Managing High Tunnel Soil Fertility

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UNIVERSITY OF VERMONT
EXTENSION

Very different tunnel production systems

Nutrients affect quality not just yield

Rooting volume matters: small=less buffered

You have to “dial it in” for small plugs

Excess nutrients can lead to high salts in a potting mix

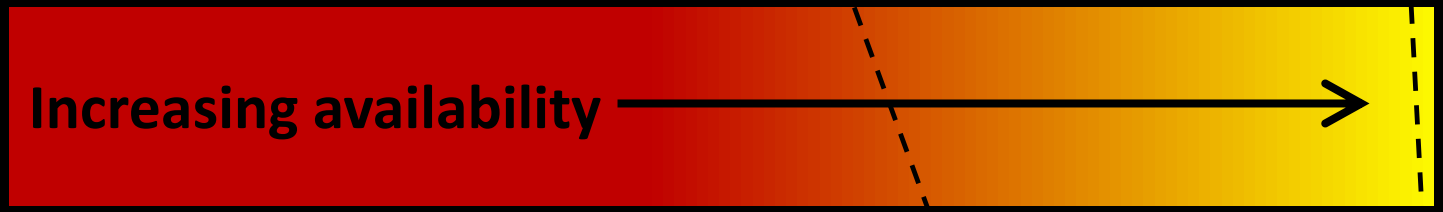
Salts can build up in a tunnel, especially near the surface

Available N may run out when “growing on” in a mix

organic growing medium is a ‘black box’
looks good, feels good…what’s in it?

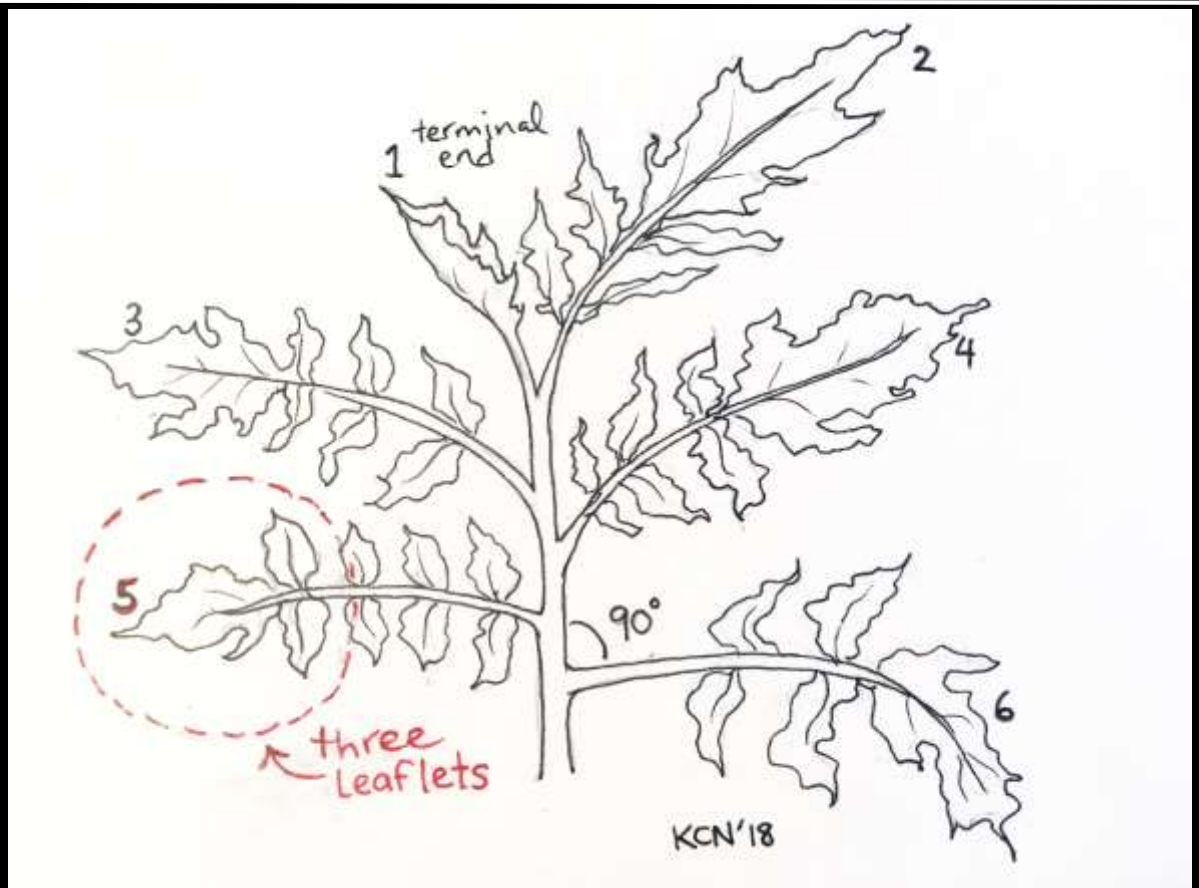
Monitoring Nutrient Levels

Soil



Modified Morgan **Saturated Media**

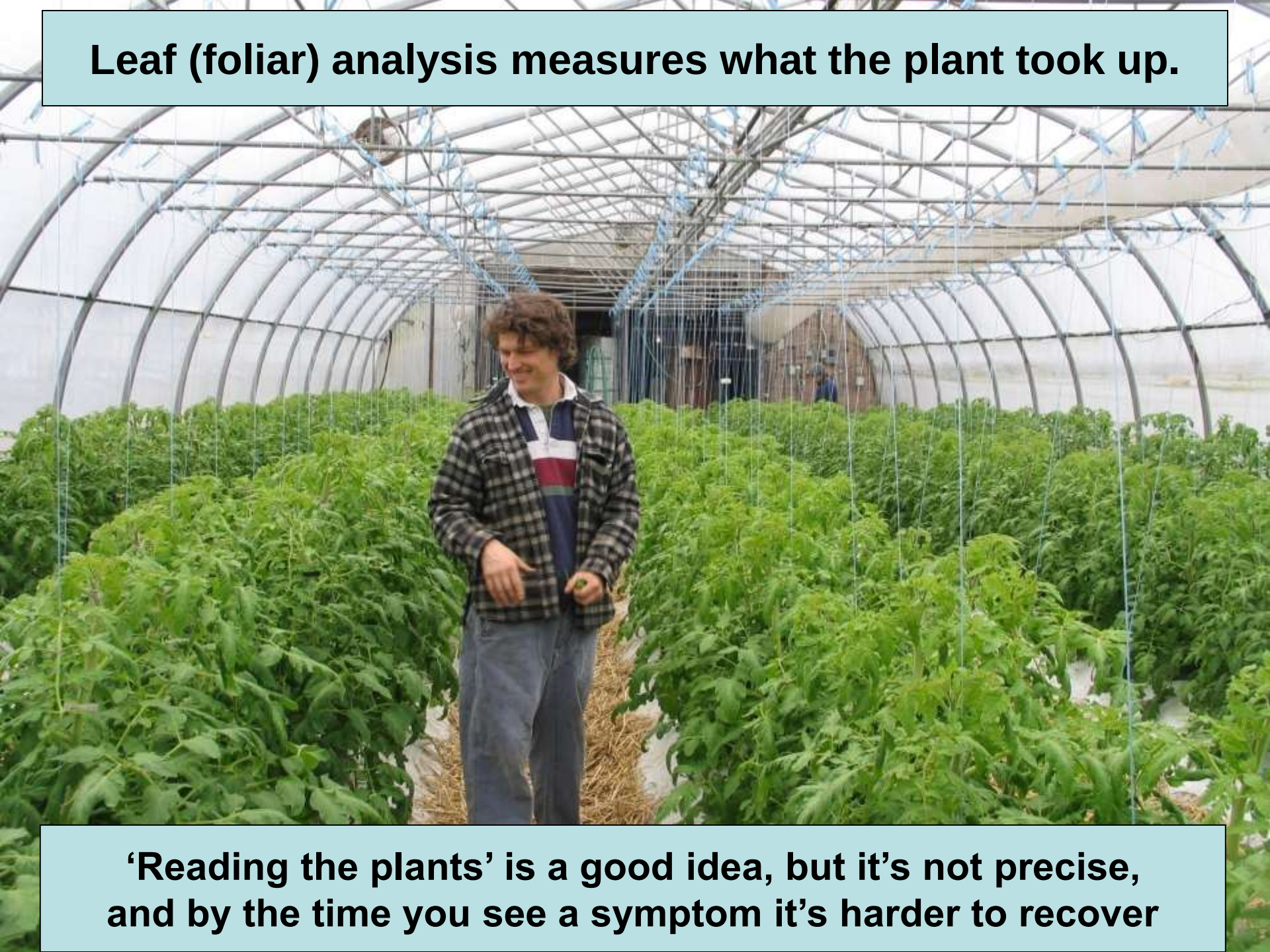
Leaf



Saturated media extract (SME) adds water to soil then measures soluble nutrients, immediately available to plants. Also measures soluble salts and nitrogen levels (not in field soil tests.)

Field soil tests use different acid solutions (modified Morgan's Mehlich, Brays) to extract reserve nutrients prior to measuring.

Leaf (foliar) analysis measures what the plant took up.



‘Reading the plants’ is a good idea, but it’s not precise, and by the time you see a symptom it’s harder to recover

Different tests require different samples

Field soil test*: use modified Morgan's only! Submit 1 cup soil – stick to same time each year.*

SME test: Submit 1 pint of soil that's been warm and moist for 1-2 weeks, a month or so before you'll be ready to plant.

Compost test: Submit 1 quart, warm and moist for 1-2 weeks.

Leaf analysis: take samples from correct place on ~20 plants.


Tools of the trade for field and tunnel sampling:
soil probe and a clean plastic bucket

All types of tests have 4 parts to the process

1) Sampling

2) Analysis

3) Interpretation of results

4) Recommendations

Any type of test requires a good sample for accurate results

- Test a uniform area of soil, potting mix, plants… avoid abnormal areas
- Sample correct soil depth, plant part, etc.
- Take 10 sub-samples, 20 is better, mix well
- Use a zig zag, haphazard pattern to sample
- Do not contaminate the sample
- Label sample clearly with location and date

Some Testing Options

UMaine:

SME: $18 + $8 for OM

Long term tunnel test: $25

(SME plus modified Morgan's field test)

Compost: $55

UMass:

SME: $30 + $6 for OM

Penn State:

SME: $40 w/o OM

Compost: $55 - $75 (with micros)

Organic potting mix (credited to Eliot Coleman in Kuepper, 2004).

1 part sphagnum peat
1 part peat humus (short fiber)
1 part compost
1 part sharp sand (builder's)
to every 80 quarts of this add:

1 cup greensand
1 cup colloidal phosphate
1½–2 cups crabmeal or blood meal
½ cup lime

Use the SME test

Table 1. General information guidelines for greenhouse growth media analyzed by the Saturated Media Extract (SME) method.

Analysis	*CATEGORY*				
	Low	*Acceptable*	*Optimum*	*High*	*Very High*
Soluble Salt, mS/cm	0-.75	.75-2.0	2.0-3.5	3.5-5.0	5.0+
Nitrate-N, ppm	0-39	40-99	100-199	200-299	300+
Phosphorus, ppm	0-2	3-5	6-9	11-18	19+
Potassium, ppm	0-59	60-149	150-249	250-349	350+
Calcium, ppm	0-79	80-199	200+	-	-
Magnesium, ppm	0-29	30-69	70+	-	-

Depends what you're growing: herbs? tomatoes?

Sample Name: Potting Soil

Crop Grown: Transplants

Comments:

Analytical Results

Determination	Optimum Level	Level Found
pH	5.8 - 6.4	6.9
Soluble Salts	0.75 - 3.50 mmhos/cm	4.38 mmhos/cm
Nitrate-N	40 - 200 ppm	11.7 ppm
(as % soluble salts)	(8 - 10 %)	(0.4 %)
Ammonium-N	2 - 20 ppm	167 ppm
Calcium	60 - 400 ppm	193 ppm
(as % soluble salts)	(14 - 16 %)	(6.9 %)
Potassium	40 - 300 ppm	366 ppm
(as % soluble salts)	(11 - 13 %)	(13.1 %)
Magnesium	30 - 200 ppm	48 ppm
(as % soluble salts)	(4 - 6 %)	(1.7 %)
Phosphorus	5 - 30 ppm	7.2 ppm

Saturated Media Extraction Method

Lab ID:	**J1724-1**	**J1724-2**	**J1724-3**
Sample ID:	**Fort Lite Mix**	**Fafard #2**	**Our Mix**
pH:	6.08	6.09	7.65
Conductivity ms/cm:	4.79	0.992	1.69
NO3 ppm:	276	0.493	0.202
NH4 ppm:	1.27	0.783	94.8
Phosphorus mg/L	20.5	13.1	6.15
Potassium mg/L	858.0	93.0	151.0
Calcium mg/L	218.0	49.5	38.6
Magnesium mg/L	122.0	58.0	37.2
Sodium mg/L	200.0	36.3	63.3


In-ground growing is highly buffered, due to soil volume
usually the soil is amended with a lot of compost, nutrients

If soil on site is poor quality or compacted, make raised beds


If adding a lot of compost to potting mix or tunnel soil, it's a good idea to do a compost test first

Compost test results – UMaine lab

STANDARD ANALYSIS

Parameter	Dry Basis	As is Basis	Lbs/Ton (as is)
Total Solids (%)		41.7	

C:N of 17, low NH4, neutral pH = mature (stable)

