Balanced Nutrition for Forages by Using 4R Nutrition Management

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IPNI INTERNATIONAL PLANT NUTRITION INSTITUTE

•A not-for-profit, scientific organization dedicated to responsible management of plant nutrients for the benefit of the human family, www.ipni.net

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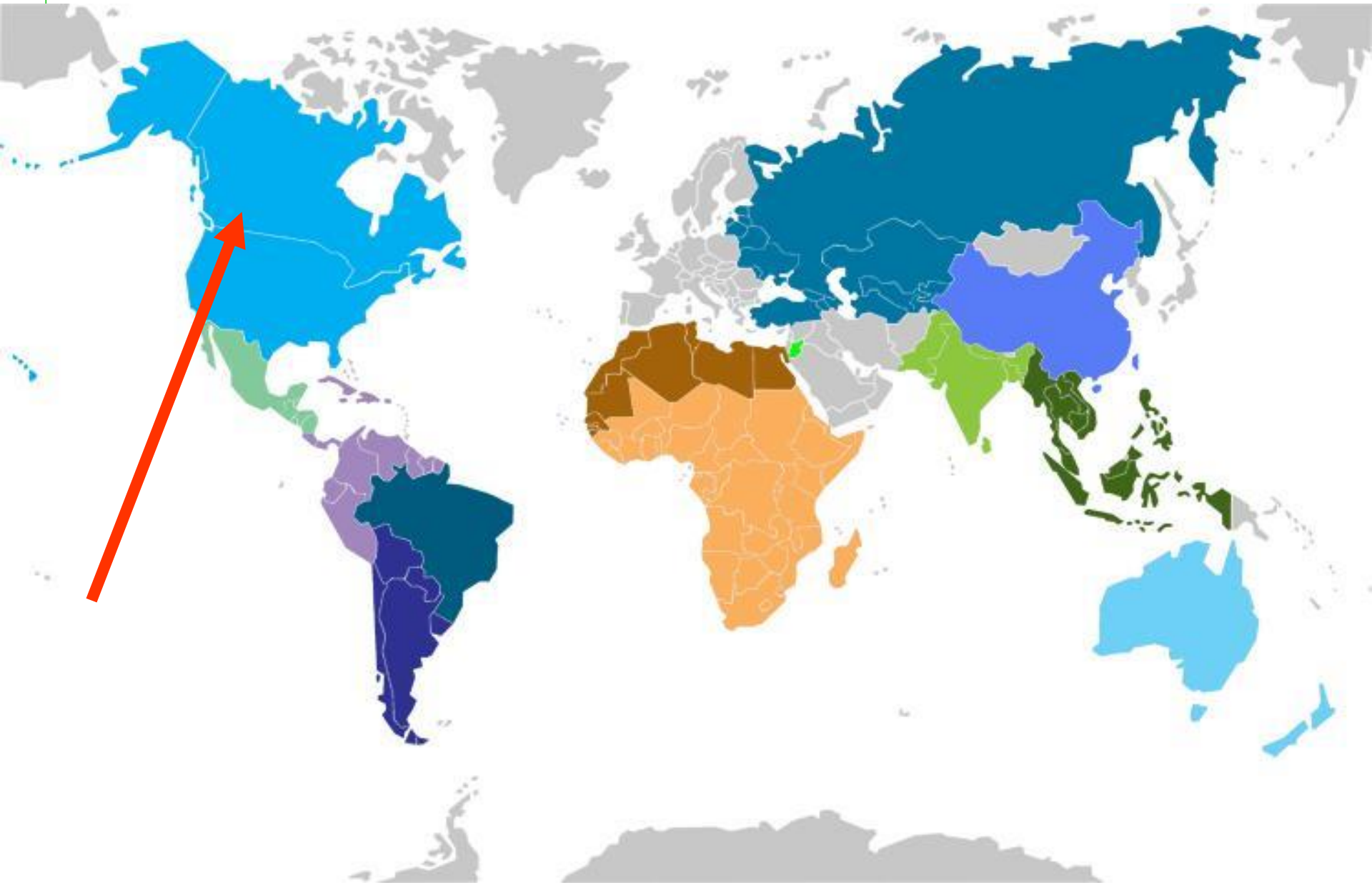
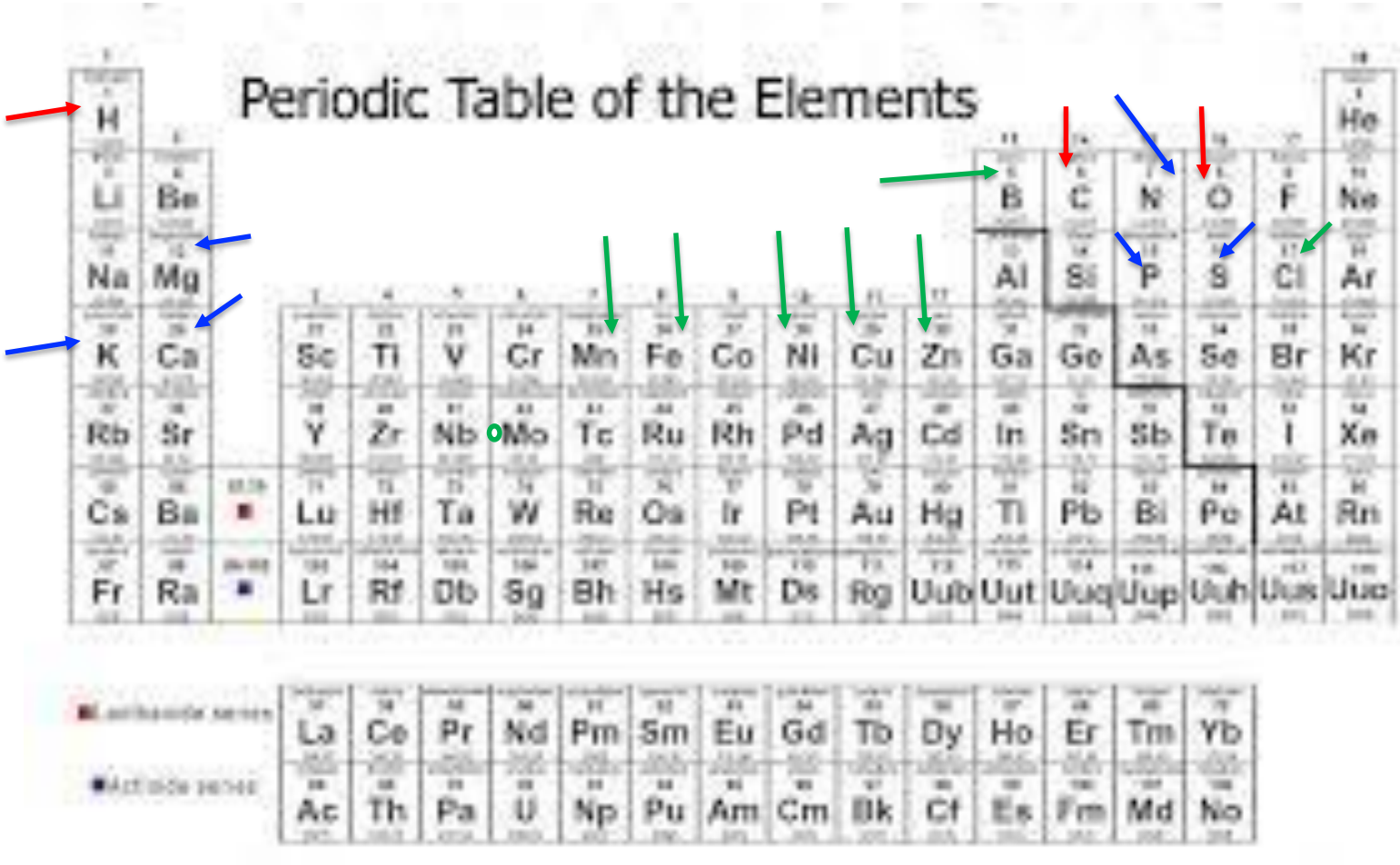


