Physiology, Nutrition, and Nitrogen Fertilization of Corn in the United States

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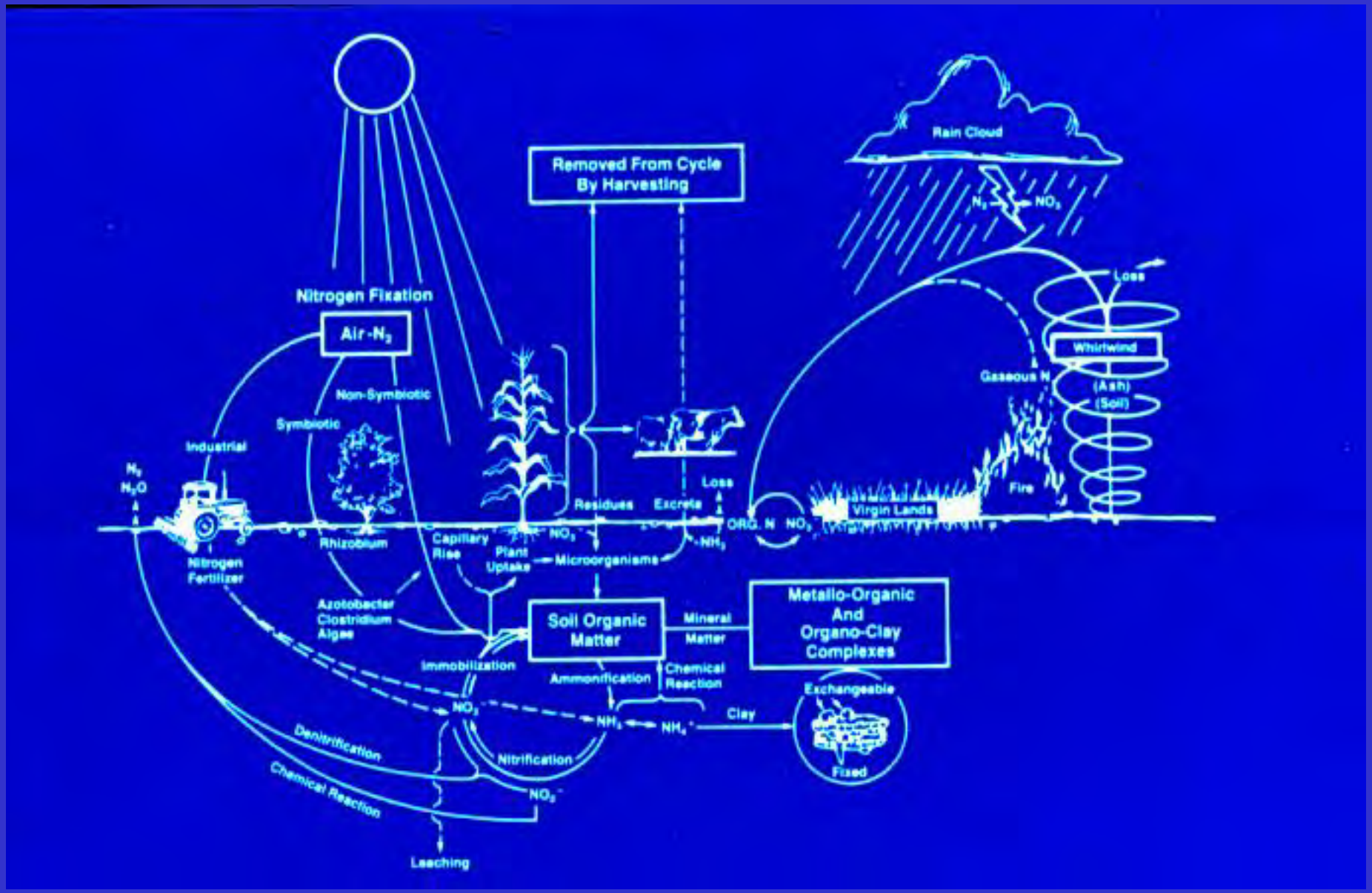
Nitrogen in Corn Production

