Macro & Micro Nutrients for Wheat Production

Crop School, Willow Creek

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EXTENSION

Goals Today

- Introduce basics of soil fertility
- Describe function and deficiency symptoms of nutrients
- Introduce soil sampling
- Show how to use Fertilizer Guidelines and soil lab results to estimate fertilizer need
- HELP your bottom line!

There are 14 mineral nutrients that have been found to be essential for growth of most plants:

Macronutrients	Micronutrients
Nitrogen (N)	**Boron (B)**
Phosphorus (P)	**Chloride (Cl)**
Potassium (K)	**Copper (Cu)**
Sulfur (S)	**Iron (Fe)**
Calcium (Ca)	**Manganese (Mn)**
Magnesium (Mg)	Molybdenum (Mo)
	Nickel (Ni)
	Zinc (Zn)

The macronutrients are simply needed in larger amounts by the plant than the micronutrients.

Nutrient deficiencies of the bolded nutrients have been observed in Montana

Mobility in soil of selected nutrients

Mobile (and soluble)	Relatively immobile	Very immobile (and insoluble)
Nitrogen (as nitrate) Sulfur Boron Chloride	Potassium	Phosphorus Copper Iron Manganese Zinc

Why important? Affects fertilizer placement

Fertilizer guidelines

- Guidelines for N, P, K and 5 micro-nutrients for winter wheat and spring wheat production are provided in *Fertilizer Guidelines for Montana Crops* (EB 161).
- They are based on soil analysis.

Advantages of soil testing (even if only occasionally)

- To identify nutrient deficiency or imbalance
- To help calculate optimal fertilizer rates
- Especially important in case where soil nutrient availability has been depleted or is in excess
- Can increase yield and/or save on fertilizer costs, and decrease environmental risks

N function and deficiency symptoms

N is important for high photosynthetic activity, vegetative growth and protein

1. Pale green to yellow lower (older) leaves Why lower leaves?

   N is MOBILE in plant

2. Stunted, slow growth

Spring Wheat

What makes yield?

Heads/area x Kernels/heads x Weight/kernel

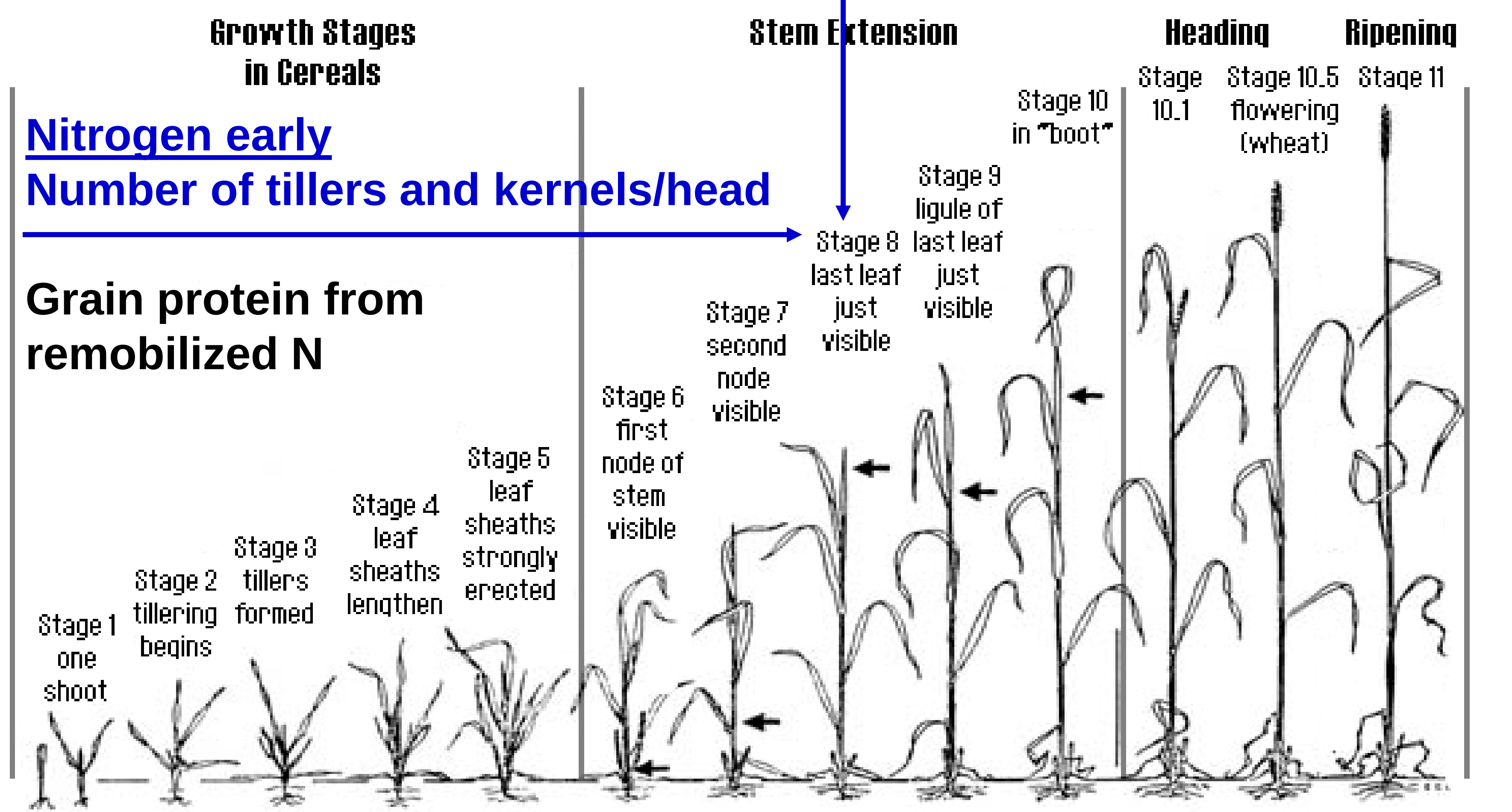
N application timing effects on yield and protein

