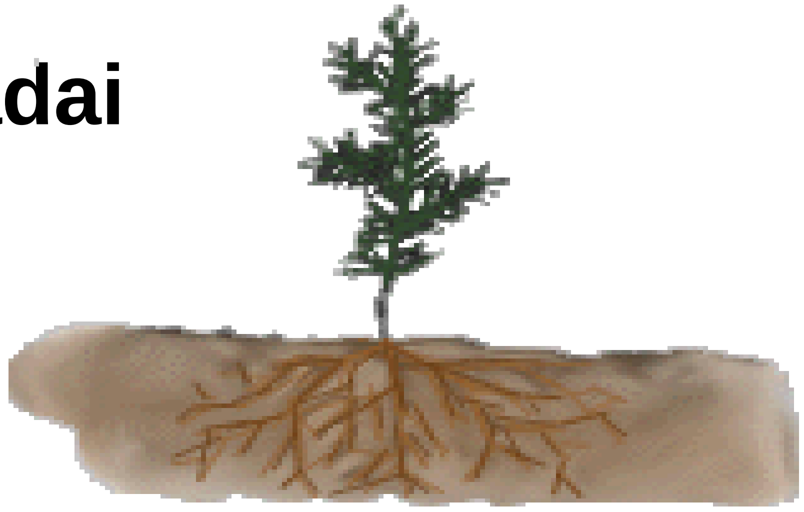
NUTRISI DALAM SISTEM PRODUKSI TANAMAN

PERTUMBUHAN TANAMAN dipengaruhi oleh :

- Cukup Cahaya/Light
- Dukungan fisik tanah yang memadai
- Emperatur optimum
- Udara cukup
- Air cukup
- Jumlah Hara tanaman cukup
  - Semuanya ada dlm tanah kecuali cahaya



PERANAN HARA DALAM TANAMAN

- **NITROGEN**

Jumlah dalam tanaman paling banyak, 2 – 4 % dari berat kering

Diserap tanaman dalam bentuk NH_4^+ dan NO_3^-,
namun beberapa asam amino dan urea juga dapat diserap oleh akar

Nitrat (NO_3^-), merupakan bentuk yang paling banyak tersedia, dan sumber yang penting untuk tanaman

Amonium (NH_4^+) adalah bentuk N penting untuk tanaman padi yang hidup dalam kondisi tergenang , dan anaerob.
Penggunaan NH_4^+ Lebih efektif dibanding NO_3^- dalam setiap tahap pertumbuhan padi

TRANSFORMASI N DALAM TANAMAN

- $NO3^{-}$ yang diserap akar akan mengalami
  - Di reduksi di akar
  - Di pindahkan ke tajuk dan tereduksi di Tajuk
  - Direduksi di akar dan di tajuk

NITRATE ASSIMILATION

$NO_3 \rightarrow NO_2 \rightarrow NH_{4+} \rightarrow$ amino acids

nitrate *nitrite* *ammonium*

- Requires large input of energy
- Forms toxic intermediates
- Mediated by specialized enzymes that are closely regulated
- Doesn’t have to start at the beginning

Nitrite reduction ($NO_2 \longrightarrow NH_4$)

- $NO_2^- + 6\ Fd_{red} + 8\ H^+ + 6\ e^- \longrightarrow NH_4^+ + 6\ Fd_{ox} + 2\ H_2O$

- Chloroplastic reaction
- Requires more e- and reducing power
- Form toxic ammonium
- Mediated bay nitrite reductase

Plants assimilate nitrate in both roots and shoots

- In many plants, when the roots receive small amounts of nitrate, this nitrate is reduced primarily in the roots

- As nitrate supply increases, a greater proportion of the absorbed nitrate is translocated to the shoot and assimilated there

- Generally, species native to temperate rely more heavily on nitrate assimilation by the roots than do species of tropical or subtropical origins

Faktor-faktor yang mempengaruhi Reduksi Nitrat

1. CAHAYA

- suplai karbohidrat
- suplai feredoxin / NADPH
- stabilitas enzim

} → aktifitas enzim NR

Cahaya <<< → akumulasi NO_3

Reduksi nitrat dalam daun; siang hari > malam hari.

2. UNSUR HARA

Mo → komponen nitrat reduktase.

Mo <<< akumulasi NO_3^- → NH_3 <<

Mn → mempengaruhi fotosistem II

3. SUPLAI NO_3

Suplai NO_3 <<< → Reduksi NO_3 pada akar >>>

Suplai NO_3 >>> → Reduksi di tajuk >>>

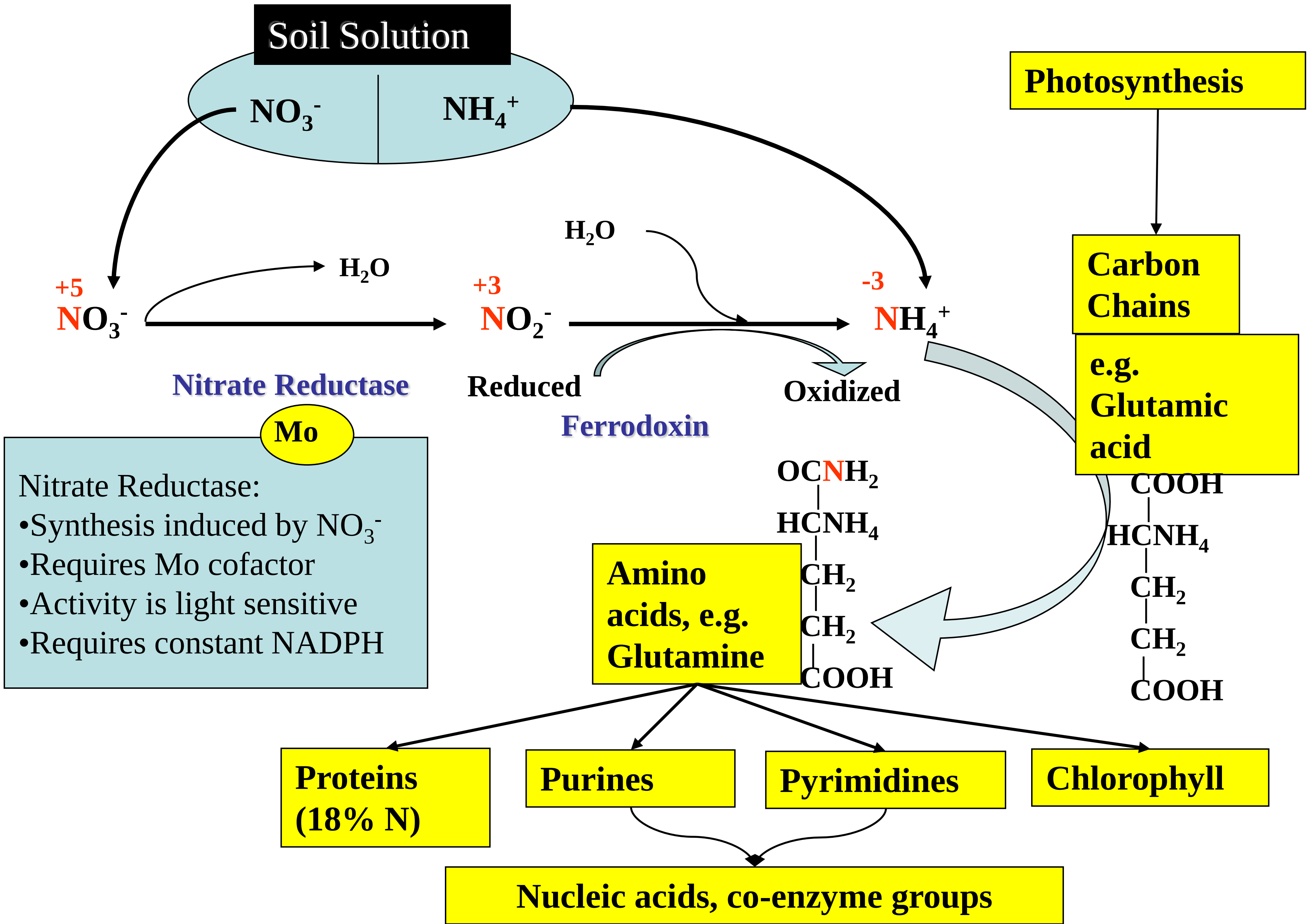
↓

kapasitas reduksi akar terbatas.

