Fertility requirements for peas and alternative crops

Rich Koenig, Extension Soil Fertility Specialist
Topics

• 2005 pea fertility study results
• General information on fertilizing legumes
  ▪ Generally, minimal fertility requirements
• Liming studies - winter wheat
• Hard wheat N fertility
2005 green pea fertility trial soil test results (1 foot depth)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Average of 4 samples</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil pH</td>
<td>5.5</td>
<td>Borderline for peas (&gt;5.5)</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>22 ppm</td>
<td>Adequate for peas (&gt;12)</td>
</tr>
<tr>
<td>Potassium</td>
<td>360 ppm</td>
<td>Adequate for peas (&gt;75)</td>
</tr>
<tr>
<td>Sulfur</td>
<td>3 ppm</td>
<td>Very low for peas (&gt;10)</td>
</tr>
<tr>
<td>Zinc</td>
<td>1.7 ppm</td>
<td>Adequate for peas (&gt;0.8)</td>
</tr>
<tr>
<td>Boron</td>
<td>0.18 ppm</td>
<td>Very low for peas (&gt;0.5)</td>
</tr>
<tr>
<td>Iron</td>
<td>49 ppm</td>
<td>Adequate for peas (&gt;5)</td>
</tr>
<tr>
<td>Manganese</td>
<td>27 ppm</td>
<td>Adequate for peas (&gt;1)</td>
</tr>
<tr>
<td>Copper</td>
<td>1.5 ppm</td>
<td>Adequate for peas (&gt;0.2)</td>
</tr>
</tbody>
</table>
2005 green pea yields

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (lb/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfertilized</td>
<td>2230</td>
</tr>
<tr>
<td>11-52-0</td>
<td>2561</td>
</tr>
<tr>
<td>11-37-0+2 lb Zinc</td>
<td>2561</td>
</tr>
<tr>
<td>11-37-0</td>
<td>2579</td>
</tr>
<tr>
<td>11-37-0+0.25 lb boron</td>
<td>2718</td>
</tr>
<tr>
<td>16-20-0-13S</td>
<td>2788</td>
</tr>
</tbody>
</table>

Fertilizer banded 2 inches below seed

Treatment (20 lbP2O5/ac)
Dry pea, lentil and chickpea fertility

• University of Idaho guides
  ▪ http://www.uidaho.edu/wq/wqfert/wqfertls.html
• Authored by R. Mahler
• Emphasize
  ▪ Inoculation for fields without a history of legume for last 5 years, or pH below 5.7
    • Inoculum for peas/lentils is different than for chickpeas
  ▪ Soil test for phosphorus, sulfur, zinc and boron
  ▪ Molybdenum when pH < 5.7 (seed treatment)
Fertilizer placement for legumes

• No nitrogen, potassium or sulfur with the seed (too soluble)
• Small amounts of phosphorus (<10 lb P$_2$O$_5$/ac) with the seed are okay
• Ideal placement is below or below and beside the seed
Rooting patterns and starter and deep band fertilizer placements

Wheat

Legumes

Secondary root system

Primary root systems
Soil pH issues

- Native prairie soil pH was 6.5 to 7.2
- 1984 survey conducted by R. Mahler at University of Idaho found >45% of soils in N. Idaho have pH below 5.6
- Critical pHs
  - Pea: 5.5
  - Lentil: 5.6
  - Chickpea: ?? (likely in the same range as peas/lentils)
  - Wheat: 5.1
- Issues: nutrient availability, toxicity, disease interactions, herbicide persistence
Long term liming studies

• Milton-Freewater
  ▪ Initiated in 2005
  ▪ Lime rates of 0, 2000, 4000, 10000 lb/acre
  ▪ Sulfur rate of 2000 lb/ac
  ▪ Wheat-pea rotation
  ▪ Established on pea side in spring 2005 (site A); wheat side in fall 2005 (Site B)
  ▪ 2005 pea crop yield; 2006 pea and wheat crop yields

• Dayton
  ▪ Initiated in spring 2006 on established winter wheat
Initial soil pH, 0 to 6-inch depth

- MF - Site A: 5.60
- MF - Site B: 4.90
- Dayton: 4.76
Soil pH distribution with depth in a long term (20+ year) direct seeded field near Dayton, WA.
2006 winter wheat yields - MF

No significant difference

Yield (bushels/ac)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (bushels/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 lime</td>
<td>65.6</td>
</tr>
<tr>
<td>2000 lime</td>
<td>70.2</td>
</tr>
<tr>
<td>4000 lime</td>
<td>67.4</td>
</tr>
<tr>
<td>10000 lime</td>
<td>67.9</td>
</tr>
<tr>
<td>2000 sulfur</td>
<td>65.8</td>
</tr>
</tbody>
</table>
2006 winter wheat yields - Dayton