Nitrogen late
Weight/kernel

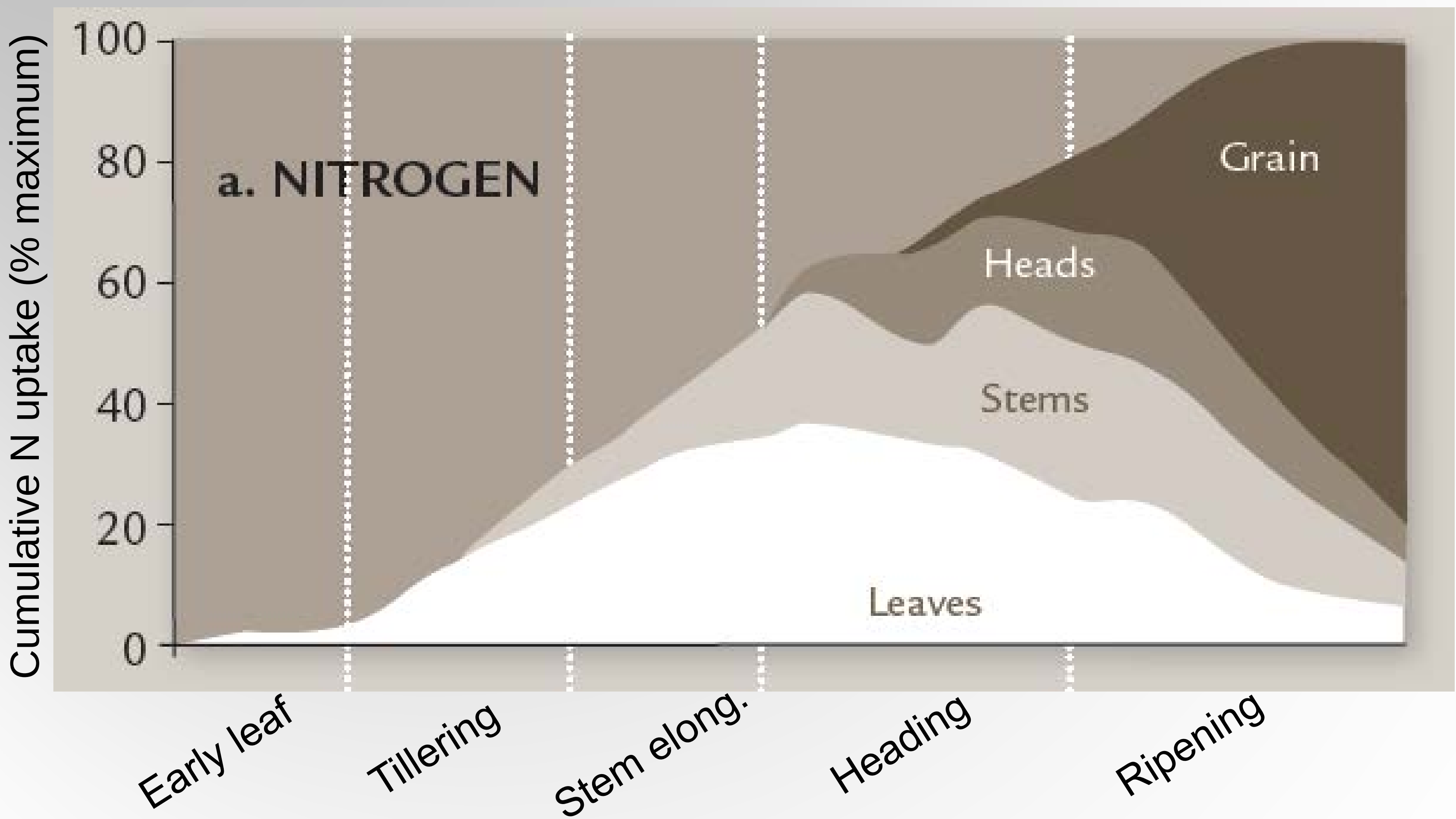
Higher grain protein

Nitrogen early
Number of tillers and kernels/head

Grain protein from remobilized N



N uptake by irrigated spring wheat



Miller et al. 1994/EB0191

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

* Attainable yield with ***all*** growth factors optimized.
** Fertilizer N = Available N - soil analysis NO_3-N.
***Includes durum and hard red and hard white spring wheat at 13% and 14% protein, respectively.

EB 161: http://www.montana.edu/wwwpb/pubs/eb161.pdf

Example

- Winter wheat
- Yield potential = 40 bu/ac
- Soil test N = 54 lbs/ac (top 2 ft.)

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

Fertilizer N = Available N – soil test N

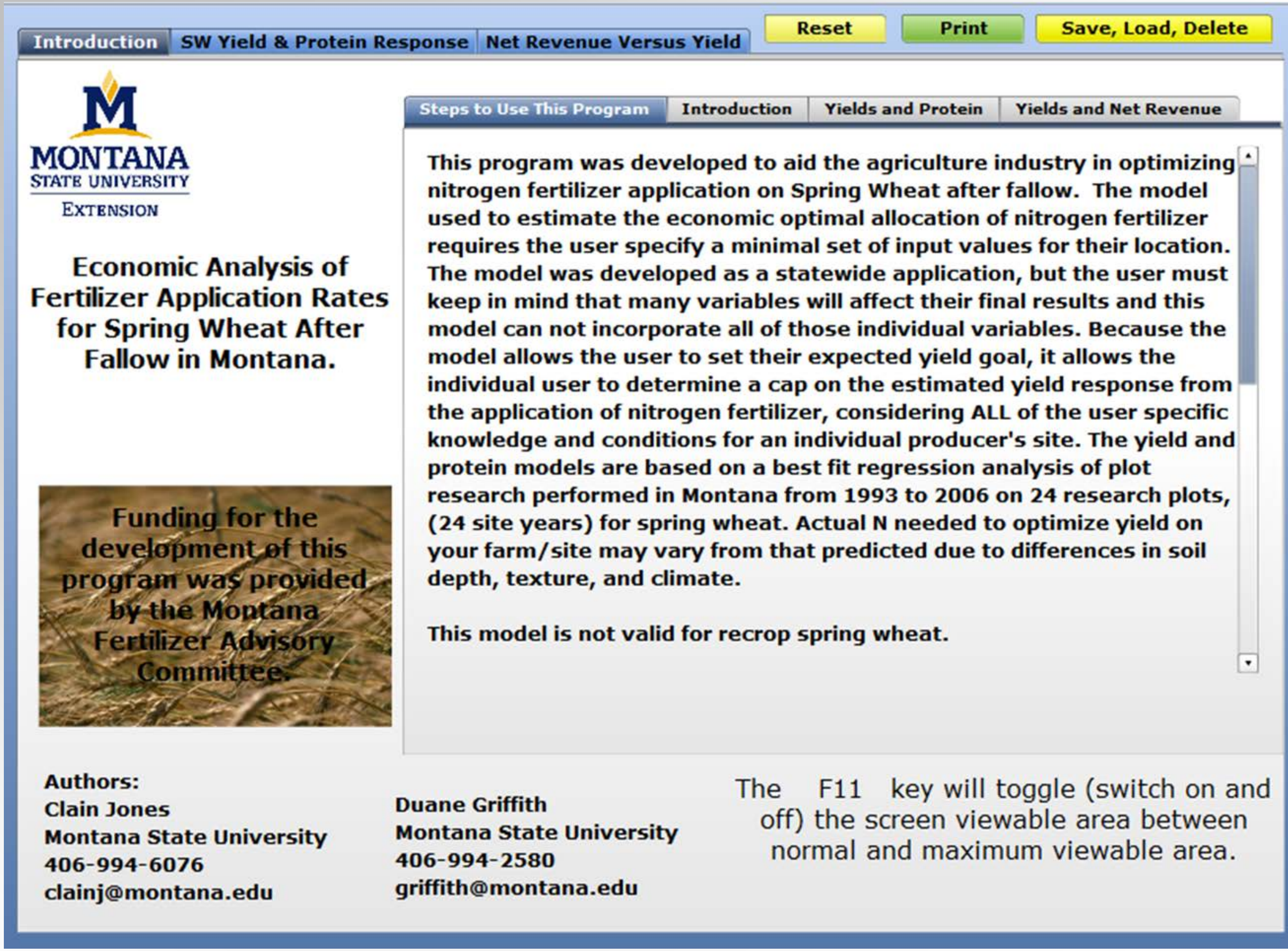
Fertilizer N =104 lbs/ac – 54 lbs/ac = **50 units**

Legumes for N

Consider replacing fallow with legume

N credit following legume for grain is ≈ 10 lb/ac, more if grown for ‘green manure’

Economic Model spring wheat fertilizer – web site home page



Introduction | SW Yield & Protein Response | Net Revenue Versus Yield | Reset | Print | Save, Load, Delete

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Economic Analysis of Fertilizer Application Rates for Spring Wheat After Fallow in Montana.

Funding for the development of this program was provided by the Montana Fertilizer Advisory Committee.

Steps to Use This Program | Introduction | Yields and Protein | Yields and Net Revenue

This program was developed to aid the agriculture industry in optimizing nitrogen fertilizer application on Spring Wheat after fallow. The model used to estimate the economic optimal allocation of nitrogen fertilizer requires the user specify a minimal set of input values for their location. The model was developed as a statewide application, but the user must keep in mind that many variables will affect their final results and this model can not incorporate all of those individual variables. Because the model allows the user to set their expected yield goal, it allows the individual user to determine a cap on the estimated yield response from the application of nitrogen fertilizer, considering ALL of the user specific knowledge and conditions for an individual producer's site. The yield and protein models are based on a best fit regression analysis of plot research performed in Montana from 1993 to 2006 on 24 research plots, (24 site years) for spring wheat. Actual N needed to optimize yield on your farm/site may vary from that predicted due to differences in soil depth, texture, and climate.

This model is not valid for recrop spring wheat.

