Soil Quality, Nutrient Cycling and Soil Fertility

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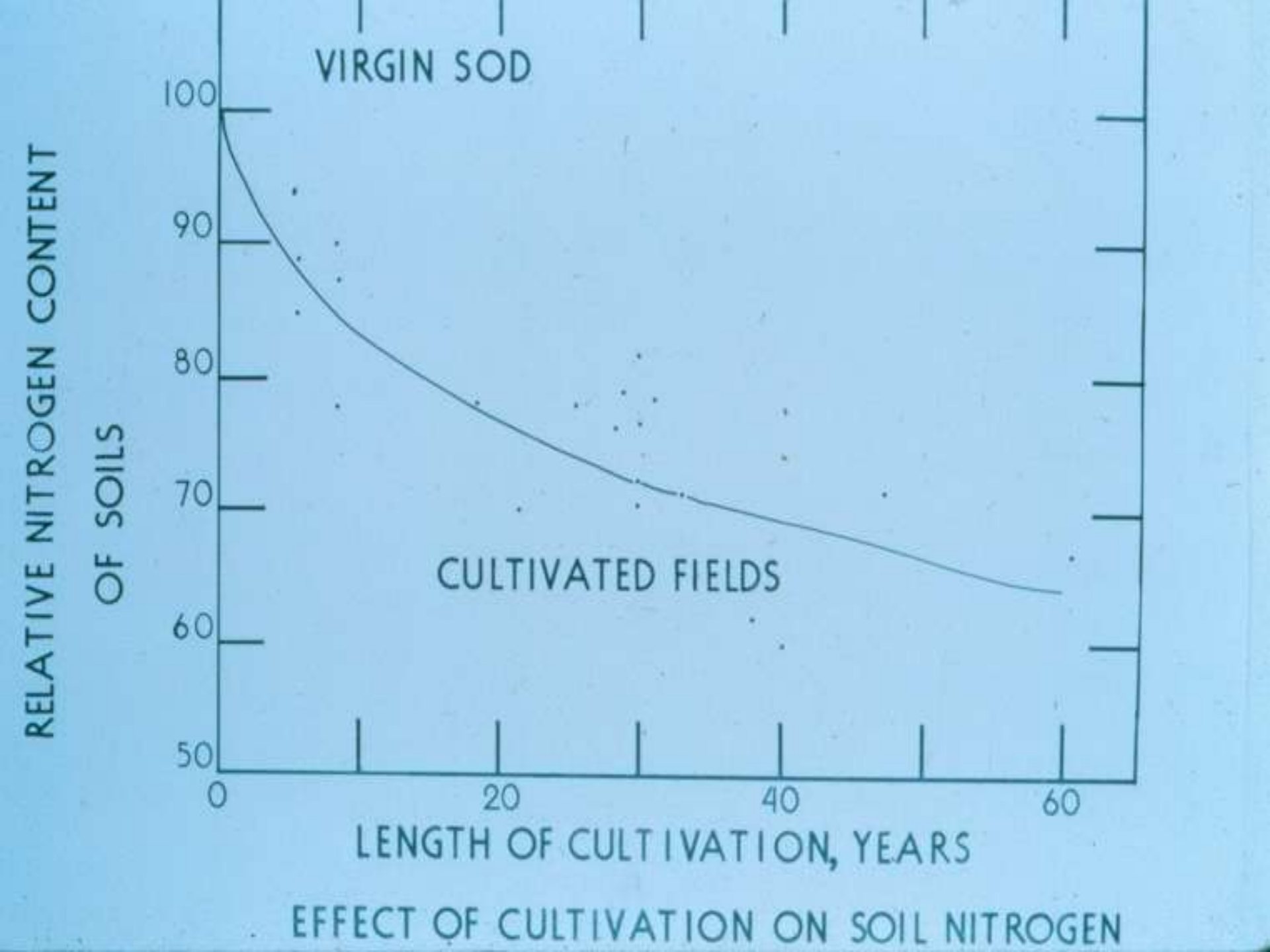
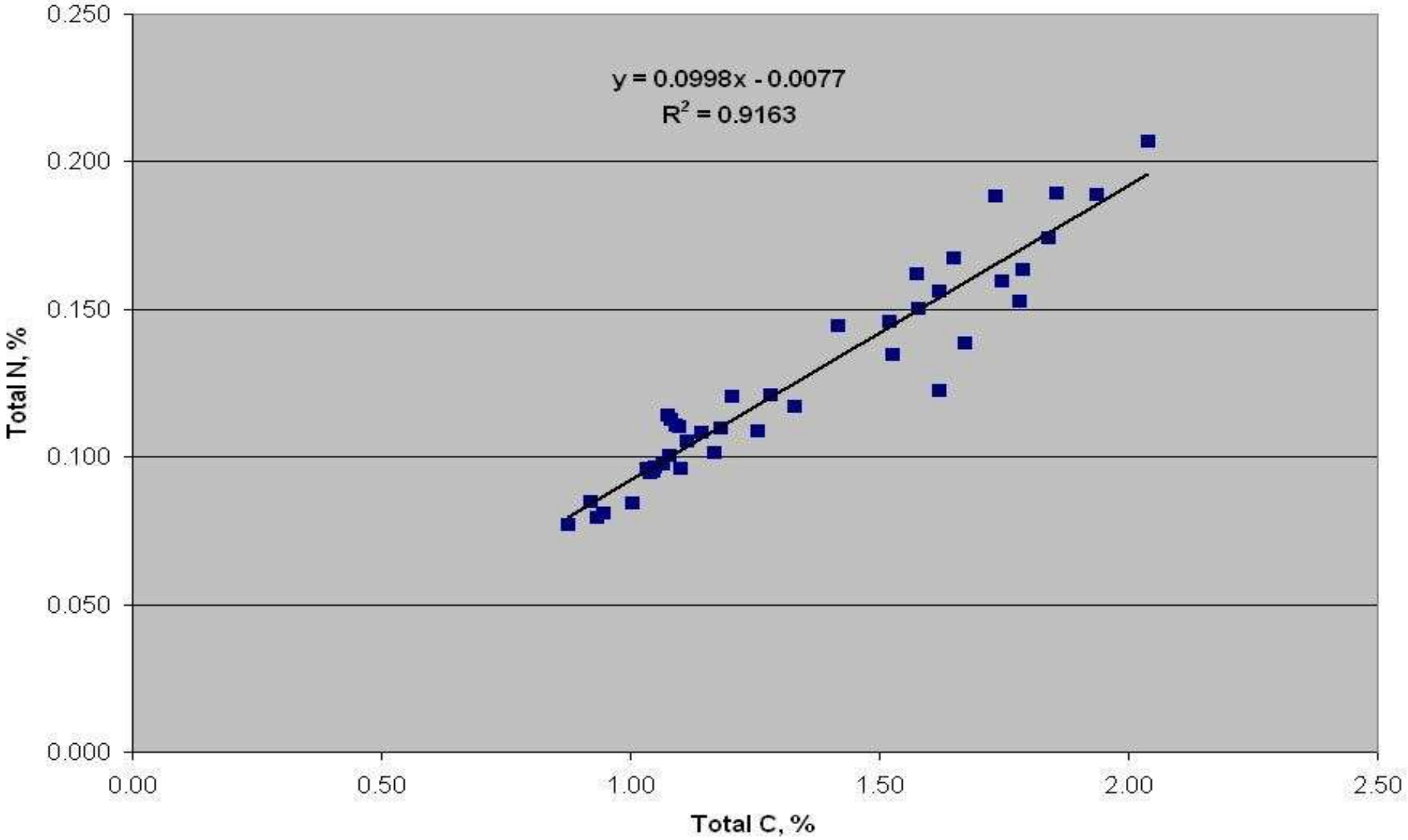
Purposes of Soil Quality

- Employ new & modified crop management systems
- Increase efficiency of nutrients and water
- Increase quantity & quality of organic matter
- Decrease soil erosion
- Increase biological diversity



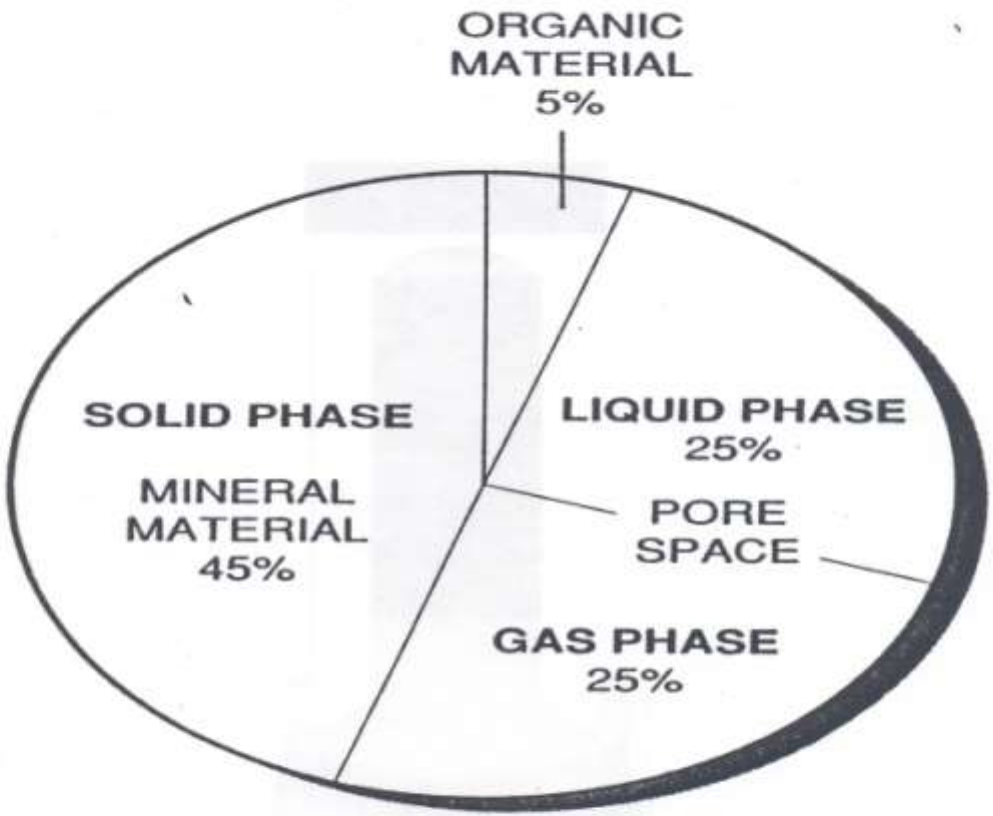
EFFECT OF CULTIVATION ON SOIL NITROGEN

Total N vs Total Carbon



Soil Organic Matter

- Enhance crop productivity
- Build soil fertility
- Improve structure
- Build aggregate stability
- Increase nutrient retention
- Increase water holding capacity

