University of California

Nitrogen Management Training

for Certified Crop Advisers

MODULE 4

Nitrogen Sources

PART 2

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Crediting N sources for N management planning

Crediting Nitrate in Irrigation Water

How efficiently is this N taken up ?
What about irrigation efficiency ?

Crediting Nitrate in Irrigation Water:

- **A conservative approach is to count only the NO_3^--N contained in water transpired by the crop**

Example:

Processing tomato transpires about 25 inches of water

If irrigation water NO_3^--N is 6 PPM, the 'fertilizer credit' would be:

6 PPM NO_3^--N x 0.23 = 1.4 lb NO_3^--N per acre-inch

1.4 lb NO_3^--N per acre-inch x 25 inches = 35 lb NO_3^--N per acre

Crediting N in Organic Sources

Organic fertilizers and amendments:

- **Animal waste products (dry or liquid)**
- **Compost**

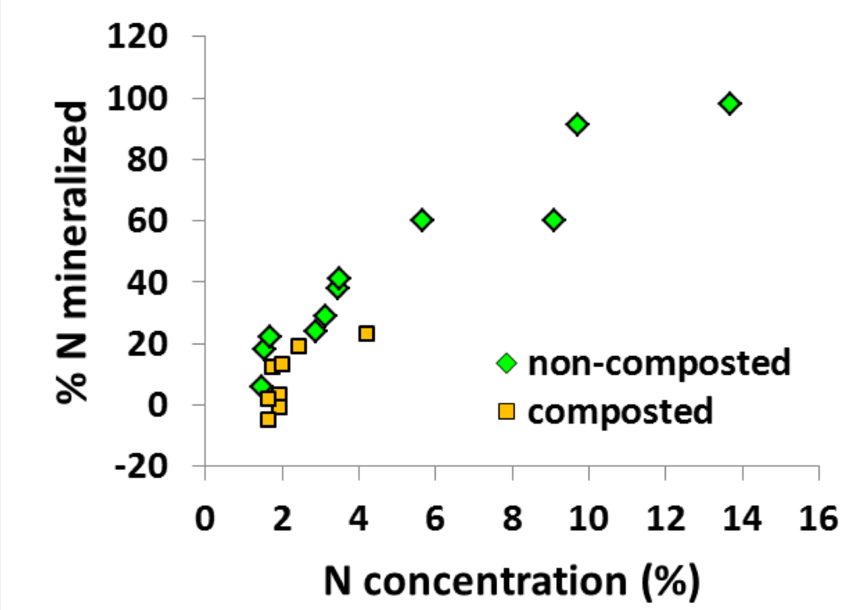
- **Initial mineral N content is typically low, predominately in NH_4^+-N form**
- **Organic N initially mineralizes to the NH_4^+-N form and is then nitrified**

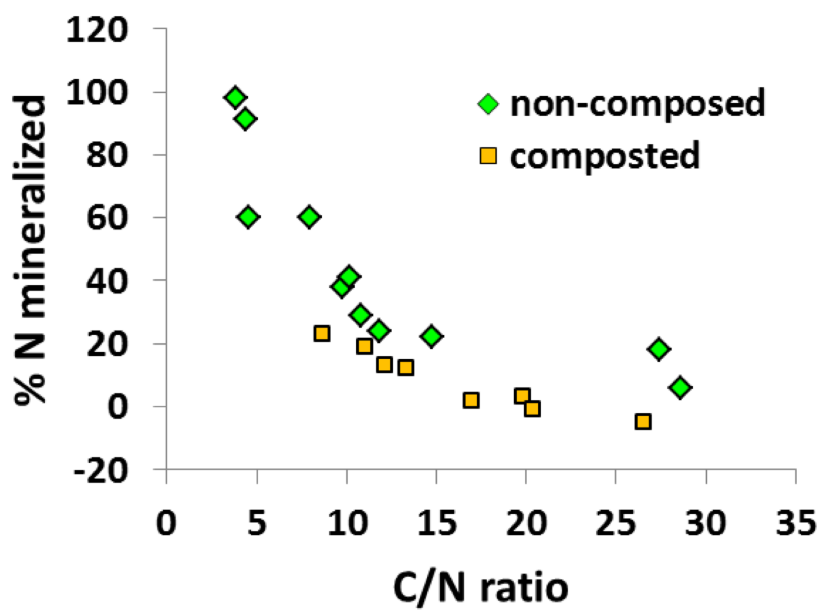
Crediting N in Organic Sources

Nitrogen 'credit' from organic amendments depend on:

