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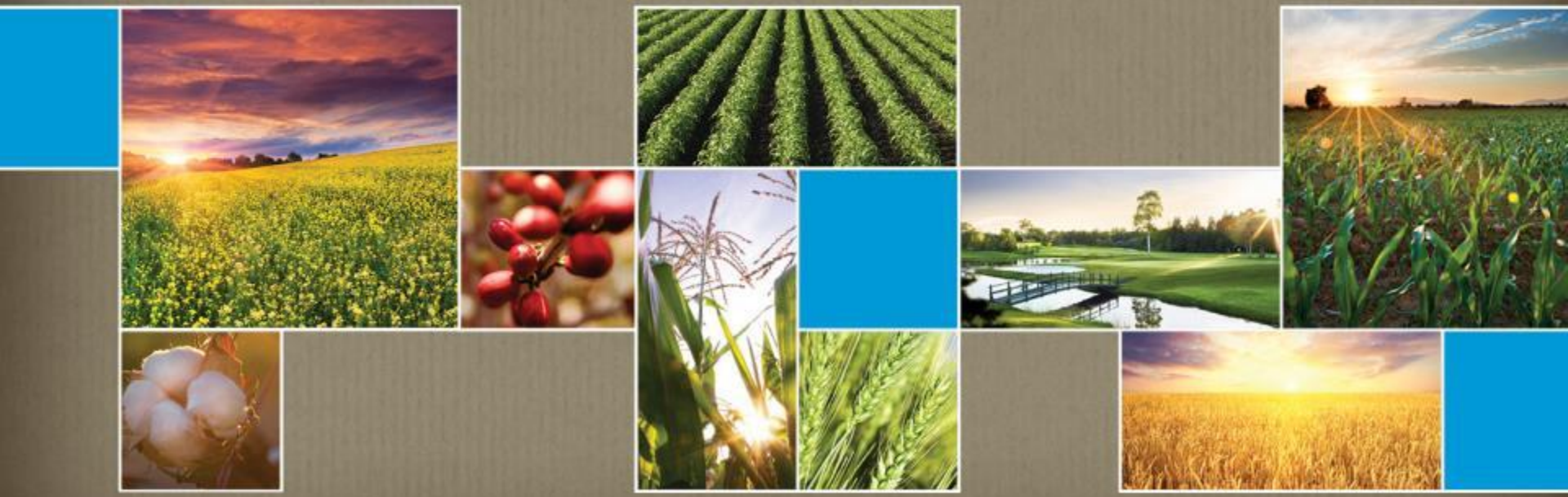
Post Emergent Fertilization
Macros and Micros – What Works?



THE POWER TO MAKE THINGS GROW

Post Emergence can be

- Topdressing
- Banding application
- Foliar application

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Topdressing









THE POWER TO MAKE THINGS GROW

Which Nutrients?

- Nitrogen (most common)
- Sulphur (not common)
- Other?

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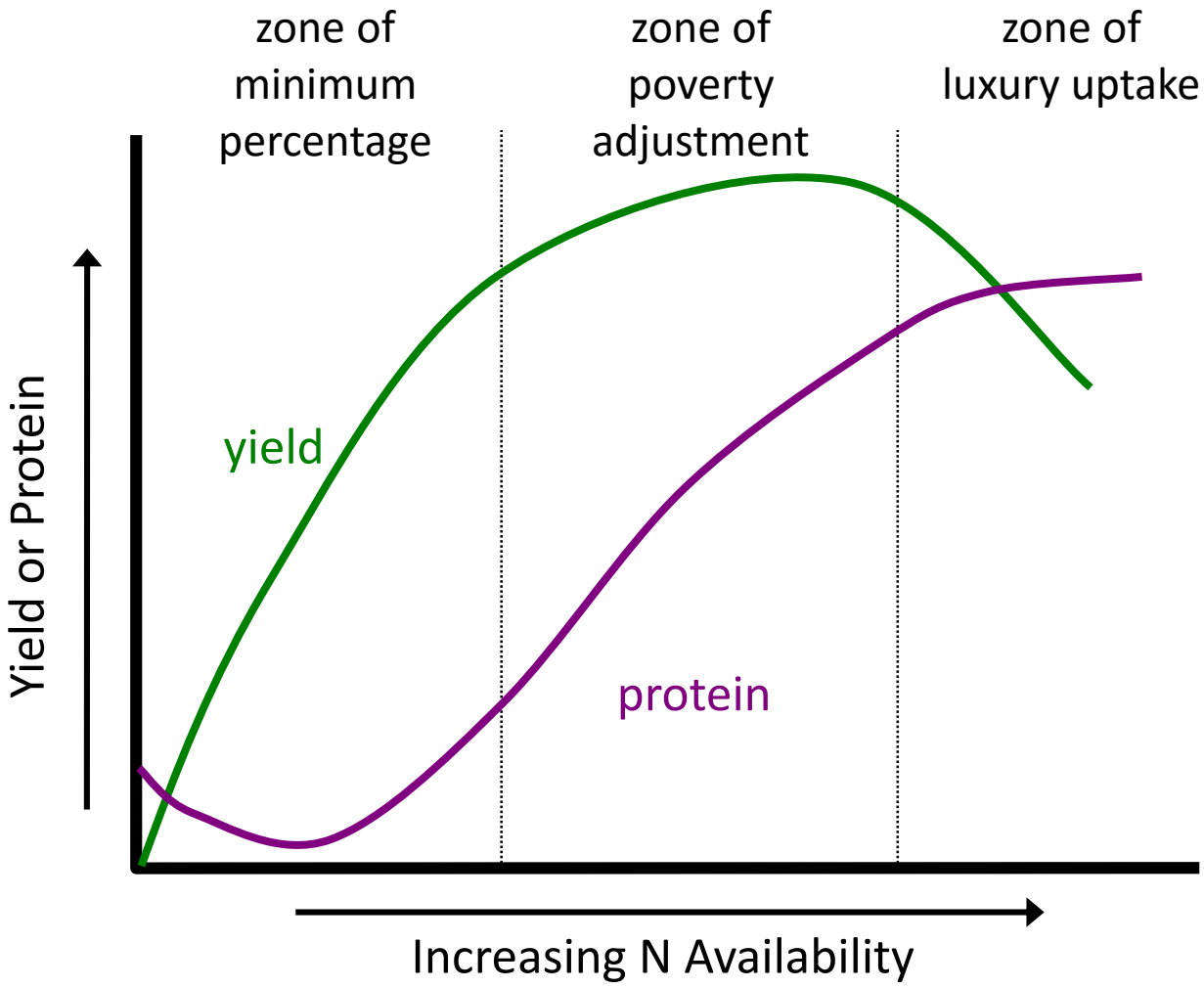
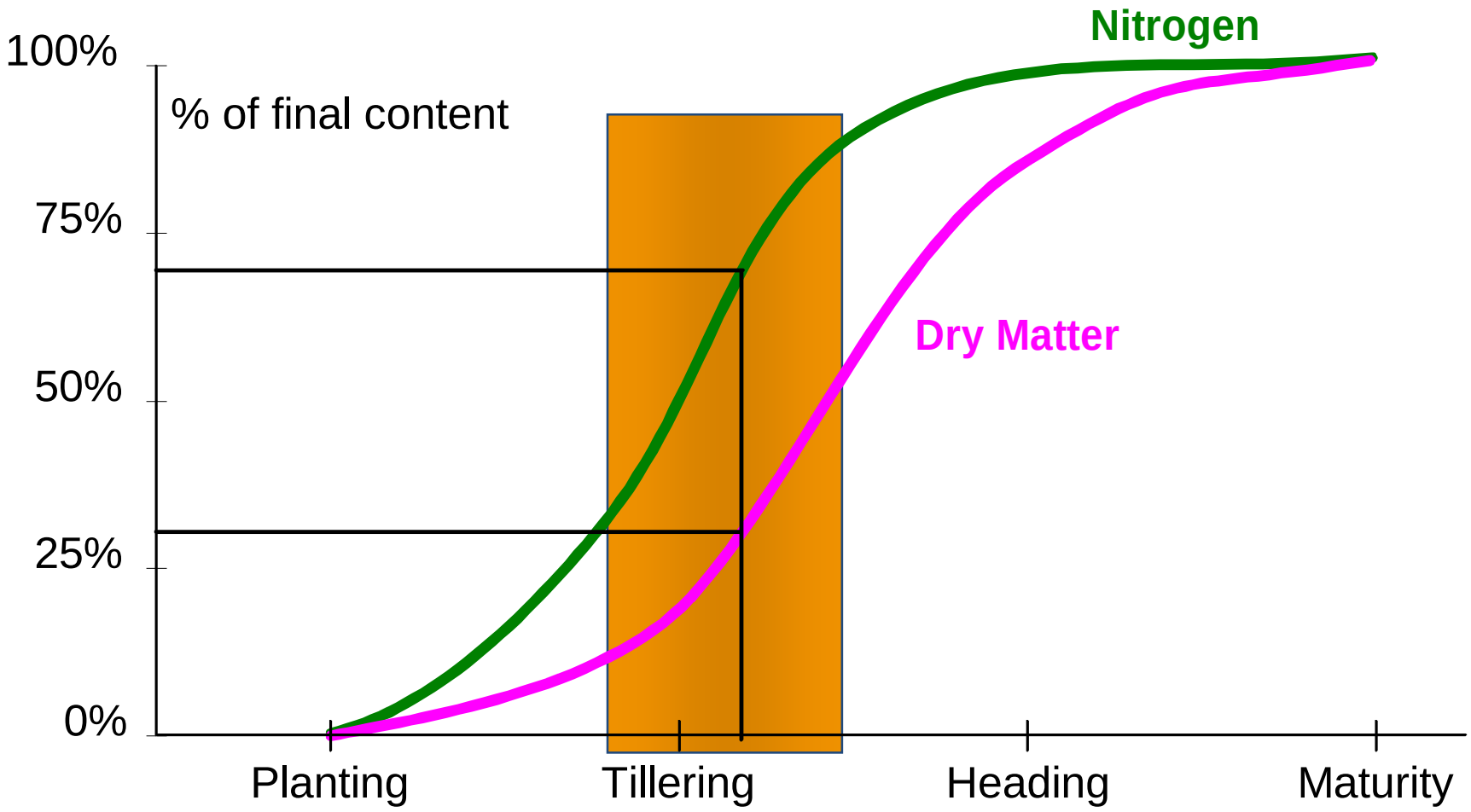
Topdressing N cereals

Background…


zone of minimum percentage
zone of poverty adjustment
zone of luxury uptake
Yield or Protein
yield
protein
Increasing N Availability

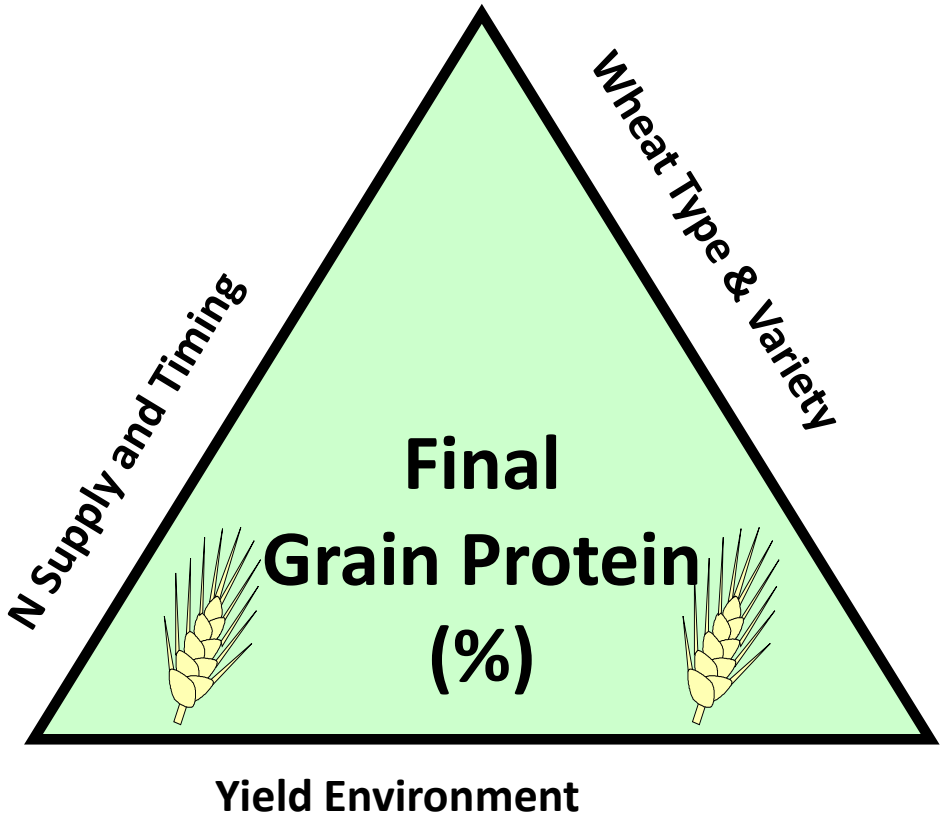
Critical Stage of Nitrogen Uptake



Questions:

- **Are post-emergent applications of N agronomically viable to achieve:**
  - **Higher grain protein levels?**
  - **Higher grain yields?**
- **If so, what are the appropriate:**
  - **Rates?**
  - **Time of application?**
  - **N products?**

Topdressing N for Protein



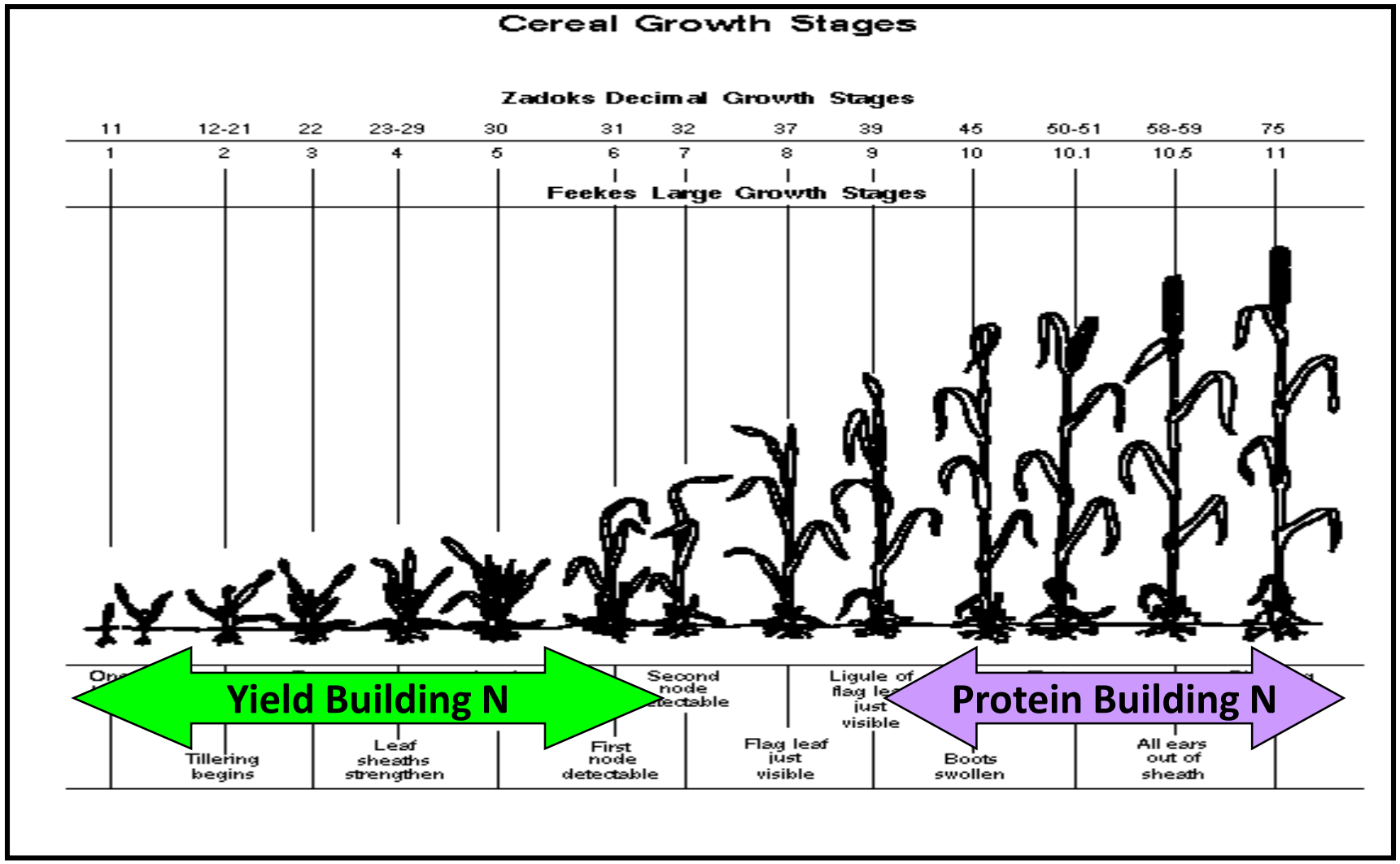
Effect of Soil and Post-Emergent N Rates Overall N response

- Own research*: Soil test N and growing season precipitation explained 78% of the yield increase due to N application
- Other research (Selles et al. 2003):

Factor	Contribution to Protein Variation
Cultivar (protein yield)	3%
N Fertility	70%

* Karamanos et al. 2005. Can. J. Plant Sci. 85: 327–342.

