FERTILIZER RATE CALCULATIONS

Extension Agent Agronomy College
September 24, 2014

Clain Jones
clainj@montana.edu 994-6076

Objectives

- To understand basic concept of yield response curves
- To take a soil test result and turn it into a fertilizer recommendation using published rate tables and online tools

Nutrient balance

Liebig-Sprengel Law of the Minimum

Growth is limited by the limiting factor

Proper balance leads to

- Optimal production
- Best use of fertilizer $
- Protection of water and air

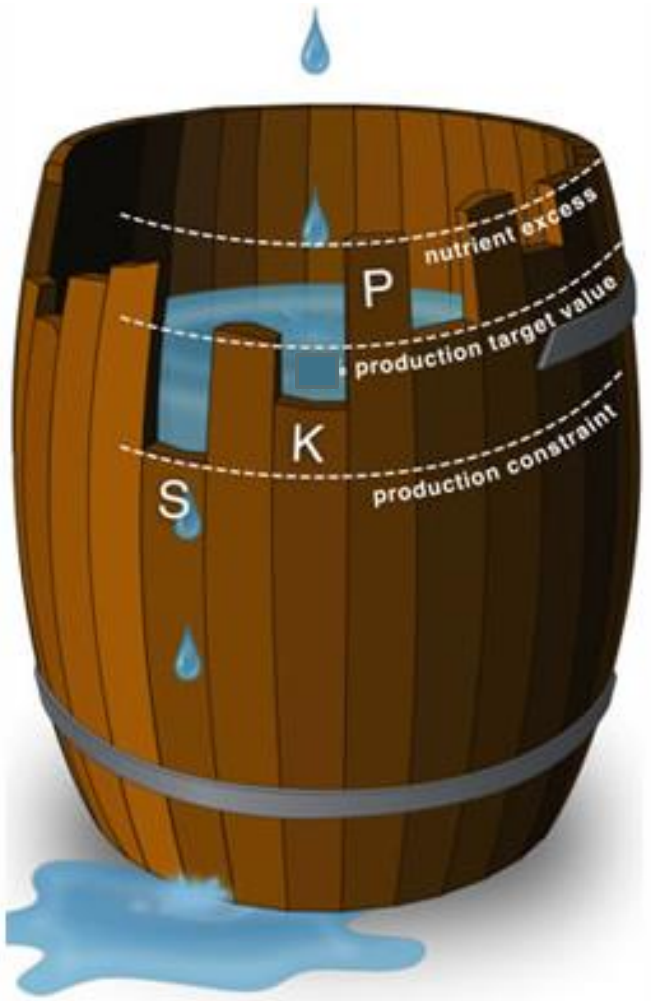
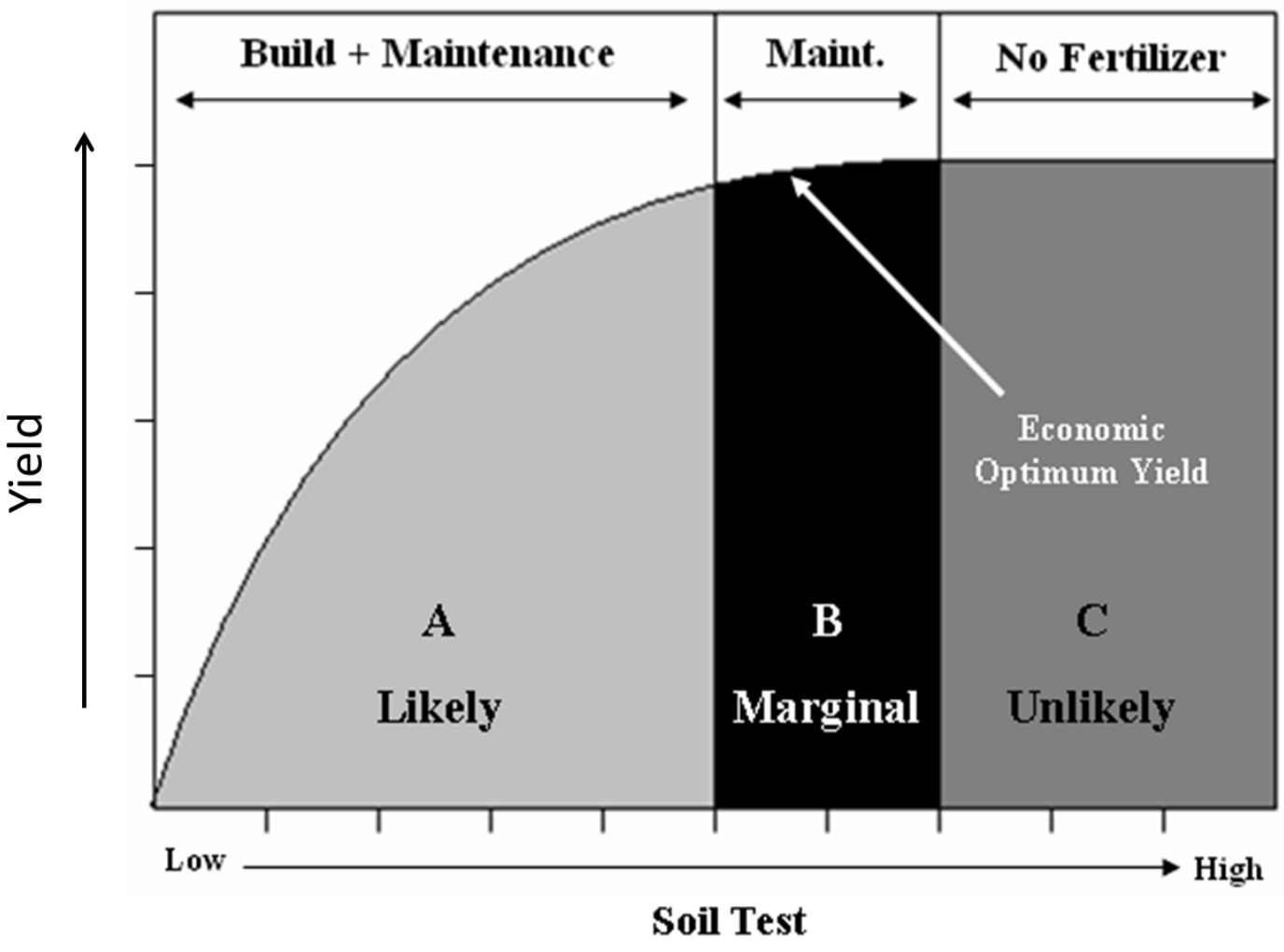