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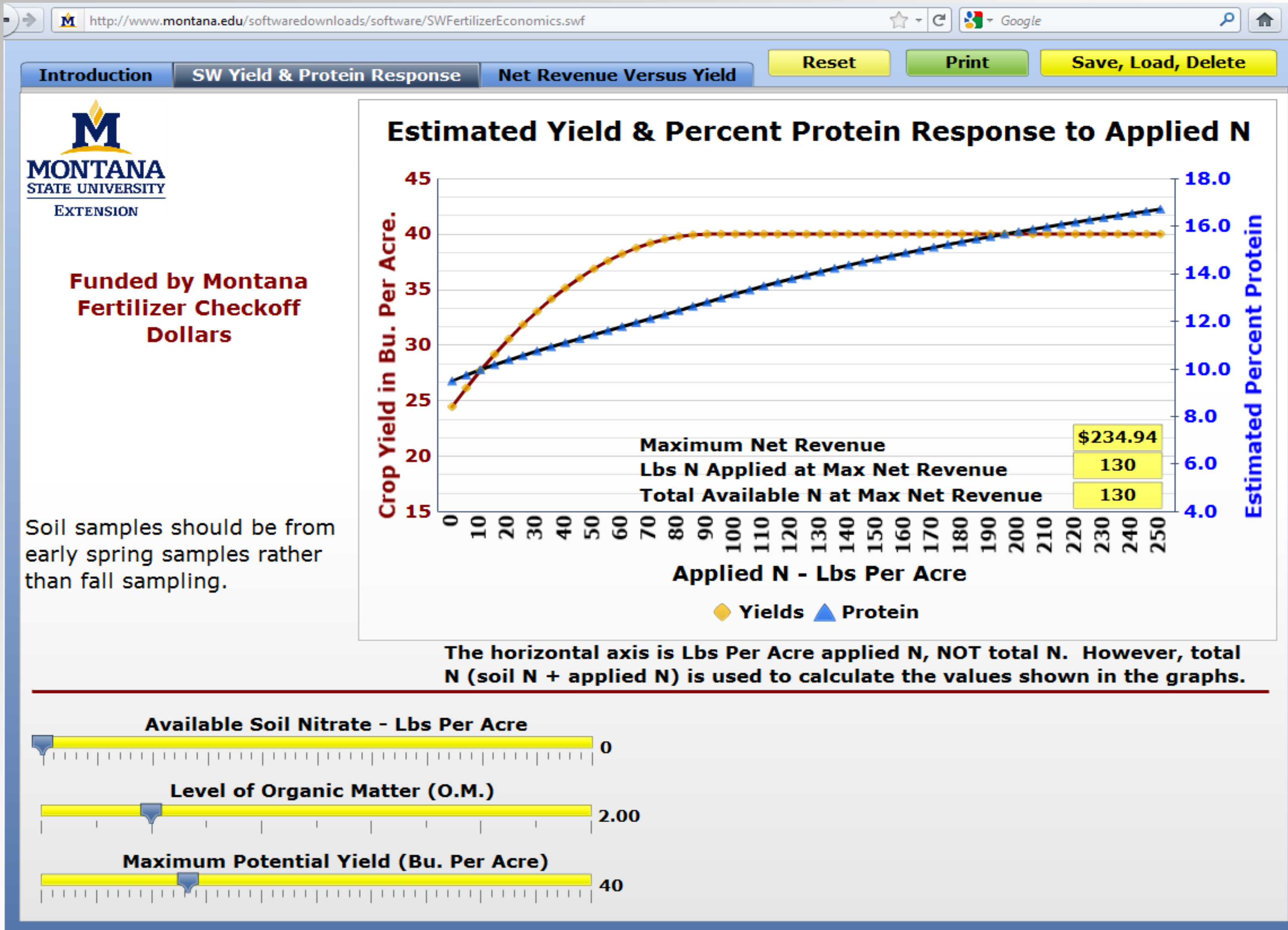
The F11 key will toggle (switch on and off) the screen viewable area between normal and maximum viewable area.

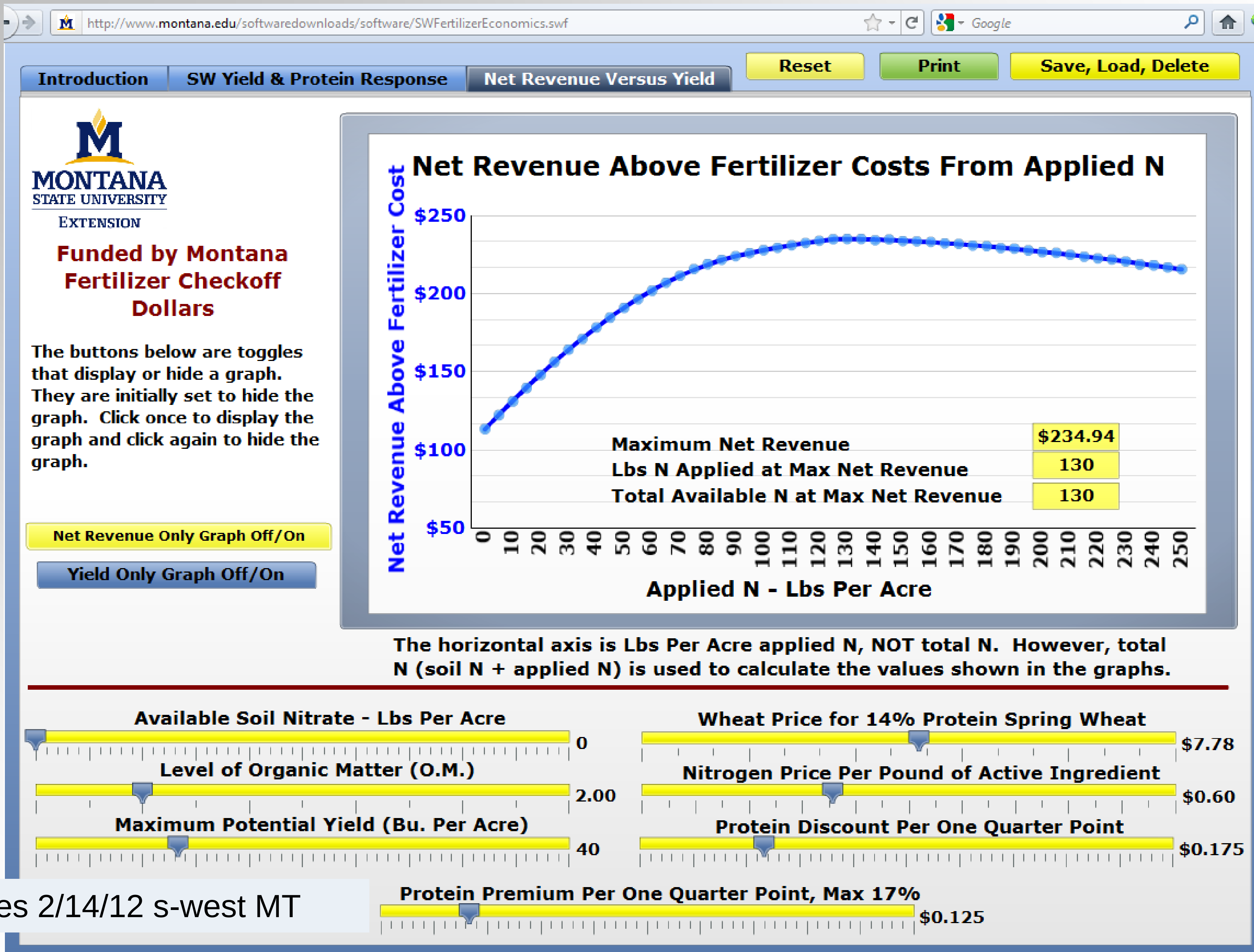
http://www.montana.edu/softwaredownloads/software/SWFertilizerEconomics.swf