Plant Growth Stage and N Uptake



Effect of Soil and Post-Emergence N Rates: Overall N response*

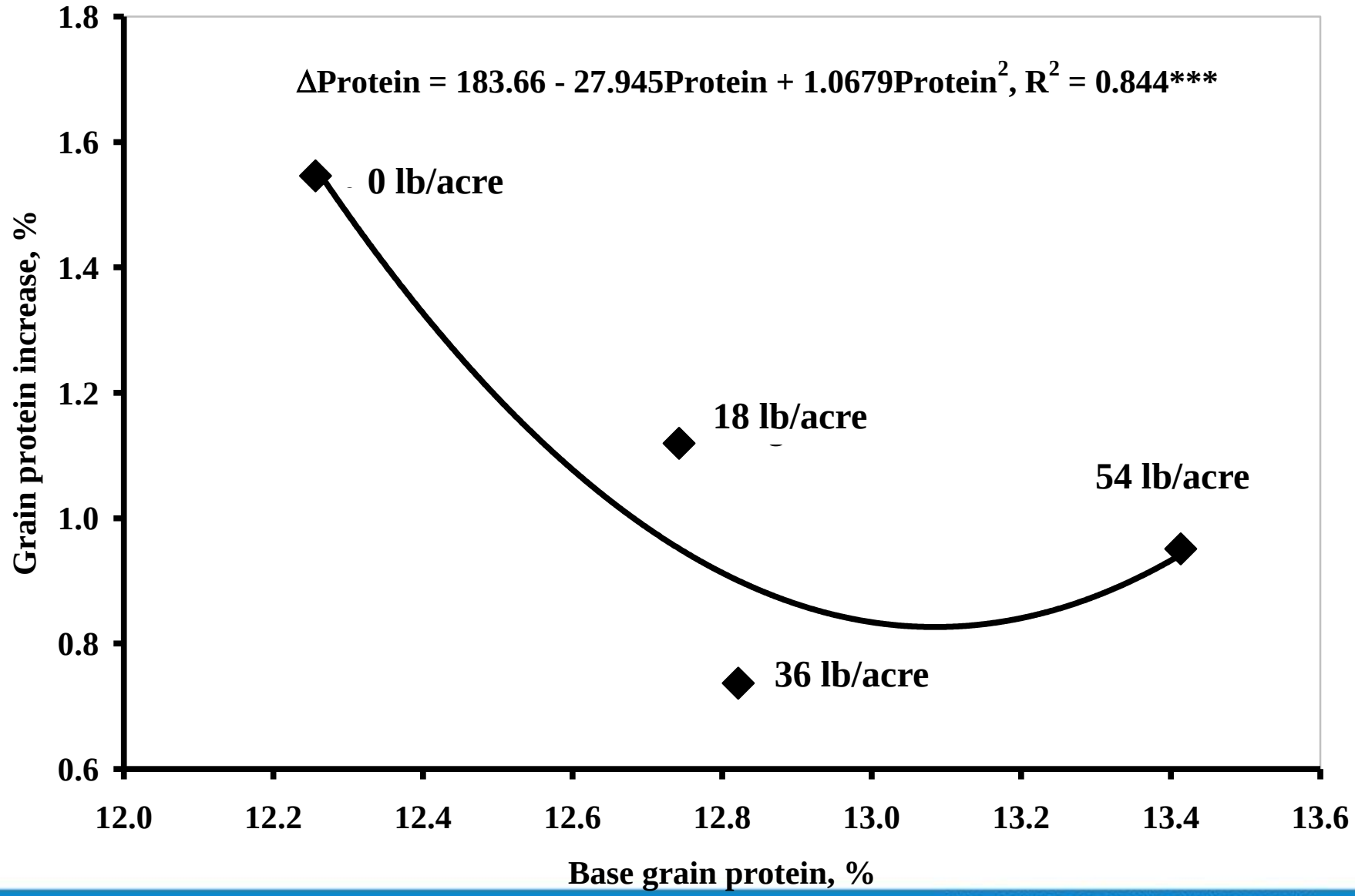
- Soil test N and growing season precipitation explained 78% of the yield increase due to N application:

Yield increase = 13.827 – 0.287×N + 4.398×Precipitation

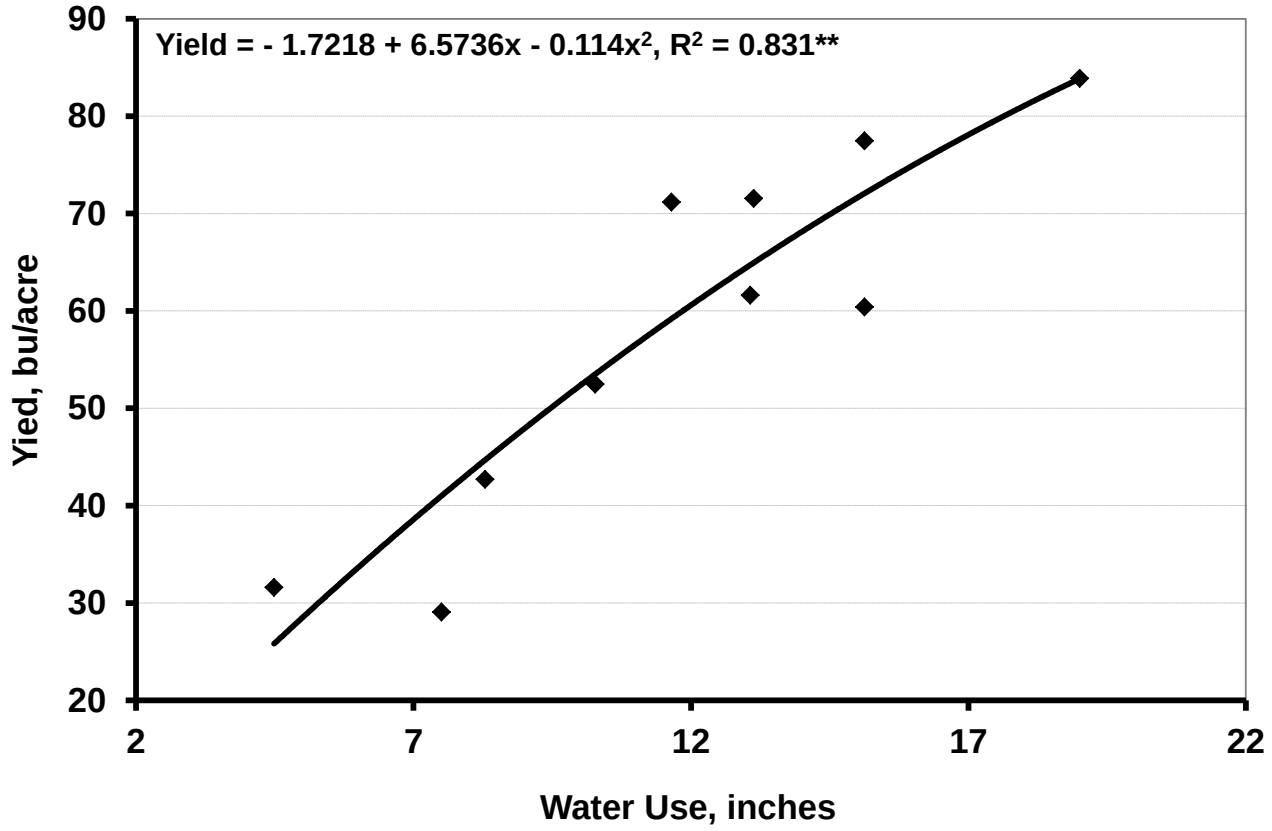
Note: including OM in the multiple regression did not improve R^2 (in other words OM did not explain much of the yield increase)

***Karamanos et al. 2005. Can. J. Plant Sci. 85: 327–342**

Average Increase in Protein

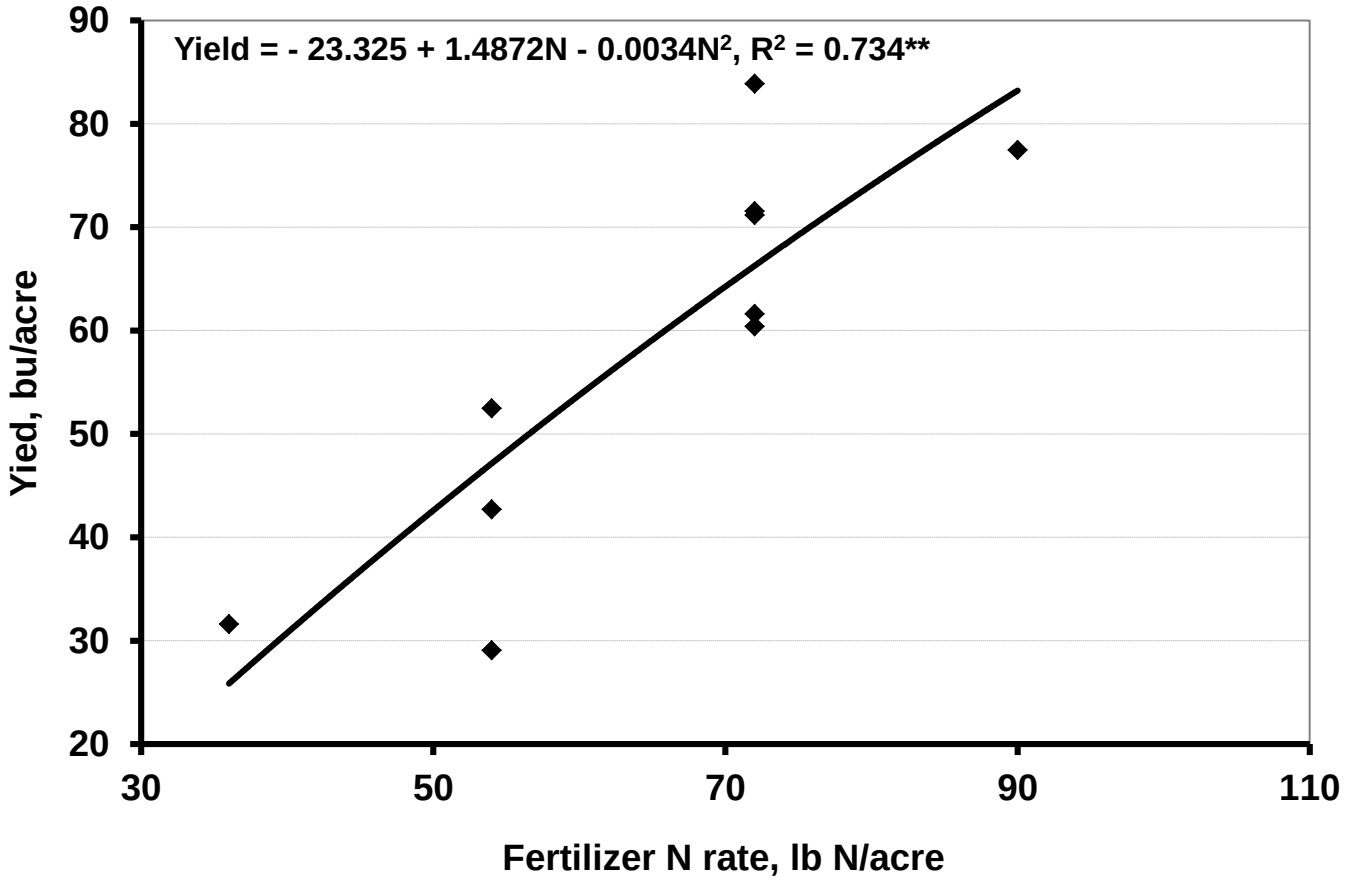


Effect of water use on wheat yield*



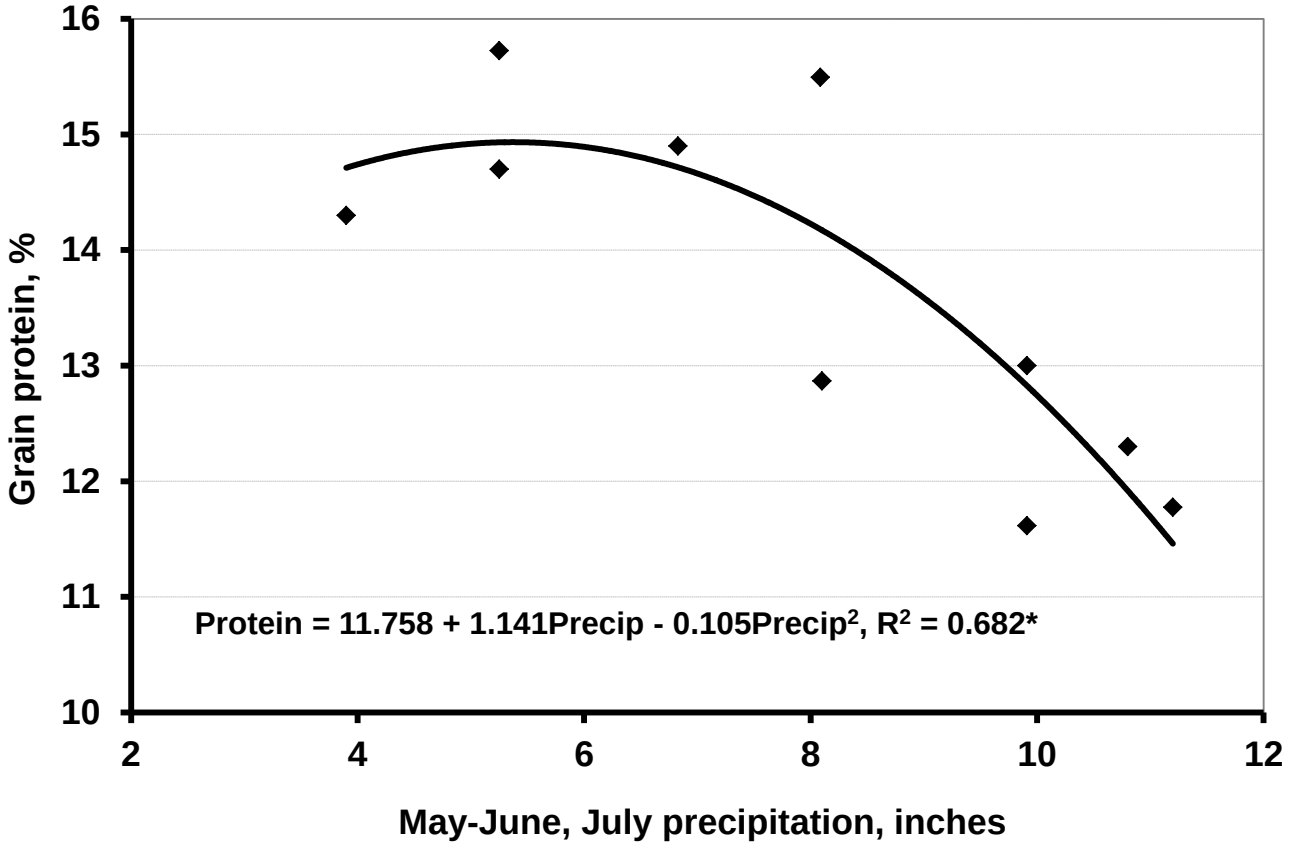
*Karamanos, R. E., Harapiak, J. T. and Flore N. A. 2013. Can. J. Soil Sci. 93: 223-228.

Effect of fertilizer N on wheat yield*



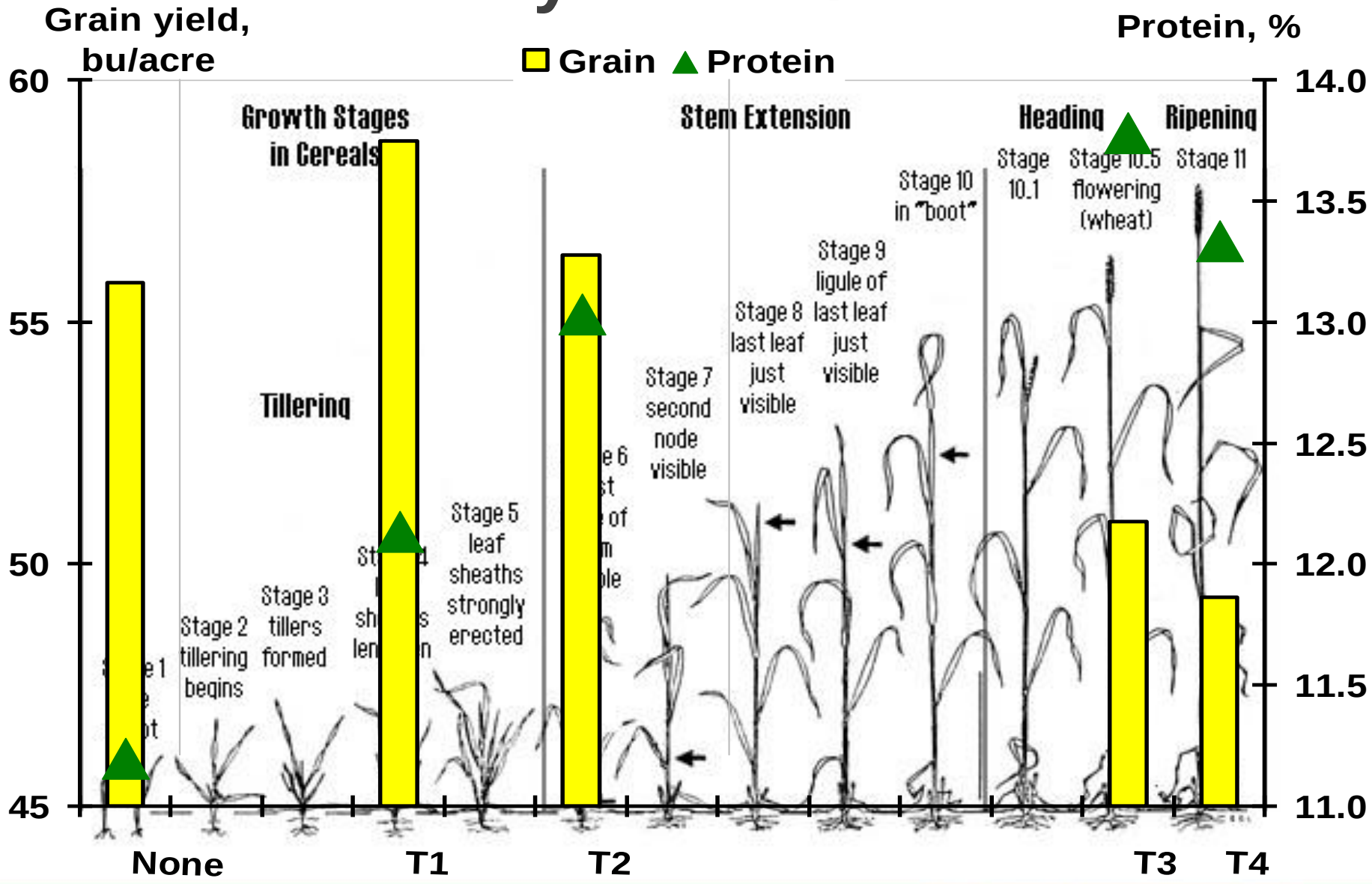
*Karamanos, R. E., Harapiak, J. T. and Flore N. A. 2013. Can. J. Soil Sci. 93: 223-228.

