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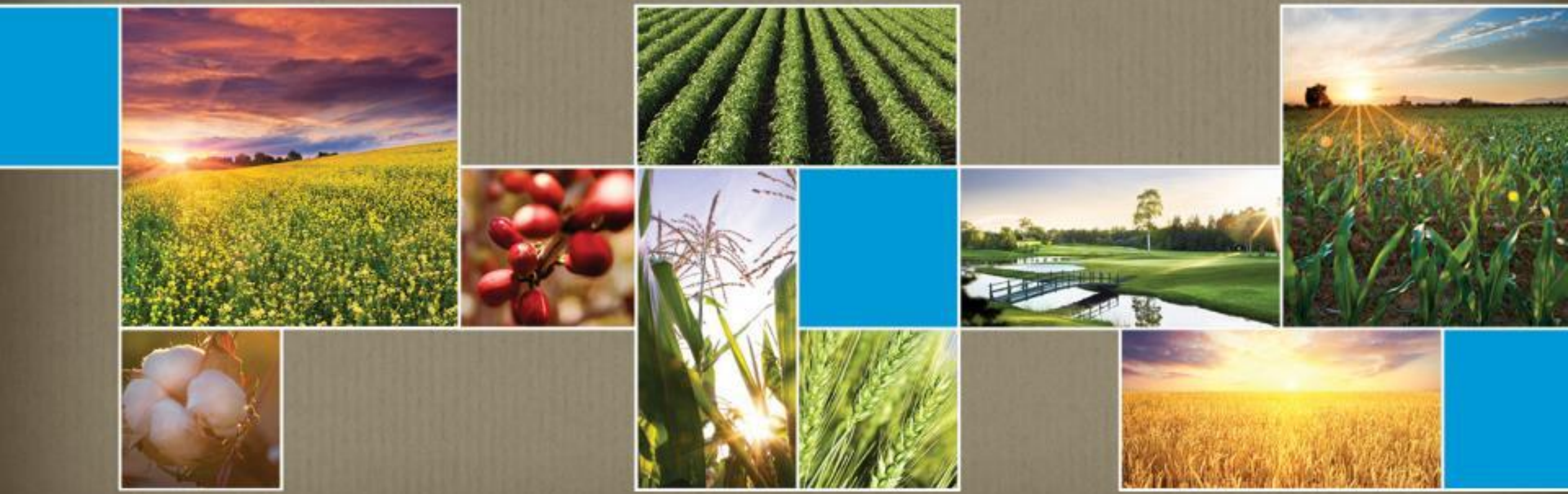
Investing fertilizer dollars in products that will return additional income - Emphasis on K, S and Micronutrients



Maximum crop production cannot be achieved with fertilizers and amendments alone – We need to answer first:

- **What Crop Yields Are Possible?**
- **What fertility and moisture is required to get there?**
  - **Crops exhibit different water use efficiency in every part of the prairies and the Red River valley is not an exception.**
  - **Water use efficiency is also weather dependent and when combined with best management practices for fertilizers and desirable crop genetics leads to maximum yields.**
- **Fertility products that work and those that don't.**

What determines Maximum Yield?

- **Crop genetics**
- **Solar radiation**
- **WATER**
- **Nutrients**

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Potassium

Types of Responses to KCl (0-0-60)

- ✓ **responses to K on low soils**
- ✓ **responses to K on high soils**
- ✓ **responses to chloride**

General Soil Test K criteria*

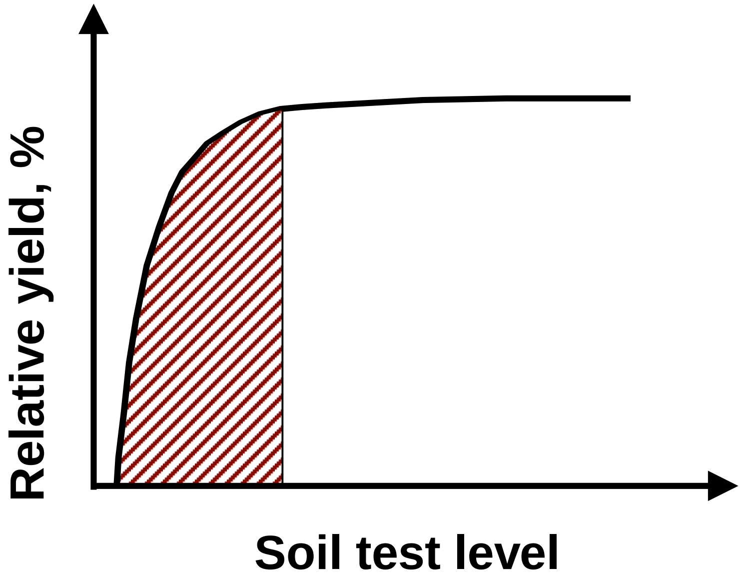
Soil Test K (0-6" depth)			General Potassium Recommendations to correct deficiency** lb K_2O/acre
Rating	**ppm**	**lb/acre**	
Very deficient	0-25	0-50	130-180
"	26-50	51-100	90-150
"	51-75	101-150	50-100
Moderately deficient	76-100	151-200	10-70
	101-125	201-250	10-50
Critical level	**125**	**250**	**0-20**
High Potassium levels (Marginal to Adequate)	**126+**	**251+**	0

** cereals and oilseeds

***Sources: Malhi et al. (1993); McKenzie (2001); Saskatchewan Agriculture and Food (2000).**

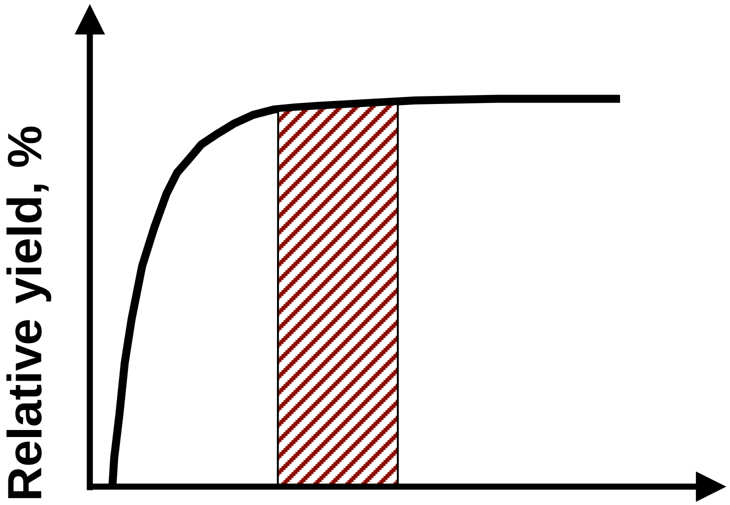
Sufficiency Approach to Fertilization

- Apply nutrient to maximize net returns to fertilization in the year of application
  - **Strategy: fertilize only when there is a good chance that a profitable yield response will be realized**
  - Soil test levels kept in lower, responsive ranges



Build and Maintenance Approach

- Remove P or K as a yield-limiting variable
  - **Strategy: apply extra P or K (more than expected crop removal) to build soil tests to levels that are not yield-limiting**
  - Soil test levels kept in higher, non-responsive ranges



Build and Maintenance Criteria

- **Add P and K at a rate equal to crop removal + to build the soil levels.**
  - **50 bu/A wheat @ 0.5 lb P_2O_5/bu = 25 lbs**
- **To build soil P by 1 lb/A you need 12-28 lb P_2O_5/A.**
- **To build soil K by 1 lb/A you need 8-16 lb K_2O/A.**

Sufficiency vs. BCSR

- the main objective when using the sufficiency level concept is to fertilize according to the plant's needs
- the BCSR aims to fertilize according to the soil's needs

The Base Cation Saturation Ratio Concept

- This “ideal soil” was originally proposed by Firman Bear and coworkers in New Jersey during the 1940s but **It is unclear, however, how these values for the ideal soil were established**.
- According to the BCSR concept, maximum plant growth will be achieved only when the soil’s exchangeable Ca, Mg, and K concentrations are approximately **65% Ca, 10% Mg, and 5% K** (termed the ideal soil).
- **the experiments carried out in New Jersey and Missouri were neither well designed nor well interpreted by today’s standards**.