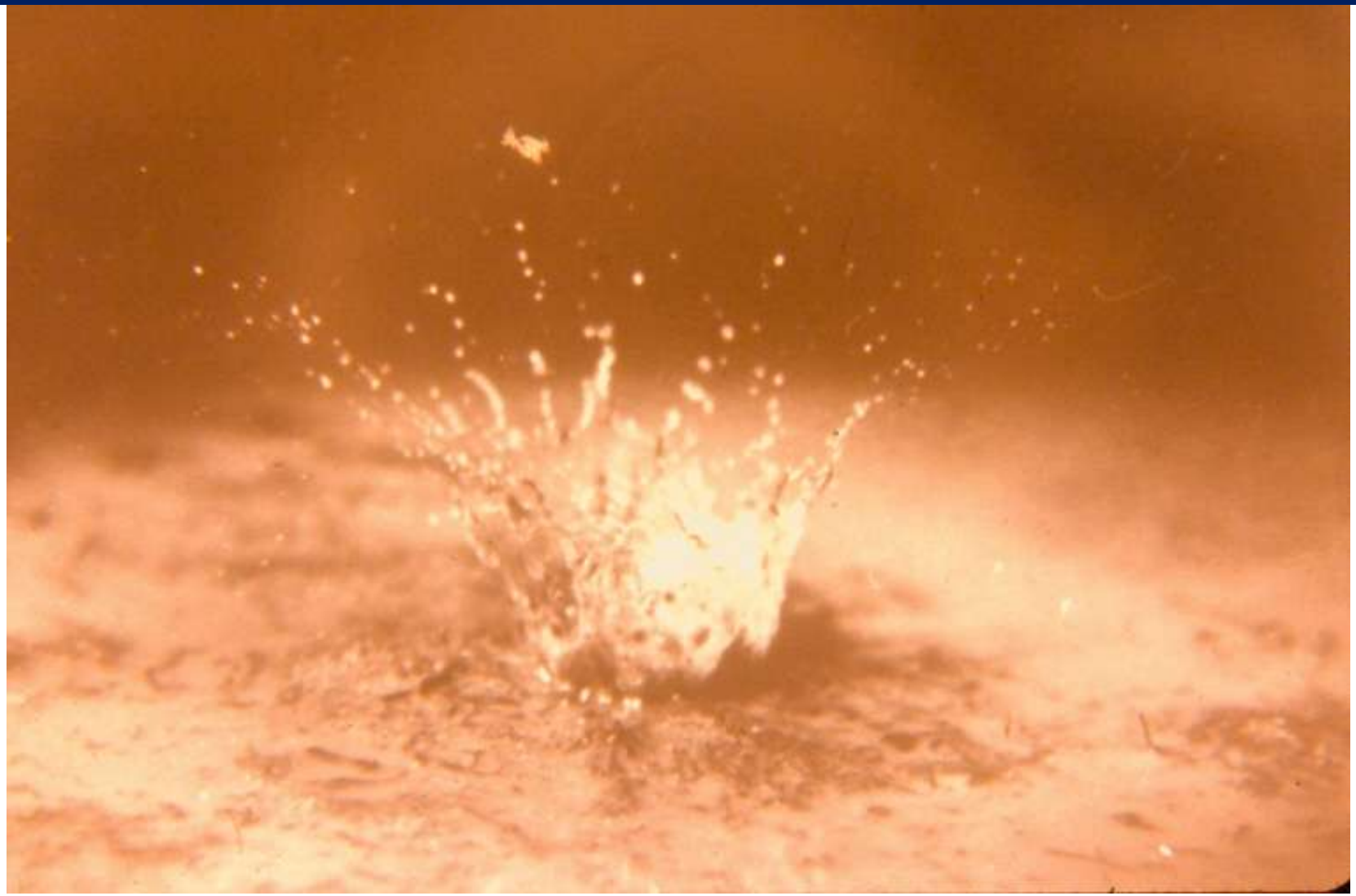

ORGANIC
MATERIAL
5%
SOLID PHASE
MINERAL
MATERIAL
45%
LIQUID PHASE
25%
PORE
SPACE
GAS PHASE
25%

Soil Structure

- Retention & transport of water & nutrients
- Habitat for Microbes
- Reduced Soil Erosion

Granular Soil Structure

Raindrop Splash



Crusted Soil

Soil Compaction

Soil Structure and Root Growth

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Over 14 years of No-Till

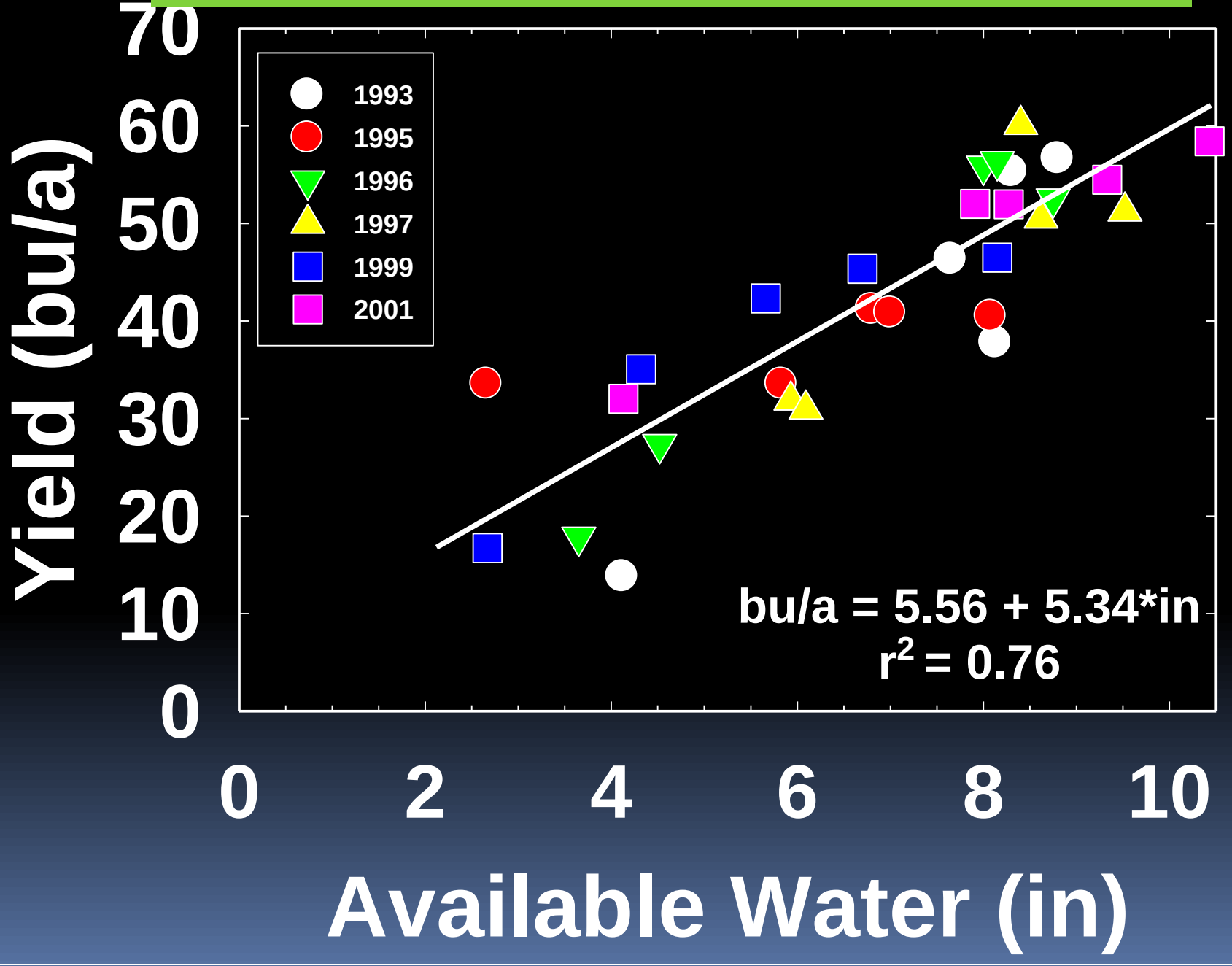
Native Soil Structure

Success of No-Till

- Sanitation
  - Prevent weeds from going to seed
  - Avoid introducing weeds or disease
  - Break insect and disease cycles
- Competition
  - Fast uniform canopy formation
  - Less than optimum conditions for weeds
- Rotations
  - Diversity, Intensity, and Profitability