Effect of May-June-July precipitation on wheat protein*

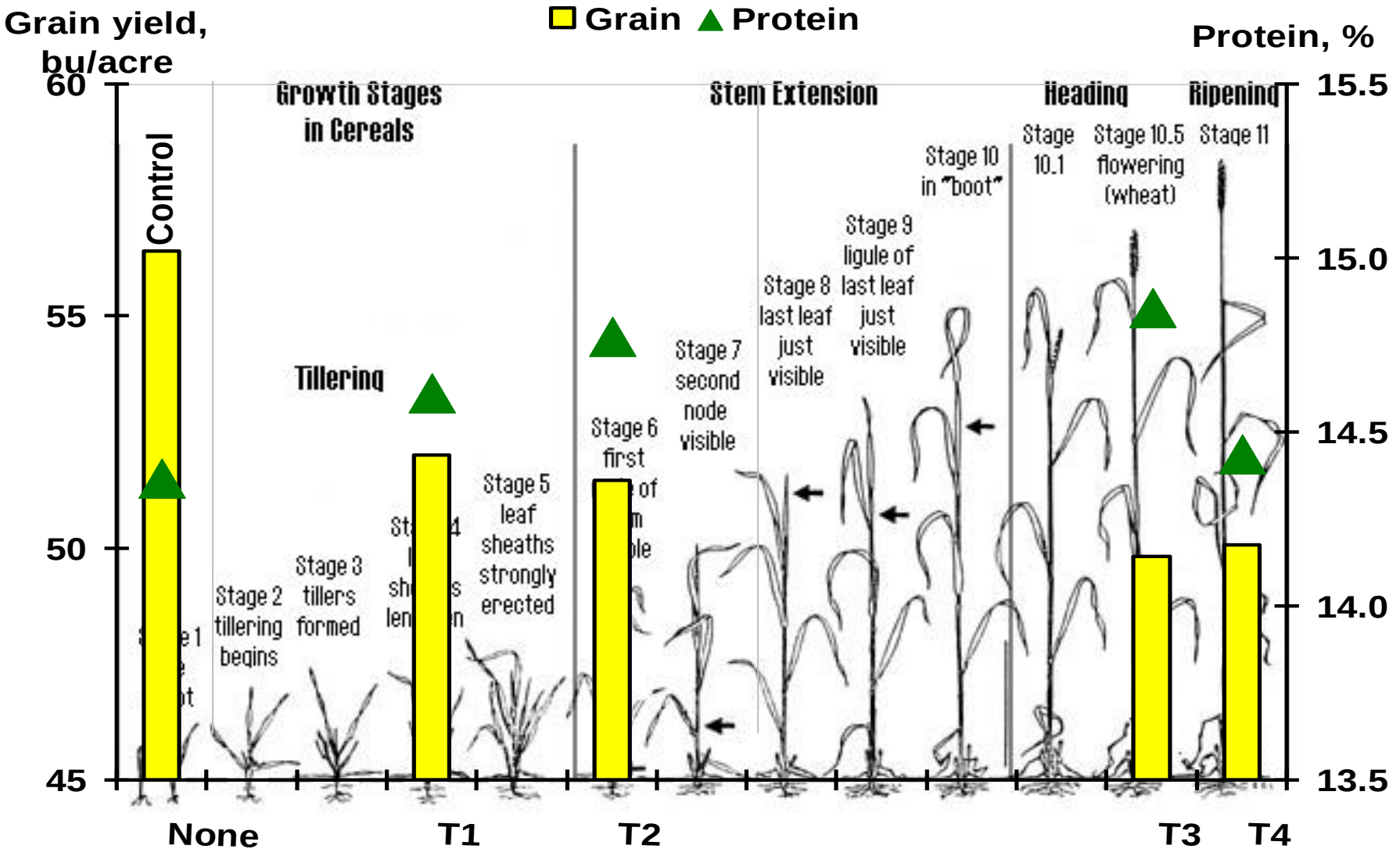


*Karamanos, R. E., Harapiak, J. T. and Flore N. A. 2013. Can. J. Soil Sci. 93: 223-228.

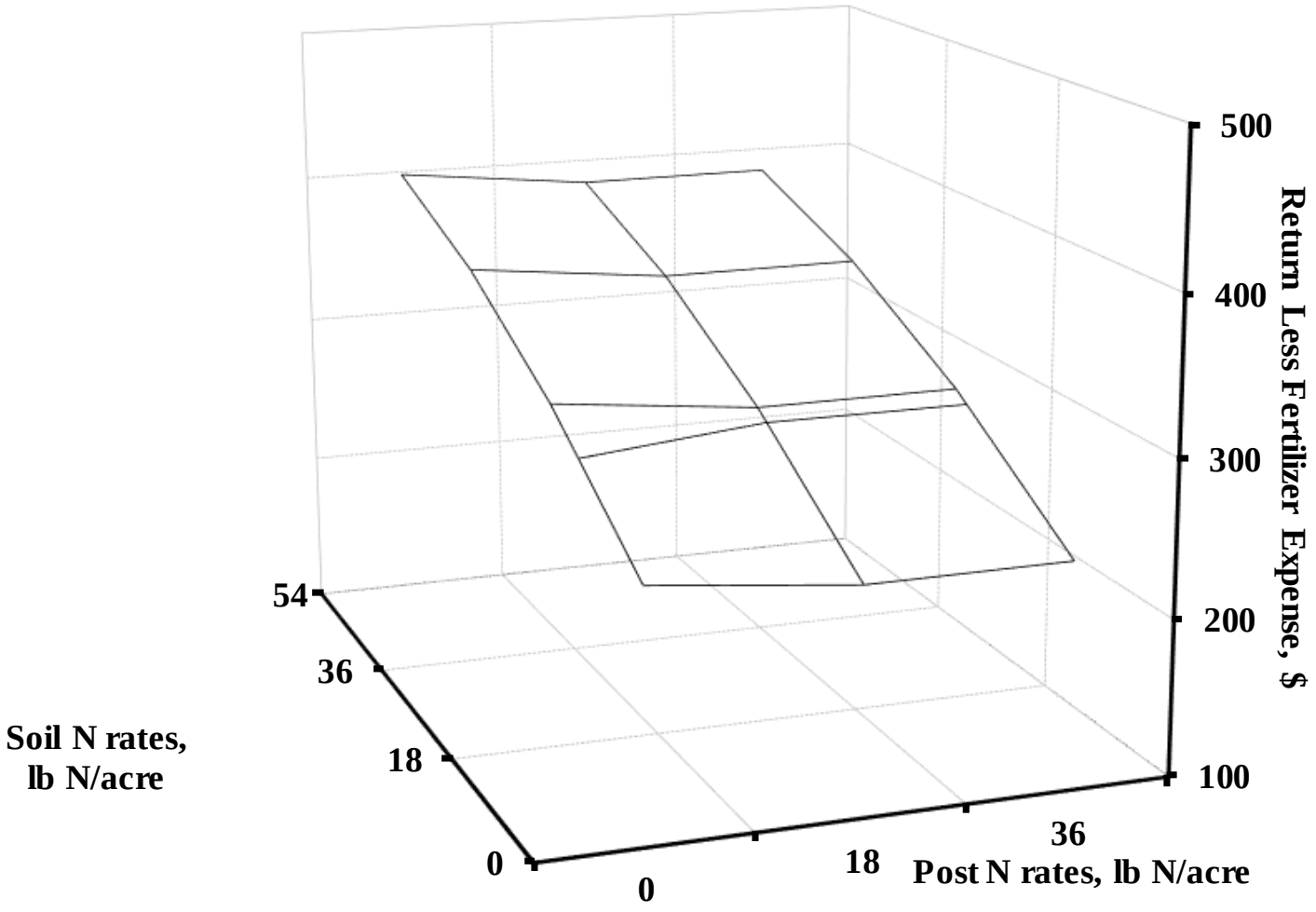
Take away 20 lb N/acre



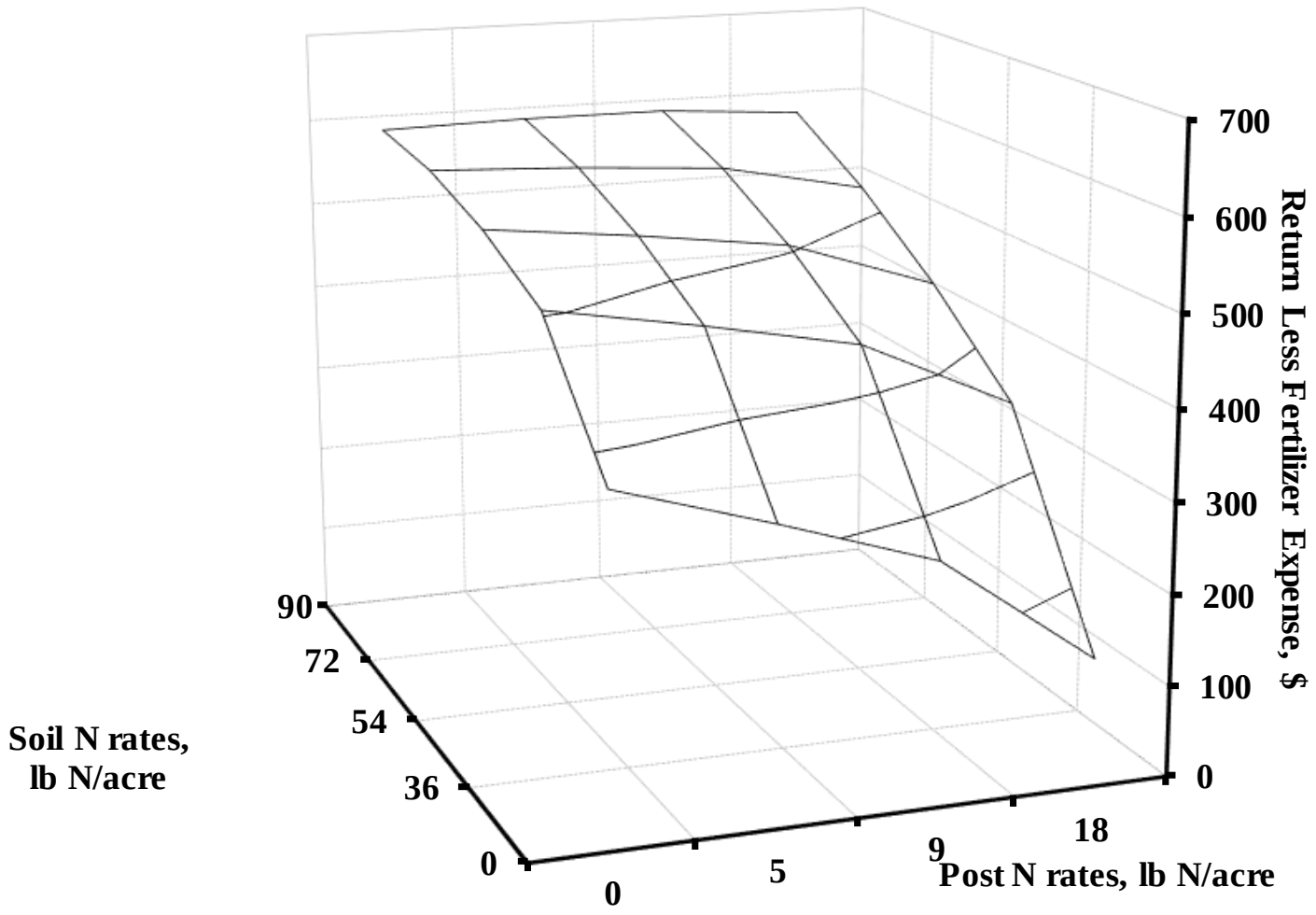
Take away 40 lb N/acre



Economic analysis

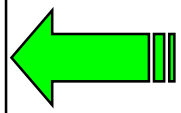


Economic analysis



Protein Premiums Influence Economics

N Rate (lb/ac)	Yield (bu/ac)	Protein (%)	$/bu	Grain $/ac	Fert $/ac	Net $/ac
Protein Based Price						
0	32.1	9.3	3.77	121	0.00	121
25	39.3	10.2	3.77	148	6.25	141
50	47.3	10.5	3.77	178	12.50	165
75	49.8	12.5	4.07	203	18.75	183
100	**53.2**	**14.4**	**4.48**	**238**	**25.00**	**213**
125	**56.7**	**15.7**	**4.74**	**269**	**31.25**	**238**
150	55.8	15.5	4.74	264	37.50	226
175	53.1	16.2	4.74	252	43.75	208



Source D. Johnston, Melfort

1997-98 Final Payment - Melfort

Protein Premiums Influence Economics

Wheat GROWERS Connecting Solutions

SPRING WHEAT PROTEIN SCALES

3/2/16

+.04 each 1/5 premium over 14.0 to 16.0 with a 0.25 kicker at 15.0

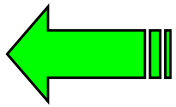
-.04 each 1/5 below 14.0 to 12.0

Protein	Premium/Discount per Bu.
12.0	-0.40
12.2	-0.36
12.4	-0.32
12.6	-0.28
12.8	-0.24
13.0	-0.20
13.2	-0.16
13.4	-0.12
13.6	-0.08
13.8	-0.04
14.0	0
14.2	+0.04
14.4	+0.08
14.6	+0.12
14.8	+0.16
15.0	+0.45
15.2	+0.49
15.4	+0.53
15.6	+0.57
15.8	+0.61
16.0	+0.65

http://www.wheatgrowers.com/images/File/SPRING-WHEAT-PROTEIN-SCALES-3-2-16.pdf

Protein Premiums Influence Economics

N Rate (lb/ac)	Yield (bu/ac)	Protein (%)	$/bu	Grain $/ac	Fert $/ac	Net $/ac
Protein Based Price						
0	32.1	9.3	3.78	121	0	121
25	39.3	10.2	3.78	149	6.25	142
50	47.3	10.5	3.78	179	12.5	166
75	49.8	12.5	4.08	203	18.75	184
100	**53.2**	**14.4**	**4.48**	**238**	**25**	**213**
125	**56.7**	**15.7**	**4.99**	**283**	**31.25**	**252**
150	55.8	15.5	4.95	276	37.5	239
175	53.1	16.2	5.05	268	43.75	224



Adapted for current premiums: http://www.wheatgrowers.com/images/File/SPRING-WHEAT-PROTEIN-SCALES-3-2-16.pdf

Conclusions for wheat in w. Canada

- Effect of topdressing:
  - N deficiency corrected by N application at or prior to seeding -> increase in grain protein but overall no economic benefit
  - N deficiency not corrected by N application at or prior to seeding -> increase in grain protein but loss in yield and no economic benefit (actually loss)
- **Post emergent application of N to enhance either grain yield or grain protein of dryland wheat in western Canada is a high risk practice.**

R.E. Karamanos, N.A. Flore and J.T. Harapiak, 2005. Effect of post-emergence nitrogen application on the yield and protein content of wheat. Canadian Journal Plant Science 85, 327-342.