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The BCSR Concept

- First cracks in the concept appeared with the research by Giddens and Toth (1951), who carried out an experiment with four soils that were saturated at seven Ca/Mg/K ratios (with one being “ideal”), and compared plant growth between treatments.
- **They concluded that provided Ca was the dominant cation, no specific cation ratio produced the best yield.**

The BCSR Concept

- Than there is another issue: **The system is based on a faulty understanding of CEC and soil acids, as well as a misuse of the greatly misunderstood term percent base saturation.**

The BCSR Concept

- Once soils are much above pH 5.5 (and almost all agricultural soils are above this pH, making them moderately acid to neutral to alkaline), the entire CEC is occupied by Ca, Mg, and K (as well as some Na and ammonium). There are essentially no truly exchangeable acids (hydrogen or aluminum) in these soils. This means that the actual CEC of the soils in this normal pH range is just the sum of the exchangeable bases. **The CEC is therefore 100% saturated with bases when the pH is over 5.5 because there are no exchangeable acids.**

The BCSR Concept

- Using this system, **will usually mean applying more nutrients than suggested by the sufficiency system - with a low probability of actually getting a higher yield or better crop quality.**

Example from Manitoba CanoLAB

The BCSR Concept

Ca:Mg ratio	Ca	Mg	Yield
	---- % -----		ton/acre
Theresa silt loam:			
2.28	34	35	3.31
3.4	45	22	3.31
4.06	46	19	3.4
4.76	49	17	3.4
5.25	52	16	3.5
8.44	62	12	3.22
Plainfield loamy sand			
2.64	32	20	4.14
2.92	35	20	4.28
3.48	38	18	4.35
4.81	43	15	4.12
7.58	65	13	4.3
8.13	68	15	4.35

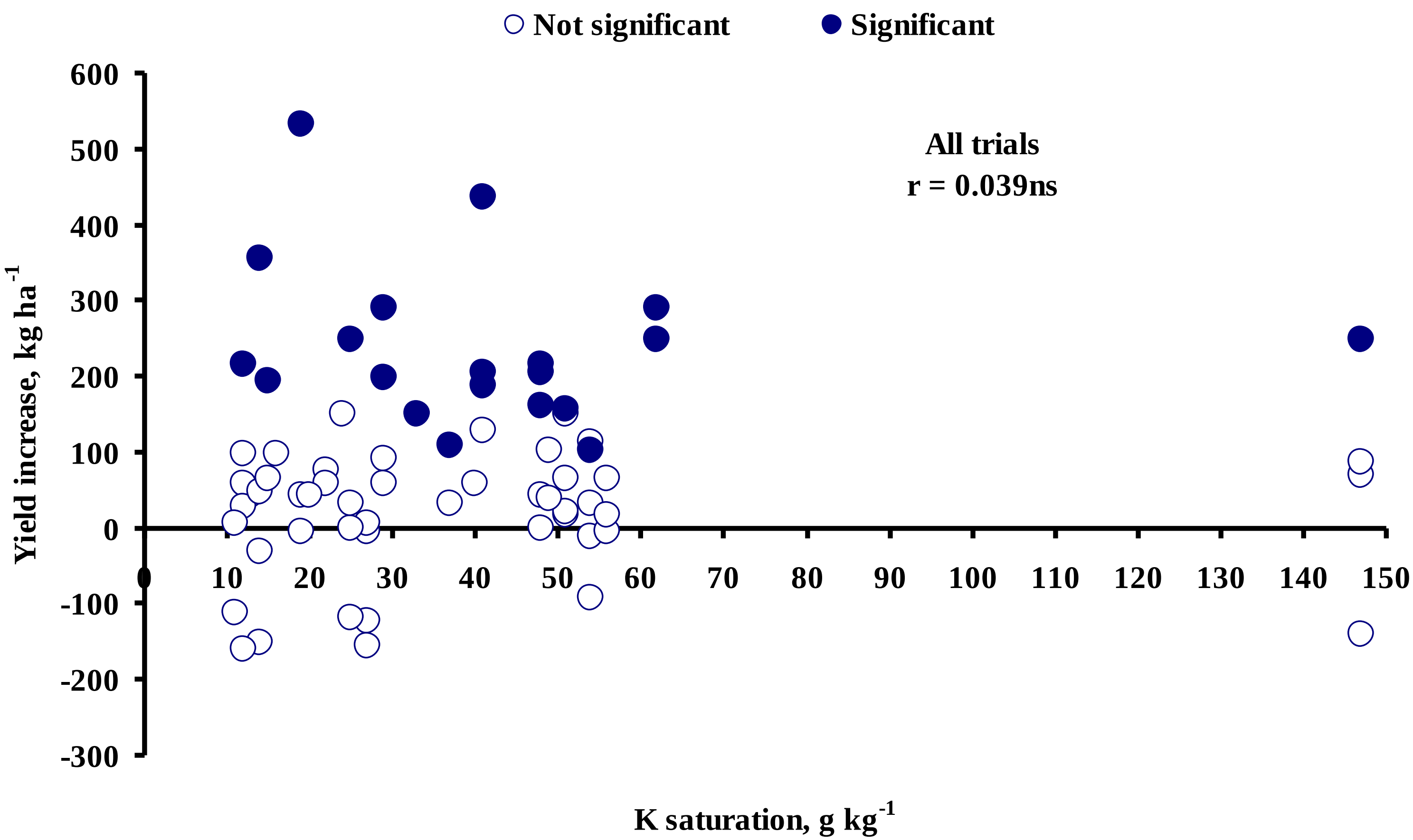
Simpson et al. 1979. Comm. Soil Sci. plant Anal. 10:153-162

McLean et al. 1983. Agron. J. 75: 635-639.

The main conclusions were:

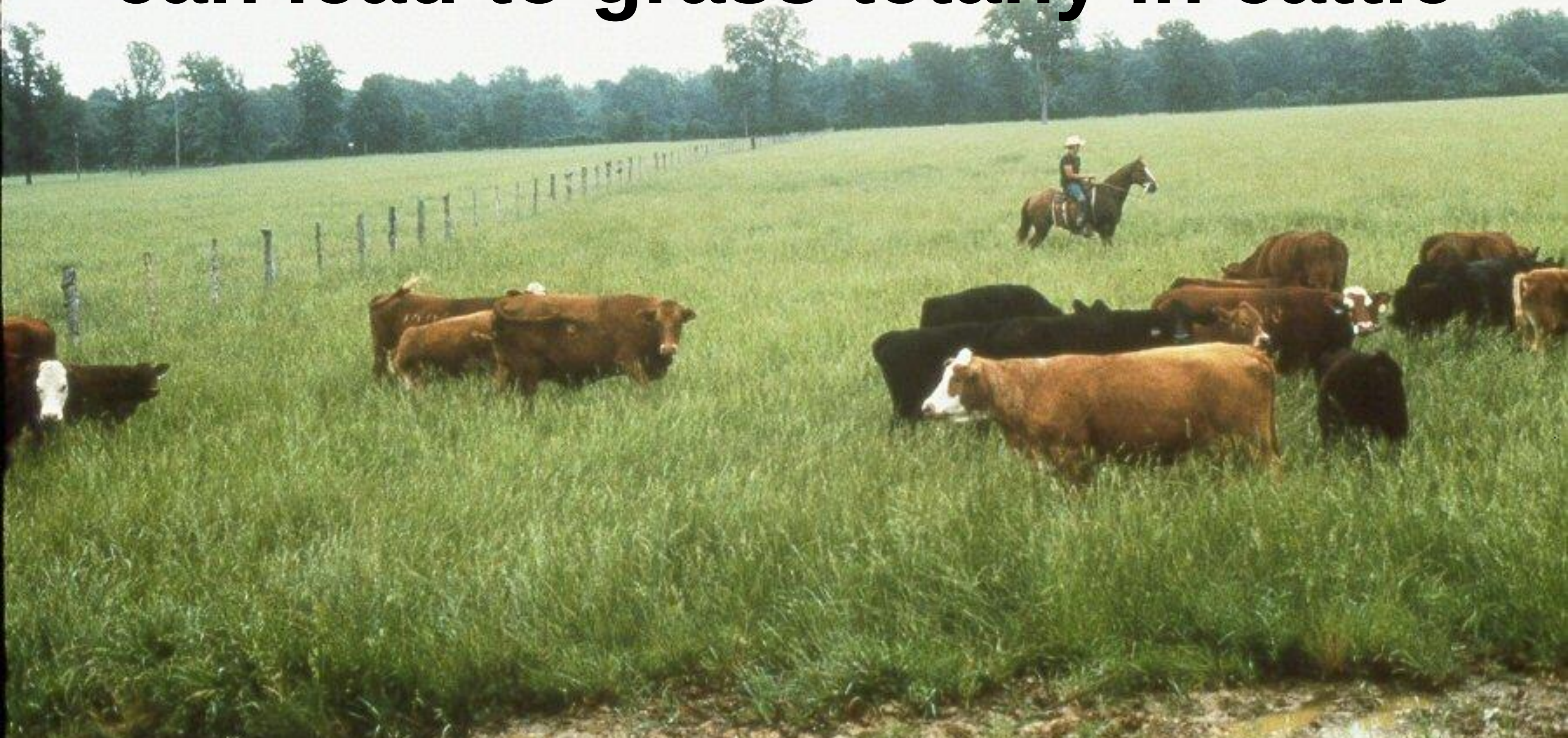
- Sufficiency concept still worked the best.
- The results strongly suggest that for maximum crop yields, emphasis should be placed on providing sufficient, but non-excessive levels of each basic cation rather than attempting to attain a favorable BCSR **which evidently does not exist**.