Economic Model spring wheat fertilizer, yield & protein



http://www.montana.edu/softwaredownloads/software/SWFertilizerEconomics.swf

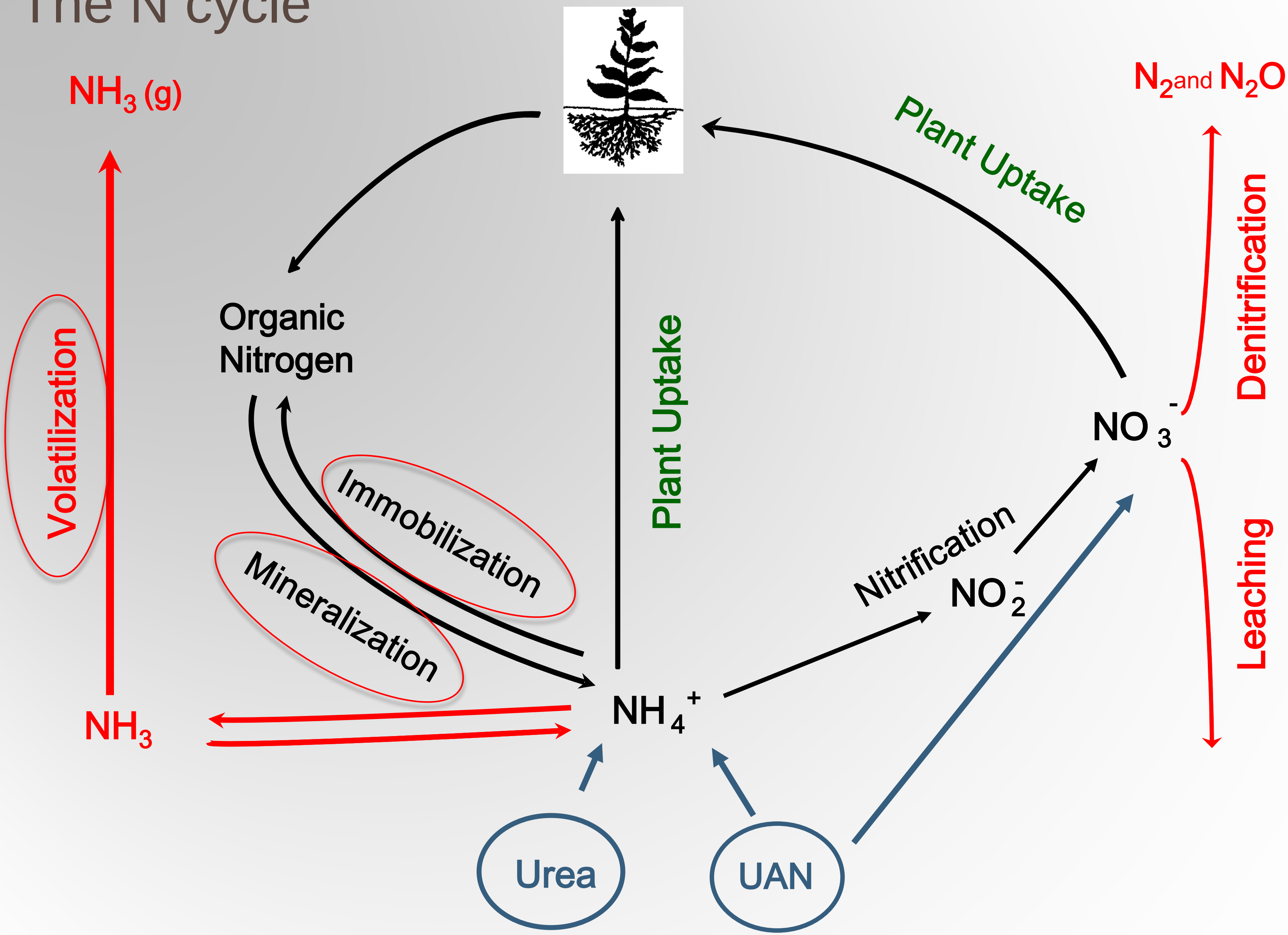
Economic Model spring wheat fertilizer, net revenue



Prices 2/14/12 s-west MT

QUESTIONS?

The N cycle



NH3 (g)
Volatilization
NH3
Organic Nitrogen
Immobilization
Mineralization
Plant Uptake
Plant Uptake
NH4+
Nitrification
NO2-
NO3-
N2 and N2O
Denitrification
Leaching
Urea
UAN

‘Mineralization’

Release of minerals as organic matter (O.M.) is decomposed, releasing soluble N

Organic-N → Plant-Available N

If have higher than normal O.M. (>3%), can back off on N fertilizer by 20 units of N

‘Immobilization’

Uptake of available N into microbial cells or plant tissue

Plant-Available N → Organic-N

If leave more than ½ ton stubble, increase N fertilizer by 10 units of N

How know how much stubble (straw residue)?

Ex: Spring wheat straw (lb/ac) = 1.33 x grain yield (lb/ac)

Ammonia volatilization

Soluble 'Ammonium' → Ammonia Gas

- Not an issue if fertilizer is incorporated at least 1.5 inches into soil-not an option with no-till

Factors affecting volatilization

- Soil pH and Temperature
- Wind
- Cation Exchange Capacity (CEC). WHY?
- Buffering capacity (resistance to pH change)
- Soil moisture/humidity
- Rainfall/Irrigation following fertilization (depth in soil)
- Ground cover/vegetation/residue. WHY?
- Soluble and Exchangeable Calcium

Bottom line: Large number of factors make volatilization amounts VARIABLE and difficult to predict.

Volatilization loss of urea applied in cold weather

- In 13 trials over 3 years in Montana, urea applied during cold weather averaged 20% loss of applied N, with wide range (3 – 44%). Engel et al 2011.
- Significant ammonia losses (30-40% of applied N) from surface-applied urea can occur even though soil temperatures are near freezing!
- Soil moisture conditions at surface that dissolve urea granules (i.e. prolonged damp) without rain promote high ammonia losses (*more common to find these conditions in MT during late fall or early spring*)
- NBPT (Agrotain®) reduced losses 62% over untreated urea

N source

“A pound of N is a pound of N”- cost per unit of N, available equipment to apply N, and potential losses should be most important factors in selecting N. Beware of those who say differently.

If you want more information on N cycling, see Nutrient Management Module 3:

http://landresources.montana.edu/nm

More information on urea volatilization, see:

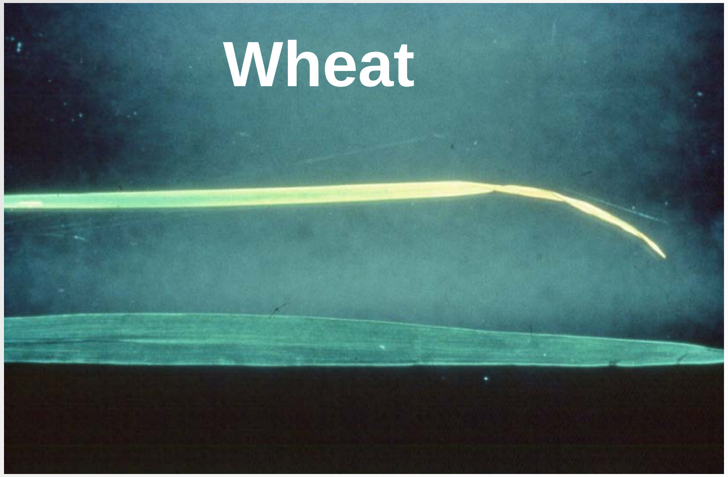
http://landresources.montana.edu/soilfertility/ammonvolat.html

QUESTIONS?

