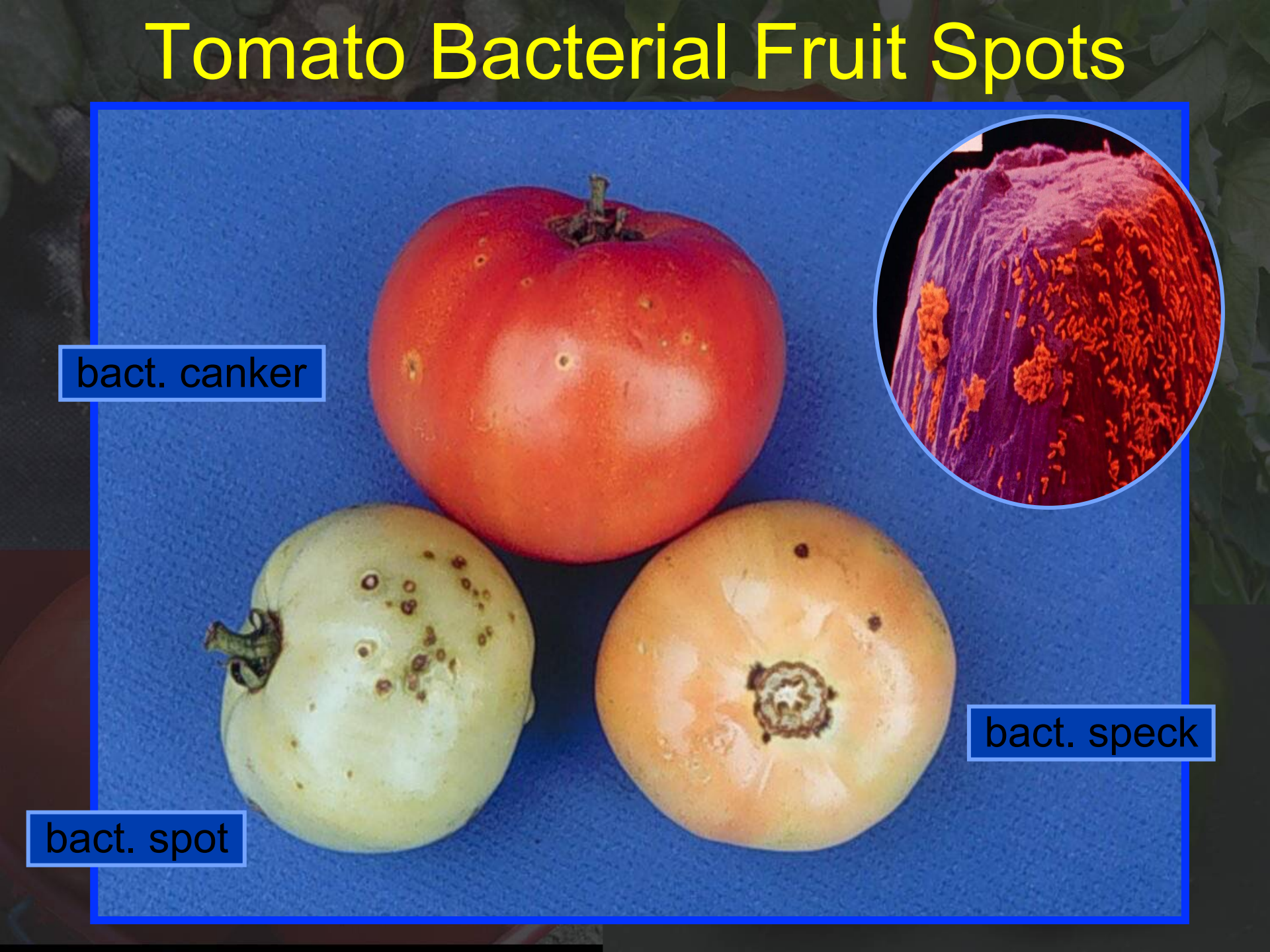
Evaluation of products for management of bacterial canker and bacterial spot on tomato

Frank Louws

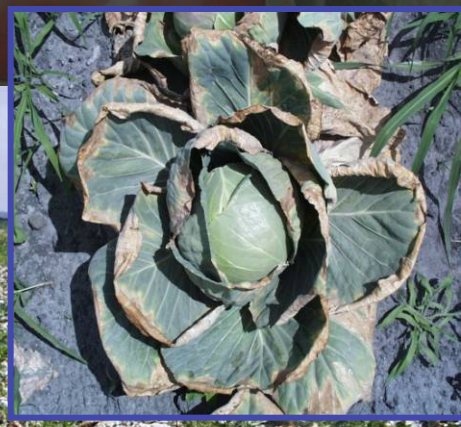
NC STATE UNIVERSITY

Tomato Bacterial Fruit Spots



Over 100 years of documented Xanthomonas problems

North Carolina 1999



Cabbage field (120 acres) in NC, showing all plants attacked and destroyed by Xcc. Not a head was harvested.

