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IS SULFUR REALLY DEFICIENT IN OUR ORCHARDS?

Some slides and information courtesy D. Beegle & J. Spargo

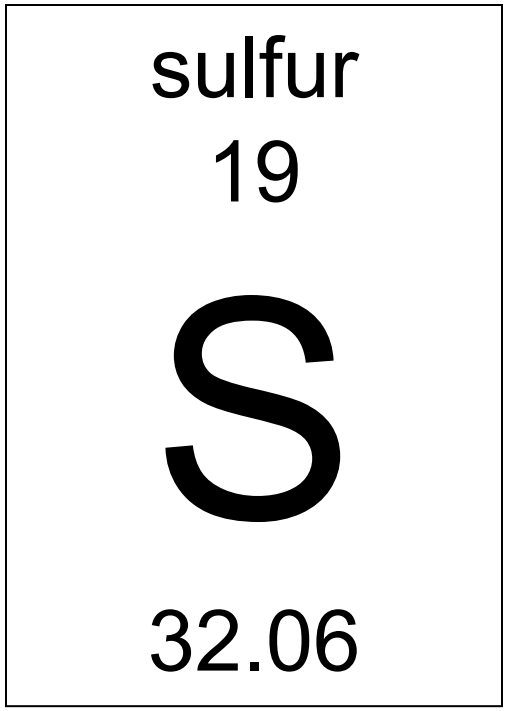
Sulfur is considered a macronutrient (% dw)

However, plants contain less S than any other macronutrient

N ≥ K > Ca > Mg ≥ P > S

2016-18 Sulfur levels avg. 0.17%

- suggested at 0.2 – 0.4%



Typical skyline in the Midwest

Atmospheric deposition

In the past, coal power plants released significant S into the atmosphere which was deposited with rainfall (acid rain)

Clean air policies have required cleaner coal & improved scrubbers.

Atmospheric deposition has been drastically reduced

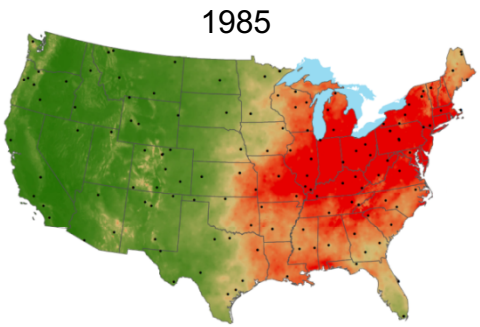
1970 Clean Air Act passed

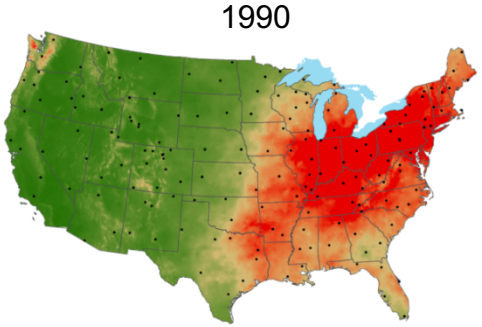
impacted national & state standards

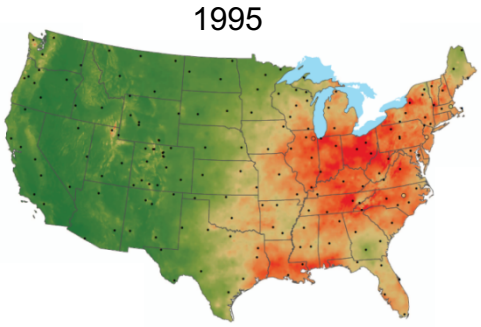
Sulfate ion wet deposition

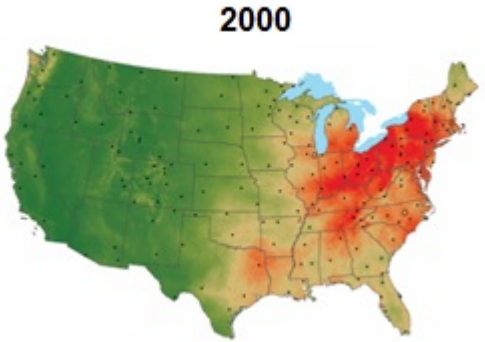
Decrease in sulfur emissions to the atmosphere has resulted in a decrease in atmospheric deposition