Response of barley to K application on high K soils*



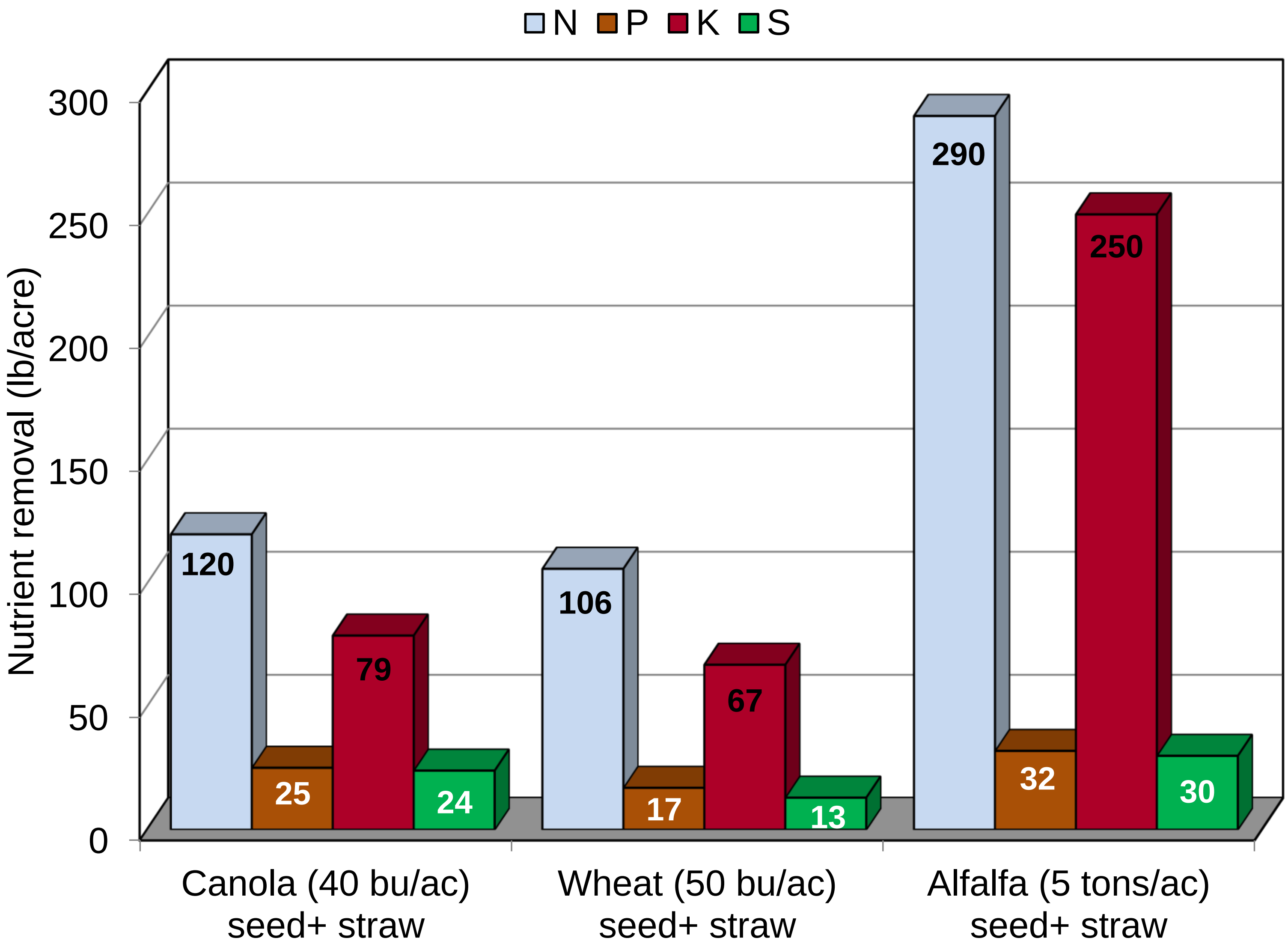
*adapted from Karamanos et al. 2003

Imbalance between K and Mg in grass tissue can lead to grass tetany in cattle



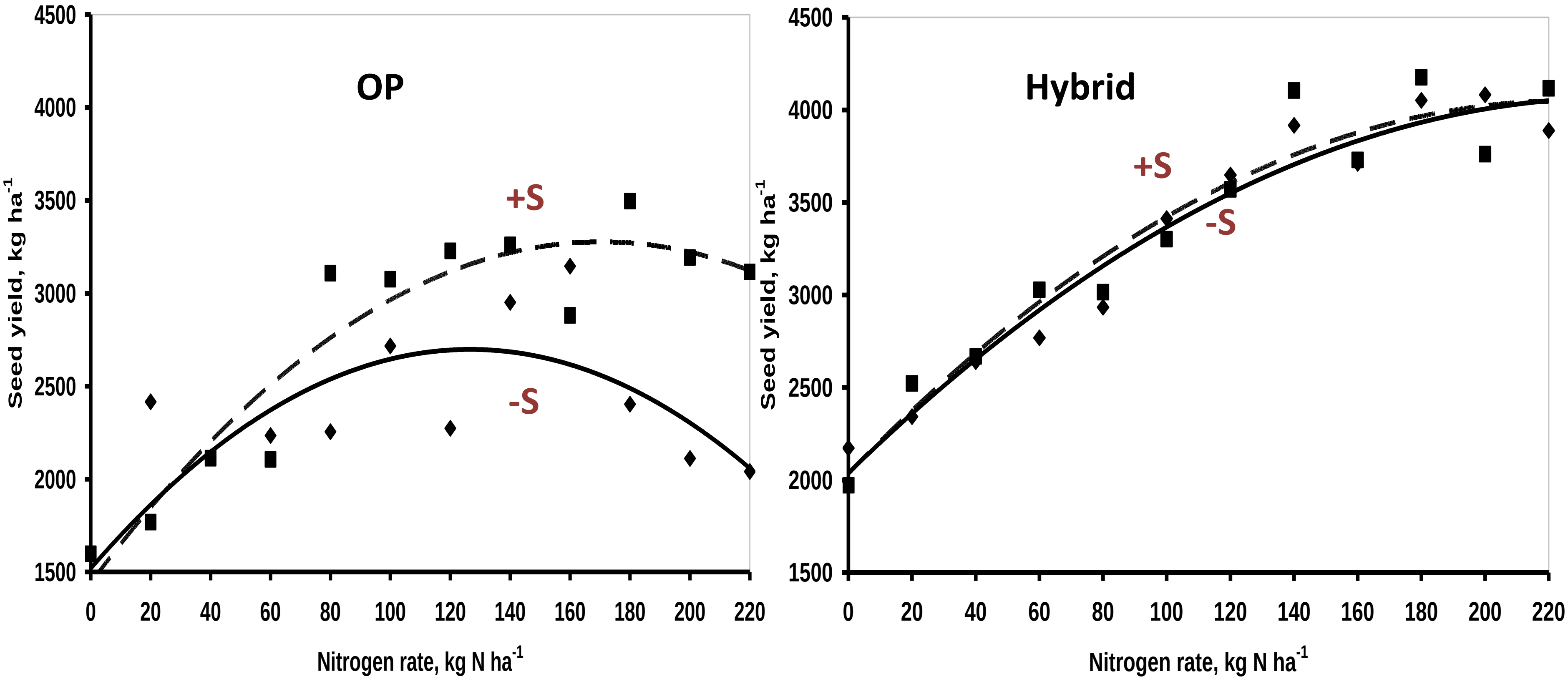
Sulphur

Crops Remove Similar Quantities of S as P



Yield of OP or Hybrid Canola as a function of N application with or without 40 kg S ha^{-1}

- **Hybrid cultivars produced higher seed yield than OP lines but did not require additional S**