AMMONIUM ASSIMILATION

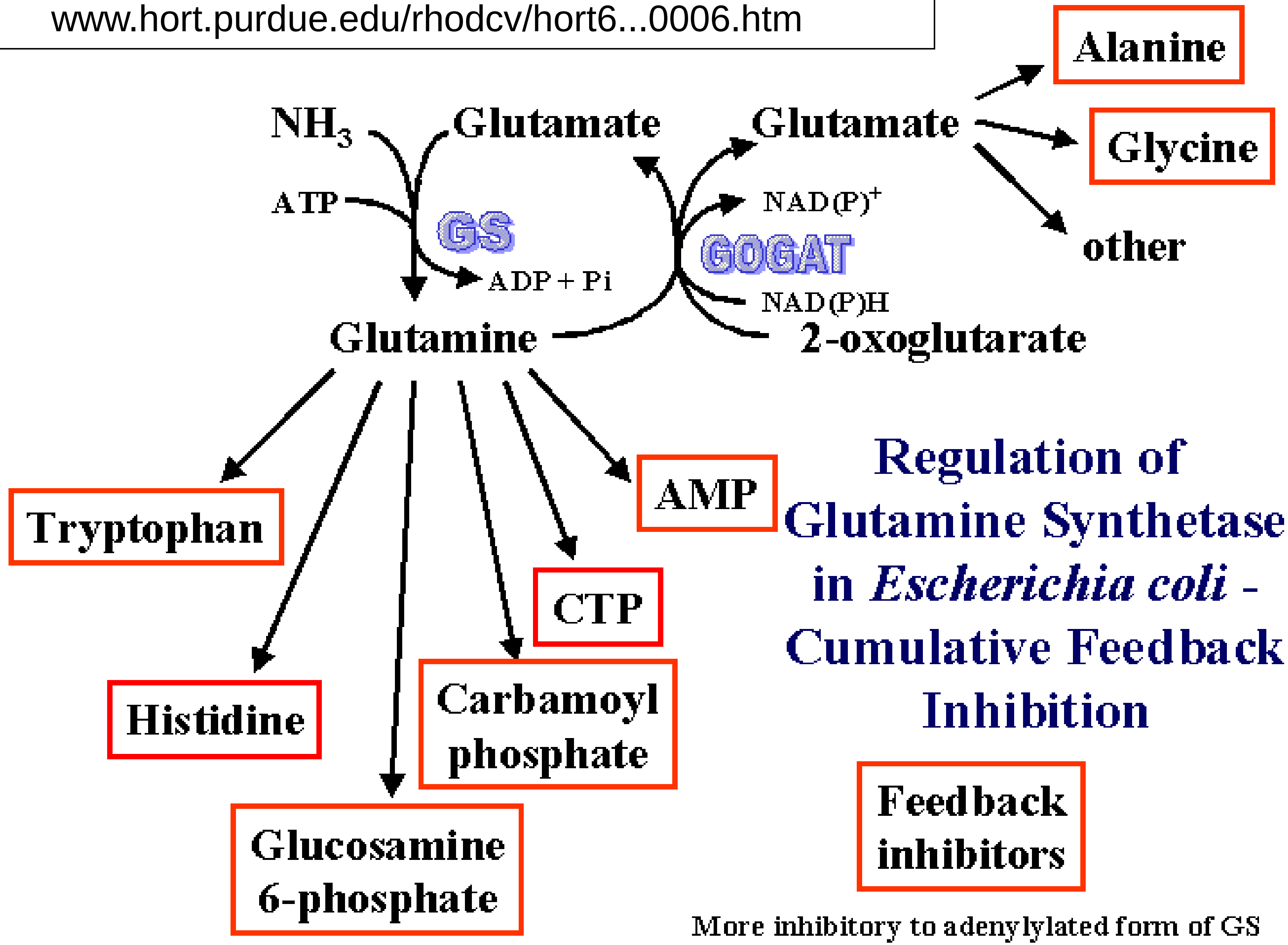
- Plants cells avoid ammonium toxicity by rapidly converting the ammonium generated from nitrate assimilation or photorespiration into amino acids
- This requires the action of two enzymes
  - ***Glutamine synthetetase*** – **combines ammonium with glutamate to form glutamine**
  - ***Glutamate synthase*** – **stimulated by elevated levels of glutamine synthetase**
  - **Transfers the amino group of glutamine to an intermediate yielding two molecules of glutamate**

Nitrogen Assimilation by the Plant



www.hort.purdue.edu/rhodcv/hort6...0006.htm

Regulation of Glutamine Synthetase in *Escherichia coli* - Cumulative Feedback Inhibition



More inhibitory to adenylylated form of GS

Nitrogen as essential plant nutrient

Ammonium (NH_4^+)

- "preferred" source at pH > 7
- May be toxic if a high % of N taken up
- Lowers rhizosphere pH