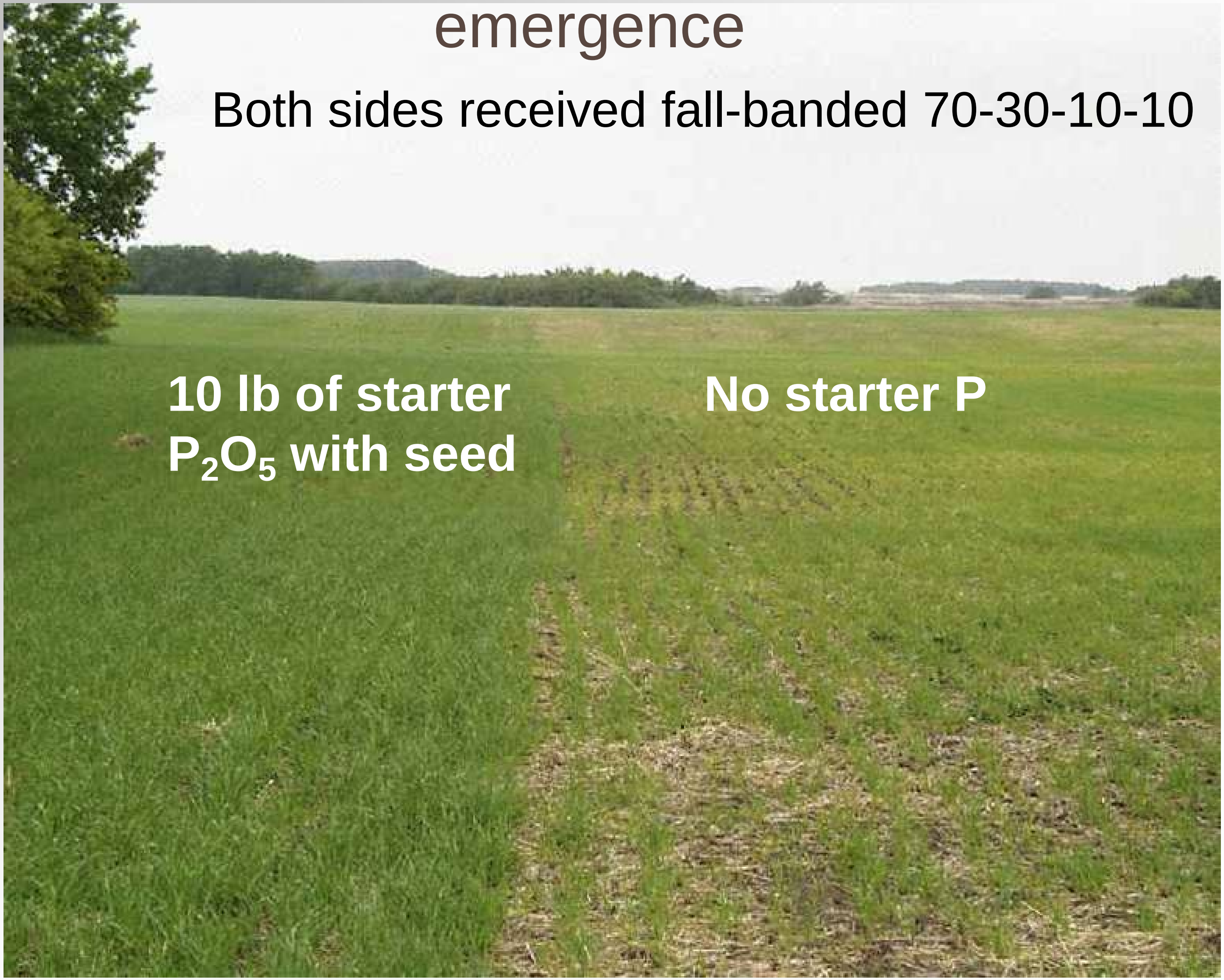
P function and deficiency symptoms

P is critical in the first 5-6 weeks for rooting and tillering

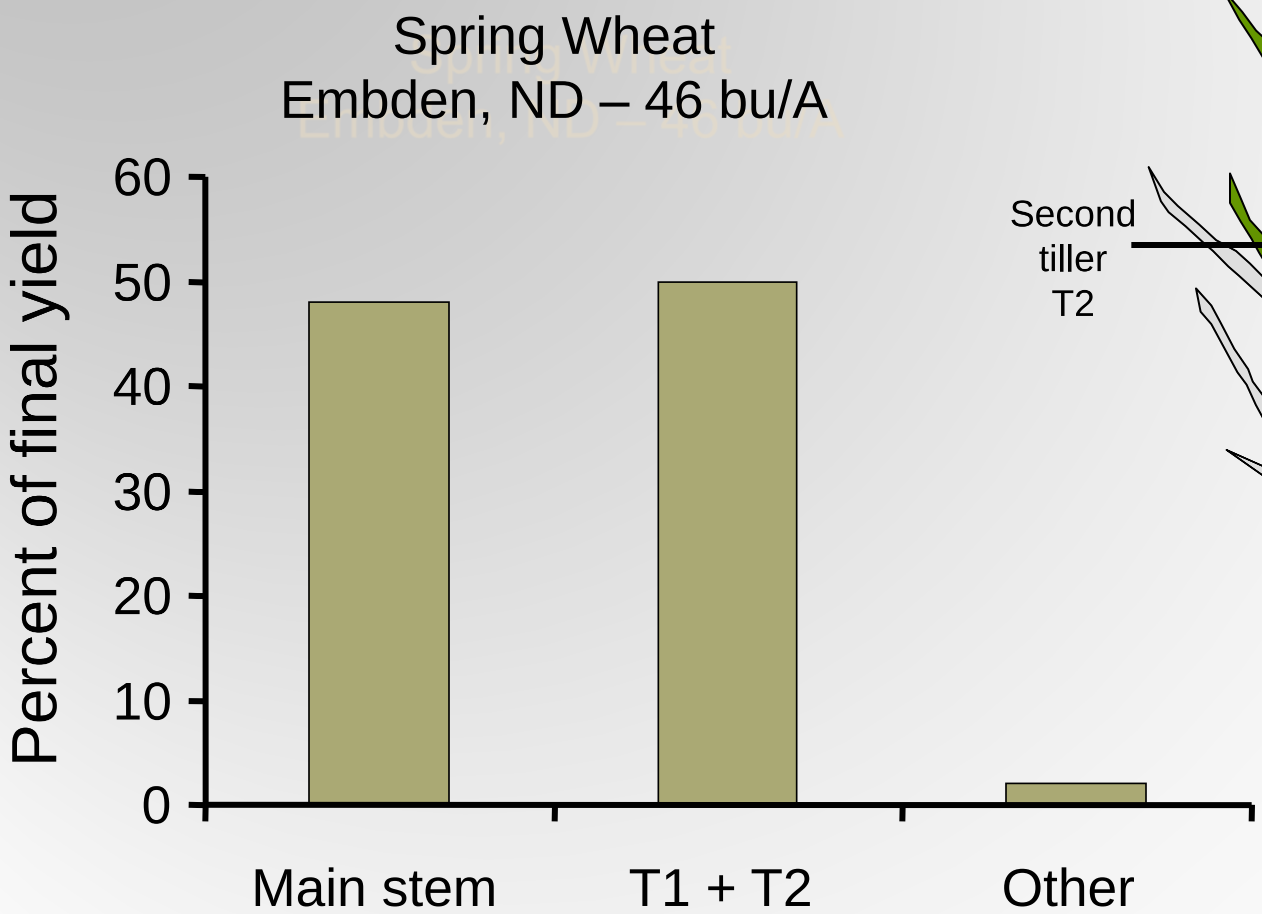
1. Dark green, often purple
2. Lower leaves sometimes yellow
3. Often seen on ridges of fields