Yield (bushels/ac)

Treatment (lb lime or sulfur/acre)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 lime</td>
<td>104</td>
</tr>
<tr>
<td>2000 lime</td>
<td>102</td>
</tr>
<tr>
<td>4000 lime</td>
<td>102</td>
</tr>
<tr>
<td>10000 lime</td>
<td>103</td>
</tr>
<tr>
<td>2000 sulfur</td>
<td>105</td>
</tr>
</tbody>
</table>

No significant difference
Hard Wheat Nitrogen Fertility

Research funded by the Washington Wheat Commission
Information

• Protein management (on the web)
  ▪ Nitrogen management for hard wheat protein enhancement – PNW 578

• Fertilizer guides (on the web)
  ▪ Dryland winter wheat – EB 1987 from WA State University
  ▪ Other guides from Oregon and Idaho

• WSU Variety testing program (variety.wsu.edu)

• Fertilizer “briefs” from the Washington Wheat Commission
Data from WSU Variety Testing Program
Average performance of HRSW (2002-05)

<table>
<thead>
<tr>
<th>Rainfall zone</th>
<th>Yield (bu/ac)</th>
<th>Protein (%)</th>
<th>Applied N (lb/acre)</th>
<th>Soil+fert N (lb/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 16”</td>
<td>37</td>
<td>15.4</td>
<td>92</td>
<td>218</td>
</tr>
<tr>
<td>16 to 20”</td>
<td>55</td>
<td>14.5</td>
<td>121</td>
<td>218</td>
</tr>
<tr>
<td>Above 20”</td>
<td>76</td>
<td>13.5</td>
<td>146</td>
<td>281</td>
</tr>
</tbody>
</table>
Wheat 101: Yield and protein responses to nitrogen

- Nitrogen (N) availability
  - Low
  - Moderate
  - Adequate
  - Excessive

- Grain yield
- Grain protein

Yield and protein vs. Nitrogen (N) availability
Hard red winter wheat – Pullman

Variety: Falcon

+132 lb N/acre soil contribution
2006 Spring Wheat Data

Site near Colfax, WA; 50 lb/acre 16-20-0 starter placed with the seed; 105 lb N/ac soil contributions
# Louise Soft White Near Colfax

<table>
<thead>
<tr>
<th>Wheat price ($/bushel)</th>
<th>3.00</th>
<th>3.25</th>
<th>3.50</th>
<th>3.75</th>
<th>4.00</th>
<th>4.25</th>
<th>4.50</th>
<th>4.75</th>
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</thead>
<tbody>
<tr>
<td>$/lb N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.20</td>
<td>109</td>
<td>110</td>
<td>114</td>
<td>117</td>
<td>117</td>
<td>120</td>
<td>120</td>
<td>122</td>
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<tr>
<td>0.25</td>
<td>101</td>
<td>102</td>
<td>106</td>
<td>110</td>
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<td>114</td>
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<td>96</td>
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<td>103</td>
<td>106</td>
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<tr>
<td>0.40</td>
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<td>89</td>
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<td>100</td>
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<tr>
<td>0.45</td>
<td>66</td>
<td>71</td>
<td>77</td>
<td>82</td>
<td>85</td>
<td>89</td>
<td>91</td>
<td>95</td>
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<tr>
<td>0.50</td>
<td>58</td>
<td>63</td>
<td>70</td>
<td>76</td>
<td>79</td>
<td>83</td>
<td>85</td>
<td>89</td>
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### Tara 2002 Hard Red Near Colfax

<table>
<thead>
<tr>
<th>Wheat price ($/bushel)</th>
<th>4.25</th>
<th>4.50</th>
<th>4.75</th>
<th>5.00</th>
<th>5.25</th>
<th>5.50</th>
<th>5.75</th>
<th>6.00</th>
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<tbody>
<tr>
<td>$/lb N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>0.25</td>
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<td>132</td>
<td>134</td>
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<td>134</td>
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<tr>
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<td>130</td>
<td>131</td>
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<td>132</td>
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<td>0.35</td>
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<td>129</td>
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<td>131</td>
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<tr>
<td>0.40</td>
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<td>120</td>
<td>121</td>
<td>122</td>
<td>123</td>
<td>124</td>
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</tbody>
</table>
2006 Spring Wheat Data

Site near Colfax, WA; 50 lb/acre 16-20-0 starter placed with the seed; 105 lb N/ac soil contributions
# Unit N Supply Analysis

