College of Tropical Agriculture and Human Resources
University of Hawaii at Manoa

COVER CROP PLANT AVAILABLE NITROGEN (PAN) CALCULATOR for HAWAII

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Center of Rural Agricultural Training &

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USDA

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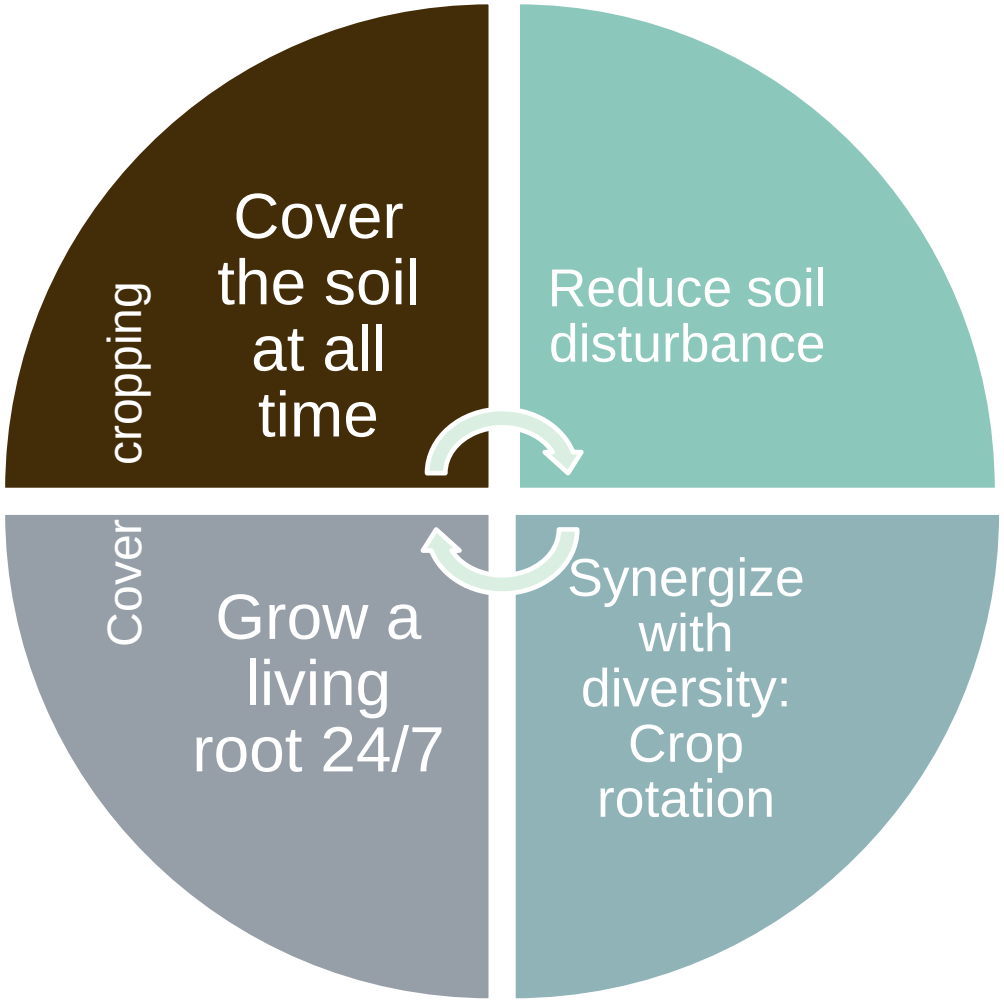
Benefits of cover cropping:

Soil Health



Water Health?

USDA NRCS
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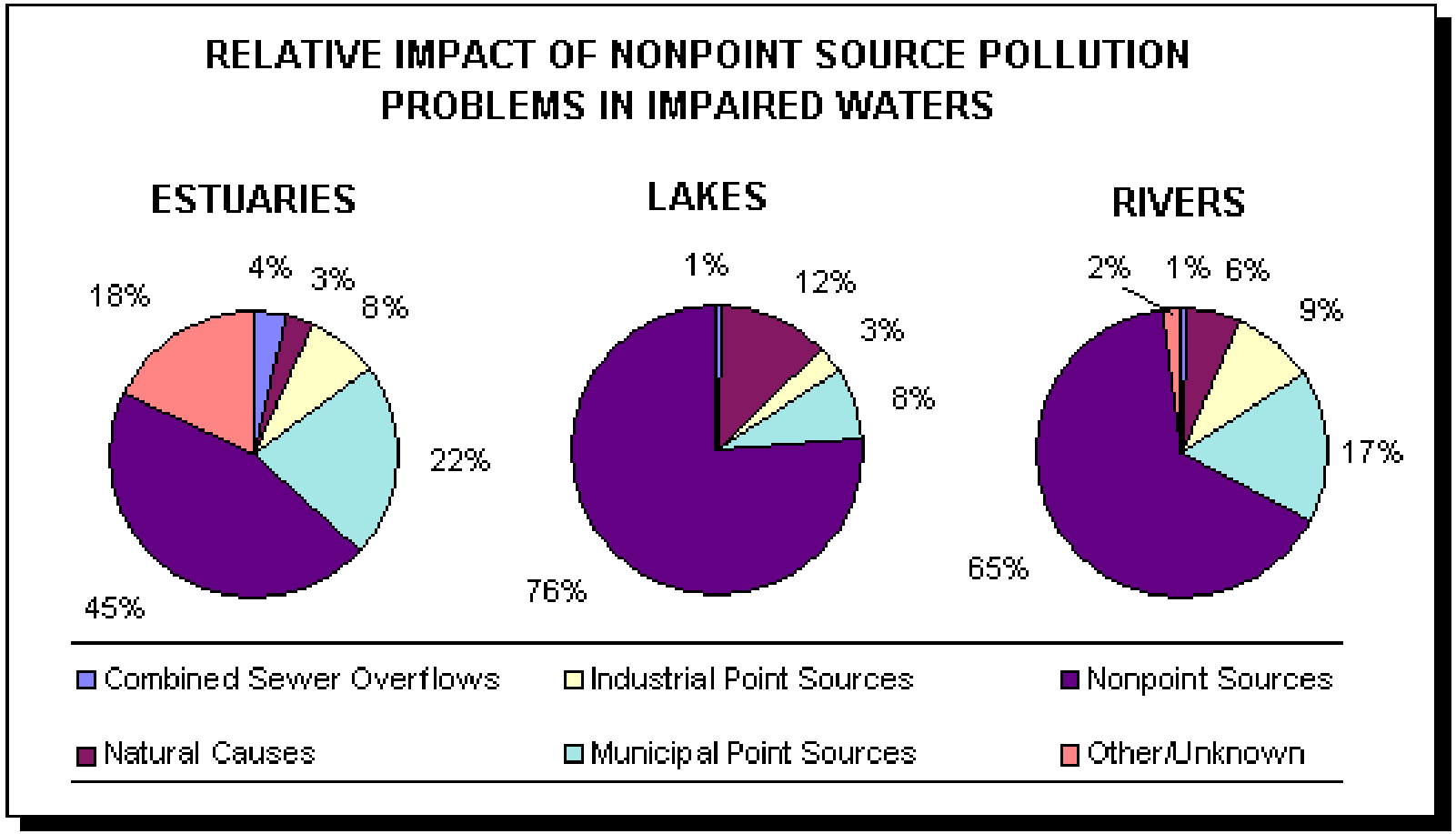
NON-POINT SOURCE POLLUTION