- **'Fresh' or composted**
- **Percent N**
- **C:N ratio**

% N mineralized in full field season, Oregon data:





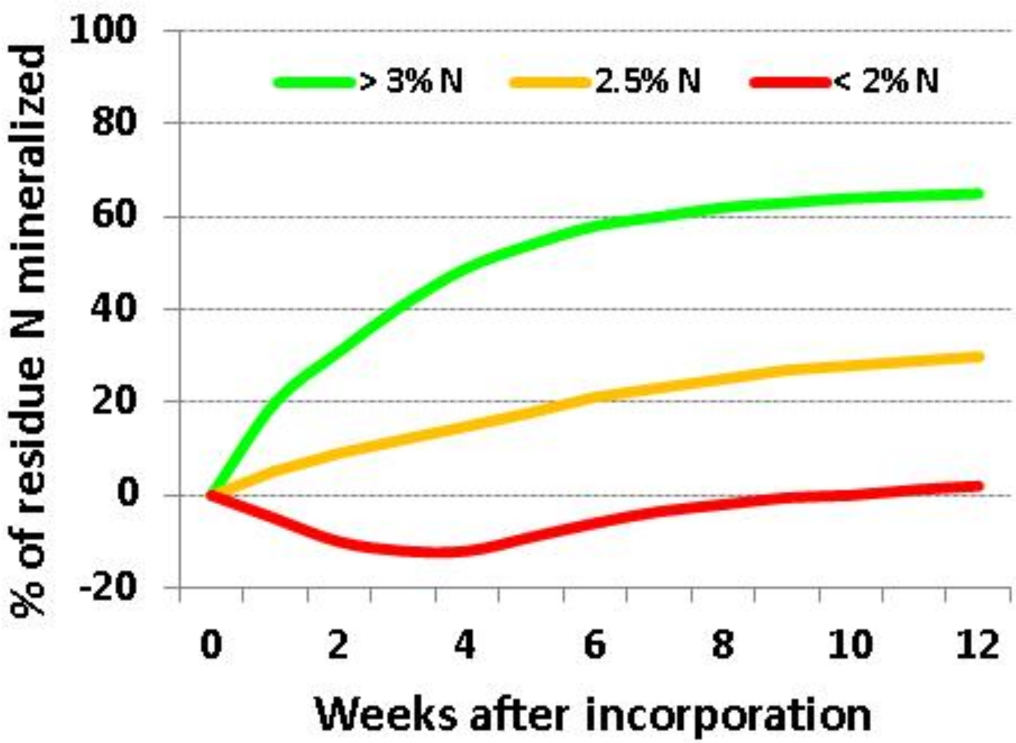
(Gale et al., JEQ 35:2321-2332, 2006)

Crediting N in Organic sources

- Cover crops
- Crop residues

Residue N content, C:N ratio, and kill date predict N mineralization behavior and potential to provide N

Crediting N Cover Crops and Crop Residue Examples cont'd.