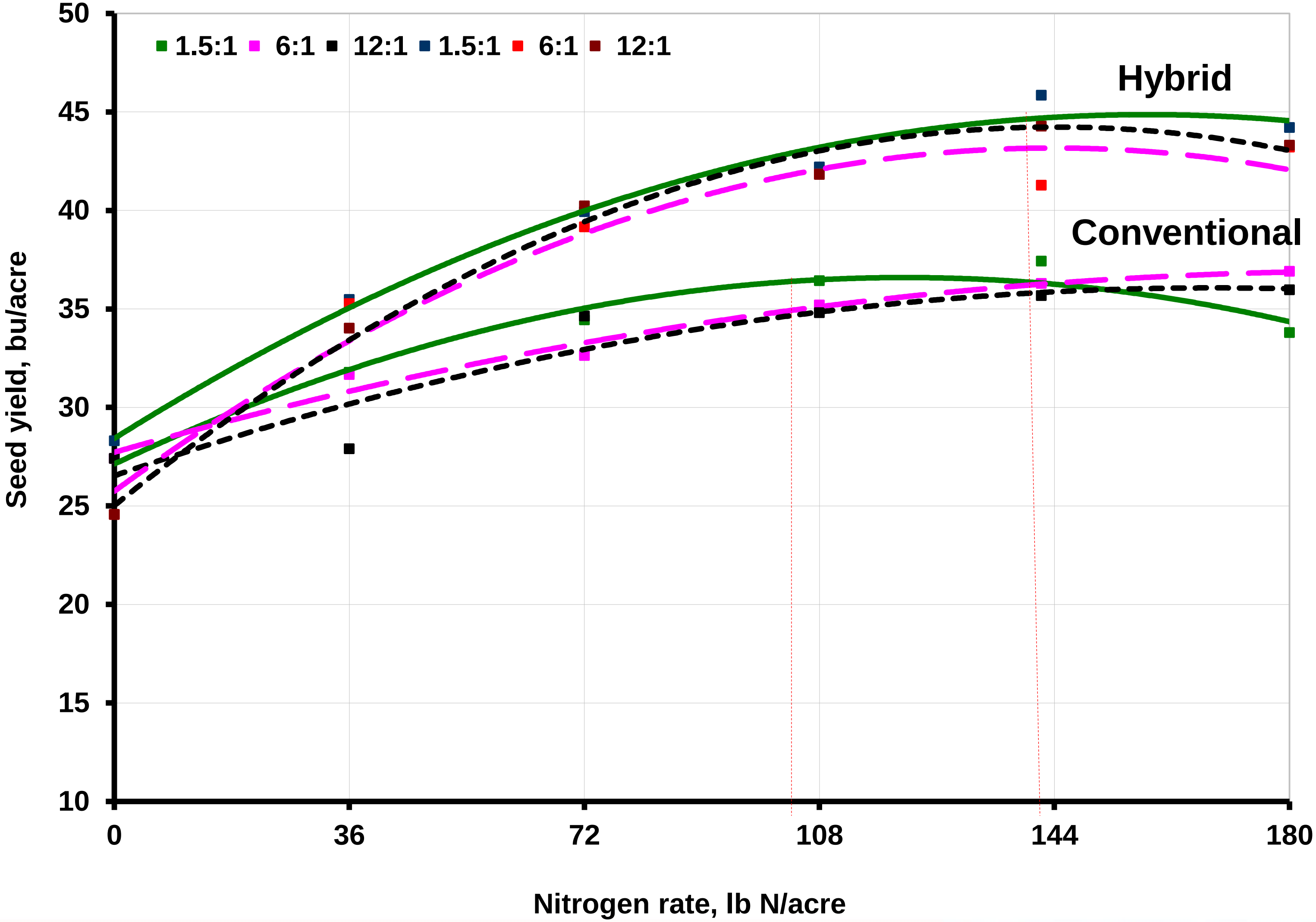


Background

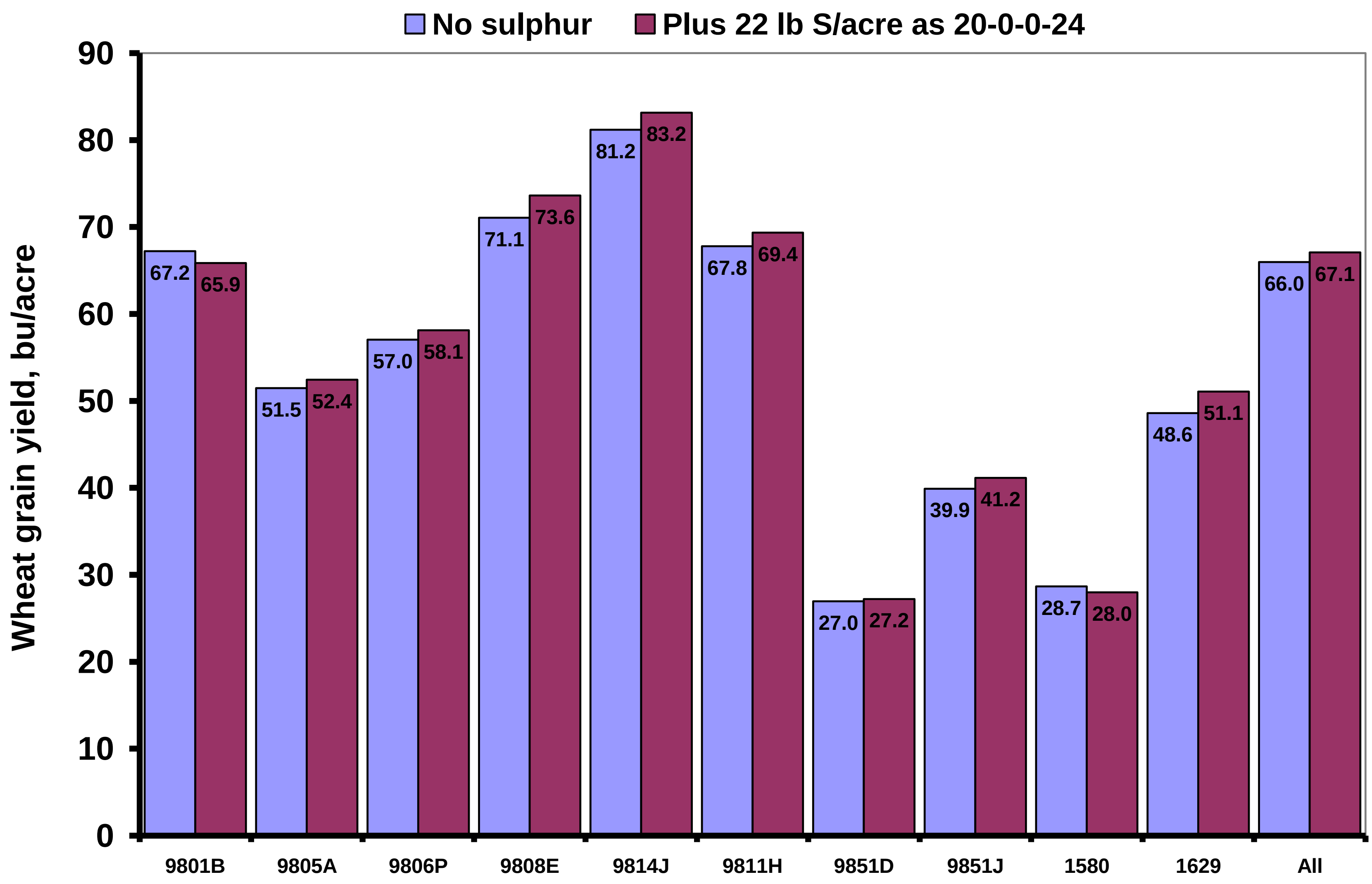
- Does balance of N and S nutrition mean a certain N:S ratio?
- Are ratios an artefact of fertilizing S deficient soils?
- Is an “optimum” N:S ratio required even even on soils that are sufficient in either or both of these two major nutrients?

R.E. Karamanos, T.B. Goh and D.P. Poisson, 2005. Nitrogen, Phosphorus and Sulfur Fertilization of Hybrid Canola. Journal of Plant Nutrition, 28, 1145 - 1161.
R.E. Karamanos, T.B. Goh and D.N. Flaten, 2007. Nitrogen and Sulphur Fertilizer management for Growing Canola on Sulphur Sufficient Soils. Canadian Journal Plant Science, 86: 201-210.

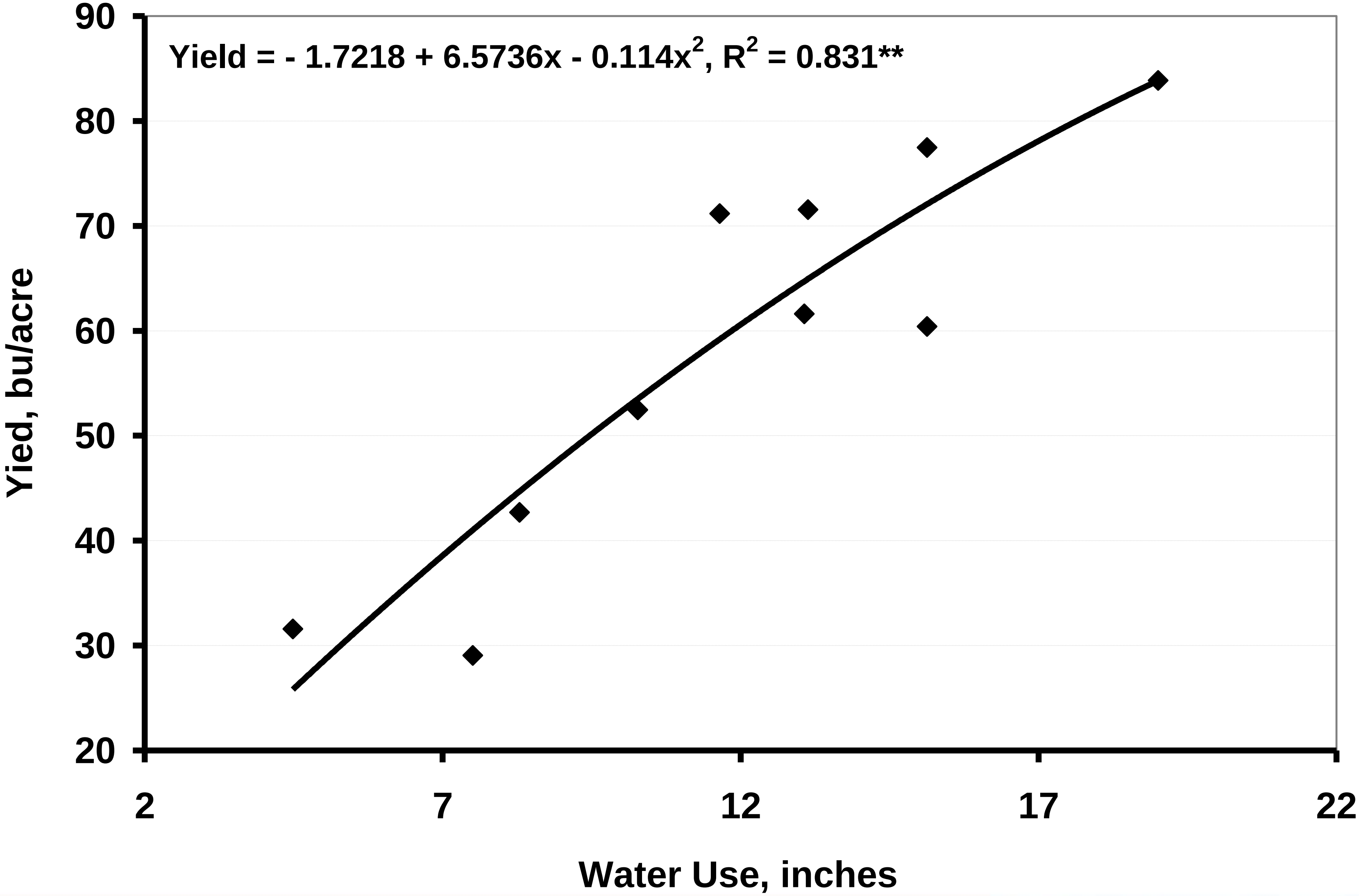
Final studies (2002-2004): Hybrid vs. Conventional Canola