<table>
<thead>
<tr>
<th>Tara 2002</th>
<th>Ib fertilizer N/bushel</th>
<th>Ib soil+fertilizer N/bushel</th>
<th>Standard Ib N supply/bushel</th>
</tr>
</thead>
<tbody>
<tr>
<td>114 lb fert N/ac</td>
<td>1.53</td>
<td>2.94</td>
<td></td>
</tr>
<tr>
<td>138 lb fert N/ac</td>
<td>1.80</td>
<td>3.17</td>
<td></td>
</tr>
<tr>
<td>155 lb fert N/ac*</td>
<td>2.01</td>
<td>3.68</td>
<td>3.6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Louise</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>58 lb fert N/ac</td>
<td>0.82</td>
<td>2.30</td>
<td>2.7</td>
</tr>
<tr>
<td>122 lb fert N/ac</td>
<td>1.58</td>
<td>2.95</td>
<td></td>
</tr>
</tbody>
</table>

*required to obtain 14% protein
The amount of available N is critical

- With soft white wheat the penalty for under-fertilization is lower yield
- With hard wheat the penalty is lower yield and, in some years, significant discounts for low grain protein
- **Protein targets for hard wheats occur at or slightly above the point of maximum yield**
- **For this reason, the ability to accurately predict yield at the time of fertilizer application seriously limits your ability to achieve protein goals**
Hard red winter wheat – Pullman

Variety: Falcon

Fertilizer N rate (lb/acre)

Yield (bu/ac)

Protein (%)

+132 lb N/ac soil contribution
Hard red spring wheat – Colfax

Was it economical to fertilize for 14%?

Variety: Tara 2002

+113 lb N/ac soil contribution
It’s not the N applied but the total N supply

• The total amount of N available to wheat is the most important factor in achieving yield and protein goals, not the N fertilizer rate
• Soil N contributions must be accounted for before determining how much fertilizer N is needed
Fertilizer nitrogen response
Hard red winter wheat – Pullman

Variety: Falcon

1.6 lb fertilizer N/bu

Yield (bu/ac)

Protein (%)

Fertilizer N rate (lb/acre)

+132 lb N/ac soil contribution
Total nitrogen supply response
Hard red winter wheat – Pullman

3 lb soil+fertilizer N/bu

Yield (bu/ac)

Protein (%)

Soil + Fertilizer N supply (lb/acre)

Variety: Falcon

132 lb N/ac soil contribution
Average nitrogen supply requirements

- Unit N supply requirement for different market classes
  - Soft white winter and spring: 2.7 lb N/bushel (range: 1.8 to 3.9)
  - Hard red winter: 3.0 lb N/bushel (range?)
  - Hard red spring: 3.6 lb N/bushel (~2 to >5)
  - Hard white winter/spring: 3.2 lb N/bushel (range?)
2005-06 hard red winter N timing studies

Yield (bu/acre)

<table>
<thead>
<tr>
<th>Location</th>
<th>All fall full</th>
<th>All fall 1/2</th>
<th>Fall-spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty (100)</td>
<td>50</td>
<td>32</td>
<td>47</td>
</tr>
<tr>
<td>Davenport (100)</td>
<td>79</td>
<td>70</td>
<td>75</td>
</tr>
<tr>
<td>Johnson (80)</td>
<td>98</td>
<td>86</td>
<td>95</td>
</tr>
</tbody>
</table>

Location (full nitrogen rate)

Spring-applied nitrogen in 3rd week in March, 2006
2005-06 hard red winter N timing studies

Grain protein (%)

<table>
<thead>
<tr>
<th>Location</th>
<th>All fall full</th>
<th>All fall 1/2</th>
<th>Fall-spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty (100)</td>
<td>14</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Davenport (100)</td>
<td>13</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>Johnson (80)</td>
<td>12</td>
<td>12</td>
<td>11</td>
</tr>
</tbody>
</table>

Spring-applied nitrogen in 3rd week in March, 2006
Hard red spring split vs. all spring

Yield (bu/acre)

<table>
<thead>
<tr>
<th>Location</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wilke</td>
<td>40</td>
</tr>
<tr>
<td>Fall-spring</td>
<td>39</td>
</tr>
<tr>
<td>Mockonema</td>
<td>70</td>
</tr>
<tr>
<td>All spring</td>
<td>68</td>
</tr>
<tr>
<td>Fall-spring</td>
<td>69</td>
</tr>
</tbody>
</table>

100 lb N/acre with 50-50 split (Wilke); 140 lb N/ac with 80-60 split (Mockonema)
2006 spring wheat (Davenport) - fall applied 50 lb N/ac

Fall 2005 sampling
April 2006 sampling of 50 lb N/ac applied 9/05
Hard red spring split vs. all spring

Grain protein (%)

Location

100 lb N/acre with 50-50 split (Wilke); 140 lb N/ac with 80-60 split (Mockonema)
Fall fertilizing for spring wheat