- Greatest activity occurs in the initial 6-8 weeks after incorporation
- Soil temperature / moisture effects can be significant

Crediting N Cover Crops: Plant Available Nitrogen (PAN) at time since termination and different growth stages and

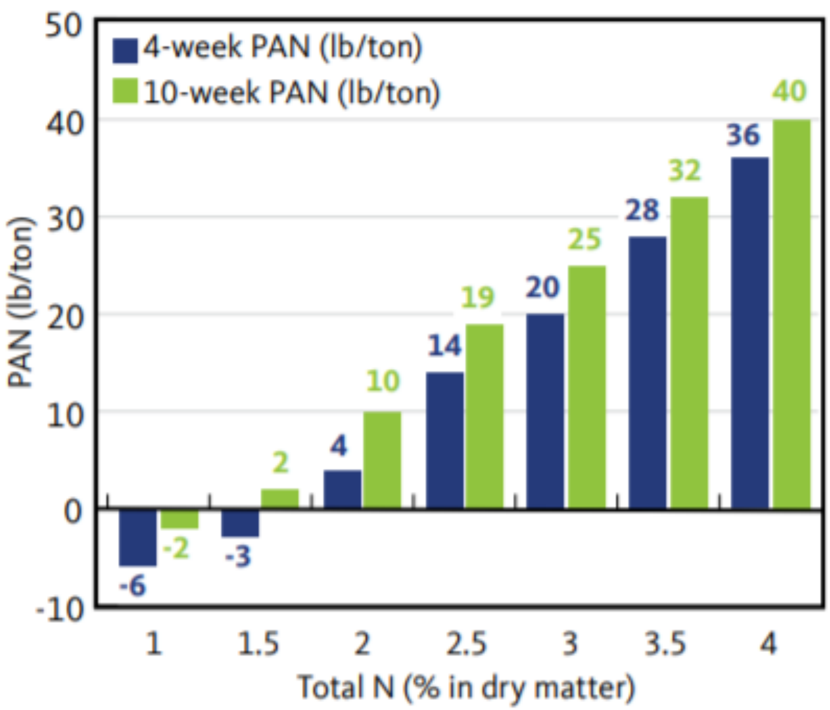


Figure 5. Calculator predictions for PAN from cover crop residues; PAN in units of lb/dry ton