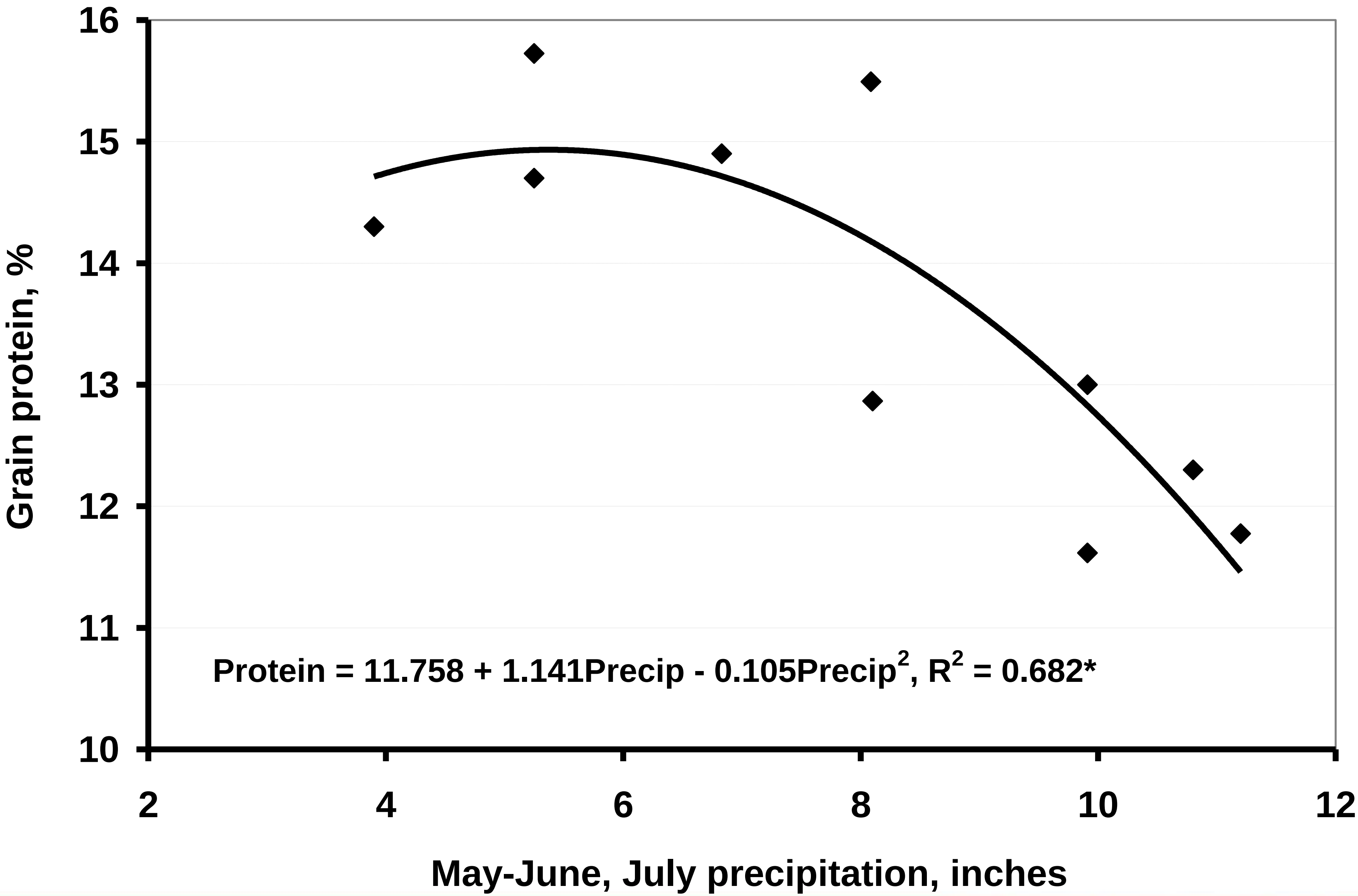
Effect of S on wheat yield



Effect of S on wheat yield

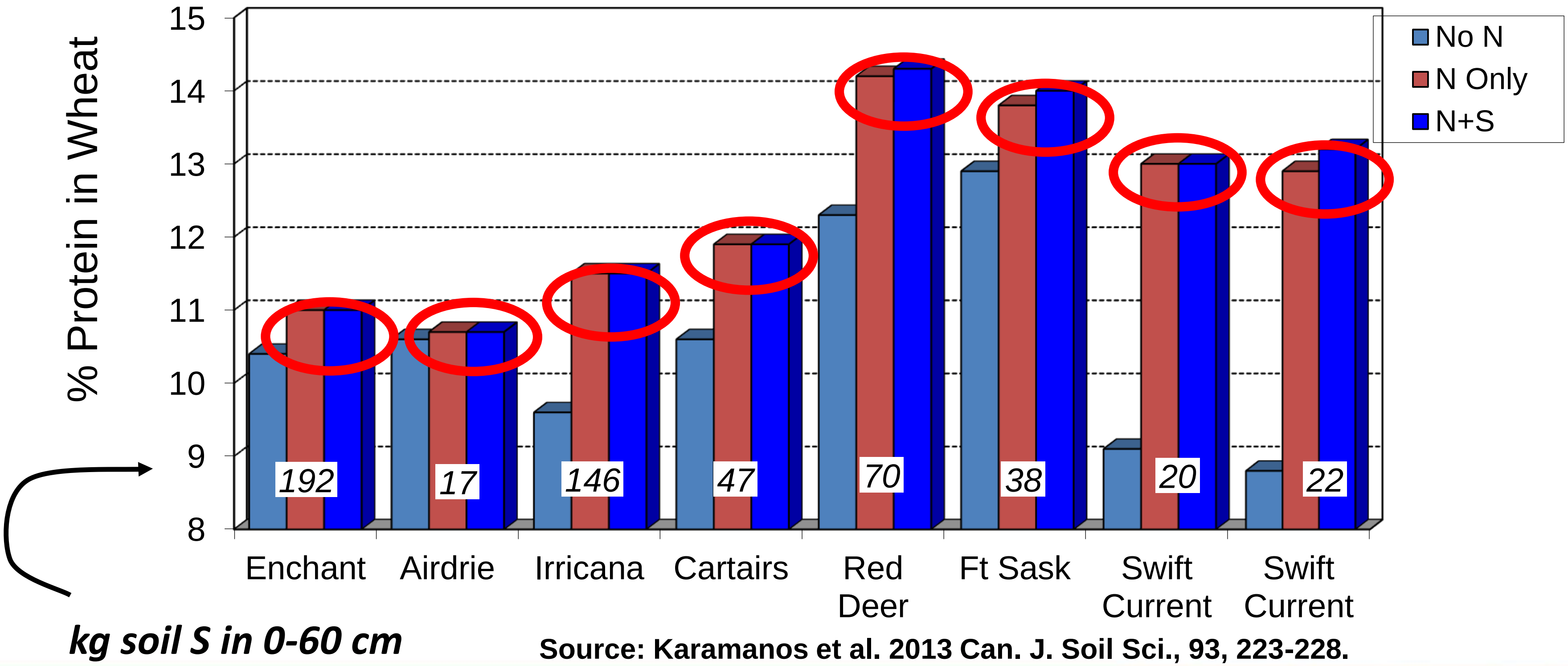


Effect of S on protein



Sulphur Fertilization and Wheat Quality

- **Bread-making wheat requires protein quantity & quality**
- **Protein premiums for wheat reflect the importance of protein in crop quality … <u>but only protein N is measured</u>**
- **As currently measured, S has little effect on % protein**



Source: Karamanos et al. 2013 Can. J. Soil Sci., 93, 223-228.