Save Water

Wheat Yield Starting Soil Water



SOIL MOISTURE LOSS

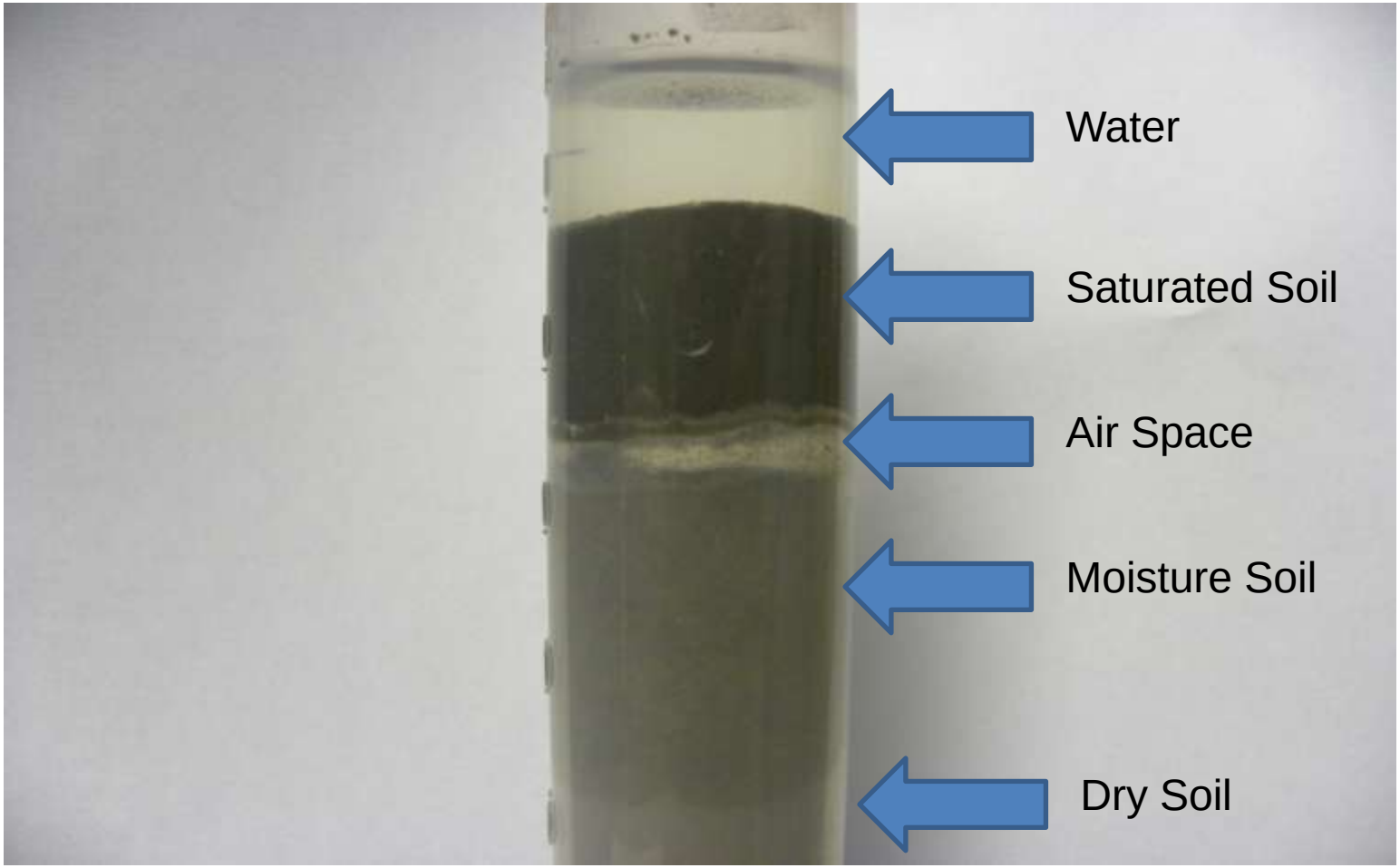
½ TO ¾ INCH LOSS PER TILLAGE OPERATION

TILLING FOR A GROWING SEASON … WATER LOSS IS 2 – 2 ½ INCHES OF WATER

SOIL MOISTURE SAVINGS

1 – 4 INCHES OF WATER SAVED FROM STANDING RESIDUE

Poor Soil Structure Prevents Water Movement



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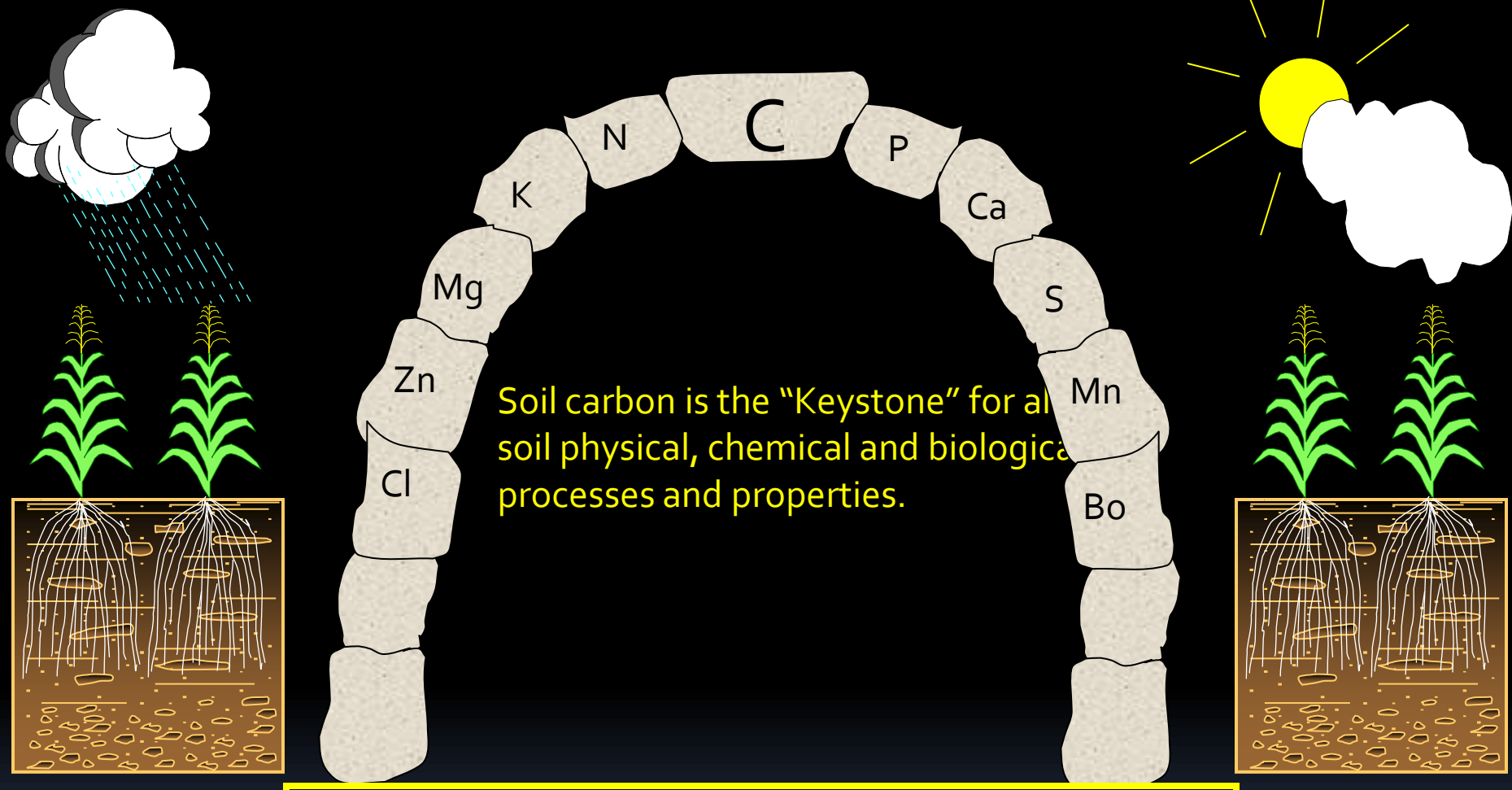
Rainfall Simulator

Water Penetration

No. 1 Environmental Enemy in Production Agriculture

Intensive Tillage

Carbon is a "keystone" in nutrient cycling!