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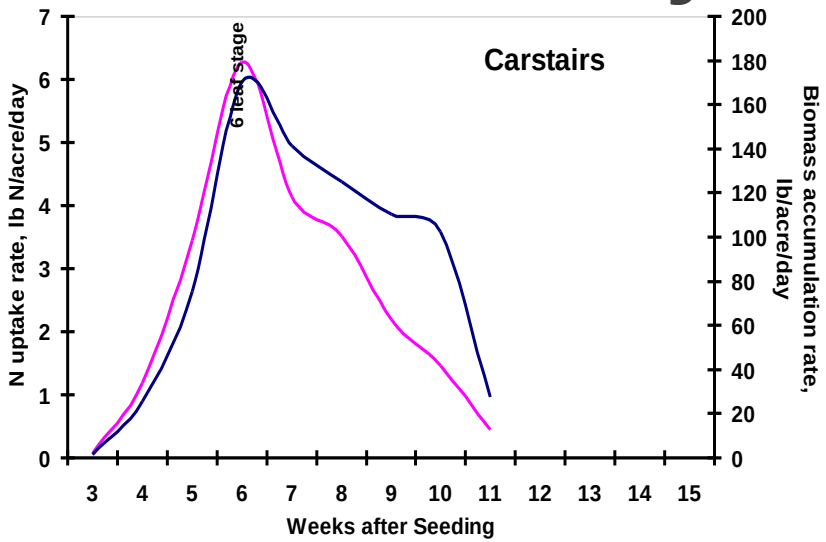
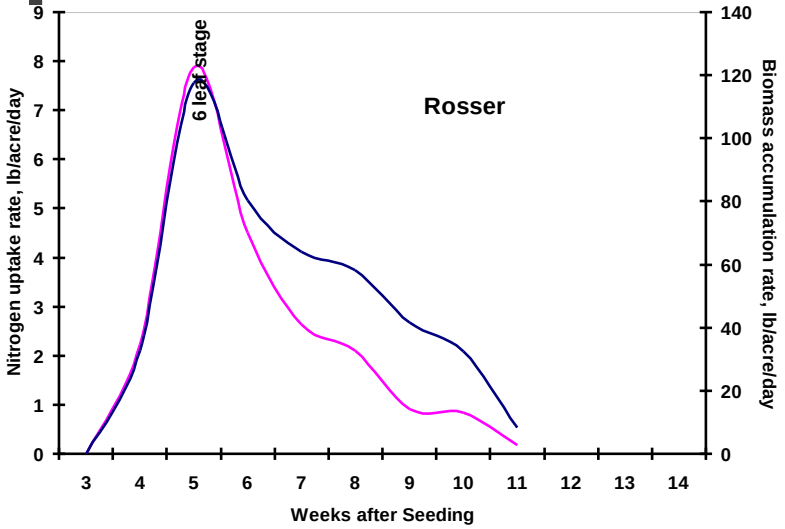
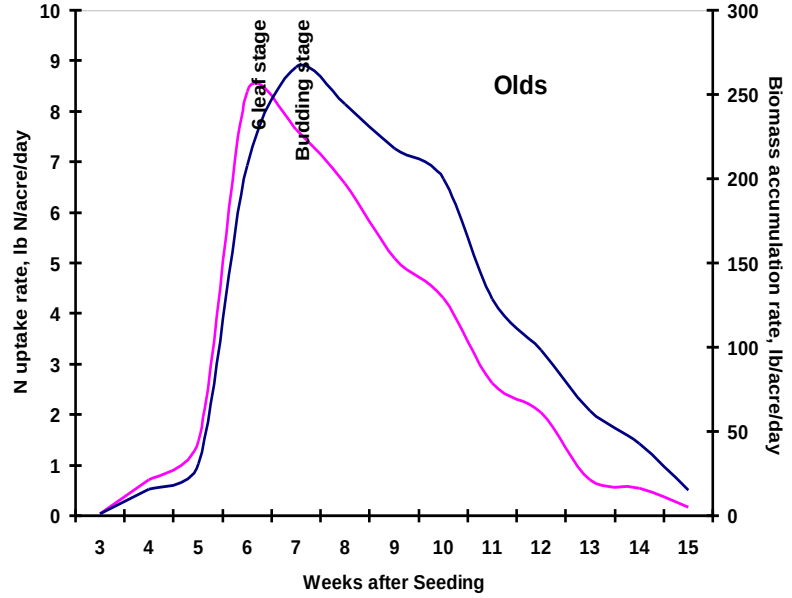
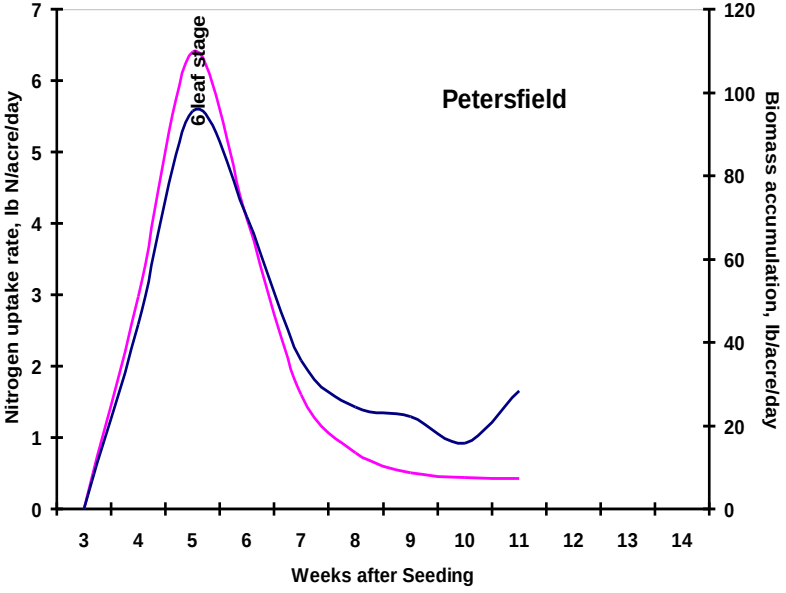
Topdressing N canola

Daily N uptake*



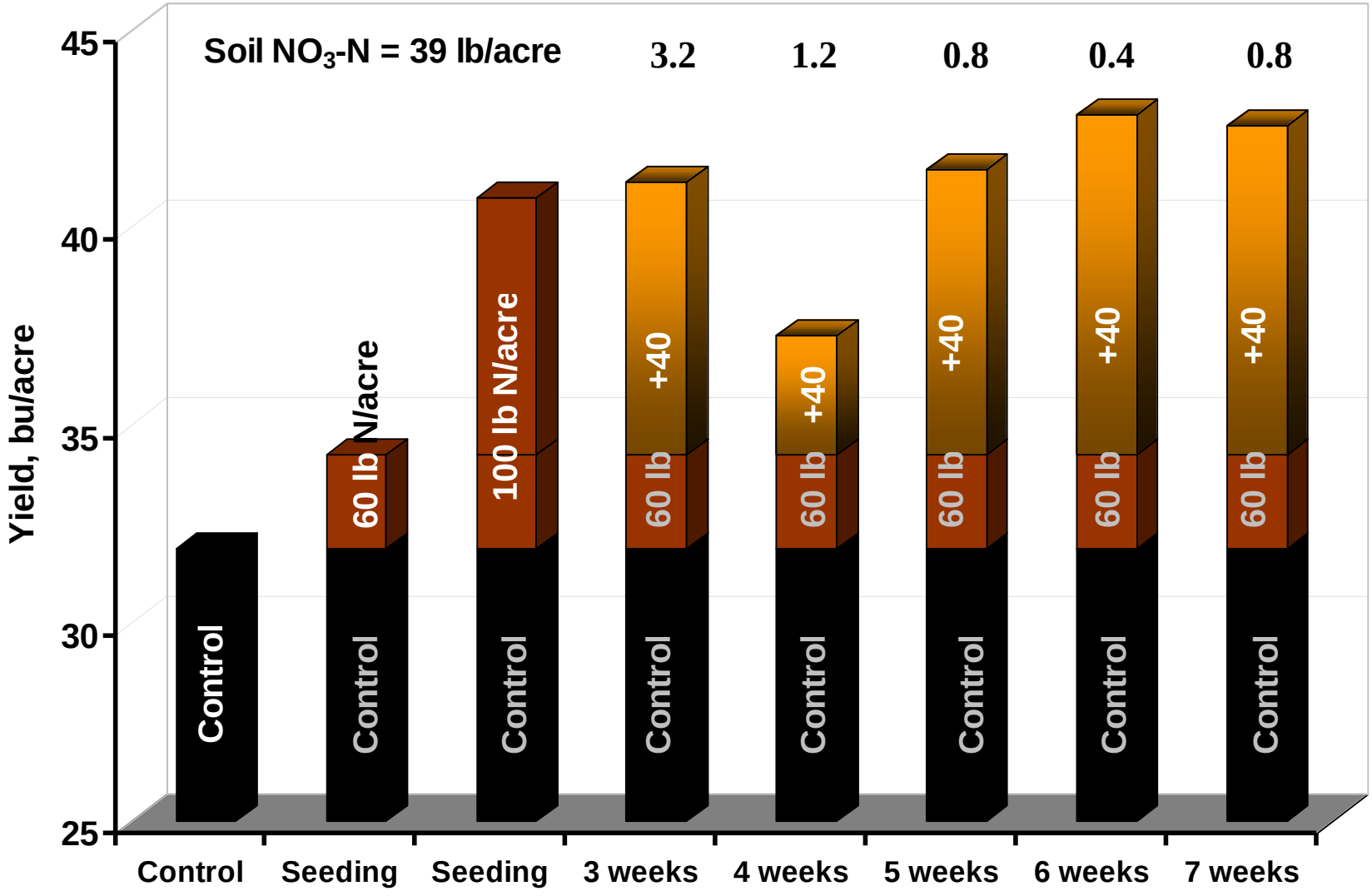




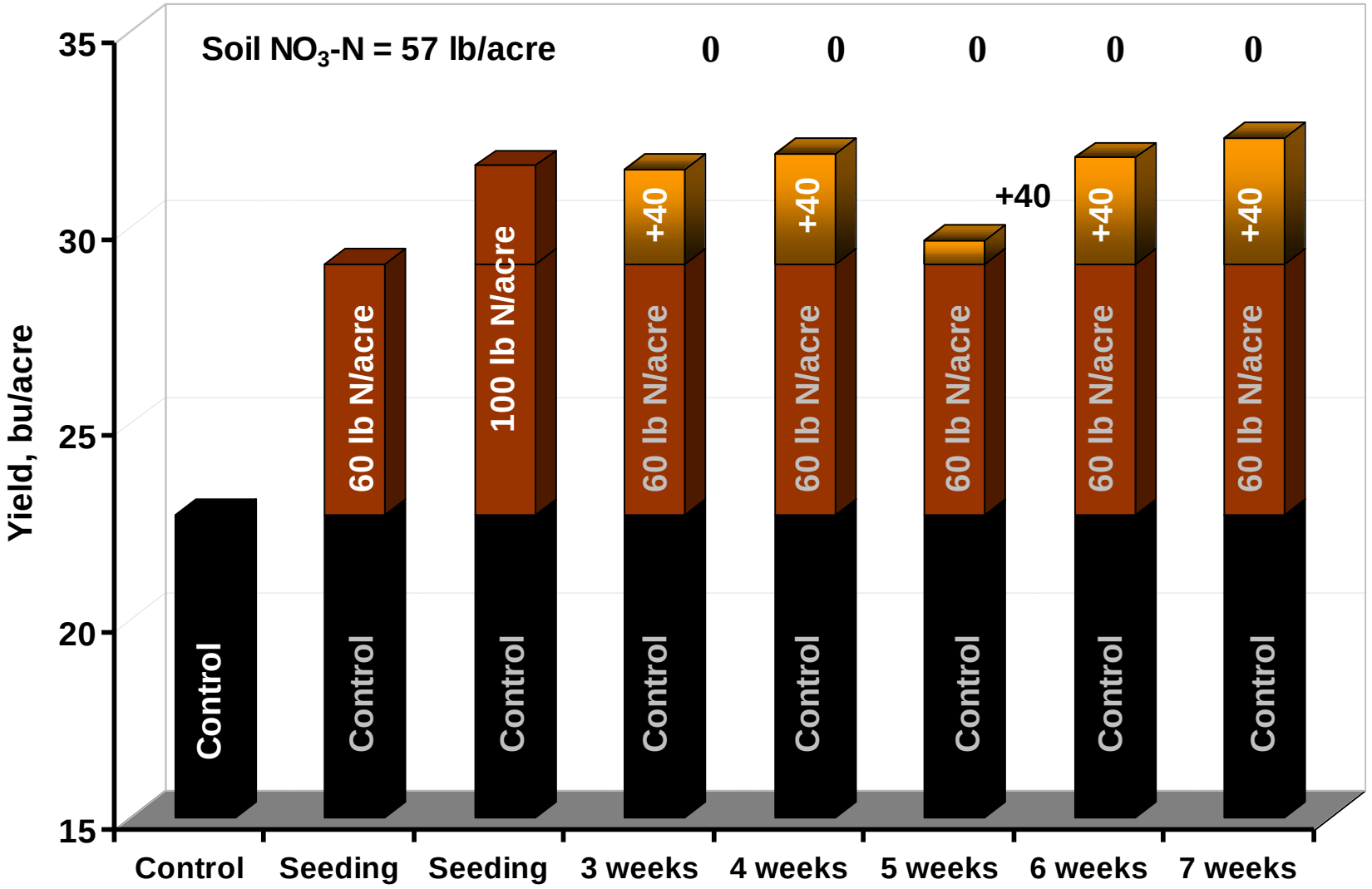


*Karamanos et al. 2004. Soils and Crops 2004

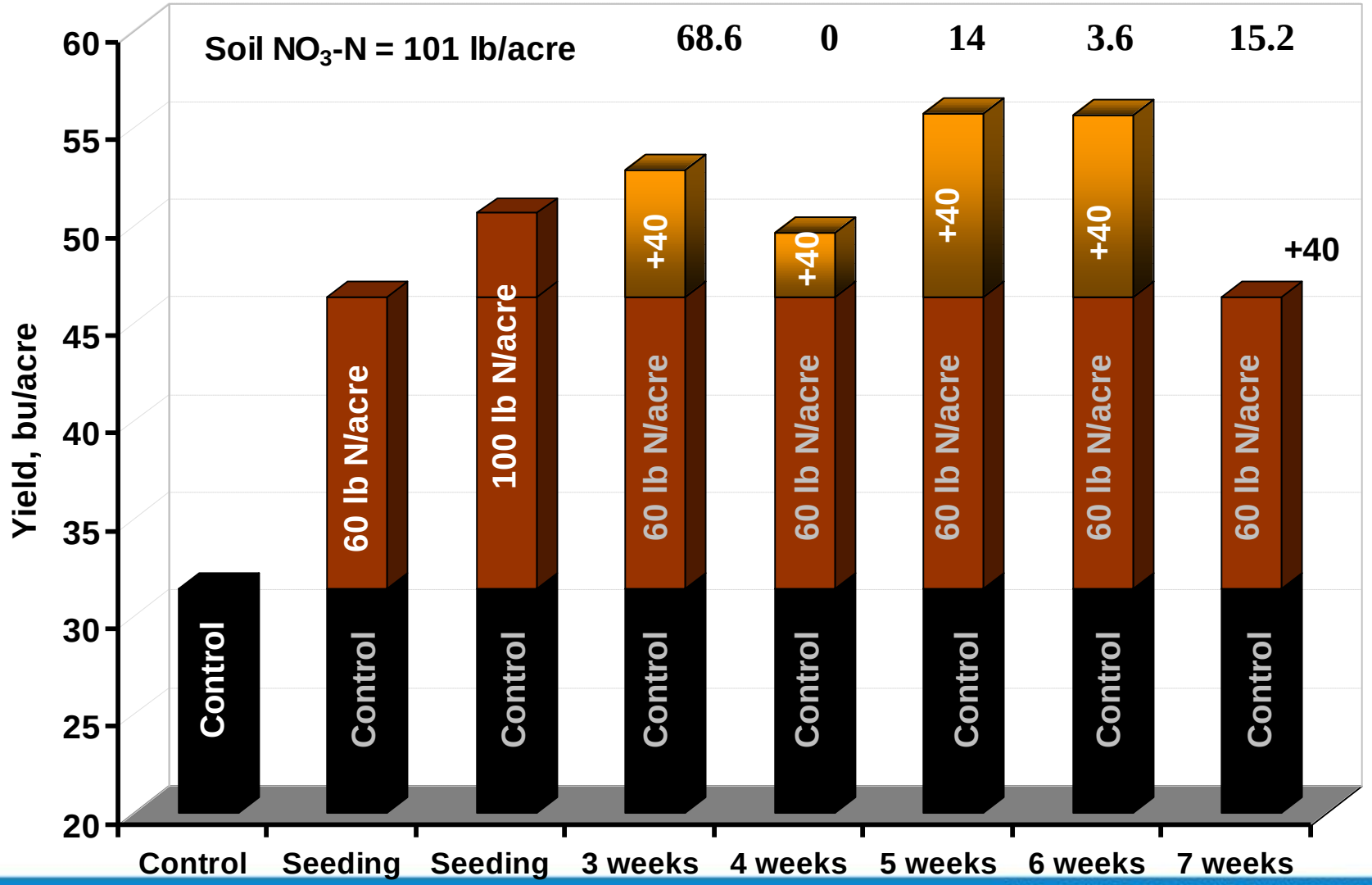
Topdressing “normal” precipitation



Topdressing “dry” weather



Topdressing “favorable” precipitation



Conclusion

- **Post emergent application of N to enhance grain yield of canola has to occur prior to the 6th leaf stage and is predicated on the crop receiving adequate rainfall.**
- **Splitting N applications could be an advantage if it remains dry and there is no need for additional N**
- **It can be uneconomical because of:**
  - **extra cost of application**
  - **damage to standing crop**
- **It is considered a “high risk” practice**
- **Emergency practice ONLY**