Nutrient Inputs and Time.

No Commercial Fertilizer

N and P at low rates

N, P, K, S, Ca, Mg and Micronutrients



- Plants need 16 elements out of 118 total elements, 14 are mineral nutrients
- Humans and animals need 21 *(22?),* additional are: Na, Cr, Co, Se, and I *(V?)*

Plant Nutrients

- Non-Mineral Nutrients
  - C, H, O
- Mineral Nutrients
  - macro: N, P, K, S, Ca, Mg
  - micro: B, Cl, Cu, Fe, Mn, Mo, Zn, Ni

The 4Rs of Nutrient Management and Forage Crops

Right Form @

at the Right Rate, Time and Placement

Maximize crop uptake and minimize unwanted losses



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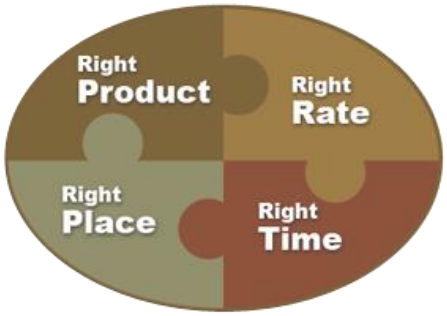
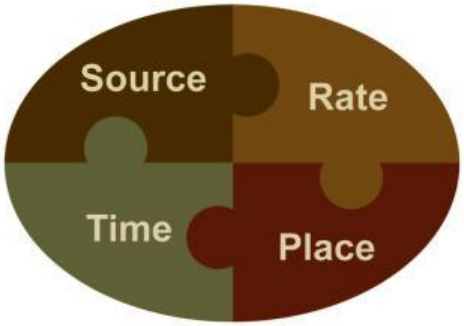
Background of 4R Nutrient Stewardship

4R





- The concepts began as the 4Rs for nutrient management
  - Right Kind, Right Rate, Right Time, and Right Place
    - Thorup and Stewart 1988
- Changed to "Right Product" that was later further changed to "Right Source"
  - Roberts 2009
- These principles where accepted as a useful way to for the fertilizer portion of the agriculture industry to present a concise and clear stewardship message, within the industry and to the public generally.

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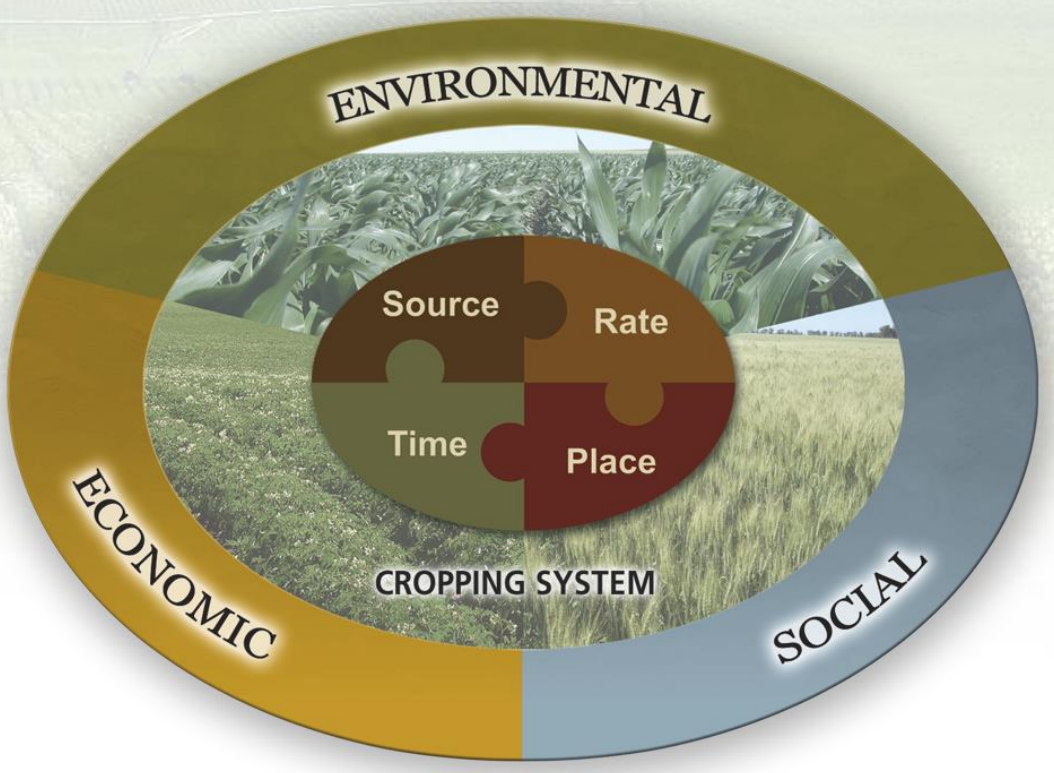
The 4Rs connect to cropping systems