Management platform

fertility, variety, irrigation, species, cover crop, manure, rotations, tillage, soil type, erosion, timing,

Water Management

- Greater Soil Cover To:
  - Reduce evaporation
  - Increase water penetration
  - Decrease water runoff
- GOAL: Efficient Water Use

Oats and Turnips

Turnip Cover Crop for Grazing

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Maintenance of Soil Cover

- GOAL: Keep soil surface covered with crop or residue at all times
  - Reduce runoff & erosion
  - Conserves moisture by reducing evaporation
  - Aggregate stability is enhanced
  - Improves infiltration of rain & irrigation
  - Increases organic matter & bioversity

Microbes/Livestock

• Bacteria	1000 lbs/A
• Actinomycetes	1000 lbs/A
• Molds	200 lbs/A
• Algae	100 lbs/A
• Protozoa	200 lbs/A
• Nematodes	50 lbs/A
• Worms	1000 lbs/A

Nutrient Uptake and Root Structure

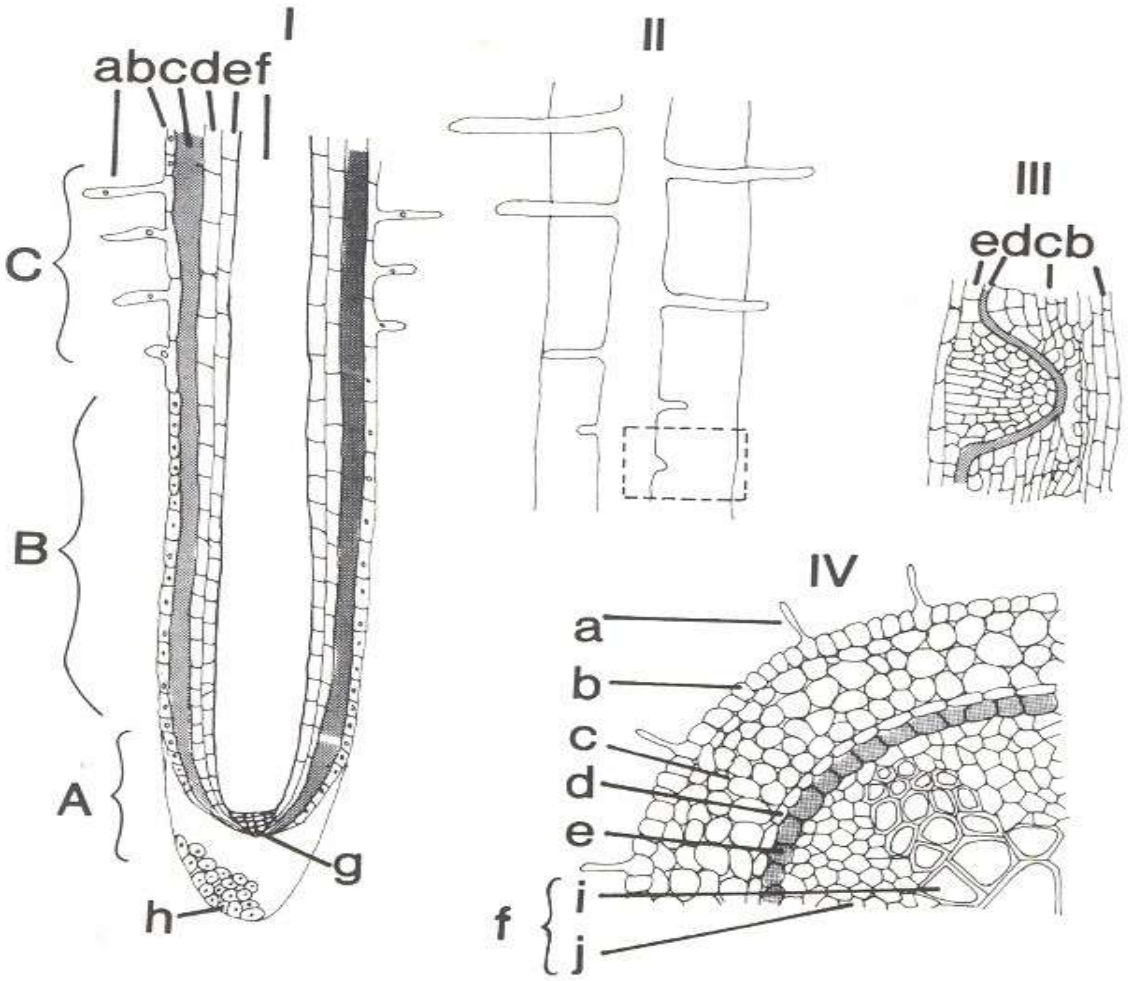
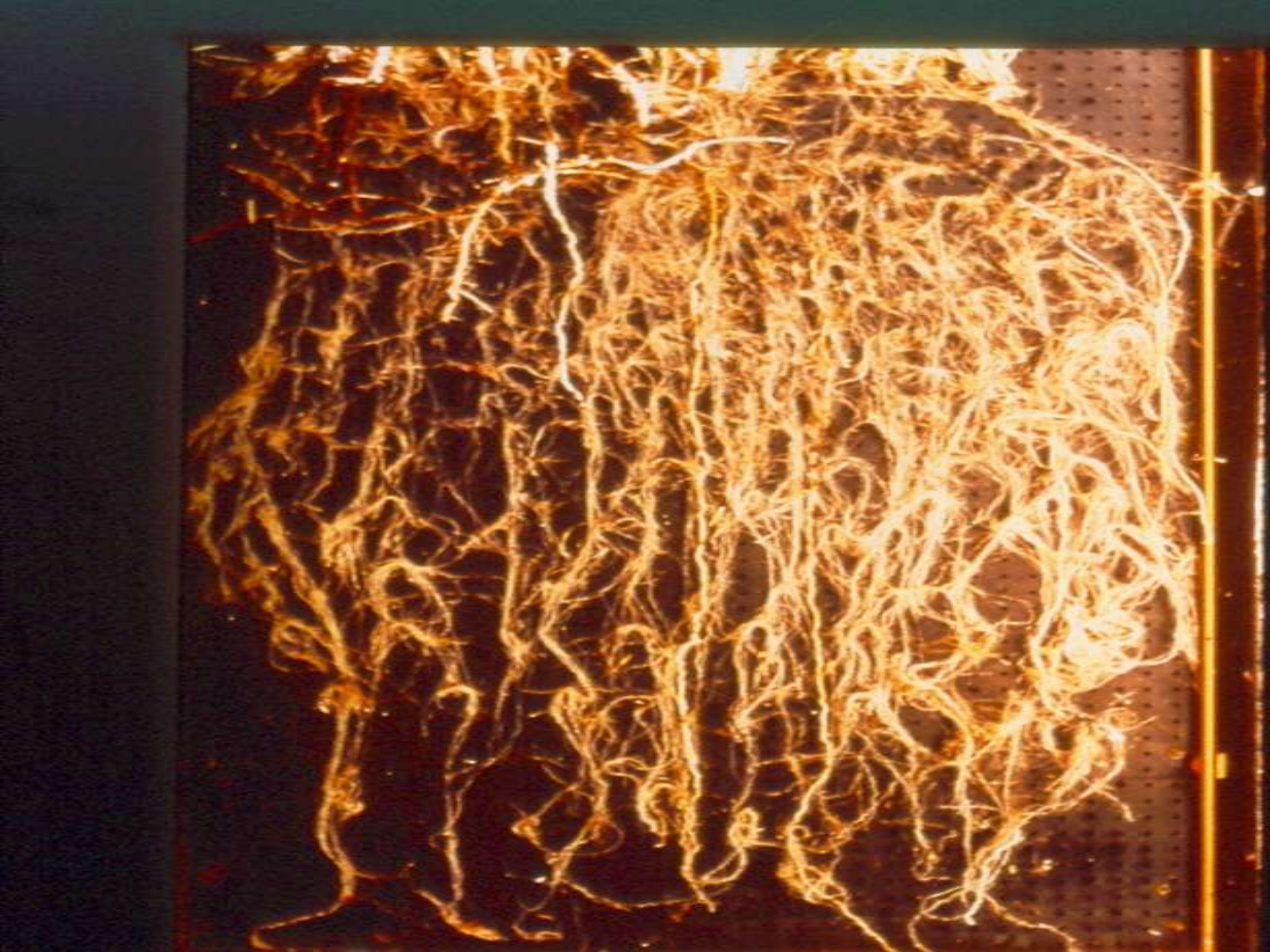


Fig. 10.2. Longitudinal section of herbaceous dicot root. *I.* Root tip with regions of cell division (*A*), elongation (*B*), and maturation (differentiation) (*C*). *II.* Section of mature root with lateral roots in varying stages of development. *III.* Meristem of a lateral root arising from the pericycle. *IV.* Cross section of a young root. Differentiated tissues: root hair (*a*), epidermis (*b*), cortex (*c*), endodermis (*d*), pericycle (*e*), central cylinder or stele (*f*), meristem with quiescent center (*g*), root cap (*h*), xylem (*i*), phloem (*j*).