US Forest Service (NA-PR-07-91)

Nonpoint source pollutants, such as sediments, nutrients, pesticides, herbicides, fertilizers, animal wastes and other substances that enter our water supply as components of runoff and ground water, have increased in relative significance and accounts for > 50% of the pollution in U.S. waters

EUTROPHICATION

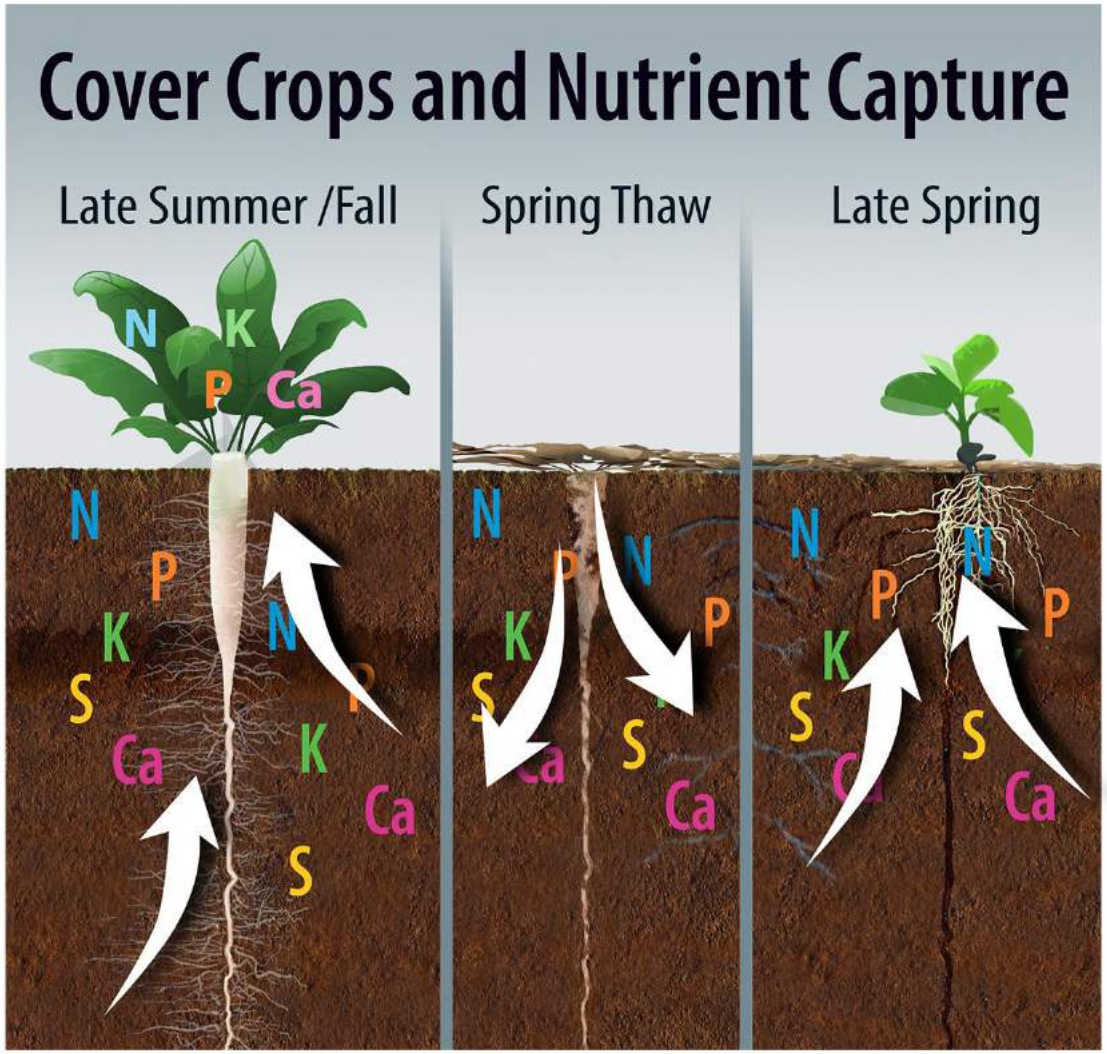
Excess Nitrogen and Phosphorous Spur Algal Growth, Deplete Oxygen and Kill Fish.

Algae bloom

Many species, including fish, are sensitive to low oxygen levels and die as a result.

OUTLINE

- ✓ Benefits of cover crop for soil fertility management
- Cover crop calculator
  - Factors affecting plant available N% (PAN%)



Cover crops can increase the amount of nutrients available for the next crop by taking up nutrients that remain in the soil and holding them in plant tissue until they are released the next spring, when they can be used by the following crops. *Courtesy: Cover Crop Solutions*

1. COVER CROP SCAVENGE SOIL NUTRIENTS

- Fibrous-rooted cereal grains or grasses – scavenging excess N left in soil after a cash crop, reduce nutrient leach.
- **Need to plant early:** Rye can took up 70 lb **N**/A when planted soon after termination of last crop.
- Deep-rooted cover crops (such as oil radish) draw **Ca and K** that leach down the soil profile to upper soil surface.
- Although P doesn't leach, it is not readily available for plant to uptake. Cover crops such as buckwheat and lupins, secrete acids into soil that put P into a more soluble form for plant to uptake.
- Cover crops could also enhance plant P uptake by hosting mycorrhizae fungi.