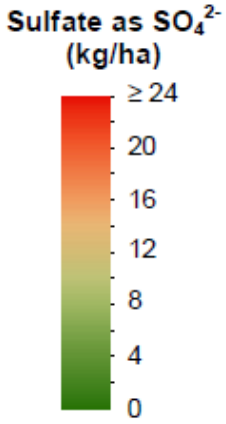
National Atmospheric Deposition Program/National Trends Network
http://nadp.slh.wisc.edu/NTN/annualmapsByYear.aspx

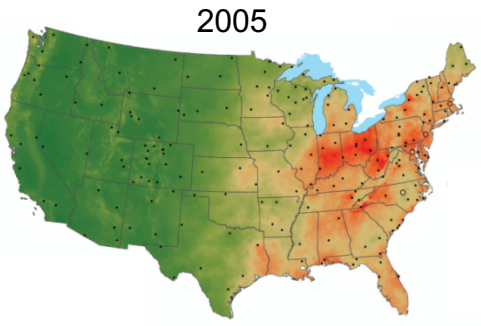


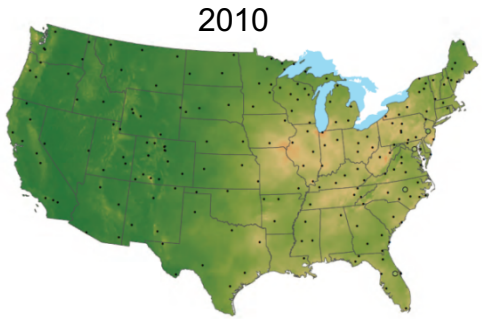


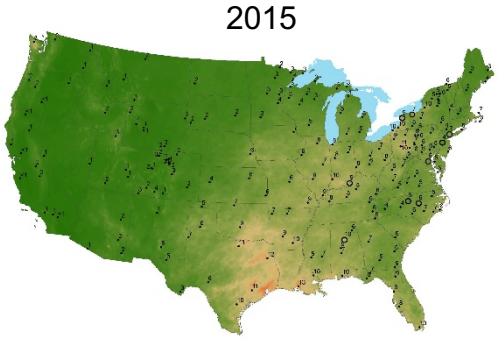












Sulfur Deficiency

Field Crops:

Begin appearing in agronomic crops

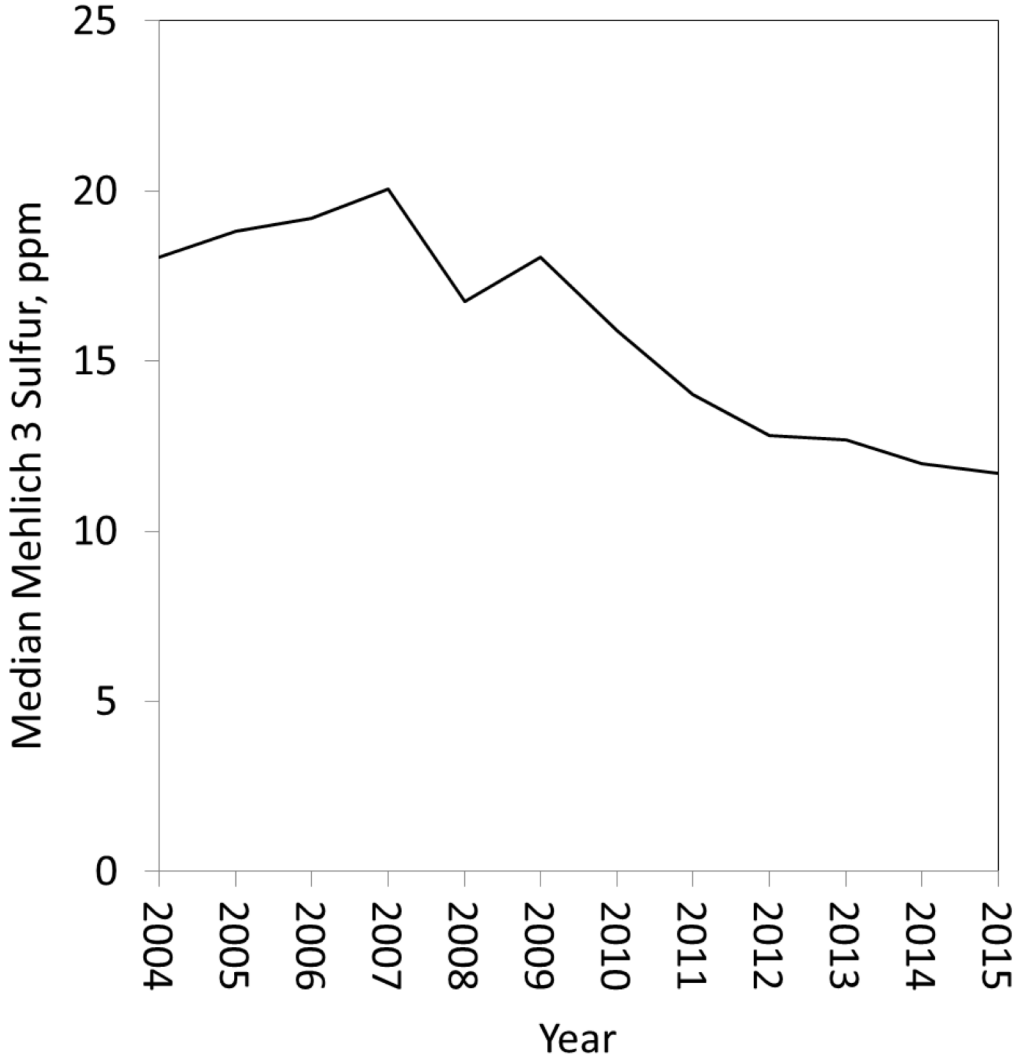
Deficient plants stunted and pale green (lack of chlorophyll)

