UC DAVIS
UNIVERSITY OF CALIFORNIA

Department of
LAND, AIR AND WATER RESOURCES
University of California, Davis
Climate Change • Sustainable Agriculture
Environmental Quality • Landscape Processes

Soil Testing for P and K in Annual Crops

Daniel Geisseler

Nutrient Management Specialist, UC Davis

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Overview

- Phosphorus and potassium in soil
- Soil tests for phosphorus and potassium
- Principles of soil sampling
- Combining soil tests with other tools

Presentation based on:

Geisseler, D., Miyao, G., 2016. Soil testing for P and K has value for annual crops. California Agriculture 70, 152-159.

Phosphorus and potassium in soil

- Plant uptake from soil solution as K^+ or phosphate ($H_2PO_4^-$, HPO_4^{2-})
- Very small fraction of P and K is in solution. Needs to be replenished constantly from other pools to meet crop demand.
  - Dissolution of labile Ca^{2+}, Al^{3+} and Fe^{3+} phosphates
  - Mineralization of P in organic form
  - Exchange of K^+ held on cation exchange sites
  - Weathering of soil minerals

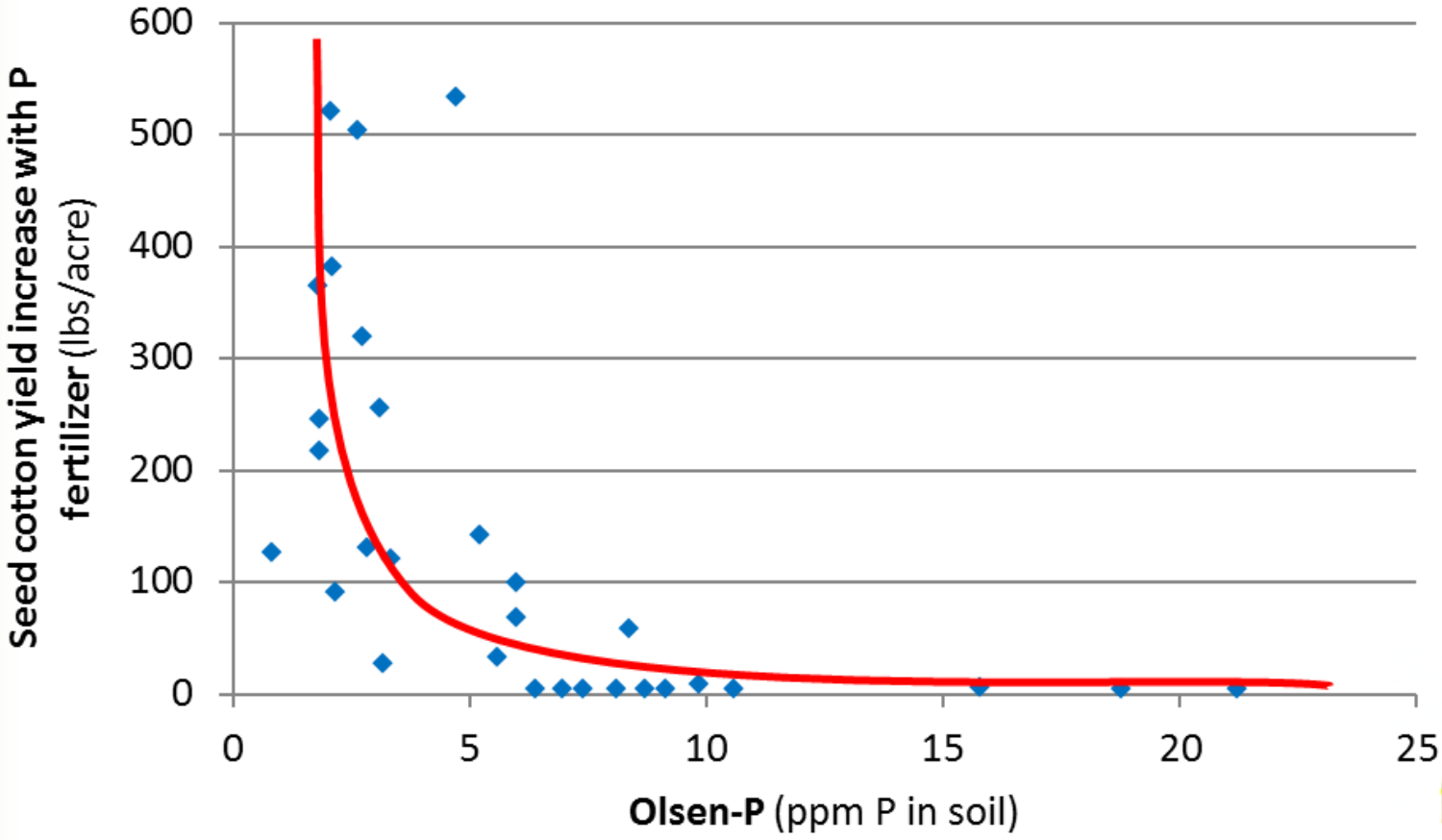
Soil tests for phosphorus

- Common soil tests in California:
  - Olsen (bicarbonate): soil pH > 6
  - Bray1: soil pH < 6
- Soil tests are indices of inorganic P availability
- However, 30-80% of P in organic form

⇨ Tests may underestimate available P in soils with high and active soil organic matter content