Illustration courtesy Government of Western Australia Dept. of Agriculture and Food

Soil test indicates probability of response



Toxic levels can reduce yield, nutrient can be lost to water or air

Very high

Limiting soil nutrient levels

Nutrient	Limiting level in top 6 inches (ppm)
N	Crop and yield goal dependent
P	16
K	250
S	Not available –tissue testing better
B	1.0
Cl	30 lb/ac in top 2 feet
Cu	0.5
Fe	5.0
Mn	1.0
Zn	0.5

Table 1. *Interpretation of Soil Test Reports for Agriculture* (MT200702AG)

Fertilizer guidelines

- Guidelines for N, P, K and 5 micro-nutrients for production of most MT crops are provided in *Fertilizer Guidelines for Montana Crops* (EB0161).
- They are based on soil analysis – discussed earlier. See *Soil Sampling and Laboratory Selection* (MT4449-1), *Soil Sampling Strategies* (MT200803AG). There is not a good soil test for S.

FINALLY!!!!

How do I determine N fertilizer amount?

Basic steps for all crops

1. Determine yield potential
2. Determine available soil nutrient level – soil test
3. Look up suggested nutrient guidelines for given crop and yield in *Fertilizer Guidelines for MT Crops* or crop specific bulletins (e.g. pulse, forage)
4. Calculate difference between what is available and what is needed to get fertilizer recommendation

Yield potential

How determine?