First seen in alfalfa, mustards (rapeseed), onion crops

Soil Test Sulfur, 2004 - 2015

Routine soil testing can not be used to accurately predict S need, but it is useful for monitoring

Declining soil test S is a logical result of reduced atm. deposition, continued crop removal, leaching losses, etc.



Source: Penn State Ag Analytical Services Lab (all agronomic crops; avg. 20,000 obs./yr)

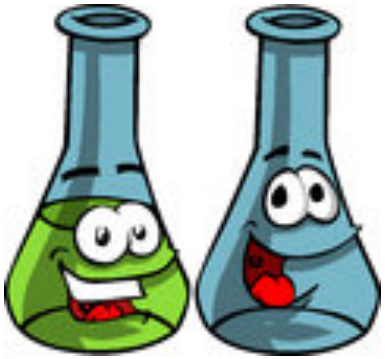
Sulfur

Soil testing

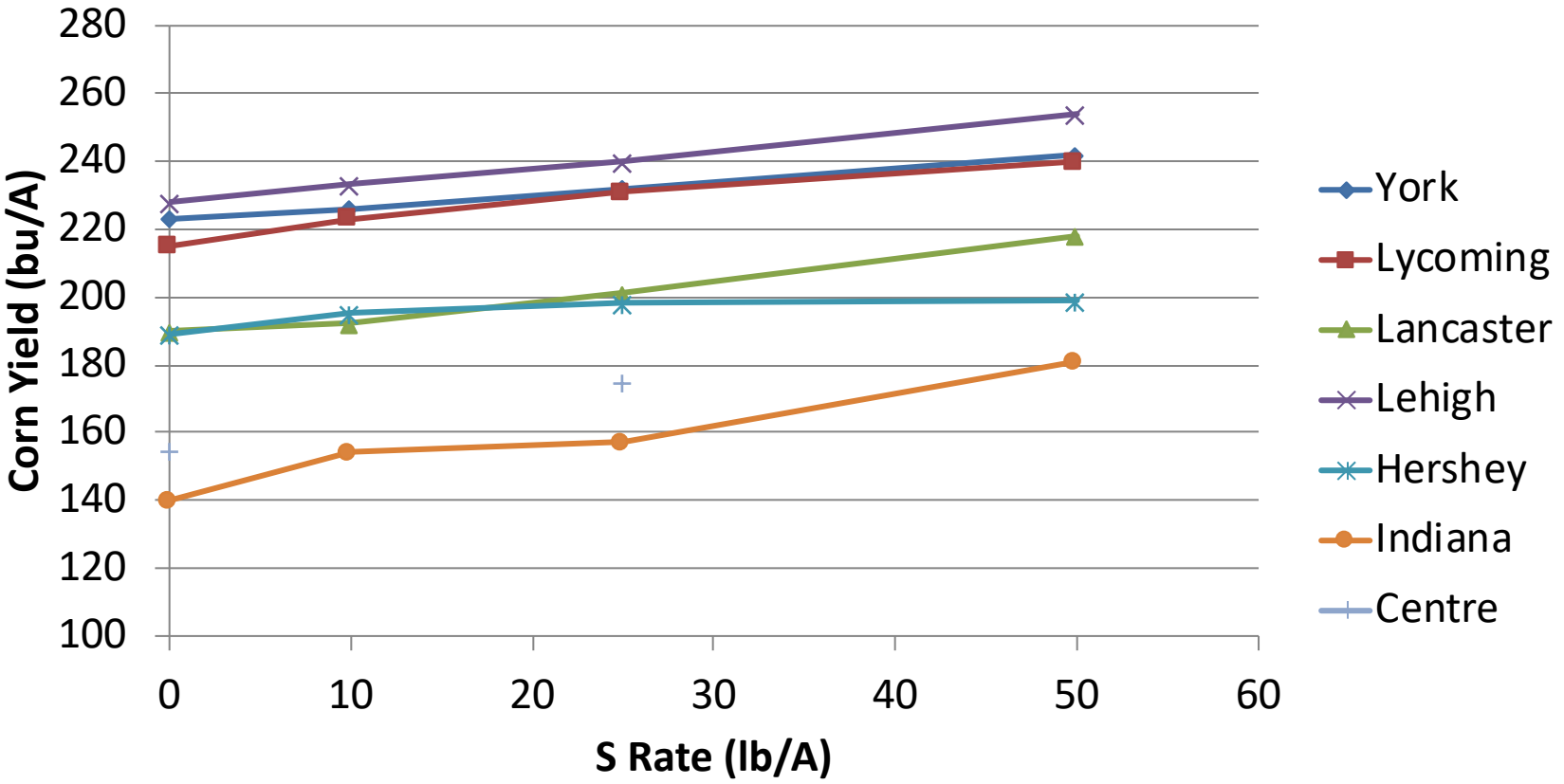
Soil testing for S has not been very successful