1 cu. yd. = 1/2 ton contains about 5-3-2

20 yards would add 100-40-20 of N-P-K

lb of N is immediately available as nitrate-N

Zinc (ppm)	114	47.8	0.10

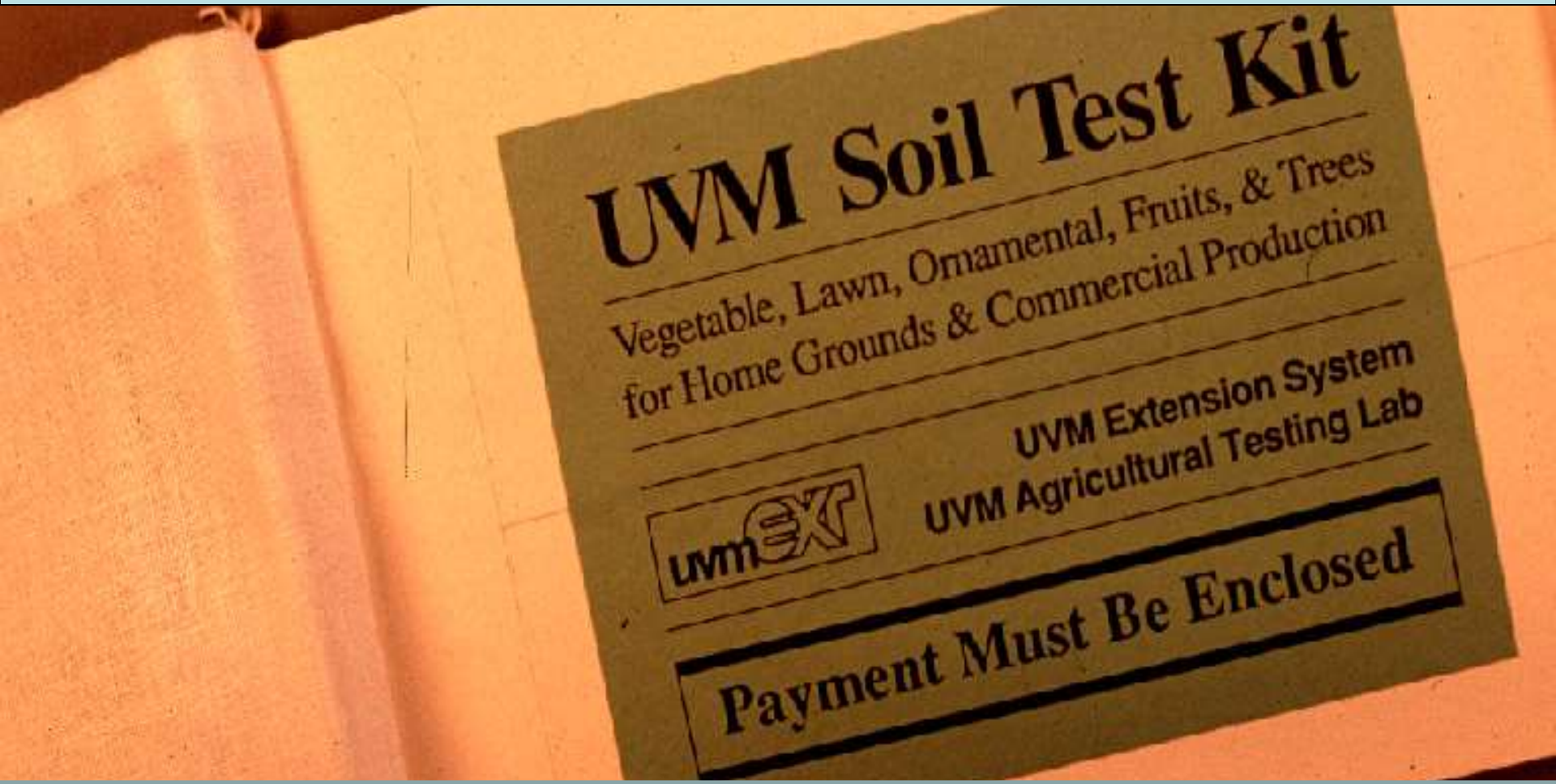
MATURITY ANALYSIS

Parameter	Dry Basis	As is Basis	Lbs/Ton (as is)
C:N Ratio		16.9	
NH4-N (ppm)	0.85	0.355	< 0.01
NO3-N (ppm)	364	152	0.30

Tomatoes: plan ahead for heavy nutrient demand, yields can be much greater than in the field


What about leafy greens, winter growing?
A lot less nutrients are needed, but data is lacking.

‘Field’ soil test alone for established tunnel soil is not so helpful: nutrients are usually ‘off the chart’ but that is for field yields. Also does not include soluble salts, nitrate-N, ammonium-N



Best option is SME + field soil test

Results VT County: Chittenden

Nutrient	Low	Medium	Optimum	High or Excessive
Phosphorus (P):				
Potassium (K):				
Magnesium (Mg):				

Phosphorus is excessive!!!

Analysis	*Value Found*	*Optimum Range (or Average *)*
Soil pH (2:1, water)	7.2	
Modified Morgan extractable, ppm		
Macronutrients		
Phosphorus (P)	310.1	4-10
Potassium (K)	749	100-160
Calcium (Ca)	6060	**
Magnesium (Mg)	781	50-120
Sulfur (S)	18.0	11*
Micronutrients		
Iron (Fe)	5.3	7.0*
Manganese (Mn)	16.0	8.0*
Boron (B)	2.6	0.3*
Copper (Cu)	0.1	0.3*
Zinc (Zn)	3.6	2.0*
Sodium (Na)	121.0	20*
Aluminum (Al)	6	35*
Soil Organic Matter %	14.8	**
Effective CEC, meq/100g	38.7	**
Base Saturation, %		
Calcium Saturation	77.3	40-80
Potassium Saturation	4.9	2.0-7.0
Magnesium Saturation	16.6	10-30

SME optimal ranges for greenhouse tomatoes

• pH	6 – 7
• nitrate-N	125 – 200 ppm
• P	1 – 5 ppm
• K	150 – 275 ppm
• Ca	> 250 ppm
• Mg	> 60 ppm
• soluble salts	2- 4 (mmhos)

Adapted from: Greenhouse Tomatoes, Lettuce and Cucumbers. by S. H. Wittwer and S. Honma. 1979 . Michigan State Univ. Press.

SME test results – UMaine lab

pH	6.0 - 7.0	7.4		HIGH
Soluble Salts	2.0 - 4.0 mmhos/cm	2.57	mmhos/cm	OK
Organic Matter	8 - 12 %	8.3	%	OPTIMUM
Nitrate-N	100 - 200 ppm	30.5	ppm	LOW
Ammonium-N	< 10 ppm	< 0.5	ppm	OK
Phosphorus	1 - 5 ppm	1.4	ppm	OPTIMUM
Potassium	150 - 275 ppm	12	ppm	LOW
Magnesium	> 60 ppm	151	ppm	OPTIMUM
Calcium	> 250 ppm	403	ppm	OPTIMUM
Aluminum	< 10 ppm	0.1	ppm	OK
Boron	0.05 - 0.50 ppm	0.05	ppm	OPTIMUM
Copper	0.01 - 0.5 ppm	0.027	ppm	OPTIMUM
Iron	0.3 - 5.0 ppm	0.06	ppm	LOW
Manganese	0.1 - 3.0 ppm	0.02	ppm	LOW
Sodium	< 100 ppm	74	ppm	OK

Same soil sample:
Modified Morgan's (field soil) test results – UMaine lab

Level Found	7.4	0.00	328	490	1607	16650	14.2(A)	4.4	13.1	82.5	0.0
	Soil pH	Lime Index 2	Phosphorus (lb/A)	Potassium (lb/A)	Magnesium (lb/A)	Calcium (lb/A)	CEC (me/100 g)	K	Mg (% Saturation)	Ca	Acidity
Optimum Range	6.0-7.0	N/A	40-80	400-600			> 5		10-20	60-80	< 10

Level Found	8.3	230	0.17	4.2	10.6	2.3
	Organic Matter(%)	Sulfur (ppm)	Copper (ppm)	Iron (ppm)	Manganese (ppm)	Zinc (ppm)
Normal Range	8-12	> 25	.25-.60	6 - 10	4 - 8	1 - 2

Level Found	1.0	107	2.57	32	3
(Extras)	Boron (ppm)	Sodium (ppm)	Soluble Salts (mmhos/cm)	Nitrate-N (ppm)	Ammonium-N (ppm)
Normal Range	0.5-1.2	< 200	< 4.0	100-200	< 10

Additional Results or Comments:

Lead scan: NORMAL BACKGROUND LEVEL - no health risk.

Full payment received for this sample. Thank you.

Determination	Optimum Range	Level Measured	Relative Level
pH	6.0 - 7.0	6.1	OPTIMUM
Soluble Salts	2.0 - 4.0 mmhos/cm	3.05 mmhos/cm	OK
Organic Matter	8 - 12 %	11.0 %	OPTIMUM
Nitrate-N	100 - 200 ppm	188 ppm	OPTIMUM
Ammonium-N	< 10 ppm	5.9 ppm	OK
Phosphorus	1 - 5 ppm	9.5 ppm	HIGH
Potassium	150 - 275 ppm	93 ppm	MEDIUM
Magnesium	> 60 ppm	128 ppm	OPTIMUM
Calcium	> 250 ppm	503 ppm	OPTIMUM
Aluminum	< 10 ppm	0.4 ppm	OK
Boron	0.05 - 0.50 ppm	0.43 ppm	OPTIMUM
Copper	0.01 - 0.5 ppm	0.086 ppm	OPTIMUM
Iron	0.3 - 5.0 ppm	0.51 ppm	OPTIMUM
Manganese	0.1 - 3.0 ppm	0.84 ppm	OPTIMUM
Sodium	< 100 ppm	153 ppm	HIGH
Sulfur	25 - 100 ppm	349 ppm	HIGH
Zinc	0.3 - 3.0 ppm	0.10 ppm	LOW

Same soil sample:
Modified Morgan's (field soil) test results – UMaine lab

Level Found	6.1	6.14	394	536	1048	8393	14.1(A)	4.9	14.0	68.0	13.2
	Soil pH	Lime Index 2	Phosphorus (lb/A)	Potassium (lb/A)	Magnesium (lb/A)	Calcium (lb/A)	CEC (me/100 g)	K	Mg (% Saturation)	Ca	Acidity
Optimum Range	6.0-7.0	N/A	40-80	400-600			> 5		10-20	60-80	< 10

Level Found	11.0	270	0.36	10.5	15.8	6.4
	Organic Matter(%)	Sulfur (ppm)	Copper (ppm)	Iron (ppm)	Manganese (ppm)	Zinc (ppm)
Normal Range	8-12	> 25	.25-.60	6 - 10	4 - 8	1 - 2

Level Found	1.7	192	3.05	184	12
(Extras)	Boron (ppm)	Sodium (ppm)	Soluble Salts (mmhos/cm)	Nitrate-N (ppm)	Ammonium-N (ppm)
Normal Range	0.5-1.2	< 200	< 4.0	100-200	< 10

Additional Results or Comments:

Lead scan: NORMAL BACKGROUND LEVEL - no health risk.

know your organic fertilizer options, beyond compost

common organic soil amendments

- **N**: soy, peanut, feather meal; Chilean (sidedress)
- **P**: bone meal, bone char, rock phos
- **K**: potassium sulfate, sul-po-mag, greensand
- **Ca**: lime, gypsum
- **Mg**: lime, sul-po-mag, epsom salts
- **Blends**: ProGro, Cheep-Cheep, alfalfa meal etc.
- **Micros**: compost, borax, Azomite, chelates
- **Organic matter**: compost, peat moss

PRO-GRO 5-3-4
A NATURAL/ORGANIC FERTILIZER

This product is blended from the following list of natural ingredients:

BONEMEAL
ROCK PHOSPHATE
COLLOIDAL PHOSPHATE
OYSTER MEAL
KELP MEAL

GREENSAND
LANGBEINITE
VEGETABLE PROTEIN MEALS
MEAT AND BONE MEAL

NATURAL NITRATE OF SODA
LEATHER MEAL
FISH MEAL
BENEFICIAL BACTERIA
HUMATES
TRACE MINERALS


Dried
Blood
12-0-0


NITRATE
OF SODA
For Greener Growth
16-0-0
NET WT. 5 LBS.