- Average yield from past records, can be adjusted for soil moisture in late March, early April
- Average yield x 1.05 (optimistic or realistic?)

Example N calculation

Producer has the following soil test report:

- Wants to grow malt barley
- Wheat yield goal 50 bu/ac
- S wheat yield goal = 0.70 x 50 = 35 bu/ac
- Barley yield goal 50 bu/ac

Look up N guidelines in *Fertilizer Guidelines for MT Crops*

- Barley feed ≈ 80 lb N/ac
- Barley malt ≈ 66 lb N/ac
- W wheat ≈ 130 lb N/ac
- S wheat ≈ 115 lb N/ac

Table 2. Feed and malt barley N guidelines based on soil analysis.

BARLEY - FEED	
Yield Potential (bu/a) *	Available N (lbs/a) **
40	64
60	96
80	128
100	160
120	192
140	224

BARLEY - MALT	
Yield Potential (bu/a) *	Available N (lbs/a) **
60	72
70	84
80	96
90	108
100	120
110	132
120	144

Table 17. Spring and winter wheat N guidelines based on soil analysis.

WHEAT- SPRING***	
Yield Potential (bu/a) *	Available N (lbs/a) **
30	99
40	132
50	165
60	198
70	231
80	264
90	297
100	330

WHEAT- WINTER	
Yield Potential (bu/a)*	Available N (lbs/a) **
30	78
40	104
50	130
60	156
70	182
80	208
90	234

Date Sampled	Date Received **08/28/2014**	Date Reported **8/28/2014**

Nutrient In The Soil		Interpretation			
		VLow	Low	Med	High
Nitrate	0-6" 24 lb/ac 6-24" 61 lb/ac 24-42" 63 lb/ac 0-24" 85 lb/ac total 148 lb/ac	********			
Phosphorus	Olsen 4 ppm	******			
Potassium	368 ppm	******	******	******	******
Chloride	0-24" 20 lb/ac	********			
Sulfur	0-6" 14 lb/ac 6-24" 36 lb/ac	******** ********	******** ********	**********	
Boron					
Zinc					
Iron					
Manganese					
Copper	0.5 ppm	********	********		
Magnesium					
Calcium					
Sodium					
Org.Matter	2.3 %	**********			
Carbonate(CCE)					
Sol. Salts	0-6" 0.36 mmho/cm 6-24" 0.35 mmho/cm	******** ********	******** ********		

1st Crop Choice		
Wheat-High Pro.		
YIELD GOAL		
50 Bu		
SUGGESTED GUIDELINES		
Band		
LB/ACRE		APPLICATION
N	111	30
P_2O_5	36	Band *
K_2O	10	Band (Starter)*
Cl	20	Broadcast
S	9	Band (Trial)
B		
Zn		
Fe		
Mn		
Cu	2	Band
Mg		
Lime		

2nd Crop Choice		
Wheat-High Pro.		
YIELD GOAL		
60 Bu		
SUGGESTED GUIDELINES		
Band		
LB/ACRE		APPLICATION
N	141	80
P_2O_5	43	Band *
K_2O	10	Band (Starter)*
Cl	20	Broadcast
S	9	Band (Trial)
B		
Zn		
Fe		
Mn		
Cu	2	Band
Mg		
Lime		

3rd Crop Choice		
Barley-Malting		
YIELD GOAL		
70 BU		
SUGGESTED GUIDELINES		
Band		
LB/ACRE		APPLICATION
N	45	Customized
P_2O_5	35	Band *
K_2O	10	Band (Starter)*
Cl	20	Broadcast
S	9	Band (Trial)
B		
Zn		
Fe		
Mn		
Cu	2	Band
Mg		
Lime		

Soil pH	Buffer pH	Cation Exchange Capacity	% Base Saturation (Typical Range)				
			% Ca	% Mg	% K	% Na	% H
0-6" **8.1** 6-24" **8.4**							

What do you suggest and why?

What soil N value should you use?

24, 61, 63, 85, 148

Why?