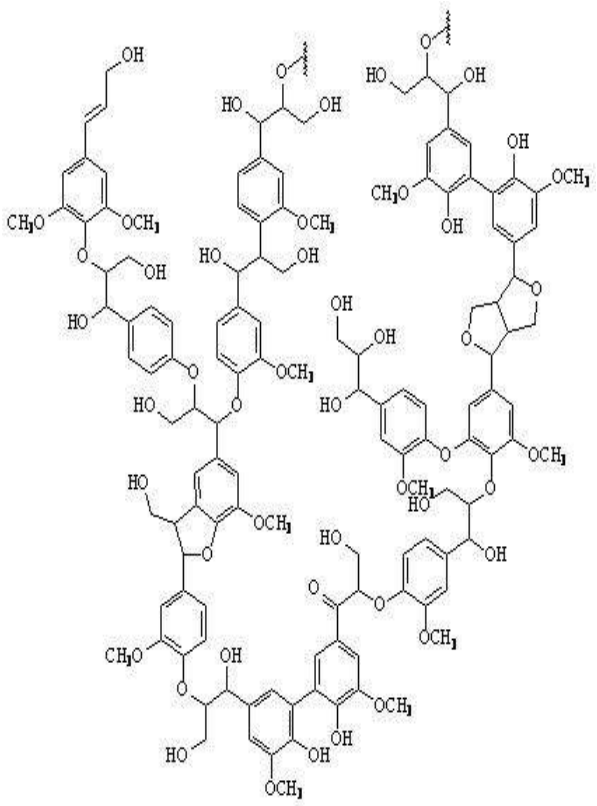
Oil radish

Lupin

2. Leguminous cover crops contribute N to cash crops

- 30-60% of N that the legume produced can be available for the subsequent cash crop (WSARE, 2007)
- But plant N available rates varies by cover crop and soil condition --- Cover crop calculator

3. ADDING SOIL ORGANIC MATTER (SOM)



- Soil organic matter contributes to improve soil structure, increase infiltration and water holding capacity, increase cation exchange capacity (help soil to store nutrients).
- Two portions of soil organic matter:
  - Active fraction -- rich in simple sugars, proteins, fresh residues, microbial cells (responsible for the release of most N, P, K from organic matter)
  - Stable fraction – rich in celluloses and lignins, tougher to break down, contribute to humus (responsible for real soil organic matter, dark content, water holding capacity, cation exchange capacity or CEC)

EFFECTS OF COVER CROPS ON SOM

Crimson clover
Trifolium incarnatum

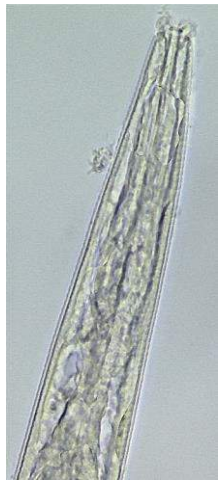
Oat
Avena sativa

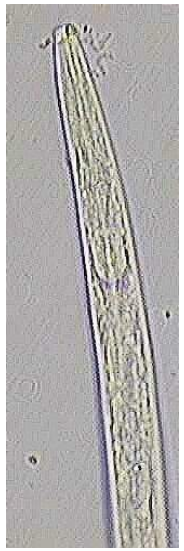
White clover
Trifolium repens

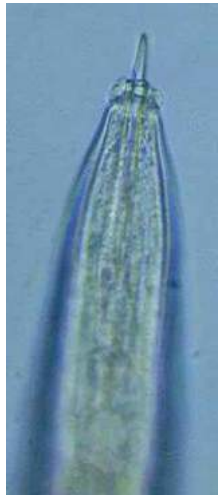
- **Annual legumes:** Produce plant materials that are succulent and rich in proteins and sugars – leave little long-term organic matter.
- **Grain and grasses, non-legumes:** Produce plant materials that are woodier or more fibrous – promote more stable organic matter (humus), increase soil structure, CEC, but might tie up nutrients temporarily.
- **Perennial legumes/Long-term annuals** such as perennial peanut, white clover or sunn hemp (if let sunn hemp grown for months) may fall in both categories – leaves will break down quickly, but stems and root systems can contribute to humus accumulation.

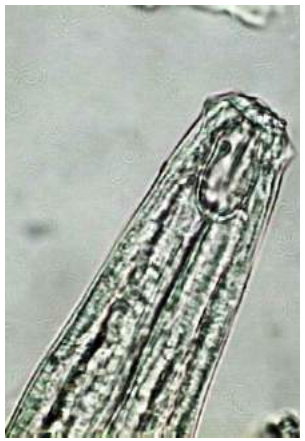
4. IMPROVE SOIL NUTRIENT CYCLING

Cover crops enhance microbial activities involve in soil nutrient cycling









Outline

- Benefits of cover crop for soil fertility management
- Cover crop calculator
  - Factors affecting plant available N% (PAN%)

http://www.ctahr.hawaii.edu/WangKH/Downloads/CCChart-Hawaii-KHWang.pdf

Cover Crop Chart for Hawaii

Koon-Hui Wang and Archana Pant, CTAHR, University of Hawaii

CRATE

High Elevation ⟷ Low Elevation

Grass	Broadleaf	Legume	Broadleaf	Grass
Black Oat 75 lb/acre			Sesame 4 lb/acre	
Barley 90 lb/acre			Buckwheat 20-30 lb/acre	Pearl Millet 15 lb/acre
Cereal Rye 90 lb/acre	Canola 7-10 lb/acre	Hairy vetch 30-50 lb/acre; Woolly pod Vetch 40-60 lb/acre; Jack bean 50-60 lb/acre; Cowpea 40-60 lb/acre ('CA Blackeye 5', 'Purple knuckle', 'TS Brown', 'MS Silver')	Mustard 7-10 lb/acre	Oat 90 lb/acre
Oat 90 lb/acre	Mustard 7-10 lb/acre	Bell Bean 150 lb/acre; Yellow Sweetclover 10-15 lb/acre; Velvet Bean 40 lb/acre; Soybean 50-75 lb/acre	Rape Seed 7-10 lb/acre	Black Oat 75 lb/acre
Winter Wheat 120 lb/acre	Rape Seed 7-10 lb/acre	Red Clover 20 lb/acre; White Clover 20 lb/acre; Pigeon Pea 40-60 lb/acre; Lablab 11-18 lb/acre	Oil Radish 10 lb/acre	Grain Sorghum 25-30 lb/acre
Annual Ryegrass 100 lb/acre	Oil Radish 10 lb/acre	Austrian Winter pea 100 lb/acre; Alfalfa ('Moapa 55') 15 lb/acre; Perennial Peanut 40 lb/acre; Sunn Hemp 30-60 lb/acre	Marigold 3 lb/acre	Sorghum-Sudangrass 35-60 lb/acre

P = seedig rate

A = annual; B= Biennial; P = Perennial; SP = Short-term perennial.

