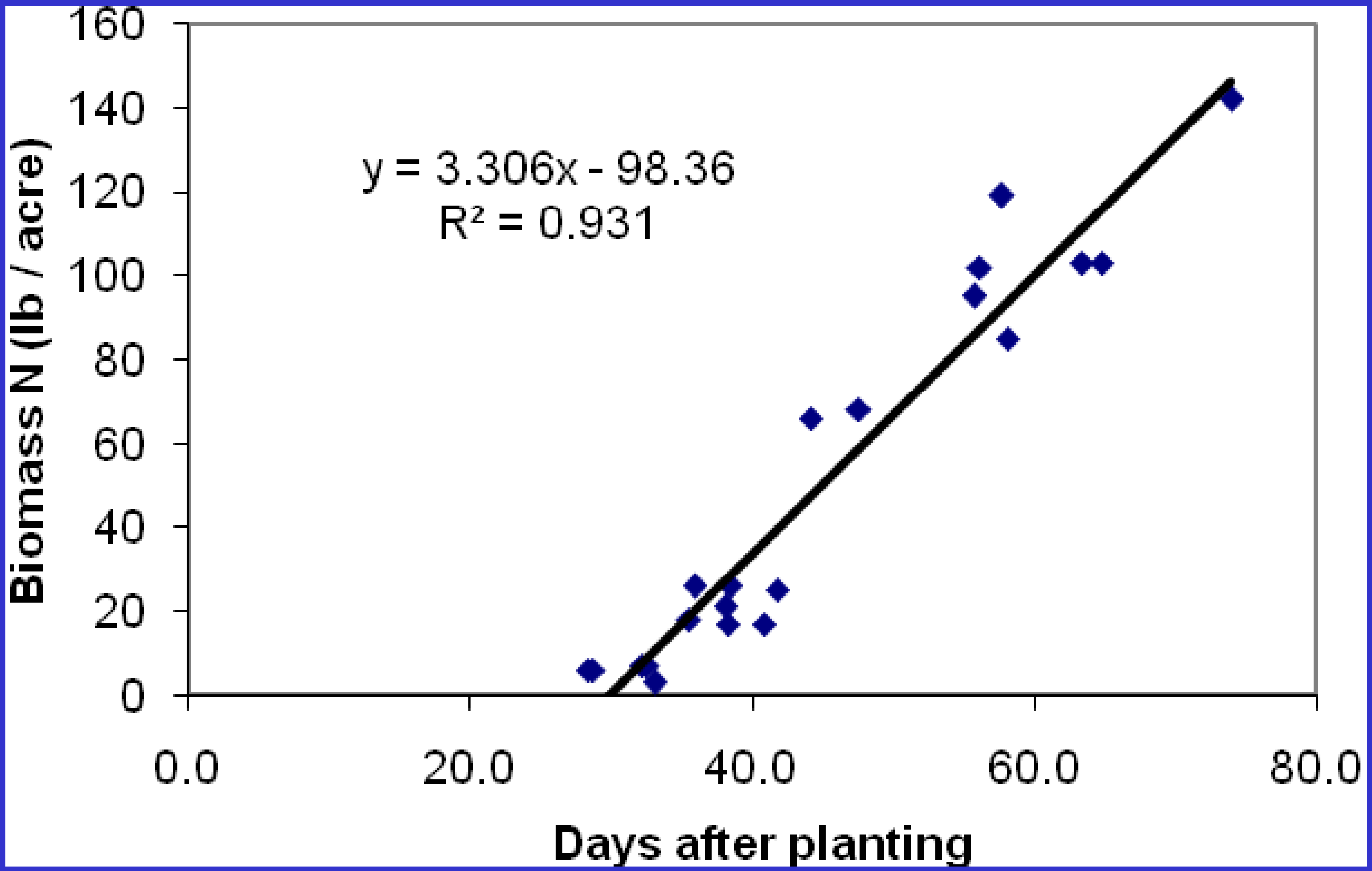
- **The residual soil nitrate acts just like fertilizer nitrogen and can be used for crop growth**
- **The nitrate quick test measures the pool of nitrate in the soil**
- **It gives a rapid measurement of nitrate that is available for crop growth**
- **20 ppm is considered adequate for lettuce growth**



Nitrogen Uptake Characteristics of Lettuce

- **Lettuce takes up nitrogen in a predictable way:**
  - **30 days after the first water lettuce takes up no more than 5-7 lbs of N**
  - **Between 30 to 60 days lettuce grows exponentially and requires careful fertilization**
  - **In total, it takes up about 120 - 140 lbs of N in the tops**

Daily Nitrogen/A Uptake by Head Lettuce in Summer



N Uptake of Lettuce

- In the northern Salinas Valley with a summer temperature regime that averages 21 GDD per day
- On average lettuce take up 3.3 lbs of N/A/day
- Lettuce grown in areas with higher GDD would have higher daily N uptake. For instance in King City, with warmer temperatures mean daily lettuce N uptake would average > 4 lbs of N/A.

Interest in Increasing Nitrogen Use Efficiency

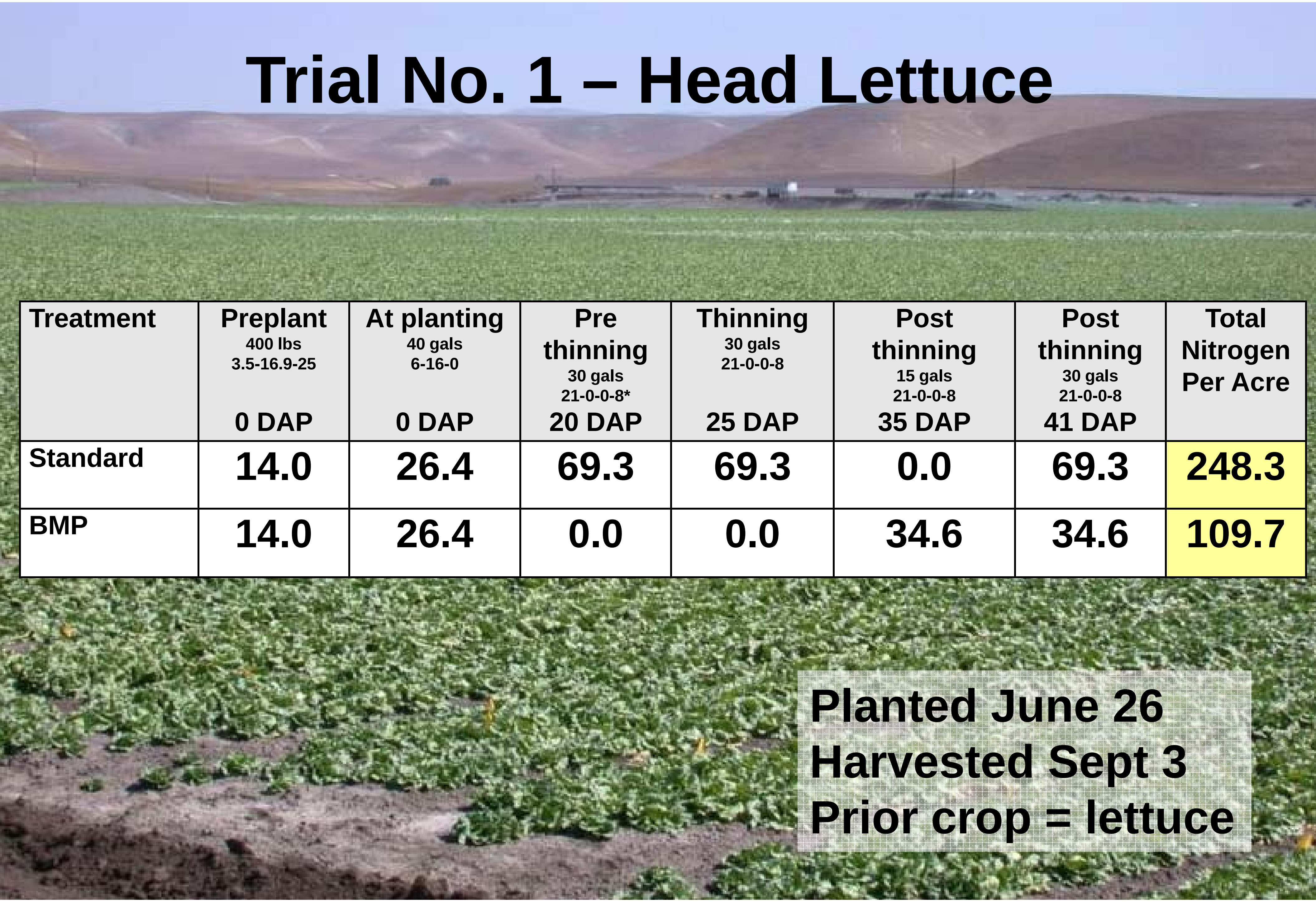
Pressure for improving nitrogen use efficiency grew in 2008 due to:

- **Spike in fertilizer prices**
- **Increased pressure to reduce nitrate losses from agricultural fields by the Regional Water Quality Control Board (renewal of the conditional waiver in 2009)**

Farm-Scale Nitrogen Management Evaluations

Three trials conducted:

- **Each field 20 – 27 acres**
- **Two treatments: Standard and BMP**
- **All conducted on the 2nd crop of the season (more residual N available in the soil)**
- **Nitrogen in BMP plots managed based on use of the nitrate quick test**

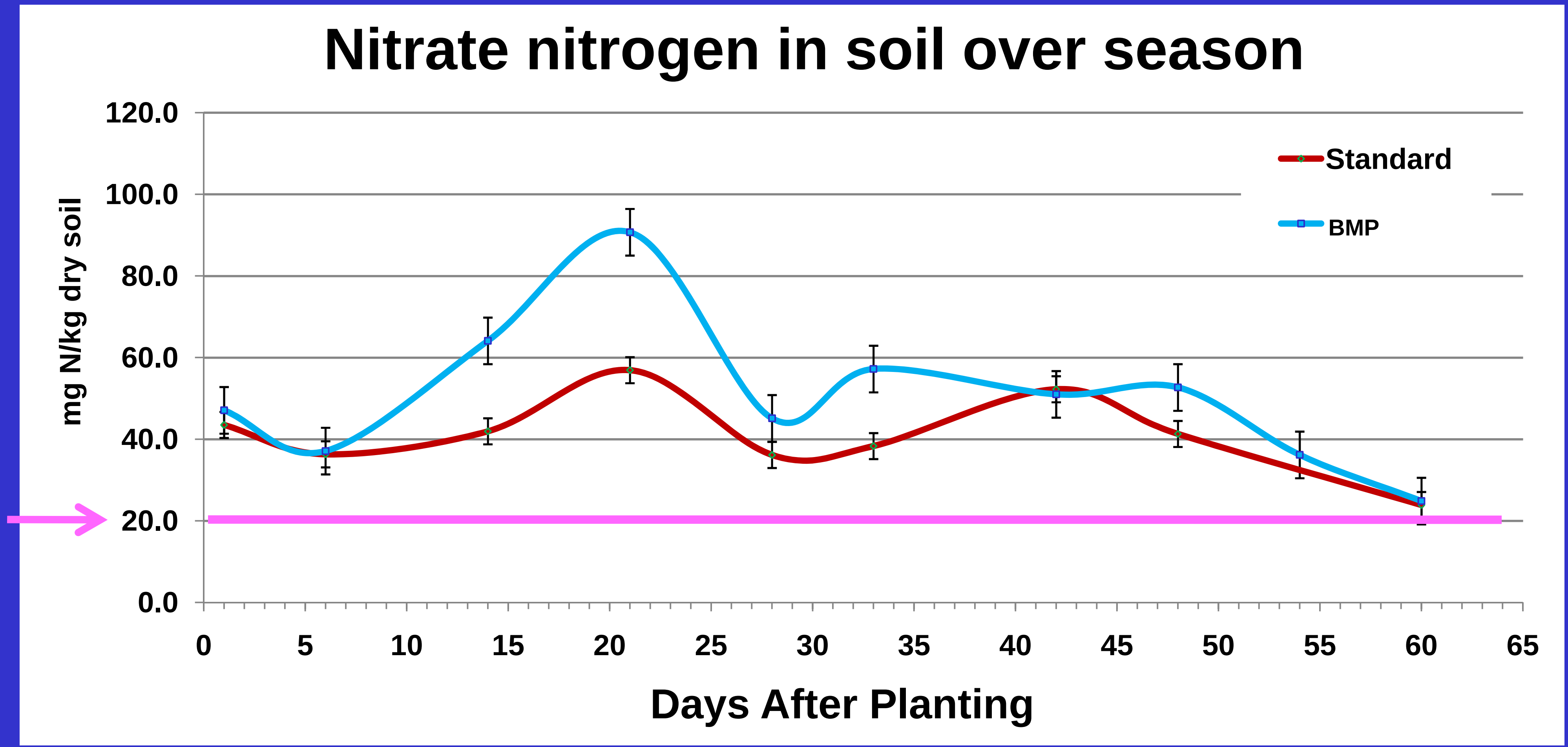


Trial No. 1 – Head Lettuce

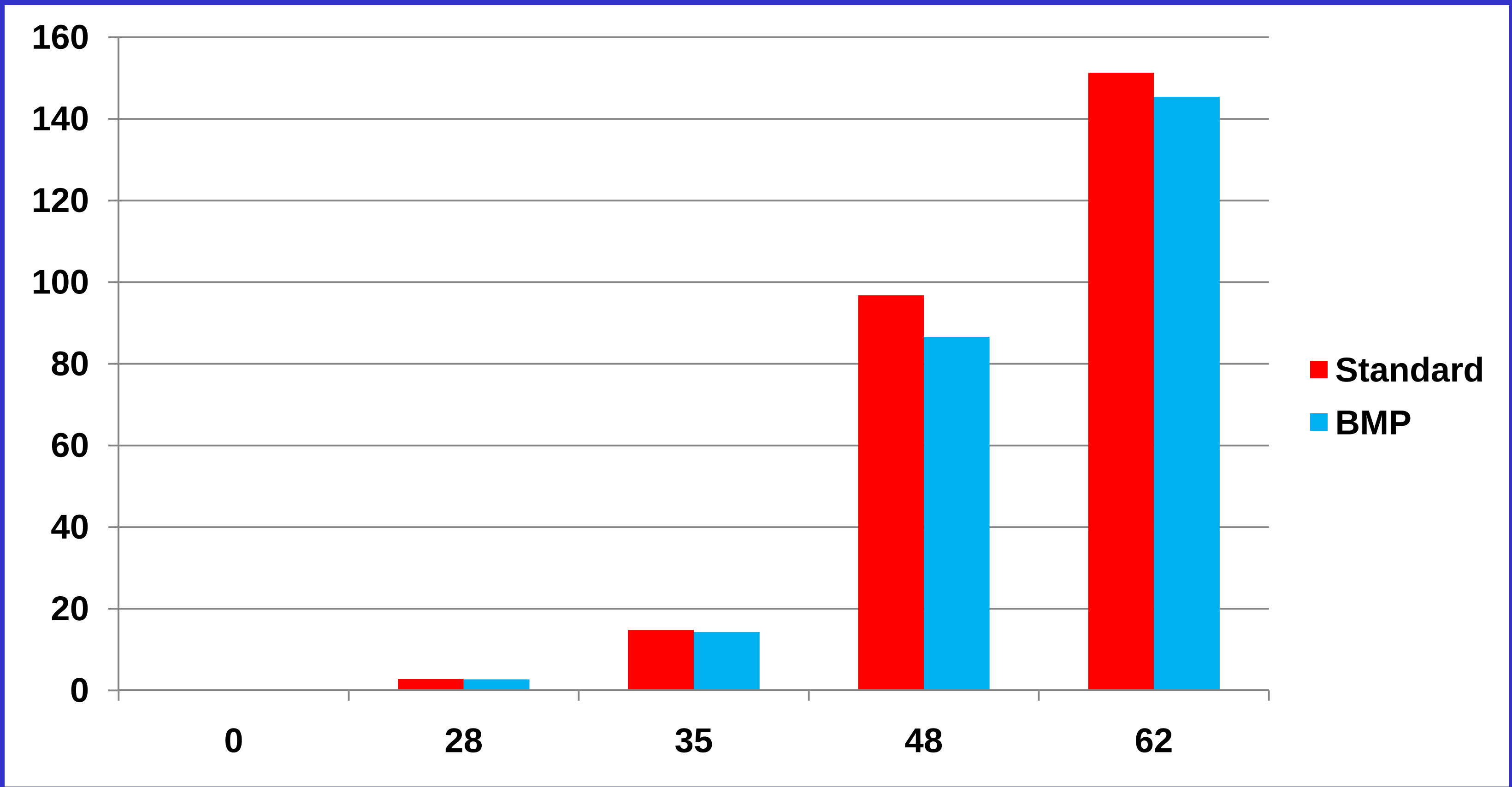
Treatment	Preplant 400 lbs 3.5-16.9-25 0 DAP	At planting 40 gals 6-16-0 0 DAP	Pre thinning 30 gals 21-0-0-8* 20 DAP	Thinning 30 gals 21-0-0-8 25 DAP	Post thinning 15 gals 21-0-0-8 35 DAP	Post thinning 30 gals 21-0-0-8 41 DAP	Total Nitrogen Per Acre
Standard	14.0	26.4	69.3	69.3	0.0	69.3	248.3
BMP	14.0	26.4	0.0	0.0	34.6	34.6	109.7