- Soil, water, air, and temperature influence nutrient availability



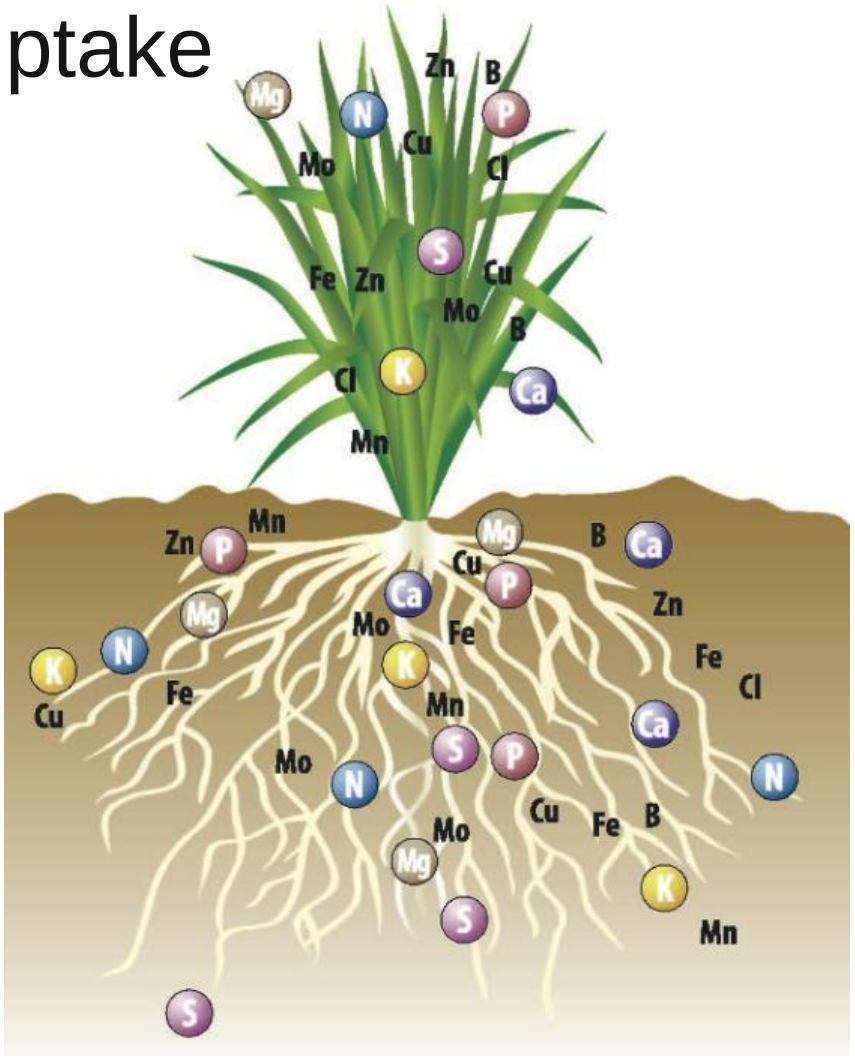
- Crop yield potential
- weeds
- insects
- diseases
- mycorrhizae
- soil texture & structure
- drainage
- compaction
- salinity
- temperature
- precipitation
- solar radiation

4R is supported by the
following industry organizations initially,
support is now growing around the world
in counties, states, provinces, countries, agricultural industries, and environmental groups

RIGHT SOURCE

Nutrients need to be in plant-available forms for uptake

- Nutrients are only taken up by roots when dissolved in water
- Insoluble nutrients are not immediately useful for plant nutrition



There is no one “right source” for every soil and crop condition

- Each crop, soil, and farmer has different needs and objectives …for example

Farmer issues:

Fertilizer availability?
Product price?
Application equipment?
Environmental concerns?

Soil and Crop issues:

Ammonia loss from broadcast urea?
Gaseous loss of nitrate from wet soil?
Runoff of P from applications on the soil surface?

Sources

- manure,
- granular fertilizer,
- or foliar fertilizer,
- or combinations of the above

RIGHT RATE

Scientific Principles for Right Rate

- Assess plant nutrient demand
- Assess soil nutrient supply
- Assess all available nutrient sources
- Predict fertilizer use efficiency
- Consider economics

- Set realistic yield targets
- Attainable yield in an average season
- 10% above 3 to 5-year average yield