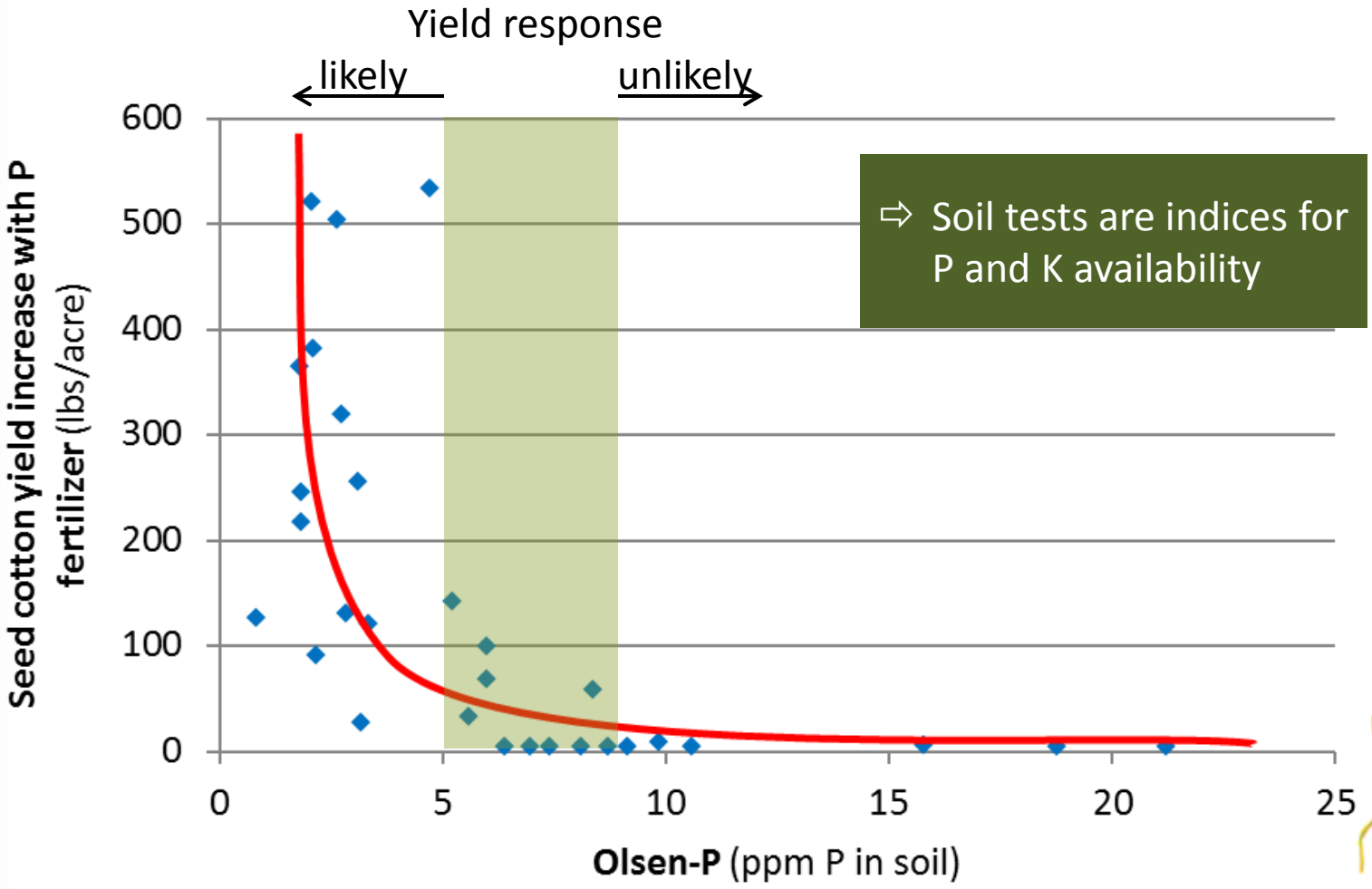
- P availability strongly depends on pH

Development of critical values



Redrawn from Mikkelsen, 1955

Development of critical values



Redrawn from Mikkelsen, 1955

Soil test for potassium

- Common soil test in California:
  - Ammonium acetate extraction
- K is not a component of organic molecules
- Test may be inaccurate in K-fixing soils
  - East side of the San Joaquin Valley
  - Soils formed on Sierra Nevada alluvium
  - On these soils:
    - Soil test K < 50 ppm: K fixation very likely