Planted June 26
Harvested Sept 3
Prior crop = lettuce

Trial No. 1 – Head Lettuce

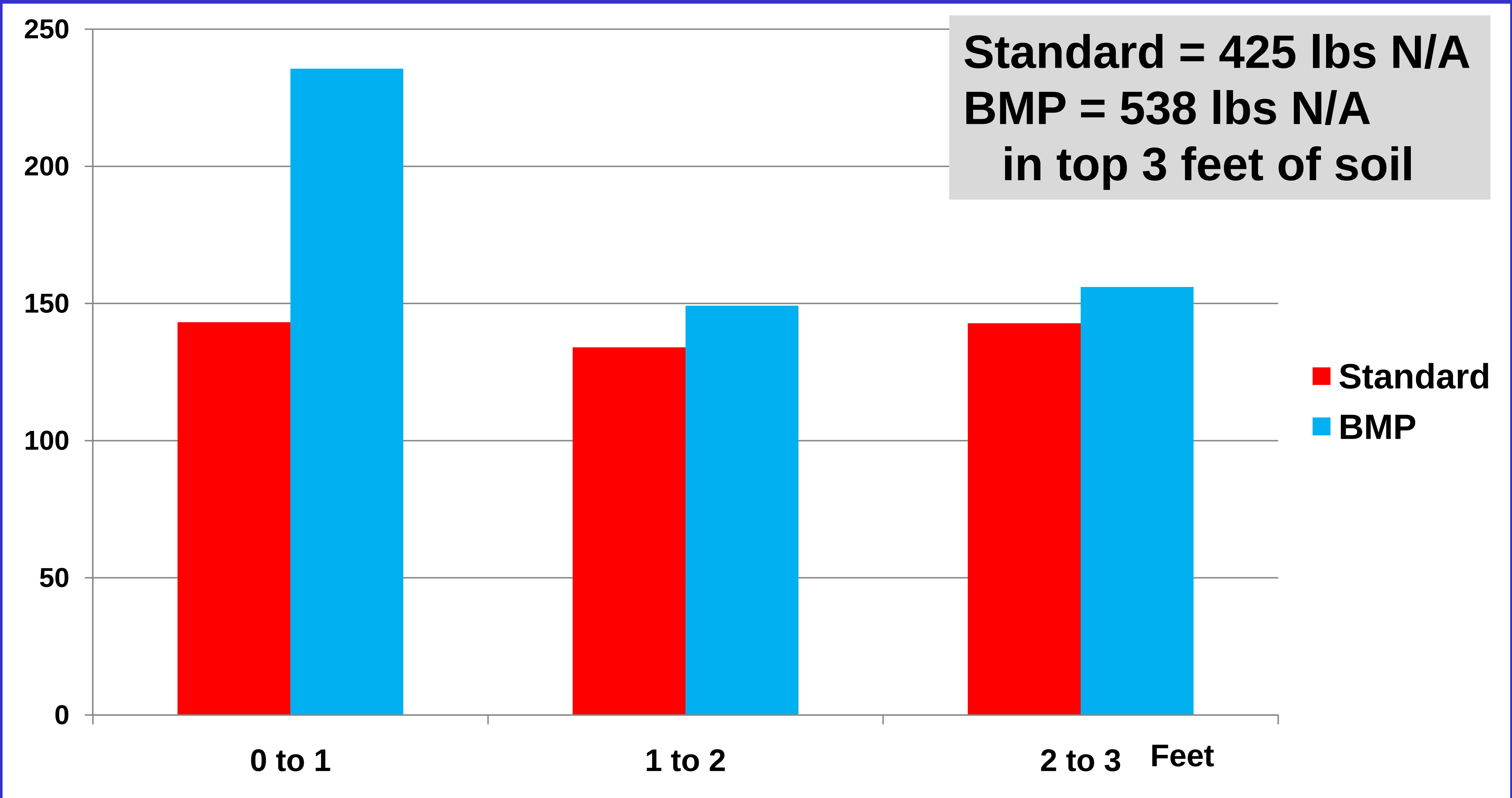


Lettuce Nitrogen uptake lbs/A

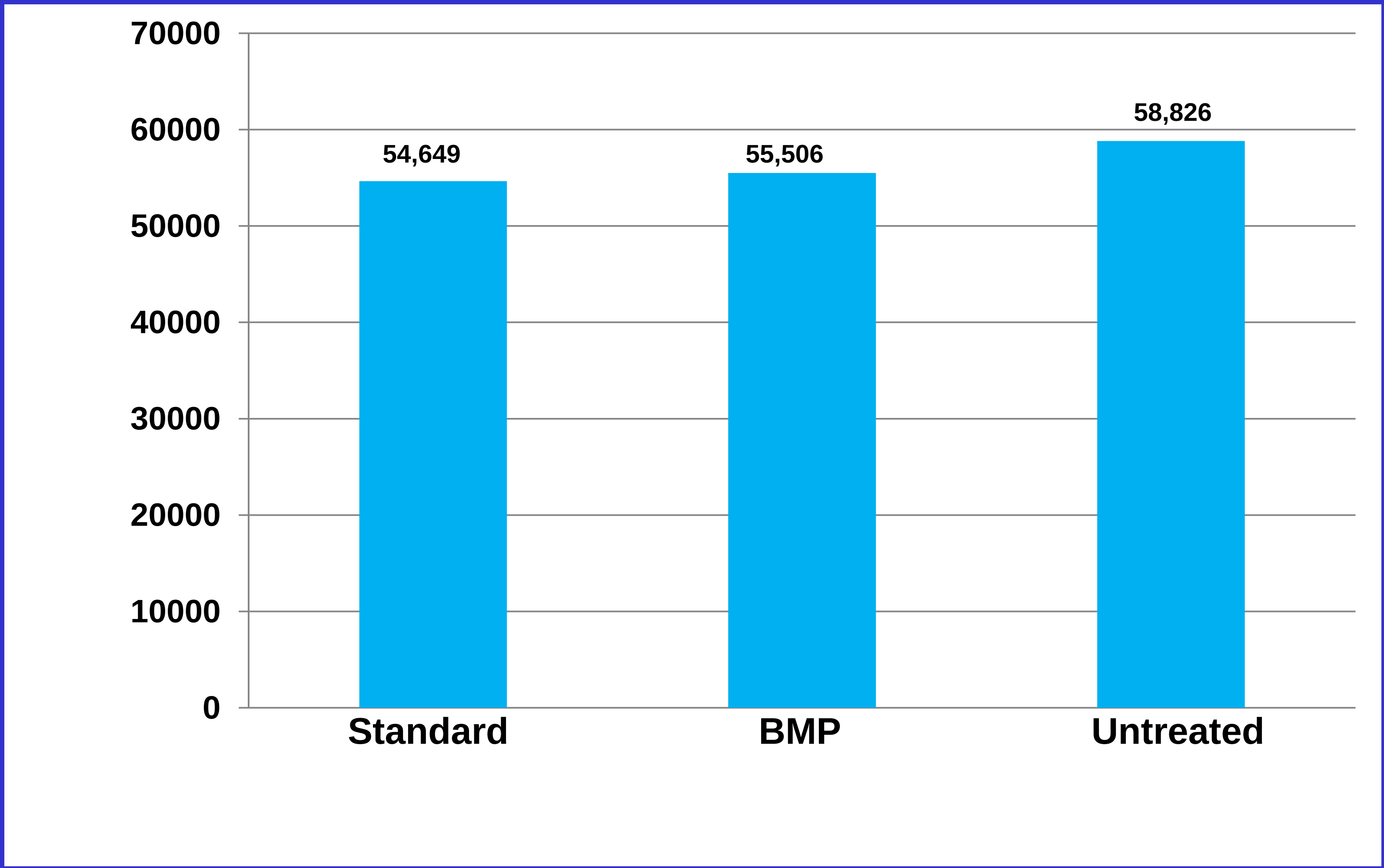


Days after planting

Amount of Nitrogen in Top Three Feet of Soil on July 25 (30 DAP)



Cored Head Lettuce Yield lbs/A



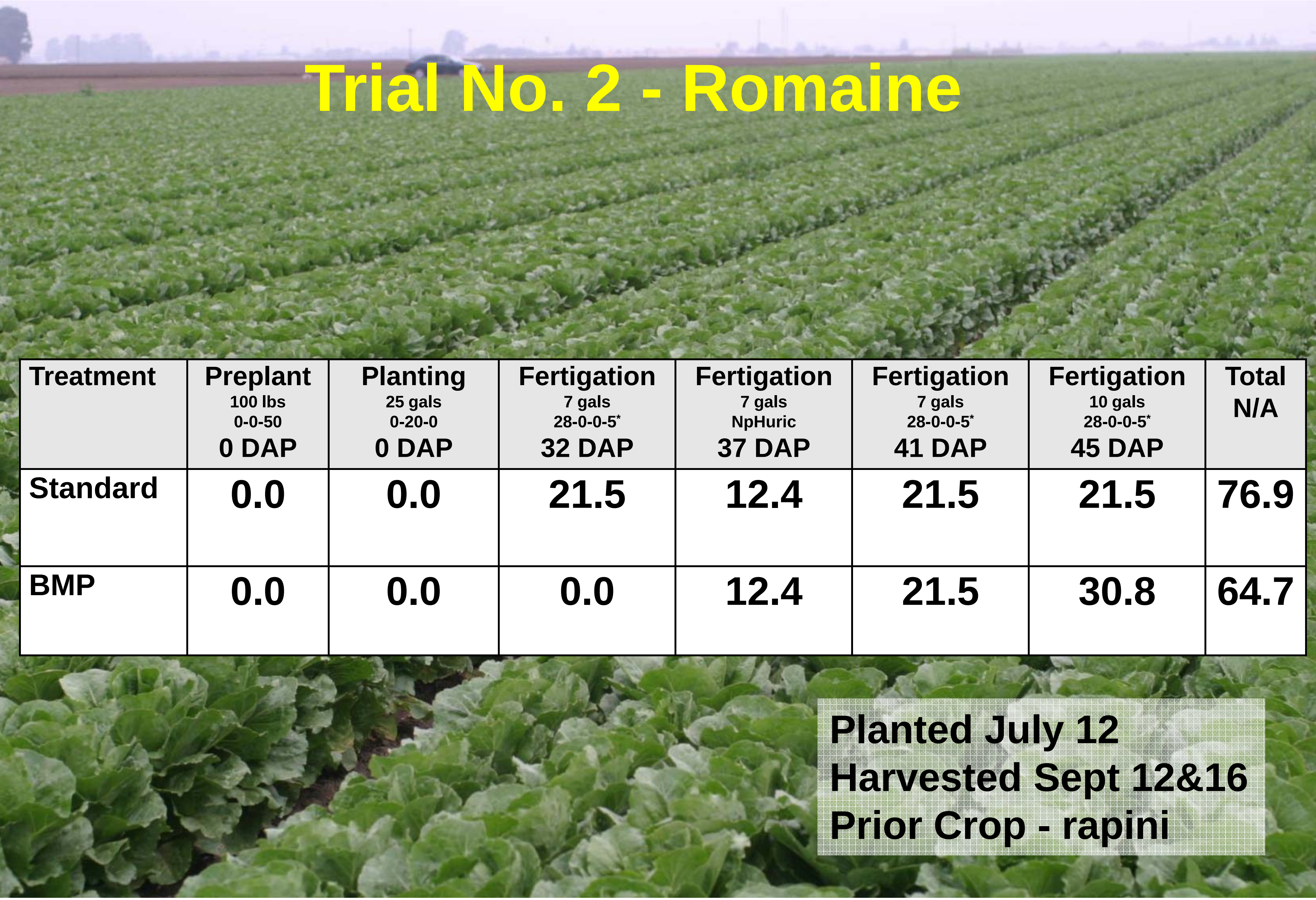
Lysimeters were installed and maintained at suctions that approximated the flow of gravitational water. Samples of this water were analyzed for nitrate content. From the concentration of nitrate in this water and estimations of movement of water through the soil we could estimate nitrate loss