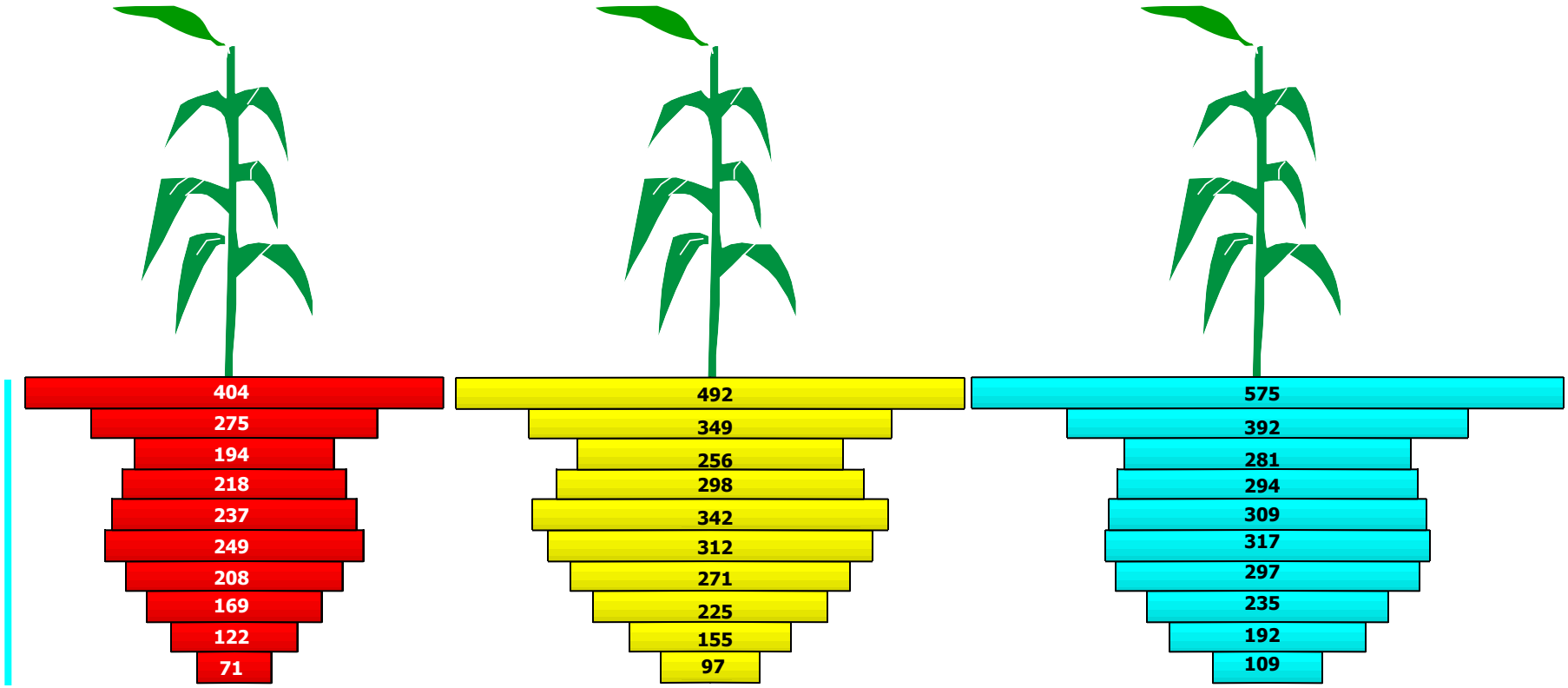

General view of the research plots (Ponta Grossa - PR)


No residue


5 ton/ha


10 ton/ha

Effect of the amount of residue in the corn root system distribution with depth (Mean 13 hybrids / residue treatment)



100%

130%

140%

C:N Ratio and Rate of Residue Decomposition

1. Average microbe C:N ratio is 8:1
2. 1/3 of the carbon used by microbes is incorporated into their cells
3. 2/3 of the carbon is respired as CO2
4. Therefore, microbes need 1 lb N for every 24 lbs of carbon in their food
5. If the C:N ratio is greater than 24:1 the microbes must scavenge soil solution for Nitrogen

C:N Ratio: An Example

- Wheat Straw
- 100 lbs per bushel of wheat grain
- 50 bushels of wheat/A = 5000 lbs Straw
- 42 % C in straw = 2100 lbs of Carbon/A
- 4 % Protein in straw = 32 lbs of N/A
- C:N Ratio = 66:1

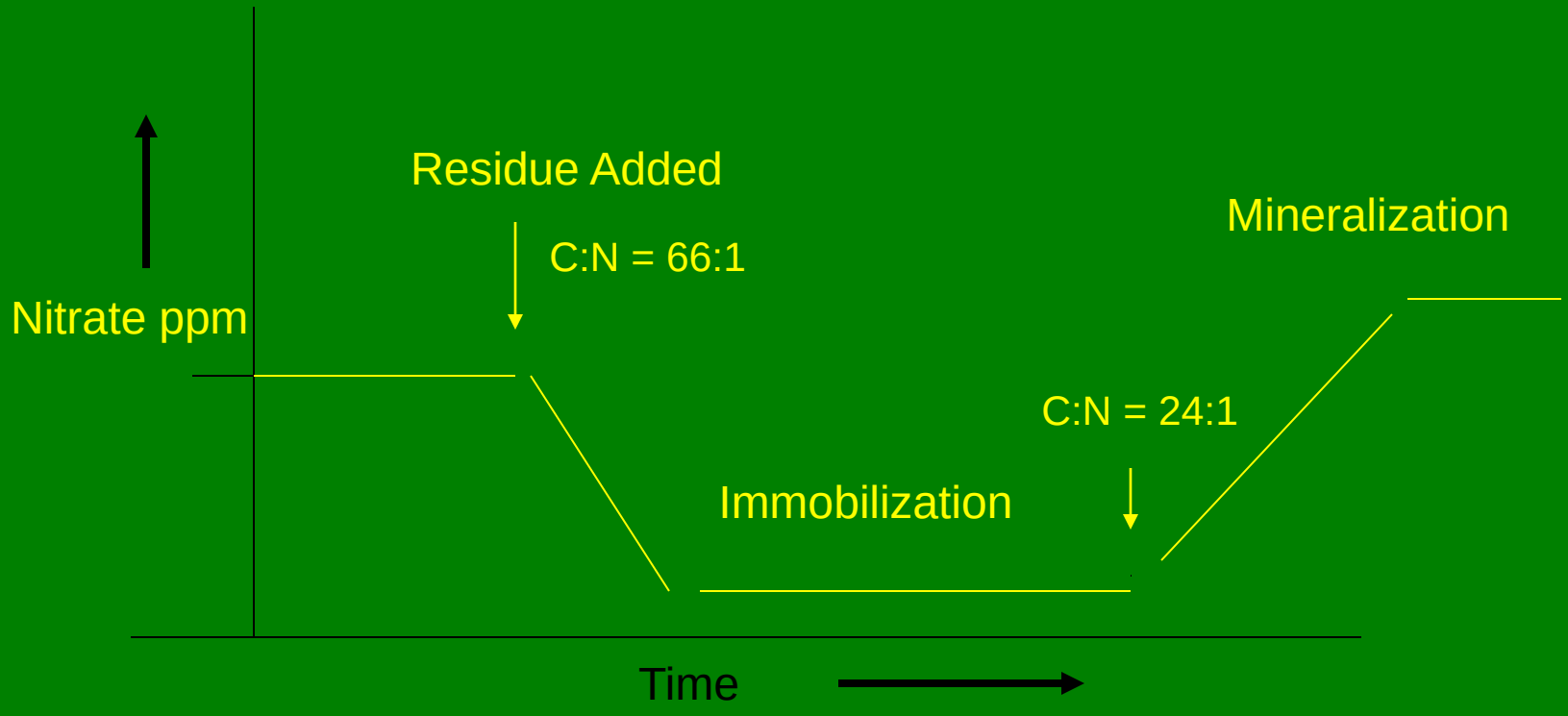
N Release From Wheat Straw

C:N ratio 66:1
5000 lbs of straw/acre

Carbon: 2100 lbs of lbs of Carbon per acre
88 lbs of N is needed to bring the C:N ratio to 24:1
88 – 32 = 56 lbs of N will be taken from the soil by the decomposers before N can be released.

Nitrogen Tie-up or Nitrogen Release

- Wheat Straw C:N = 66:1



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Cover Crop Contribution

Legume cover crop

12 inches tall, about 2000 lbs of dry hay @ 18 % protein or 2.9 % N = 58 lbs of N/ton

If left on the soil it will be available for the next crop

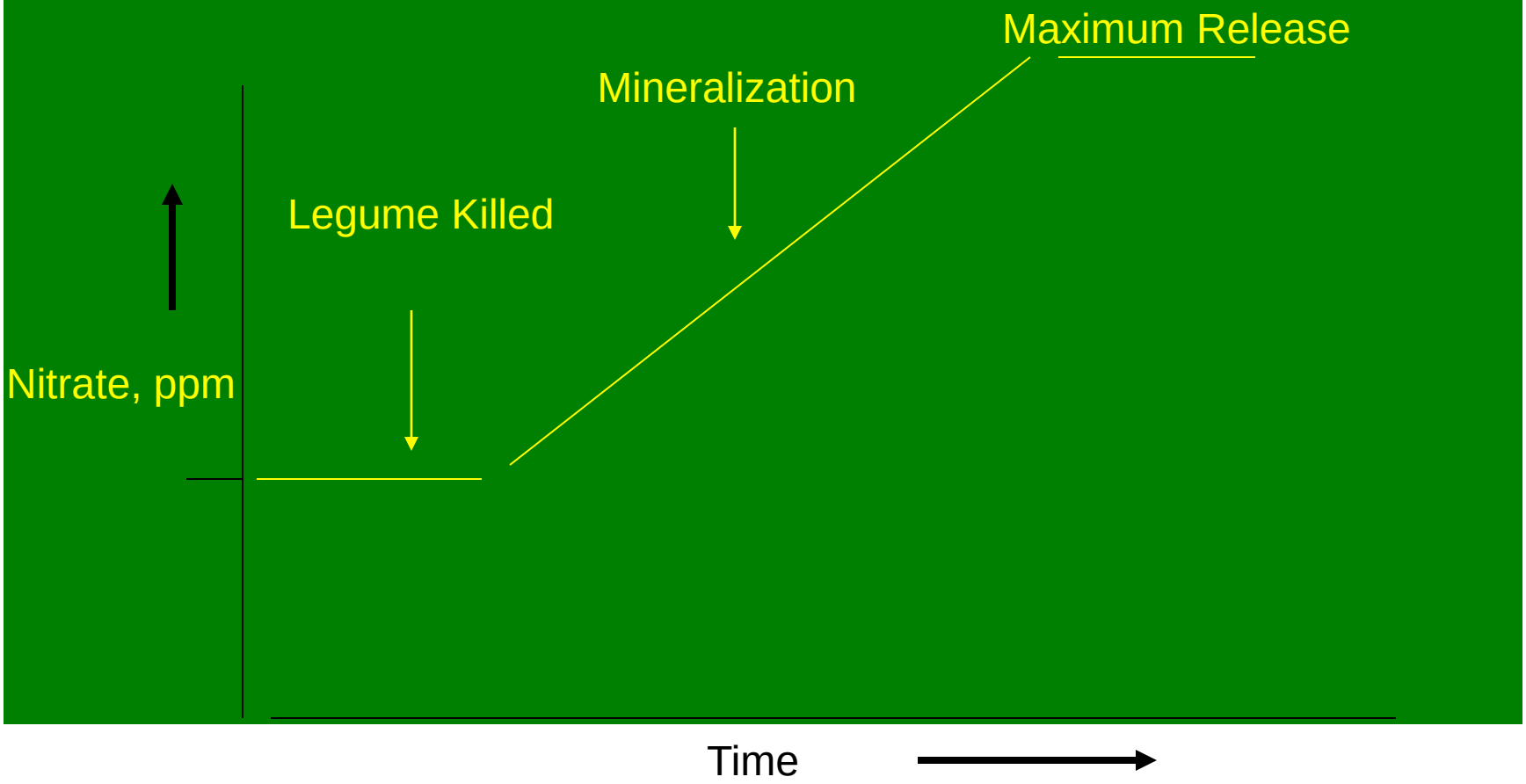
If Legume is Grazed, there will be about 46 lbs of N remaining for the next crop