N is a Major Constituent of Protein

- Remember you get paid:

  %N × 5.7

Conclusions

- Deliberate and indiscriminate application of S to increase protein in CWRS and Durum wheat grain is not a recommended practice, unless S deficiency is corrected in which case an indirect benefit of increased grain protein might ensue.

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Micronutrients

THE POWER TO MAKE THINGS GROW

Question: Micronutrients - When should we use them?

Answer: When their application results in an economic benefit to the farmer!

Define what “works” means to you

- Greener the next day?
- Higher nutrient concentration in leaves?
- Better than the neighbor’s?
- Better than last year?
- Logical?

How is the Economic Benefit Measured?

- Increased yield
- Improved quality (mostly perception)

How is the Economic Benefit Not Measured?

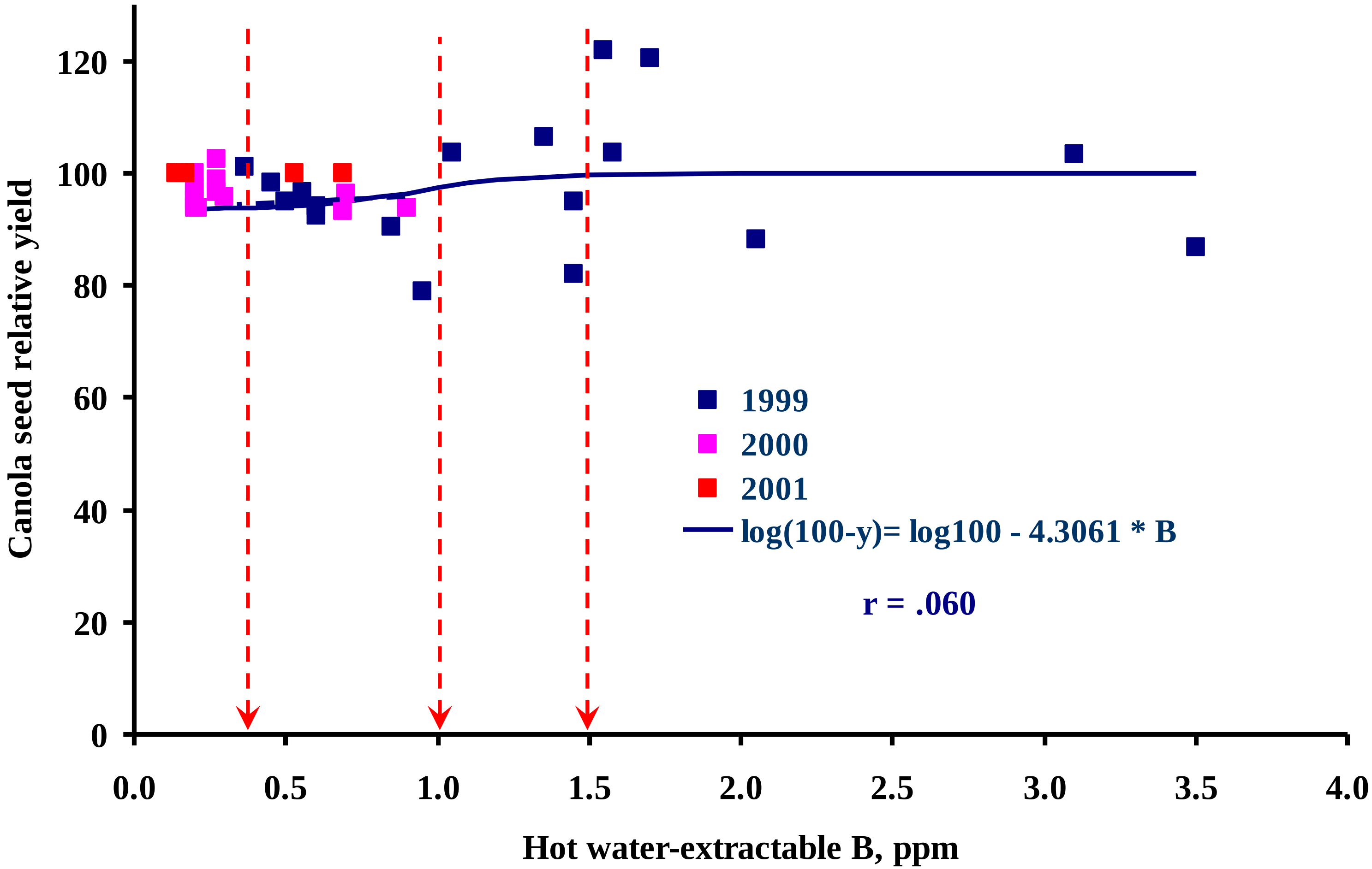
- In most cases when soil test value above critical level – “marginal” range
- Increased tissue level as a result of a micronutrient application

Micronutrient-Deficient Environments

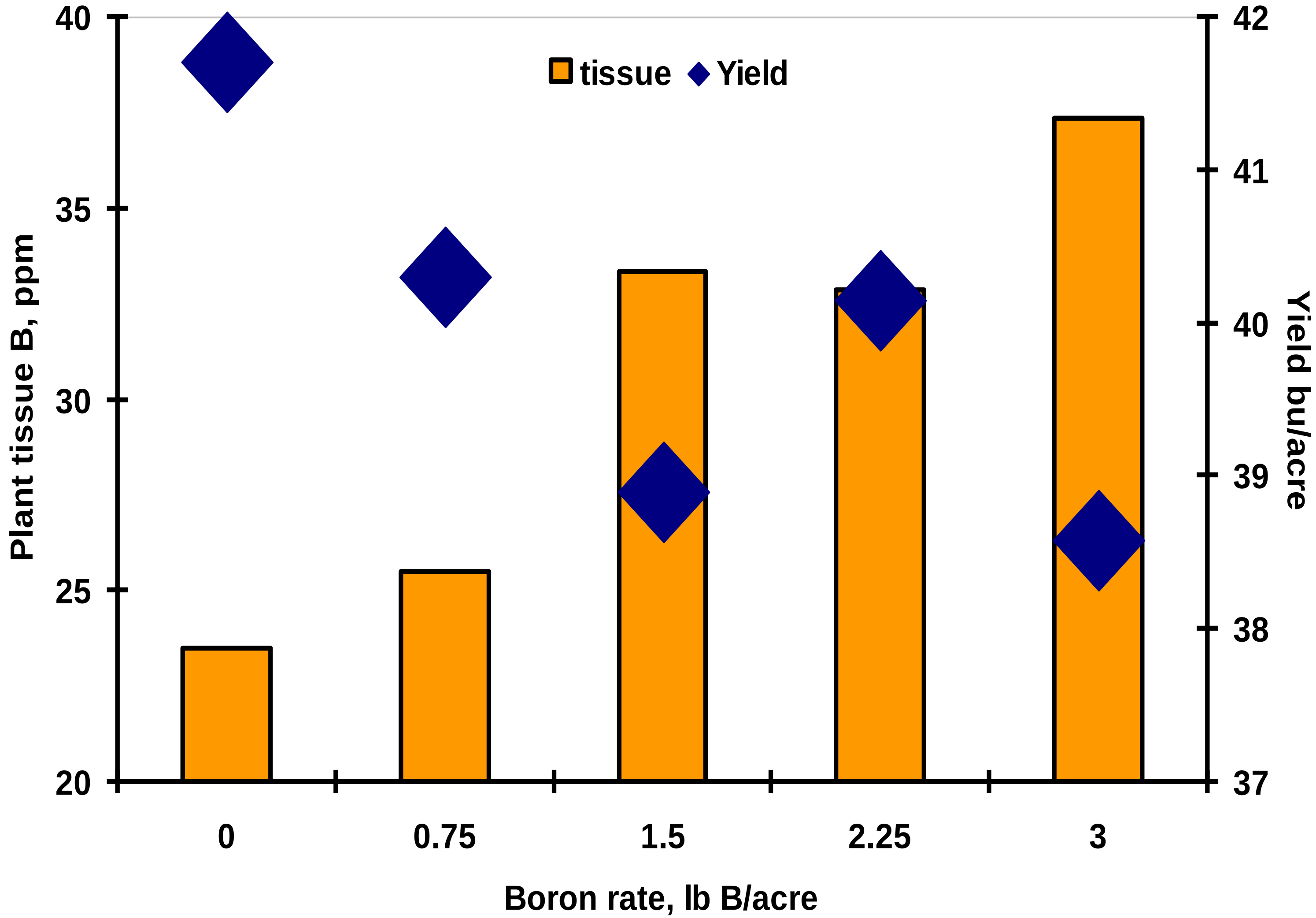
- Best way to define by Yield Responses.
- Responses can be obtained as a result of
  - **Soil Deficiencies**
  - **Plant physiological effects**

Boron

Interpretation of Soil Tests w. Canada 40 sites (yield 18-63 bu/ac)