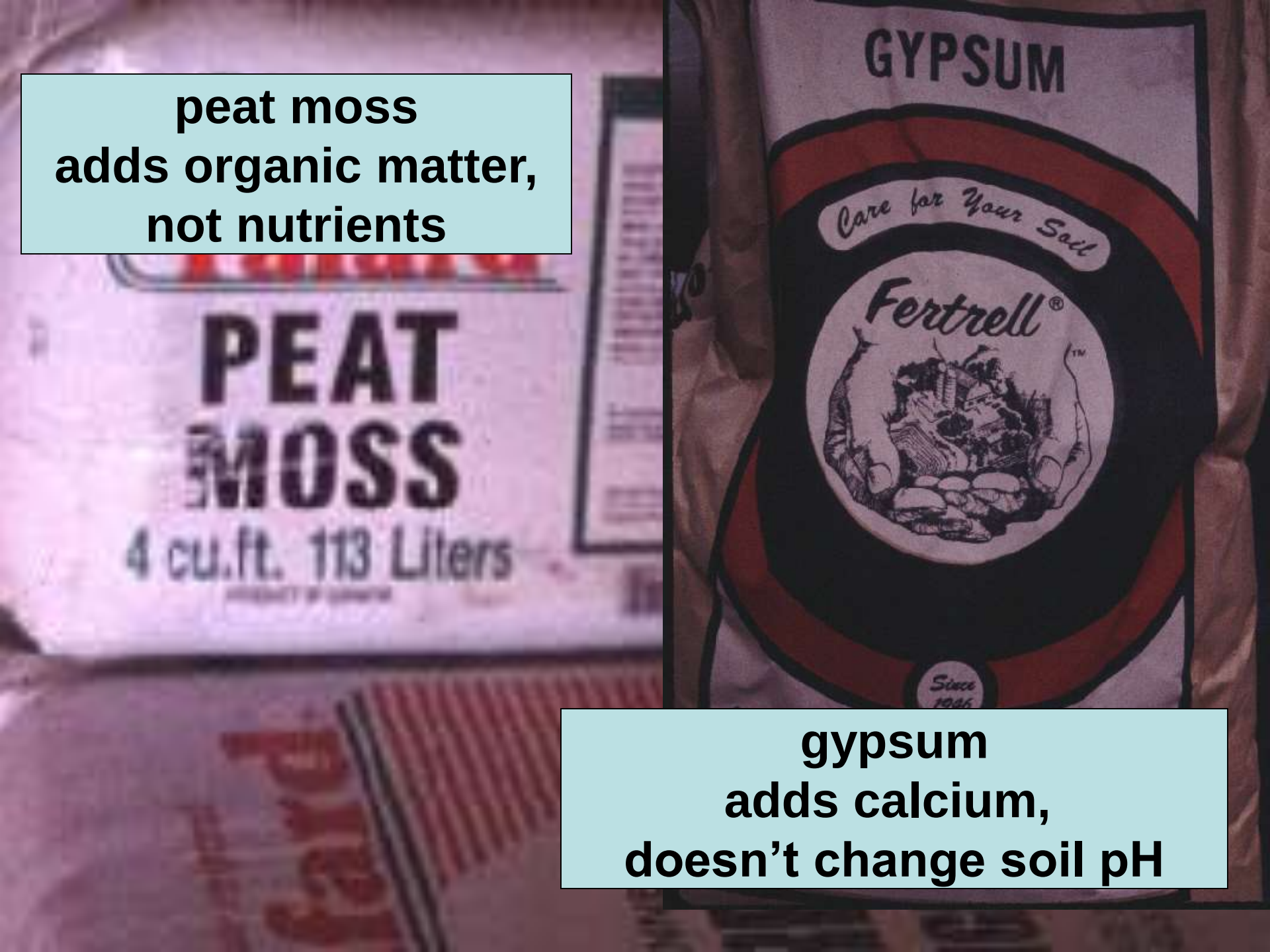

BONE CHAR 0-16-0
BONE CHAR 0-16-0
BONE CHAR 0-16-0
BONE CHAR 0-16-0
BONE CHAR 0-16-0
NORTH COUNTRY

For K, potassium sulfate is a better value, unless you also need magnesium

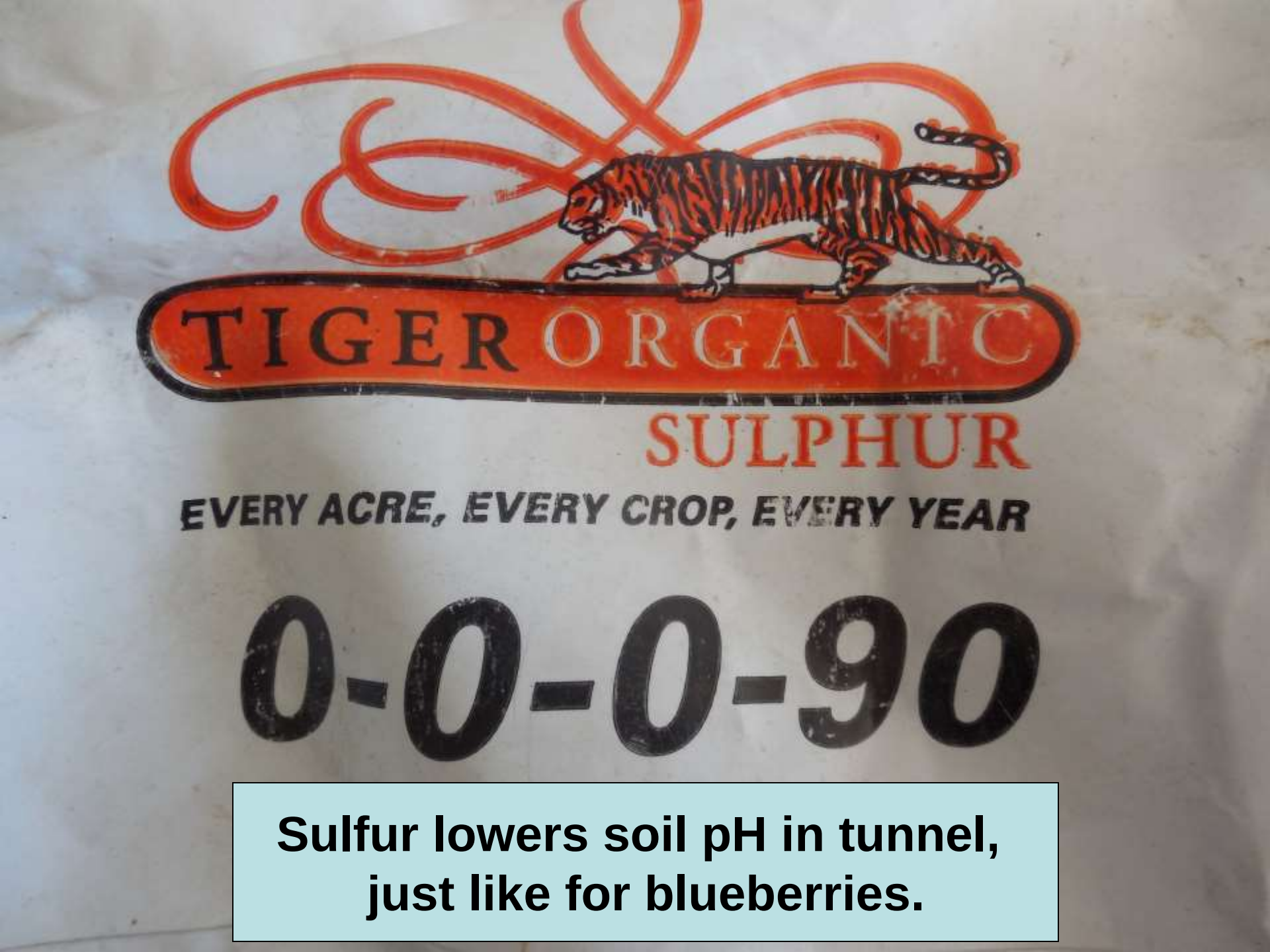
sul-po-mag 0-0-22-11 Mg
(same as langbenite, Kmag)

potassium sulfate 0-0-50
“fines” are more available


2-1-2
7-2-1
alfalfa meal
soy meal

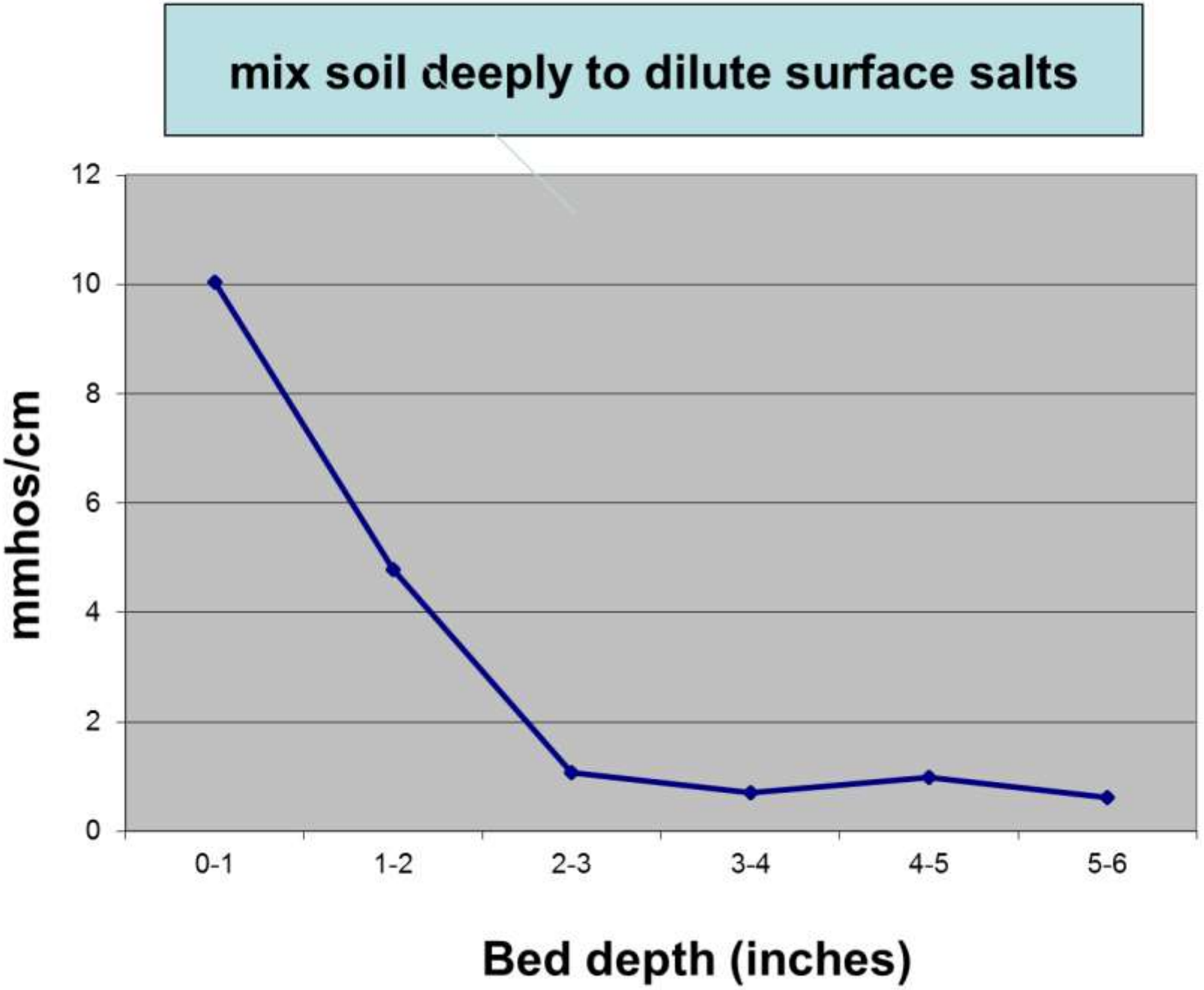

peat moss
adds organic matter,
not nutrients
PEAT
MOSS
4 cu.ft. 113 Liters
GYPSUM
Care for Your Soil
Fertrell
gypsum
adds calcium,
doesn't change soil pH

3-5 bales compressed peat moss per 1000 sq ft (+ lime if needed)



Sulfur lowers soil pH in tunnel, just like for blueberries.


spread soil amendments materials evenly!


mix soil deeply to dilute surface salts
12
10
8
6
4
2
0
mmhos/cm
0-1
1-2
2-3
3-4
4-5
5-6
Bed depth (inches)


maintain OM: compost, peat moss, and/or cover crops
H&S

How important is cover cropping to tunnel soil fertility? fall-planted oats

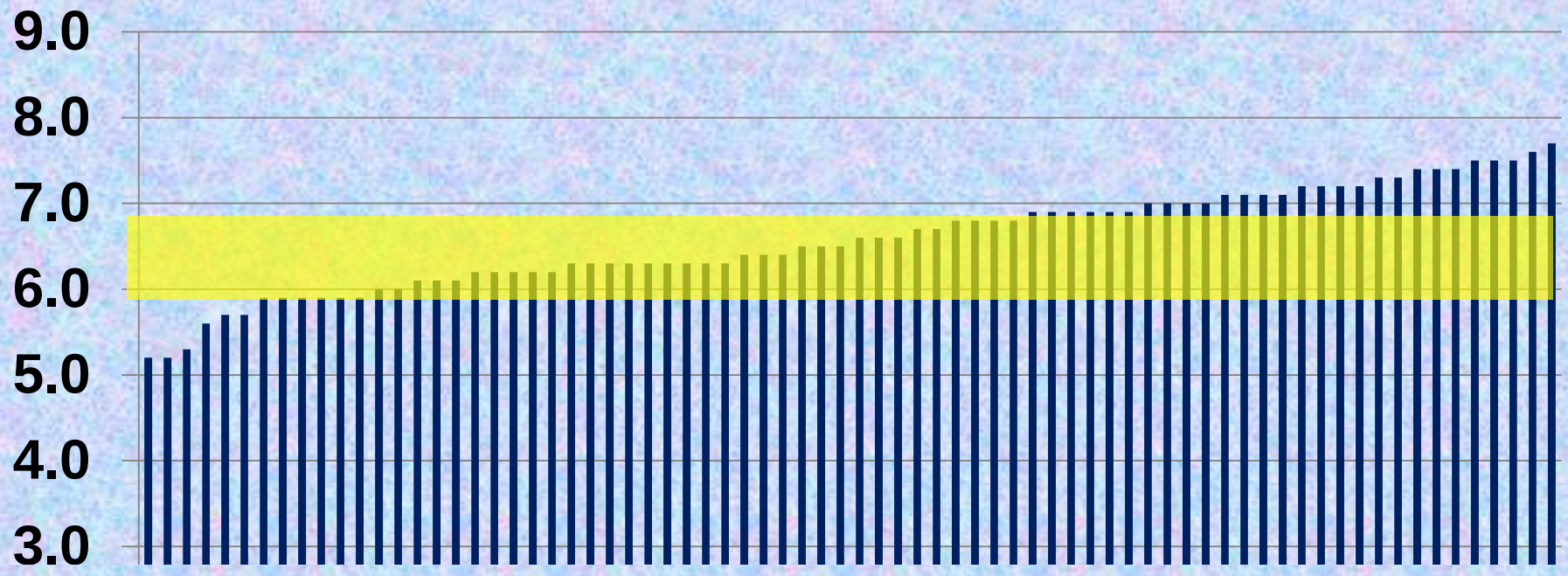

summer-planted cowpeas


buckwheat

What have we found out about tunnel **in-ground soil fertility on commercial farms**?