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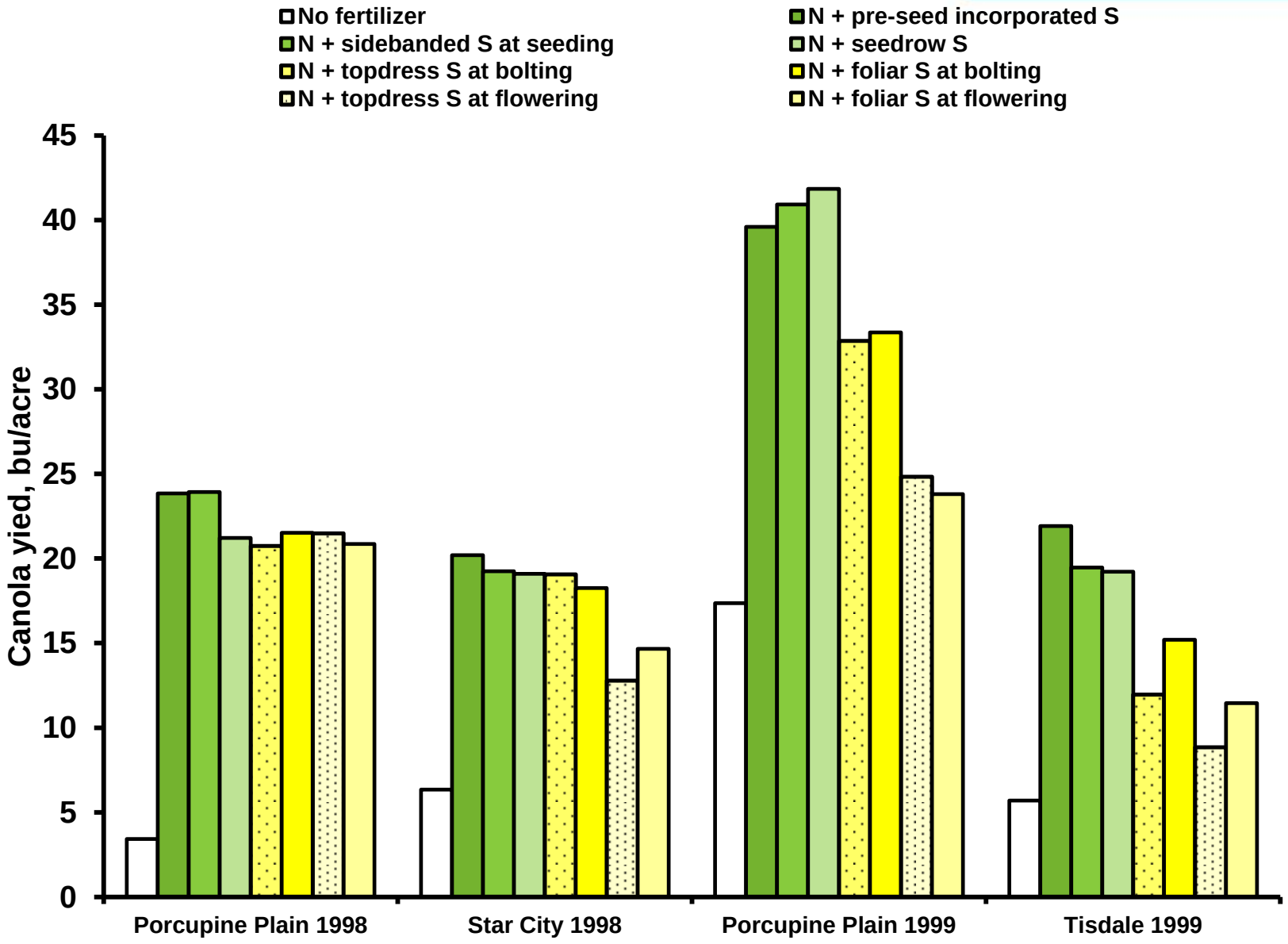
Topdressing S



Malhi and Leech, 2000

Sulphur

- Sulphur in gaseous form is easily absorbed by plants leaves
- Research on application S to foliage is fairly limited, since only a small percentage (<3 %) of soluble S applied to leaves is utilized
- Malhi and Leach (2000) reported that foliar application of 13 lb S/acre as ammonium sulphate at bolting and at flowering resulted in correction of S deficiency in experiment carried out over one year at two sites in north-eastern Saskatchewan, but… 18 gallons of water!

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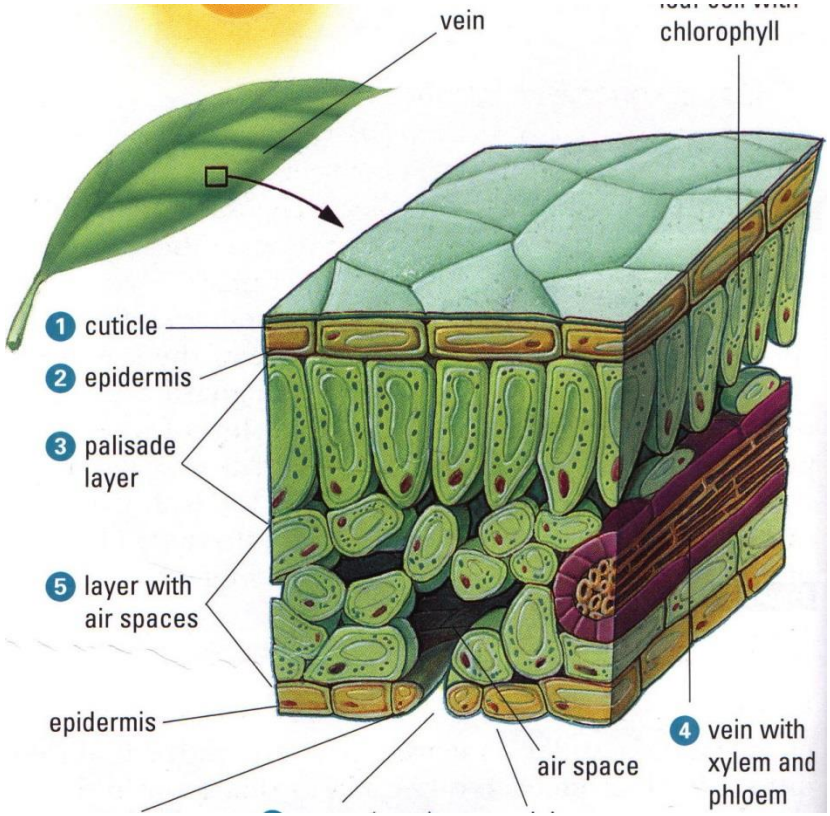
Foliar Fertilization

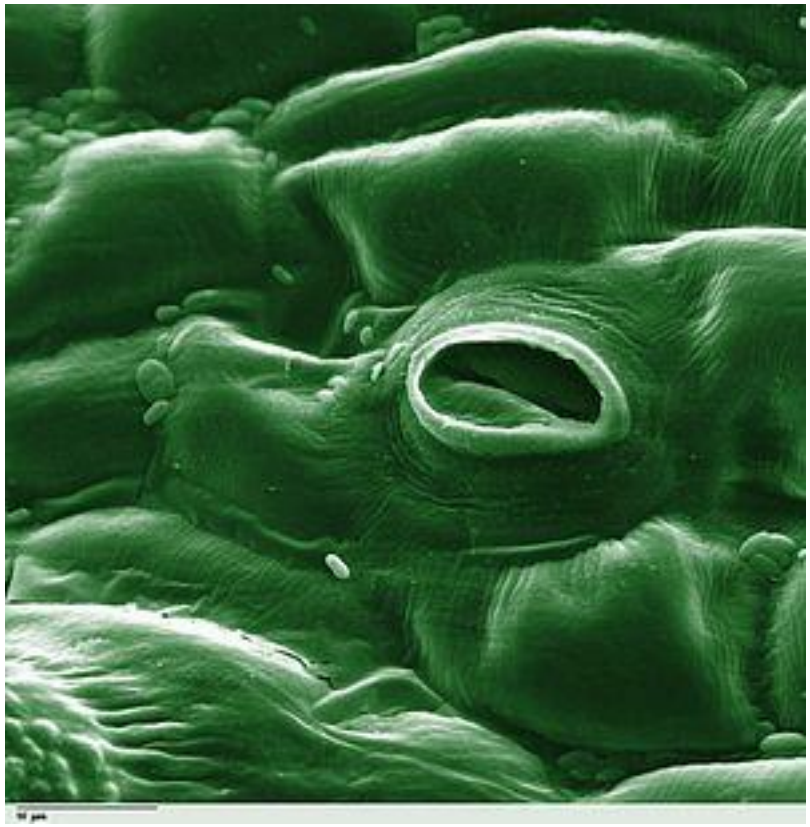
WHY FOLIAR FERTILIZATION?

- **Feeds plants when soil conditions are unfavorable.** There is significant agronomic justification for the use of foliar fertilizers when high nutrient demand coincides with inadequate soil supply or poor plant transport of essential nutrients.
- **Timing is critical.** The growth stage at which plant root uptake is limited will vary by plant species. This variance should be considered when applying foliar fertilizers and makes timing of application more critical than in soil applied fertilizers.
- **A targeted delivery.** Foliar fertilization is conceptually more efficient and target-oriented than soil fertilization since nutrients can be directly delivered to plant tissues during critical stages of plant growth.
- **Opportunities to Innovate.** Foliar fertilizer blends offer a unique value proposition for companies serving the farm community.

Foliar Nutrients for Plants – How It Works?

- by nutrient penetrating the cuticle of the leaf or the stomata and subsequently entering the plant cells





Foliar Nutrients for Plants – When It Works?

- Its effectiveness is predicated on the ability of a plant to absorb the applied nutrient through its leaf surface
- **Although plant leaves and other aerial plant organs are very well equipped to absorb nutrients in gaseous forms via the stomata, e.g., CO_2, O_2, SO_2, etc., absorption of nutrients in ionic forms can be limited because the outer epidermal cells of the leaf are covered by the cuticle**

Foliar Nutrients for Plants – What Works?

- How does foliar nutrition work?
  - Nutrients soluble in water are applied to foliage, and if absorbed through leaf surface, provide rapid response.
  - Absorption is influenced by environmental factors, temperature, humidity, light intensity, etc.
  - Two to three applications are often used to have an impact when correcting a deficiency.

Foliar Nutrients for Plants – What Works?

- What are the challenges with foliar nutrition?
  - the quantity of nutrients absorbed by plant leaves is very small in comparison to the overall plant demand.
  - Mainly with macronutrients, getting enough on without causing foliar burning.
  - Rates of <1-2% (<0.4-0.5% P) to avoid foliar damage.

Foliar Nutrients for Plants – What criteria should be used ?

- Amount of nutrient that is required by crop (i.e., macronutrients vs. micronutrients)
- Effectiveness of application at the timing (growth stage) that best matches crop response
- Suitability of a product formulation for absorption (uptake) of the intended nutrient by a crop
- Impact of method, time, concentration, etc. of applied foliar product on crop foliage.

Foliar Nutrients for Plants

Daily Uptake 6-7 weeks after seeding*

Nutrient	Canola	Wheat	Barley
N	7.5 lb/acre/d	2.8 lb/acre/d	3.0 lb/acre/d
P	0.8 lb/acre/d	0.35 lb/acre/d	0.5 lb/acre/d
Cu	1.3 g/acre/d	2 g/acre/d	1.6 g/acre/d
B	17.5 g/acre/d	7.4 g/acre/d	13.1 g/acre/d
Yield	47 bu/acre	38 bu/acre	86 bu/acre

*Malhi et al. 2006. Can. J. Plant Sci. 86: 1005–1014, and,
Malhi et al. 2007. J. Plant Nut. 30: 641-658

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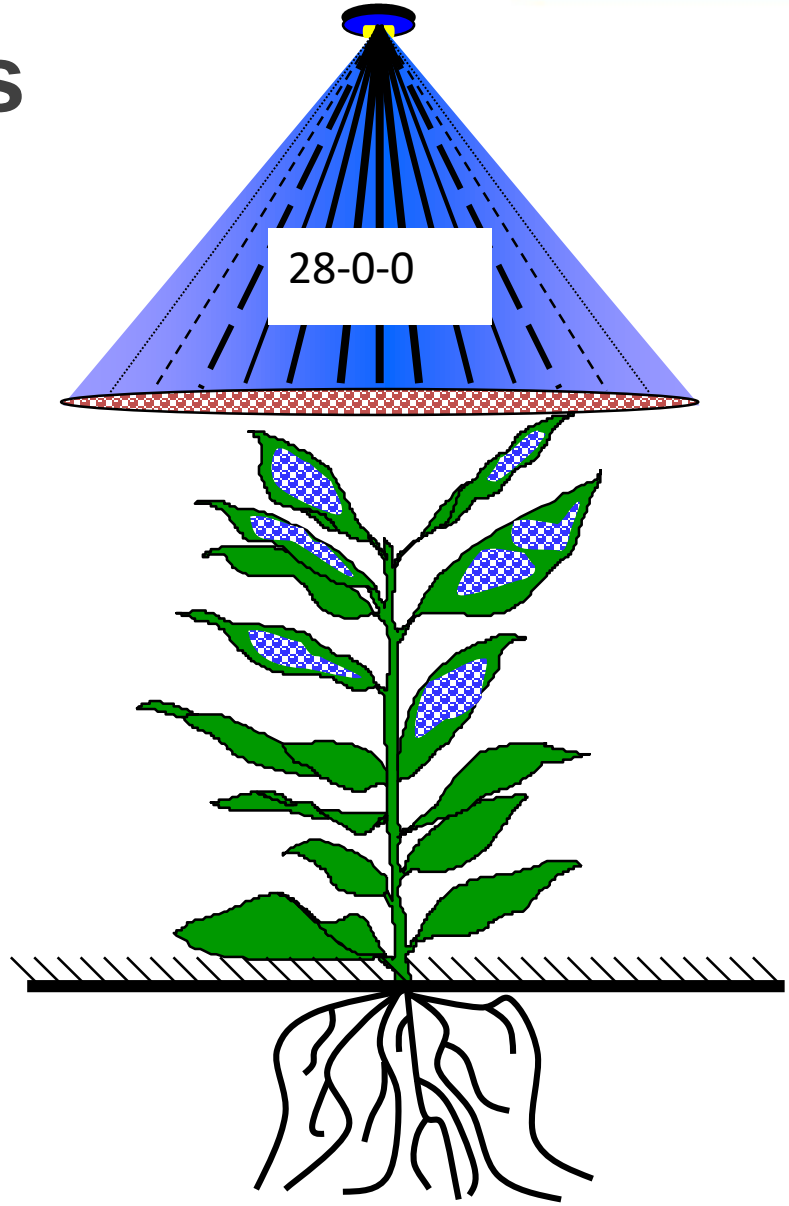
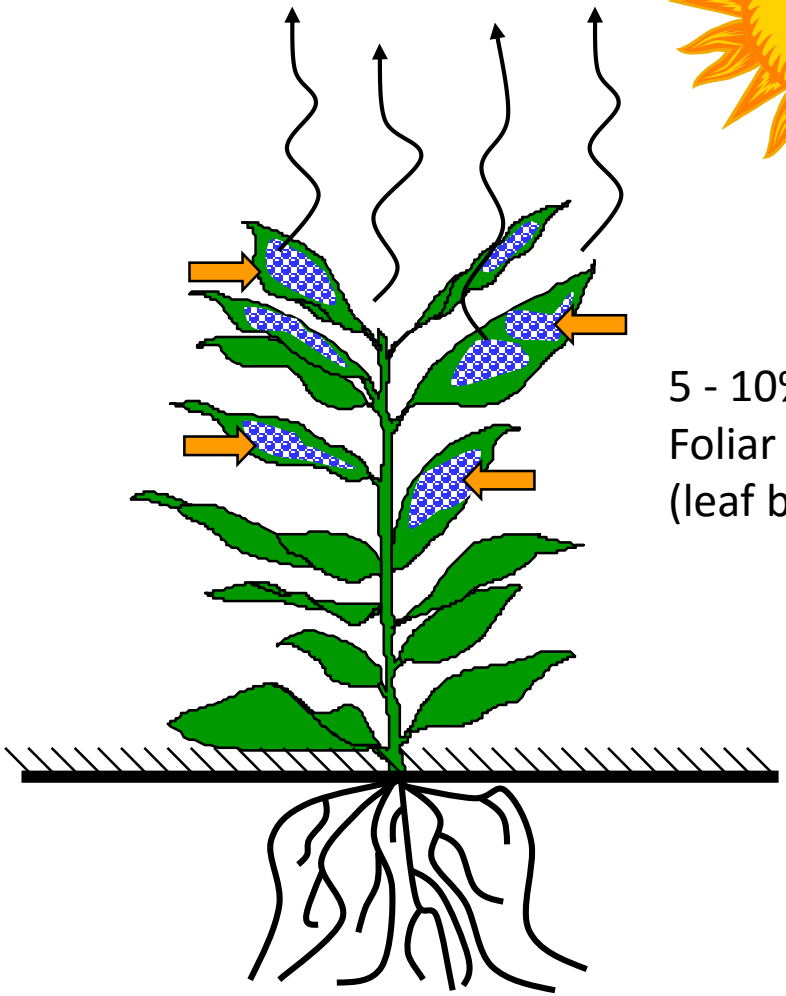
Nitrogen

Small window (4-6 weeks after seeding)