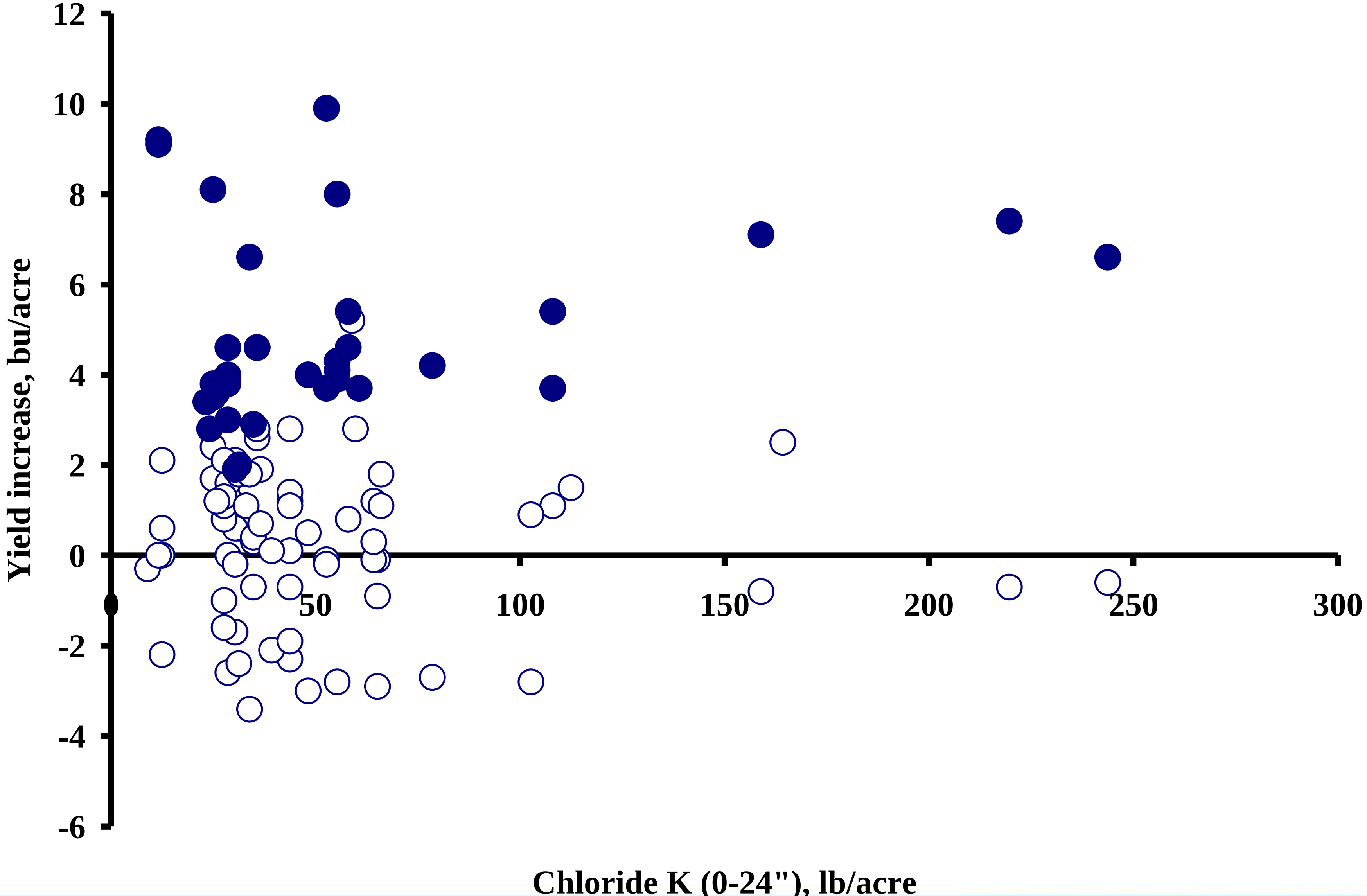


Tissue B and yield (high yield)



Chloride

Barley Response to Chloride



Copper

Copper

- **5 million acres have been identified as potentially deficient in copper in western Canada**
- **Copper fertilization has recently been found to prevent Fusarium Head Blight in North Dakota, although yield responses have been inconsistent**
- **Sensitivity of crops to Cu deficiency is usually in the order of:**

(wheat, flax, canary seed) > (barley, alfalfa) > (timothy seed, oats, corn) > (peas, clovers) > (canola, rye, forage grasses)

Copper Soil Criteria

- Criteria were developed in 1980-85
  - **Manitoba 0.2 ppm**
  - **Saskatchewan 0.4 ppm**
  - **Alberta 0.6 ppm**
  - **DTPA extraction**
- But most of marketing/selling is happening between 0.4 and 1.2 ppm!

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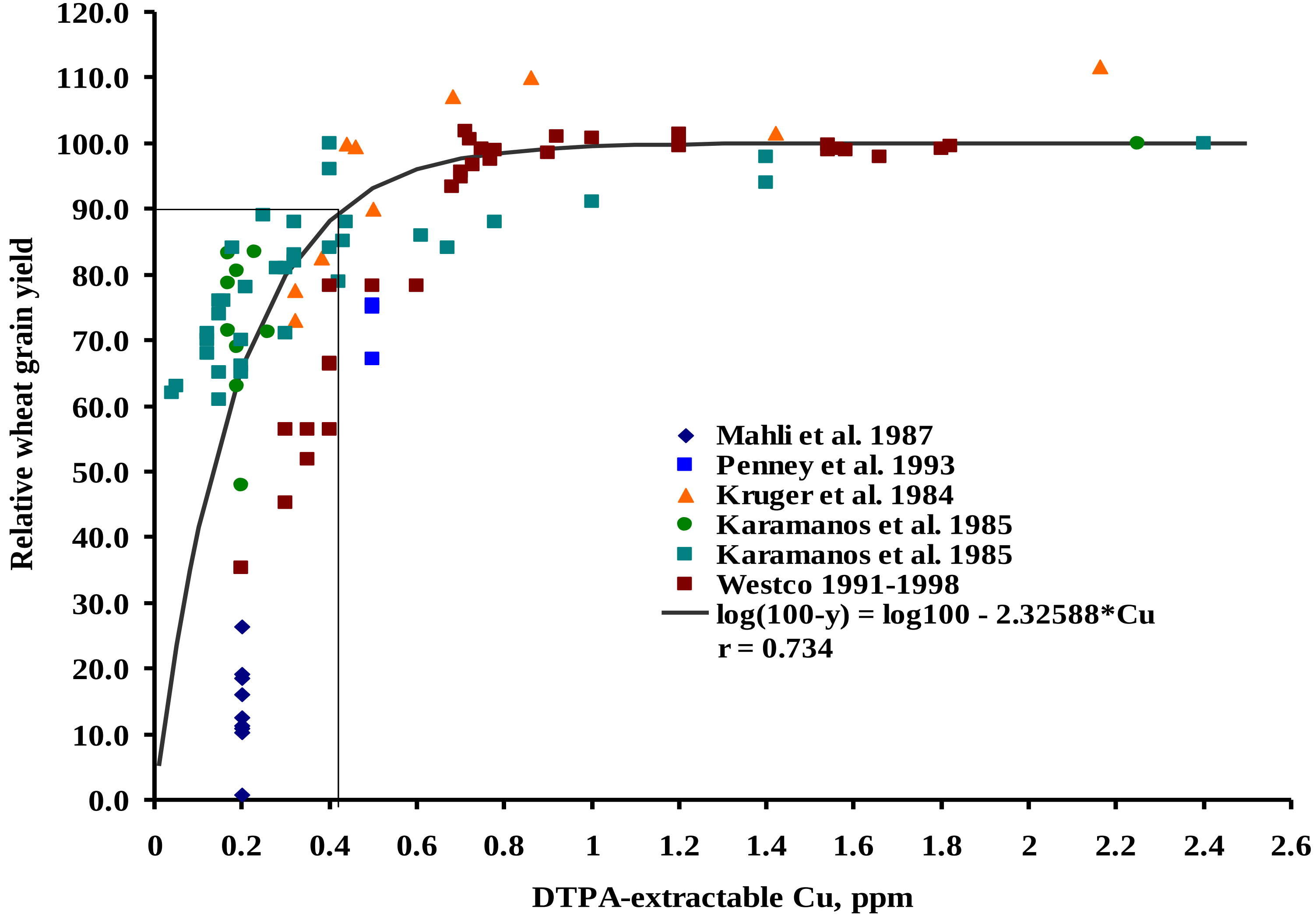
Interpretation of Soil Tests - Mineral soils



Interpretation of Soil Tests for Copper

- Based on 102 tests with spring wheat in western Canada
  - **Deficient < 0.4 ppm (52 tests):**
    - **Average Cu test 0.24±0.09 ppm**
    - **94% probability of obtaining an agronomic response**
    - **62% probability of obtaining an economic response**
  - **Marginal 0.4 – 1.2 ppm (50 tests)**
    - **Average Cu test 0.68±0.24 ppm**
    - **16% probability of obtaining an agronomic response**
    - **2% probability of obtaining an economic response**

Manganese

Manganese

- **Extensive work has been carried out on organic (peat) soils in all three Prairie Provinces**
- **Closest as far as mineral soils are concerned: Responses of soybeans growing on calcareous soils to Mn in North Dakota have been reported as a result of Mn induced deficiency by FeEDDHA and low soil temperature**

Manganese toxicity

- pH 5.2
- Mn 81.3 ppm
- Plant tissue 1090 ppm

Zinc

Zinc

Extensive work on zinc has been carried out with

- **corn**
- **beans**
- **flax**
- **wheat**

Zinc Identification

- Extensive database
- NO RESPONSES with cereals and oilseeds
- Responses with corn and beans
- DTPA extraction (proven unsuitable for mineral soils in western Canada!)