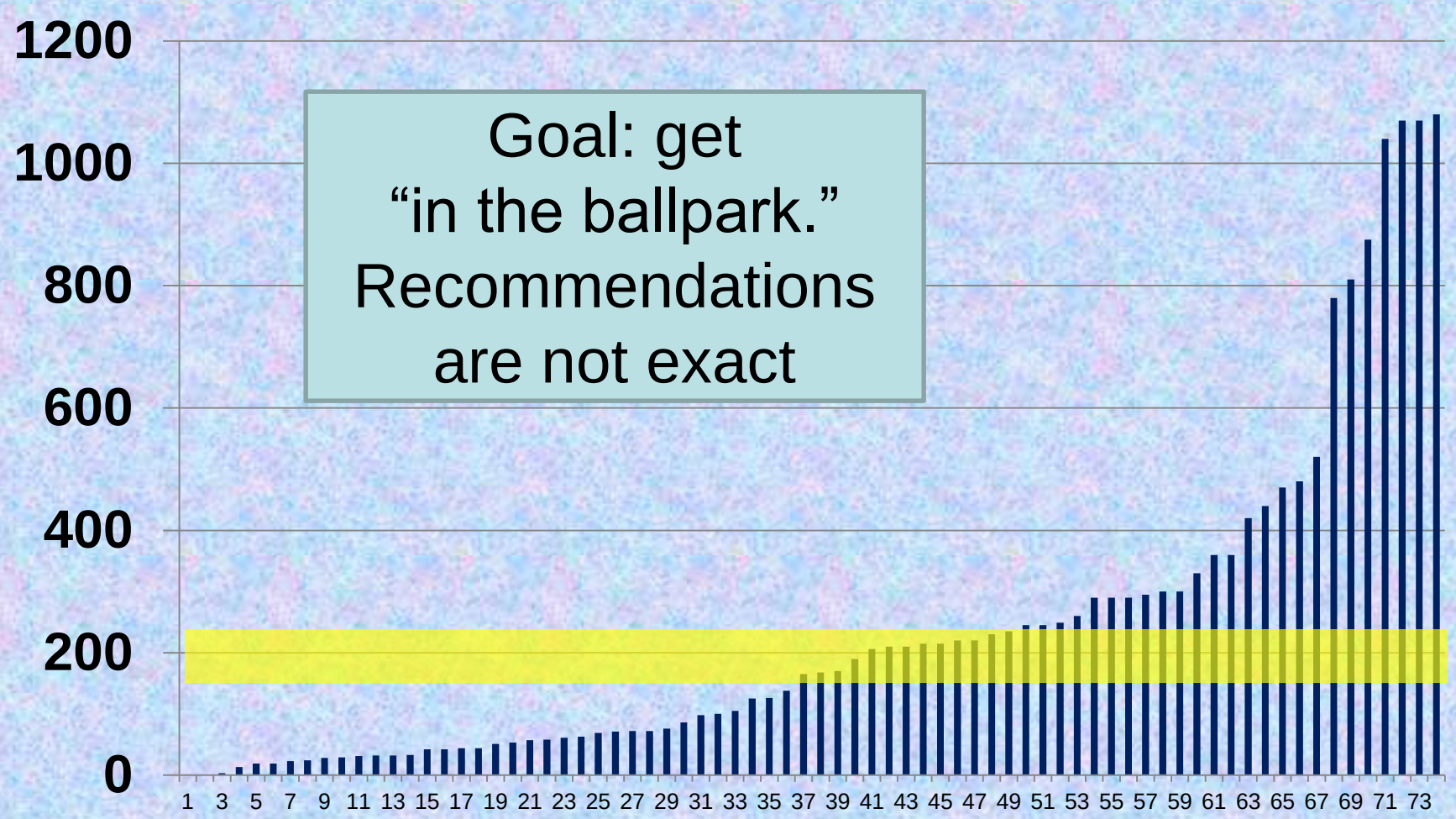
pH of tunnel ‘soil’

75 VT farm samples 2008-09



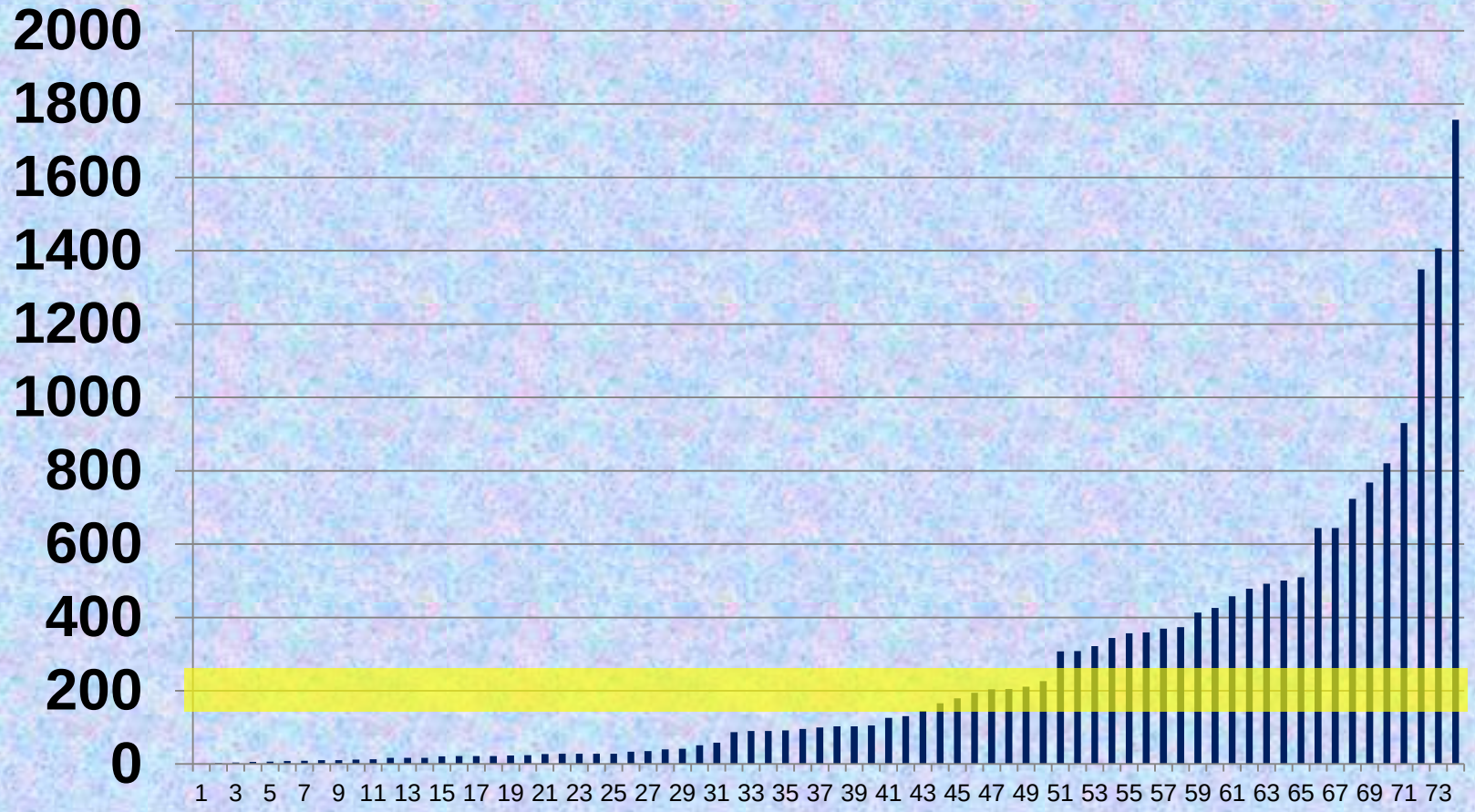
ppm NO_3-N in tunnel ‘soil’

75 VT farm samples 2008-09



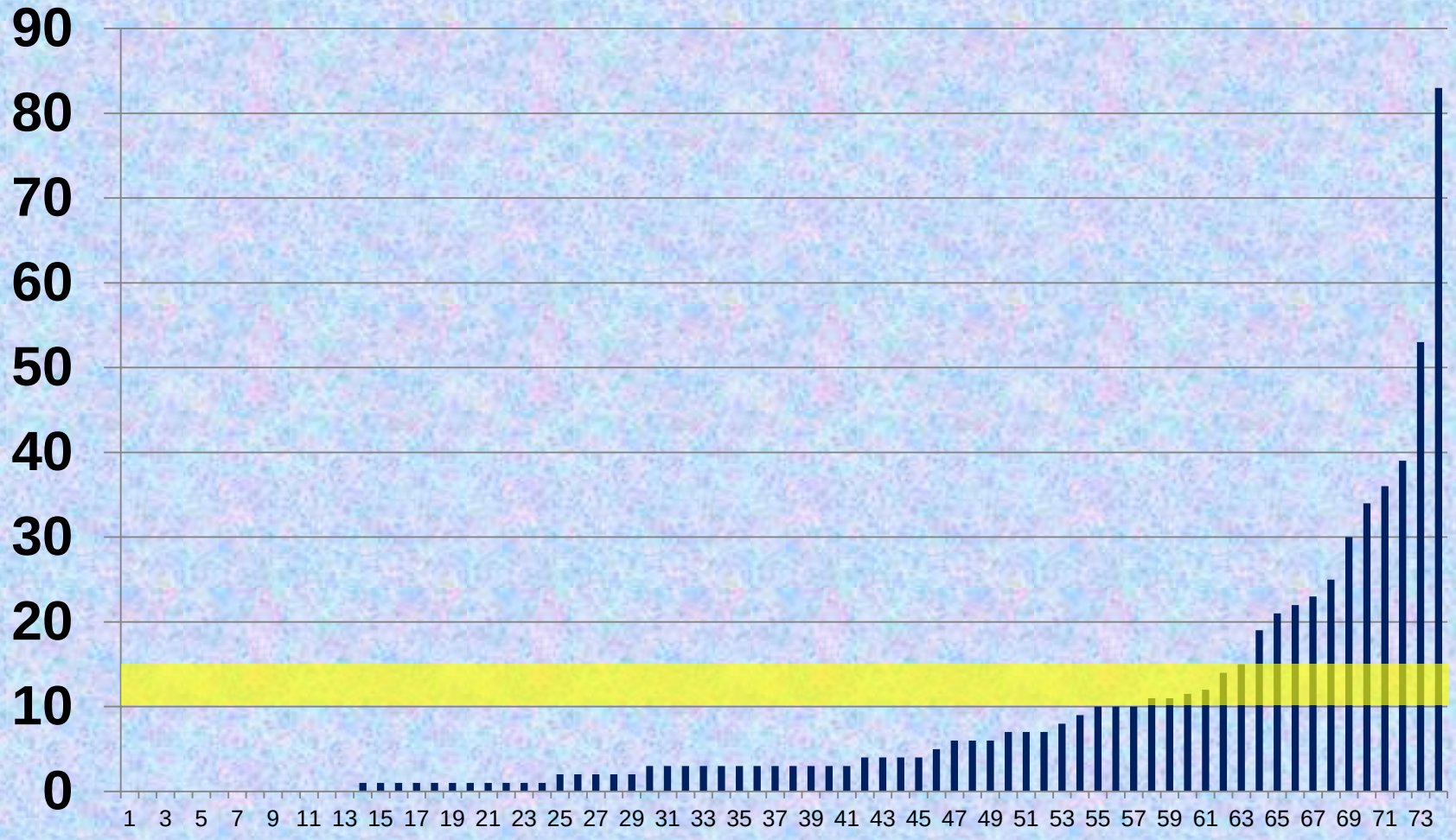
ppm K in tunnel ‘soil’

75 VT farm samples 2008-09



ppm P in greenhouse ‘soil’