- **The most limiting fertilizer element**
- **Many important roles in the plant**
- **Difficult to manage in production systems**

Nitrogen as the Limiting Element

- **Plants require large quantities**
- **Not part of soil parent materials**
- **Not all plant available**
- **Complex cycle in the environment**


Removed From Cycle By Harvesting
Rain Cloud
N_2 — NO_3
Nitrogen Fixation
Air-N_2
Loss
Whirlwind
Gaseous N
(Ash)
(Soil)
Non-Symbiotic
Symbiotic
Industrial
N_2
N_2O
Residues
Excreta
Loss
Fire
Virgin Lands
ORG. N
NO_3
Rhizobium
Capillary Rise
Plant Uptake
NO_3
NH_3
Microorganisms
Nitrogen Fertilizer
Azotobacter
Clostridium
Algae
Soil Organic Matter
Mineral Matter
Metallo-Organic And Organo-Clay Complexes
Immobilization
Ammonification
Chemical Reaction
Exchangeable
NO_2
NH_3
NH_4^+
Clay
Fixed
Denitrification
Nitrification
Chemical Reaction
NO_3^-
Leaching

Nitrogen in the Plant

- **Use as ammonium or nitrate**
- **Must be assimilated**
- **Numerous important roles**

Two Forms of Nitrogen Suitable for Plant Growth

NH_4^+

Ammonium

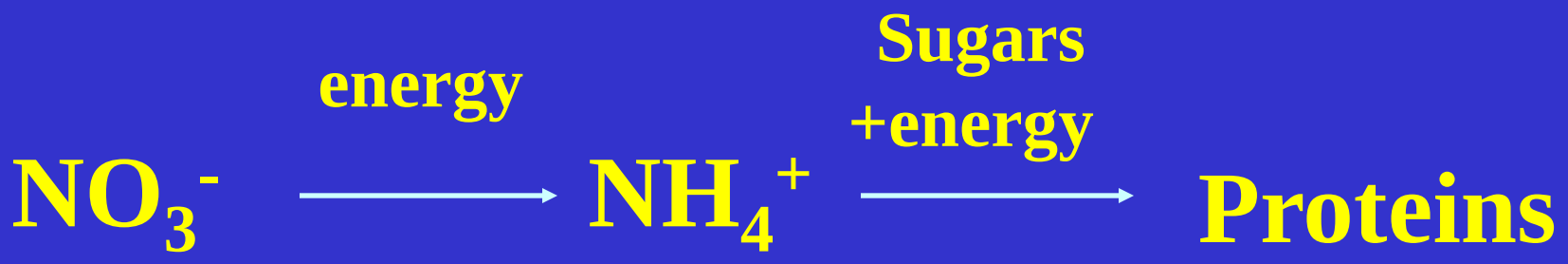
NO_3^-

Nitrate

Nitrogen in the Plant

- **Use as ammonium or nitrate**
- **Must be assimilated**
- **Numerous important roles**