Soil Criteria

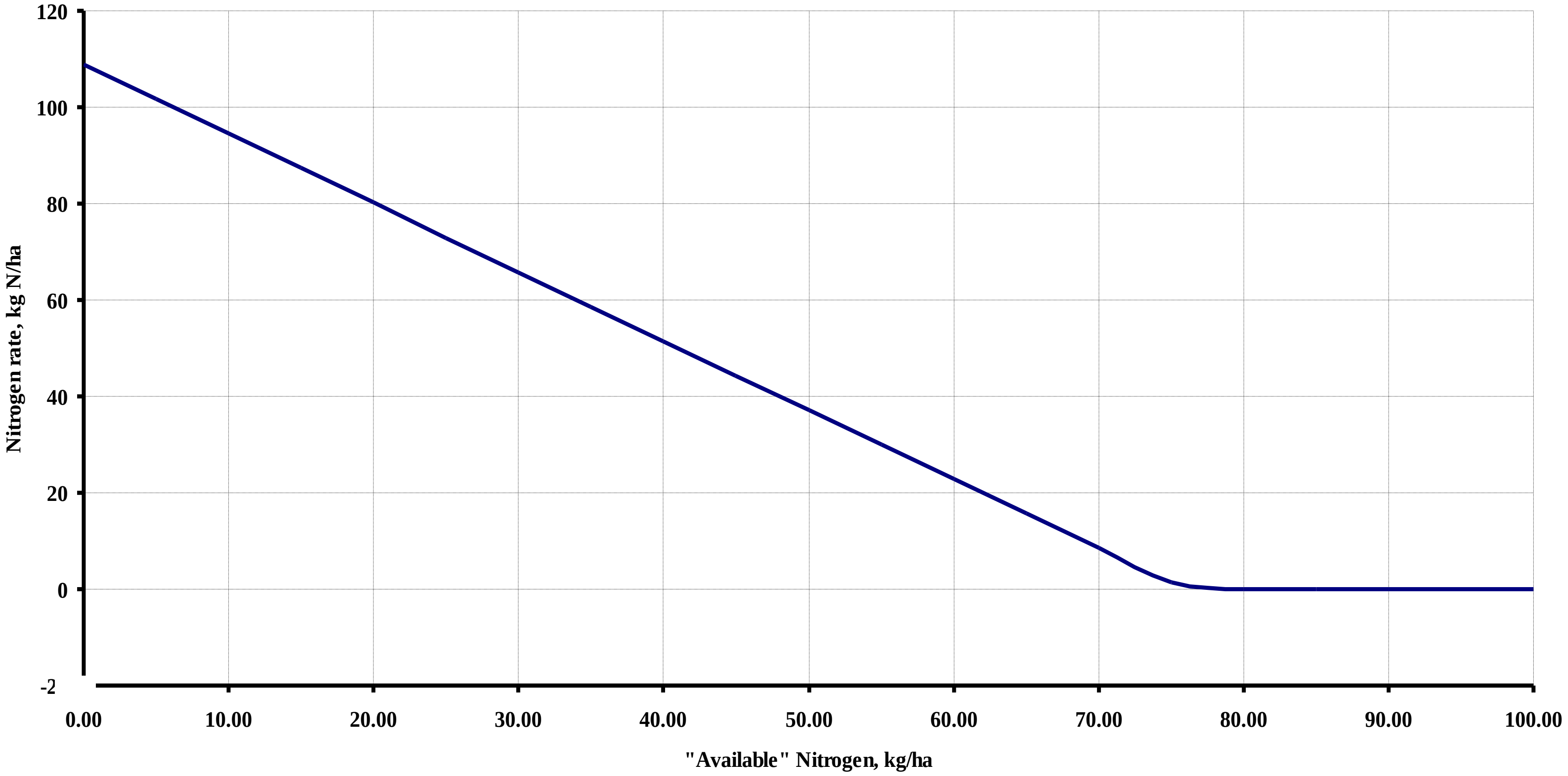
Nutrient	Method of Extraction	Crops	Critical level, ppm	Comments
Zinc	DTPA	Cereals	<0.25	Marginal
		Corn	< 1	Deficient
		Beans	<0.5	Deficient

Corrections of Micronutrient Deficiency

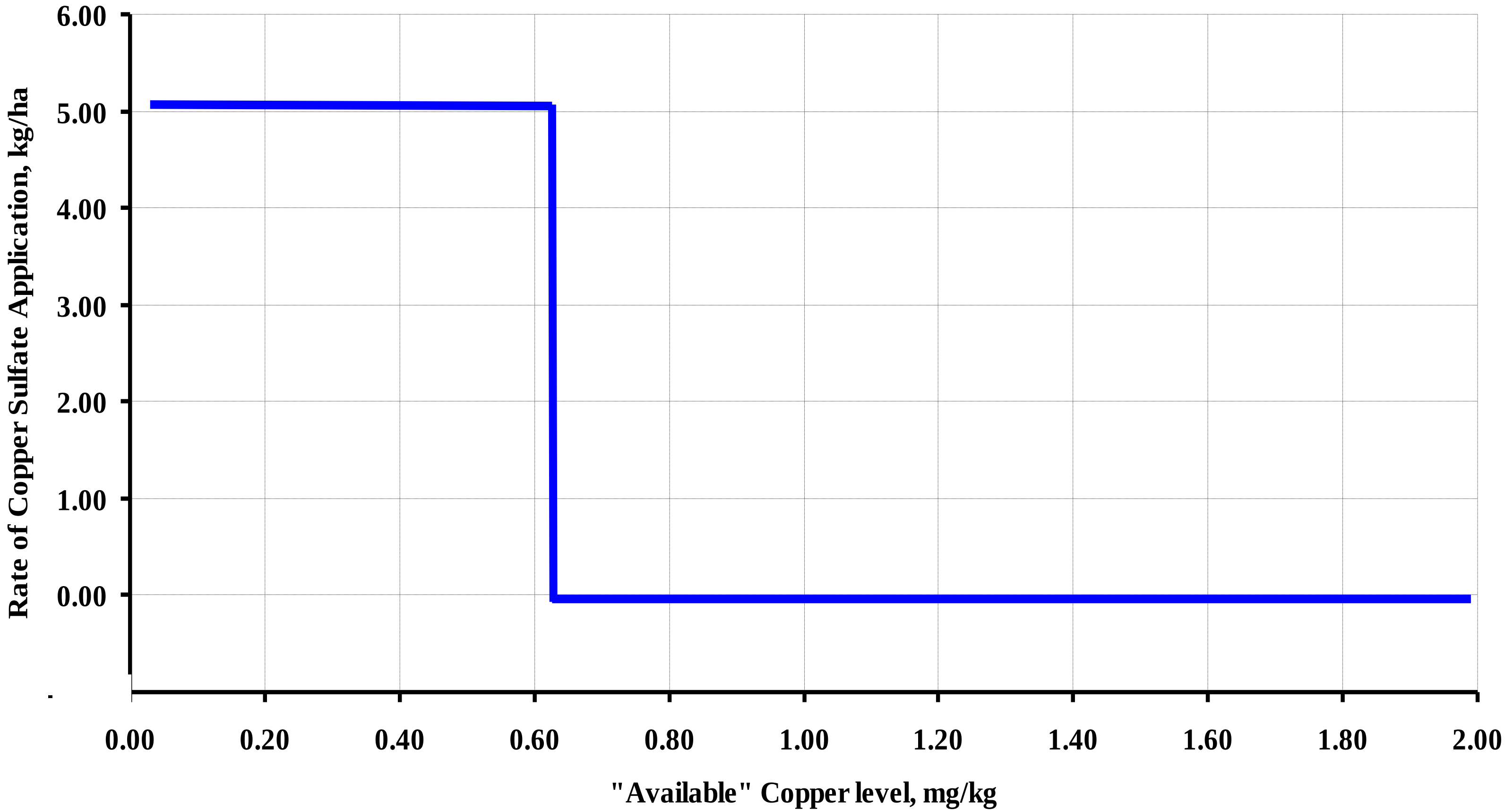
Correction of Micronutrient Deficiencies

- Consider differences from responses to Macronutrient deficiencies
- Application rates of micronutrients do not reflect a change in the nutrient requirement based on a soil test level

Nitrogen Application Rate as a Function of Soil Test Levels



Copper Application Rate as a Function of Soil Test Levels



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Granular Copper Solubility – 1 hr

Summary

- Micronutrient deficiencies not a widespread problem
- Copper is certainly the one to worry about for cereals and Zinc for dry beans and possibly corn
- $$ Economics$$ should dictate application