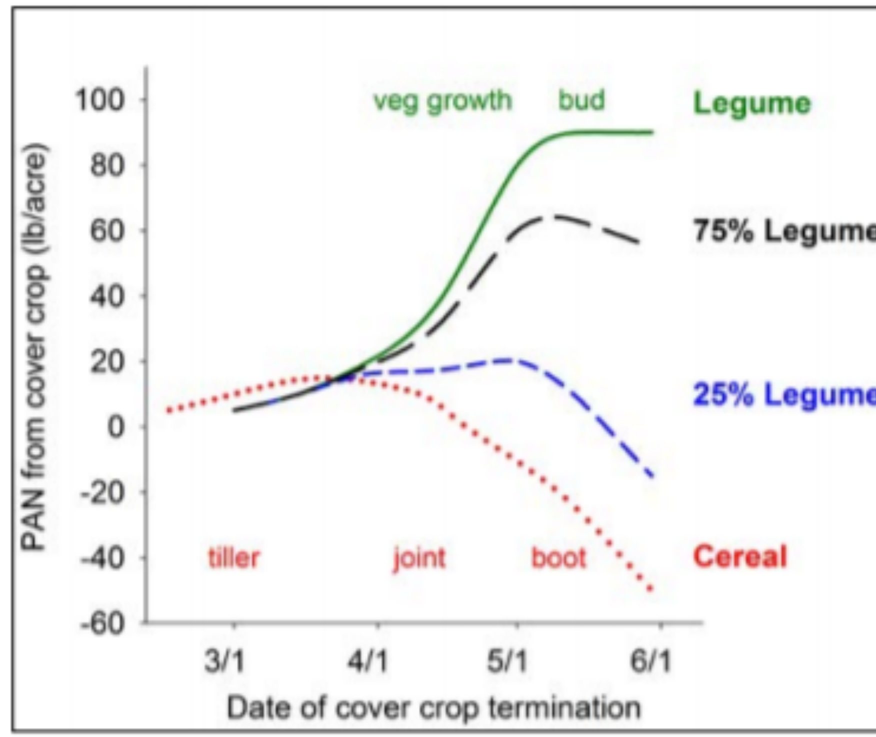
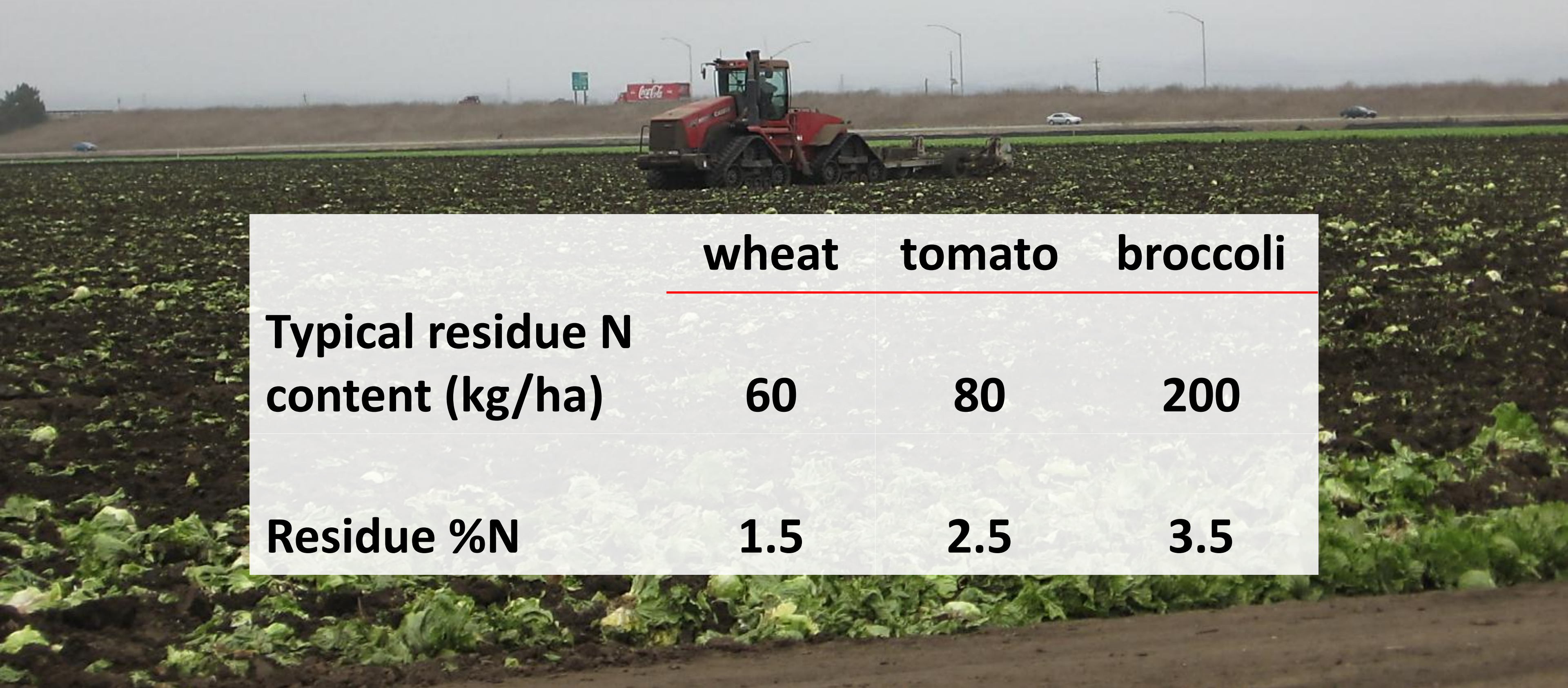


Figure 4.—Effect of kill date on typical plant-available N (PAN) release from cereal, legume, or mixed stands. Based on compilation of field data from Willamette Valley cover crop trials. Source: D. Sullivan.