MT Guidelines are based on N in top 2 feet

Fertilizer N = Suggested N – soil test N

- Barley feed = 80 – 85 = -5 lb N/ac fertilizer
- Barley malt = 66 – 85 = -19 lb N/ac
- W wheat = 130 – 85 = 45 lb N/ac
- S wheat = 115 – 85 = 30 lb N/ac

Is malt barley the best choice?

If 46 lbs per acre of N needed, how much urea (46-0-0) is needed?

The 46-0-0 means this fertilizer is 46% N, 0% P_2O_5, and 0% K_2O. So the fraction of N in urea is 0.46 (46/100).

$$\text{N fertilizer} = \frac{(46 \text{ lbs/acre})}{0.46}$$

$$= \textbf{100 lbs urea/acre}$$

N rate adjustments

- Stubble: small grains stubble is high in carbon to N (C:N). Adjust fertilizer N up or down?

  10 lb N/1000 lb stubble up to 40 lb N

- Fallow: assume ½ of stubble has decomposed over previous year when adjusting

- After legume rotation:

  Adjust fert up or down?

  Legumes credit (add) N

Crop	N credit (lb N/acre)
Alfalfa	40
Annual legume 1 x	~10
Annual legume >3 x	~20

N rate adjustments (cont)

- SOM
  - <1% SOM, add 15-20 lb N/acre
  - >3% SOM, reduce 15-20 lb N/acre
- Tillage – No-till may require extra N for 6 to 15 years

N rate adjustments for remaining stubble

Continuous winter wheat

Stubble Weight = Grain Weight (lb grain/ac) x Stubble/Grain Ratio (lb stubble/lb grain)

= 3000 lb grain/ac x 1.67 lb stubble/lb grain

= **5000 lb stubble/ac**

Stubble Remaining = Stubble Weight (lb stubble/ac) - Stubble Removed (lb stubble/ac)

= 5000 lb/acre – 2000 lb/acre

= **3000 lb/acre**

Nitrogen adjustment for Stubble Remaining = 10 lb N/1000 lb Stubble x Stubble Remaining (lb/ac) (add this to N rate, up to 40 lb N/ac)

= 0.01 lb N/lb x 3000 lb/ac

= **30 lb N/ac**

These examples are in *Developing Fertilizer Recommendations for Ag*

N adjustments for remaining stubble: Fallow-barley

Stubble Weight = Grain Weight (lb grain/ac) x Stubble/Grain Ratio (lb stubble/lb grain)

= 4800 lb grain/ac x 1.13 lb stubble/lb grain

= _____ **lb stubble/ac**

Stubble Remaining = Stubble Weight (lb stubble/ac) - Stubble Removed (lb stubble/ac)

= _____lb/acre – 2000 lb/acre

= _____ **lb/acre**

Nitrogen adjustment for Stubble Remaining = 10 lb N/1000 lb Stubble x Stubble Remaining (lb/ac) (add this to N rate, up to 40 lb N/ac)

= 0.01 lb N/lb x _____lb/ac

= _____ **lb N/ac**

Nitrogen Adjustment for Stubble Decomposition in Crop-Fallow Systems = 0.5 x Nitrogen adjustment for stubble remaining (lb N/ac)

= 0.5 x _____lb N/ac = _____ **lb N/ac**

N adjustments for remaining stubble: Fallow-barley

Stubble Weight = Grain Weight (lb grain/ac) x Stubble/Grain Ratio (lb stubble/lb grain)

= 4800 lb grain/ac x 1.13 lb stubble/lb grain

= **5424 lb stubble/ac**

Stubble Remaining = Stubble Weight (lb stubble/ac) - Stubble Removed (lb stubble/ac)

= 5424 lb/acre – 2000 lb/acre

= **3424 lb/acre**

Nitrogen adjustment for Stubble Remaining = 10 lb N/1000 lb Stubble x Stubble Remaining (lb/ac) (add this to N rate, up to 40 lb N/ac)

= 0.01 lb N/lb x 3424 lb/ac

= **34.24 lb N/ac**

Nitrogen Adjustment for Stubble Decomposition in Crop-Fallow Systems = 0.5 x Nitrogen adjustment for stubble remaining (lb N/ac)

= 0.5 x 34.24 lb N/ac = **17.12 lb N/ac**

Optimize fertilizer N rate

Danger of aggressive N fertilization?