    - Soil test K 50-200 ppm: K fixation possible
    - Soil test K > 200 ppm: K fixation unlikely

Management practices for K fixing soils

- Higher application rates are necessary
- Band apply fertilizer, fertigate (broadcast K is generally less effective)
- Don’t apply far in advance of crop need
- Foliar application

⇨ Limit contact between soil and K

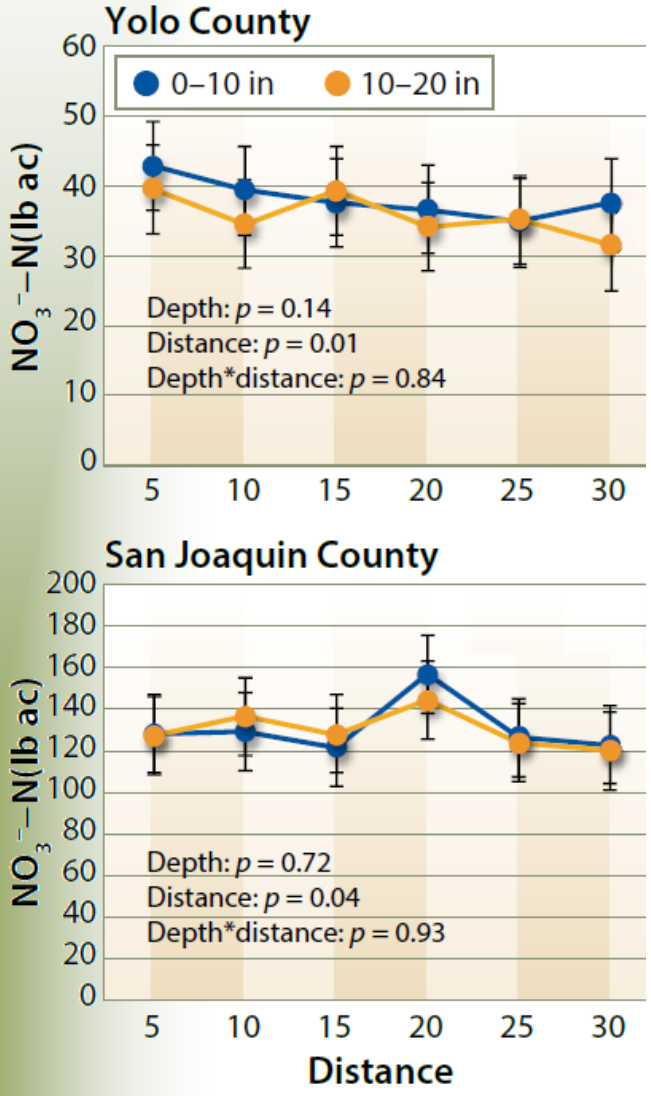
Principles of soil sampling

- The sampled area should be as uniform as possible
- Sample needs to be representative of the field or block