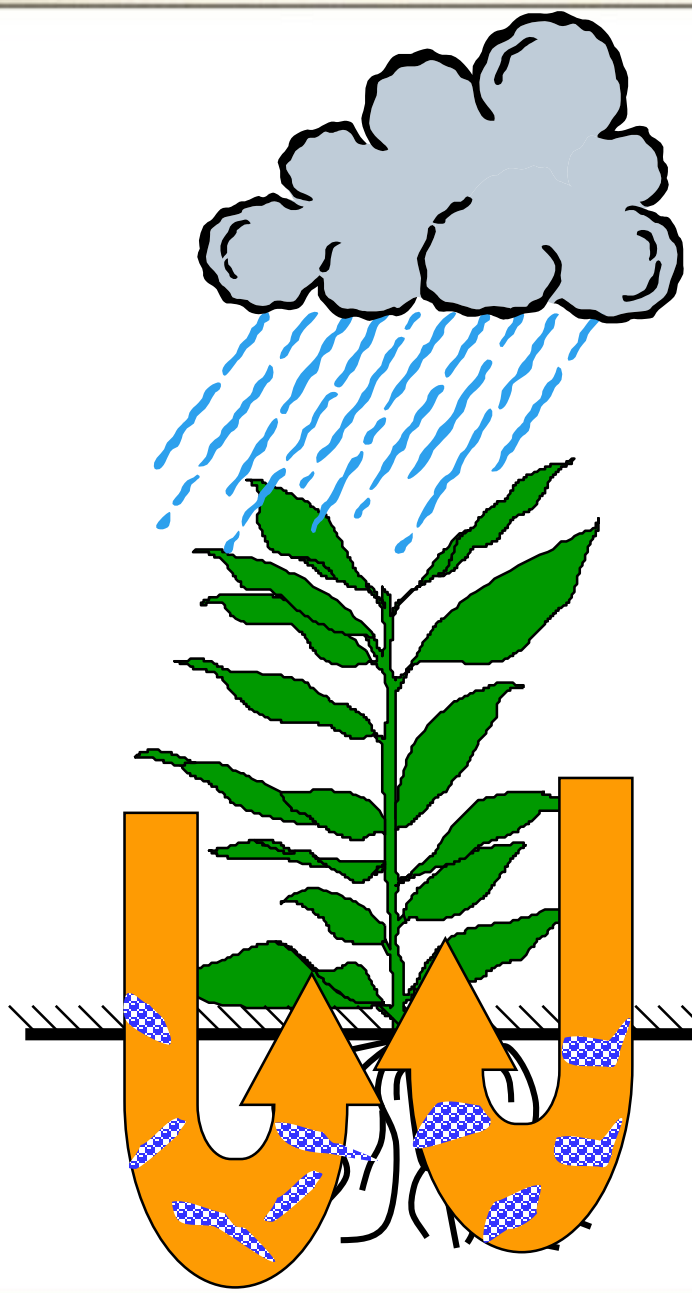
False Promises with Foliar N



False Promises with Foliar N



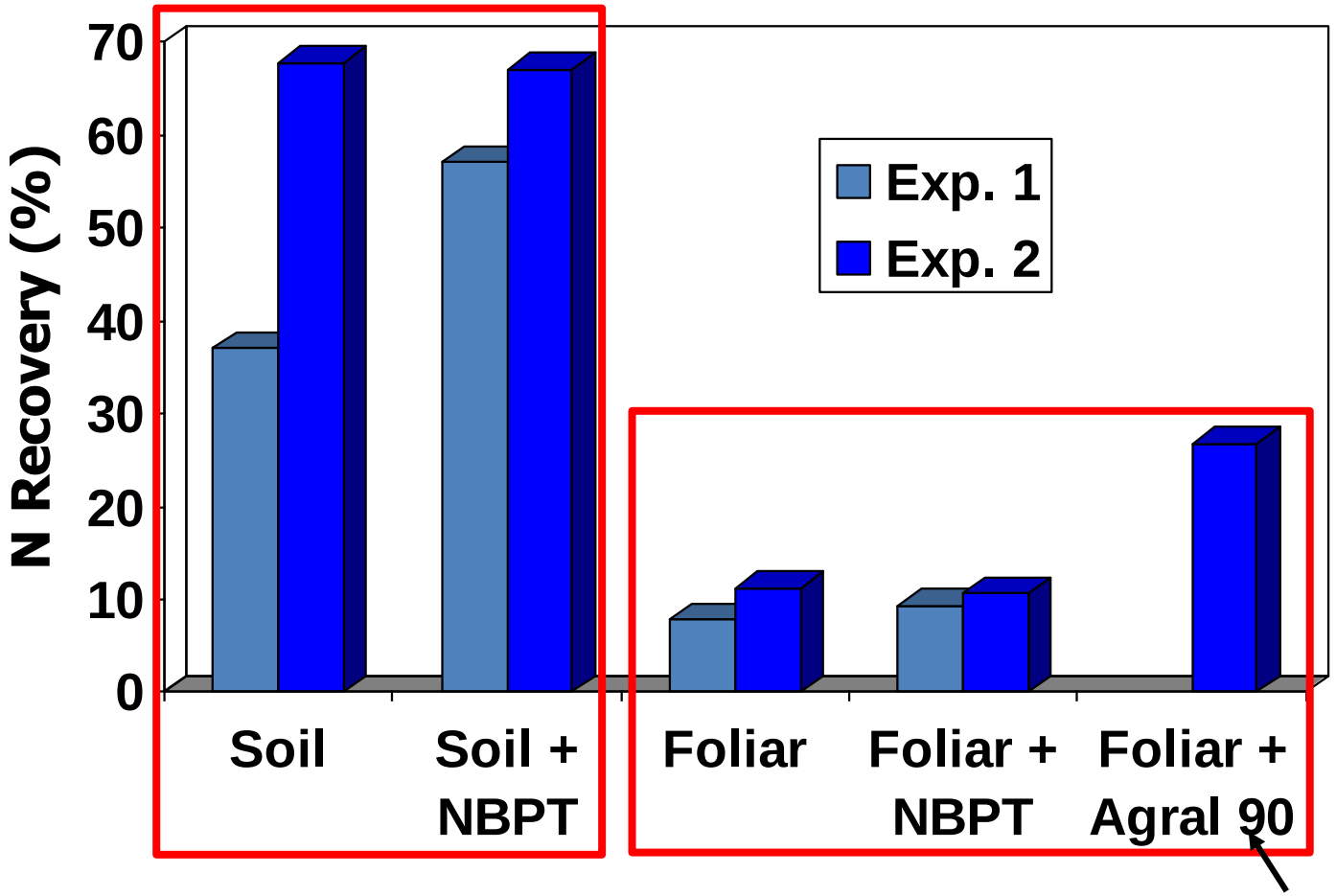
5 - 10%
Foliar Absorption
(leaf burn)



90 – 95%
Root Uptake

Uptake of foliar-applied urea by wheat is very low compared to soil application

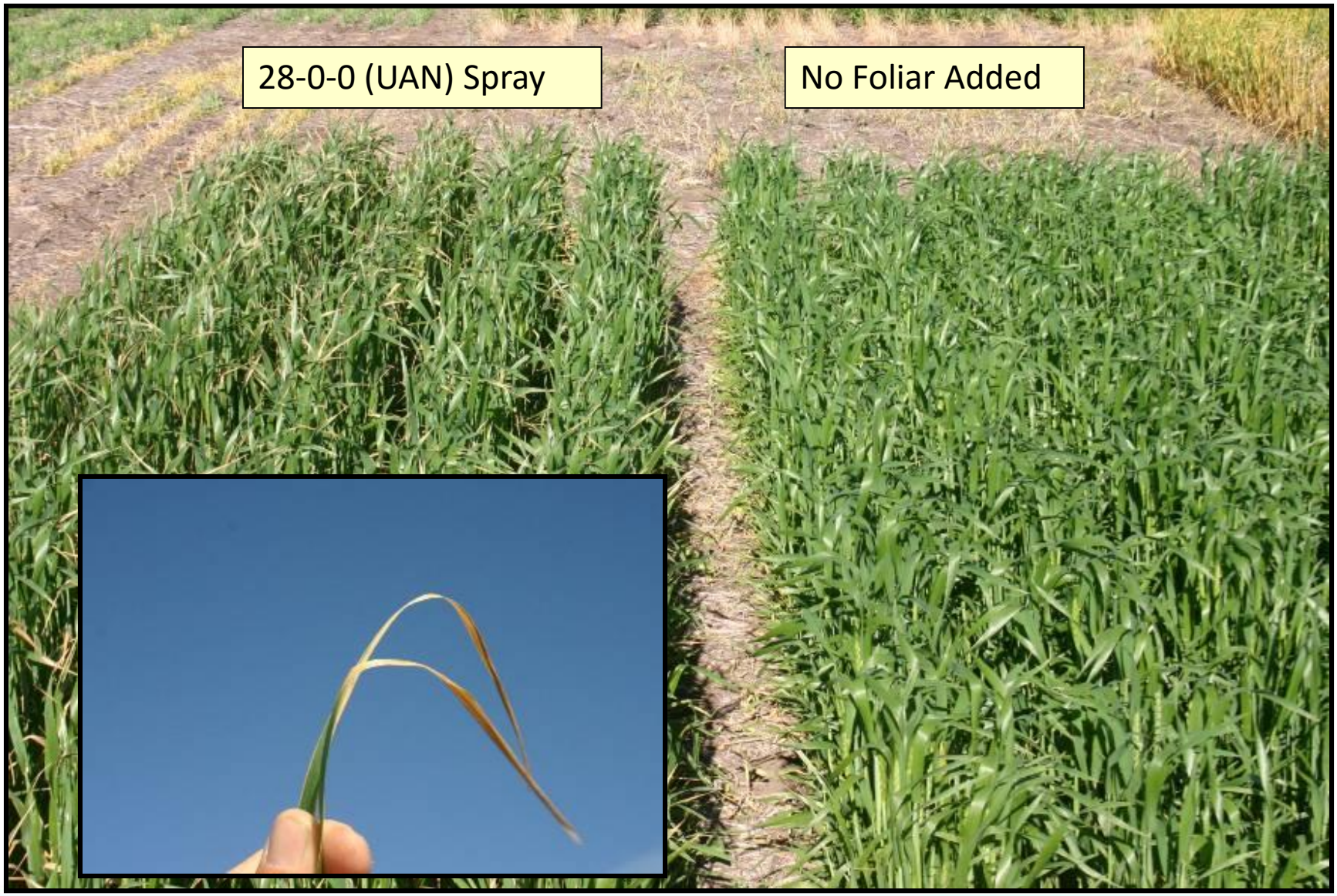
(two growth chamber studies with ^{15}N labelled urea)



*Rawluk, Grant and Racz . 2000. Can. J. Plant Sci. 80: 331–334

a non-ionic surfactant

Caution When Applying UAN as a Foliar



Tip Burn from Spray Applied N

Options for Foliar Fertilization

- Nitrogen rates between 5-15 lb of N acre
- Theoretically any nitrogen source could be used but there are specific limitations (e.g., NH_4^+, NO_3^-)
- Urea is widely used but with limitations (e.g., burning potential, NH_3 volatilization, crystallization)
- UAN is also a common source, again with some limitations
- Methylene-urea and urea triazone foliar fertilizers bring higher value to the overall spray blend than other liquid nitrogen.

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Exception!

Corn

Nitrogen Uptake in Corn

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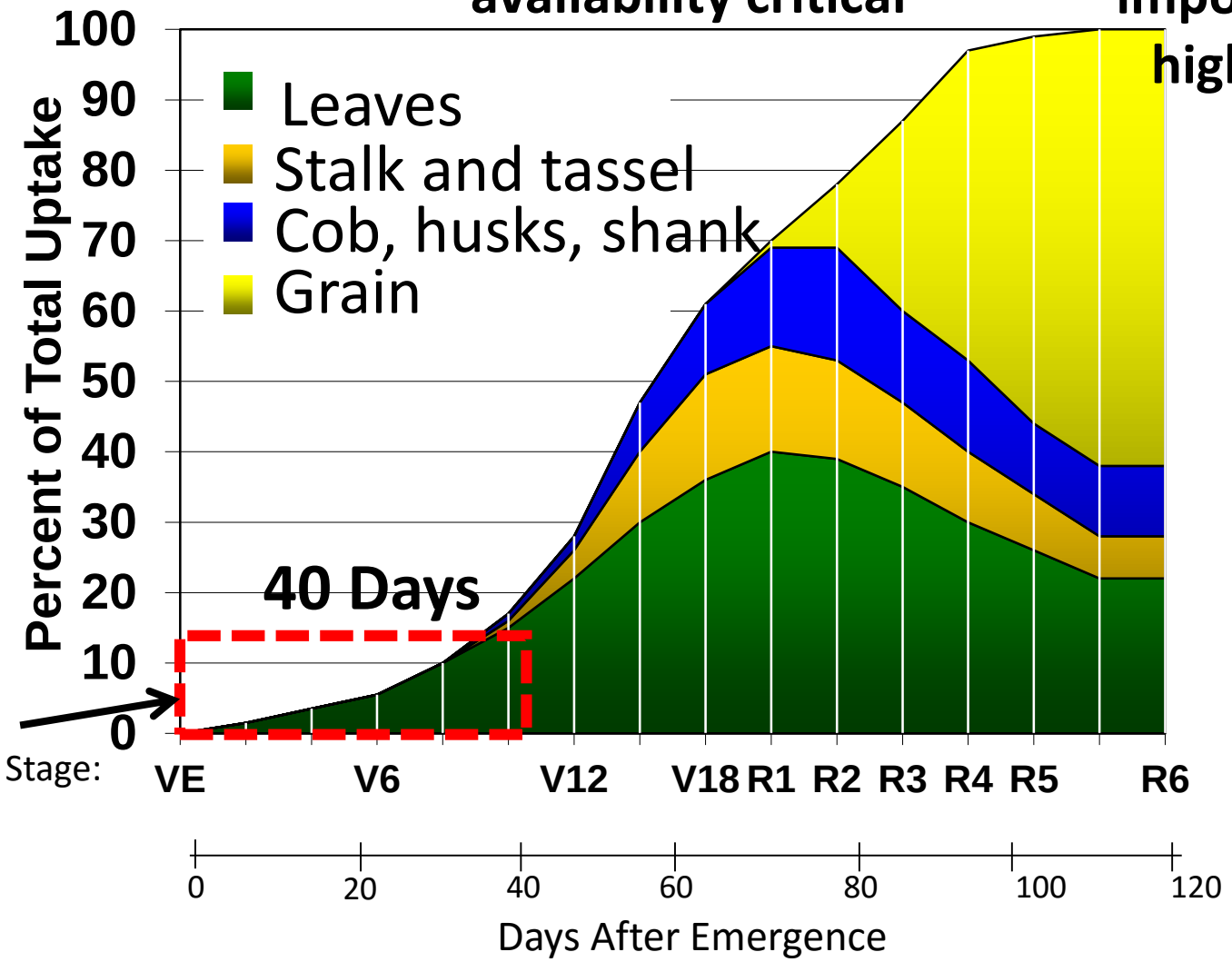
Mid-season N availability critical

Late season N important for high yields



Early N availability important

Source: Adapted from How a Corn Plant Develops, Special Report 48 Iowa State University

How Do We Insure Adequate N Availability for Corn?

- **Apply early and a lot!** **NO!!**
  - **Economics**
  - **Environment**

Des Moines struggling to clean nitrates from drinking water blamed on farming, might sue state

Article by: DAVID PITT , Associated Press | Updated: November 21, 2014 - 1:45 PM

Farm tiling called major cause of hypoxia

By freshwatersocietyblog

Phosphorus & Potassium

- Not recommended for three reasons:
  - Most P and K compounds are damaging to leaves when sprayed in amounts that are beneficial
  - High cost due to multiple applications
  - The efficiency of the application is very low

Missing Phosphorus (P) Fertilization in the spring – Consequences and Remedies

- It is important to apply some P to the soil at the beginning of the crop growth cycle to provide essential P for early growth and, if a maintenance fertilization strategy is required, to replace P exported in previous crops.
- But what happens when this application is missed or inadequate P is applied at seeding, especially since low levels of available P is a major factor limiting crop yields on many prairie soils?

Phosphorus & Potassium

- Foliar applications of P are the most effective way for a grower to supply P to crops late in-season, should there be a need to increase P supply to the crop.
- Research on the effectiveness of foliar P application in cereals has not been systematic, with research occurring in temporally and spatially isolated pockets.
- The majority of the research has occurred in the US and some in Australia.

Barel, D. and Black, C.A. 1979a. J. Agric. Biol. Sci. 1: 15-21.
Barel D., Black, C.A. 1979b. Agro. J. 71: 21-24.
Sawyer, J.E. and Barker, D. 1994. Foliar fertilization of corn with mono-potassium phosphate and urea. Iowa State University, Ames, IA.
Mosali, J., Desta, K., Teal, R.K., Freeman, K.W., Martin, K.L., Lawles, J.W. and Raun, W.R. 2006. J. Plant Nutr. 29: 2147-2163.
Girma, K., Martin, K.L., Freeman, K.W., Mosali, J., Teal, R.K., Raun, W.R., Moges, S.M. and Arnall, B. 2007. Comm. Soil Sci.e Plant Anal. 38: 1137-1154.
Bouma, D. and Dowling, E.J. 1976. Austr. J.l Agric. Res. 27: 53-62.
Alston, A.M. 1979. Austr. J. Agric. Res. 30: 577-585.

Do we have examples from western Canada?