75 samples 2008-09



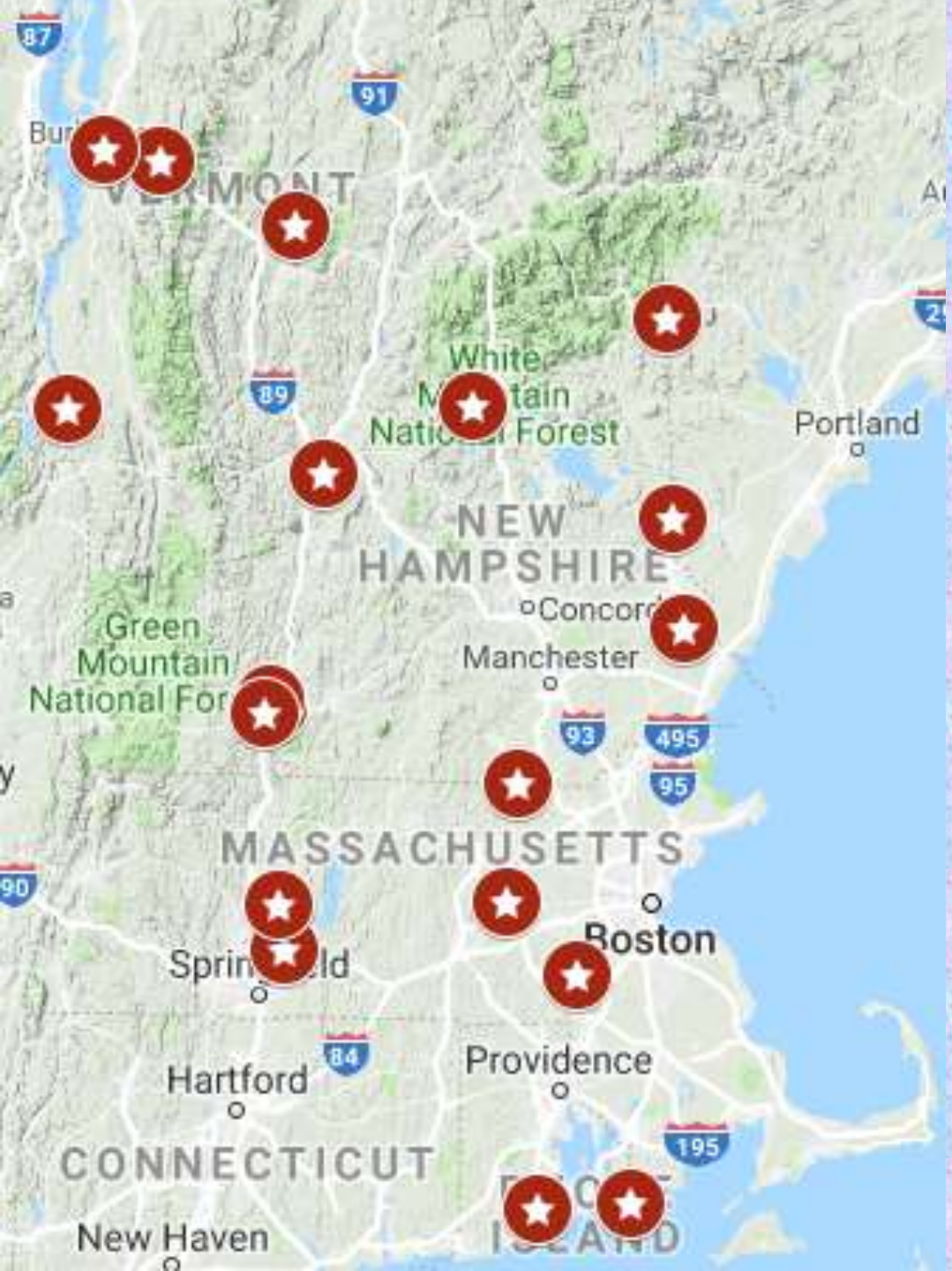
2018 New England Tomato High Tunnel Study

Purpose of the Study

To improve our understanding of tunnel tomato production practices, with a focus on crop nutrition, across New England.

This was a ‘landscape scan’ of management and fertility practices for in-ground tomatoes.

Results will help Extension identify research needs and improve recommendations.



Data collected

From 20 farms

In-ground culture

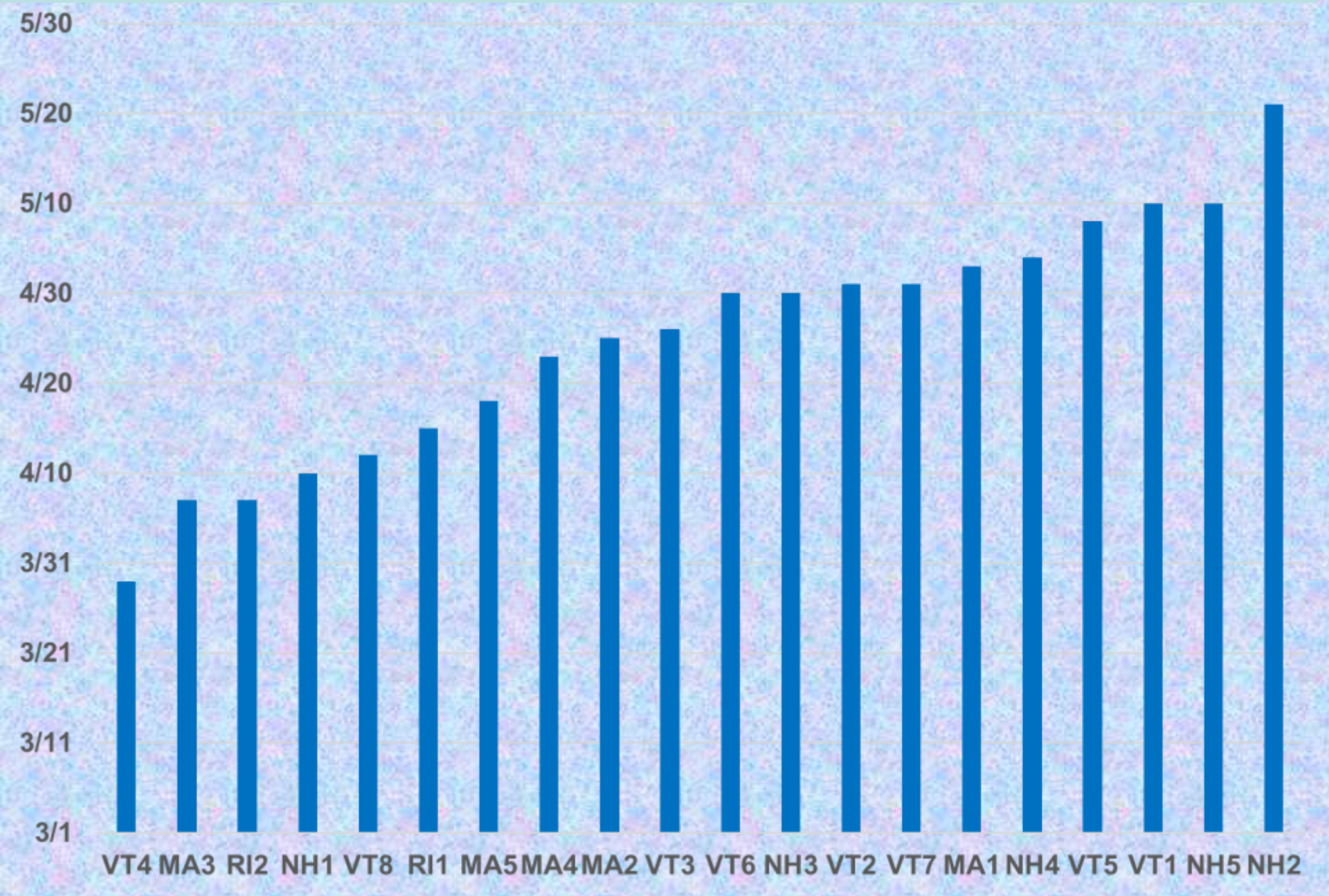
Slicers

- Compaction
- Spacing / # of leaders
- Irrigation
- Fertilizer
- Pesticides
- Varieties
- Yield
- Monthly Lab Analyses:
  - Modified Morgan
  - Saturated Media
  - Leaf Tissue

Production practices used

- 13 of 20 farms planted Geronimo
- 12 farms used grafted plants
- 11 farms are certified organic
- Avg. of 1.8 drip lines/row, 11 farms fertigate
- 9 farms used more than one leader/plant
- Mulch: black plastic (6), white plastic (4), none (3), landscape fabric (3), weed mat (2), silver (1)

Tomato transplant date



Monthly crop images

May 1st

June

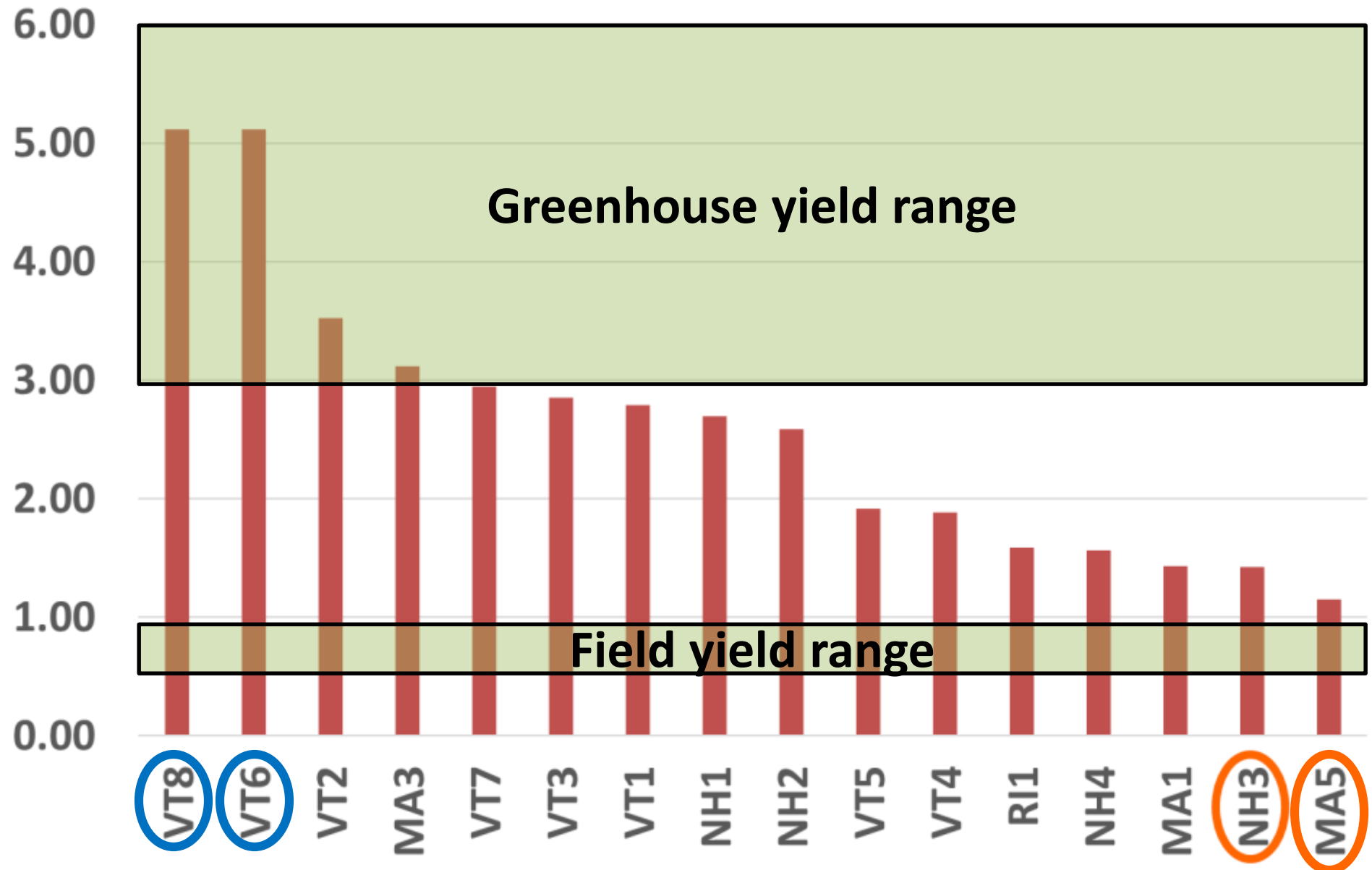
July

August

September

November

Yield lbs per ft^2



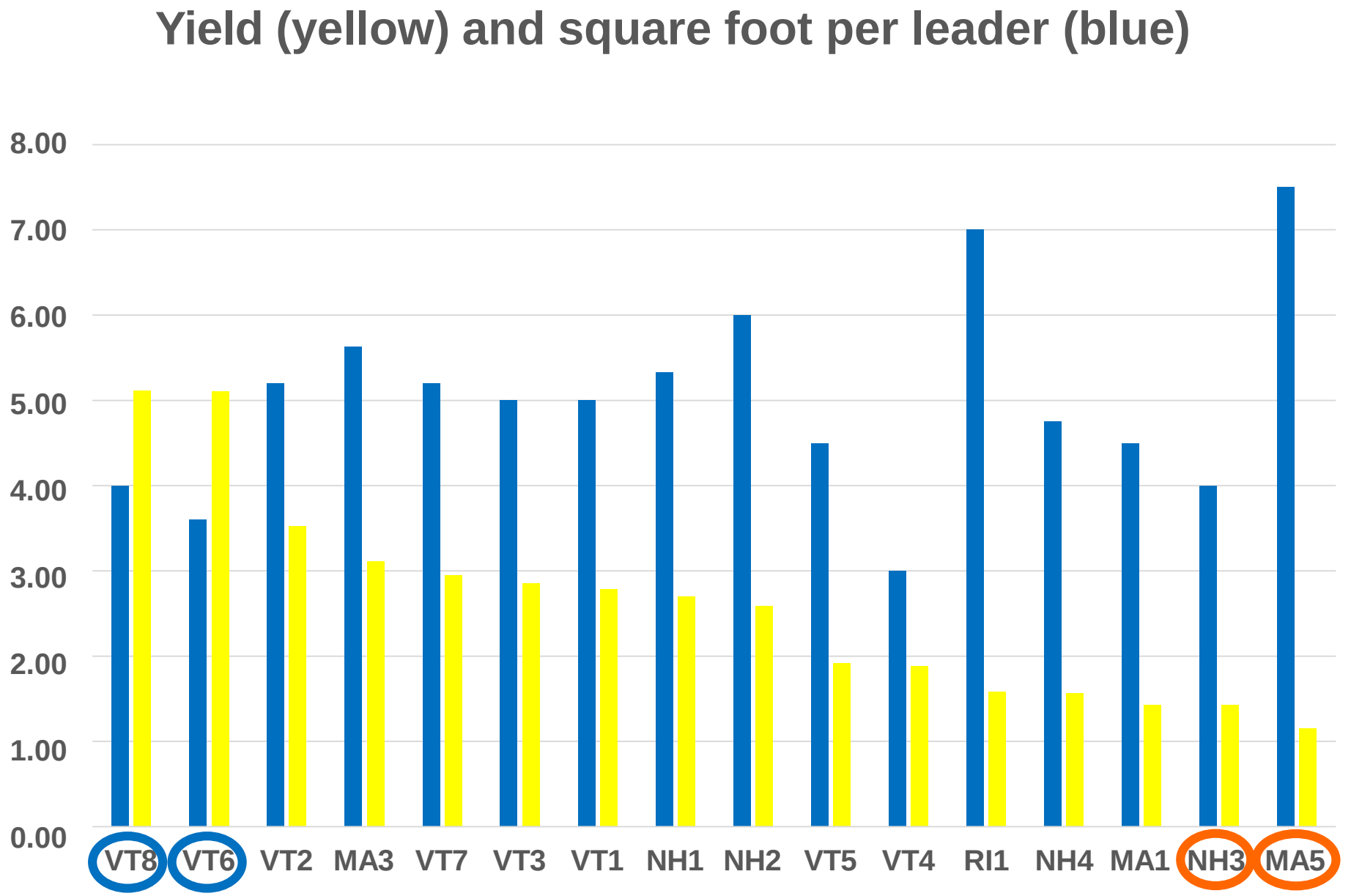
Estimating N fertilizer needs for in-ground high tunnel tomatoes