- Hot dry season, low protein discounts, lower net returns, and higher leaching/volatilization N losses.
- In wet year if all N is applied early can lead to excess tiller production and decreased yields.
- Risk of high forage nitrates

Strategy to avoid this possibility?

- Use a conservative pre-plant N rate
- Apply a 2nd application if needed – will discuss split applications in 'Timing' section

Questions on N rate calculations?

P fertilizer calculations

Table 18 (subset). P fertilizer guidelines based on soil analysis (EB0161)

Crop	Olsen P soil test level (ppm)				
	0	4	8	12	16*
	P fertilizer rate (lb P_2O_5 /acre)				
Alfalfa	140	110	75	40	*20*
Barley	50	40	30	20	10
Grass	45	35	30	20	5
Lentil, pea	35	30	25	20	15
Wheat - Spring	50	45	35	30	20
Wheat - Winter	55	50	45	40	35

* With P>16 ppm consider using crop removal rates (EB0161 Table 21) as P fertilization guideline. P guideline for alfalfa at 16 ppm (0 lb) is likely an error in EB0161.

<u>Example</u>

Winter wheat, Olsen P = 10 ppm

P_2O_5 needed = **42.5 lb/ac**

Rates based on different approaches

Example banded P fertilizer recommendations using different approaches.		
WWheat grain yield potential = 60 bu/acre Producer leaves straw on field Critical test level for P is approximately 16-18 ppm for all crops		
	Recommended P rate (lb P_2O_5/acre)	
	Olsen P 4 ppm	Olsen P 20 ppm
Sufficiency approach[1.]	50	0
Maintenance approach[2.] = crop removal	Your turn	
Build approach = sufficiency + maintenance		
[1.] Table 18 in Fertilizer Guidelines for Montana Crops [2.] Table 21 in Fertilizer Guidelines for Montana Crops		

To calculate ‘maintenance or build’ rates, need crop removal rates

- Table 21 in EB0161
- IPNI nutrient removal calculator: crop nutrient removal estimates for a broad, and continually expanding, list of field crops http://ipni.info/calculator

Rates based on different approaches

Example banded P fertilizer recommendations using different approaches.		
WWheat grain yield potential = 60 bu/acre Expected straw removal = 1.5 ton/acre Critical test level for P is approximately 16-18 ppm for all crops		
	Recommended P rate (lb P_2O_5/acre)	
	Olsen P 4 ppm	Olsen P 20 ppm
1. Sufficiency approach	50	0
2. Maintenance approach = crop removal	60 bu x 0.62 lb P_2O_5/bu = 37	
Build approach = 1+2	87	

- Why might you recommend a maintenance approach?
- Why would you recommend a build approach?

How much MAP (11-52-0) do you need to get 43 lb P_2O_5/ac?

The 52 means MAP is 52% P_2O_5 so fraction is 0.52

$$\text{MAP} = \frac{43 \text{ lb } P_2O_5/\text{ac}}{0.52}$$

MAP needed = **85 lb/ac**

Potassium

Table 19. K fertilizer guidelines based on soil analysis (EB0161)

crop	K soil test level (ppm)					
	0	50	100	150	200	250*
	K fertilizer rate (lb K_2O /acre)					
Alfalfa	240	205	170	140	95	30
Barley – malt	90	80	65	50	35	25
Grass	80	70	60	45	30	15
Lentil, pea	45	40	35	30	25	20
Wheat	135	115	90	70	40	10

* With K>250 ppm consider using crop removal rates as K fertilization guideline

Example

Malt barley, K = 100 ppm, K_2O needed = **??? lb/ac**

MSU Soil fertility recommendations

http://www.sarc.montana.edu/php/soiltest/

Submit Clear form

1. Topsoil sample results:			*2. Soil Nitrate Results:*				
Olsen P	6	ppm	Sample #	top	bottom	Soil test value	
Extractable K	50	ppm	1	0	6	60	ppm
Soil Organic Matter	1.5	%	2	6	12	65	
			3	0	0	0	
			4	0	0	0	