Crediting N in Organic Sources

Crop residue examples:

Residue N content predicts N mineralization behavior:



	wheat	tomato	broccoli
Typical residue N content (kg/ha)	60	80	200
Residue %N	1.5	2.5	3.5

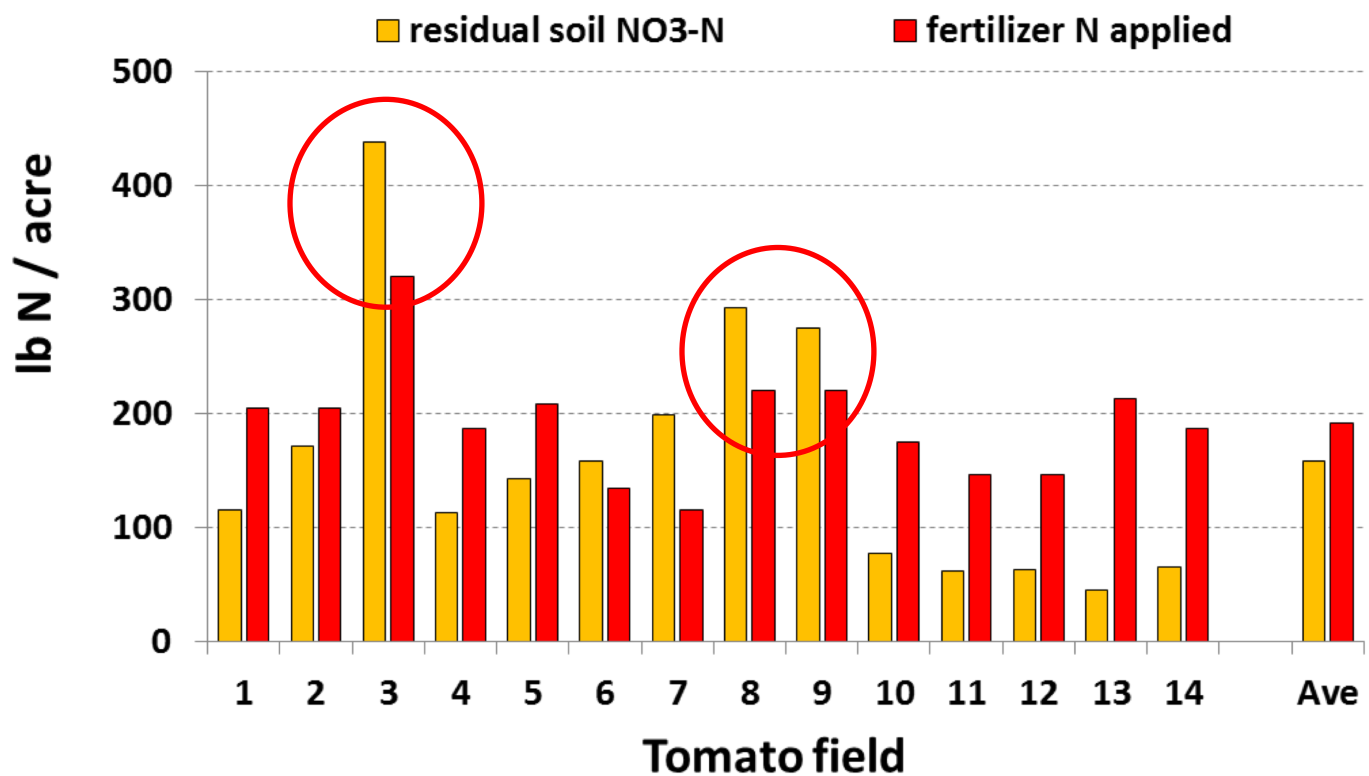
Crops have very different N uptake/removal characteristics…

	lb N/acre				
	Common N fertilization rates	Crop N uptake	Typical N removal in harvest	Typical N in residue	Partial N balance
broccoli	170-250	250-350	90	200	120
lettuce	100-220	120-160	70	70	90
spinach	160-200	100-130	80	40	100
processing tomato	160-230	220-300	140	110	60

Therefore,

- **improving the N balance may require different strategies**
- **rotational management must be considered**

Residual soil NO_3-N varies widely, but few growers consider it when formulating N fertilization programs:



2013 data from Lazcano et al., 2015

How to calculate a ‘fertilizer credit’ for residual soil NO_3-N ?

