COVER CROP
PLANT AVAILABLE NITROGEN (PAN) CALCULATOR for HAWAII

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Benefits of cover cropping:

Soil Health

Cover the soil at all time

Reduce soil disturbance

Grow a living root 24/7

Synergize with diversity: Crop rotation

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

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%)
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.
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 cellulosics 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**

- **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

- Detrital N, P
- Inorganic N, P
- Fungal N, P
- Bacterial N, P
- Fungal-feeding Nematode
- Bacterial-feeding Nematode
- Omnivorous and Predatory Nematode

Plant N, P
Outline

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

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.

Plant Available Nitrogen (PAN %) = \[
\frac{[\text{Soil nitrate with cover crop (mg/kg)} - \text{soil nitrate without cover crop}]}{\text{Total N added by cover crop (mg/kg)}} \times 100
\]

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

\[\% \text{ N in tissue} \times \text{cover crop biomass} = \text{Total N}\]

Actual PAN = \% N \times \text{cover crop dry biomass} \times \text{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

\[
PAN (\%) = -53.44 + 16.98 \times 10^{\frac{1}{2}} (\% \text{ N in tissue} \times 10)
\]

However, Hawaii has many micro-climates and soil types. Thus, different PAN prediction models need to be developed for different regions in Hawaii.................
% 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.html
### PAN FROM COVER CROPS IN POAMOHO, OAHU (SUMMER)

<table>
<thead>
<tr>
<th>Cover Cropping Practice</th>
<th>Season/tillage</th>
<th>Cover Crop</th>
<th>Fresh Weight (lb/ft²)</th>
<th>Dry Content (%)</th>
<th>Dry Weight (lb/Acre)</th>
<th>Tissue N (%)</th>
<th>Total N (lb/A)</th>
<th>PAN (%)</th>
<th>Actual PAN (lb/A)</th>
<th>PAN (%)</th>
<th>Actual PAN (lb/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Winter/No-till</td>
<td>Sunn hemp</td>
<td>1.07</td>
<td>24.62%</td>
<td>11475.19</td>
<td>2</td>
<td>229.50</td>
<td>56.85</td>
<td>130.47</td>
<td>66.72</td>
<td>153.12</td>
</tr>
<tr>
<td></td>
<td>Winter/No-till</td>
<td>Cowpea (Blackeye #5)</td>
<td>1.47</td>
<td>44.20%</td>
<td>9092.71</td>
<td>2</td>
<td>181.85</td>
<td>56.6</td>
<td>102.93</td>
<td>65.42</td>
<td>118.97</td>
</tr>
<tr>
<td></td>
<td>Summer/No-till</td>
<td>Sunn hemp</td>
<td>0.72</td>
<td>21.34%</td>
<td>6692.91</td>
<td>2.72</td>
<td>182.05</td>
<td>60.54</td>
<td>110.21</td>
<td>75.14</td>
<td>136.79</td>
</tr>
<tr>
<td></td>
<td>Summer/No-till</td>
<td>Cowpea</td>
<td>1.54</td>
<td>14.24%</td>
<td>9552.53</td>
<td>2.83</td>
<td>270.34</td>
<td>67.57</td>
<td>182.67</td>
<td>74.43</td>
<td>201.21</td>
</tr>
<tr>
<td></td>
<td>Summer/No-till</td>
<td>Lablab</td>
<td>0.34</td>
<td>13.31%</td>
<td>1971.26</td>
<td>3.13</td>
<td>61.70</td>
<td>78.05</td>
<td>48.16</td>
<td>81.91</td>
<td>50.54</td>
</tr>
<tr>
<td></td>
<td>Summer/No-till</td>
<td>Sudex</td>
<td>0.96</td>
<td>16.02%</td>
<td>6699.18</td>
<td>1.33</td>
<td>89.10</td>
<td>43.48</td>
<td>38.74</td>
<td>54.95</td>
<td>48.96</td>
</tr>
<tr>
<td></td>
<td>Summer/No-till</td>
<td>Oat (TAM406)</td>
<td>0.51</td>
<td>14.72%</td>
<td>3270.14</td>
<td>1.84</td>
<td>60.17</td>
<td>46.25</td>
<td>27.83</td>
<td>62.55</td>
<td>37.64</td>
</tr>
<tr>
<td></td>
<td>Summer/No-till</td>
<td>Oil Radish</td>
<td>0.55</td>
<td>6.40%</td>
<td>1533.31</td>
<td>2.49</td>
<td>38.18</td>
<td>70.8</td>
<td>27.03</td>
<td>77</td>
<td>29.40</td>
</tr>
</tbody>
</table>