Nitrate Leaching

- The lysimeters were used to estimate nitrate leaching to two feet in irrigation events
- In one irrigation event from July 24 to July 29 we estimated the following movement of nitrate:

Treatment	Lbs of N	Value of N*
Standard	37.3	$15.67
BMP	11.2	$4.70

* at $0.42/lb N

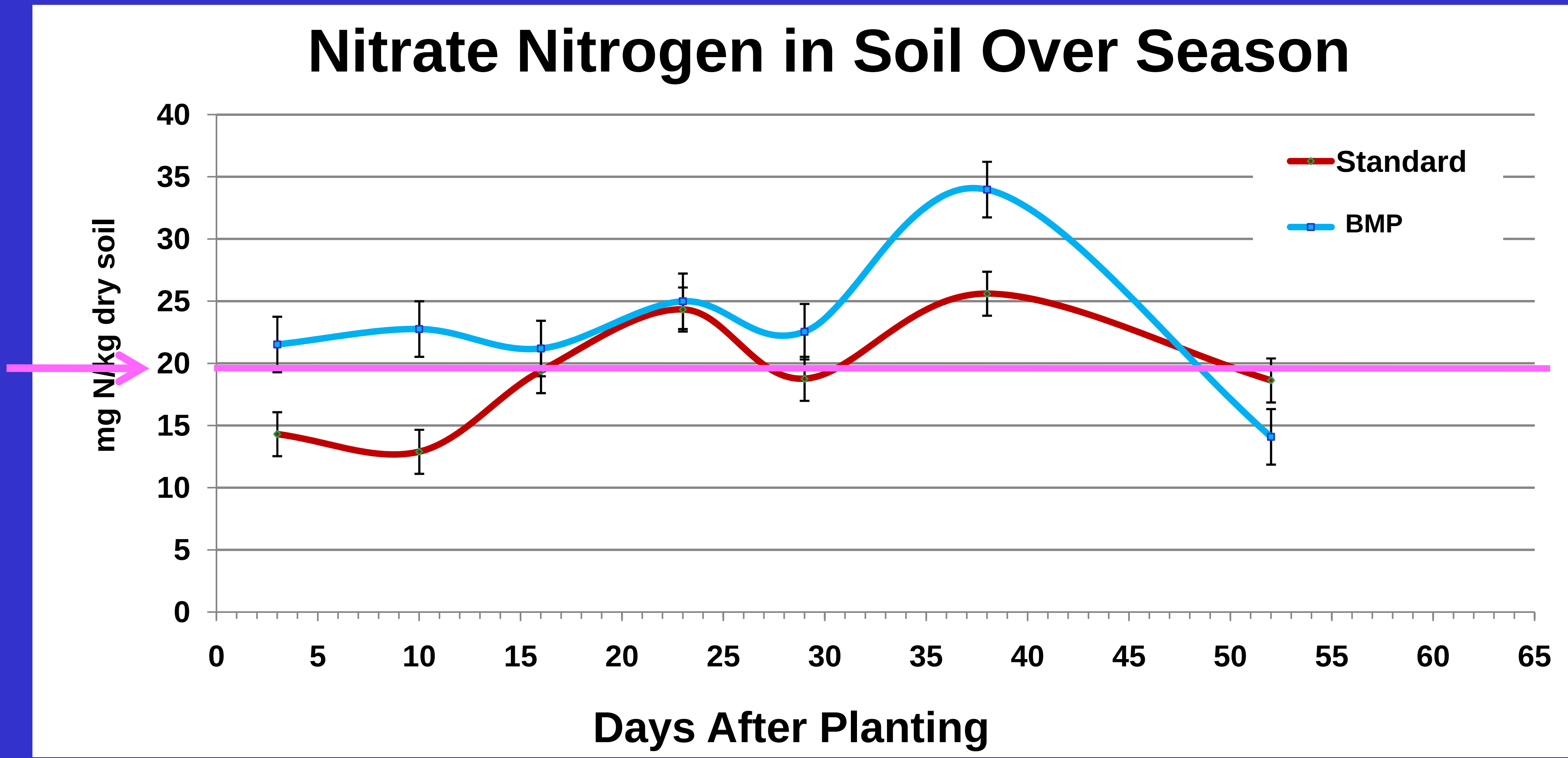


Trial No. 2 - Romaine

Treatment	Preplant 100 lbs 0-0-50 0 DAP	Planting 25 gals 0-20-0 0 DAP	Fertigation 7 gals 28-0-0-5* 32 DAP	Fertigation 7 gals NpHuric 37 DAP	Fertigation 7 gals 28-0-0-5* 41 DAP	Fertigation 10 gals 28-0-0-5* 45 DAP	Total N/A
Standard	0.0	0.0	21.5	12.4	21.5	21.5	76.9
BMP	0.0	0.0	0.0	12.4	21.5	30.8	64.7