There is no ‘right’ answer for all situations

- To what depth?
- What about spatial variability?

Possible approaches:

- Credit all residual NO_3-N in top foot?
- Credit a fraction of residual NO_3-N in whole root zone (50-75% ?)
- Credit all residual NO_3-N above a ‘threshold’ (5 PPM ?)

Our approach for drip irrigated processing tomatoes:

- Credit 50% or residual NO_3-N in 1^{st} foot and 80% in 2^{nd} foot

For more information:

Review Article

Soil nitrate testing supports nitrogen management in irrigated annual crops

by Patricia A. Lazicki and Daniel Geisseler

Soil nitrate (NO_3^-) tests are an integral part of nutrient management in annual crops. They help growers make field-specific nitrogen (N) fertilization decisions, use N more efficiently and, if necessary, comply with California's Irrigated Lands Regulatory Program, which requires an N management plan and an estimate of soil NO_3^- from most growers. As NO_3^- is easily leached into deeper soil layers and groundwater by rain and excess irrigation water, precipitation and irrigation schedules need to be taken into account when sampling soil and interpreting test results. We reviewed current knowledge on best practices for taking and using soil NO_3^- tests in California irrigated annual crops, including how sampling for soil NO_3^- differs from sampling for other nutrients, how tests performed at different times of the year are interpreted and some of the special challenges associated with NO_3^- testing in organic systems.

Growers in California face increasing pressure to use nitrogen (N) fertilizers efficiently to reduce the risk of nitrate (NO_3^-) leaching to groundwater, which makes soil NO_3^- testing an important component of N management. However, soil NO_3^- sampling and interpretation are not straightforward. The soil NO_3^- pool is subject to additions and losses throughout the year, and a soil NO_3^- test gives a snapshot only of the NO_3^- present when the sample is taken.

In most agricultural soils, NO_3^- is the major inorganic form of N. Because of this, and its mobility in soil, it is the form primarily taken up by plants in fertilized agricultural systems, although plants also take up ammonium (NH_4) and to a lesser degree small organic molecules (Schimel and Bennett 2004). The soil NO_3^- pool may include N left over from the previous crop, N from recent fertilizer applications, N released from organic materials such as organic matter, manure or crop residues in a process known as mineralization, and N from irrigation water (Huggins and Pan 1993).

If winter rainfall is insufficient to leach it below the rooting zone, soil NO_3^- can accumulate and NO_3^- may be high in spring. However, NO_3^- can also be quickly leached with excess irrigation or heavy rainfall (Magdoff 1991; Spellman et al. 1996). Soil NO_3^- concentrations in spring can therefore be extremely variable. In a recent study of drip-irrigated tomato fields in the Central Valley, Lazcano et al. (2015) reported NO_3^- concentrations in the top 10 inches ranging from 20 to well above 200 pounds per acre.

Irrigated agriculture presents both challenges and opportunities for efficient N management. A major advantage of irrigated agriculture is that water volume can be controlled to a much greater extent than in rain-fed systems. Furthermore, when irrigation systems have good uniformity, N can be applied with the irrigation water at any time during the season, rather than in one large dose early in the season (as with rain-fed systems). This enables growers to avoid excessive soil NO_3^- during early crop growth when the plant demand is low and the leaching risk is greater (fig. 1). In a well-managed irrigated system, both water and N applications are fit to crop needs to maximize N use efficiency. However, because excess irrigation can result in considerable NO_3^- leaching losses, irrigation management needs to be taken into account when obtaining samples and interpreting soil NO_3^- test results.

We reviewed methods for obtaining and interpreting soil NO_3^- samples that are appropriate for irrigated annual cropping systems in California. Similar principles apply to perennial crops, but we focused on annual crops as tissue

Online: https://doi.org/10.3733/ca.2016a0027
Published online December 15, 2016

Preplant soil samples should be taken in spring, as closely as possible to a planned fertilizer application and after any pre-irrigation.