- Highly dependent on residual soil N, its distribution in the profile, the rainfall zone and weather
  - If there is already substantial residual N in the profile then there is no need to fall apply N for hard spring wheat
  - Fall applied N may not be necessary in years when late spring moisture leads to active rooting and good utilization of spring-applied N by spring wheat
- Fall timing important
  - Early fall (low rainfall) → late fall (high rainfall)
Foliar N for increasing grain protein?
2005 data for Tara 2002 at St. John

Graph showing the relationship between fertilizer and soil N supply (lb/acre) and yield (bu/ac) and protein (%). The graph includes three data sets:
- Tara yield
- Tara protein + foliar
- Tara protein

20 lb N/ac as foliar urea applied post-anthesis
Foliar N for increasing grain protein?
2005 data for Tara 2002 at St. John

+1.31% protein = 4.4 lb N/ac from foliar

20 lb N/ac as foliar urea applied post-anthesis
2006 hard red spring (Hank) response to foliar N

=3 lb N/ac absorbed from foliar (15% efficient)

Grain protein (%)
(Average yield = 69 bu/acre)

Kamiak

No foliar
Foliar

20 lb N/ac as foliar urea applied post-anthesis
Considerations with hard wheat

• Higher risk crop in high rainfall zones
  ▪ Greater $ investment in nitrogen
  ▪ Possibly lower yields than soft white wheat
  ▪ Protein more difficult to achieve
    • Premiums and discounts are an issue
    • Fertilize at planting or in crop year but you don’t know what premiums and discounts are until harvest

• Greater potential return in high rainfall zones due to higher yield

• Should you grow it?
Economic considerations

• January 22, 2007 prices
  ▪ Common soft white ~$4.50/bu
  ▪ Hard red winter ~$5.15/bu ($0.03 per ½ down protein discount; no premium)

• Hard red winter wheat requires ~10% (0.3 lb/bushel) more nitrogen than soft white winter
  ▪ ~$0.15/bu higher cost
  ▪ But, many hard red varieties yield 5+ bushels lower than soft whites (see variety.wsu.edu)
Economic considerations

- January 22, 2007 prices
  - Common soft white ~$4.50/bu
  - Hard red spring ~$5.30/bu ($0.01 per ¼ down protein discount; no premium)
- Hard red spring requires ~30% more nitrogen than soft white spring
  - ~$0.45/bu higher cost
  - But, many soft white springs yield the same as hard red springs (see variety.wsu.edu)
# Soft white winter wheat unit N supply

*Data from T. Fiez (1994)*

<table>
<thead>
<tr>
<th>Site-year</th>
<th>Footslope</th>
<th>S. Backslope</th>
<th>Shoulder</th>
<th>N. Backslope</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmington-1990</td>
<td>2.5 lb N/bu</td>
<td>1.8 lb N/bu</td>
<td>2.2 lb N/bu</td>
<td>2.1 lb N/bu</td>
<td><strong>2.1 lb N/bu</strong></td>
</tr>
<tr>
<td>Pullman-1990</td>
<td>3.3 lb N/bu</td>
<td>2.3 lb N/bu</td>
<td>2.7 lb N/bu</td>
<td>2.3 lb N/bu</td>
<td><strong>2.6 lb N/bu</strong></td>
</tr>
<tr>
<td>Farmington-1991</td>
<td>3.6 lb N/bu</td>
<td>3.3 lb N/bu</td>
<td>3.0 lb N/bu</td>
<td>2.9 lb N/bu</td>
<td><strong>3.2 lb N/bu</strong></td>
</tr>
<tr>
<td>Pullman-1991</td>
<td>3.1 lb N/bu</td>
<td>2.3 lb N/bu</td>
<td>3.9 lb N/bu</td>
<td>3.4 lb N/bu</td>
<td><strong>3.2 lb N/bu</strong></td>
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<tr>
<td>Mean</td>
<td><strong>3.1 lb N/bu</strong></td>
<td><strong>2.4 lb N/bu</strong></td>
<td><strong>3.0 lb N/bu</strong></td>
<td><strong>2.7 lb N/bu</strong></td>
<td><strong>2.8 lb N/bu</strong></td>
</tr>
</tbody>
</table>
Tools: sampling

• Soil
  ▪ Fall
    • Moisture
    • Preplant for winter wheat
    • Pre-fall fertilization for spring wheat
  ▪ Spring
    • Moisture
    • Over-winter N movement in winter wheat
    • Preplant for spring wheat

• Tissue or leaf sampling
Flag leaf N and grain protein relationship in spring wheat at head emergence.

The graph shows a positive correlation between flag leaf N (%) and grain protein (%). The coefficient of determination ($R^2$) is 0.68.
Flag leaf N and grain protein relationship in spring wheat at flowering

$R^2 = 0.48$