Wisconsin 1905

II. THE BLACK ROT OF CRUCIFERS

Type.—This is a common vascular disease of cabbage, cauliflower, kohlrabi, kale, rape, turnips, and mustard. Often whole fields are destroyed (Fig. 79). Dr. F. C. von Faber also found

FIG. 79.—Cabbage field in Wisconsin, showing all of the plants attacked and destroyed by *Bacterium campestre*. Not a head was harvested. (After Russell.)

10

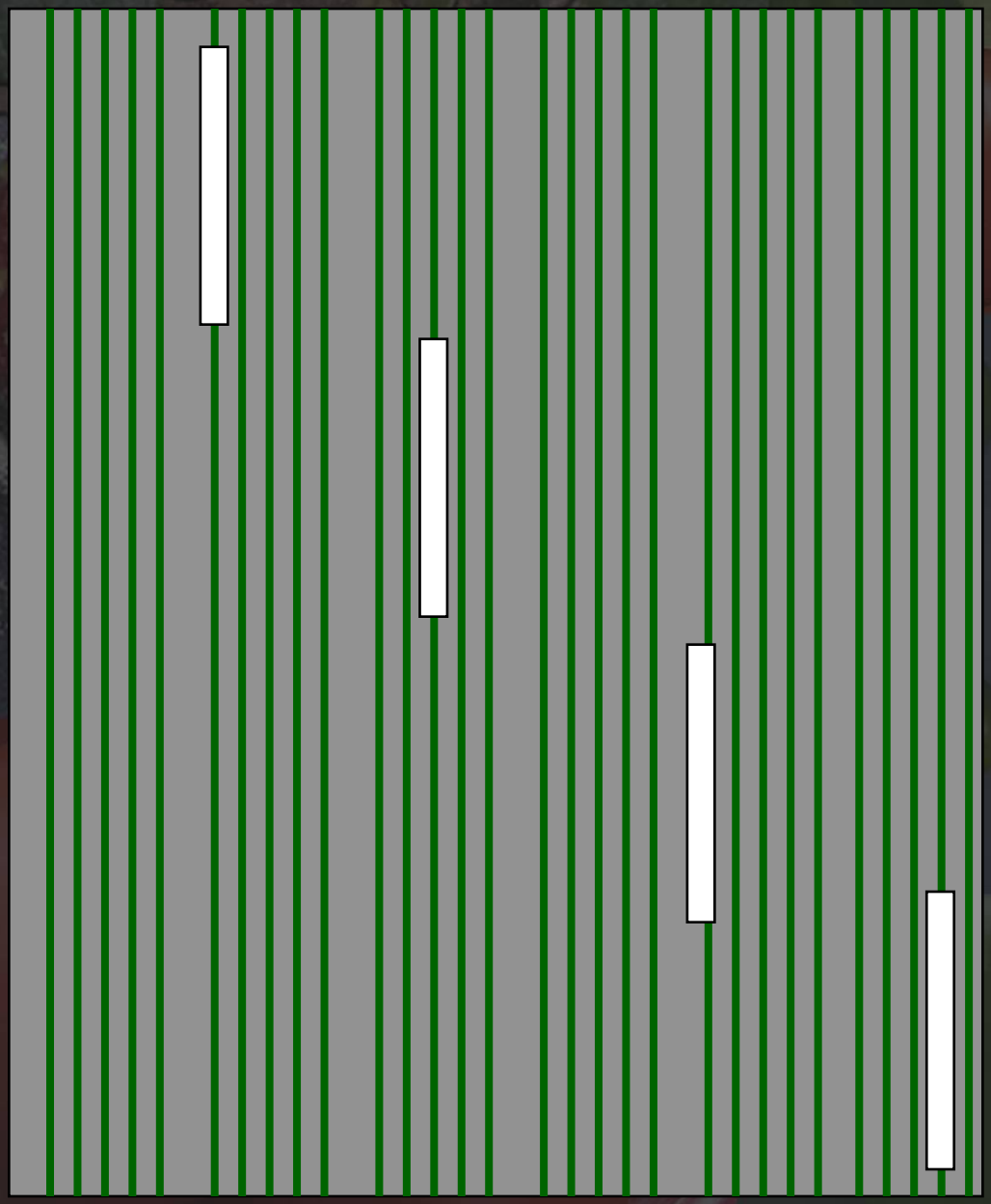
Bacterial speck lesions on the stem, leaves, and developing flowers.

Bacterial speck lesions on young tomato fruit.