Planted July 12
Harvested Sept 12&16
Prior Crop - rapini

Trial No. 2 – Romaine

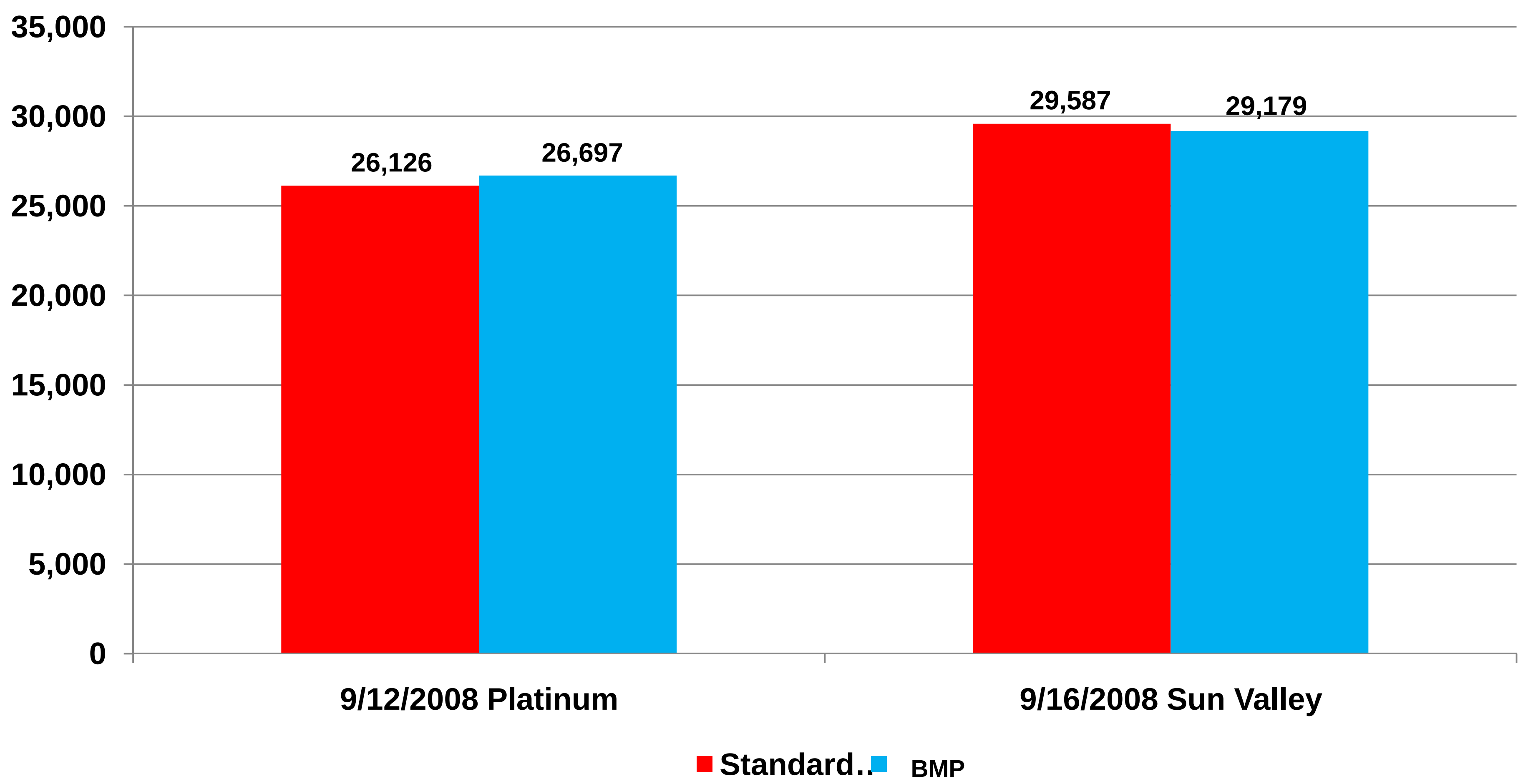


Trial No. 2 - Romaine

Total N Applied to the crop:

- **Standard = 77 lbs**
- **BMP = 65 lbs**
- **If an average lettuce crop contains 120 lbs N/A the remainder of the N that was supplied to this crop was from residual N (prior crop residues and nitrogen mineralization from organic matter)**