- Behavior in soil similar to N it is dynamic
  - Main source of available S is mineralization of organic matter.
  - Sulfate (SO_4^{2-}) is relatively mobile– subsoil testing necessary

- Routine soil testing can be used for monitoring (e.g., Mehlich 3) but not for predicting response
  - Doesn't measure organic S
  - Routine sampling depth insufficient



S Agronomic Crop Response Curves



From Beagle & Spargo

Sulfur

Plant use

Several amino acids/proteins contain S

S is required for production of chlorophyll molecule

Found as part of vitamins

Necessary for respiration

Not as mobile as N

Sulfur

Deficiency symptoms:

Deficient plants stunted and pale green (lack of chlorophyll)

Visual symptoms similar to N deficiency; however, S is not easily translocated from old to new growth – *symptoms appear first in younger leaves (opposite of N deficiency where symptoms appear first in older leaves)*

Sulfur

Plant response to sufficient S:

Improves protein production and chlorophyll content

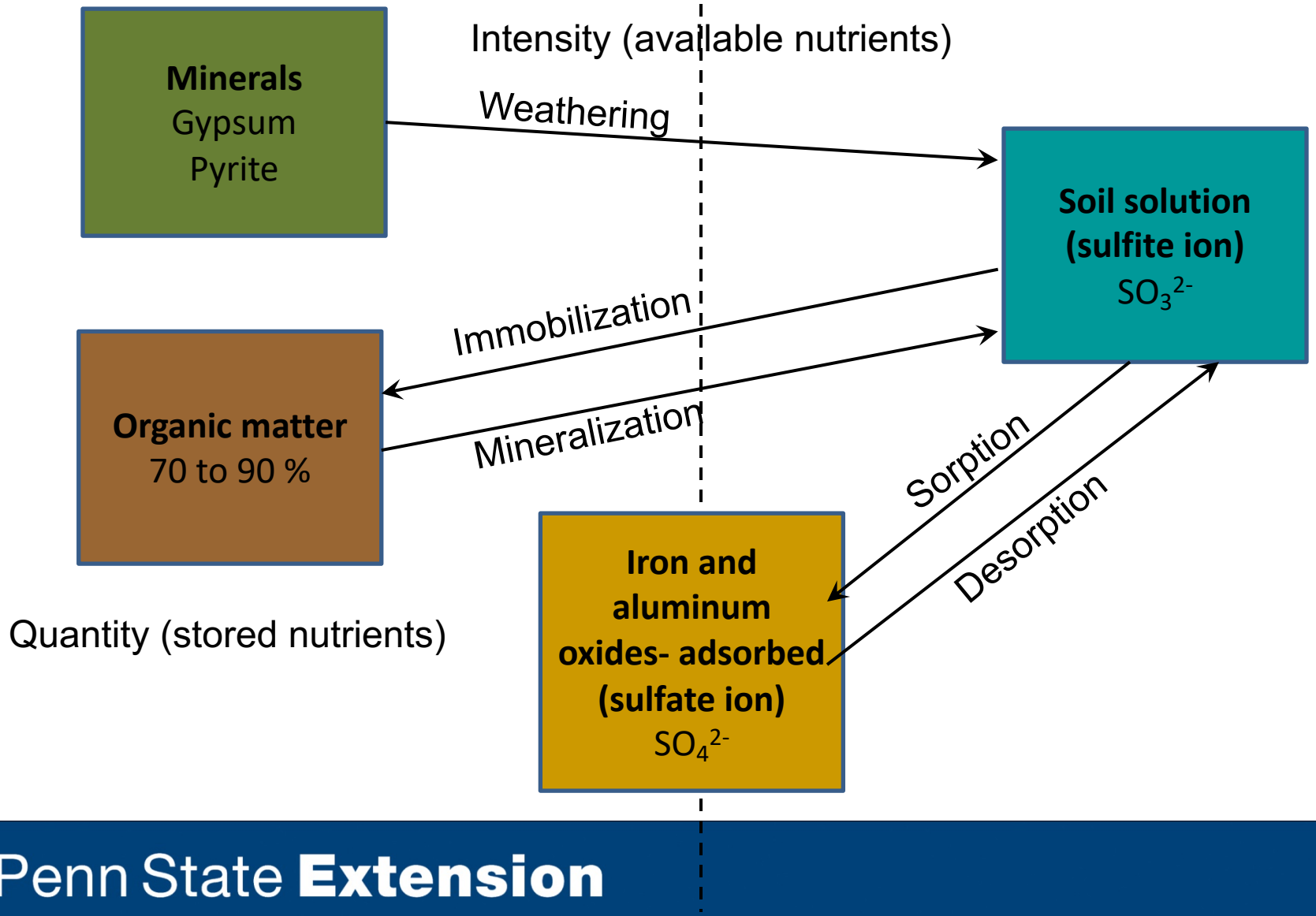
Increased N use efficiency

Horticultural crops high in sulfur

- *Peaches & Apricots*
- *Broccoli, Asparagus & Spinach*

Sulfur

Existing forms of S in soil:



Sulfur

Exisiting Forms of S in soil

The sulfate anion, SO_4^{2-}, is susceptible to leaching losses but not as much as NO_3^-

Sorption to iron and aluminum oxides, similar to PO_4^{3-} but not as strong.

- Mainly occurs in acidic subsoil

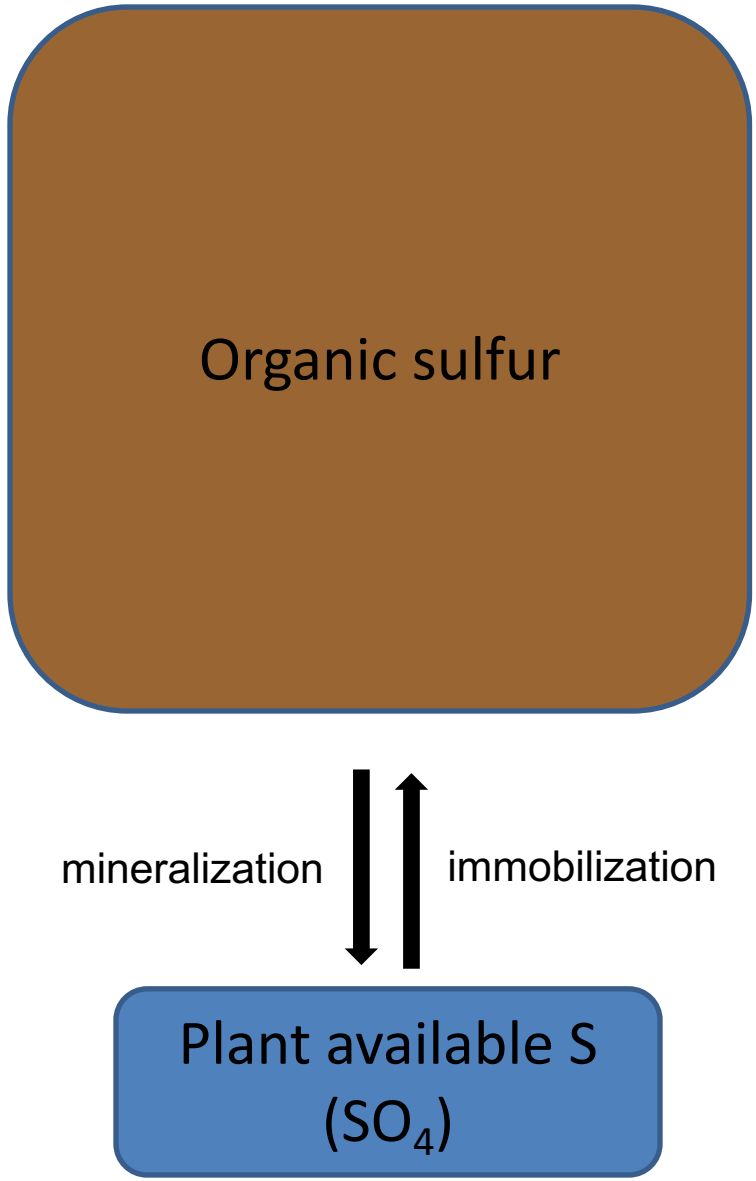
Sulfur deficiencies are most common in coarse textured & low organic matter soils