Cover Crop Nutrients
1.83 tons/acre

Nutrient	lbs/acre	
Carbon, C	1520	
Nitrogen, N	110	C:N = 13.8
Phosphorus, P_2O_5	28	
Potassium, K_2O	123	
Sulfur, S	16	
Zinc, Zn	0.13	
Calcium, Ca	60	

Nitrogen Tie-up or Nitrogen Release

- Legume Cover Crop C:N = 13.8



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Total Organic Carbon

- Food for Microbes, especially recent additions to organic matter
- Nutrient for Plants
- Soil Organic Matter is 58 % C
- Soil Aeration very Important to Form CO_2
- Soil Organic Matter test
  - Loss on Ignition (LOI)

Carbon/Organic Matter

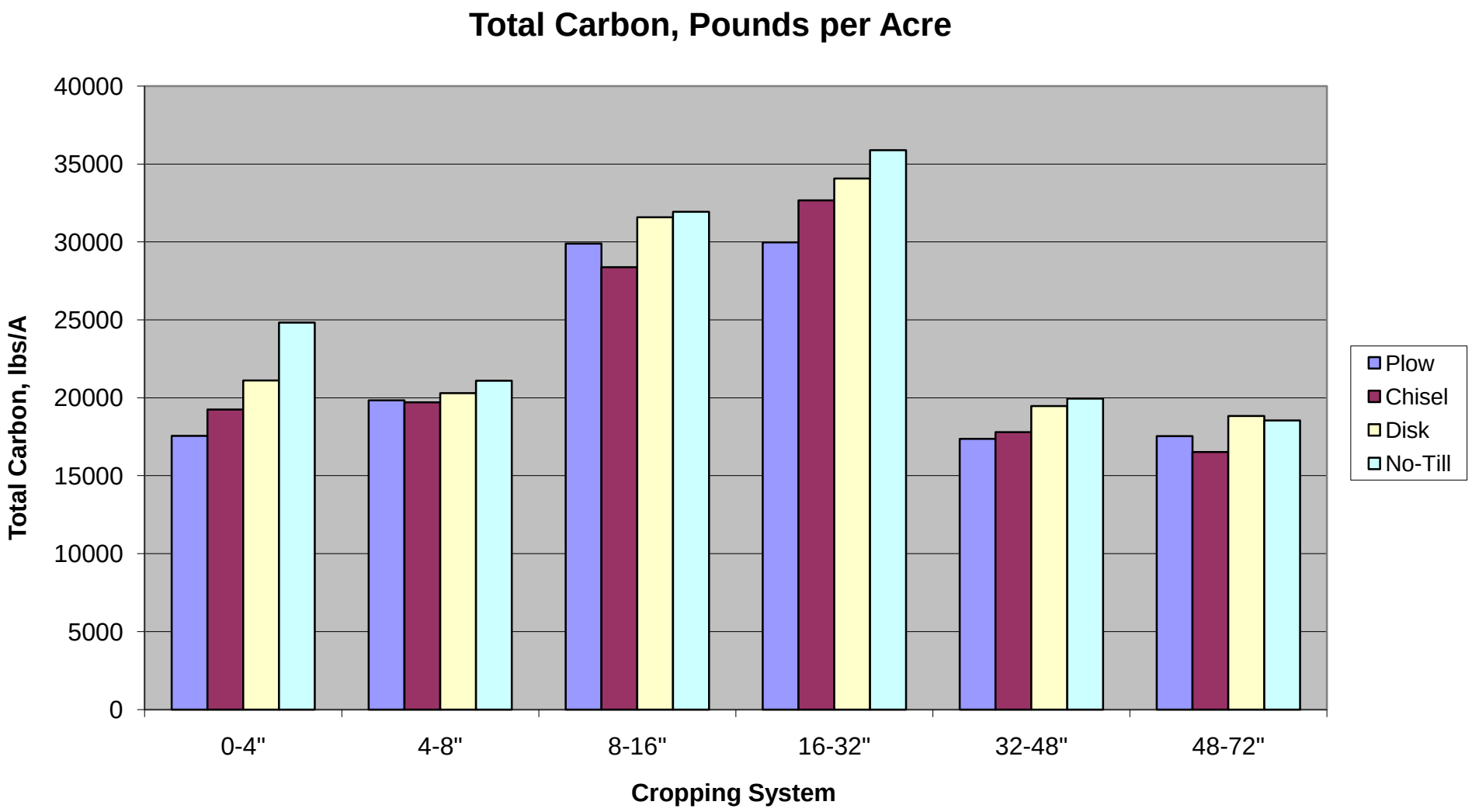
- Organic Matter is about 58 % C
- Ratio becomes 170 OM : 10 N : 1.4 S
- 1 % OM in 8 inches of Soil is 24,000 lbs/A
- This Quantity of OM Holds About 1400 lbs of N and 200 lbs of S per Acre.

No-Till Sulfur Deficiency

- Most of the Sulfur in the soil is held in the organic matter portion of the soil
- The idea is the build soil organic matter to improve soil quality and health and increase soil productivity
- C : N : S ratio
- 100C : 10N : 1.4S