R = resistant to root-knot but not reniform nematode; (note: only certain cultivars are resistant to root-knot nematodes for alfalfa and cowpea; cowpea is very susceptible to reniform nematode).

S = suppressive to plant-parasitic nematodes

R*= sunn hemp and velvetbean are resistant to root-knot and reniform nematodes; marigold, Tagetes patula, is resistant to root-knot and reniform, *T. erecta* is only resistant to root-knot; sesame is resistant to southern and peanut root-knot nematode (*Meloidogyne incognita* and *M. arenaria*) but not Javanica root-knot (*M. javanica*).


Sunn hemp


Oil radish


Wolly pod vetch


Sudangrass + lablab


Buckwheat

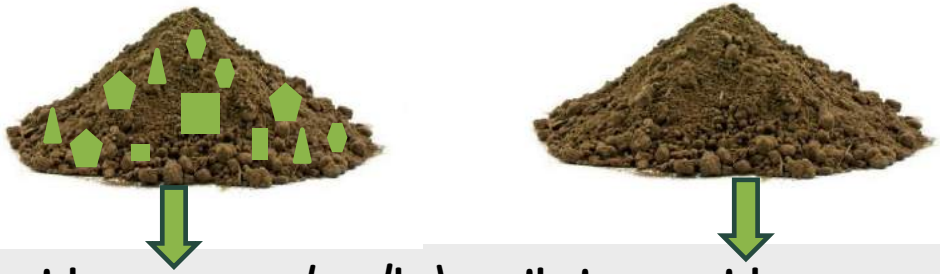

Cowpea + marigold

PLANT AVAILABLE NITROGEN (PAN)

- Although cover crops can fix or accumulate nitrogen (N) in plant tissues, not all the N in the tissue will be released into a plant available form.

At 28 days after cover crop incorporation
At 70 days after cover crop incorporation

$[NO_3^-]$ $[NO_3^-]$



Plant Available Nitrogen (PAN %) = [Soil nitrate with cover crop (mg/kg) - soil nitrate without cover crop] X 100
Total N added by cover crop (mg/kg)

% N in tissue × cover crop biomass = Total N

Actual PAN = cover crop dry biomass × % N × PAN%

Amount of N fertilizer input that farmers can cut back

FACTORS AFFECTING PAN% FROM COVER CROP

- climate conditions, season
- soil types
- cover crop species
- biomass, plant age, % N in tissue
- time after cover crop termination
- farming practice (till vs no-till)
- microbial activities in your soil

Based on studies in Kansas, Vigil and Kissel (1991) found strong correlation between PAN released % with % N in tissues

$$PAN\ (\%) = -53.44 + 16.98\ (\%\ N\ in\ tissue \times 10)^{1/2}$$

However, Hawaii has many micro-climates and soil types. Thus, different PAN prediction models need to be developed for different regions in Hawaii……

PAN FROM COVER CROPS IN POAMOHO, OAHU (WINTER)

Cover Cropping Practice				Cover Crop Tissue			28 Days		70 Days	
Season/tillage	Cover Crop	Fresh Weight (lb/ft^2)	Dry Content (%)	Dry Weight (lb/Acre)	Tissue N (%)	Total N(lb/A)	PAN (%)	Actual PAN (lb/A)	PAN (%)2	Actual PAN(lb/A)
Winter/Till	Sunn hemp	1.2	23.10%	12074.83	1.66	200.44	55.24	110.72	67.82	135.94
Winter/Till	Cowpea (Blackeye #5)	1.04	13.70%	6206.43	2.87	178.12	63.74	113.54	75.17	133.90
Winter/Till	Lablab	0.78	14.89%	5059.15	2.75	139.13	62.72	87.26	75.22	104.65
Winter/Till	Pigeon pea	0.55	20.47%	4904.20	3.47	170.18	66.14	112.55	81.69	139.02
Winter/Till	Woolypod vetch	0.55	9.21%	2206.53	4.43	97.75	70.52	68.93	84.19	82.30

- % Tissue N varied among cover crop species.
- Some cover crop released PAN more efficiently than others (70.5% vs 55.2%).
- Actual PAN can be strongly influenced by cover crop biomass.

http://www.ctahr.hawaii.edu/WangKH/cover-crop.htm

PAN FROM COVER CROPS IN POAMOHO, OAHU (SUMMER)

Cover Cropping Practice				Cover Crop Tissue			28 Days		70 Days	
Season/tillage	Cover Crop	Fresh Weight (lb/ft^2)	Dry Content (%)	Dry Weight (lb/Acre)	Tissue N (%)	Total N(lb/A)	PAN (%)	Actual PAN (lb/A)	PAN (%)2	Actual PAN(lb/A)
Winter/No-till	Sunn hemp	1.07	24.62%	11475.19	2	229.50	56.85	130.47	66.72	153.12
Winter/No-till	Cowpea (Blackeye #5)	1.47	14.20%	9092.71	2	181.85	56.6	102.93	65.42	118.97
Summer										
Summer/No-till	Sunn hemp	0.72	21.34%	6692.91	2.72	182.05	60.54 ✓	110.21	75.14 ✓	136.79
Summer/No-till	Cowpea	1.54	14.24%	9552.53	2.83	270.34	67.57 ✓	182.67	74.43 ✓	201.21
Summer/No-till	Lablab	0.34	13.31%	1971.26	3.13	61.70	78.05	48.16	81.91	50.54
Summer/No-till	Sudex	0.96	16.02%	6699.18	1.33	89.10	43.48	38.74	54.95	48.96
Summer/No-till	Oat (TAM406)	0.51	14.72%	3270.14	1.84	60.17	46.25	27.83	62.55	37.64
Summer/No-till	Oil Radish	0.55	6.40%	1533.31	2.49 ✓	38.18	70.8 ✓	27.03	77 ✓	29.40

- PAN released % was higher in summer than winter.
- Grassy cover crops had lower % N and slower PAN released % compared to legumes, but that in oil radish was equivalent or higher than legumes, thus a good nutrient scavenging crop.