Trial No. 2 - Romaine Commercial Yield – Cored

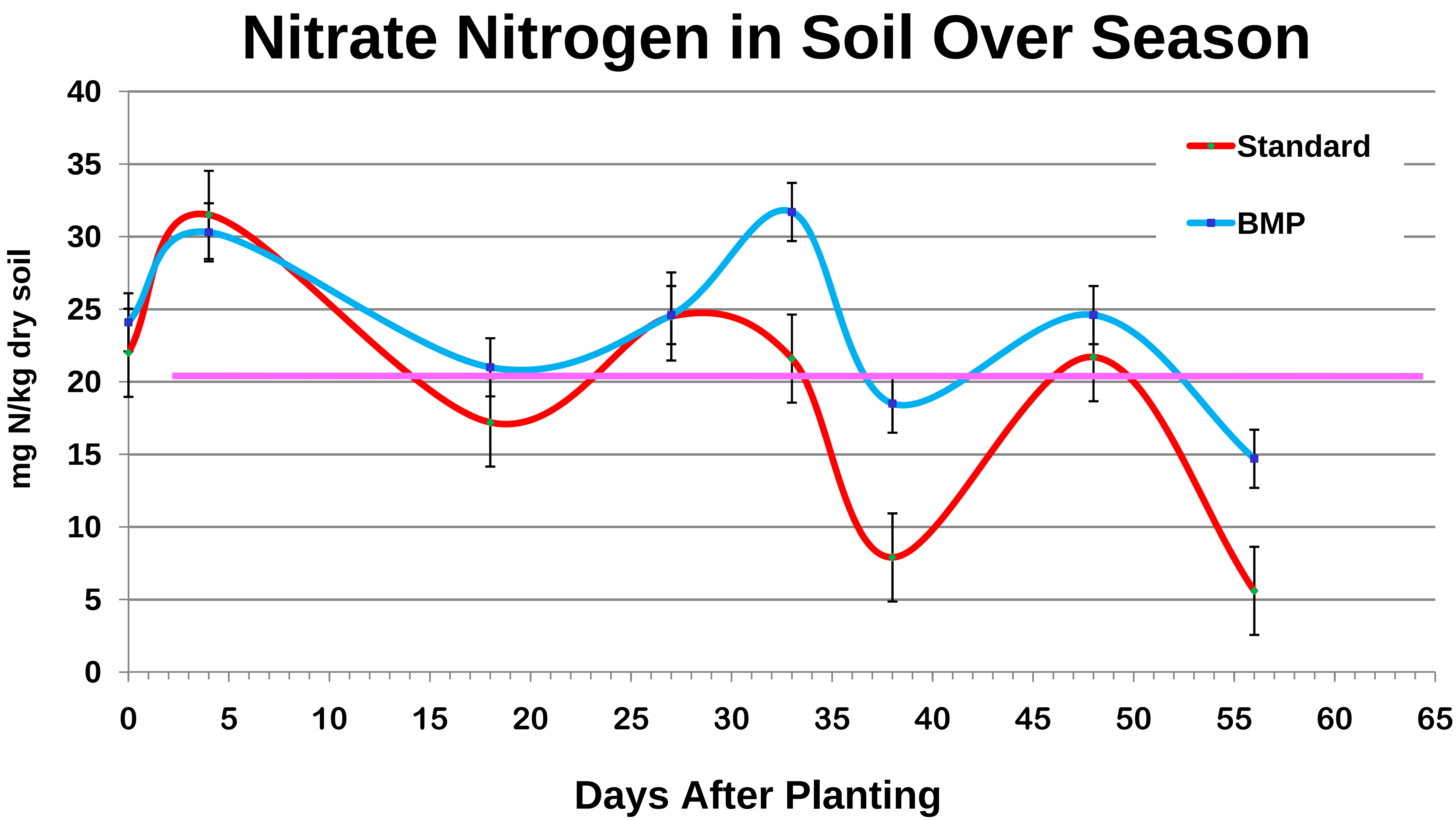


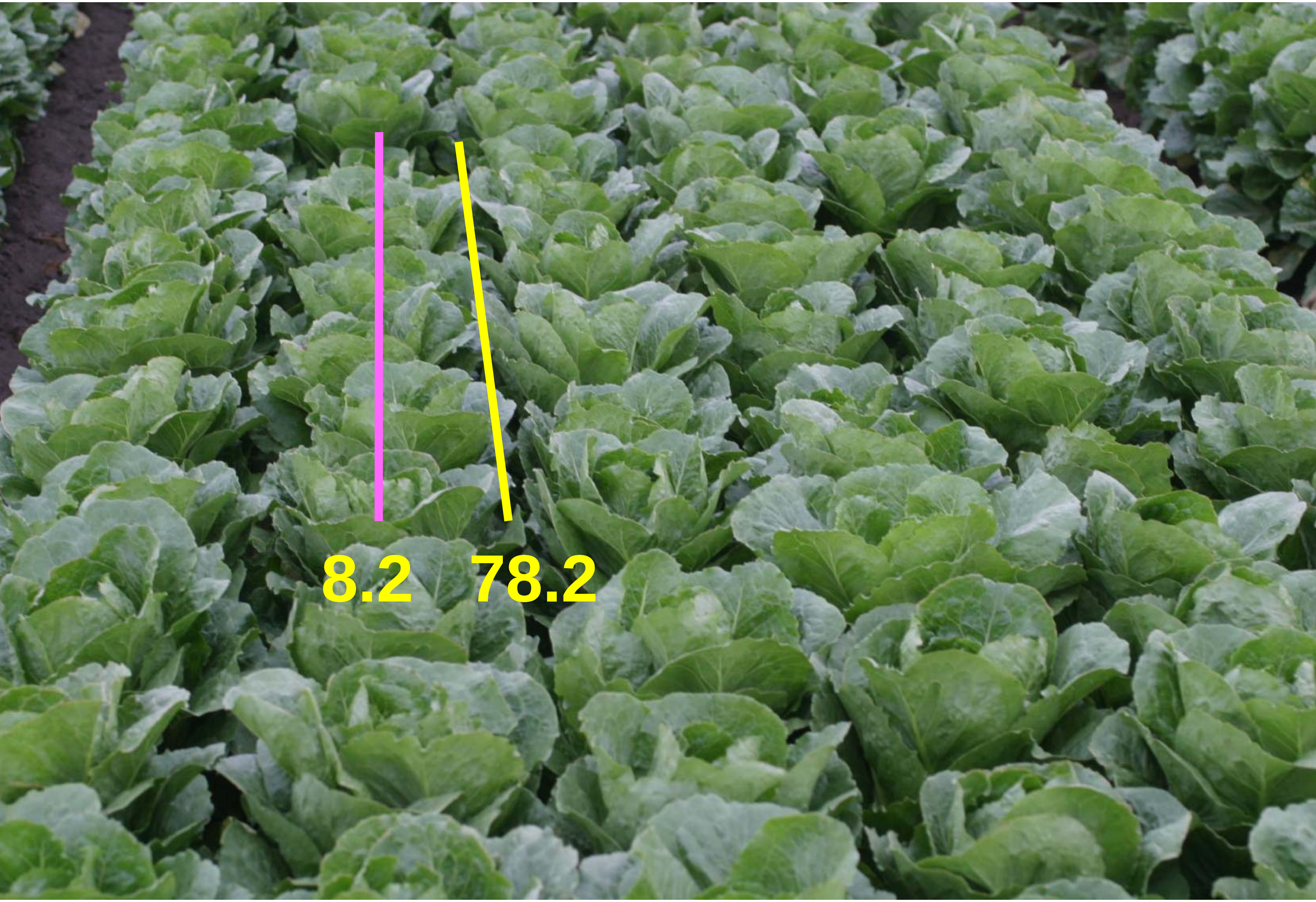
Trial No. 3 - Romaine

Treatment	Planting 40 gals 6-16-0 0 DAP	Post thinning 21-0-0-8* 27 days	Rosette 21-0-0-8 34 days	Mid growth 21-0-0-8 42 days	Total N/A to date
Standard	26.4	57.8	57.8	57.8	199.7
BMP	26.4	34.7	57.8	34.7	153.6