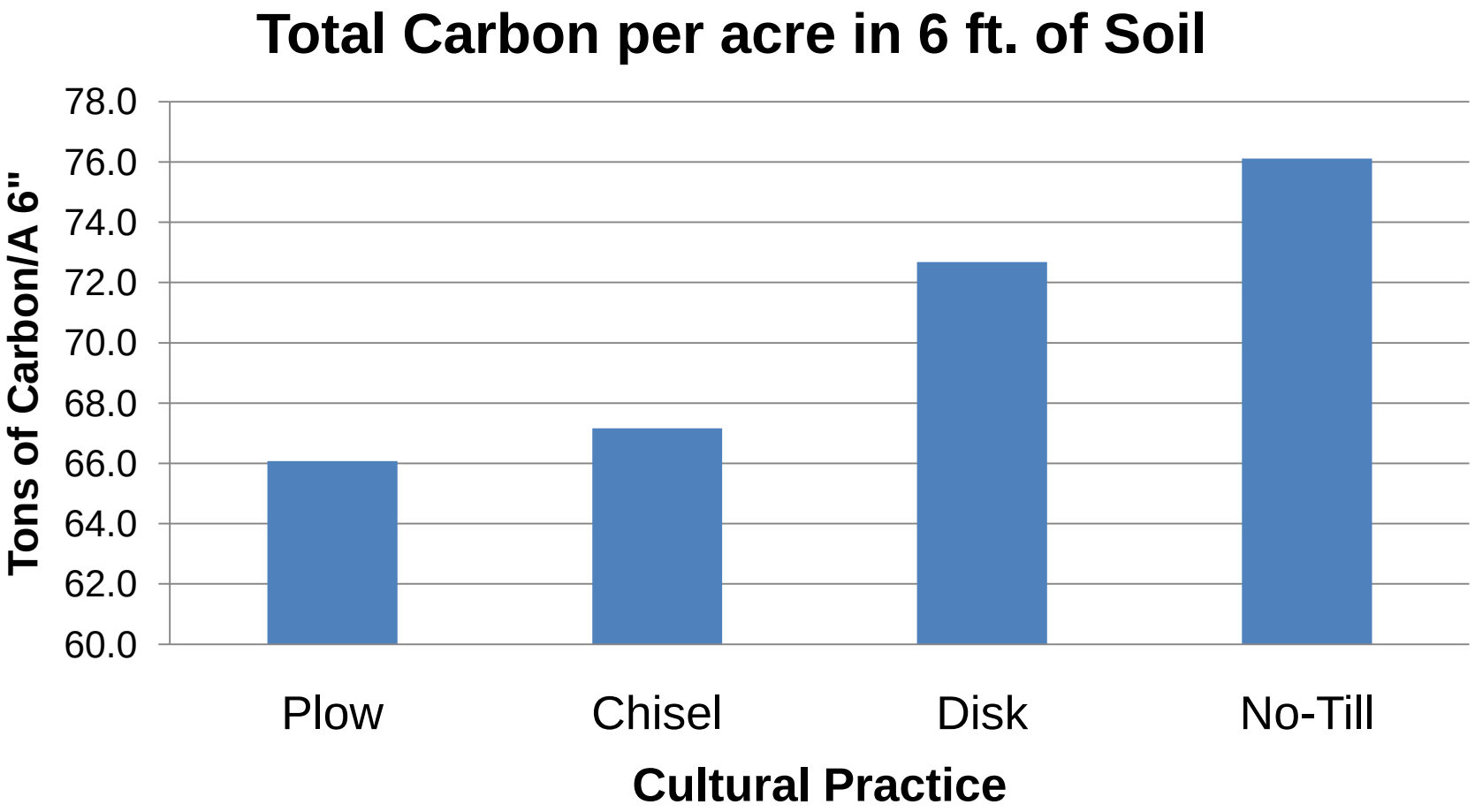
ROGERS MEMORIAL FARM

PAUL JASA, UN-L

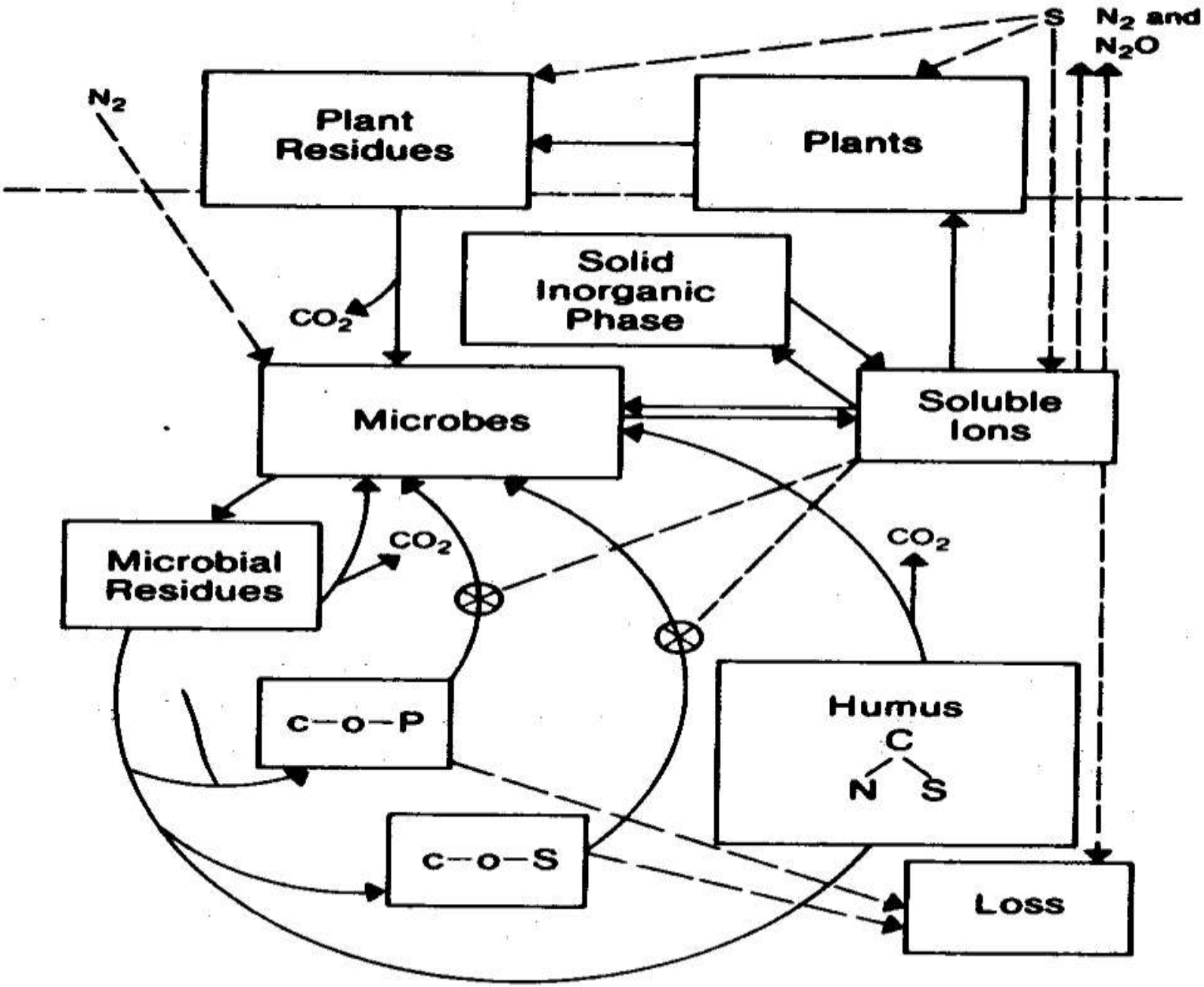


Rogers Memorial Farm

Paul Jasa, Un-L



The Carbon Cycle



Fertilizer Rates for 2010

- Crops do not respond to prices
- Proper rate of nitrogen cannot be reduced without yield loss
- Sulfur may be needed in no-till systems
- Non-mobile nutrients should be applied at rates suggested by soil test. Strive at least to have P at 25 ppm P and K to 200 ppm K

Nitrogen Requirement

- Corn 1.2 lbs N/Bu
- Wheat 2.4 lbs N/Bu
- Milo 1.1 lbs N/Bu
- Grass 40 lbs N/Ton
- Millet 1.7 lbs N/Bu

Nitrogen Recommendation

N lbs/A = (yield * N req.)

lbs of NO_3-N in 24”

Legume credit

Manure credit

Irrigation water credit

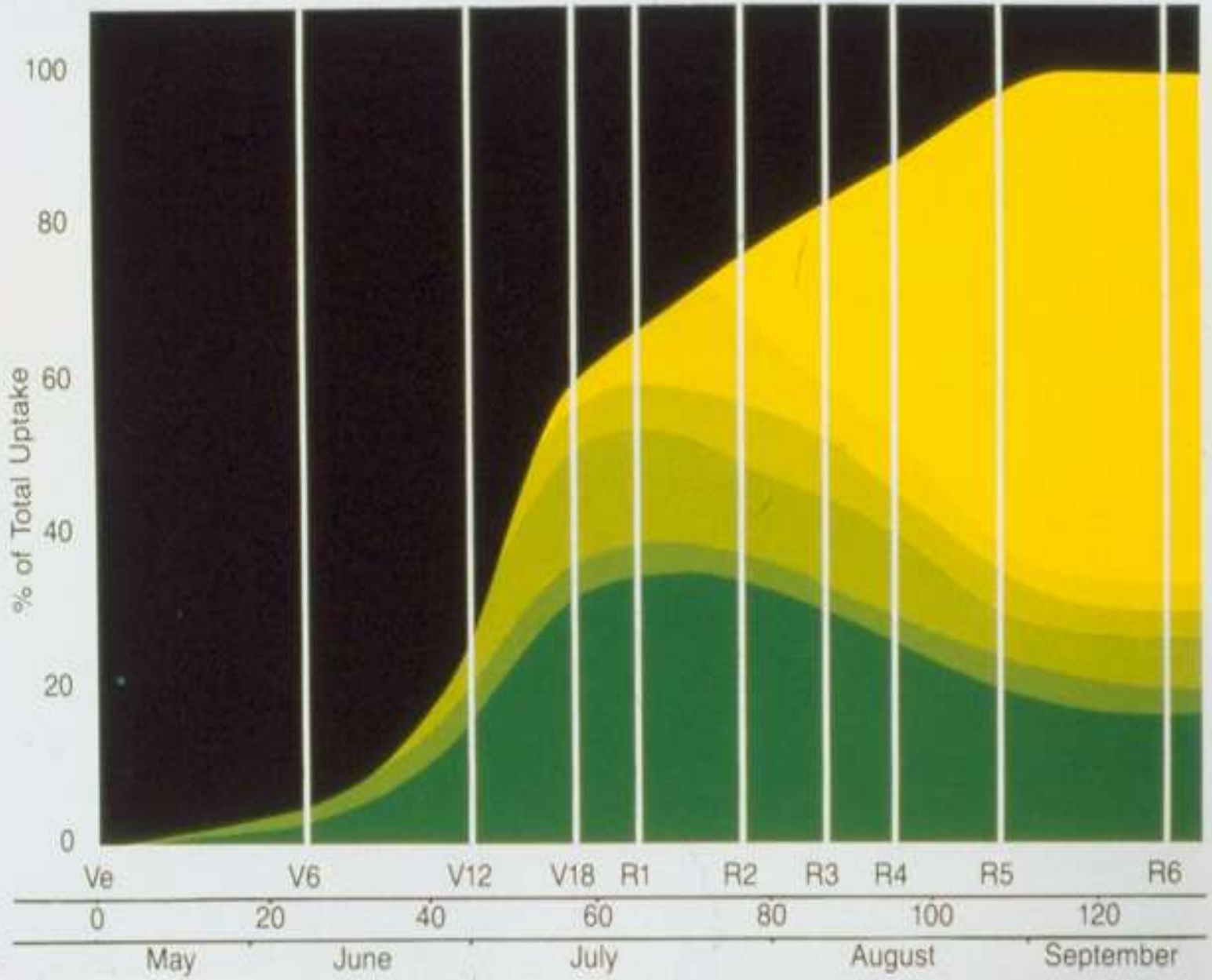
Suggested N Credits for Legume Crops

	% Stand	lb. N/A
Alfalfa	100%	100
	50%	50
	less than 50%	none
Sweet Clover		80
Red Clover		50
Soybeans		40-60

Nitrogen Recommendation

- An Example
- Corn after Soybeans
- 200 bu/A X 1.2 = 240 lbs of N required
- Subtract the following
- Soil nitrate = 30 lbs of N
- Past soybeans = 40 lbs of N
- Amount of N to apply = 170 lbs of N/A