PAN FROM COVER CROPS IN LALAMILO, HAWAII

Cover Cropping Practice				Cover Crop Tissue			28 Days		70 Days	
Season/tillage	Cover Crop	Fresh Weight (lb/ft^2)	Dry Content (%)	Dry Weight (lb/Acre)	Tissue N (%)	Total N(lb/A)	PAN (%)	Actual PAN (lb/A)	PAN (%)2	Actual PAN(lb/A)
Winter/Till	Bell bean	0.78	10.60%	3601.54	4.2	151.26	64.03	96.85	69.95	105.81
Winter/Till	Austrian Winter Pea	0.6	11.70%	3057.91	4.9	149.84	63.34	94.91	67.72	101.47
Winter/Till	Annual ryegrass	0.36	13.42%	2104.47	4.72	99.33	54.76	54.39	60.58	60.17
Winter/Till	Woolypod vetch	0.45	11.20%	2195.42	5.32	116.80	58.46	68.28	66.57	77.75
Winter/Till	Oat (Cayuse)	1.15	17.20%	8616.17	2.34	201.62	42.55	85.79	53.28	107.42

- PAN released % could change from location to location.
- Although N % in these cover crops were higher than the tropical legumes tested earlier, the actual PAN released were lower.
- Farmers could calculate amount of N fertilizer needed to full-fill the crop requirement.

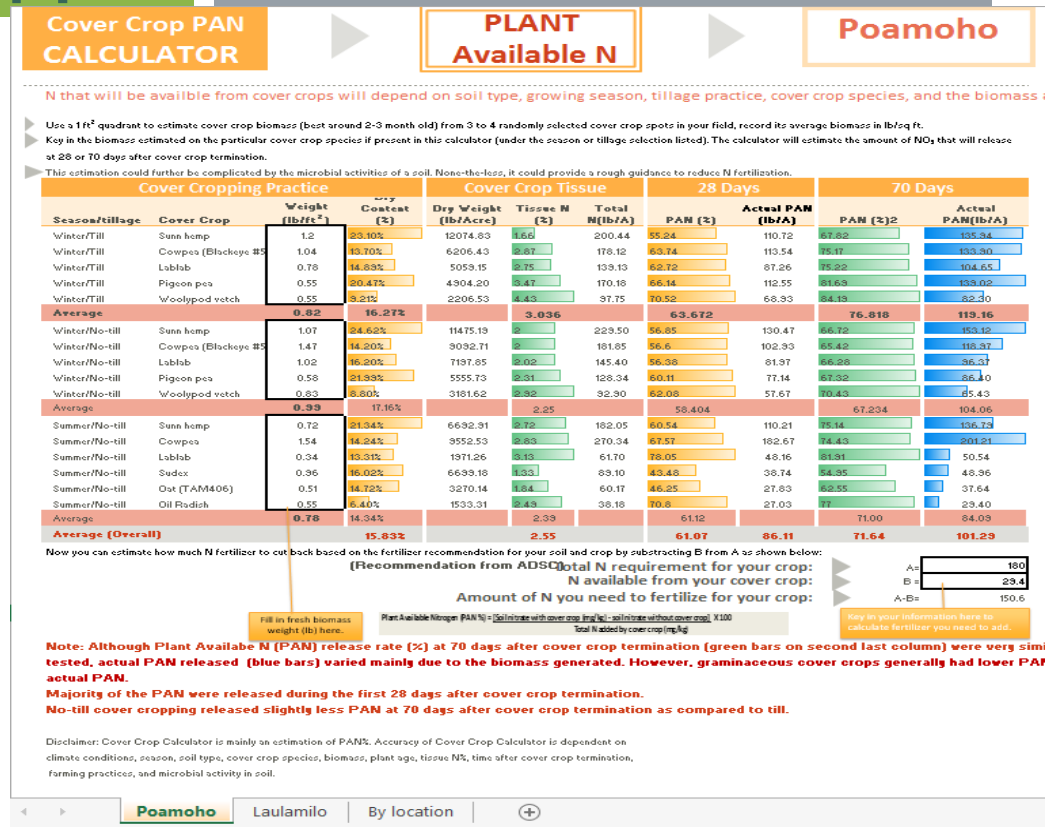
Total N requirement for your crop: (Recommended by ADSC)	A =	180
N available from your cover crop:	B =	105
Amount of N you need to fertilize for your crop:	A-B =	75

How to use Cover Crop Calculator?

Tissue N%

1. Estimate cover crop dry biomass (lbs/acre)

2. Send tissue to analyze for tissue N content (%)



3. Find a location in Cover Crop Calculator similar to your area, calculate actual PAN at 4 or 10 weeks after cover crop termination.

Amount of N fertilizer input that farmers can cut back

=

Actual PAN = % N × cover crop dry biomass × PAN%

Cover Crop PAN CALCULATOR

PLANT Available N

By location

- In the event that you grow a cover crop mix, you can send a sample of your cover crop tissue at crop termination to Agriculture Diagnostic Service Center (ADSC) to assay for **tissue N (%)**, and estimate the **dry weight** of your cover crop biomass in lb/acre.
- Estimate **dry weight** by collecting fresh cover crop biomass in lb/ft^2, dry tissue in sun, and weigh.
- Estimate plant available Nitrogen (PAN) from your cover crop mix by using PAN-N regression lines generated for your location.