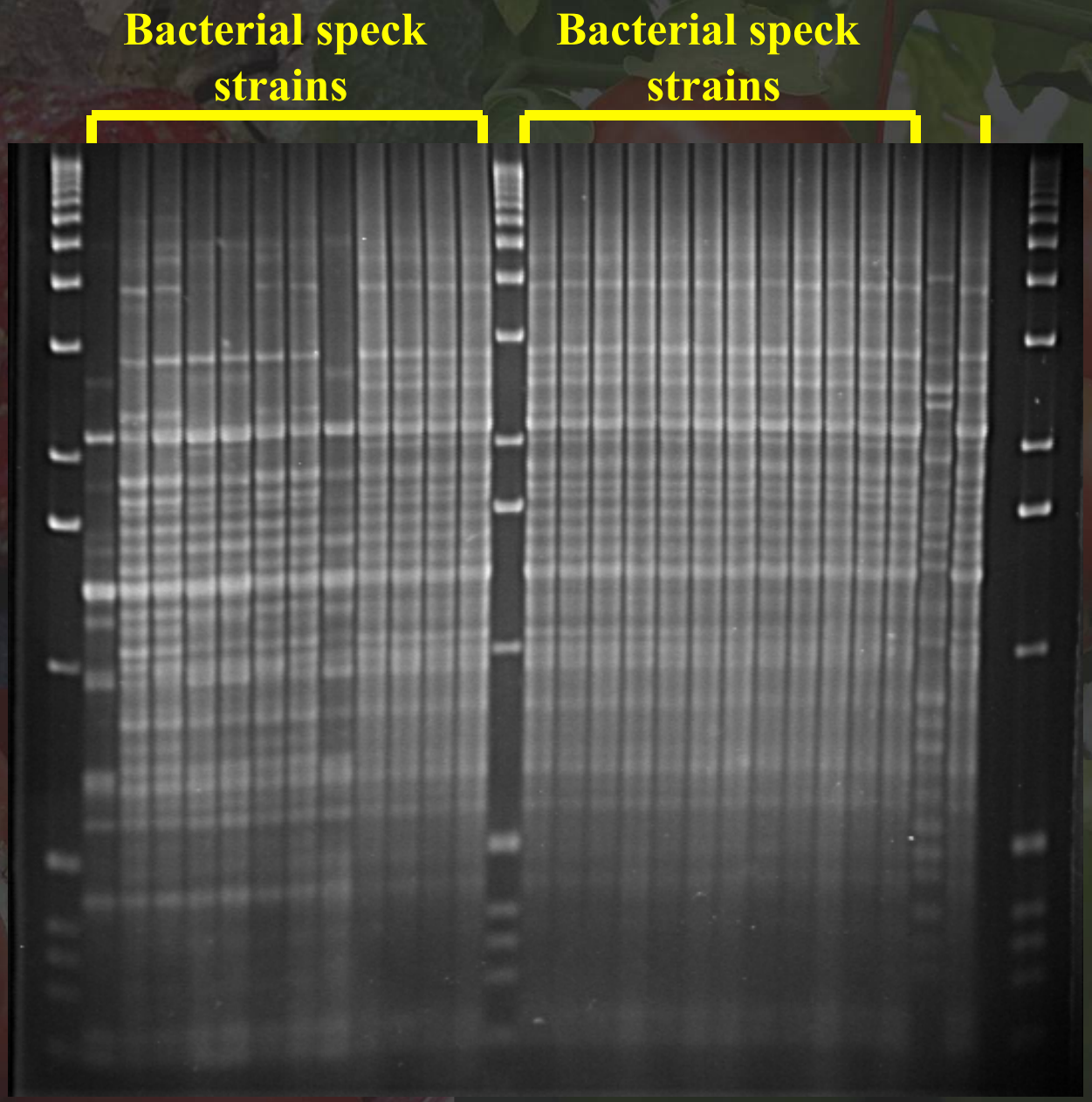
LEFT: Intensive systems for producing tomato transplants can lead to widespread distribution of bacterial inoculum.

RIGHT: Bacterial speck lesions on young tomato transplants

Bacterial Spot on Seedlings



- Random start
- 4 quadrants
- 5 symptomatic leaves per quadrant



BOX-PCR Fingerprints of *P. syringae* pv. *tomato*

Summary of Bacterial Speck survey and work 1999

Grower or field No.	County	Variety	Foliar incidence	Fruit incidence	number of isolates cultured	number resistant to copper	number resistant to Strep
1	Buncombe	FL 47	1-3%	0%	11	11	0
2	Madison	Sun Leap	4%	20%	4	4	0
3	Buncombe	FL 47	3	1	12	12	0
4	Haywood	Florilina	trace	0	could not isolate		
5	Haywood	Mt. Fresh	trace	0	na		
6	Buncombe				16	16	0
7	Haywood	Mt. Fresh	0	0	na		
8	Haywood	Mt. Spring	20-30	3	20	20	0
9	Macon	Mt. Spring	3	0	could not isolate		
10	Buncombe				19	19	0
11	Henderson	Plum Dan	20	0	13	13	0
12	Henderson	Mt. Spring	3-5%	1	20	20	0
13	Henderson	FL AG47	trace	0	18	18	0
14	Henderson	Mt. Belle	5	0	20	20	0

n=153

Summary of Bacterial Speck survey and work 2000

Grower or field No.	County	Variety	Foliar incidence	Fruit incidence	number of isolates cultured	number resistant to copper	number resistant to Strep
1	Buncombe	FL 91	1%	0%	4	4	0
2	Buncombe	FL 47	1%	0%	0	0	0
3	Buncombe	FL 47	3%	0%	7	7	0
4	Macon	?	20%	1%	-	-	-
5	Macon	?	10%	trace	10	10	0
6	Henderson	Mt. Fresh	4%	trace	6	6	0
7	Rabon (GA)	?	1%	trace	4	4	0
8	Henderson	Mt. Fresh	25%	5%	2	2	0
9	Rabon (GA)	?	20%	trace	1	1	0
10	Henderson	NC 633	1%	trace	9	9	0
11	Henderson	FL 47	20%	trace	3	3	0
12	Haywood	?	51%	trace	0	0	0
13	Buncumb	FL 47	5%	trace	1	1	0

n=47

TOMATO BACTERIAL SPECK MANAGEMENT STUDY

Seed: 20% Clorox seed soak (40 min)