Fate of Nitrogen in the Plant



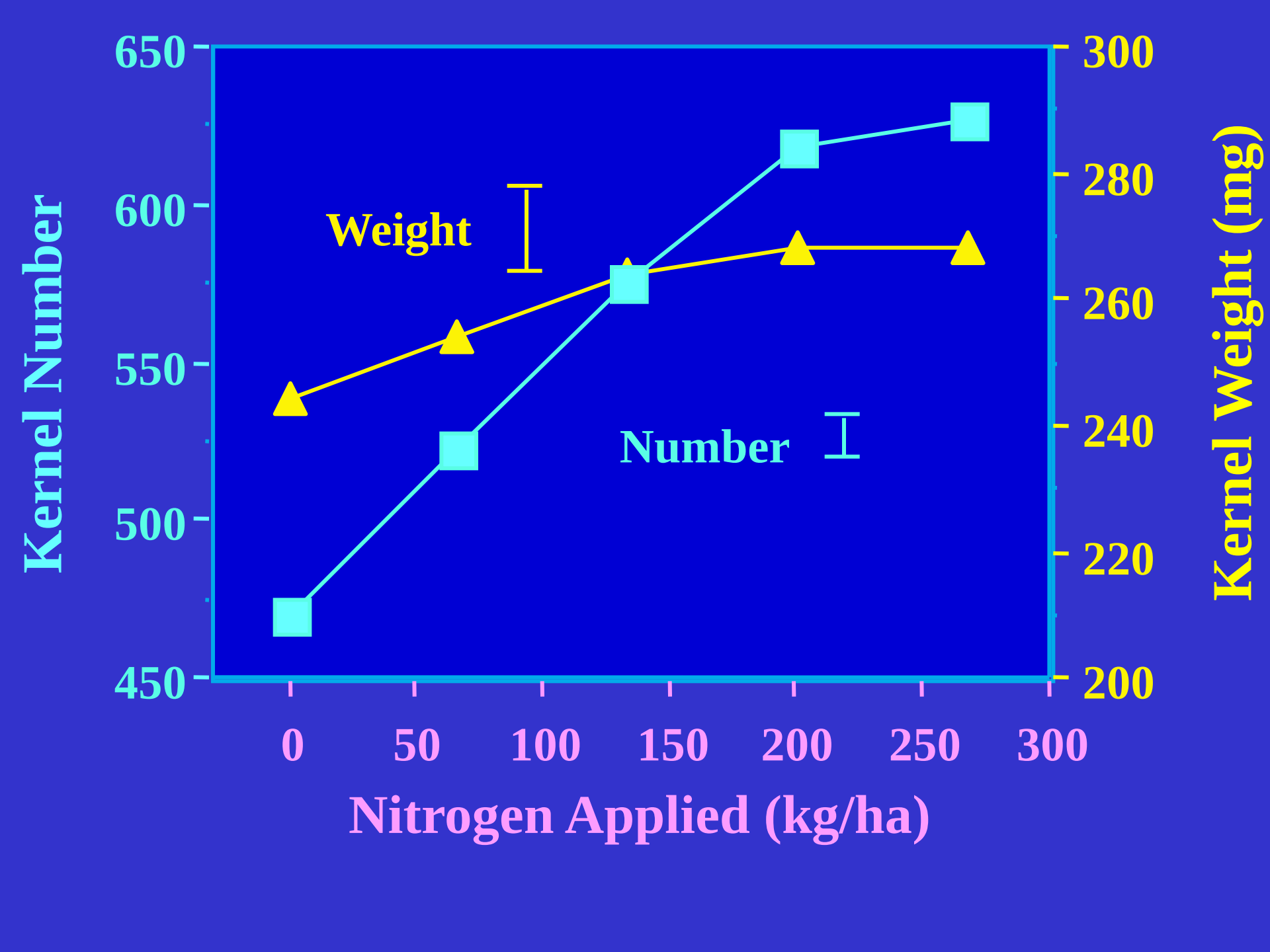
Nitrogen in the Plant

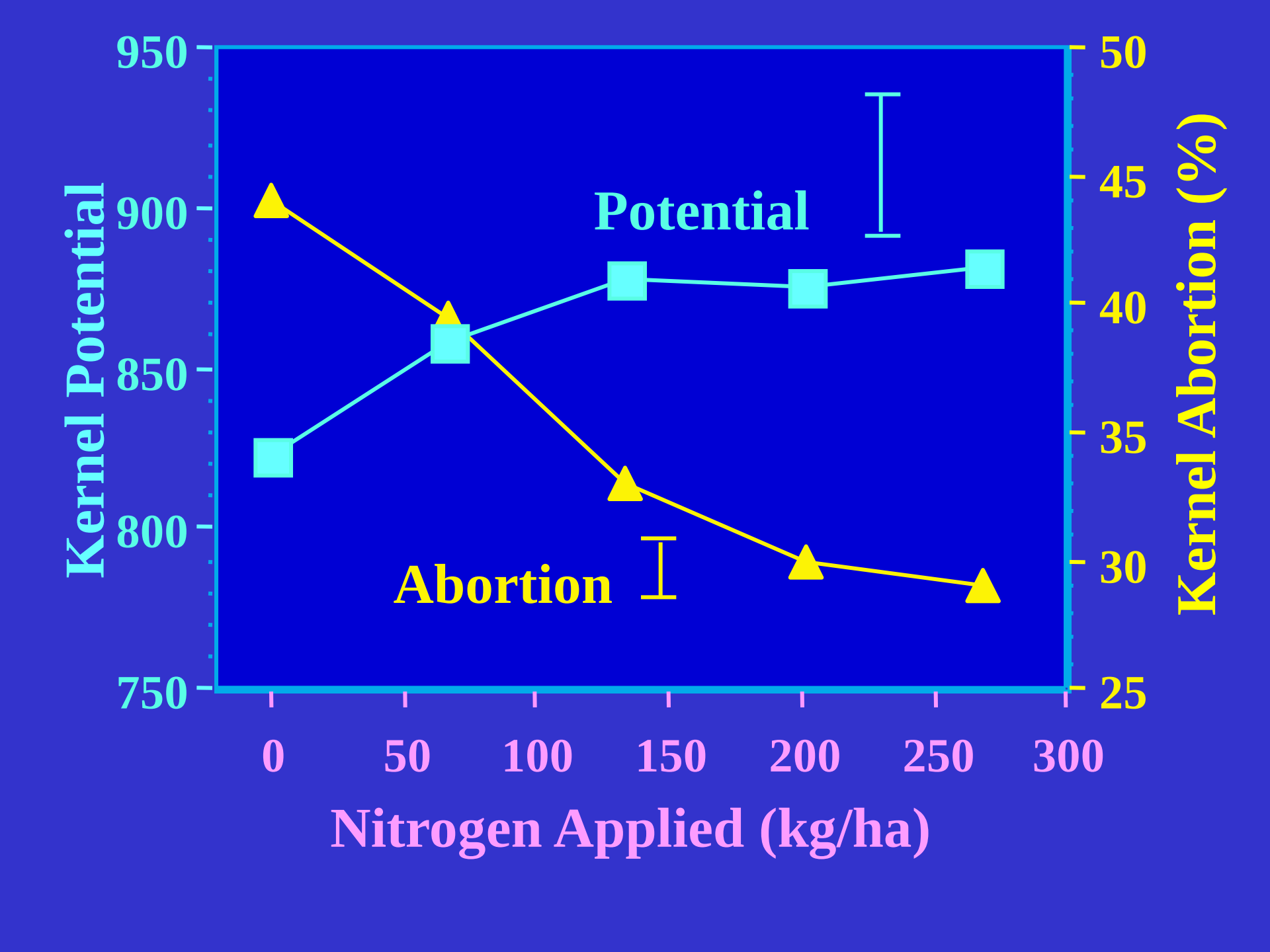
- **Use as ammonium or nitrate**
- **Must be assimilated**
- **Numerous important roles**

Important Roles for Nitrogen

- **Establishment of leaf photosynthesis**
- **Reproductive development**


Deficient N
Sufficient N


650
600
550
500
450
Kernel Number
300
280
260
240
220
200
Kernel Weight (mg)
Weight
Number
0
50
100
150
200
250
300
Nitrogen Applied (kg/ha)


950
900
850
800
750
Kernel Potential
50
45
40
35
30
25
Kernel Abortion (%)
Potential
Abortion
0
50
100
150
200
250
300
Nitrogen Applied (kg/ha)

Difficulties Managing Nitrogen

- **How much to apply?**
- **What type to apply?**
- **When to apply?**
- **Affected by cultural practices**

