

## Fertilizer Research in High Tunnels



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## Topics



- Background
- Nutrient budget demonstration
  - Tomato & cucumber
- Fertigation study - tomato
  - Compost vs. compost + fertigation

## Yield Potential & Nutrient Needs

- Yields in a high tunnel can be 3 to 4 times the yield obtained in the field
- Higher yields will require more nutrients, but knowing how much to apply is a challenge
  - Lack of nutrients – deficiencies
  - Excessive nutrients – salt build up
  - Both situations affect yield and quality

## “Book Values” for Tomatoes

Plant Part	N	P	K
	----- lb per ton F.W. -----		
Fruit	3.4	0.4	6.0
Vines	2.6	0.4	3.4
Total	6.0	0.8	9.4

A 50 ton yield/A would require:

300 lbs N/A  
40 lbs P/A (92 lbs P<sub>2</sub>O<sub>5</sub>)  
470 lbs K/A (564 lbs K<sub>2</sub>O)

## Staples High Tunnel Demonstration

- Objective:
  - To determine the nutrient uptake capacity of tomato and cucumber in a high tunnel system
- Conducted at the Central Lakes College Ag Center in Staples in 2005

## Soil Amendments

- Verndale sandy loam
- Amended with 4-6 inches of compost in the fall
  - grass clippings, turkey manure, old sod



## Staples High Tunnel

- Constructed in 2004
- 20' wide x 48' length



## Soil Test Properties in the Spring

Depth	Organic Matter	pH	Nitrate-N	Bray P	K	Ca	Mg
Inches	%		lb/A	ppm			
0-6	4.6	5.7	294	73	356	1734	292
6-12	1.8	6.3	54	48	84	960	179
12-24	1.2	6.2	72	29	55	903	166

- All nutrients were in the very high range
- No preplant fertilizer was applied



## The Set-up

- 'Sunshine' tomato (determinate)
- 'Sweet Success' cucumber
  - Transplants of both planted May 4
- Double row beds 4 ft apart; 18" between plants
- One cup 20-20-20 (1 oz/gal) applied to each transplant



## Fertigation

- Plants irrigated with a drip tape system installed beneath black plastic
- A batch fertigation system was used to supply nitrogen and calcium
  - UAN (28%) and calcium nitrate
- Three, 9-ft sections of each vegetable monitored for yield and nutrient uptake



## Application Dates and Rates

Application Date	Source	oz of N per 100' of row	lbs of N per Acre
26-May	UAN 28%	1.4	9.5
1-Jun	UAN 28%	1.3	8.7
7-Jun	UAN 28%	1.3	8.7
15-Jun	UAN 28%	1.3	8.7
24-Jun	CAN 15.5%	1.5	10.1
29-Jun	UAN 28%	1.3	8.7
8-Jul	CAN 15.5%	1.9	12.7
14-Jul	UAN 28%	1.6	10.7
21-Jul	CAN 15.5%	1.9	12.7
28-Jul	UAN 28%	1.7	11.7
4-Aug	CAN 15.5%	2.0	13.5
12-Aug	UAN 28%	1.7	11.7
18-Aug	CAN 15.5%	1.9	12.7
30-Aug	UAN 28%	1.6	10.7
<b>Total</b>		<b>22.4</b>	<b>150.8</b>

## Sampling and Timeline

- Plants pruned periodically
- Petiole samples collected periodically
- Tomatoes harvested July 13 – October 7
- Cucumbers harvested June 28 – October 19

## Petiole Sampling



## Measurements

- All plant parts weighed and subsamples saved for dry weight and nutrient analysis
  - Pruned material, vines at final harvest, fruit



## "Sunshine" Tomato Yields - Staples -

Marketable Fruit			Non-marketable Fruit		
number/100 ft	lbs/100 ft	Tons/A	number/100 ft	lbs/100 ft	Tons/A
2381	1065	58	96	46	2.5
(~16 lbs/plant)					



## "Sweet Success" Cucumber Yields - Staples -

Marketable Fruit			Non-marketable Fruit		
number/100 ft	lbs/100 ft	Tons/A	number/100 ft	lbs/100 ft	Tons/A
1894	2517	137	100	59	3.2
(~39 lbs/plant)					



## Nutrient Uptake - Tomatoes

Plant Part	oz/100 feet of row			lb/acre		
	N	P	K	N	P	K
Prunings	8.1	1.1	7.9	55	7	54
Vines	6.7	1.0	7.1	46	7	48
Fruit	22.0	4.0	34.8	150	27	243
<b>Total</b>	<b>36.8</b>	<b>6.1</b>	<b>49.8</b>	<b>251</b>	<b>41</b>	<b>345</b>
<u>Total (lbs/100 feet)</u>			~94 lb/A P <sub>2</sub> O <sub>5</sub>			
	2.3 N	0.9 P <sub>2</sub> O <sub>5</sub>	3.7 K <sub>2</sub> O	~414 lb/A K <sub>2</sub> O		
<u>Total (oz/plant)</u>						
	0.55 N	0.2 P <sub>2</sub> O <sub>5</sub>	0.9 K <sub>2</sub> O			