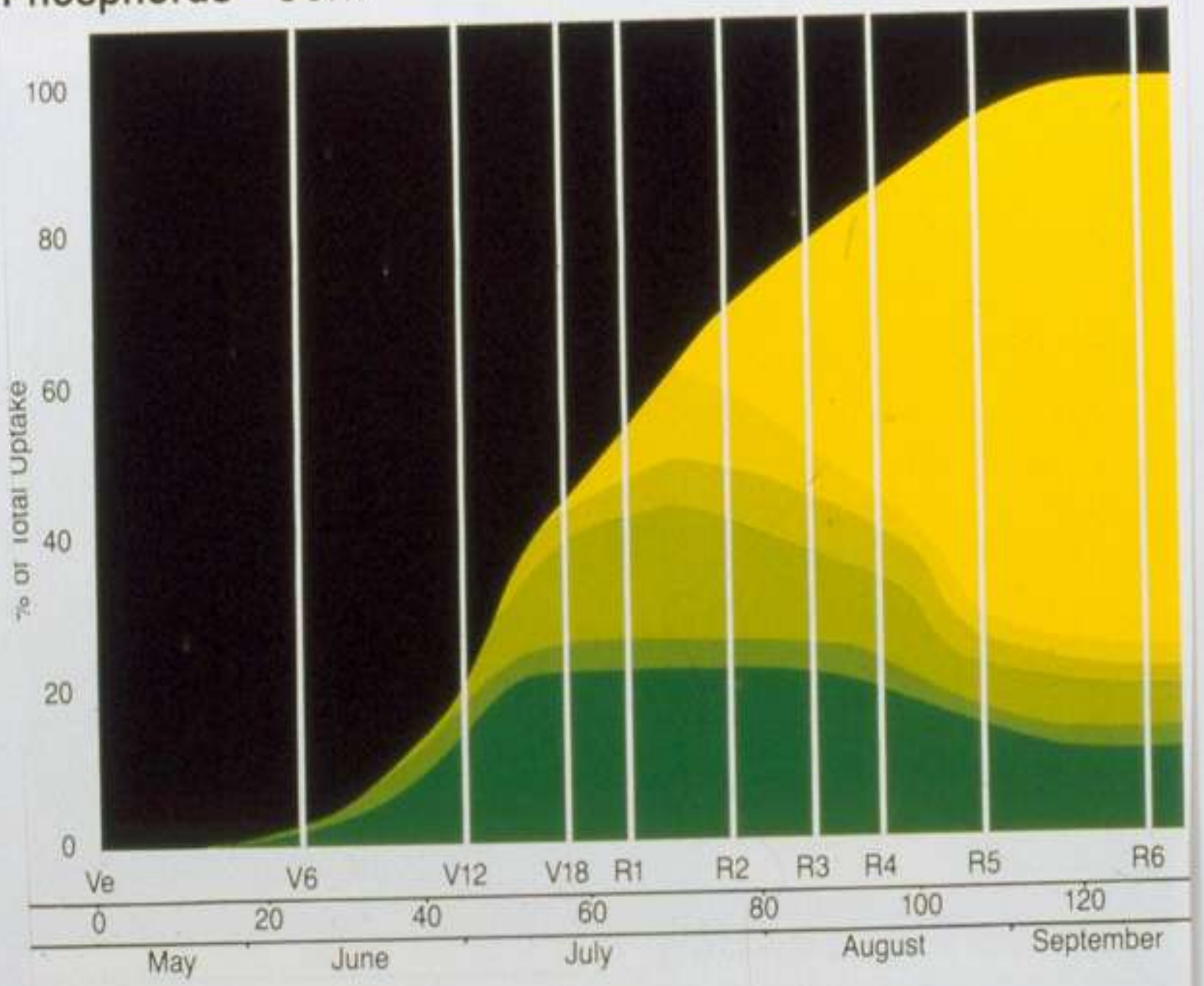
Nitrogen—Corn



Phosphorus Recommendations

Soil test ppm P	Rating	lbs P_2O_5/A
0-5	Very Low	60-140
6-12	Low	35-75
13-25	Medium	20-45
26-50	High	0-30
51+	Very High	None

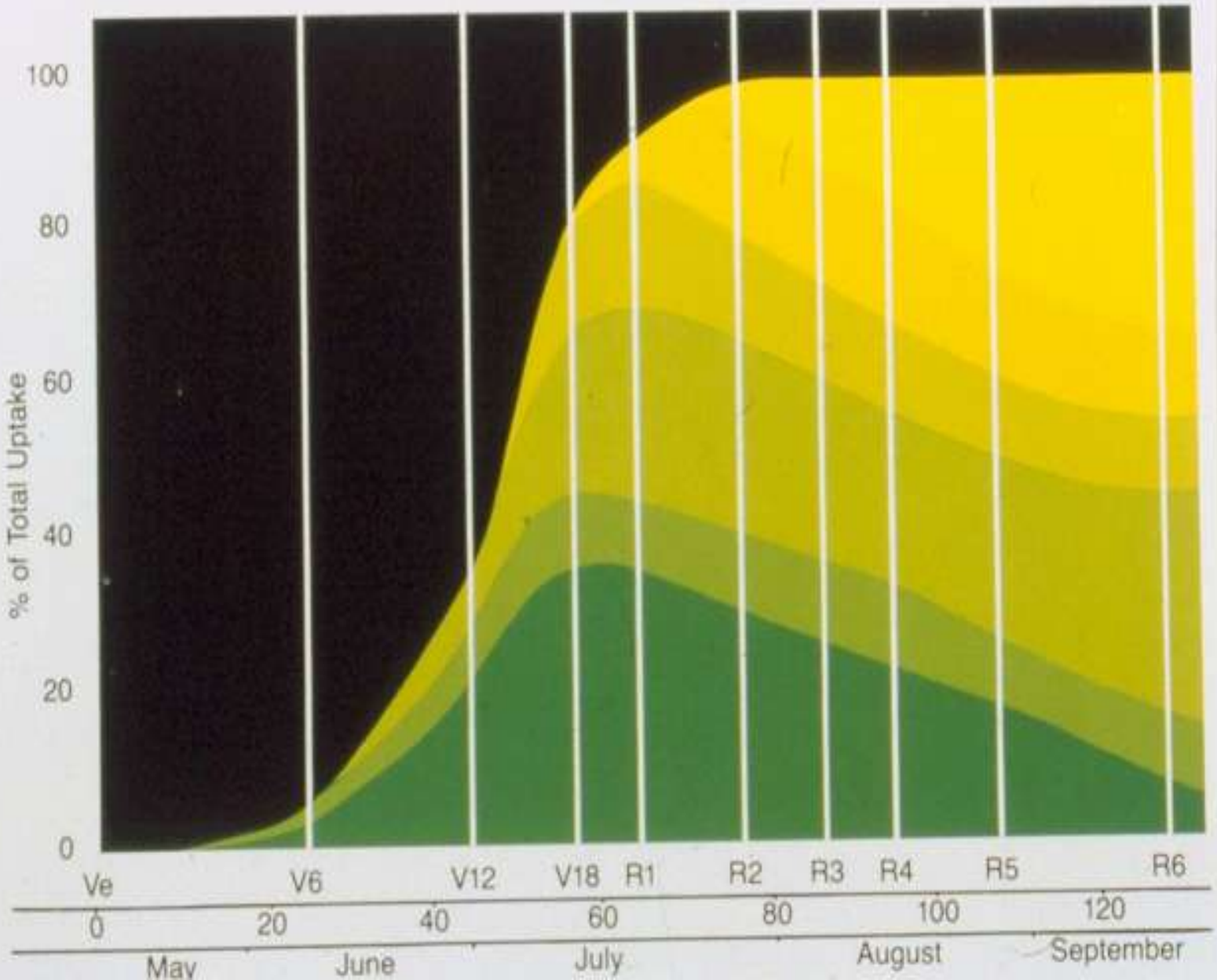
Phosphorus—Corn



Potassium Recommendations

Soil Test ppm K	Rating	lbs K2O
0-40	Very Low	90-200
41-80	Low	50-120
81-120	Medium	25-60
121-200	High	0-35
201+	Very High	None

Potassium—Corn



Sulfur Soil Test, Ca-P Extractable

Soil Test ppm S	Rating
0-4	Very Low
5-7	Low
8-11	Medium
12-15	High
16+	Very High

Sulfur Requirement

Crop	Yield Unit	LBS of S
Corn	Bushel	0.18-0.26
Soybean	Bushel	0.20-0.29
Wheat	Bushel	0.28-0.35
Alfalfa	Ton	4.7 – 6.3
Grass	Ton	2.2 – 3.6

Sulfur Recommendation Example

Wheat 80 bu/A Yield Goal

Sulfur Requirement is .28 to .35 lb S/bu

Total S Required is 22 to 28 lbs/A

Sulfate Soil Test is 8 ppm S

8 ppm X .3 X 8 inches = 19 lbs S/A

Recommendation is 3 to 9 lbs S/A

Sulfur Recommendation Example

Corn 200 bu/A Yield Goal

Sulfur Requirement is .18 to .26 lb S/bu

Total S Required is 36 to 52 lbs/A

Sulfate Soil Test is 8 ppm S

8 X 2.4 = 19 lbs S/A

Recommendation is 17 to 33 lbs S/A

Zinc Recommendations

Soil Test ppm Zn	Corrective Rate lb Zn/A
0-0.25	3-12
0.26-0.50	1-7
0.51-.75	0-6
0.76-1.00	0-3
1.01+	None

*Annual rate: Divide Corrective Rate by 6.

Nutrient Cycle?

1. Nutrients are removed from the land any time grain or forage is transported from the area.
2. How are the nutrients replaced? Higher yields - the more nutrients that have to be replaced.
3. Carbon comes from the air and from microorganisms decomposing organic matter.
4. Others come from soil minerals, decomposition of organic matter, soil microbes including Rhizobia, manures and fertilizer.

In Furrow Fertilizer

Crop	Pounds N + K2O 30 “ rows	7 “ rows
• Corn	8	32
• Milo	4	16
• Sunflowers	4	16
• Beans	0	6
• Wheat	8	32

The Best Combination:

Banding and broadcasting fertilizer P to build soil fertility levels and to optimize long-term yield potential and profits