- In Manitoba, preliminary research conducted at two locations in 1998*, one of which was P deficient, concluded that foliar applications increased wheat yield in all treatments that had received inadequate P at seeding time and exhibited P deficiency by 4.5 bu/acre.

* Green, D.R. and Racz, G.J. 1999. The effect of foliar phosphate solution application on wheat quality and yield. P. 90-96 in Proc. 1999 Manitoba Soil Science Workshop, University of Manitoba, Winnipeg, MB.

When should foliar P be applied?

- It is common to only add P at the early stages of plant establishment, but with high yield potential crops can become deficient in P later in the growing season[1].
- Applying foliar P in early growth stages can increase the number of fertile tillers[2,3]. This may result in an early dry matter response but may not necessarily supply the P needed for a significant grain yield response.
- Research into the best timing to apply this in-season 'top up' P suggests that prior to anthesis is the optimal time, but this covers a large proportion of the total growing season. A higher supply of P prior to heading resulted in a higher grain yield compared to P added at ripening[4].

[1]Gray, R.C. 1977. Foliar fertilisation with primary nutrients during the reproductive stage of plant growth. Proc. Fertilizer Society 164: 23.
[2]Grant, C.A., Flaten, D.N., Tomasiewicz, D.J. and Sheppard, S.C. 2001. The importance of early season phosphorus nutrition. Can. J. Plant Sci. 81: 211–224.
[3]Elliott, D.E., Reuter, D.J., Reddy, G.D., Abbott, R.J. 1997. Phosphorus nutrition of spring wheat (Triticum aestivum L.) 1. Effects of phosphorus supply on plant symptoms, yield, components of yield, and plant phosphorus uptake. Austr. J.l Agric. Res. 48: 855-867.
[4]Romer, R and Schilling, G. 1986. Phosphorus requirements of the wheat plant in various stages of its life cycle. Plant and Soil 91, 221-229.

How do I decide that I should apply foliar P?

- Stunted growth would be the first and most obvious indicator of P deficiency.
- Check your soil test. Soil test levels of less than 20 lb P/acre (10 ppm) would suggest a high probability (> 75%) of obtaining a yield response to P and a greater probability that a benefit from foliar P may ensue.
- Unfortunately, there are no criteria for tissue testing for most common crops in western Canada, except for specialty crops, e.g., potatoes, where foliar applications are often utilized to avert mid-season P deficiency.

Foliar S

- ammonium sulphate > Potassium thiosulphate > Ammonium thiosulphate > Potassium sulphate when applied at approximately 18 gallons/acre*
- S at seeding always provides maximum yield

***Malhi and Leach, 2000. Soils and Crops 200.**

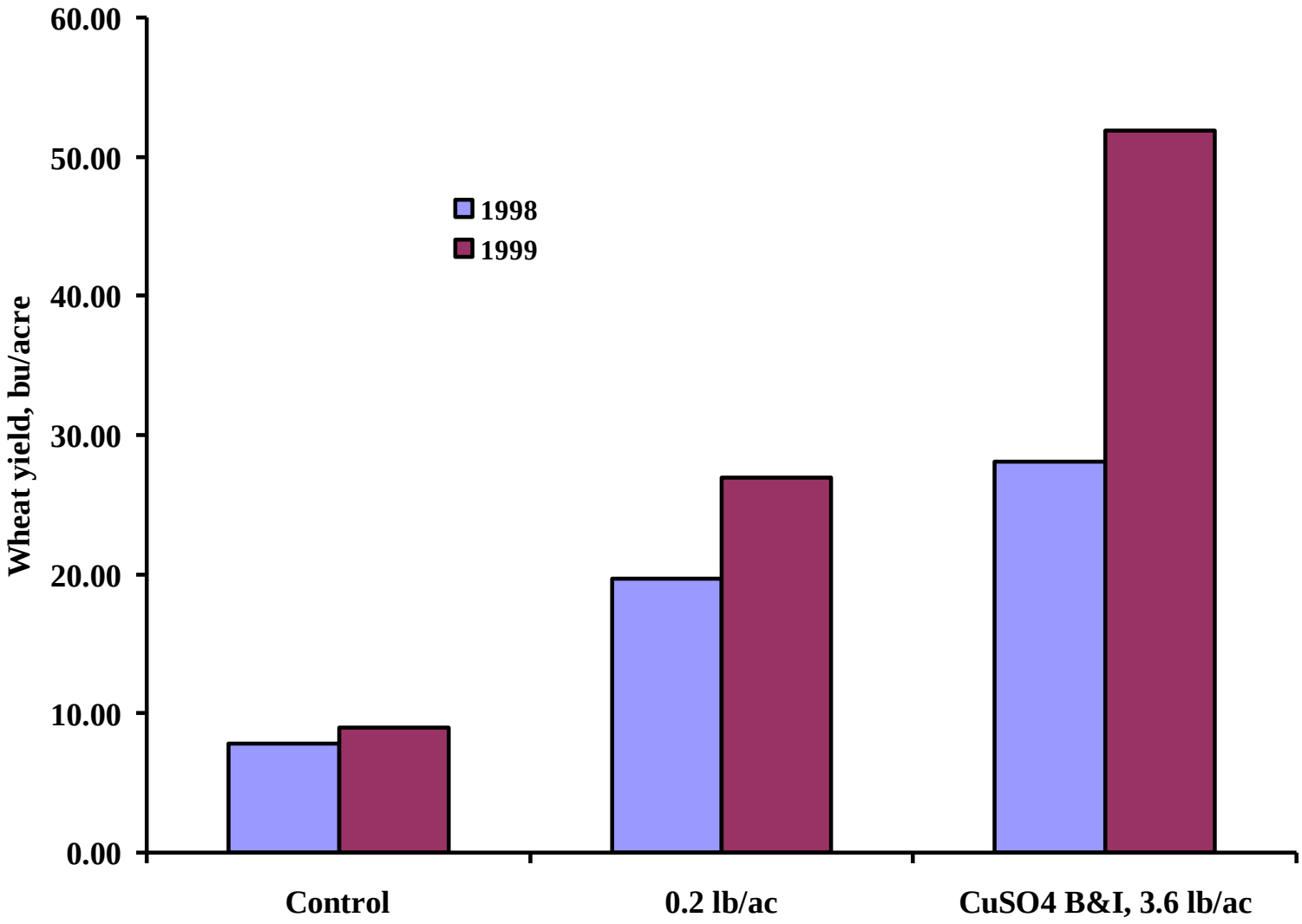
Micronutrients

- **Best suited for foliar applications**
- Efficiency of foliar applications often higher than soil applications

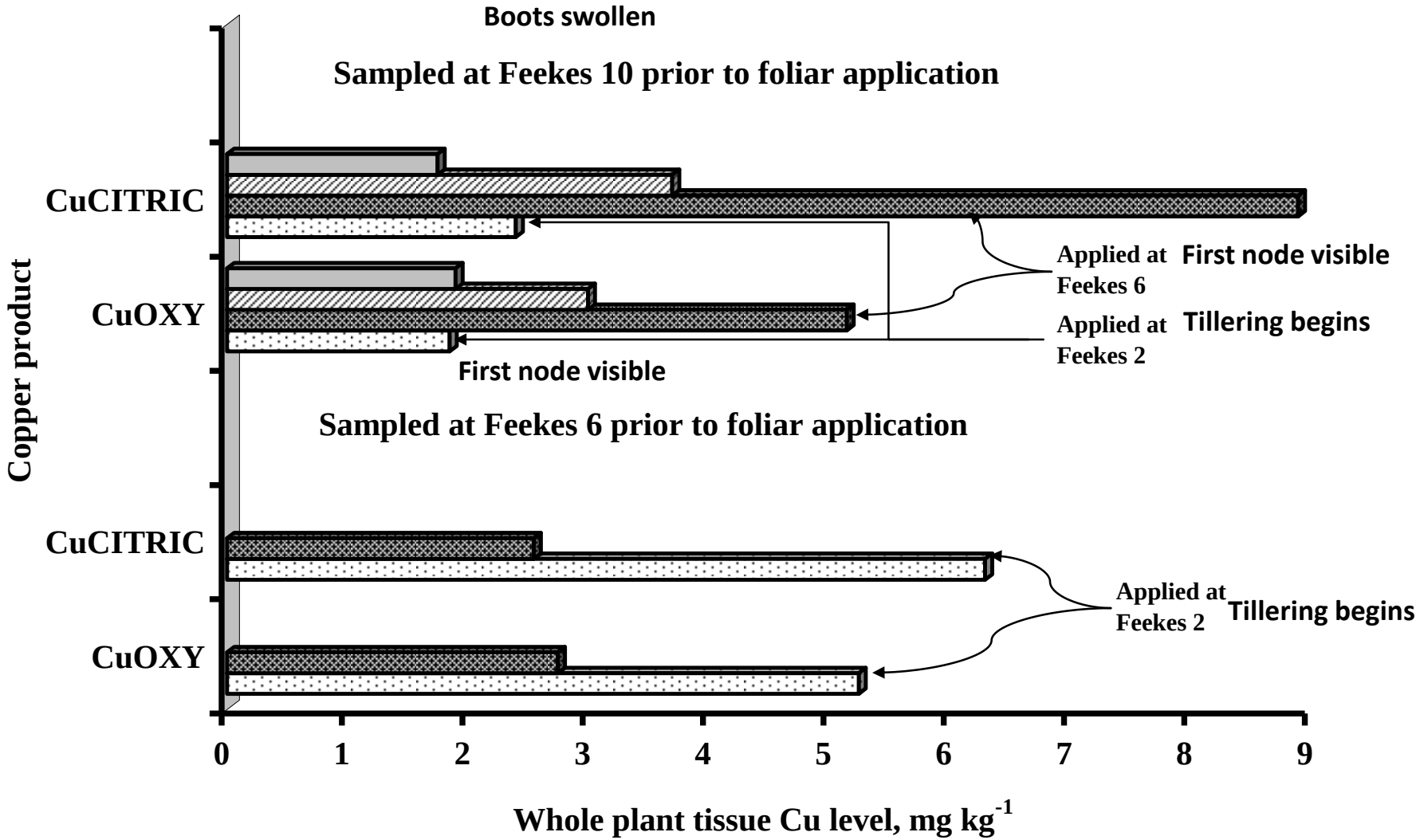
Example

	Cu in grain	Yield			Cu removal
	ppm	bu/ac	lb/ac	g/ac	g/ac
Deficient	**1**	**10**	**600**	**272,580**	**0.3**
Sufficient	**4**	**50**	**3000**	**1,362,900**	**5.5**
Minimum recommended rate			**0.2**		**91**

Foliar versus B&I

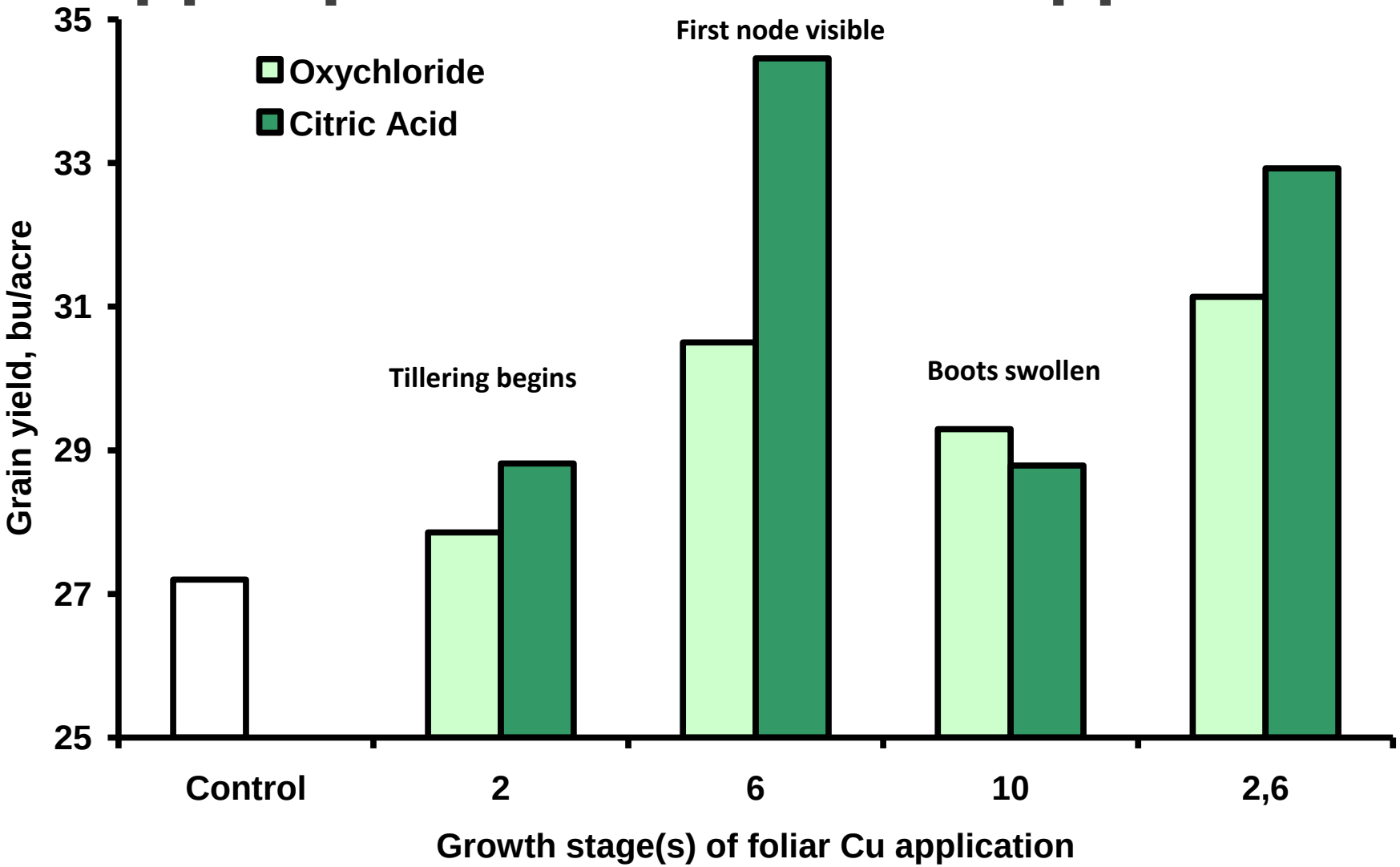


Copper products for foliar application



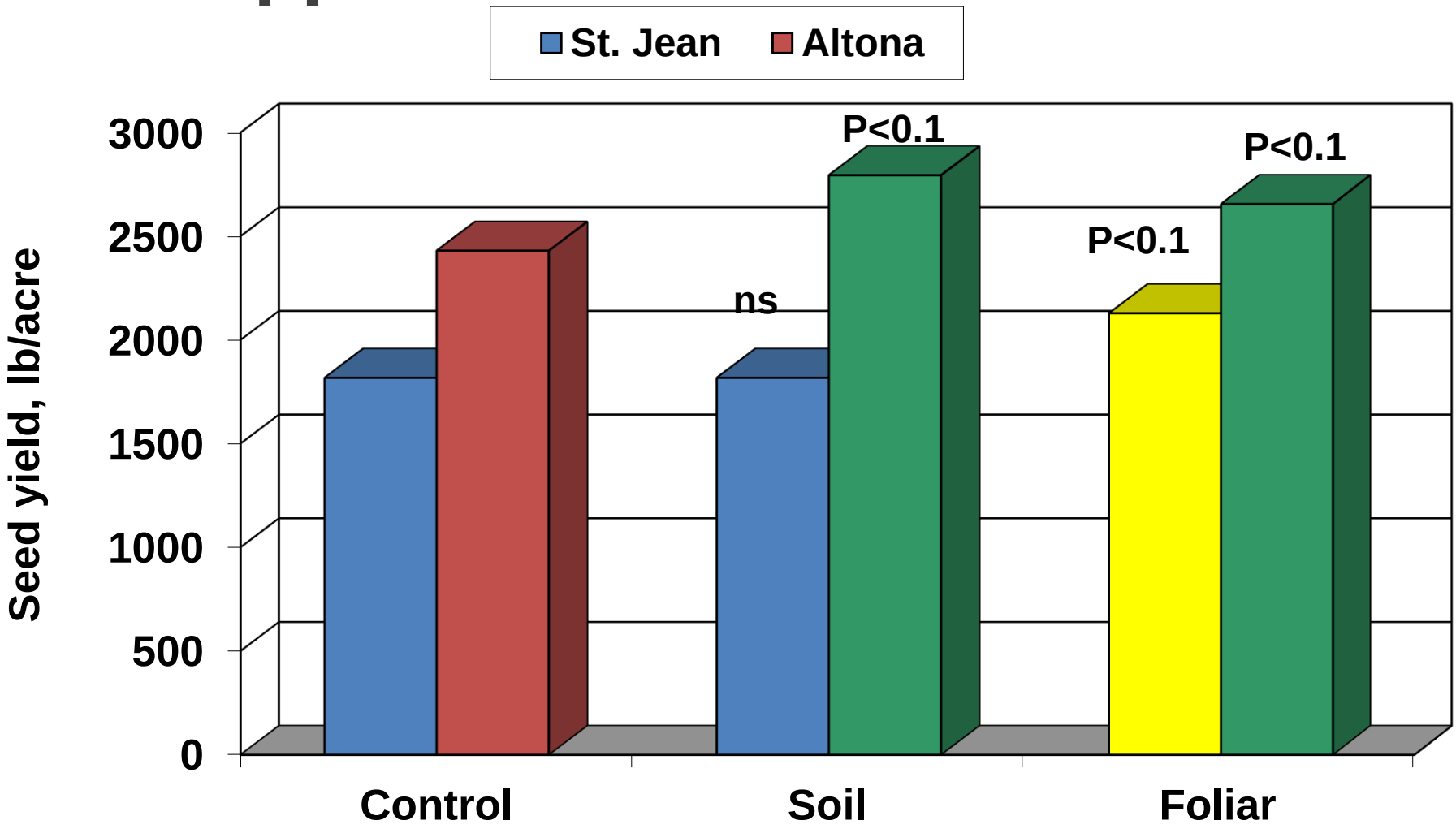
R.E. Karamanos, Q. Pomarenski, T.B. Goh and N.A. Flore, 2004. The Effect of Foliar Copper Application on Grain Yield and Quality of Wheat. Canadian Journal of Plant Science 84, 47-56.