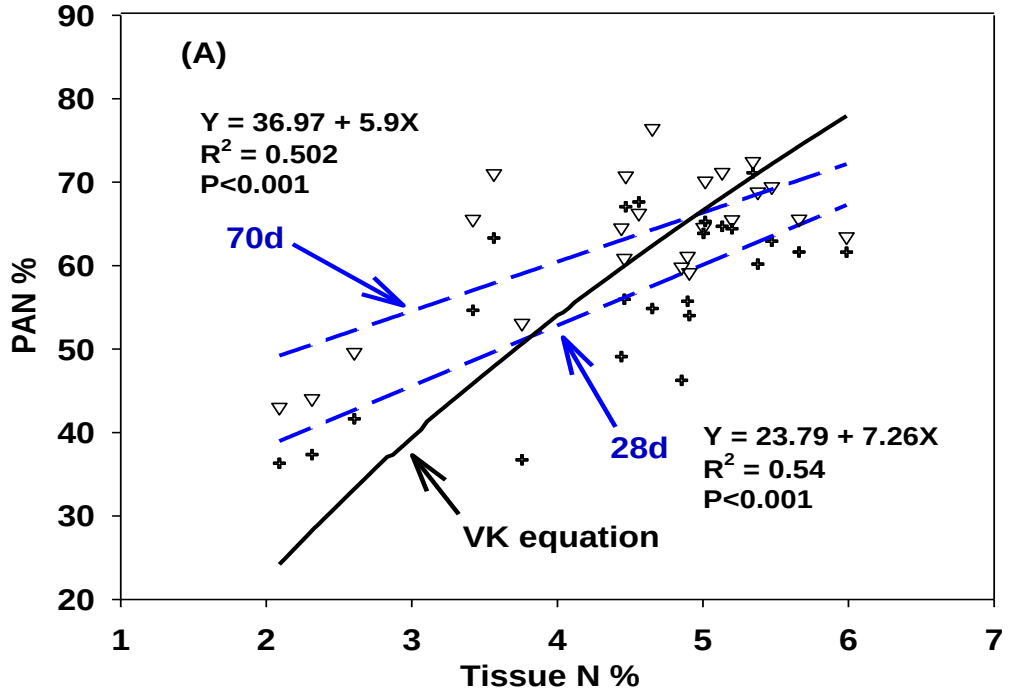
Key in

	Cover Crop Tissue				28 Days		70 Days	
Location	Dry Weight (lb/ft^2)	Dry Weight (lb/Acre)	Tissue N (%)	Total N(lb/A)	PAN (%)	Actual PAN (lb/A)	PAN (%)2	Actual PAN(lb/A)
Poamoho	0.15	6534	2	131	55.4	72	66.7	87.16356
Waimea	0.15	6534	2	131	38.31	50	48.77	63.732636
Kula	0.15	6534	2	131	39.342	51	54.518	71.2441224
Hoolehua	0.15	6534	2	131	30.179	39	39.912	52.1570016