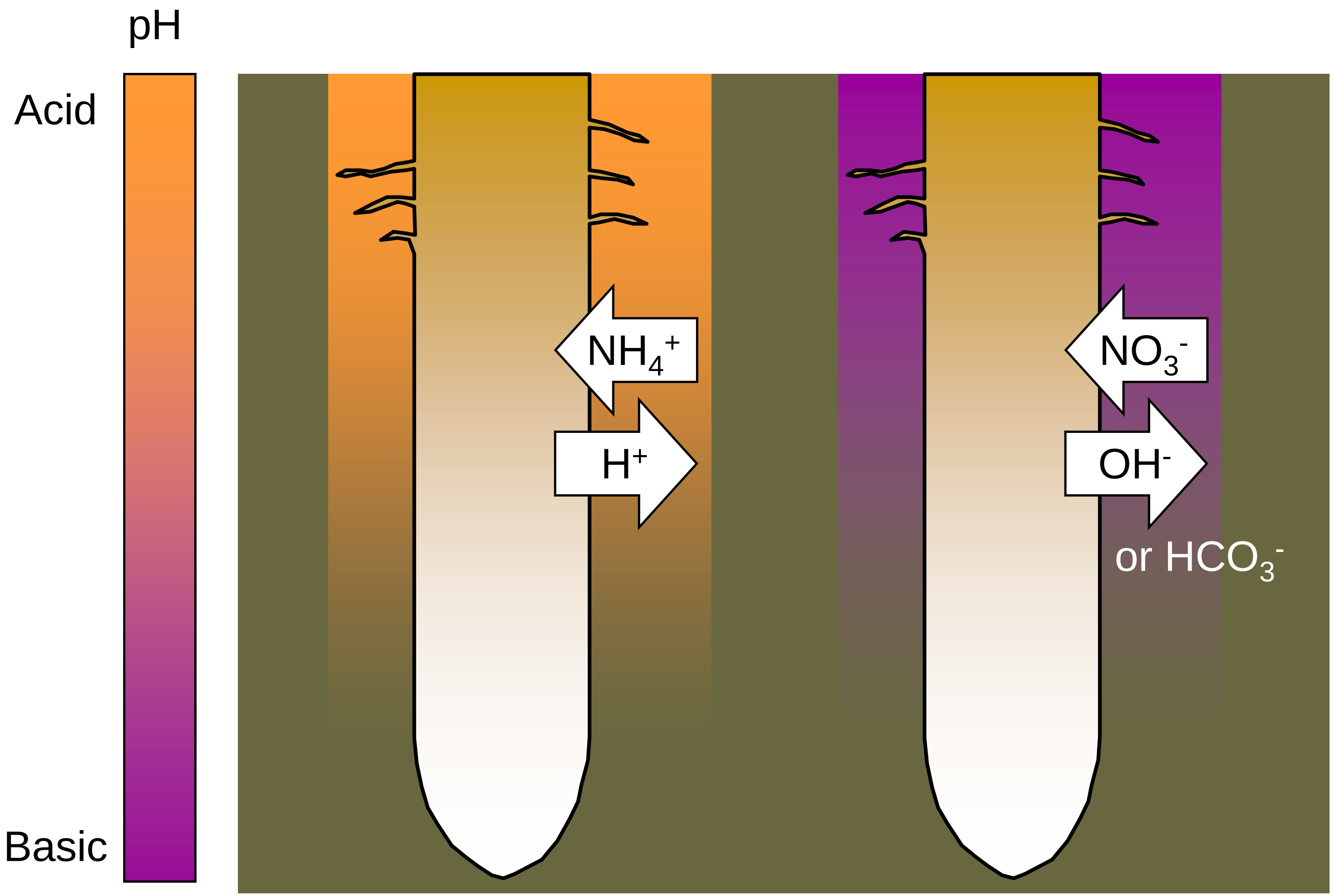
•NH_3 + H^+ $\rightleftharpoons$ NH_4^+

Gas or Aqueous

Nitrate (NO_3^-)

- Usually most abundant and easily taken up.
- Active up-take against electro-chemical gradient.
- Raises rhizosphere pH

Ammonium and nitrate: rhizosphere pH differences



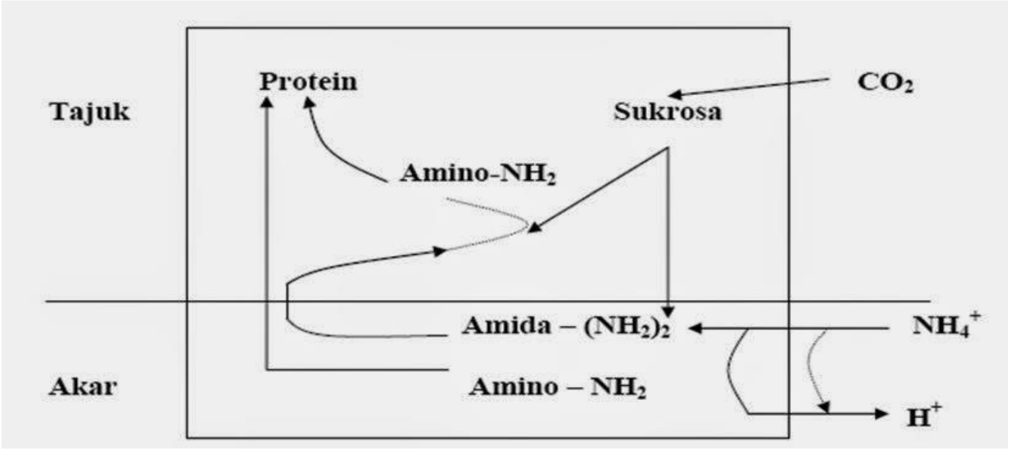
Marschner, 2002

BENTUK DAN FUNGSI N DALAM TANAMAN

SEBAGIAN BESAR bentuk N dalam tanaman , dlm bentuk terassimilasi C - N $\langle^{H}_{H}$

MOBILITAS DALAM TANAMAN.

N dalam bentuk *an organik* dapat dipindahkan dalam xylem .
N yang direduksi di akar dipindahkan dalam bentuk *organik* (as amoni amida)
N bersifat mobil dalam tanaman (phloem),
Dapat dipindahkan dari daun bagian tua ke bagian muda, ketika terjadi defisiensi.
Dapat dipindahkan dari daun ke biji yang sedang berkembang



INTERAKSI N

N dengan P sering terjadi interaksi sebab :

N dan P menjadi faktor pembatas

NH4- dari pupuk dapat meningkatkan ketersediaan P

DAP → $NH4^{+}$ + $H2PO4^{-}$

2 NH4 + 3 O2 → 2 NO 2 + H2O + 4 H

2 NO2 + O2 → 2 NO3

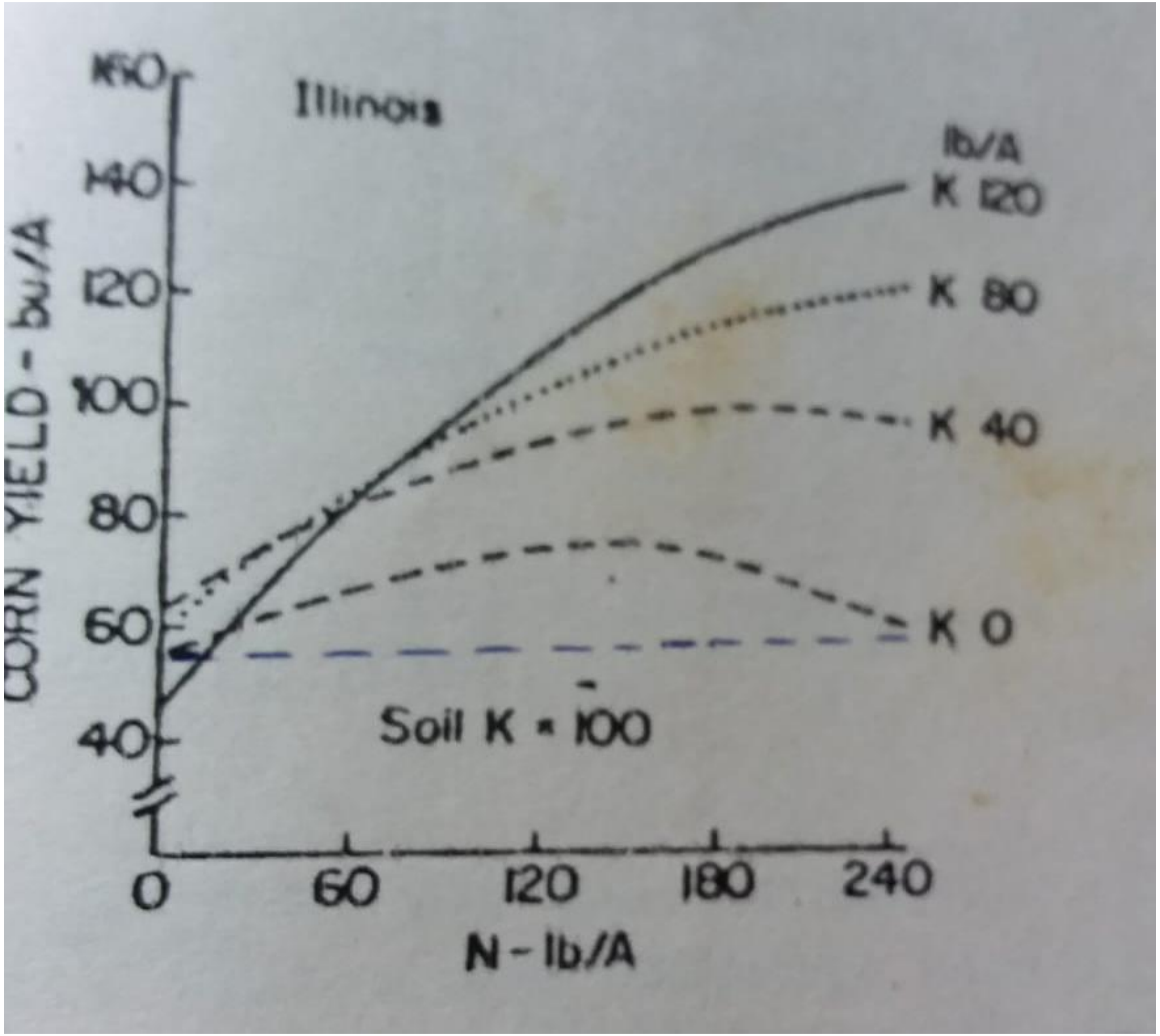
H dari proses nitrifikasi akan meningkatkan ketersedian P

Table 6.14 Nitrogen and phosphorus interactions in sorghum grain yield.