Consider all available nutrient sources

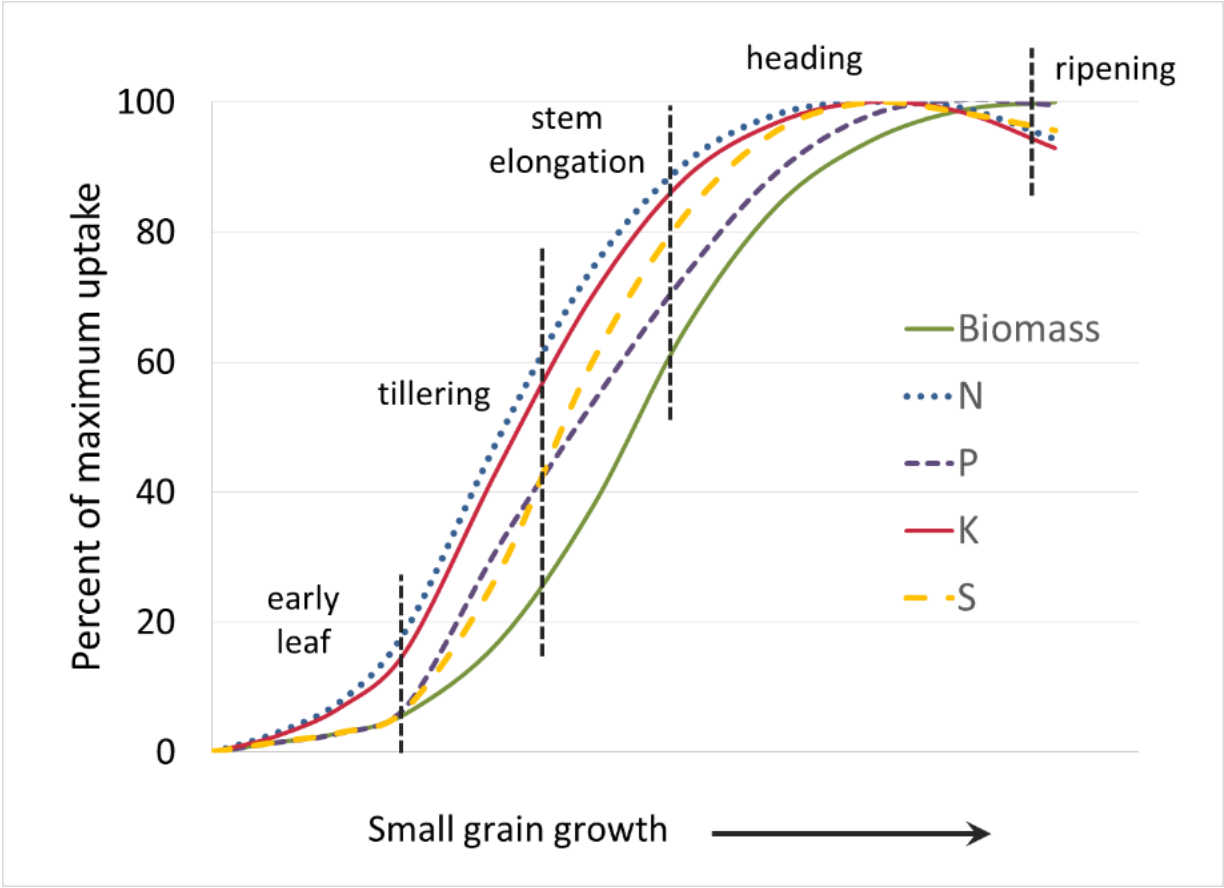
Adjust rates of externally applied nutrients for:

- Native soil supply
- Manure
- Irrigation water
- Crop residues
- Biological N fixation

RIGHT TIME

Crop Uptake Dynamics and Fertilizer Timing

- Nutrient uptake and dry matter accumulation follow S shaped or sigmoid pattern for most crops.

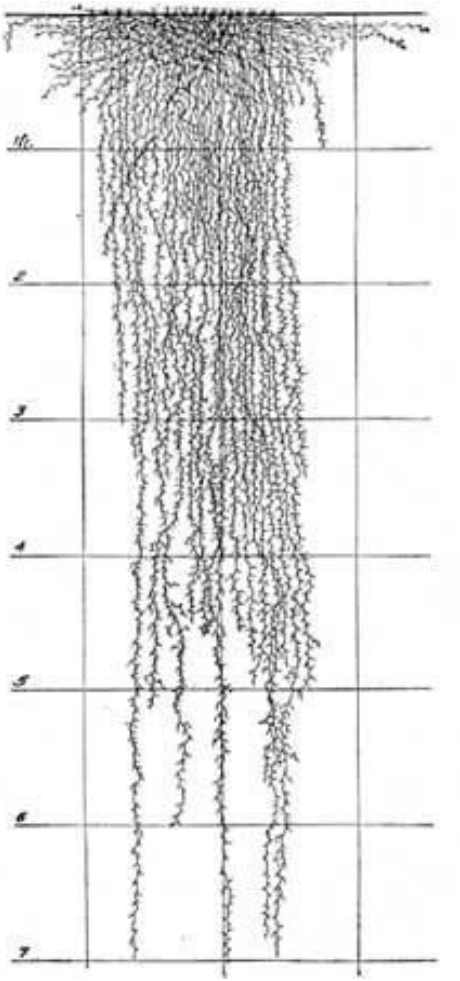


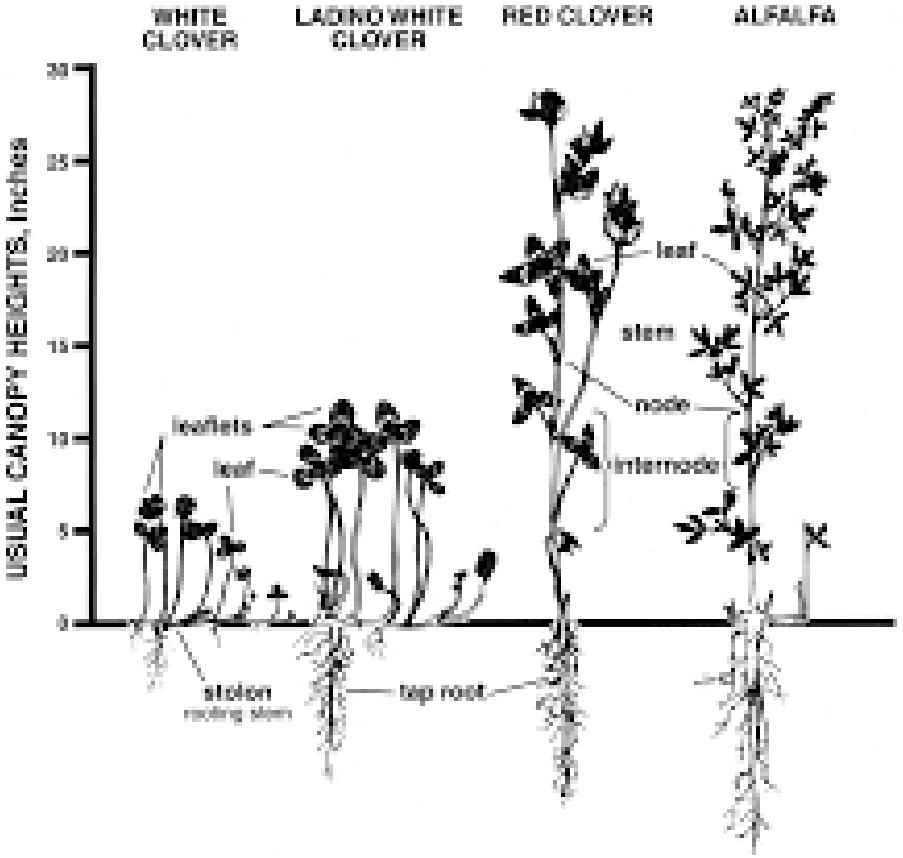
Timing of Nutrient Applications by Growth Stage is Beneficial