Sulfur

Existing Forms of S in soil

Mineralization of organic matter critical to good S nutrition in plants

Mineralization of S exactly the same as mineralization of N



Sulfur

Tree absorption:

Primarily absorb sulfur as sulfate ion (SO_4^-)

Sources: gypsum, ammonium thiosulfate, potassium thiosulfate, sulfur, zinc sulfate

Elemental sulfur (S) requires bacterial conversion to the sulfate form

Sulfur in the Orchard

- ~90% as organic compounds
- Some gaseous absorption
- Can be leached
- Availability not impacted by soil pH
- Tree need similar to P levels
- Young leaves appear light yellow or pale green

Sulfur

Traditional Leaf Analysis Guidelines

Most definitive way to diagnose S deficiency

Crop	% Dry Matter
Apple	0.20 - 0.40%
Pear	0.17 – 0.25%
Peach / Nectarine	0.20 – 0.40%
Cherry	0.15 – 0.50%
Brambles	0.21 - 0.50%
Blueberries	0.12 - 0.20%

PSU Ag Anal. Service Lab leaf analysis results last 3 years

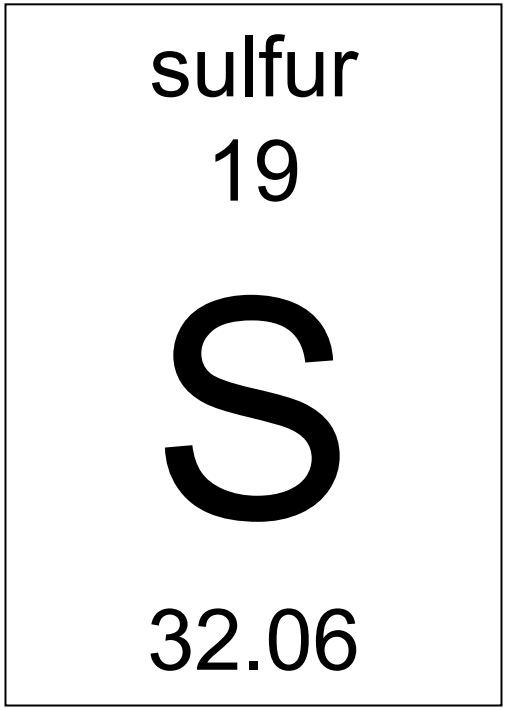
2018 avg. was 0.17%

2017 avg. was 0.18%

2016 avg. was 0.16%

Maximum level was 0.24%

Only 10% were = or >0.20%



Nitrogen & Sulfur

- Both are components of proteins
- N/S ratio important for proper formation
- Ideal N/S ~ 12 to 15 : 1 ratio (*for field crops*)
  - 2016 to 2018 ratio = 13.2*
    - *Sulfur only reported since 2015

Sulfur

Sources of Sulfur

Fertilizer:

- Ammonium sulfate, 24% S
- Gypsum, 19% S
- Ammonium thiosulfate, 26% S
- Sul-Po-Mag, 22% S
- Potassium sulfate, 18 % S

Manures also can supply sulfur but varies by the source

SO ARE ORCHARDS DEFICIENT IN SULFUR?

Probably Not Yet

- Leaf analysis began in early 1960's
  - Considerable acid rainfall existed
- Comprehensive fertilizer studies for tree fruit
  - Remobilization of reserves
- Tree fruit have a low density roots in the soil
  - Higher density plantings vs. smaller soil volume
- Impact of rootstock genetics
  - Recent work show impacts
- Will need to keep watch on future trends