Transplants: Weekly sprays with Streptomycin (200 ppm)

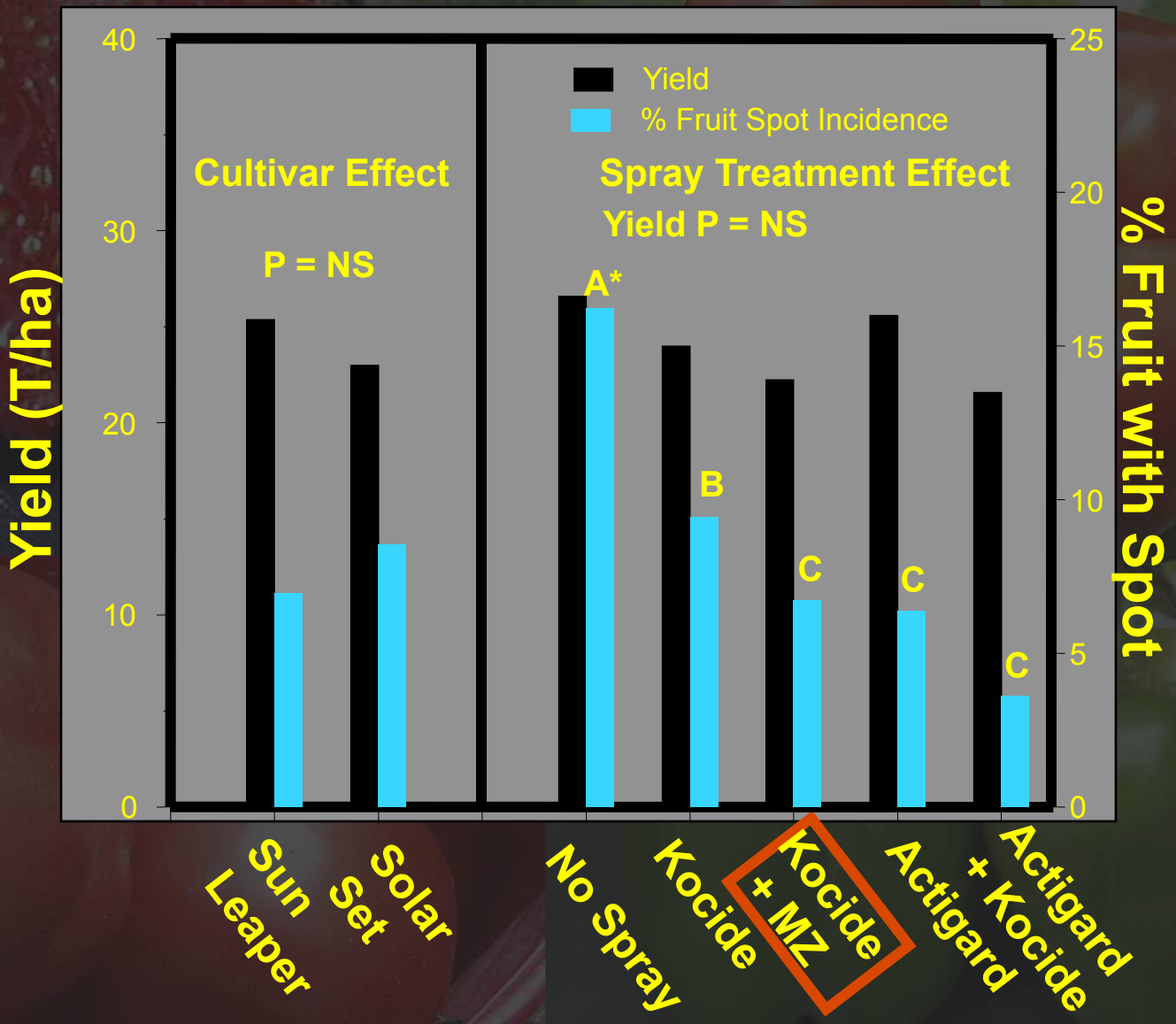
Field: Sprays with Kocide 2000 vs Actigard

Design: 2x2x3 factorial experiment, RCBD (4 reps)

RESULTS-TOMATO BACTERIAL SPECK MANAGEMENT STUDY

Treatments				Fruit infection		
Seed	Trans plant	Field spray	Foliar % LAS	Tot no spots	% fruit	Mkt t/A
None	None	None	48.3	462	46	22.6
Clorox	None	None	41.8	326	44	22.3
None	Strep	None	41.8	344	39	23.0
None	None	Kocide	35.1	768	60	13.0
None	None	Actigard	2.1	271	32	26.0
Clorox	Strep	Actigard	1.4	138	22	35.0
LSD (P=0.05)			17.1	157	13	9.0

Total Yield and Fruit Spot Incidence for Cultivar and Spray Effects (Race T1; copper sensitive)



* bars having the same letter are not significantly different (P=0.05)

NC Fungicide Application Recommendations

Table 1. Suggested weekly spray schedule and products[x] for foliar tomato disease control in NC.