Copper products for foliar application



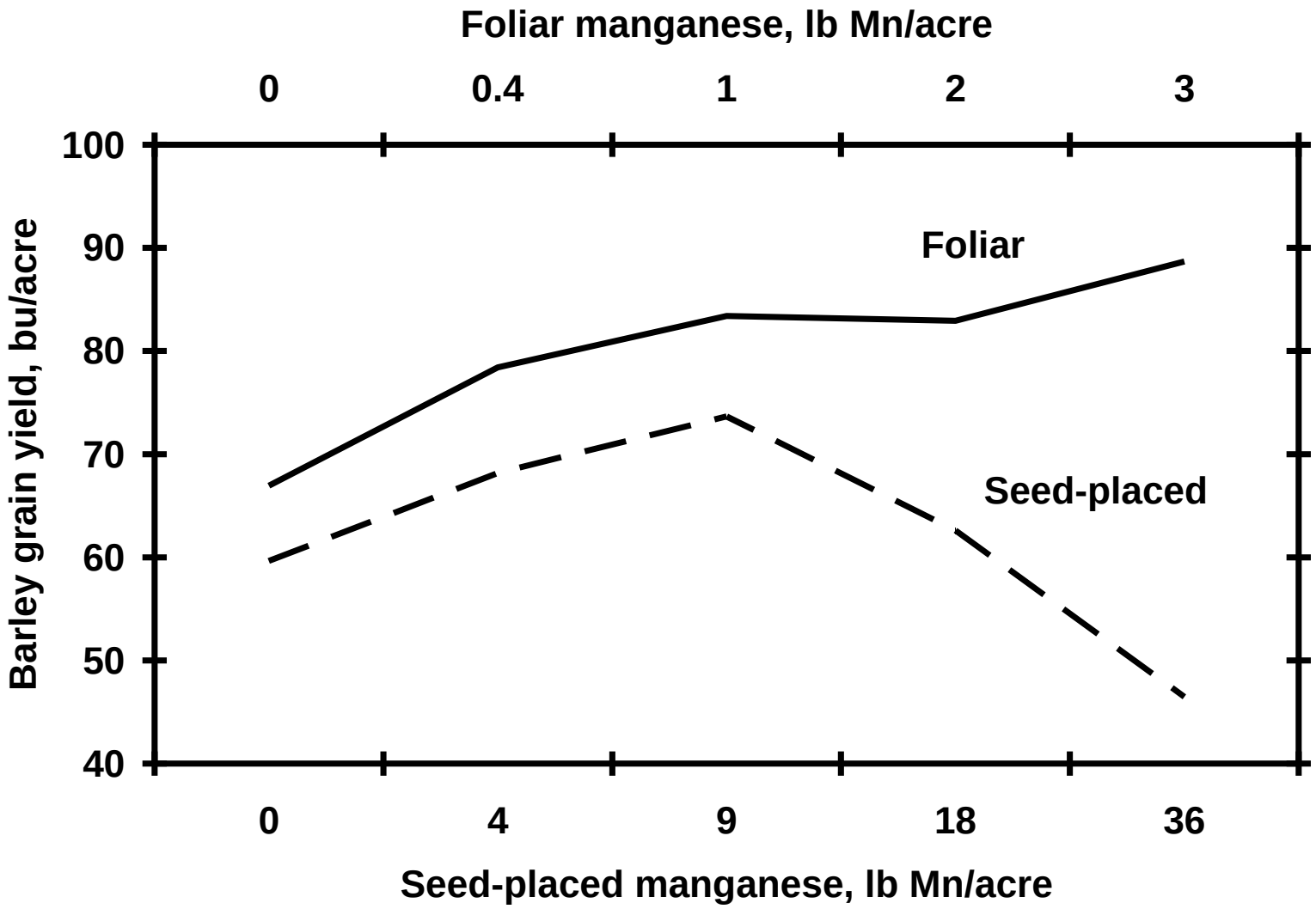
R.E. Karamanos, Q. Pomarenski, T.B. Goh and N.A. Flore, 2004. The Effect of Foliar Copper Application on Grain Yield and Quality of Wheat. Canadian Journal of Plant Science 84, 47-56.

Zn Application for Bean Production



T.B. Goh and R.E. Karamanos, 2004. Zinc Responses of Dry Beans in Manitoba. Canadian Journal of Plant Science 84, 213-216.

Manganese - barley



R.E. Karamanos, G.A. Kruger and J.L. Henry, 1984. Evaluation of Plant Tissue Criteria for Predicting Manganese Deficiency in Oats. Canadian Journal of Plant Science, 64, 836-868.

General Guidelines

Nutrient	Fertilizer form	Growth stage	Foliar
Copper	Sulphate	--	Effective but not recommended
	Oxysulphate	--	Not recommended
	Chelated	?	Not recommended
	Citric/sulphonate	F6-F10	0.2-0.25 lb Cu/acre
Zinc	Sulphate	--	Not recommended
	Oxysulphate	--	Not recommended
	Chelated	--	Not recommended
	Citric/sulphonate	F6-F10 1/10Bloom	0.3-0.4 lb Zn/acre
Manganese	Sulphate	--	Not recommended
	Chelated	F6-F10	0.5 – 1 lb Mn/acre
Boron	Sodium Borate	1/10 bloom	0.3 – 0.5 lb/acre

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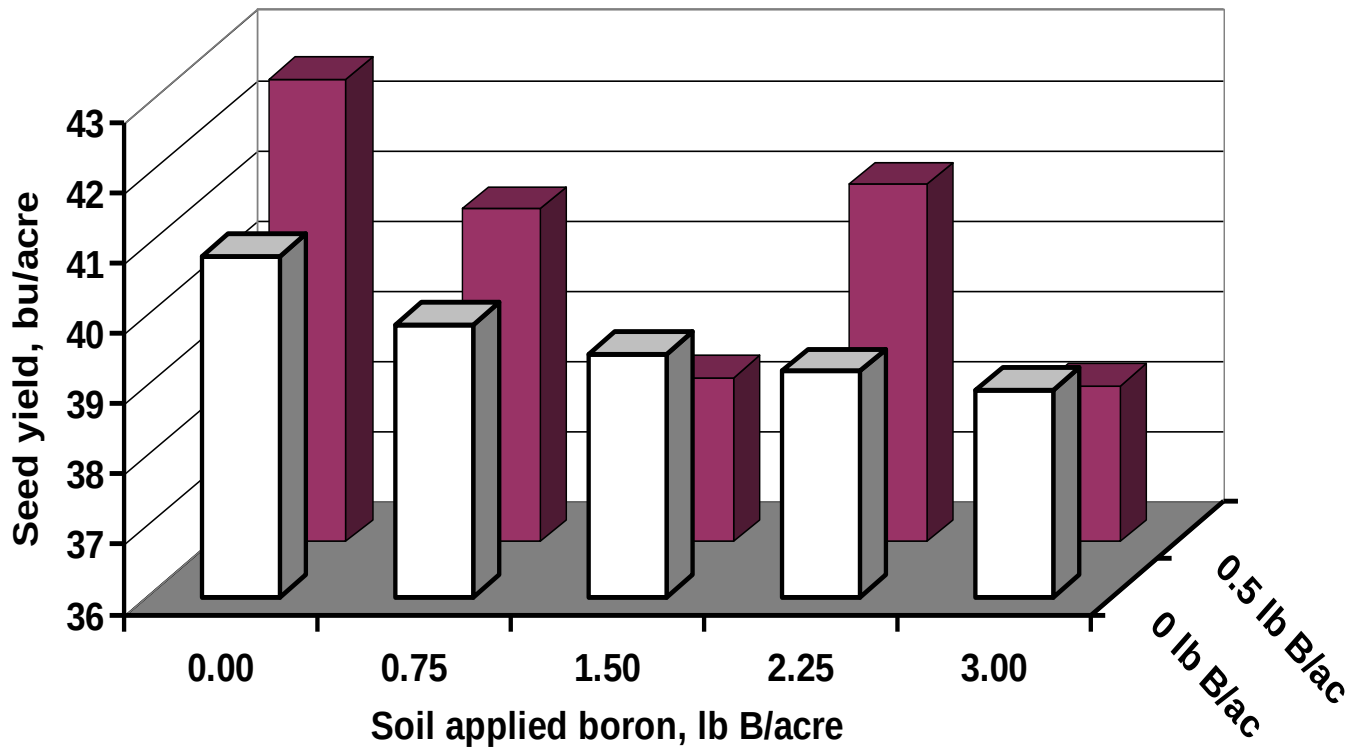
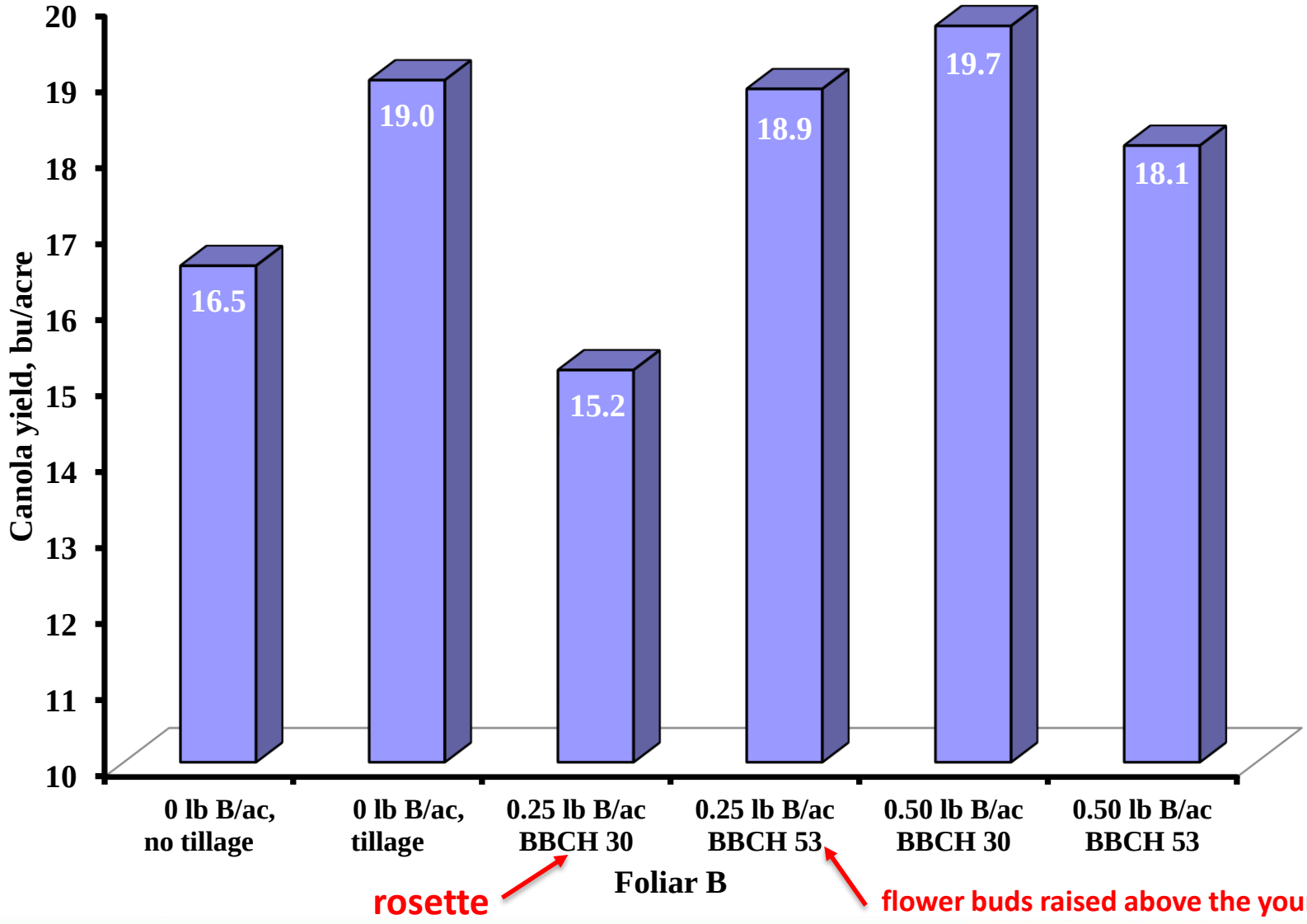
Boron

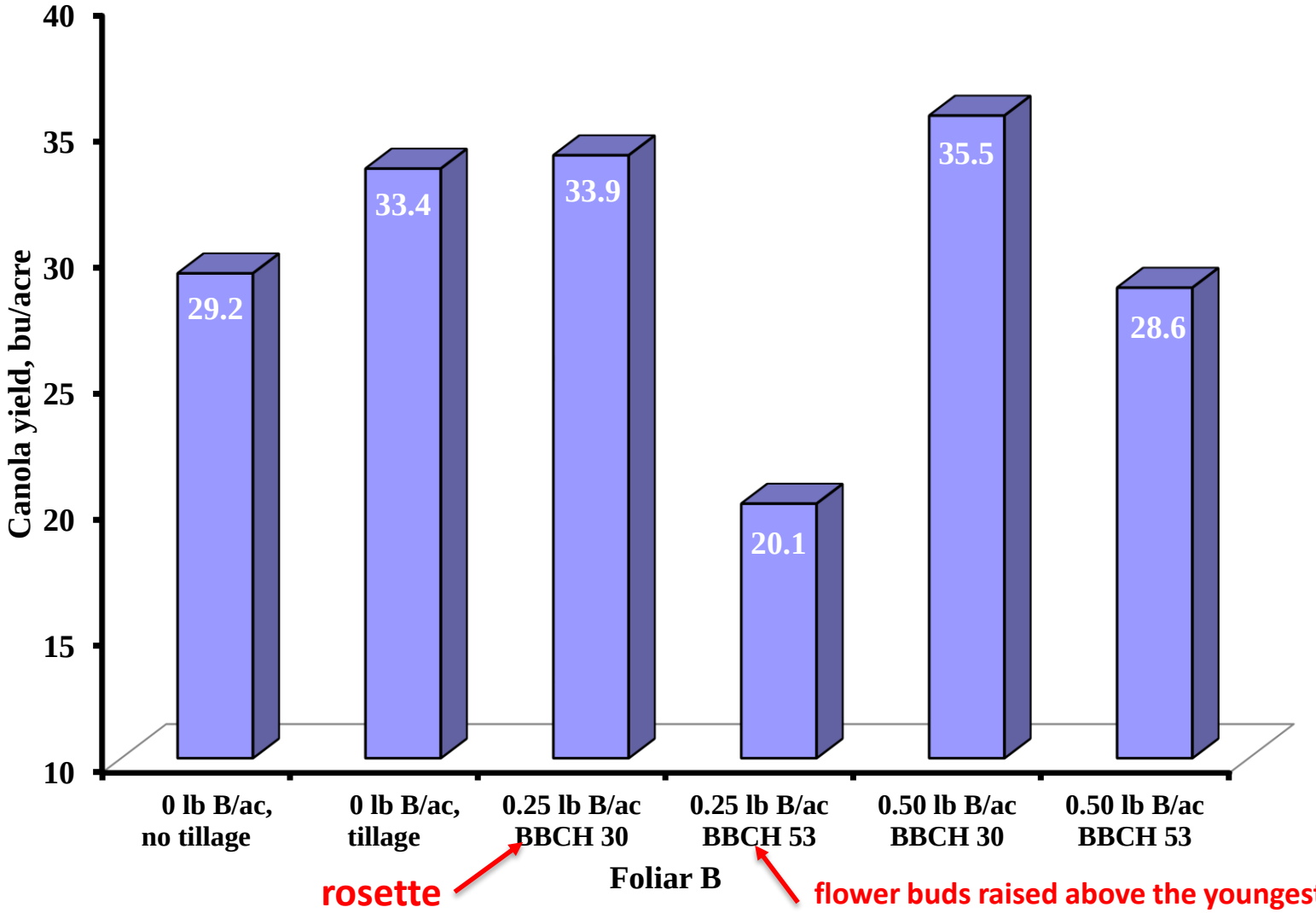
Miami – Foliar B Products/Times



Boron –Allan


Canola yield, bu/acre
20
19
18
17
16
15
14
13
12
11
10
16.5
19.0
15.2
18.9
19.7
18.1
0 lb B/ac, no tillage
0 lb B/ac, tillage
0.25 lb B/ac BBCH 30
0.25 lb B/ac BBCH 53
0.50 lb B/ac BBCH 30
0.50 lb B/ac BBCH 53
Foliar B
rosette
flower buds raised above the youngest leaves

Boron – Choiceland



The “other side” of Boron application

The “other side” of Boron application

The “other side” of Boron application



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THANK YOU