P applied (kg P ha-1	N applied (kg N ha-1 0	50	100	200
0	460	475	500	510
10	480	1120	2140	3605
20	492	2050	3200	4250

Table 6.15 The effect of fertiliser treatments on yield of grain sorghum

Fertiliser nutrients applied (kg ha-1)	Grain yield of sorghum (kg ha-1)
Control	2317
40 P (superphosphate)	2887
38 N (urea)	2598
40 P + 38 N (superphosphate + urea)	3106
40 P + 38 N (diammonium phosphate)	3725
LSD 5%	619



Illinois
CORN YIELD - bu/A
160
140
120
100
80
60
40
lb/A
K 120
K 80
K 40
K 0
Soil K = 100
0
60
120
180
240
N - lb/A

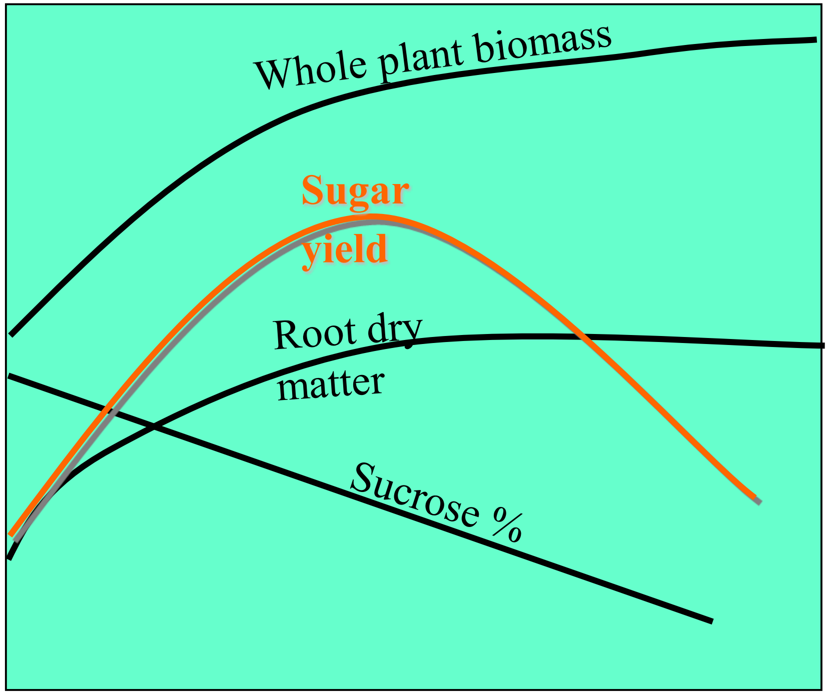
Biological function of N

- Protein (one or more N per amino acid)
- Base pairs for RNA/DNA
- Prosthetic groups for protein (ex.: heme group of chlorophyll)
- Hormones (ABA, cytokinins)
- Metal uptake (phytosiderophores) and transport in xylem & phloem (ex: Cu with amines)
- Osmoregulation (ex.: lettuce and spinach, which may accumulate 0.1 M NO3- in vacuoles!)
- Chemical defenses, alkaloids, misc. biochemicals (ex: mescaline, cocaine, morphine, nicotine, caffeine, quinine)

Plant Responses to Deficiency of Nitrogen

- Hastens maturity (flowers early)
- Lowers ratio of shoot/root
- Spindly, thin stems
- Chlorotic (light green to yellow)
- Stunted
- Old leaves yellow 1st
    - Advances up mid-rib in grass leaves
- Carbohydrates accumulate (sweeter flavor)

Example of sugar beet



Nitrogen applied (kg/ha)

Plant Responses to Excess or Unbalanced Nitrogen

- Increased fungal disease
  - (e.g. stalk rot if K is also low)
- Delayed maturity (esp. if P and K are low)
- Increased lodging
- Higher protein – lower sugar
- Weak fiber (e.g. cotton)
- Thin cell walls
  - More succulent
  - Susceptible to pests, diseases