Before harvest	Week 1	-	mancozeb (1)[y] + copper + **Actigard** (1)[y]
	Week 2	-	mancozeb (2) + copper
	Week 3	-	mancozeb (3) + **strobilurin** (1)[y] + **Actigard** (2)
	Week 4	-	mancozeb (4) + copper
	Week 5	-	Endura LOW RATE[z] (1) + **Actigard** (3)
	Week 6	-	mancozeb (6) + copper
	Week 7	-	mancozeb (7) + **strobilurin** (2) + **Actigard** (4)
	Week 8	-	mancozeb (8) + copper
During harvest	Week 9	-	Endura LOW or HIGH rate[z] (2) + chlorothalonil (1)
	Week 10	-	Revus Top (1)[y] **OR** Presidio (1)[y] **OR** Ranman (1)
	Week 11	-	chlorothalonil (2) + **strobilurin** (3)
	Week 12	-	Revus Top (2) **OR** Presidio (2) **OR** Ranman (2)
	Week 13	-	Endura LOW or HIGH rate[z] (3) + chlorothalonil (3)
	Week 14	-	Revus Top (3) **OR** Presidio (3) **OR** Ranman (3)[y]
	Week 15	-	chlorothalonil (4) + **strobilurin** (4)
	Finish season with chlorothalonil		

x Mancozeb, copper, chlorothalonil, and strobilurin are common names for products sold under various trade names (see Table 2). Actigard, Endura, Ranman, Revus Top, and Presidio are trade names of products from Syngenta, BASF, FMC, Syngenta, and Valent respectively. Refer to labels, table 2 and the text above for rates to use in volume-based spraying.

y Total number of applications per season is restricted by the label.

z Low rate of Endura controls early blight; high rate controls early blight & Botrytis gray mold. High rate is only necessary if conditions are conducive for gray mold (cool / wet right before & during harvest). Total max rate allowed per season is 25 oz

Strobilurin products must be rotated as per label restrictions, and to limit development of fungicide resistance in the early blight pathogen. Actigard applications should be limited to reduce the risk of phytotoxicity and plant stunting.

Bacterial spot pathogens resistant to copper and streptomycin in different locations of North Carolina. 2015

S.N.	Location/County	Field	Cultivar	Total # bacterial isolates	# Resistant to Copper	# Resistant to streptomycin
1	Henderson	1	Plum Regal	21	20	13
		2	BHN784	17	16	2
2	Madison	3	Red Defender	20	20	18
		4	Grafted plants	20	20	19
3	Haywood	5	Mountain Majesty	10	2	1
		6	Roma	16	16	15
		7	Roma	15	14	10
4	Buncombe	8	Biltmore	20	20	2
5	Jackson	9	Plum Regal	25	25	2
6	Swain	10	Plum Regal	19	19	1
	Total			183	172	82

Xanthomonas Species	DNA Group	Tomato Race	Pepper Race	Distribution
X. euvesicatoria	A	T1	P1-11	widespread
X. vesicatoria	B	T2		Midwest
X. perforans	C	T3,4		Southeast Midwest?
X. gardneri	D			Midwest

The Culprits…

Although *X. perforans* is an aggressive foliar pathogen, it typically does not cause severe lesions on fruit

Typical *X. perforans*, race 4

Courtesy Gary Vallad

Efficacy of Products to Manage Bacterial Canker Secondary Spread

Materials and Methods

- 6 plant plots stake and weave system; roma-type tomato
- Interplanted 2 heavily inoculated plants with *Clavibacter michiganensis* subsp *michiganensis* using 3 strains