all values are approximate

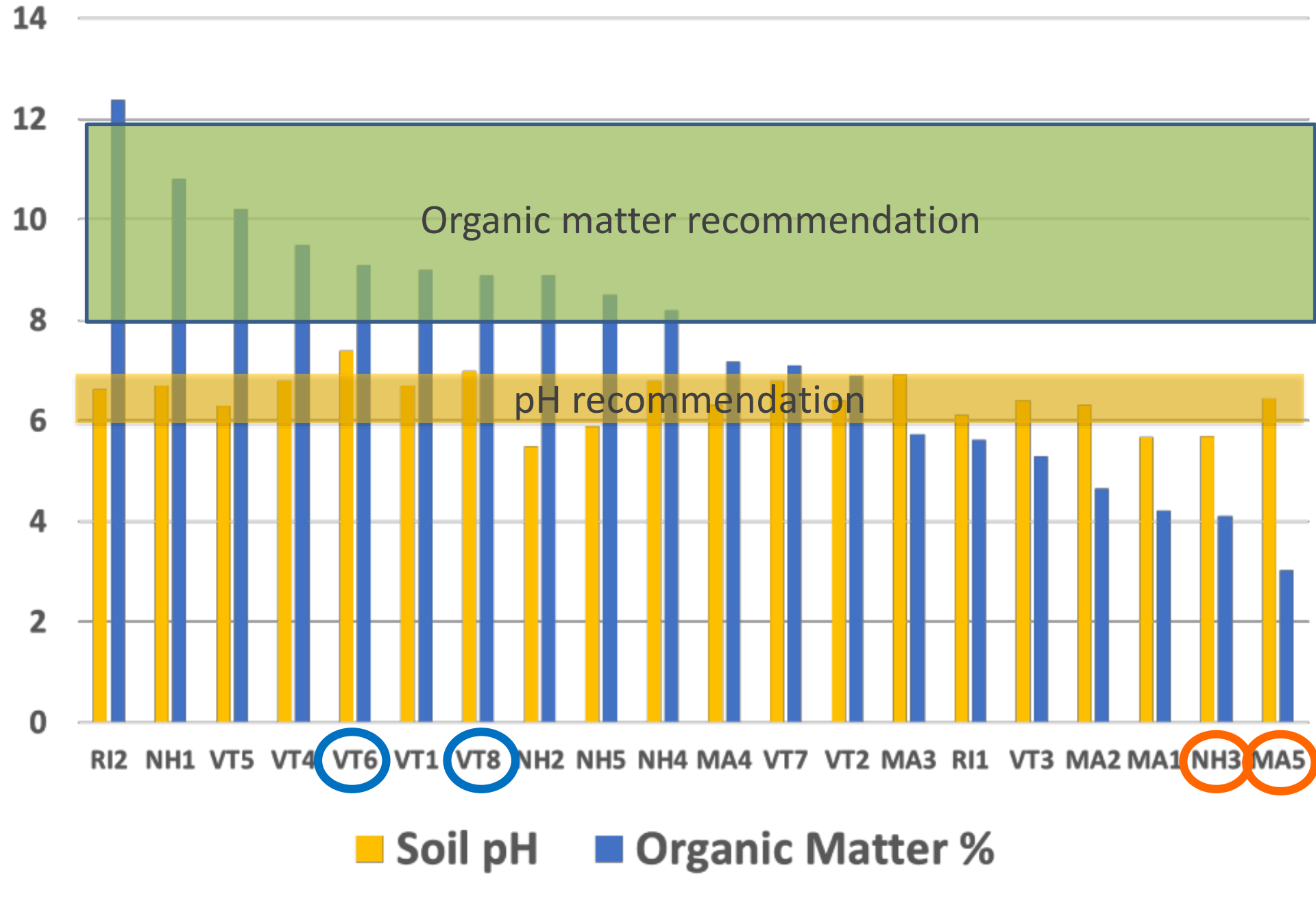
Vern Grubinger 2-14-19

	Yield goal lb/acre	=Yield lb/sqft	=Yield lb/stem =4 sqft	plant height	Total N need lb/acre	Total N need lb/1,000 sqft
Field average yield	20,000	0.5	2	4′	150 (veg guide) @ 50% recovery	3.44
Tunnel low yield	40,000	1	4	6′	150 @ 100% recovery	3.44
Tunnel medium yield	80,000	2	8	8′	200 @ 100% recovery	4.59
Tunnel good yield	120,000	3	12	10′	250 @ 100% recovery	5.74
Tunnel high yield	160,000	4	16	12′	300 @ 100% recovery	6.89