- 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

<table>
<thead>
<tr>
<th>Cover Cropping Practice</th>
<th>Cover Crop Tissue</th>
<th>28 Days</th>
<th>70 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fresh Weight</td>
<td>Dry Weight</td>
<td>Tissue N (%)</td>
</tr>
<tr>
<td>Season/tillage</td>
<td>(lb/ft²)</td>
<td>(lb/Acre)</td>
<td></td>
</tr>
<tr>
<td>Winter/Till</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bell bean</td>
<td>0.78</td>
<td>3601.54</td>
<td>4.2</td>
</tr>
<tr>
<td>Austrian Winter Pea</td>
<td>0.6</td>
<td>3057.91</td>
<td>4.9</td>
</tr>
<tr>
<td>Annual ryegrass</td>
<td>0.36</td>
<td>2104.47</td>
<td>4.72</td>
</tr>
<tr>
<td>Woolypod vetch</td>
<td>0.45</td>
<td>2195.42</td>
<td>5.32</td>
</tr>
<tr>
<td>Oat (Cayuse)</td>
<td>1.15</td>
<td>8616.17</td>
<td>2.34</td>
</tr>
</tbody>
</table>

- **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: | 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?

1. Estimate cover crop dry biomass (lbs/acre)
2. Send tissue to analyze for tissue N content (%)

#### Amount of N fertilizer input that farmers can cut back

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

\[
\text{Actual PAN} = \% \text{ N} \times \text{cover crop dry biomass} \times \text{PAN\%}
\]
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.

<table>
<thead>
<tr>
<th>Location</th>
<th>Dry Weight (lb/ft(^2))</th>
<th>Dry Weight (lb/Acre)</th>
<th>Tissue N (%)</th>
<th>Total N(lb/A)</th>
<th>Actual PAN (%</th>
<th>Actual PAN (lb/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poamoho</td>
<td>0.15</td>
<td>6534</td>
<td>2</td>
<td>131</td>
<td>55.4</td>
<td>72</td>
</tr>
<tr>
<td>Walmea</td>
<td>0.15</td>
<td>6534</td>
<td>2</td>
<td>131</td>
<td>38.31</td>
<td>50</td>
</tr>
<tr>
<td>Kula</td>
<td>0.15</td>
<td>6534</td>
<td>2</td>
<td>131</td>
<td>39.342</td>
<td>51</td>
</tr>
<tr>
<td>Hoolehua</td>
<td>0.15</td>
<td>6534</td>
<td>2</td>
<td>131</td>
<td>30.179</td>
<td>39</td>
</tr>
</tbody>
</table>

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

\[ Y = 23.79 + 7.26X \]
\[ R^2 = 0.54 \]
\[ P<0.001 \]

\[ Y = 36.97 + 5.9X \]
\[ R^2 = 0.502 \]
\[ P<0.001 \]

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

\[ y = 10.8x + 45.1 \]
\[ R^2 = 0.73 \]

\[ y = 14.9x + 25.6 \]
\[ R^2 = 0.76 \]
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 immobilization.
## FARMER’S SAMPLES

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

### Cover crops mix

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hirayama</td>
<td>Vetch, red clover, spring pea, oats</td>
</tr>
<tr>
<td>Bonk</td>
<td>Oil radish, vetch</td>
</tr>
<tr>
<td>Robbs</td>
<td>Cayuse oat, bell beans, purple vetch, Austrian winter peas</td>
</tr>
</tbody>
</table>

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.
ACKNOWLEDGEMENT

- Donna Meyer, Gareth Nagai, Noelle Lee, Jon Kam, Kaori Suda, Caio Sausa, Bryan Januar
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- J. McHugh, Pioneer; A. Archinas, Monsanto; Hirayama, Bonk, C. Robb.

Reference links

- [http://www.ctahr.hawaii.edu/WangKH/cover-crop.html](http://www.ctahr.hawaii.edu/WangKH/cover-crop.html)
- [http://www.ctahr.hawaii.edu/WangKH/Downloads/P-High-elevation-covercrops.pdf](http://www.ctahr.hawaii.edu/WangKH/Downloads/P-High-elevation-covercrops.pdf)

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