Actual PAN = Cover crop biomass (dry weight in lb/acre) × Tissue N% × PAN%

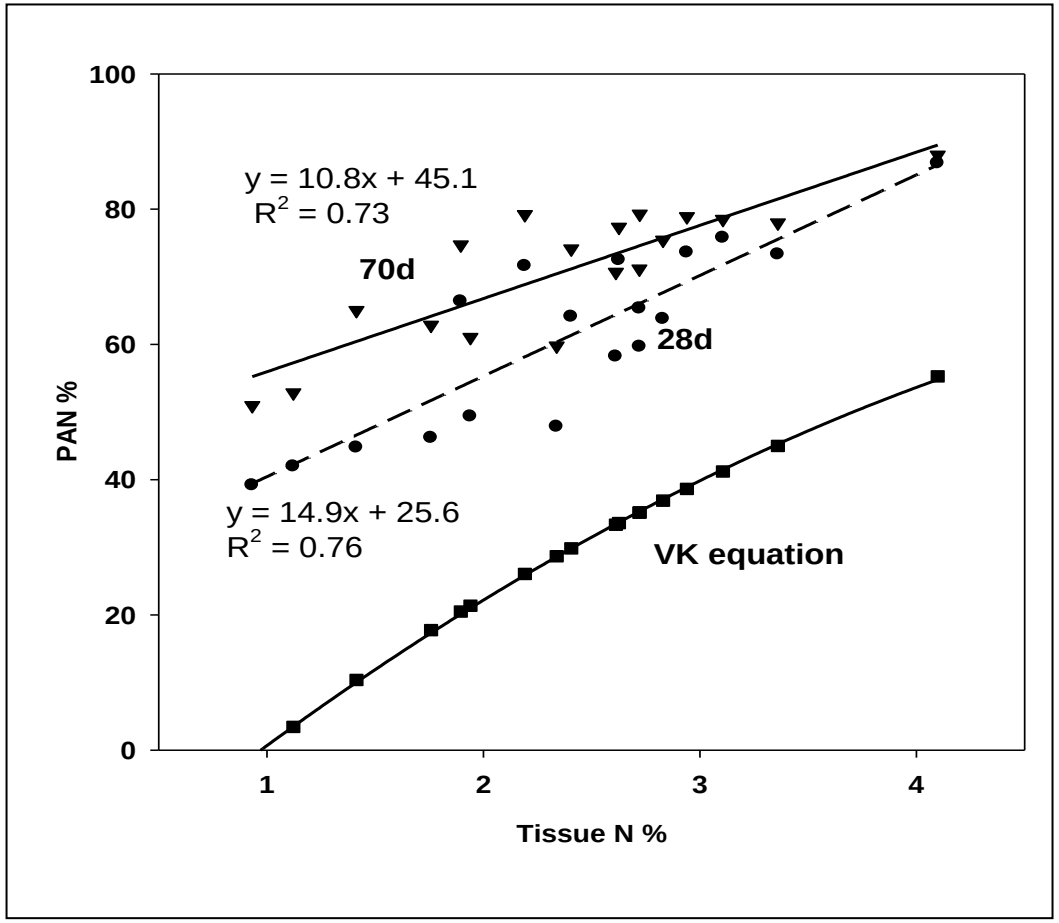
PAN% PREDICTION CURVES IN HI

PAN% Prediction Curve at Waiamea

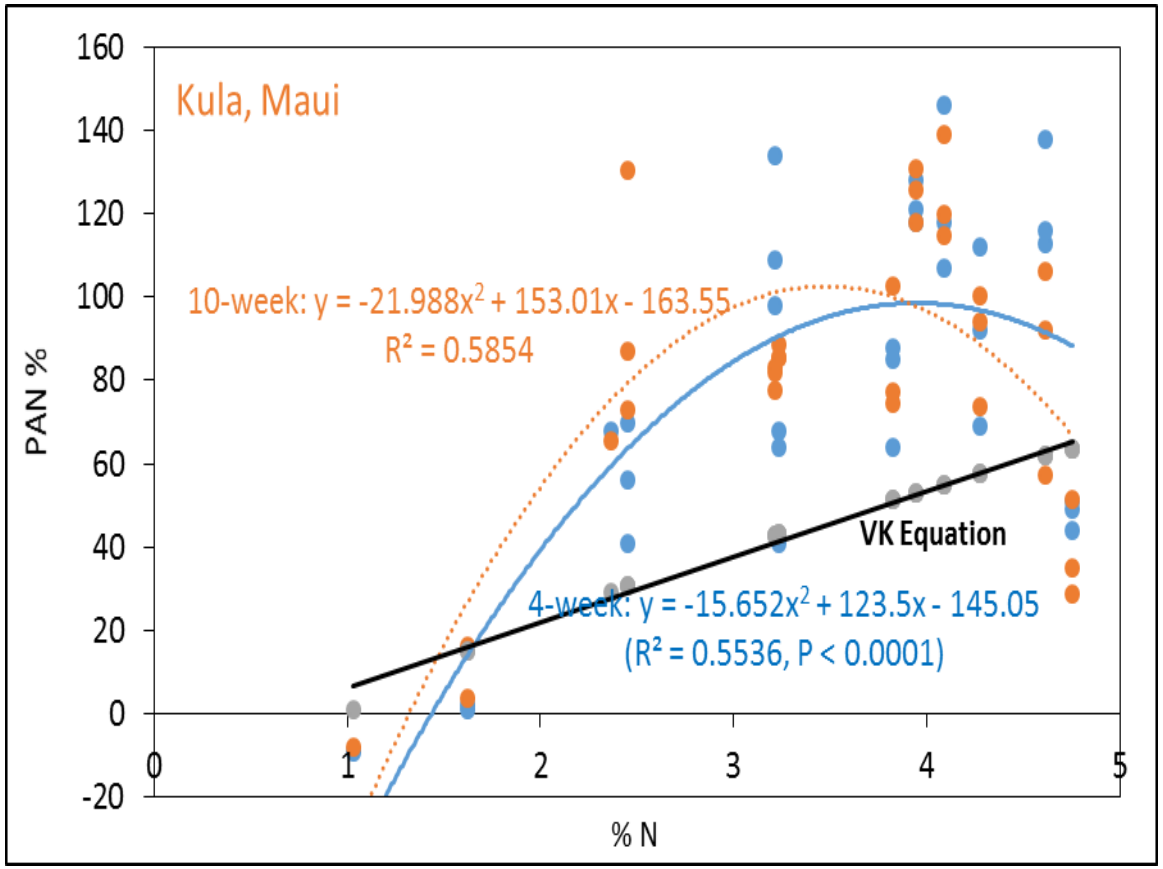


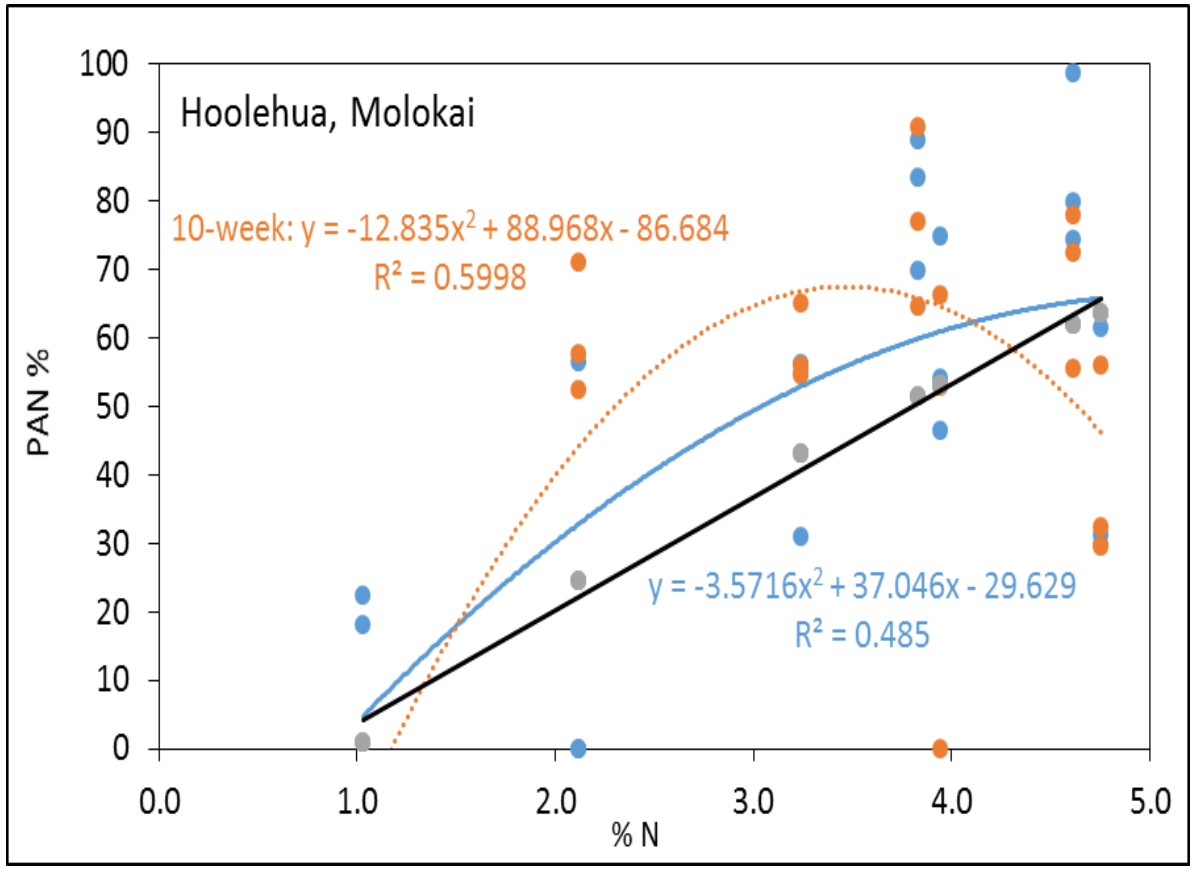
PAN% prediction curve based on %N in cover crop tissues (any cover crop mix will work) generated from Waiamea and Poamoho are very different from that predicted by VK equation.