Early plant stand

Mid-September plant growth

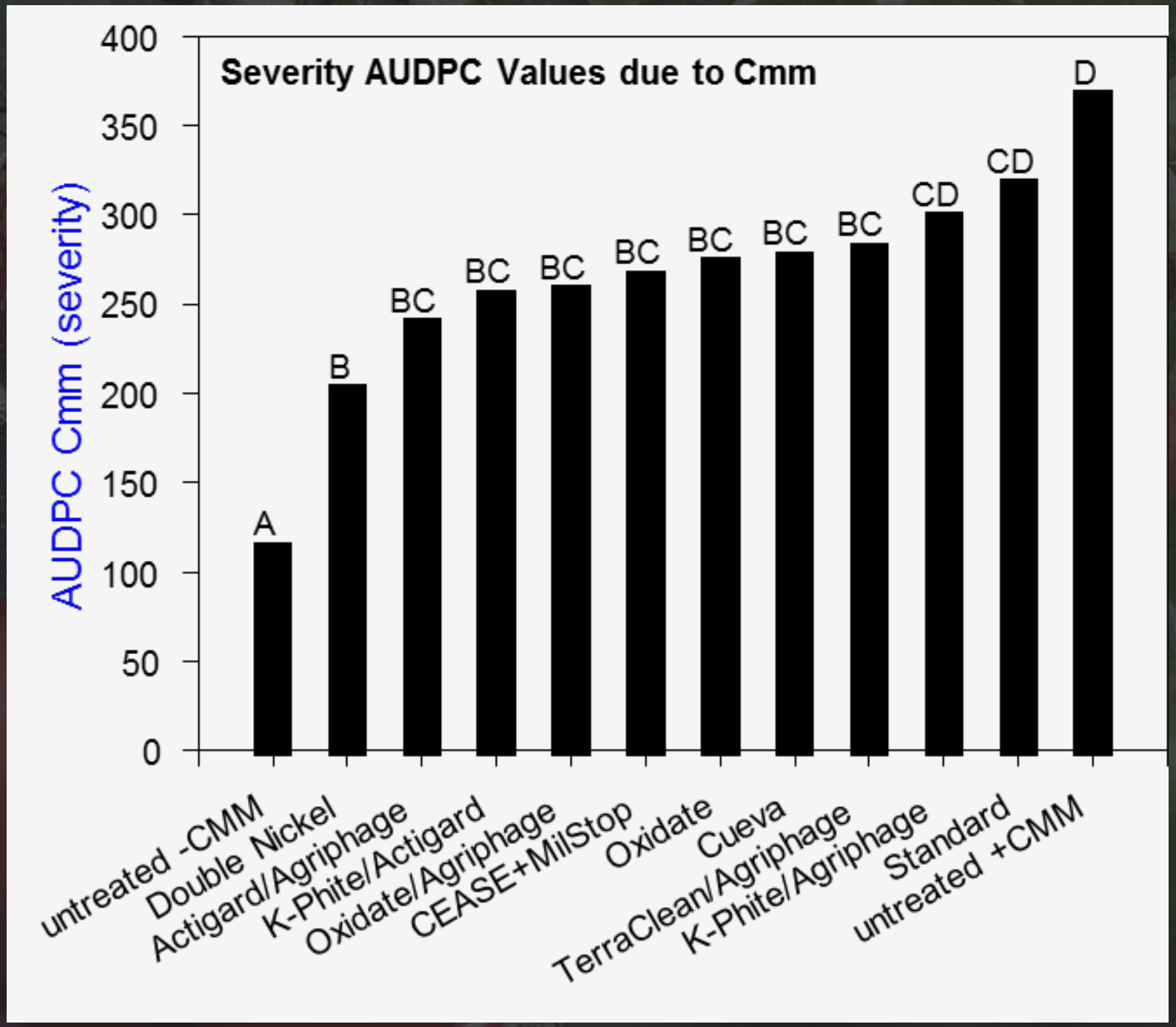
Trial Progress and Main Issue:

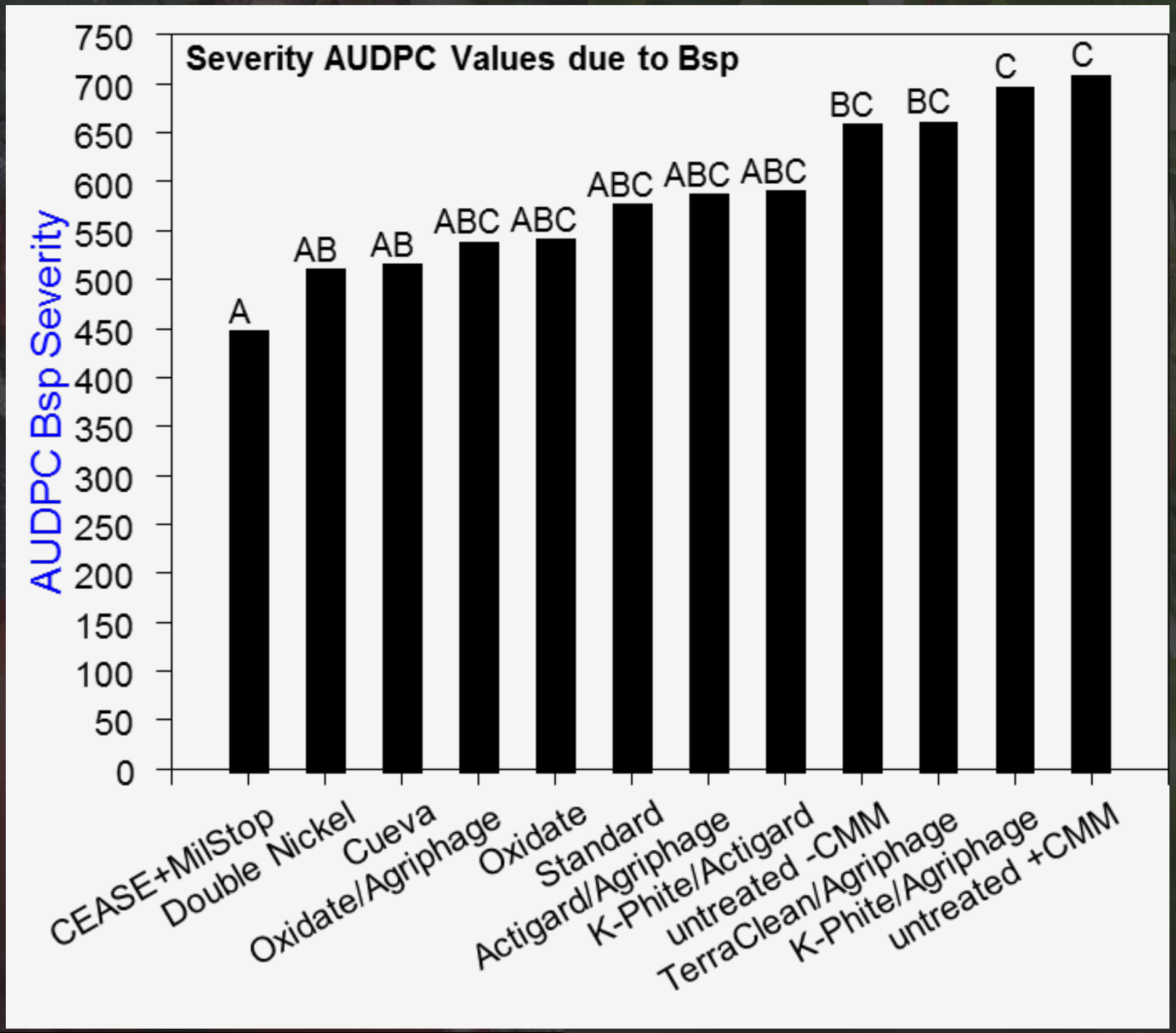
- Plants established well
- Plots are in excellent shape production-wise
- Bacterial canker symptoms progressed modestly
- *Xanthomonas* (Bacterial spot) pressure was high

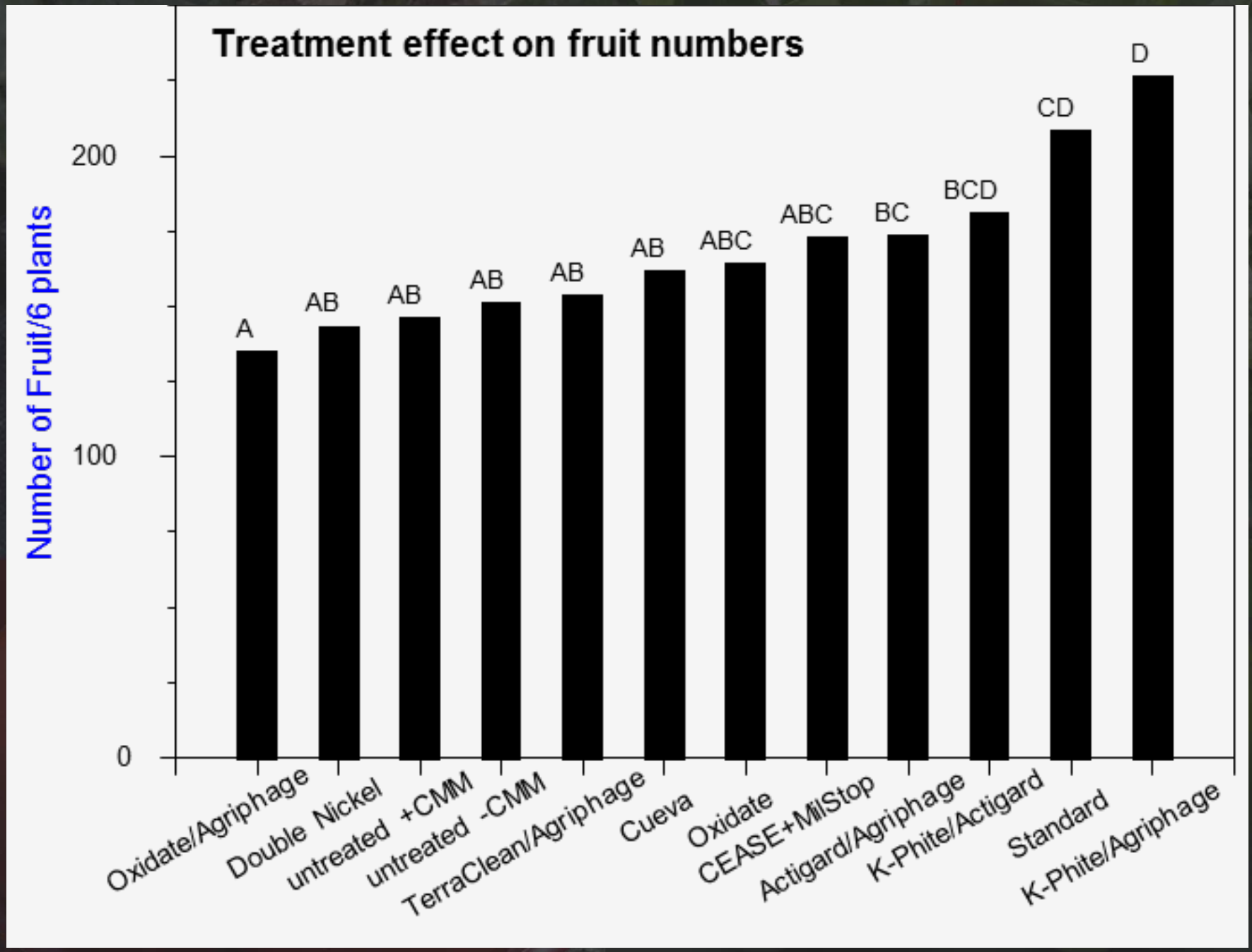
Bacterial canker (heavy symptoms) on the inoculated plant nearest the stake and spreading to neighboring plants (top left). Plant growth is excellent on a foggy 18 Sep morning (top right) and heavy dew advanced high bacterial spot pressure (lower right).