- Nitrogen (Grasses)– most of the N should be applied early before stem elongation
- Phosphorous, all forages – early in the growing season
- Potassium, all forages – early in the growing season
- Sulphur, all forages - early in the growing season

RIGHT PLACE

Differences in Root Architecture

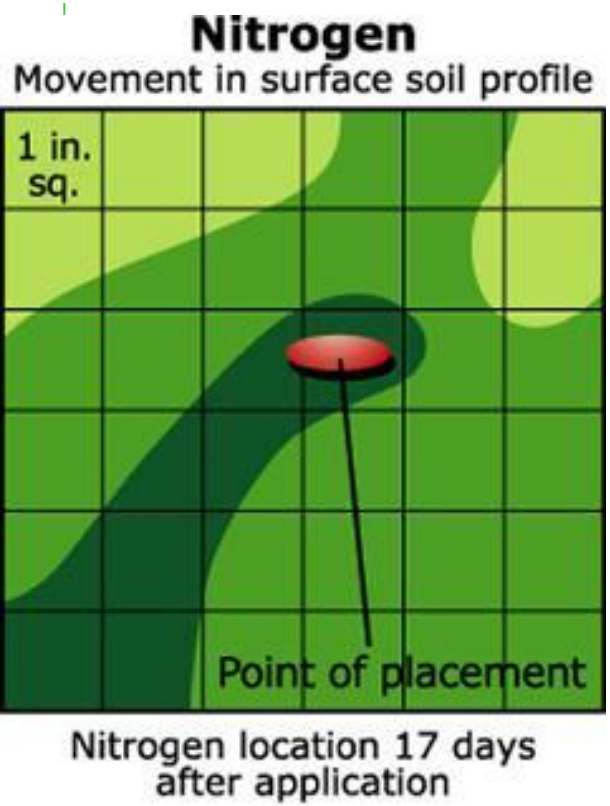




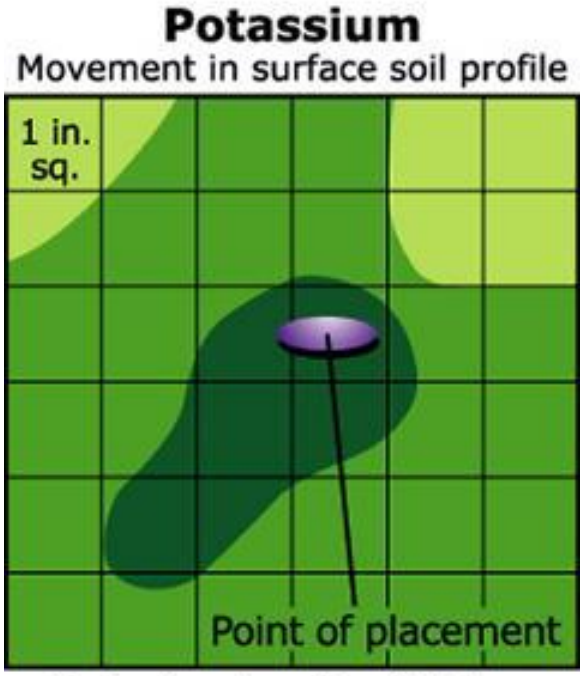
Differences in Mobility of Nutrients in Soil

Mineral Nutrient	Ionic Form/s, and charge	Mobility Rating
Nitrogen (N)	NH_4^+, and NO_3^-	NH_4^+ less mobile, and NO_3^- mobile
Phosphorus (P)	$H_2PO_4^-$ and HPO_4^{2-} as affected by soil pH	Very less mobile, due to reactivity with cations
Potassium (K)	K^+	somewhat mobile
Sulfur (S)	SO_4^{2-}	mobile
Calcium (Ca)	Ca^{2+}	somewhat mobile
Magnesium (Mg)	Mg^{2+}	somewhat mobile
Boron (B)	$H_3BO_4^{3-}$	mobile
Chloride (Cl)	Cl^-	mobile
Copper (Cu)	Cu^{2+}	less mobile
Iron (Fe)	Fe^{3+}, and some Fe^{2+}	less mobile
Manganese (Mn)	Mn^{0+2}	less mobile
Molybdenum (Mo)	MoO_4^{2-}	mobile
Nickle (Ni)	Ni^{2+}	less mobile
Zinc (Zn)	Zn^{2+}	less mobile

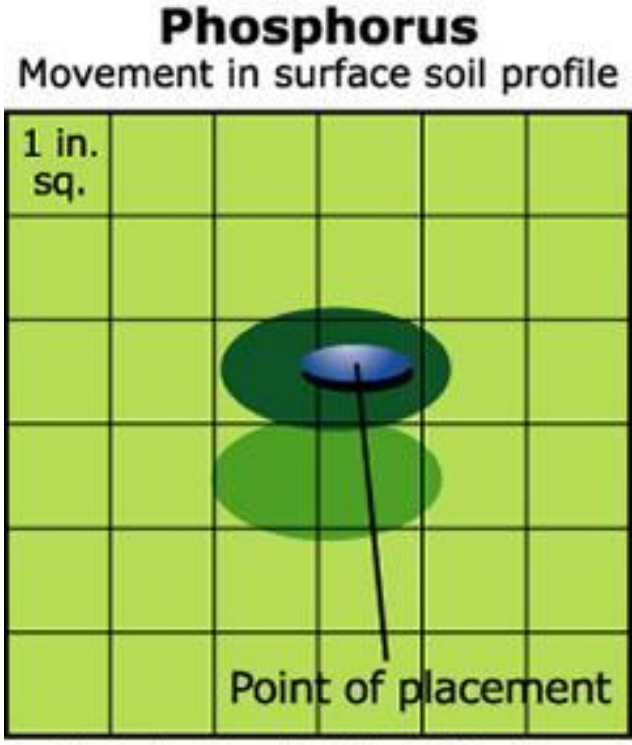
Nutrient Mobility



Nitrogen location 17 days after application



Potassium location 17 days after application



Phosphorus location 17 days after application

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Adapting 4R Nutrient Management Principles to the Whole Farm