PAN% Prediction Curve at Poamoho



PAN% PREDICTION CURVES IN HI





- In general, PAN% of tissues with %N between 2-4% are higher in Hawaii than that using VK prediction.
- But PAN% of tissues with %N higher than 4% might result in reduction of PAN% in HI possibly due to N immobil

FARMER'S SAMPLES

	Dry wt (tons/A)	Tissue N (%)	28 day PAN (%)	28 day Actual PAN (lb/A)	40 day PAN (%)	40 day Actual PAN (lb/A)
Hirayama	1.94	4.05	61.73	95.08	68.77	106.03
Bonk	1.38	4.77	62.92	90.53	71.42	93.64
Robbs	2.64	2.64	62.22	89.60	-	-

	Cover crops mix
Hirayama	Vetch, red clover, spring pea, oats
Bonk	Oil radish, vetch
Robbs	Cayuse oat, bell beans, purple vetch, Austrian winter peas

Majority of the PAN was released during the first 28 days after cover crop termination, thus **additional fertilizer should be added there after.** This is the amount of fertilizer to cut back

Reference links

- http://www.ctahr.hawaii.edu/WangKH/cover-crop.html
- http://www.ctahr.hawaii.edu/WangKH/Downloads/CRATE-Wang-HanaiAi.pdf
- http://www.ctahr.hawaii.edu/WangKH/Downloads/CCChart-Hawaii-KHWang.pdf
- http://www.ctahr.hawaii.edu/WangKH/Downloads/CRATE_CCPANCalculatorPoster.pdf
- http://www.ctahr.hawaii.edu/WangKH/Downloads/P-High-elevation-covercrops.pdf
- http://www.ctahr.hawaii.edu/sustainag/news/articles/V19-Pant-CoolSeasonCC.pdf

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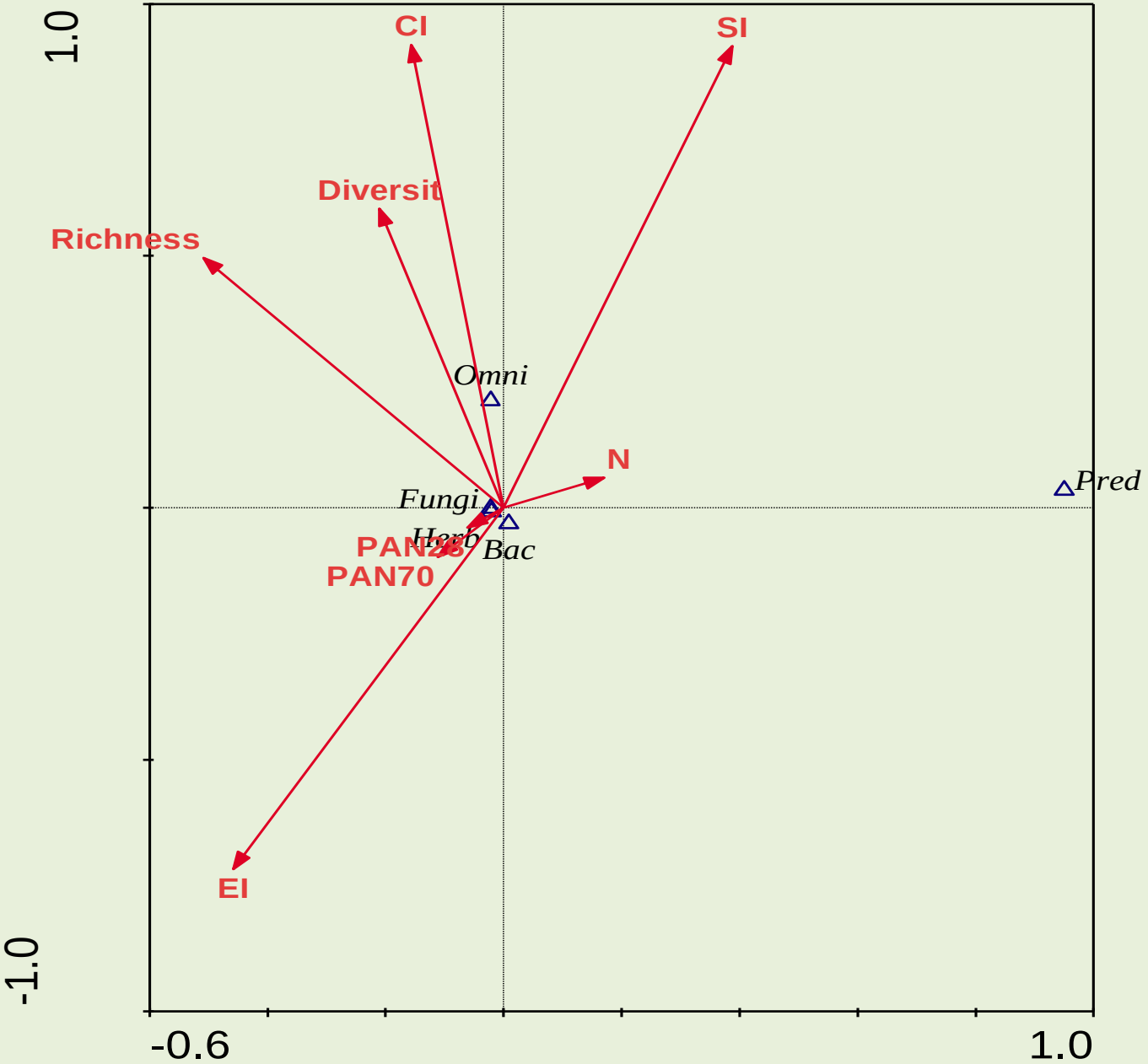
SOIL HEALTH AND PAN MINERALIZATION RATES

- 3 trials at Poamoho and 1 trial at Lalamilo.
- Soil food webs are less structured based on low abundance of omnivorous and predatory nematodes which are trophic groups higher in the soil food web hierarchy.

- PAN28 = PAN mineralization rate at 28 days after cover crop incorporation.
- PAN70 = PAN mineralization rate at 70 days after cover crop incorporation.



SOIL HEALTH AND PAN MINERALIZATION RATES

- 3 trials at Poamoho, 1 at Lalamilo, 1 at Kula.
- Soil food webs in Kula is more structured with high abundance of omnivorous and predatory nematodes (higher in the soil food web hierarchy).