Taking a representative sample

- Sample in a W-shaped pattern or by walking a zigzag course
- Take a minimum of 20 cores
- Avoid sampling:
  - Unusual areas (corners, edges, wet spots…)
  - Former borders or fence rows
- Sample where roots are:
  - Orchards: in wetting zone
  - Field crops: on beds, not in furrow

Sampling in drip irrigated fields



Recommendation:

- At each location in the field, take three cores at 5”, 10”, and 20” from center.
- Pool samples

Our experience:

- 5” too close to tape
- 20” almost on the shoulder

Our approach:

- Take two cores at 7.5” and 15”

Lazcano et al., 2015

Principles of soil sampling

- The sampled area should be as uniform as possible
- Sample needs to be representative of the field or block
- Ensure results can be compared across years

Detecting long-term trends

Ensure results are comparable:

- Sample to same depth
- Sample during same time of the year
- Use same laboratory
- Sample between the same crops in crop rotation
- Sample the same blocks / checks
- Keep your notes and the test results

Principles of soil sampling

- The sampled area should be as uniform as possible
- Sample needs to be representative of the field or block
- Ensure results can be compared across years
- Handle samples appropriately (follow lab instructions)
- Keep records of observations and sampling procedure

Combining soil tests with other tools

- Nutrient budgets
- Simple on-farm trials
- Combine soil analyses with plant tissue analyses

Nutrient budgets

- Input – output
  - Input: Fertilizer, organic amendments
  - Output: nutrients removed at harvest
- If budget is balanced, soil test value should remain at the same level in the long term

Budget examples

Crop	Plant part harvested	Average yield	Total removed	
			lbs P_2O_5/acre	lbs K_2O/acre
Winter wheat	Grain	2.30 tons/acre	22 - 44	15 - 31
	Straw	2.30 tons/acre	3 - 7	51 - 93
Barley	Grain	1.49 tons/acre	20 - 32	15 - 19
	Straw	1.49 tons/acre	4 - 5	48 - 54
Corn	Grain	4.95 tons/acre	40 - 77	20 - 54
	Silage	26.2 tons/acre	50 - 76	189 - 264
Cotton	seed and lint	1436 lbs lint/acre	41 - 42	44 - 54
Sunflower	Seeds	1233 lbs/acre	14 - 21	6 - 12
Tomatoes	Fruits	41.4 tons/acre	47 - 66	200 - 300

Geisseler and Miyao, 2016

Values for other crops:
https://www.ipni.net/app/calculator/home

Nutrient budgets - Limitations

Not very accurate when losses are large:

- Potassium:
  - K may be leached in very sandy soils
  - K-fixing soils
- Phosphorus:
  - When erosion or runoff losses are high
  - In acidic or alkaline soils where P is immobilized
  - P-fixing soils (highly weathered or volcanic soils)
- Nitrogen:
  - Nitrate is easily leached

On-farm trials

- Strip trials in uniform part of fields
- Apply one nutrient at different rates. Other management practices should not differ.
- Choose strip size based on field equipment (planting, harvest)
- Do you need to include several fields or replicates within fields to trust the results?

Plant tissue analysis

- In-season monitoring of nutrient availability
- May be too late to make adjustments during the current season
- Optimal range and critical values depend on growth stage and plant part sampled
- Not sensitive to excess availability

- Sample the same blocks or checks for plant tissue and soil

Conclusions

- Samples need to be representative of the field or area
- Using the same sampling protocol allows detecting long-term trends
- Soil test results are an estimate of nutrient availability
- Soil test are best combined with other tools for robust fertilization recommendations

Resources for soil testing, critical values, nutrient removal

Geisseler, D., Miyao, G., 2016. Soil testing for P and K has value for annual crops. California Agriculture 70, 152-159.

Lazicki, P.A., Geisseler, D. Soil nitrate testing supports nitrogen management in irrigated annual crops. California Agriculture, in press.

California Fertilization Guidelines
https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Guidelines.html

Or just google: **California Fertilization Guidelines**

Soil and Plant-Tissue Testing in California. Reisenauer, H.M. (Ed.), 1976. Available online as Google book.

Western Fertilizer Handbook 9th edition. California Plant Health Association, 2002.