- Nutrient Management Planning

4R PLANT NUTRITION

Nutrient Management Approaches

- **Sufficiency**
  - Add necessary rates of deficient nutrients so yields are not limited in present crop
- **Build-Up**
  - Add enough of needed nutrient/s to supply present crop need, and gradually increase soil supply to non-limiting level
- **Maintenance**
  - Replace crop harvest removed nutrients to keep plant nutrient levels at non-limiting levels

Steps of Using a 4R Nutrient Stewardship Plan

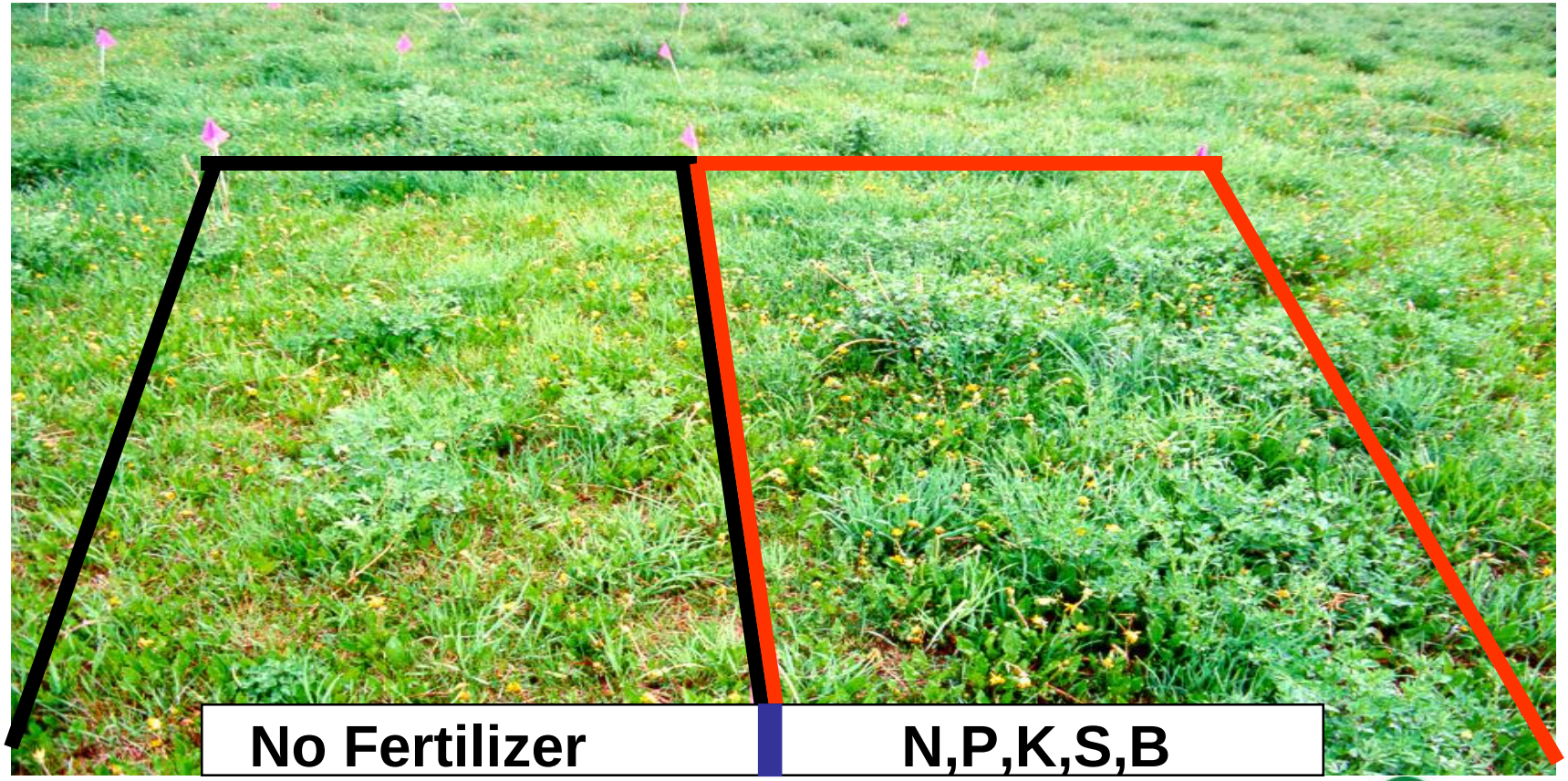
1. Understand the farm goals
2. Gather needed production information
3. Help formulate the plan
4. The farmer makes decisions and implements the chosen practices
5. Monitor the effectiveness of the practices employed

An on-farm research trial

Background

- **Not as much response to fertilizer on pasture/forage fields as desired on the Invermere, BC Ranch.**
- **Wanted to know if an adjustment in fertilization could increase pasture and forage production.**
- **It was suggested that a fertilizer experiment be conducted to observe the response to fertilization.**
- **Ranch's regular fertilizer program 35 N, 30 P_2O_5, 20 K_2O and 15 S**

Fertilizer Response, 15-May, one month after application mid-April



Total of Cut 1 and Cut 2, Topdressed(TD)

Treatment	Yield, ton/acre	Ranking and Significance
N P K S B, + TD	4.54	a
N P K S B Zn Mn Cu, +TD	4.32	ab
N P K S _, +TD, no boron	4.26	abc
N P _ S B, no potassium	4.18	abc
N _ K S B, no phosphorous	3.98	abc
N P K _ B, no sulfur	3.93	bc
_ P K S B, no nitrogen	3.72	c
Check, no fertilizer	2.93	d, significantly less than all other treatments, 90% confidence

Recommendations

- **The most deficient nutrient was N, next S, then P. There appeared to be a moderate response to K and B.**
- **Fertilizer Recommendations:**

75 N, 60 P_2O_5, 100 K_2O, 30 S and 1 B

- **1.6 ton/A more hay**
- **value 1.6 x $80 = $128**
- **Return on fertilizer investment $3.5 (ROI) from each $1 of fertilizer**