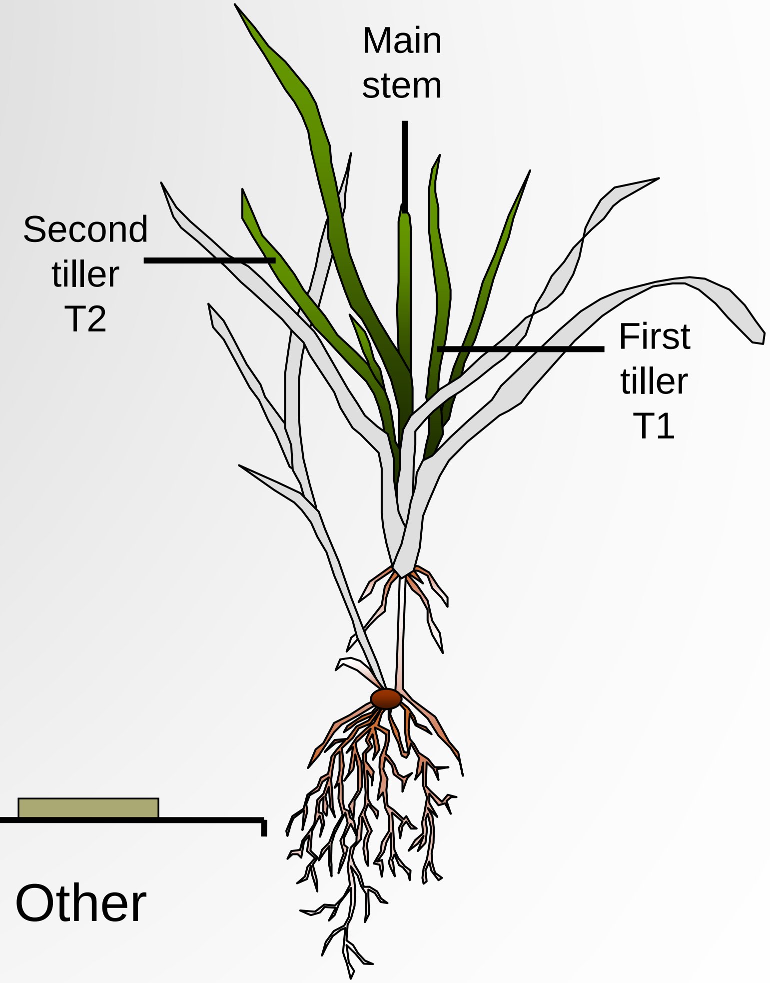


Impact of starter P in a cool spring on spring wheat emergence



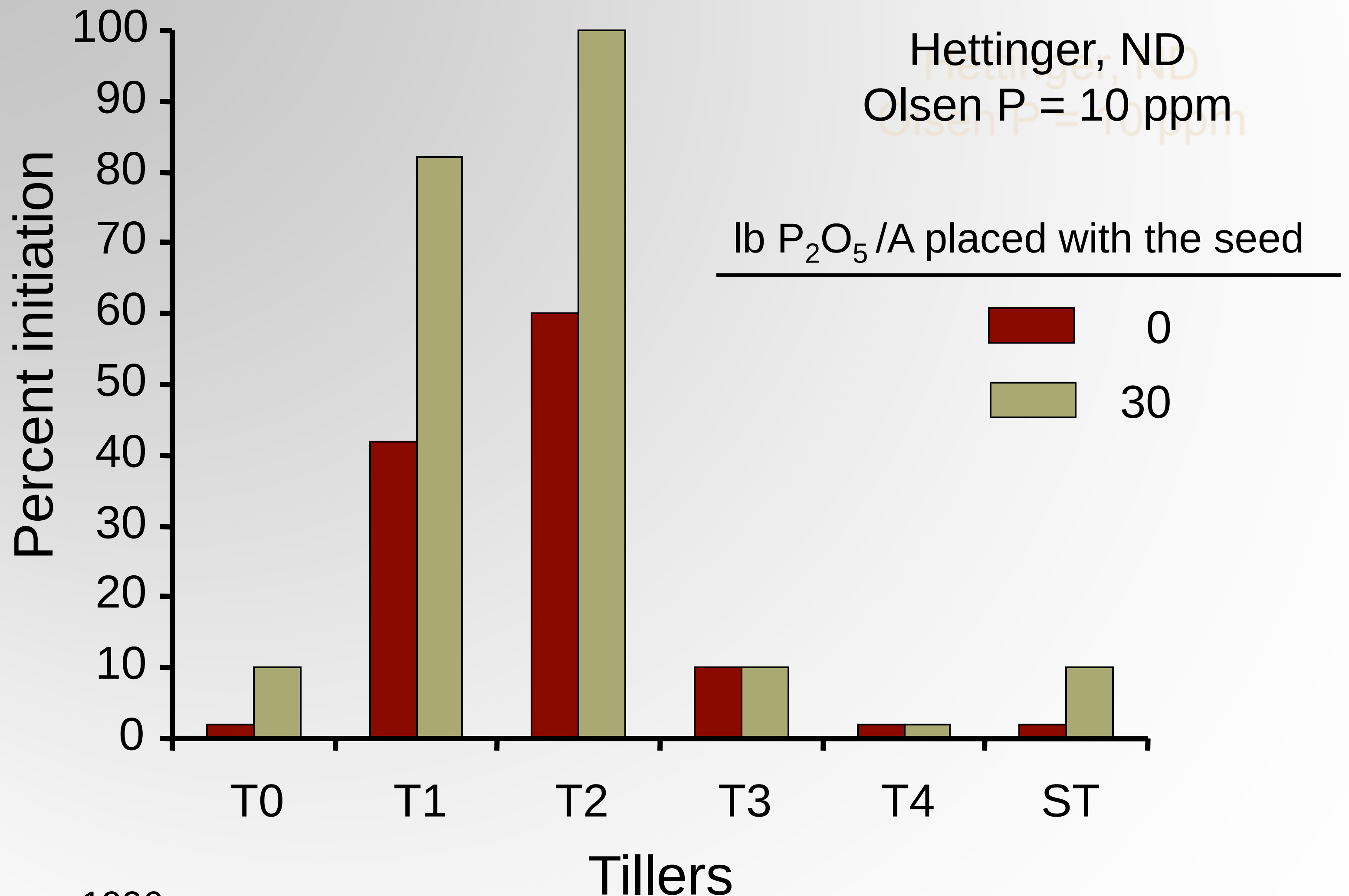
Contribution of tillers to yield





Goos and Johnson, 1996

Phosphorus increases tiller initiation



Goos and Johnson, 1996

Factors decreasing P availability

- Soil pH below 6.0 or above 7.5
- Cold, wet weather
- Calcareous soils
- Leveled soils
- Highly weathered, sandy soils

P fertilizer guidelines

Table 18. P fertilizer guidelines based on soil analysis (EB 161)					
crop	Olsen P soil test level (ppm)				
	0	4	8	12	16*
	P fertilizer rate (lbs P_2O_5 /acre)				
Spring wheat	50	45	35	30	20
Winter wheat	55	50	45	40	35
* With P>16 ppm consider using crop removal rates as P fertilization guideline					

Example

Winter wheat, Olsen P = 10 ppm

P_2O_5 needed = **42.5 lb/ac**

Banding P

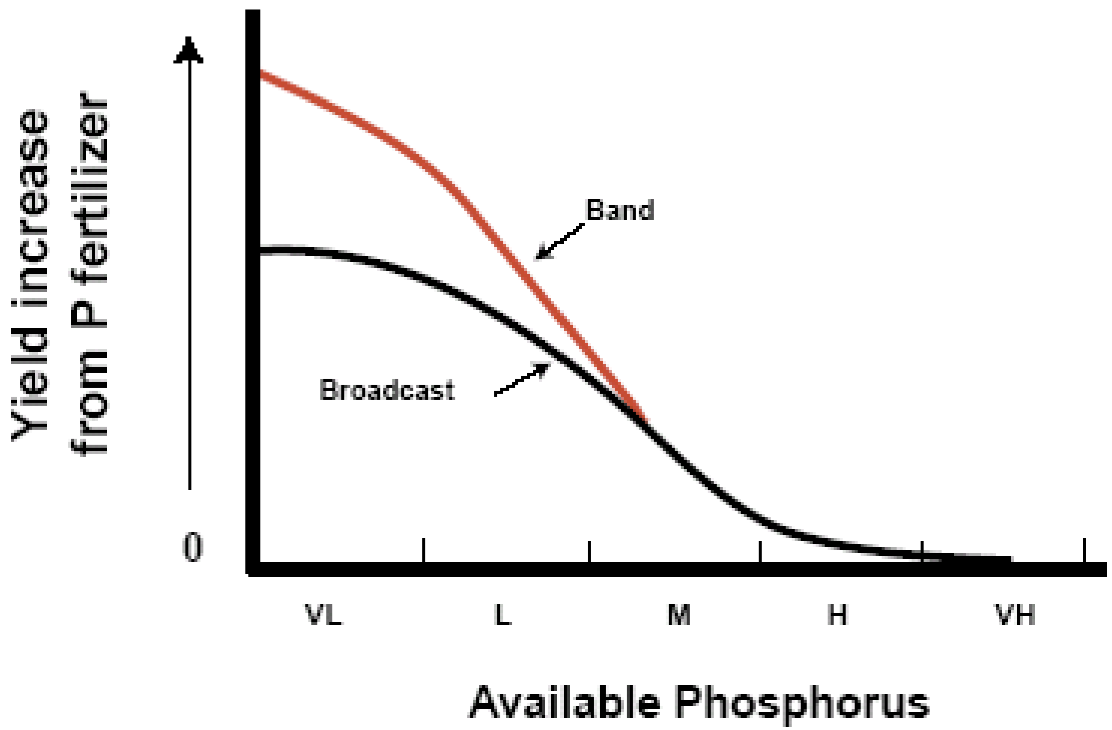


Figure 7. The advantages of P banding are greatest when STP levels are very low (VL) to low (L). From Randall and Hoeft (1988).

Banding P is much more effective than banding N, because P is much more immobile in the soil.

P fertilization

- P is immobile so needs to be close to root-zone
- With low amounts of P (< 20-30 lb P_2O_5/ac), can place fertilizer directly with seed

QUESTIONS?

K functions and factors decreasing availability

K is used in photosynthesis, protein formation, sugar transport and activation of enzymes

Factors decreasing K availability

- Cold, dry soils
- Poorly aerated soils
- High calcium and magnesium levels
- Sandy, low clay soils
- Low soil organic matter, or high amounts of available N

K deficiency symptoms

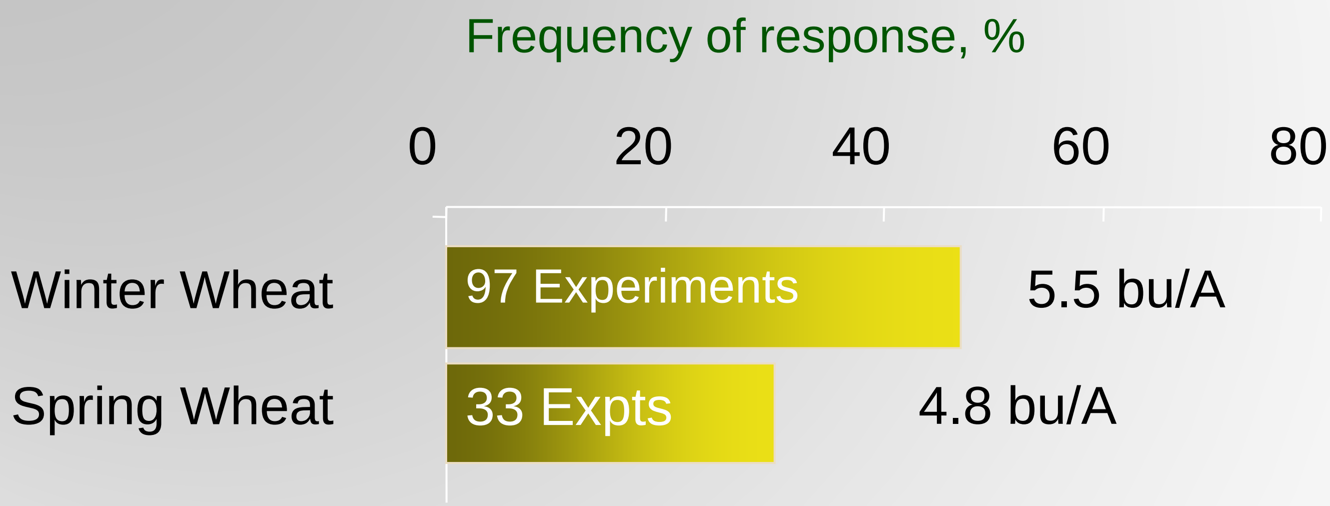
1. Corn and grasses – chlorosis and necrosis on *lower* leaves first. WHY?