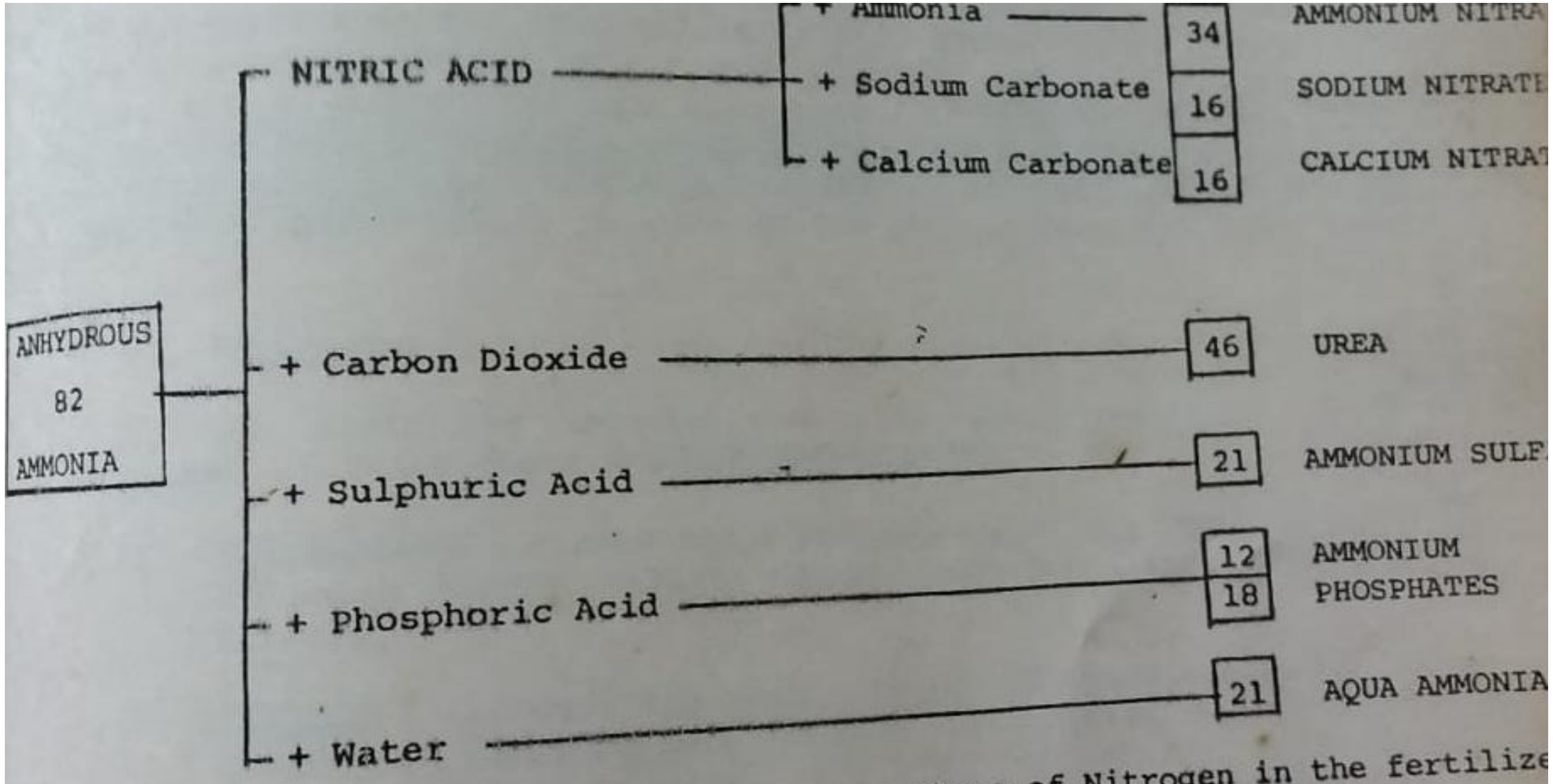
Nitrogen

- **Deficiency Symptoms**
  - Sick, yellow-green color.
  - Short stems, small leaves, pale colored leaves and flowers.
  - Slow and dwarfed plant growth.

Plant Responses to Excess or Unbalanced Nitrogen

- Increased fungal disease
  - (e.g. stalk rot if K is also low)
- Delayed maturity (esp. if P and K are low)
- Increased lodging
- Higher protein – lower sugar
- Weak fiber (e.g. cotton)
- Thin cell walls
  - More succulent
  - Susceptible to pests, diseases

N FERTILIZER



Note: Figures in squares denote percentage of Nitrogen in the fertilize

Figure 7.2 Manufacture of Nitrogenous Fertilisers

liquid either

AMONIA

NH_3

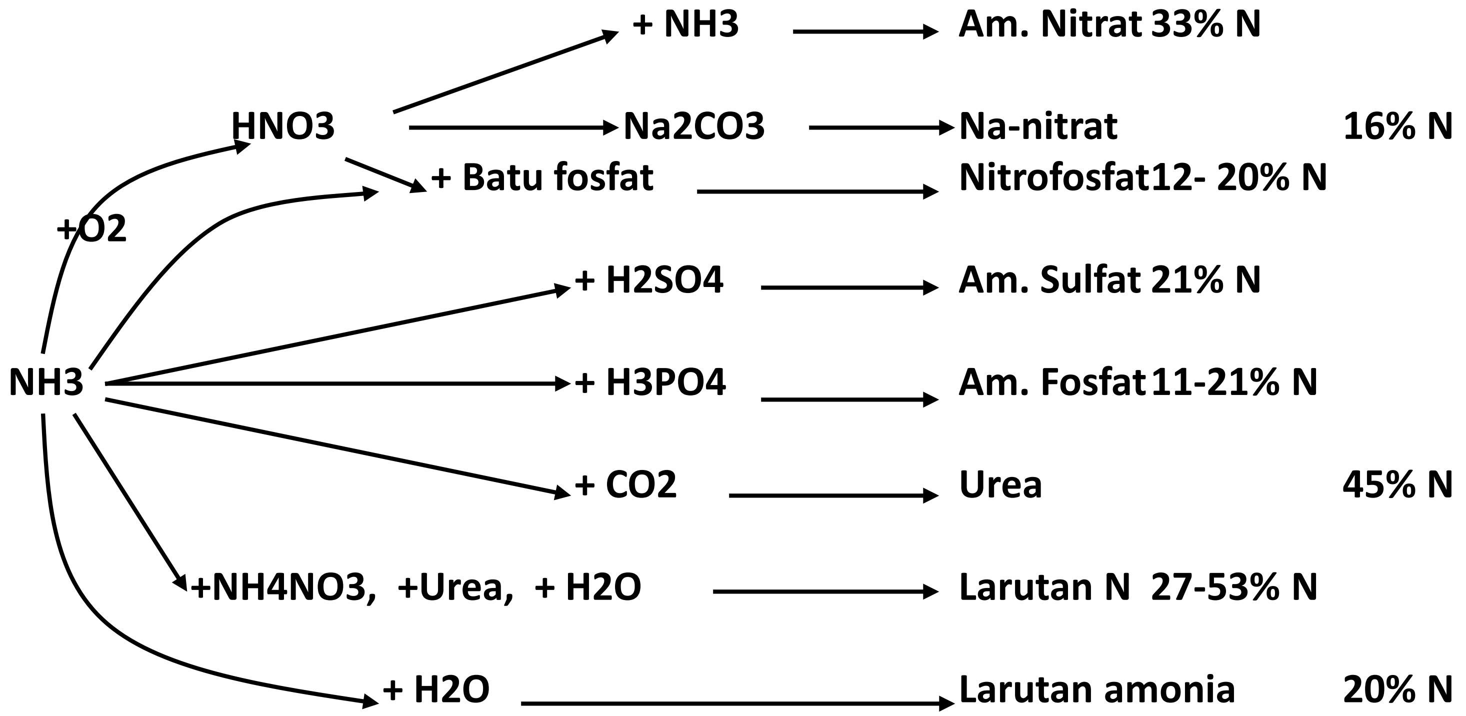
Gas amonia dibuat dari unsur-unsurnya, Hidrogen dan nitrogen:

$$N_2 + 3H_2 \longrightarrow 2\,NH_3$$

Penggunaannya:

1. Dg menggunakan tekanan tinggi dapat dicairkan menjadi amonia cair
2. Dapat dilarutkan dlm air menjadi NH_4OH
3. Gas amonia dipakai untuk pembuatan pupuk lain

Bagan pembuatan pupuk Nitrogen:



REAKSI PUPUK N DALAM TANAH

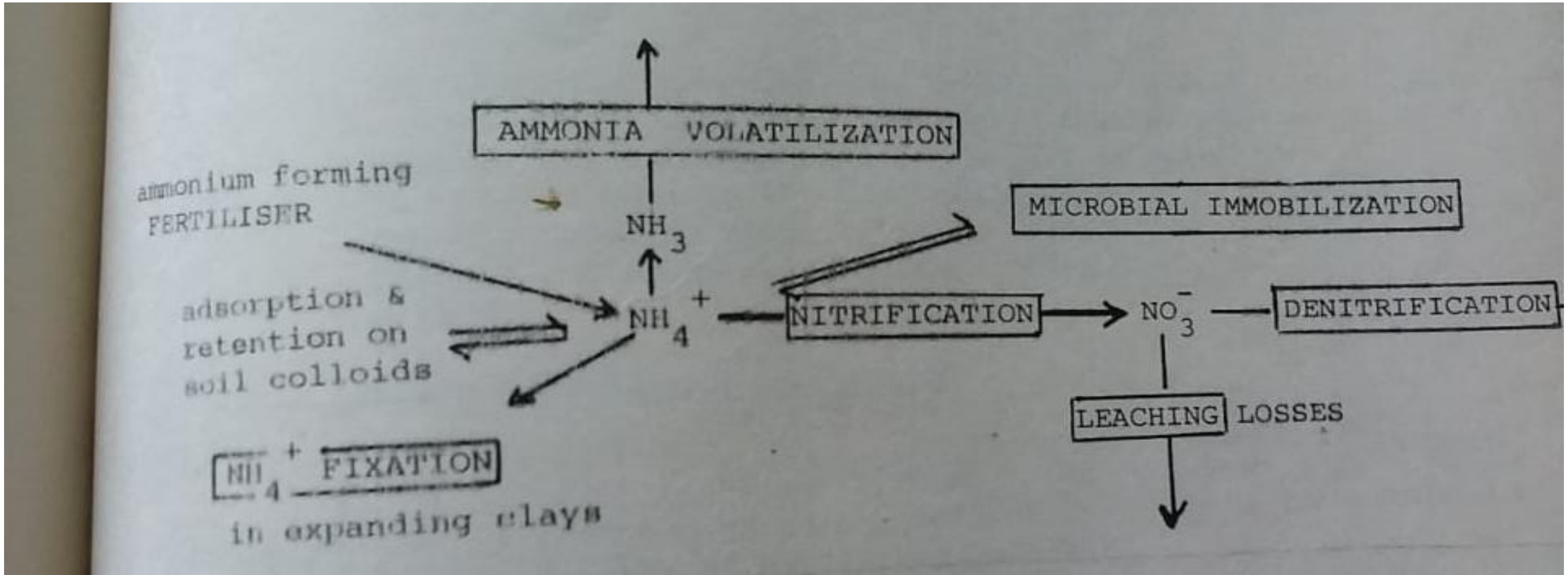


Figure 7.4 Schematic representation of the reactions of fertiliser N in soils.

Reaction of urea

Urea hydrolysis at pH 6.5 – 8.0

$$CO(NH_2)_2 + H^+ + 2H_2O \xrightarrow{\text{urease}} 2NH_4^+ + HCO_3^-$$

Urea hydrolysis at pH < 6.5

$$CO(NH_2)_2 + 2H^+ + 2H_2O \xrightarrow{\text{urease}} 2NH_4^+ + H_2CO_3$$

- **Acid-consuming**
- **pH will not increase above 9.3**

Koelliker and Kissel, 1988

Volatilization

Urea hydrolysis

1. $(NH_2)_2CO + 2H_2O \longrightarrow (NH_4)_2CO_3$
   Urea — Urease — Ammonium Carbamate

2. $(NH_4)_2CO_3 + 2H^+ \longrightarrow 2NH_4^+ + CO_2\uparrow + H_2O$
   Ammonium

3. $NH_4^+ + OH^- \longrightarrow NH_3\uparrow + H_2O$
   Hydroxyl — Ammonia

pH increase as a result of hydrolysis

at pH 7.0, 0.6% as NH_3 -- at pH 9, 37% NH_3

Volatilization of ammonia

The reaction $NH_4 \leftrightarrow NH_3 + H^+$ is driven by:

- Difference in NH_3 activity between where the fertilizer was applied and the surrounding air
- Higher pH
- Higher temperature
- Lower CEC
  (maintains a higher solution NH_4 concentration)
- Loss of CO_2, which causes the pH to increase
- Contact with crop residues, which contain urease

Koelliker and Kissel, 1988

Volatilization

- Field conditions decreasing urea hydrolysis and NH_3 loss
  - 0.25 to 0.5 inch rainfall within 2 - 3 days after application
  - Surface temperatures below 50º F
  - Surface soil pH < 7.0
  - Dry soil surface
  - Low crop residue
  - High buffer capacity soils
  - Use of a urease inhibitor

Volatilization

- Field conditions increasing urea hydrolysis and NH_3 loss
  - No rainfall/incorporation after application
  - High crop residue on soil surface
  - High surface soil pH (alkaline soils)
  - High surface temperatures
  - Moist to drying soils
  - Low soil clay and organic matter (low buffer and ability to absorb ammonium)

Phosphorus form affects urea volatilization

Treatment	Ammonia loss	
	clay, pH 5.2	silty clay loam, pH 6.0
	(% of urea N)	
Urea	4.7	9.8
Urea + TSP	1.8	4.9
Urea + MAP	4.2	4.1
Urea + DAP	12.8	14.2

Total N was kept constant at 117 lb N/acre
P rate was kept constant at 132 lb P_2O_5/acre

Fan and Mackenzie, 1993

Practical suggestions for urea use

- Avoid using as a preplant application on sandy soils
- Avoid contact with the seed
- Within 2 days:
  - Incorporate to a depth of 2 to 4 inches or
- Other considerations for no-till
  - Consider surface bands to reduce contact with urease
  - If also applying P, band MAP or TSP with the urea at the surface

Denitrification

- Biological conversion of nitrate to N gases(perubahan nitrat ke gas nitrogen)
- Occurs when the soil is full of water (kondisi tanah tergenang)

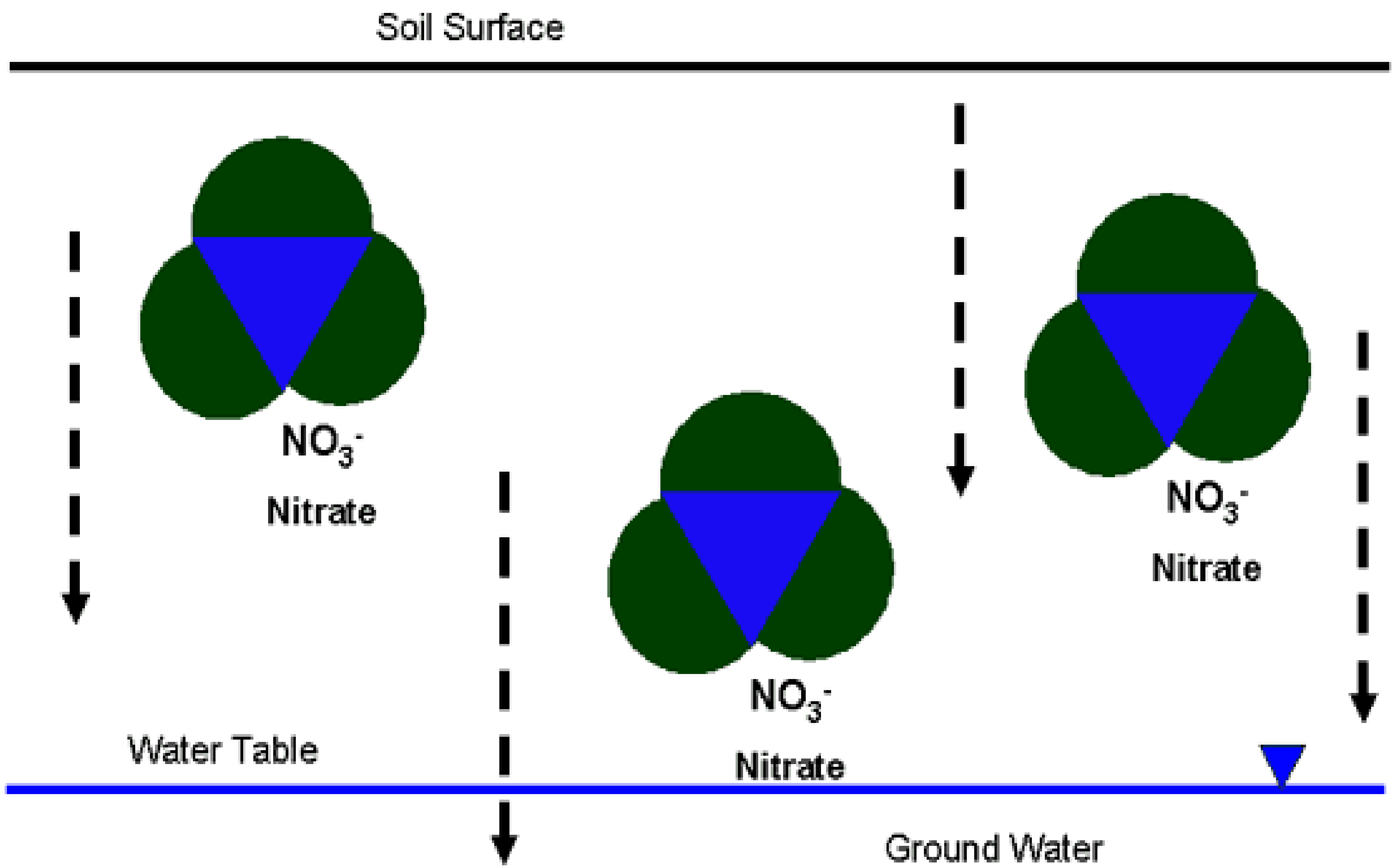
$$\mathbf{NO_3^- \longrightarrow NO_2^- \longrightarrow N_2O \longrightarrow N_2}$$