Tools to Assess Nutrient Needs

1. Nutrient uptake by forage crop
2. Soil sampling and analysis
3. Plant analysis
4. On-farm trials

1. Estimate Nutrient Uptake

- Check available sources for nutrient uptake by various forage crops.
  - Example: IPNI Estimates of Nutrient Uptake and Removal
    - http://www.ipni.net/article/IPNI-3296
- Match with your realistic target yields

2. Soil Sampling and Analysis

- At least two depths, e.g. 0-6 and 6-24 inches

(0-15 and 15 to 60 cm)

Mid to late Fall is an excellent time to take soil samples

3. Early in-season plant analysis

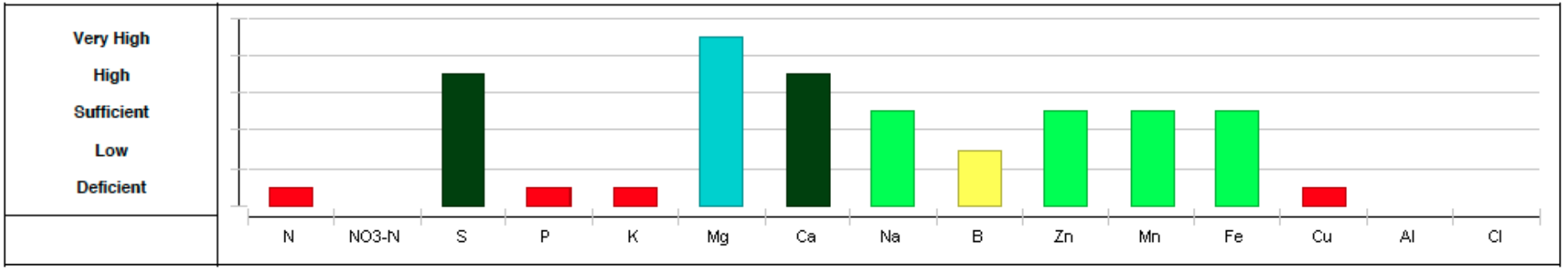
- Sample in spring incase something needs to be added in-season
- Sometimes it is too late, but great information for the next forage cut, or next year

Plant Analysis: poor versus better, soil also

Date Sampled	Lab Number	Nitrogen (%)	Nitrate Nitrogen (%)	Sulfur (%)	Phosphorus (%)	Potassium (%)	Magnesium (%)	Calcium (%)	Sodium (%)	Boron (ppm)	Zinc (ppm)	Manganese (ppm)	Iron (ppm)	Copper (ppm)	Aluminum (ppm)	Chloride (%)
2013-06-21	1770074	2.58		0.48	0.18	1.37	0.60	4.18	0.02	25	33	97	91	3	53	
Normal Range		3.80 5.00		0.20 0.48	0.30 0.80	2.50 5.00	0.35 0.50	1.00 3.00	0.01 0.03	30 80	20 80	30 150	30 250	5 30		

	N/S	N/K	P/S	P/Zn	K/Mg	K/Mn	Fe/Mn	Ca/B
Actual Ratio	5.3	1.9	0.4	54	2.3	141	0.9	1650
Expected Ratio	12.0	1.1	1.7	100	9.0	460	1.9	400

Nutrient Sufficiency Ratings



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	N/S	N/K	P/S	P/Zn	K/Mg	K/Mn	Fe/Mn	Ca/B
Actual Ratio	13.8	2.3	0.7	67	3.7	241	1.7	1943
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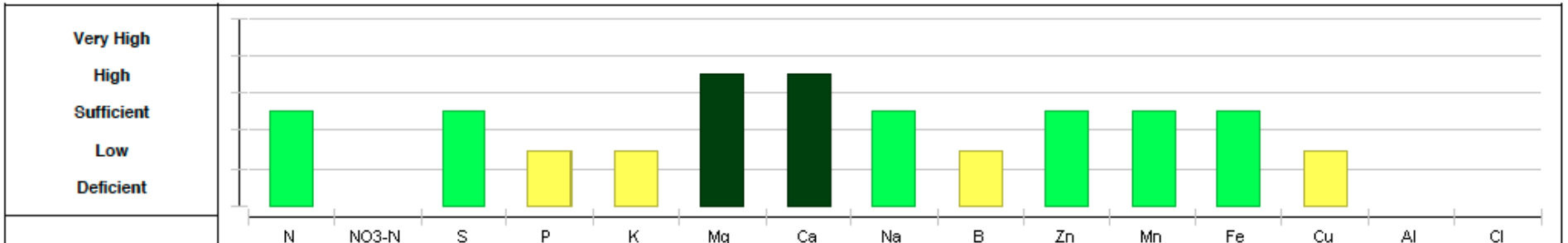
Nutrient Sufficiency Ratings