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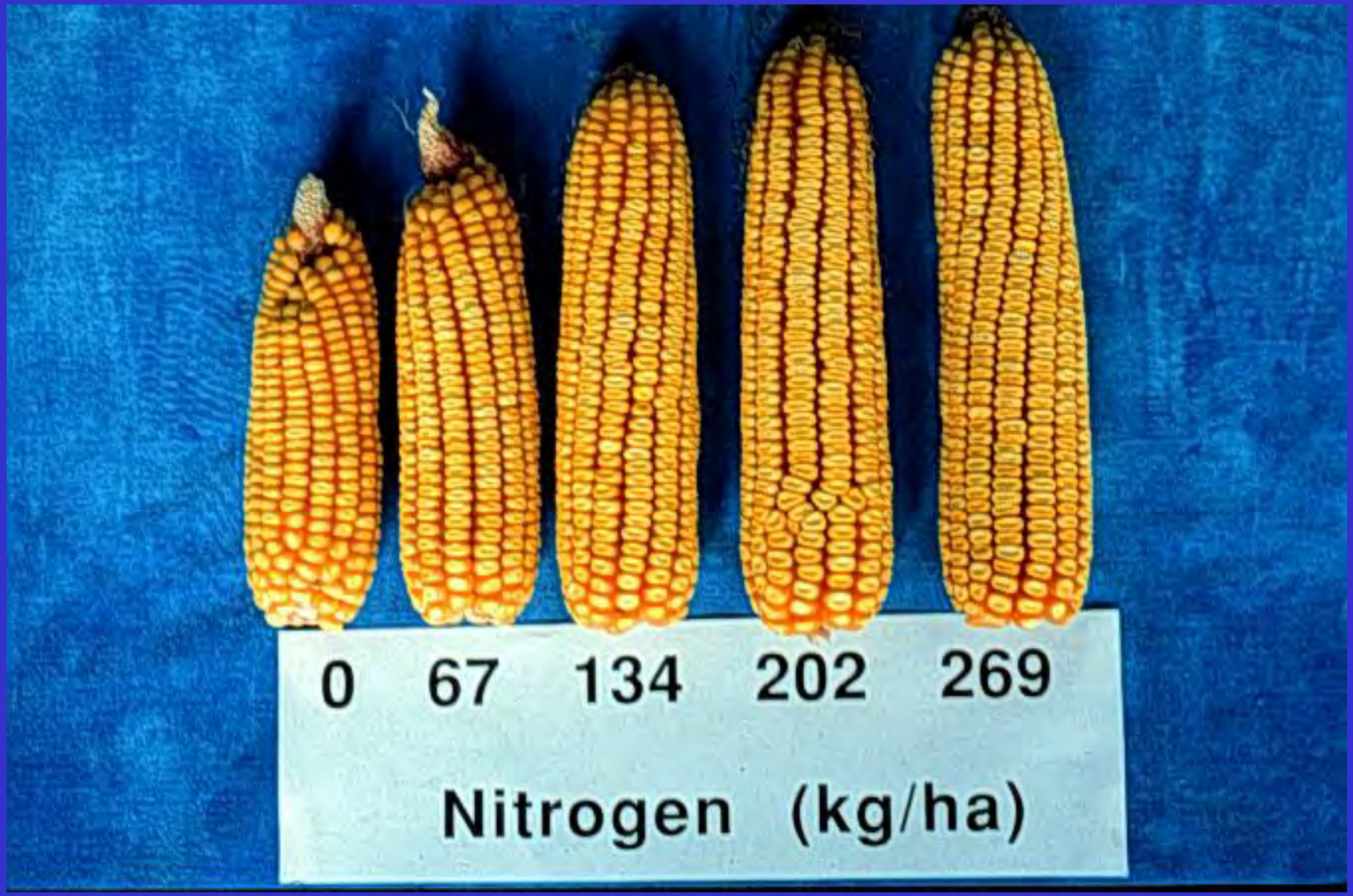

0 67 134 202 269
Nitrogen (kg/ha)

Fertilizer N Recommendation (Illinois)