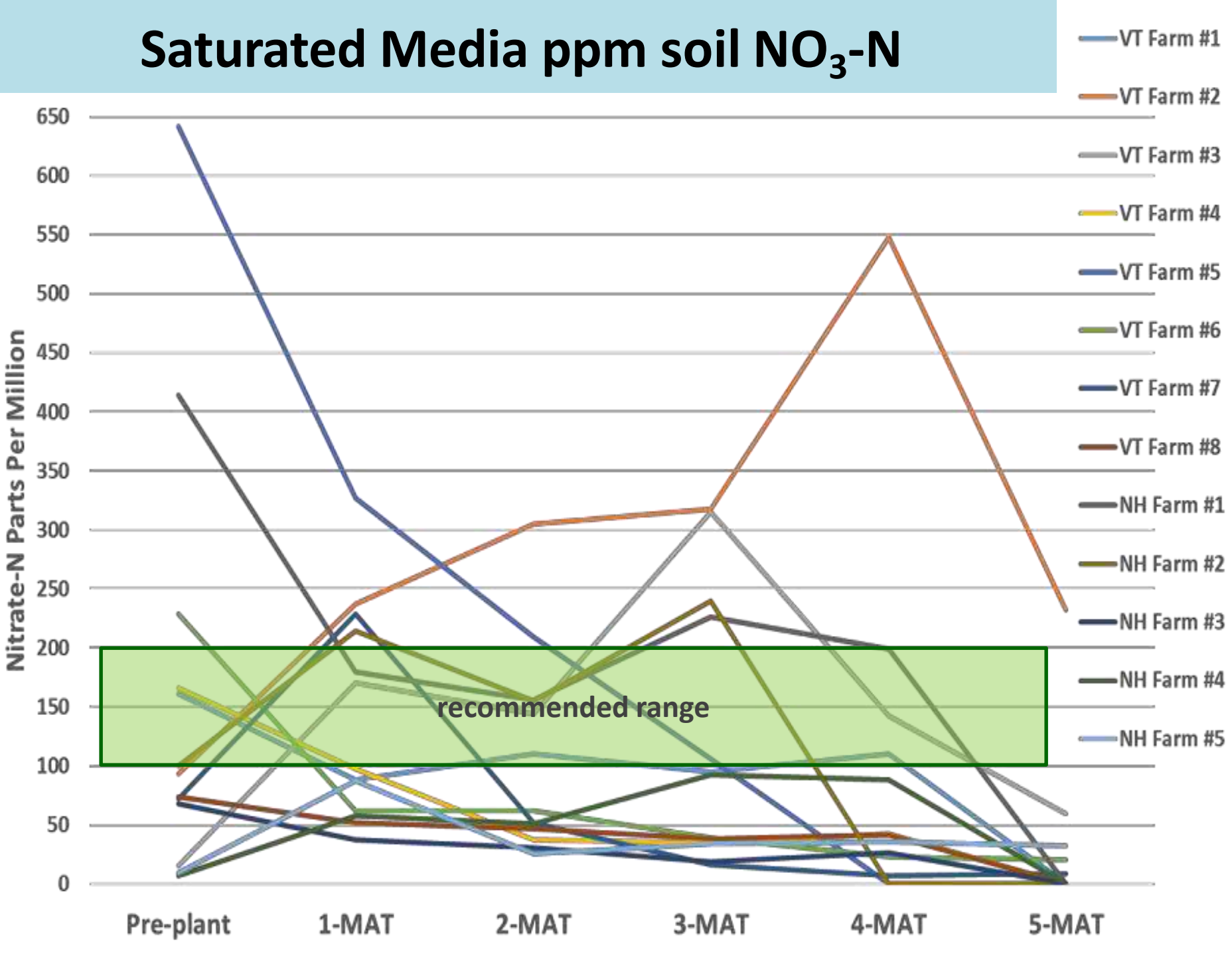
Total yield and plant spacing



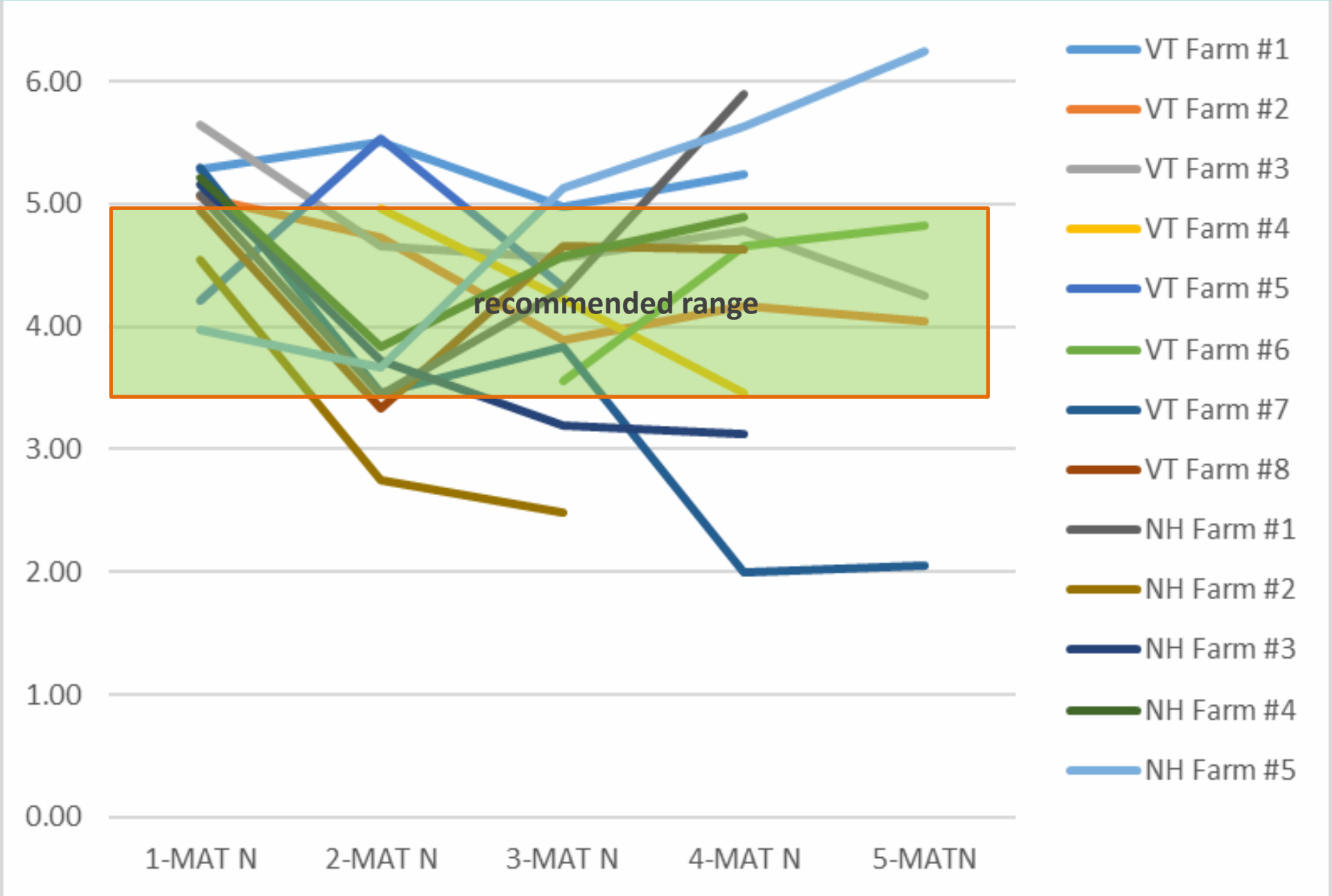
One month after transplanting



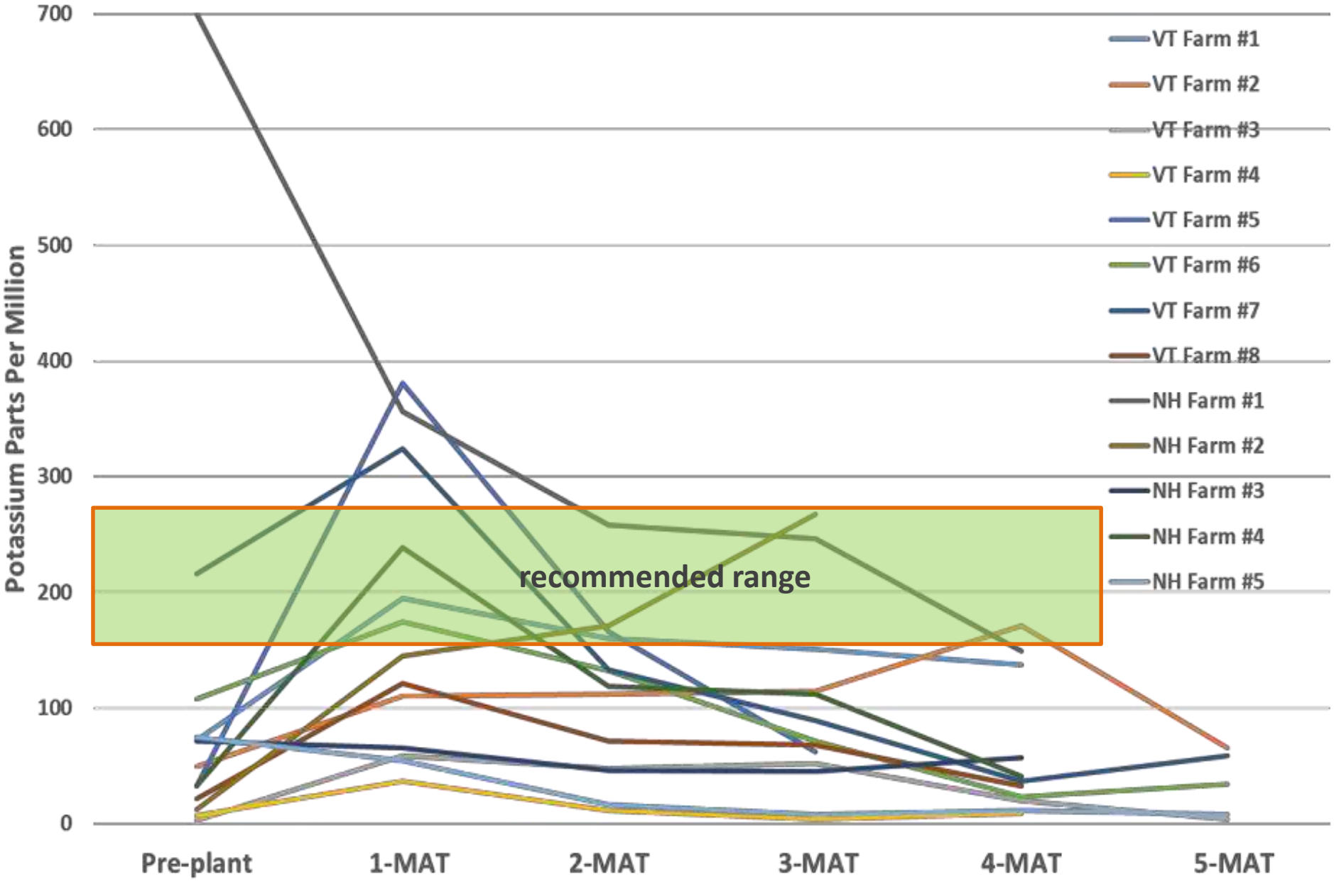
Saturated Media ppm soil NO_3-N



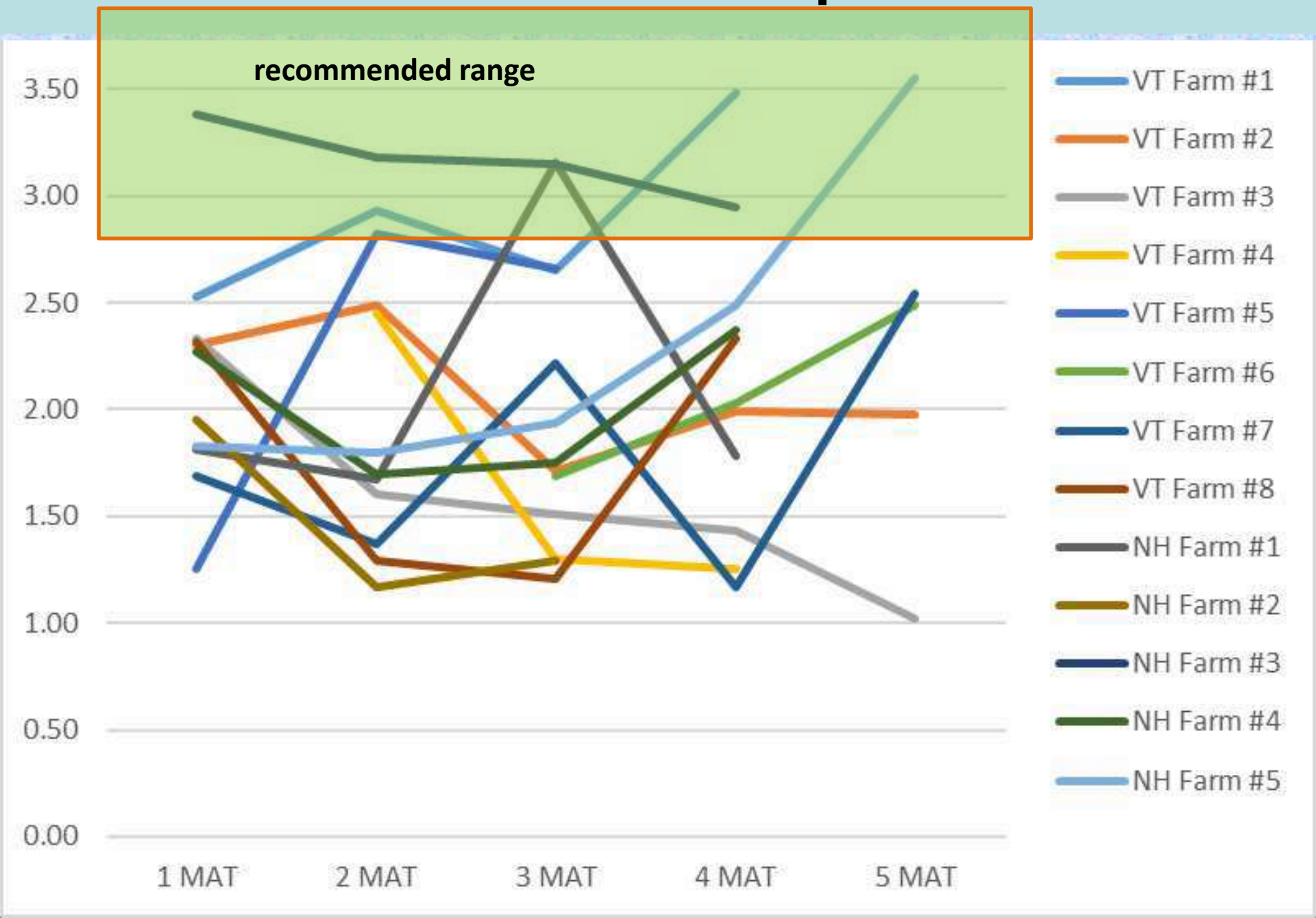
% N in leaf samples



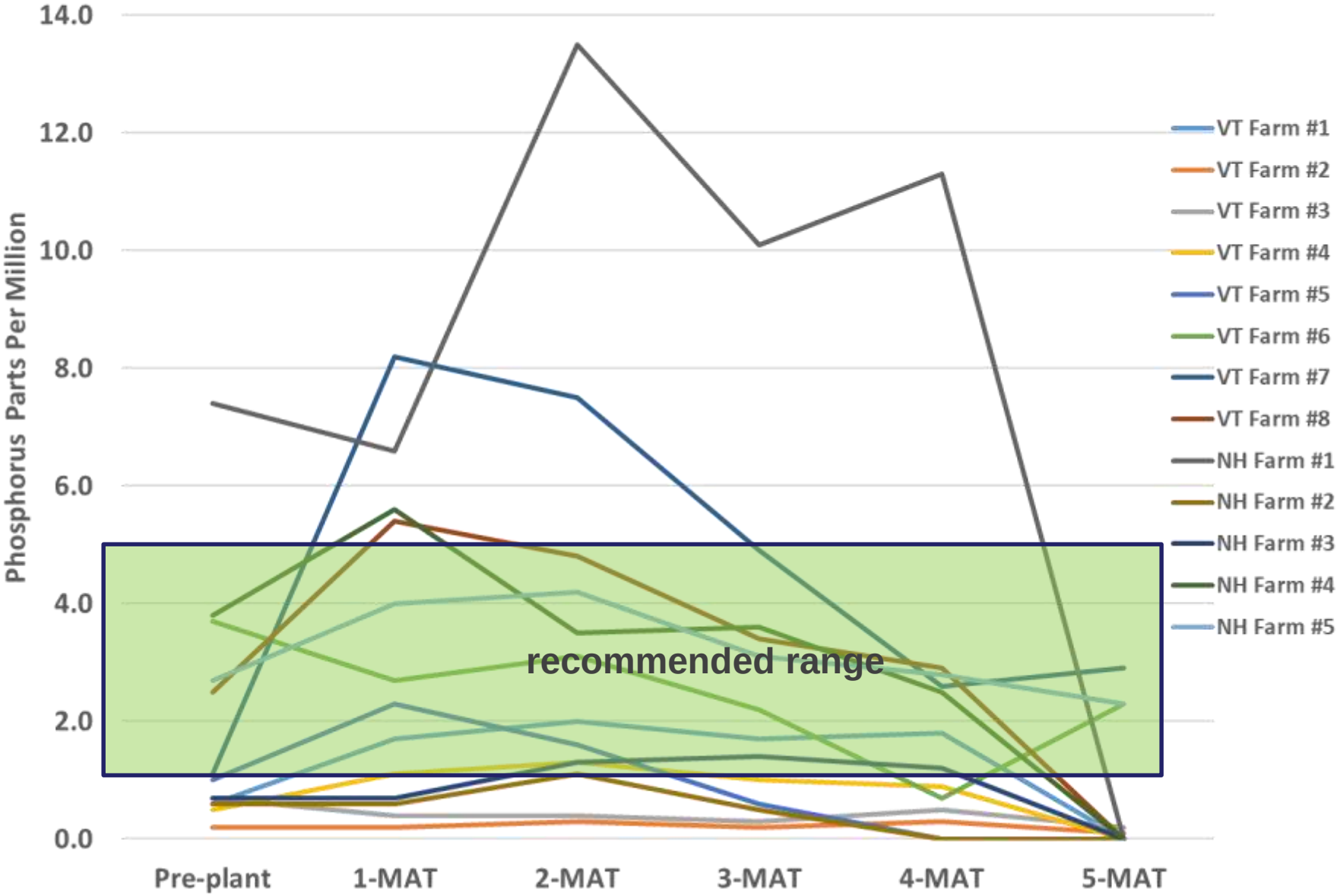
Saturated Media ppm soil K



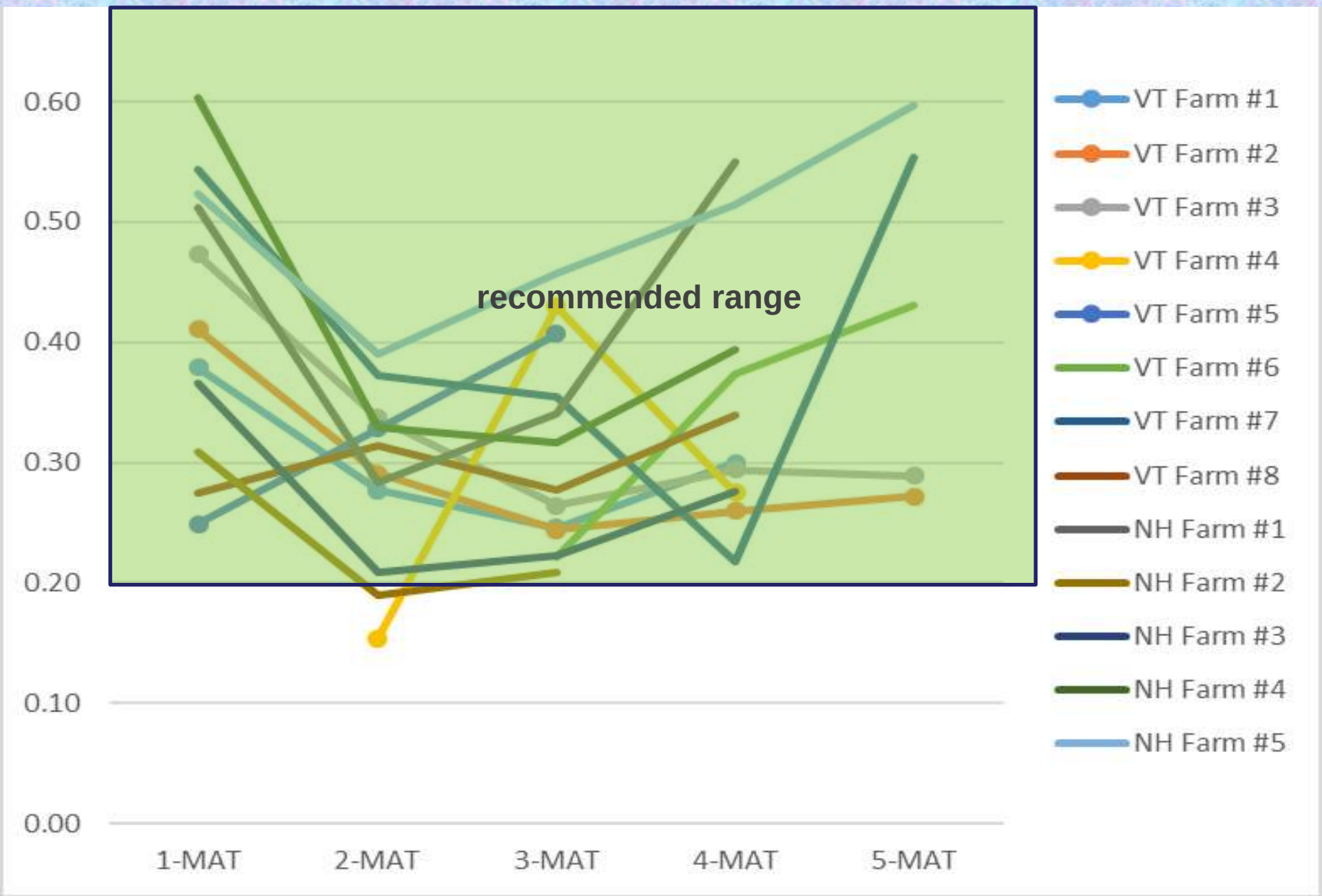
% K in leaf samples



Saturated media ppm soil P

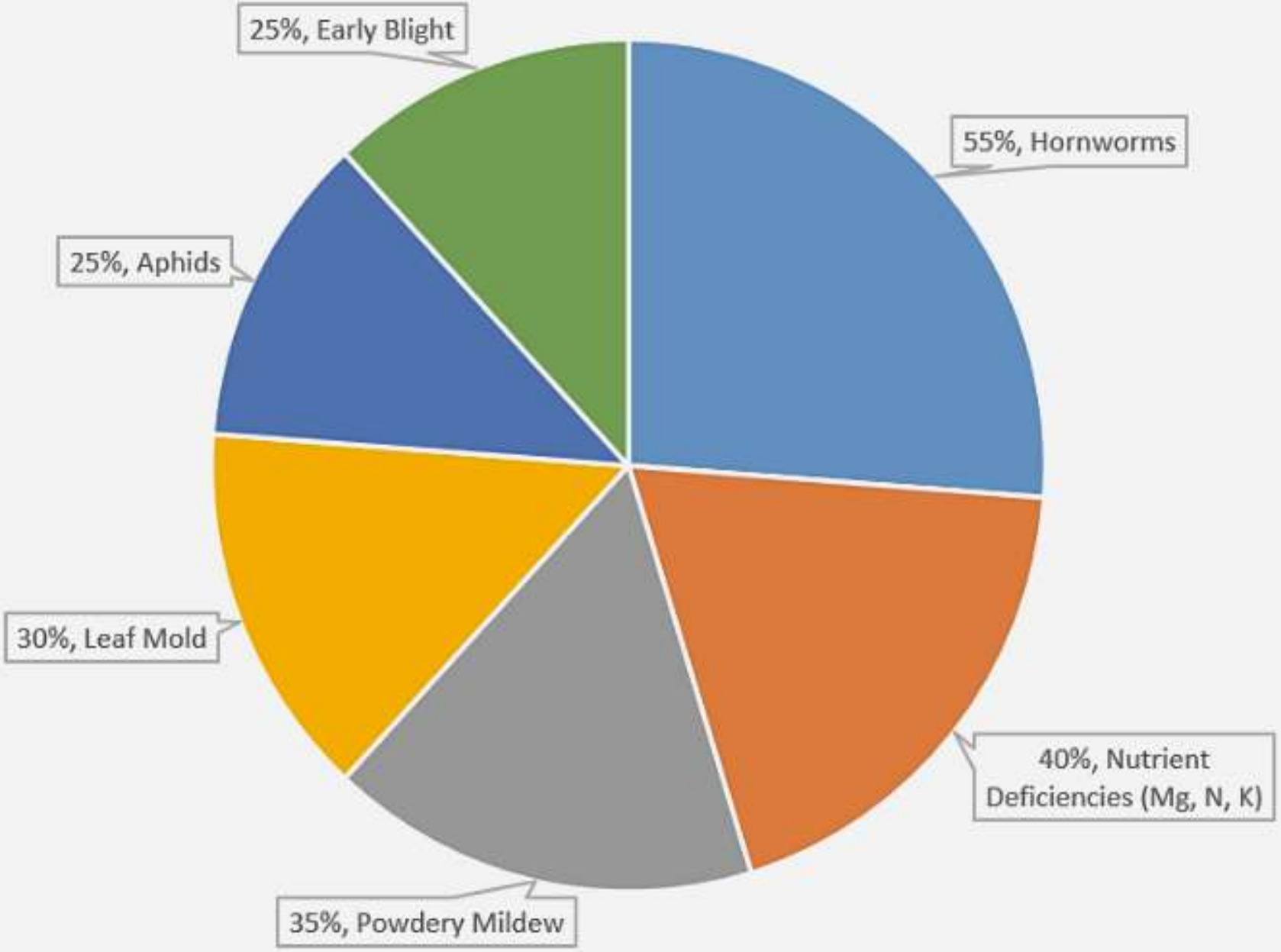


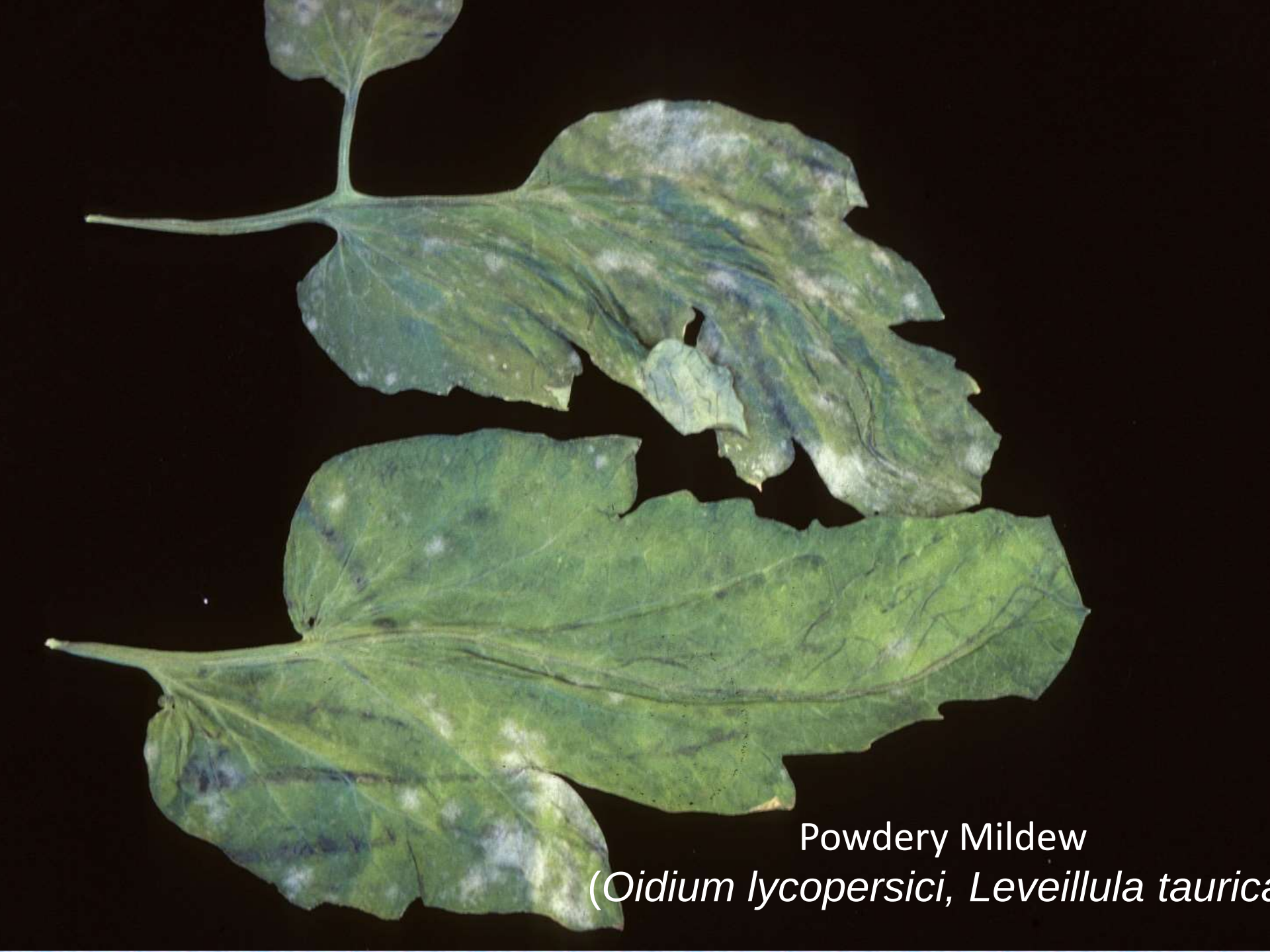
% P in leaf samples

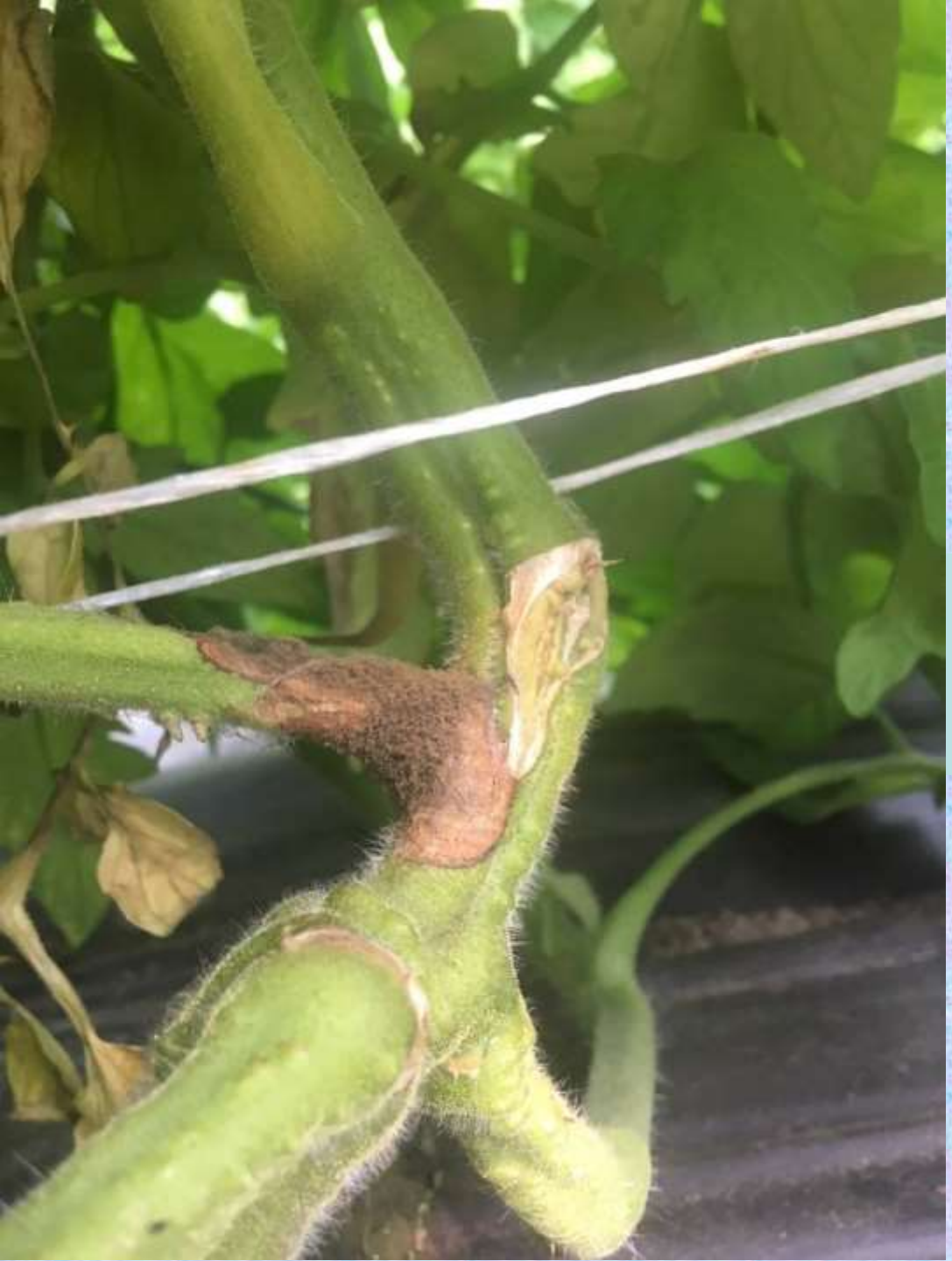


Factors besides nutrients affected yield

Top insects and diseases reported




Powdery Mildew
(*Oidium lycopersici, Leveillula taurica*



Botrytis canker (*Botrytis cinerea*)

Leaf Mold (*Passalora fulva*)

Soil compaction does not appear to be widespread, but it can be a problem in tunnels

Test before planting using penetrometer in 10+ locations. If >300 psi is found at less than ~15 inches, subsoil or form raised beds.

Use enough drip lines to moisten the entire rooting area when irrigating

	Top Yield (5lbs/ft^2)	Bottom Yield (1lbs/ft^2)
Years in Production	20	6
Variety	Geronimo grafted	Geronimo grafted
Compaction	None	15 cm
Fertigate?	No	Yes
Pests	Hornworm	Hornworm and Powdery Mildew
Feet^2 per Leader	4.15	7.5
Nutrients applied lbs/1,000 ft^2	15 N, 14 P, 34 K	5 N, 2 P, 3 K
pH	6.9	6.4
Soil Organic Matter	9.1%	3.9%

Recommendations

- **Estimate your target yield – then track yields!**
- **Consider tighter plant spacing, if appropriate**
- **Measure soil compaction, address if needed**
- **Add irrigation lines for uniform soil moisture**
- **Keep up with leaf pruning**
- **Scout for pests often; be prepared to manage them**
- **Adjust soil pH to 6-7, aim for organic matter 6%+?**
- **Monitor available and reserve soil nutrient levels**
- **Provide sufficient N and K needed for high yields**

Thanks!

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