<u>K is mobile in plant</u>

2. Weakening of straw- lodging in small grains.

3. Wilting, stunted, shortened internodes.

Crop response to added K in high K soils in Montana (264 sites)



Each crop represents 2 to 8 cropping years
Soils testing > 600 ppm (1967-1979)

Yield response to KCl fertilizer in high K soils may be a Cl response

Skogley and Haby 1981

S functions and factors decreasing availability

S is important for protein and chlorophyll synthesis

Factors decreasing S availability

- Irrigated with low S in irrigation water
- Sandy, acidic, or low organic matter soils
- Cold soils
- Soils formed from minerals low in S or far from industrial sources

S deficiency symptoms

1. Upper leaves light green to yellow. WHY?

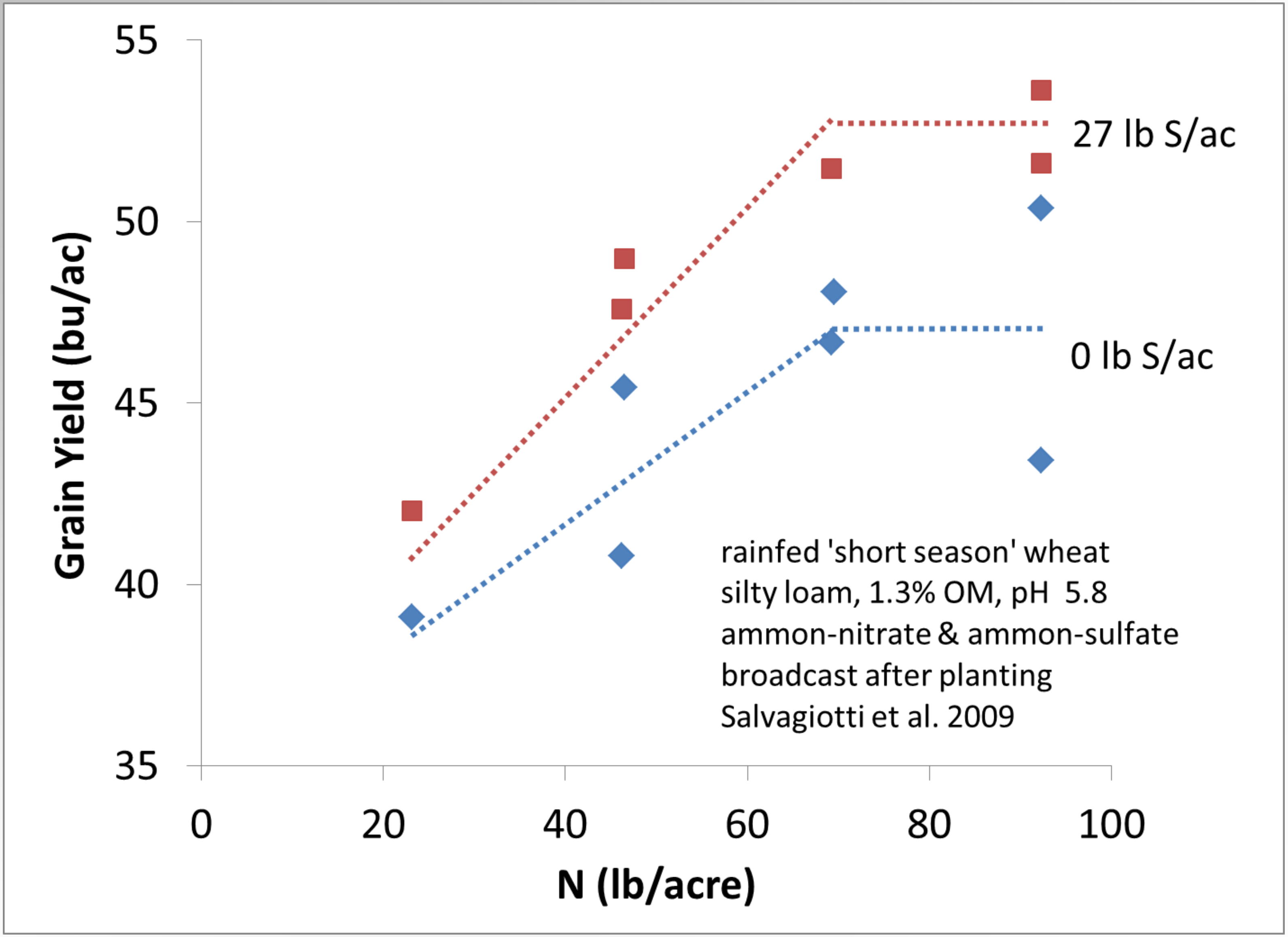
   S is immobile in plant

2. Small, thin stems
3. Low protein
4. Delayed maturity
5. No characteristic spots or stripes

S fertilization

- Tissue sampling is more reliable than soil testing. If < 0.20 to 0.25% S in uppermost leaves before heading then may limit yield and protein.
- In-season applications of ammonium thiosulfate and ammonium sulfate, can rapidly correct sulfur deficiency.
- Sulfate fertilizers are not suggested for fall application. They can leach overwinter.
- Elemental sulfur is slow to supply plant available sulfur. Apply in fall or before seeding to become available before peak demands. It will supply crop needs for over 2 to 3 years.

S can increase yield at higher N



Micronutrients

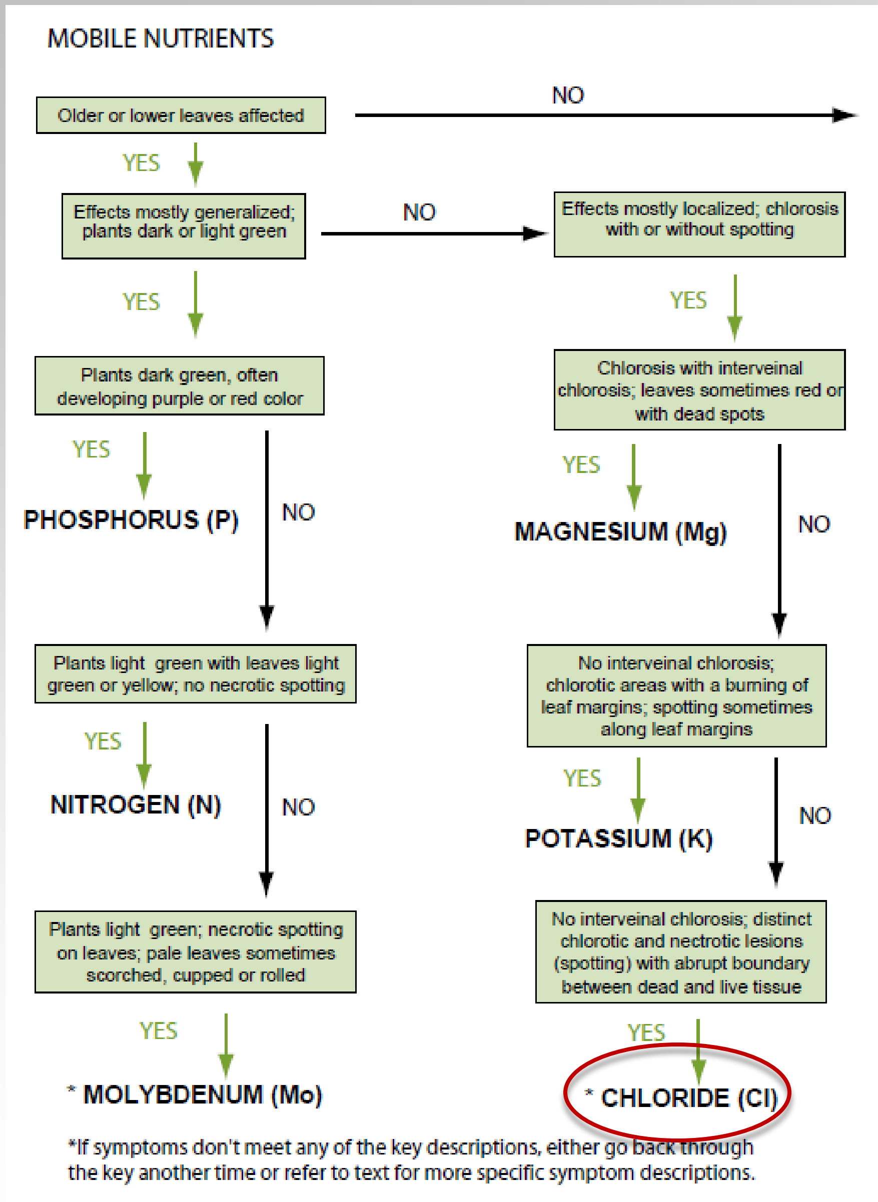
- Use visual tissue assessment for potential deficiency
- Conduct a ramp calibration strip trial