3. Crop Management:		
Last year's crop: sugarbeet	New Crop barley-malt	Yield goal of 80 bu/acre

Submit

S fertilization

- Tissue sampling more reliable than soil test. < 0.20 to 0.25% S in uppermost leaves before heading, may limit yield and protein.
- May be needed if plants appear N deficient, necessary for N utilization
- In-season rescue treatment of 20-30 lb S/acre as sulfate can help

Questions so far?

Optimize fertilizer N rate based on economics

How?

- Use a conservative pre-plant N rate based on:
  - spring soil sample
  - realistic yield potential
  - economic rate calculator

http://landresources.montana.edu/soilfertility/small%20grains%20economic%20calculator.html

- Apply a 2nd application if needed – based on adjusted yield potential, consider using in-season sensor-based technology

MONTANA STATE UNIVERSITY EXTENSION

Economic Analysis of Fertilizer Application Rates for Winter Wheat in Montana.

- Steps to Use Program
- Introduction
- Step 1 - Yields
- Step 2 - Protein
- Step 3 - Net Revenue
- Step 4 - Revenue vs Yield

Authors:

Clain Jones
Montana State University Extension
406-994-6076
clainj@montana.edu

Duane Griffith
Montana State University Extension
406-994-2580
griffith@montana.edu

The F11 key will toggle (switch on and off) the screen space from normal to maximum viewable area.

Questions?

Considerations when fertilizing with manure

Easy to over apply N, P, and K

- Rapid excess buildup of P and K if fertilizing to meet N needs
- Of 67 Midwest gardens 92% had excess P and 88% excess K after just 1 - 6 years of ‘uninformed’ fertilization with composted dairy manure

  (Hansen unpub data, Ohio State Univ)
- Feed to P and K demands
- Use legumes or source such as blood meal to supply N

Approximately how much total N, P, and K does 1” of manure compost supply?

	N	P_2O_5	K_2O
	lbs/1000 sq. ft.		
Removed annually by vegetables	3.4	0.3	3.2
Added by 1” manure	40	15	40
Added by 1” manure	6	1	6

1. 50%
2. 50%

Response Counter

Approximately how much total N, P, and K does 1” of manure compost supply?

	N	P_2O_5	K_2O
	lbs/1000 sq. ft.		
Removed annually by vegetables	3.4	0.3	3.2
Added by 1” manure	40	15	40
Added by 1” manure	6	1	6

How much organic matter?

- 1” manure compost will add about 1.5% O.M.
- 1” plant compost will add about 3% O.M.
- 5-8% O.M. is optimal – O.M. is not the cure-all for all soil ailments

How can you increase soil organic matter without adding too much P and K?

- Add organic matter high in C (dry leaves, wood shavings, straw, peatmoss), but remember, “immobilization” happens
- Add organic matter based on plant’s P needs and add N with chemical fertilizer, organic fertilizer such as blood meal, or plant legumes

Summary

- Fertilizer rates depend on crop, yield goal and soil test values
- Rates for N need to be adjusted for stubble, prior crop/fallow, SOM, no-till
- Rates vary for sufficiency, maintenance, or build approach to fertilization
- Piling it on higher and deeper is not the answer for manure in gardens

Questions?

For more information see MSU Extension's:

http://landresources.montana.edu/soilfertility/publications.html

- *Developing Fertilizer Recommendations for Ag* (MT200703AG)
- *Home Garden Soil Testing & Fertilizer Guidelines* (MT00705AG)
- *MT Cool Season Pulse Production Guide* (EB0210)
- *Nitrate Toxicity of MT Forages* (MT200205AG) – revision this fall
- *Soil Nutrient Management for Forages: P, K, S and Micros* (EB0217)
- *Soil Nutrient Management for Forages: N* (EB0218)