Planted August 22
Harvested October 31

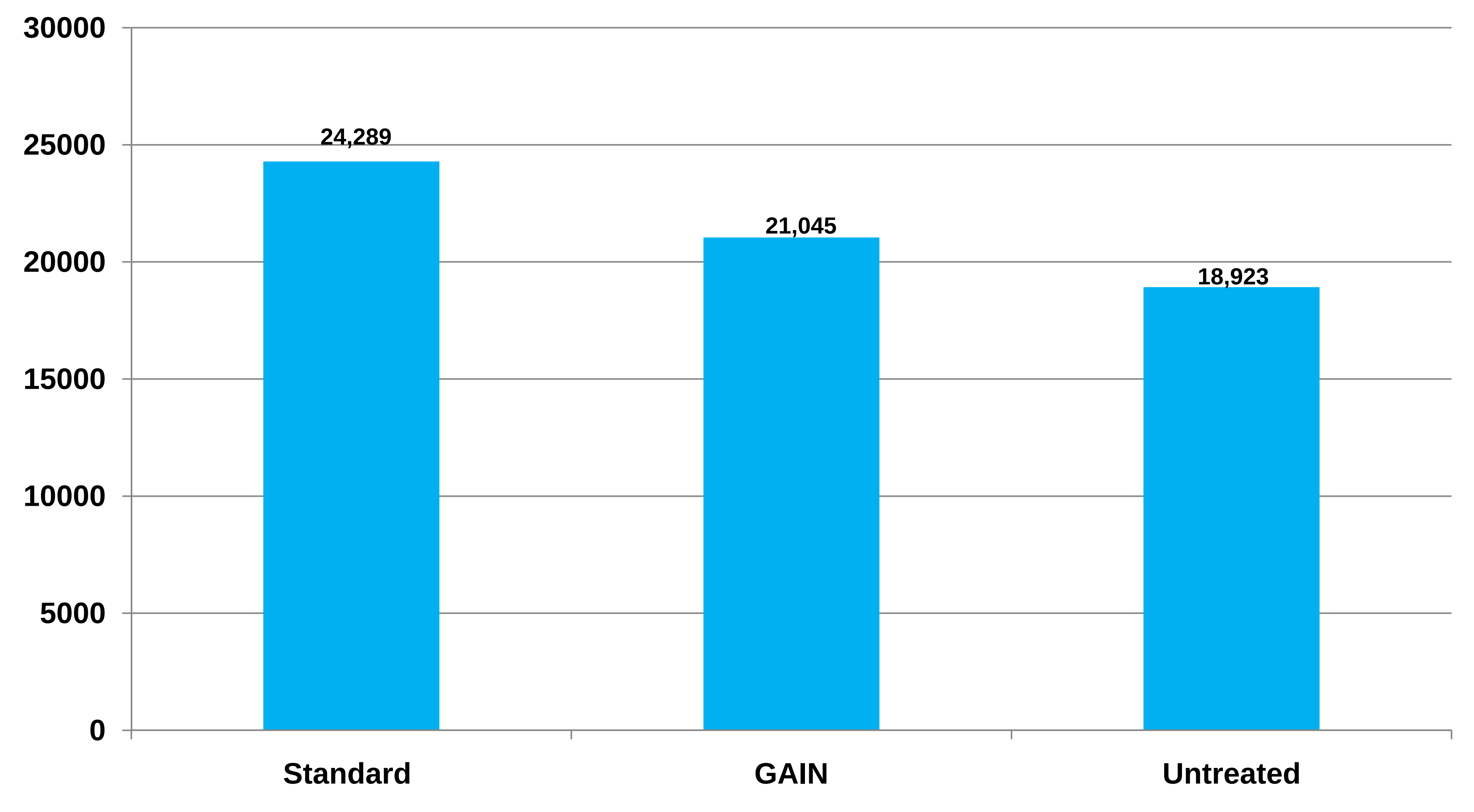
Trial No. 3 - Romaine



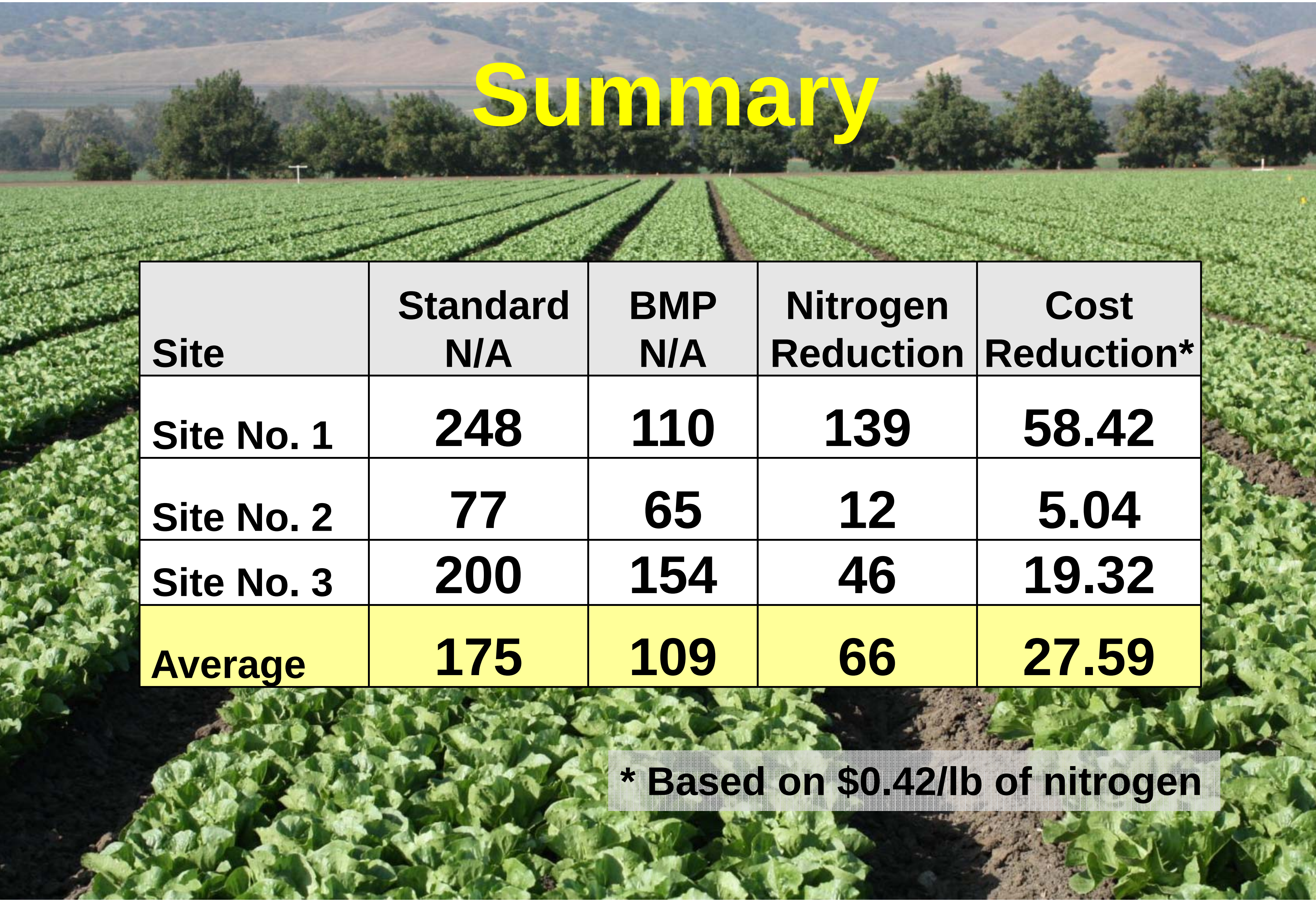

8.2
78.2

May be necessary to collect samples by angling towards the row middles

Trial No. 3 - Romaine Trimmed Yield/A

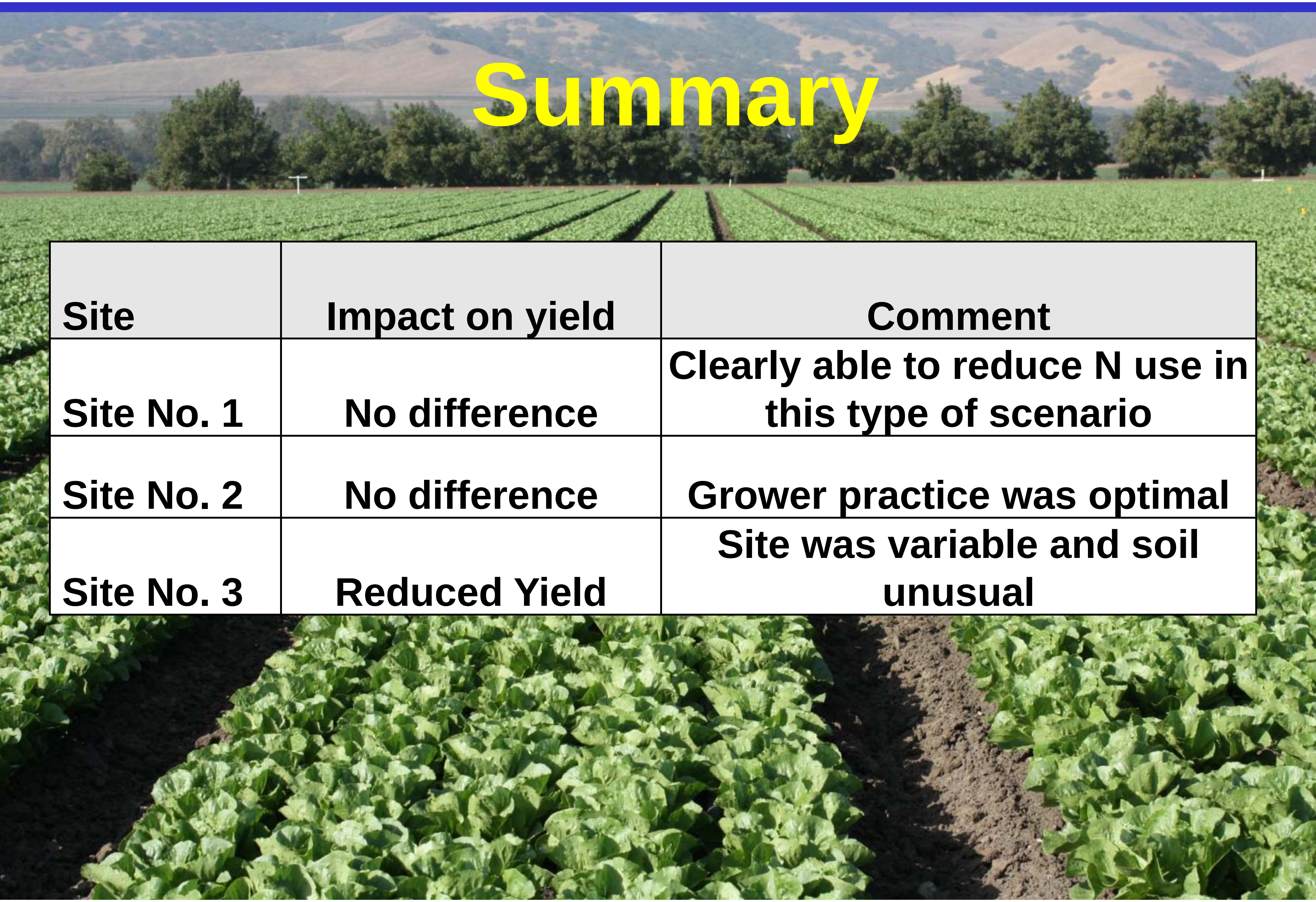


Summary



Site	Standard N/A	BMP N/A	Nitrogen Reduction	Cost Reduction*
Site No. 1	248	110	139	58.42
Site No. 2	77	65	12	5.04
Site No. 3	200	154	46	19.32
Average	175	109	66	27.59

* Based on $0.42/lb of nitrogen



Summary

Site	Impact on yield	Comment
Site No. 1	No difference	Clearly able to reduce N use in this type of scenario
Site No. 2	No difference	Grower practice was optimal
Site No. 3	Reduced Yield	Site was variable and soil unusual

- These trials showed that it is Possible to reduce nitrogen fertilizer and irrigation inputs.
- Irrigation is key to nitrogen (nitrate) fertilizer management.
- Leaching of nitrate can be an an unseen cost.
- In spite of the down swing in fertilizer prices, the need for improved nitrogen management is not reduced