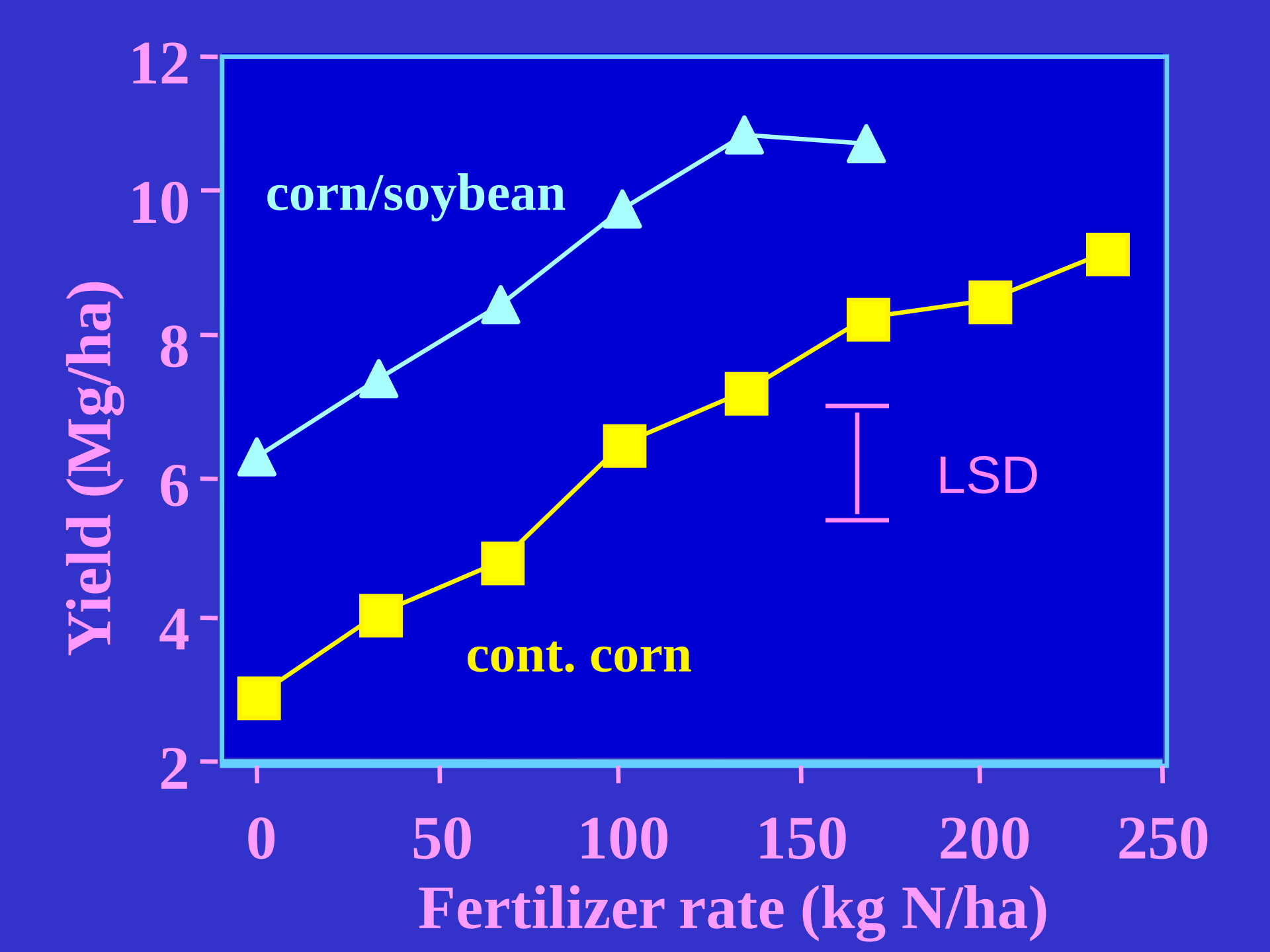
- Average yield (5 year) + 5%
- Multiply by N factor (21.4 kg N/Mg)
- Subtract N credits