Poor Growth Alfalfa

Date Sampled	Lab Number	Nitrogen (%)	Nitrate Nitrogen (%)	Sulfur (%)	Phosphorus (%)	Potassium (%)	Magnesium (%)	Calcium (%)	Sodium (%)	Boron (ppm)	Zinc (ppm)	Manganese (ppm)	Iron (ppm)	Copper (ppm)	Aluminum (ppm)	Chloride (%)
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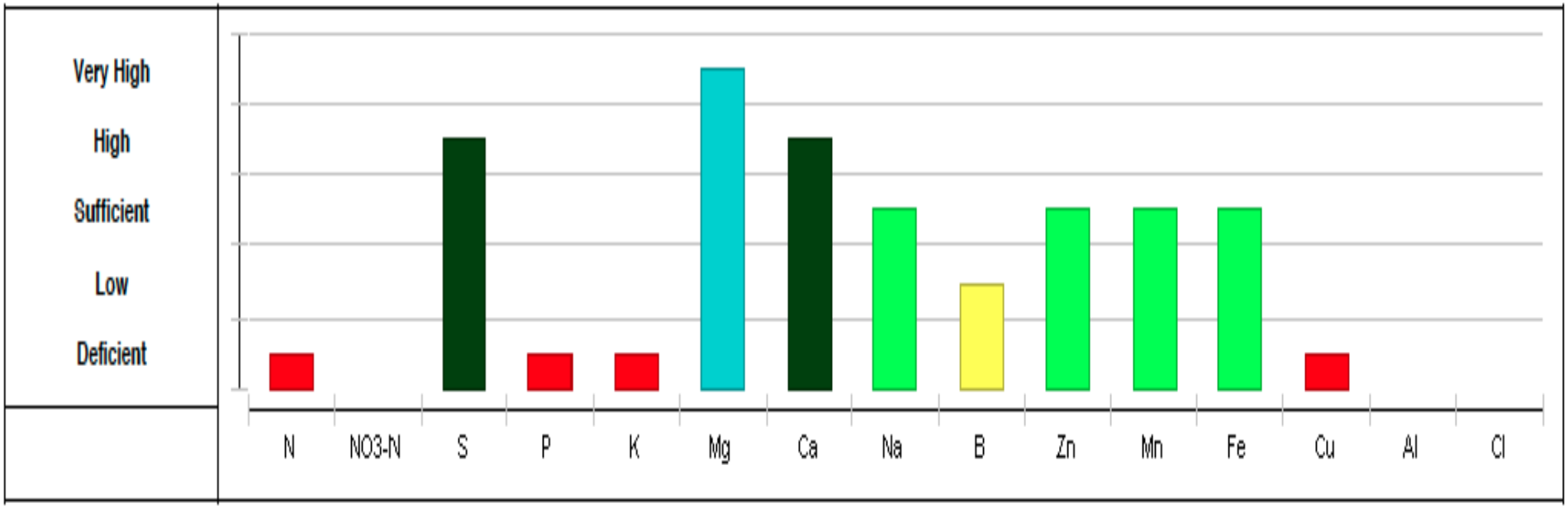

Better Growth Alfalfa

Date Sampled	Lab Number	Nitrogen (%)	Nitrate Nitrogen (%)	Sulfur (%)	Phosphorus (%)	Potassium (%)	Magnesium (%)	Calcium (%)	Sodium (%)	Boron (ppm)	Zinc (ppm)	Manganese (ppm)	Iron (ppm)	Copper (ppm)	Aluminum (ppm)	Chloride (%)
2013-06-21	1770073	4.62		0.33	0.24	1.98	0.53	4.75	0.03	24	36	82	138	4	75	
Normal Range		3.80 5.00		0.20 0.48	0.30 0.80	2.50 5.00	0.35 0.50	1.00 3.00	0.01 0.03	30 80	20 80	30 150	30 250	5 30		

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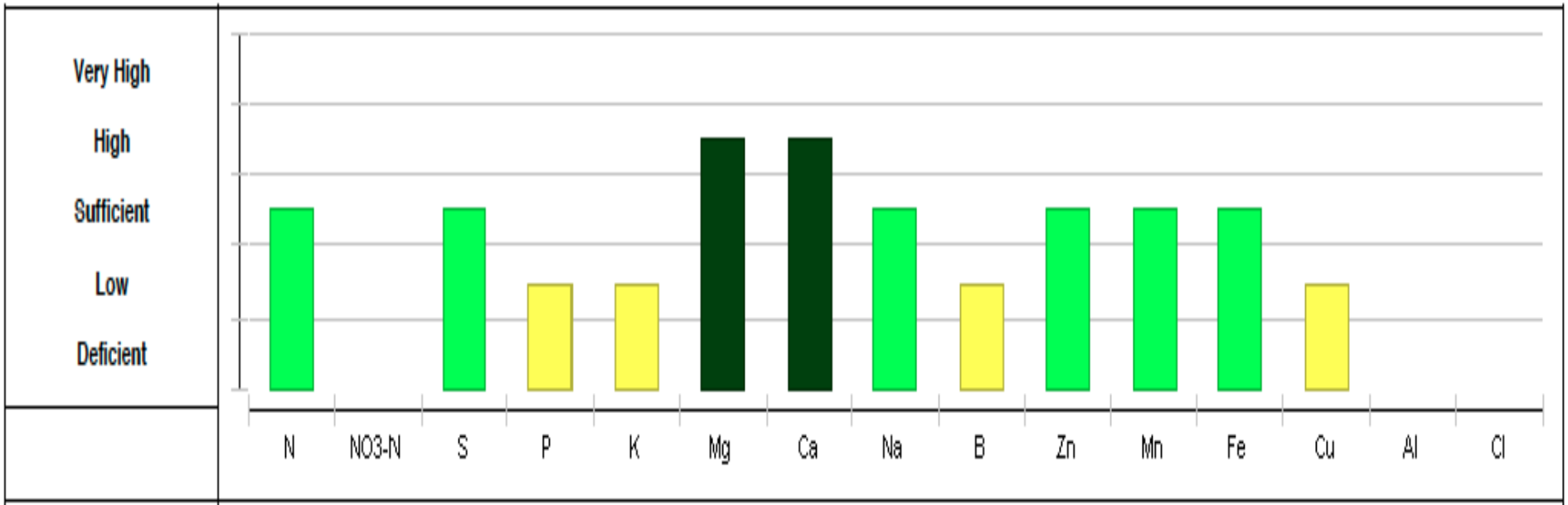

Alfalfa

Soil test result and recommendation

» P2O5	4	ppm	» 85 lb/a, broadcast
» K2O	102	ppm	» 138 lb/a, br.
» S	12	lb/a	» 20 lb/a, broadcast
» B	0.9	ppm	» 1 lb/a, br.
» Zn	0.36	ppm	» 6 lb/a, broadcast

Plant Analysis Report, Alfalfa

Reported in %

Element		Ideal Level
N	3%,	2.6-3.7
P	**0.20%**	**0.26-0.7**
K	**1.0%**	**2.5-3.8**
S	**0.22%**	**0.31-0.5**
Ca	2.42%	0.51-3.0
Mg	0.90%	0.31-1
Na	0.05%	0-0.1

Reported in ppm

Element		Ideal Level
Zn	***30***	***21-70***
Fe	67	30-250
Mn	62	21-200
Cu	5	8-29, ?
B	***44***	***31-80***

On-Farm Nutrient Trials

- Nothing more useful than local applied research trials
- Great way to try various nutrients, forms of fertilizers, rates, timing and placement, **or 4Rs**

Questions

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