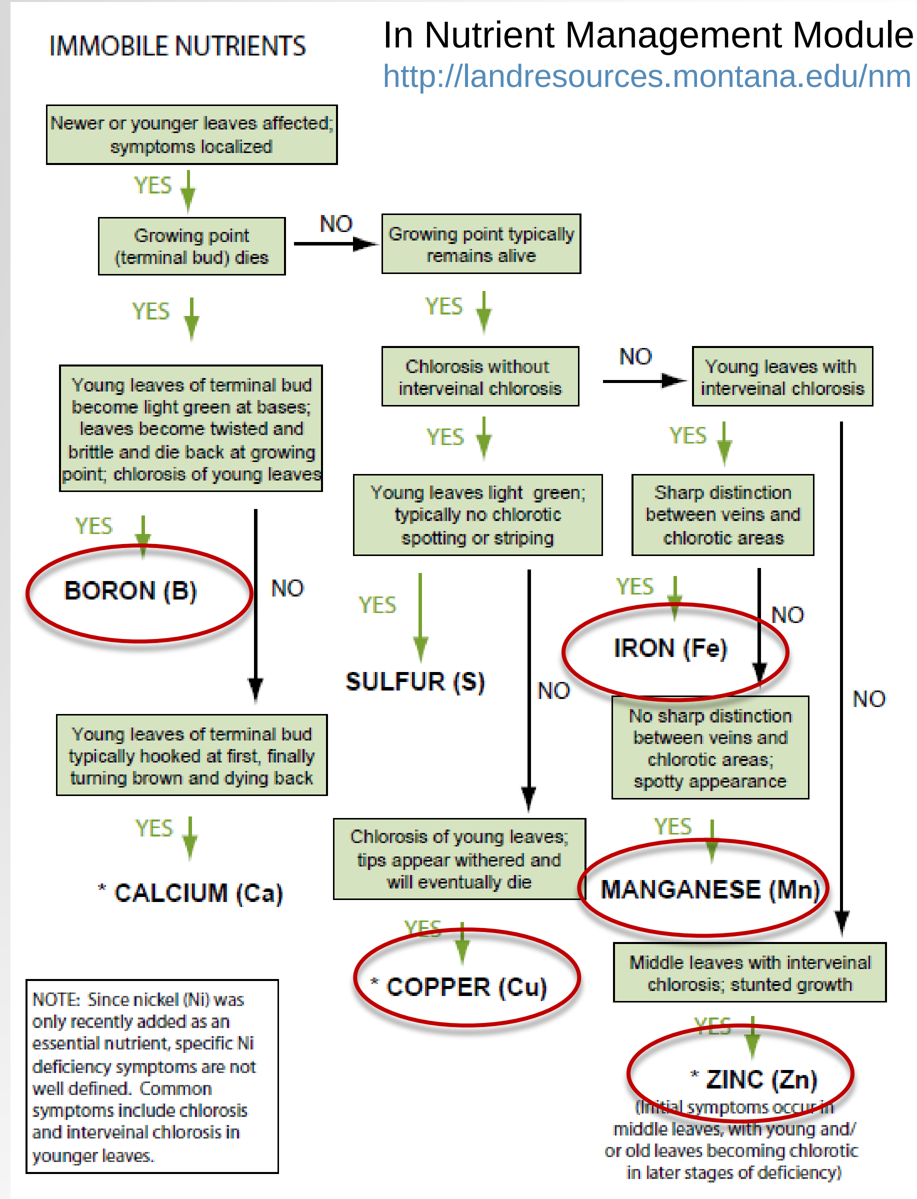
    http://landresources.montana.edu/soilfertility

    then go to “Press Releases”

Visual tissue assessment

In Nutrient Management Module 9
http://landresources.montana.edu/nm





Pseudo-deficiencies

What else can cause symptoms that look like nutrient deficiency symptoms?

- Insects
- Salinity
- Moisture stress
- Disease
- Herbicides

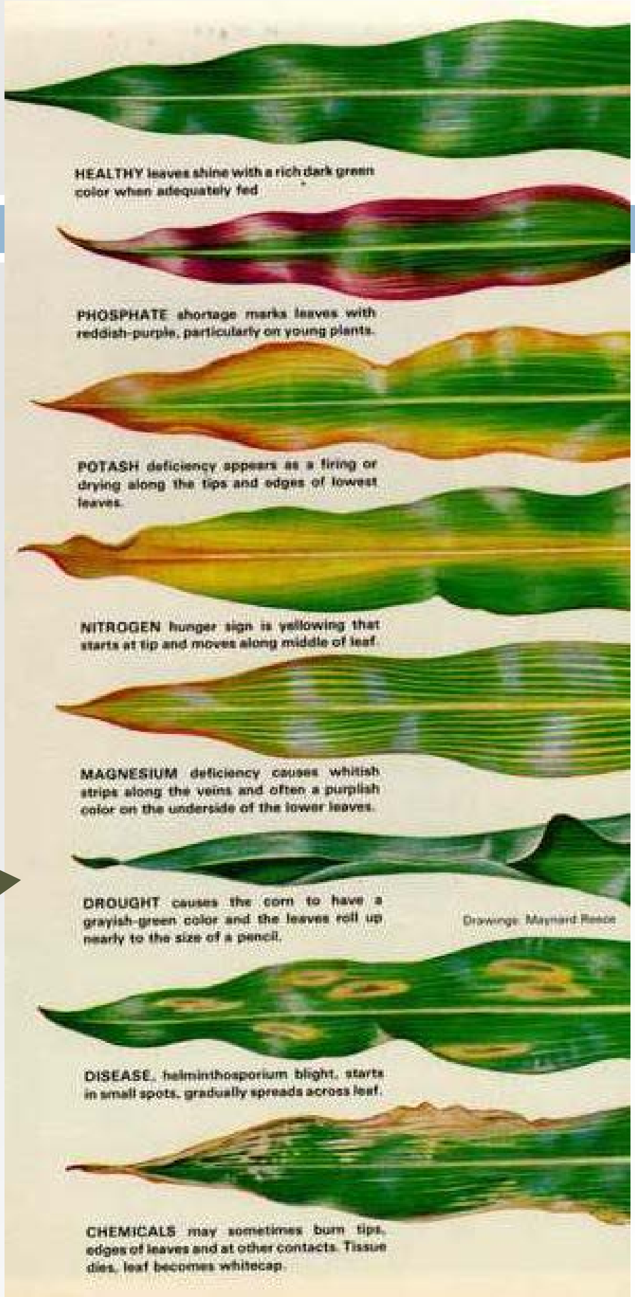


Photo: Ontario Ministry of Ag., Food & Rural Affairs

Micronutrient guidelines (EB 161)

Table 20. Micronutrient fertilizer guidelines based on soil analysis.

Micronutrient Soil Test* ppm	Micronutrient Fertilizer Rate lbs/a
Boron	
0 - 0.5	2
0.5 - 1.0	1
>1.0	0
Copper	
0 - 0.5	2
>0.5	0
Iron	
0 - 2.5	4
2.5 - 5.0	2
>5.0	0
Manganese	
0 - 0.50	20
0.50 - 1.0	10
>1.0	0
Zinc	
0 - 0.25	10
0.25 - 0.50	5
>0.50	0

Conclusions

- Efficient use of fertilizers helps production, the environment and your bottom line.
- Time applications and place fertilizer correctly for optimal plant use and minimal loss
- Deficiency symptoms can ID trouble, but if apparent then have already lost yield.
- Soil testing is necessary to apply the correct amount of nutrients.

For more information

Additional soil fertility information is available at

http://landresources.montana.edu/soilfertility

- On plant nutrient functions and deficiency symptoms, refer to Nutrient Management Module 9.
- On soil fertility and plant nutrition, look at Module 2.
- On fertilizer placement, look at Module 11.

http://landresources.montana.edu/nm

Questions?

Watrous, SK, 1920's