## Nutrient Uptake - Cucumbers

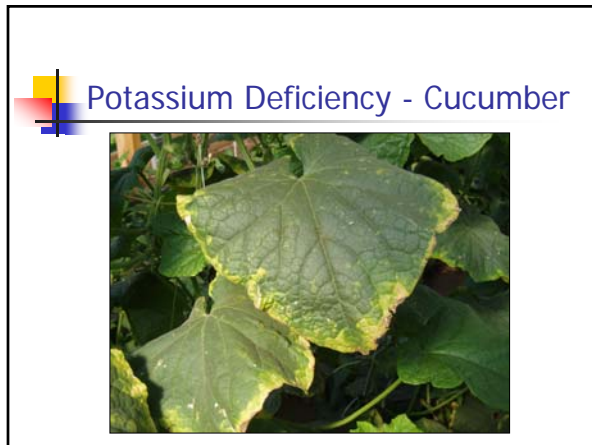
Plant Part	oz/100 feet of row			lb/acre		
	N	P	K	N	P	K
Prunings	12.8	2.0	16.4	87	14	112
Vines	13.0	1.6	12.1	88	11	82
Fruit	31.3	5.8	42.7	213	39	291
<b>Total</b>	<b>57.1</b>	<b>9.4</b>	<b>71.2</b>	<b>388</b>	<b>64</b>	<b>485</b>
<u>Total (lbs/100 feet)</u>			~147 lb/A P <sub>2</sub> O <sub>5</sub>			
	3.6 N	1.4 P <sub>2</sub> O <sub>5</sub>	5.3 K <sub>2</sub> O	~582 lb/A K <sub>2</sub> O		
<u>Total (oz/plant)</u>						
	0.86 N	0.3 P <sub>2</sub> O <sub>5</sub>	1.3 K <sub>2</sub> O			

### Petiole Nitrate-N and K - Tomato

Sampling Date	NO <sub>3</sub> -N %	NO <sub>3</sub> -N Sufficiency level (%)	% K	K Sufficiency level (%)
June 14	1.63	1.2 – 1.40	8.55	6.0 – 7.0
June 30	0.84	0.8 – 1.00	5.11	4.0 – 5.0

### Petiole Nitrate-N and K - Cucumber

Sampling Date	NO <sub>3</sub> -N %	NO <sub>3</sub> -N Sufficiency level (%)	% K	K Sufficiency level (%)
June 22	0.62	0.5 – 0.75	4.92	6.0 – 7.0
June 29	0.30	0.4 – 0.50	3.90	5.0 – 6.0
July 13	0.20	0.3 – 0.40	3.14	4.0 – 5.0
August 15	0.12	0.3 – 0.40	2.13	4.0 – 5.0



### Soil Test after Final Harvest - Tomato

Depth	pH	Soluble Salts	Nitrate-N	Bray P	K
Inches		mmhos/cm	lb/A	ppm	
0-6	6.4	1.0	234	94	167
6-12	6.2	0.3	68	71	104
12-24	6.2	0.5	184	41	99

### Soil Test After Final Harvest - Cucumber

Depth	pH	Soluble Salts	Nitrate-N	Bray P	K
Inches		mmhos/cm	lb/A	ppm	
0-6	5.9	0.8	142	107	182
6-12	6.6	0.2	24	63	137
12-24	6.6	0.2	52	43	106

### Nitrogen Budget - Tomato

Initial Soil N lb N/A	Fertilizer N lb N/A	N uptake lb N/A	Final Soil N lb N/A
492	151	251	466

Initial soil N was enough to sustain uptake

Was N fertilizer even needed with this amount of compost?

## Nitrogen Budget - Cucumber

Initial Soil N lb/A	Fertilizer N lb/A	N uptake lb/A	Final Soil N
492	151	388	218

Initial soil N was enough to sustain N uptake by the crop

Was N fertilizer needed?