Conditions That Favor Denitrification
Faktor yg mendorong denitrifikasi

- Anaerobic conditions/tergenang
- Suitable temperature
  - Rate increases > 50º F
- Decomposable organic material
- Suitable pH
  - > 5.5
- Presence of denitrifying bacteria
- Presence of NO_3^- or NO_2^-

Leaching

Created by J. Strock
University of Minnesota



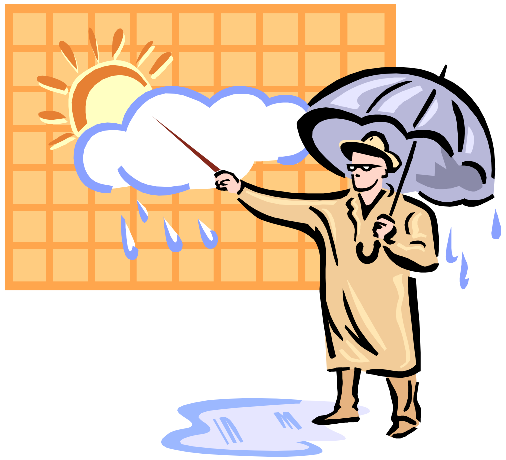
Nitrogen Rate

- Optimum fertilizer N rate to maximize yield is not related to maximum yield (corn following soybean)

Year	Maximum Yield, bu/acre	N rate to maximize yield, lb/acre
1998	241	179
1999	179	172
2000a	161	240
2000b	153	164
2001	184	225
2002	91	156
2003	237	231
2004	194	240
2005	198	175

Nitrogen Rate

- Why is fertilizer N need not related to yield potential?
  - Differences in mineralization (release of organic N to plant available form)
    - Mineralization is affected by weather during growing season
    - Currently unpredictable



Nitrogen Rate

- Organic matter in soil contains a large amount of N
  - Every 1% OM in the top six inches contains 1,000 lbs of N
  - This N is unfortunately not plant available
  - Must be mineralized

Organic Matter and N Response

- Do higher organic matter soils require as much N as a lower organic matter soil?
  - **If all things were equal, i.e. weather (moisture and temp) and nature of organic material, a soil with higher organic matter would require less N**

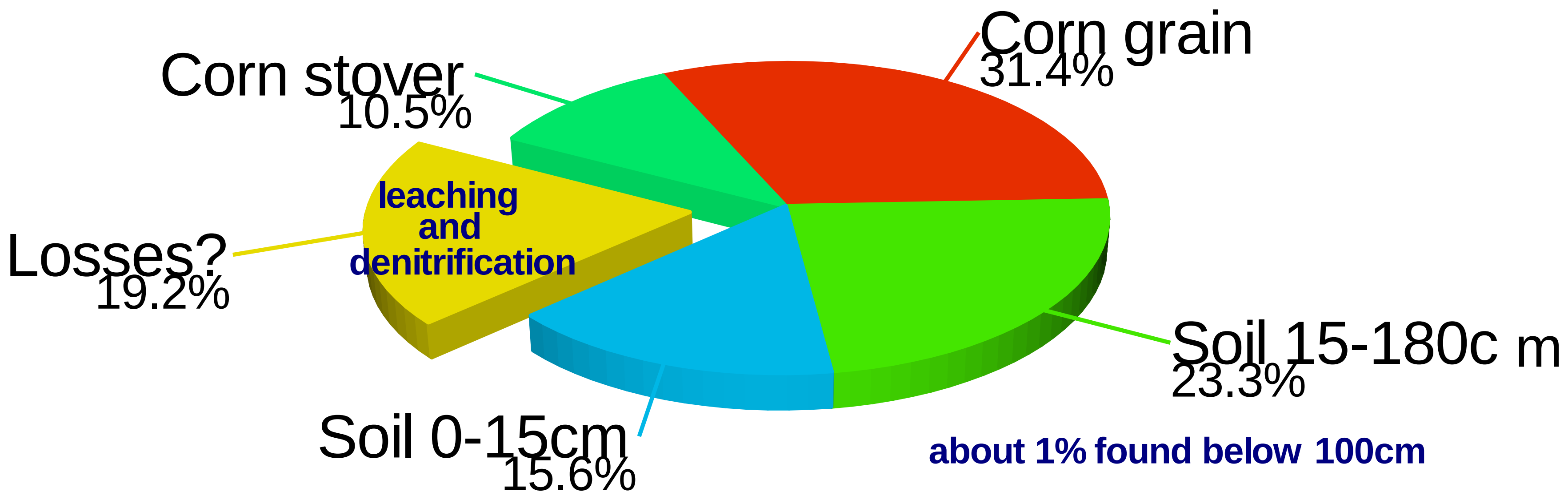
Cover Crops and N

- Can the nitrogen taken up be released back to the soil environment for the next crop?
  - Non-leguminous cover crops do not necessarily provide N benefit to subsequent crop
  - May see rotational benefit, but not necessarily decrease in nitrogen demand

Residual Fertility

- My corn productivity was not good this year and I am considering going back to corn next year, do I need to fertilize again?
- It depends
- What does your soil test say?
- Soils that contain adequate P and K based on soil test do not necessarily require fertilization.
- Nitrogen applied for corn is not likely to be around next spring due to loss mechanisms