Nitrogen Recommendation Credits

- **Ammoniated phosphate fertilizers**
- **Herbicide carriers**
- **Manure**
- **Legumes**

Soybean Nitrogen Credits

- **Subtract 17 kg N/ha per Mg of soybean harvested**
- **To a maximum of 45 kg N/ha**


12
10
8
6
4
2
Yield (Mg/ha)
corn/soybean
cont. corn
LSD
0
50
100
150
200
250
Fertilizer rate (kg N/ha)

Fertilizer N Recommendation (Illinois)

- Average yield (5 year) + 5%
- Multiply by N factor (21.4 kg N/Mg)
- Subtract N credits

Nitrogen Fertilizer Needed to Maximize Yield on the Same Field (Corn following Soybean, Champaign, IL)

Year	Grain yield	Optimum N Rate	Nitrogen Requirement
	Mg/ha	kg/ha	kg N/Mg
1995	8.0	135	22.4
1996	10.7	170	19.9
1997	11.2	180	20.0
1998	9.5	130	18.8
1999	13.2	180	16.9

Difficulties Managing Nitrogen

- **How much to apply?**
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Fertilizer N Sources and Proportion of N Forms

N Source	Nitrogen Form	
	NO_3-N	NH_4-N
	%	
Anhydrous ammonia	0	100
Ammonium sulfate	0	100
Urea	0	100
28% N solutions	25	75
Ammonium nitrate	50	50
Potassium nitrate	100	0

Nitrogen Forms and Plant Growth

- **Mainly use NO_3^- due to nitrification**
- **NO_3^- responsible for most losses**
- **Better plant growth with mixtures of NO_3^- & NH_4^+**


EARS FROM CORN
PLANTS GROWN
WITH ALL NITRATE
(100/0, at left)
AND WITH
HALF AMMONIUM/HALF NITRATE
(50/50, at right)
SOURCES OF
NITROGEN NUTRITION
100/0
50/50

Effect of N form on Grain Yield and Physiological Parameters of Corn in Field-Hydroponics (Average of All Hybrids Over 6 Years).

Parameter	Nitrate/Ammonium 100/0	50/50
Yield (Mg/ha)	12.3	13.8
Kernels (no./plant)	652	737
N Uptake (kg/ha)	279	343

Difficulties Managing Nitrogen

- **How much to apply?**
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Time of N Application on Grain Yield (N as Ammonium Sulfate, Ave.of 3 Locations/year).

	Year			
Time	1997	1998	1999	Ave.
		Mg/ha		
No N	8.0	5.8	7.0	6.9
Fall	9.4	8.5	8.6	8.8
Winter	9.3	9.4	9.2	9.3
Spring	9.7	10.0	9.6	9.8

Difficulties Managing Nitrogen

- **How much to apply?**
- **What type to apply?**
- **When to apply?**
- **Affected by cultural practices**

Effect of Tillage System on the Response to Fertilizer N (Average of Three Locations).

Nitrogen Rate	Tillage System		
	No	Strip	Mulch
kg/ha	Mg/ha		
0	6.4	7.4	8.0
45	8.9	9.6	9.8
90	11.2	11.2	12.0
135	12.5	12.7	12.4
180	13.4	13.6	13.6
246	13.6	13.9	13.9

General Conclusions

- **Nitrogen fertilizer enhances yield by reducing ovule abortion, resulting in more kernels per plant.**

- **There is a clear N benefit (i.e. N credit) to proceeding the corn crop with soybean, which may be greater than the 45 kg N/ha value currently used.**

General Conclusions

- **Nitrogen fertilizer needs are variable, but rarely exceed 20 kg of N per Mg of yield.**

- **Supplying the corn plant with a mixture of nitrate and ammonium can sometimes increase yields, by enhancing N accumulation and decreasing kernel abortion.**

General Conclusions

- **The closer the N fertilizer can be applied to the time of plant uptake the higher the potential yield.**

- **Tillage system can effect the yield response to fertilizer N, but only when N is applied in limiting amounts.**