California Agriculture, 2016. Volume 71(2):90-95.
Online: http://calag.ucanr.edu/Archive/?article=ca.2016a0027

Field-specific N management :

Post-establishment soil NO_3-N

- often called Pre-sidedress Soil Nitrate Testing (PSNT)

PSNT is often the most important field-specific modification

Why is post-establishment soil NO_3-N sampling so important ?

- **It integrates the main factors influencing soil N mineralization (rapid N mineralization from residues and amendments has already taken place)**
- **The measurement is taken after crop establishment, when additional leaching should be controllable (given good irrigation management)**

IPNI Crop Nutrient Removal Calculator

https://www.ipni.net/app/calculator/home

IPNI NUTRIENT REMOVAL CALCULATOR

Go here for:

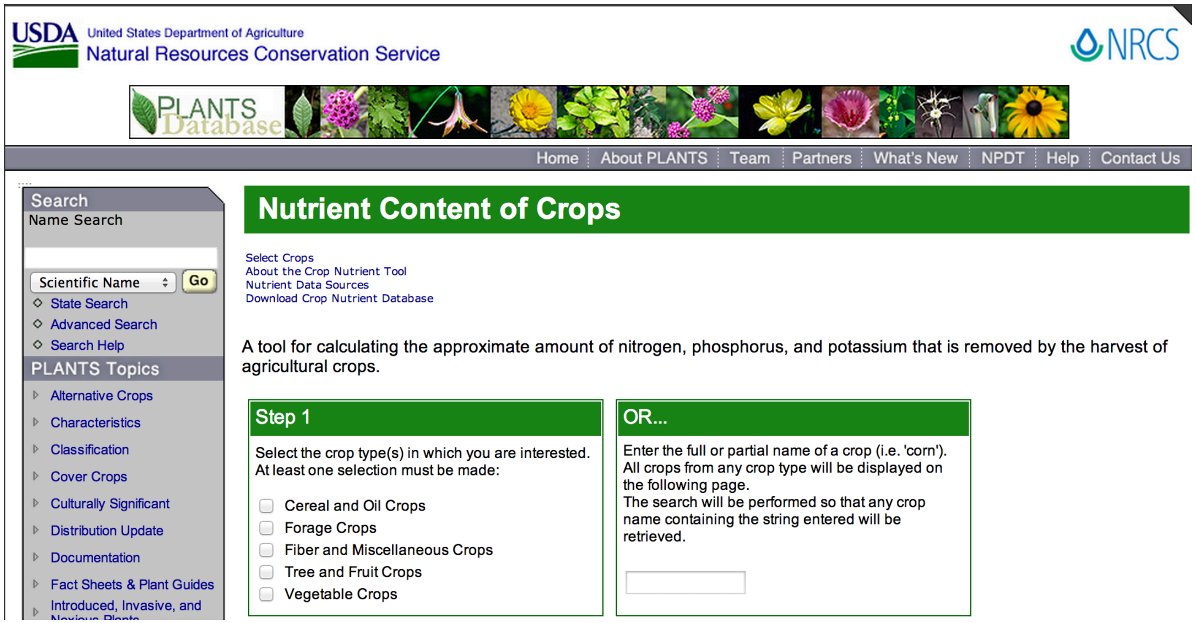
- N, P, K harvest removal estimates of field crops
- Multilingual crop nutrient calculator

Crops

- ☆ Alfalfa (DM)
- ☆ Almonds, with shell
- ☆ Alsike clover (DM)
- ☆ Apples
- ☆ Bahiagrass
- ☆ Barley grain
- ☆ Barley straw
- ☆ Barley straw per unit of grain yield
- ☆ Beans, dry

NRCS Crop Nutrient Tool

http://plants.usda.gov/npk/main



Go here for:

- Elemental N, P, K harvest removal estimates of field crops
- Explanation of how removal calculations are made

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Course materials available at:

ciwr.ucanr.edu/NitrogenManagement

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