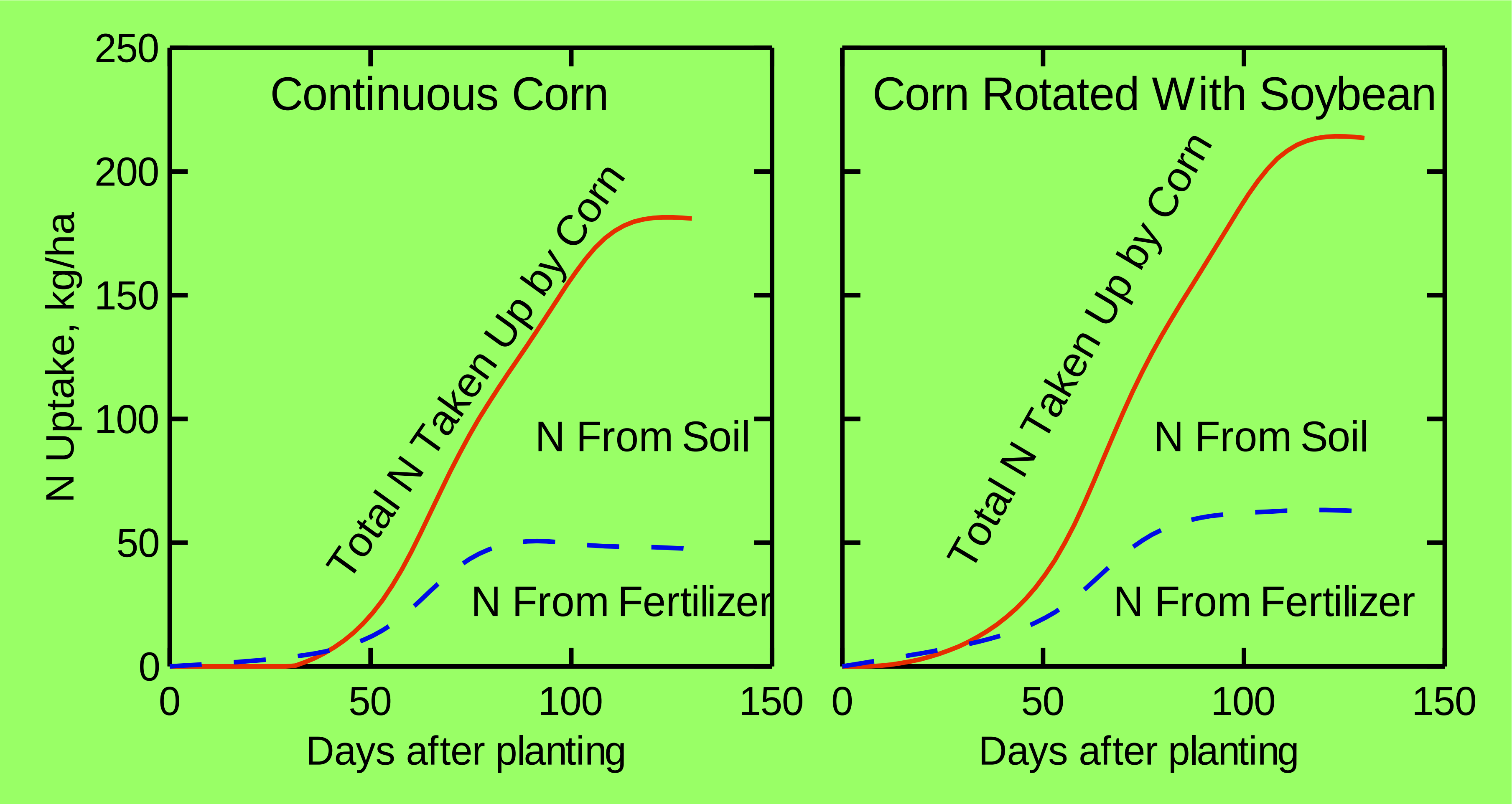
Fate of Fertilizer ^{15}N at Corn Grain Harvest



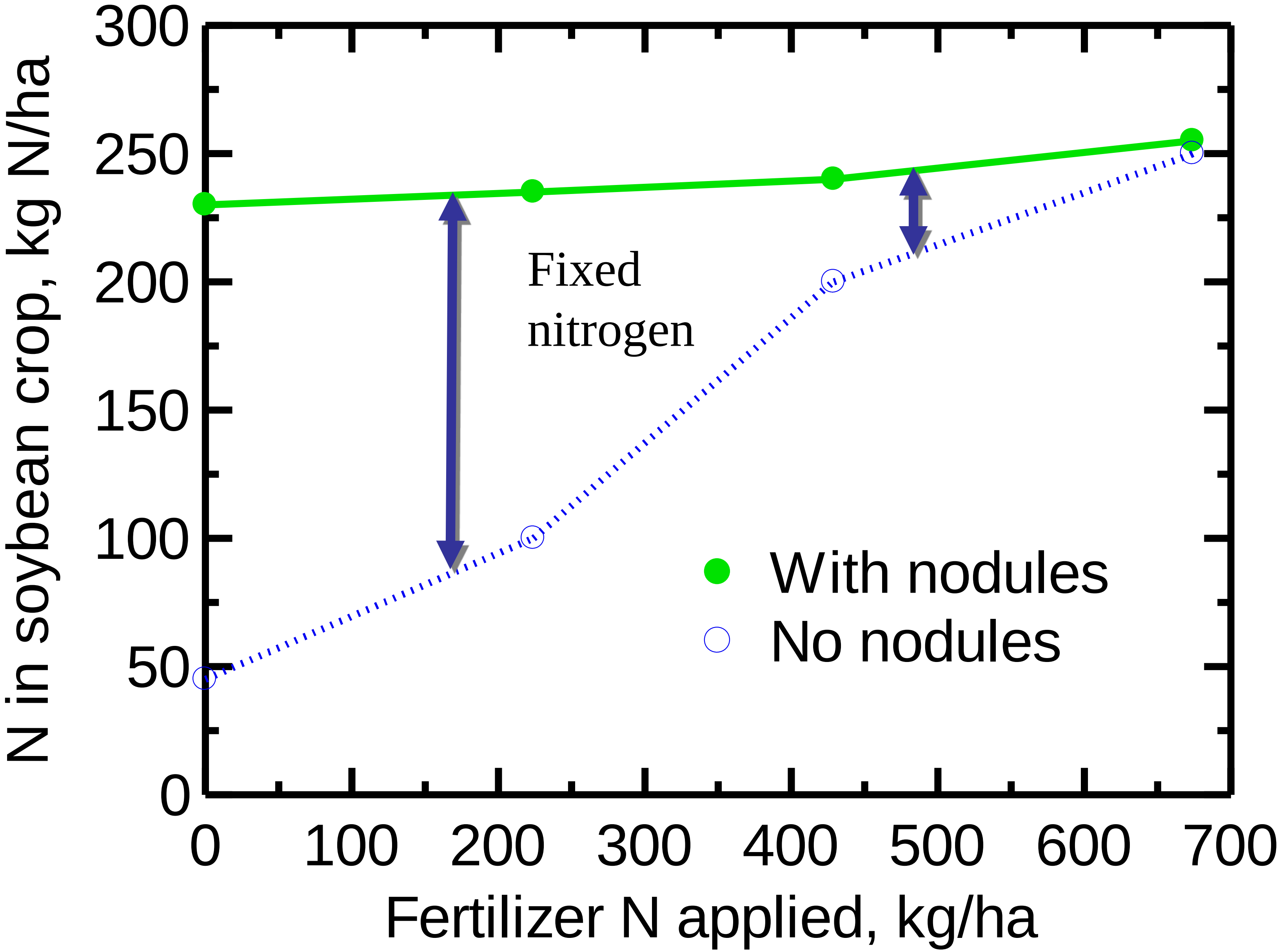
Fine sandy loam (Haplaquoll) in ND. 150 kg N/ha. 8,000 kg grain/ha.

Data from Schindler and Knighton, 1999. SSSAJ 63:1743

Fertilizer as Source of N taken Up by Corn



From Omay, et al. 1998. SSSAJ 62:1596-1603.



300
250
200
150
100
50
0
N in soybean crop, kg N/ha
0
100
200
300
400
500
600
700
Fertilizer N applied, kg/ha
Fixed nitrogen
With nodules
No nodules

Changing Nitrogen Recommendations

- As the cost of N has risen, we have begun to rethink N recommendations
- Moving away from yield goal based recommendations
- Moving toward economic based recommendations
  - Using average N response curve

How do I determine N fertilizer amount?
Basic steps for all crops ;

1. Determine yield potential
2. Determine available soil nutrient level – soil test
3. Look up suggested nutrient guidelines for given crop and yield in Fertilizer Guidelines for MT Crops or crop specific bulletins (e.g. pulse, forage)
4. Calculate difference between what is available and what is needed to get fertilizer recommendation

Yield potential, cara menentukan

Average yield from past records, can be adjusted for soil moisture in late March, early April •

Average yield x 1.05 (optimistic or realistic?)