## Conclusions

- Significant nutrient uptake by tomato and cucumber was documented
  - Cucumber > determinate tomato
- Compost and N fertilizer was sufficient to supply N and K needs of tomato, but could not supply enough K for cucumber
- Additional K is recommended times of peak fruiting

## Staples Fertigation Study

- Objective:
  - To determine if fertigation is needed for tomato when compost is used
- Conducted at the Central Lakes College Ag Center in Staples in 2008

## Soil Test Properties in the Spring-2008 (before compost application)

Soil Depth Inches	pH	Organic Matter %	Soluble Salts mmhos/cm
0-6	7.0	6.4	0.9
6-12	6.9	5.4	0.7

Soil Depth Inches	NO <sub>3</sub> -N lb/A	Bray-P ppm	K ppm
0-6	61	174	89
6-12	43	144	103

- P was in the very high range, K was medium

## Soil Amendments & Treatments

- Yard waste compost added
  - ~ 2.5 tons fresh (~50% moist) spread evenly
  - ~ 5 lbs fresh per square ft
  - 0.64% N, 0.12% P, 0.18% K
- Two treatments
  - Fertigation
    - UAN, Potassium nitrate and Calcium nitrate
  - No fertigation
- Two replications of each treatment
  - Nine plants per replication

## Procedures

- 'Cobra' tomato (indeterminate)
  - Transplants planted May 9
- Double row beds 4 ft apart; 18" between plants
- One cup 20-20-20 (1 oz/gal) applied to each transplant

## Procedures

- Plots set up so that half received fertigation and the other did not
- Each plot received the same amount of water



## Fertigation Dates and Rates

Date	Source	oz N/100'	lb N/A	oz K <sub>2</sub> O/100'	lb K <sub>2</sub> O/A
2-Jun	28%	0.48	3.2	0.0	0.0
11-Jun	28%+Knit	0.72	4.9	1.5	10.2
17-Jun	28%+Knit	0.72	4.9	1.5	10.2
24-Jun	28%+Knit	0.72	4.9	1.5	10.2
1-Jul	28%+Knit	0.82	5.6	2.0	13.6
8-Jul	28%+CaNit	1.03	7.0	2.0	13.6
15-Jul	28%+CaNit	1.03	7.0	2.0	13.6
22-Jul	28%+CaNit	1.03	7.0	2.0	13.6
29-Jul	28%+CaNit	1.03	7.0	2.0	13.6
15-Aug	28%+CaNit	1.03	7.0	2.0	13.6
12-Aug	28%+CaNit	1.03	7.0	2.0	13.6
18-Aug	28%+CaNit	1.03	7.0	2.0	13.6
28-Aug	28%+CaNit	1.03	7.0	2.0	13.6
10-Sep	28%+CaNit	1.03	7.0	2.0	13.6
<b>Total</b>		<b>12.7</b>	<b>86.5</b>	<b>24.5</b>	<b>166.6</b>

## Sampling and Timeline

- Plants pruned periodically
- Petiole samples collected periodically
- Tomatoes harvested July 24 – October 16

## "Cobra" Tomato Early Yields - First 3 Weeks-

Treatment	Marketable	
	fruit number/plant	fruit wt (lbs/plant)
Fertigated	7.5 ± 0.9	2.5 ± 0.3
Non-fertigated	8.8 ± 0.0	3.3 ± 0.1

➤ Fertigation tended to delay yield



## "Cobra" Tomato Yields - Total -

Treatment	Marketable		Non-marketable	
	fruit number/plant	fruit wt (lbs/plant)	fruit number/plant	fruit wt (lbs/plant)
Fertigated	27.5 ± 0.3	10.9 ± 0.3	1.9 ± 0.6	0.8 ± 0.1
Non-fertigated	29.9 ± 3.1	13.2 ± 1.1	2.2 ± 0.1	0.99 ± 0.2

➤ Non-fertigated as good or better than fertigated

➤ Compost supplied enough nutrients



## Petiole Nitrate-N and K

Sampling Date	Fertigated ----- % NO <sub>3</sub> -N -----	Non-fertigated	Fertigated ----- % K -----	Non-fertigated
4-Jun	2.17	2.14	6.13	5.94
16-Jun	1.05	1.02	5.30	5.36
30-Jun	0.34	0.47	5.42	5.43

No difference in nutrient levels between treatments  
Nitrate-N levels deficient on June 30

## Soil Test after Final Harvest - Tomato

With fertigation

Soil Depth	NO <sub>3</sub> -N	Bray-P	K	Soluble Salts
Inches	lb/A	----- ppm -----		mmhos/cm
0-6	50	181	117	0.4
6-12	37	161	101	0.4

Without fertigation

Soil Depth	NO <sub>3</sub> -N	Bray-P	K	Soluble Salts
Inches	lb/A	----- ppm -----		mmhos/cm
0-6	36	193	76	0.4
6-12	26	145	75	0.3

## Summary

- Maintaining nutrient supply for crops in high tunnels is essential for optimum production
- Compost applied at high rates before planting can reduce or eliminate the need for fertigation
- Use soil and tissue tests to help guide fertilizer use and soil amendment decisions



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