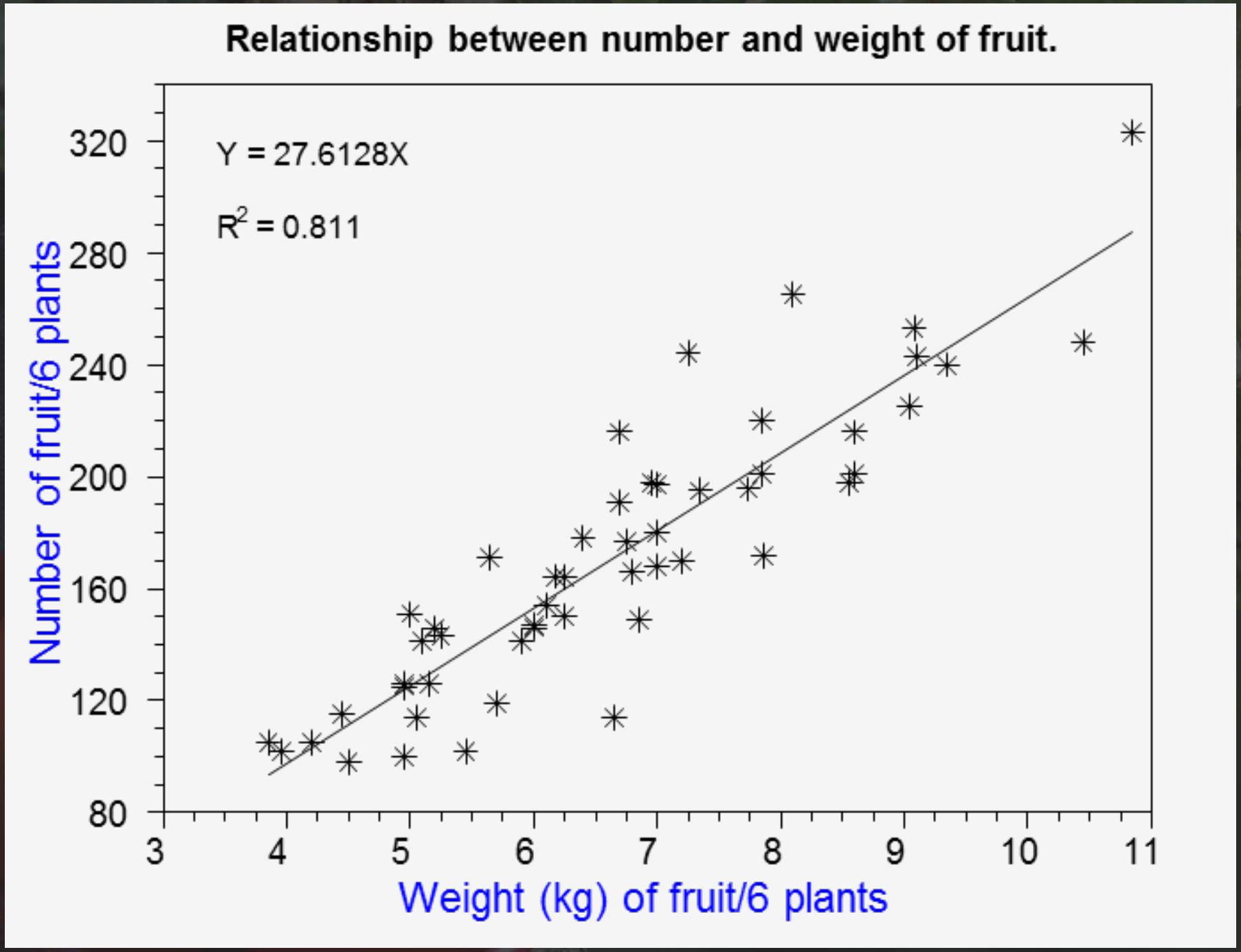
Bacterial spot pressure on the underside of the leaves (left); lower canopy (top right) and upper canopy (bottom right).

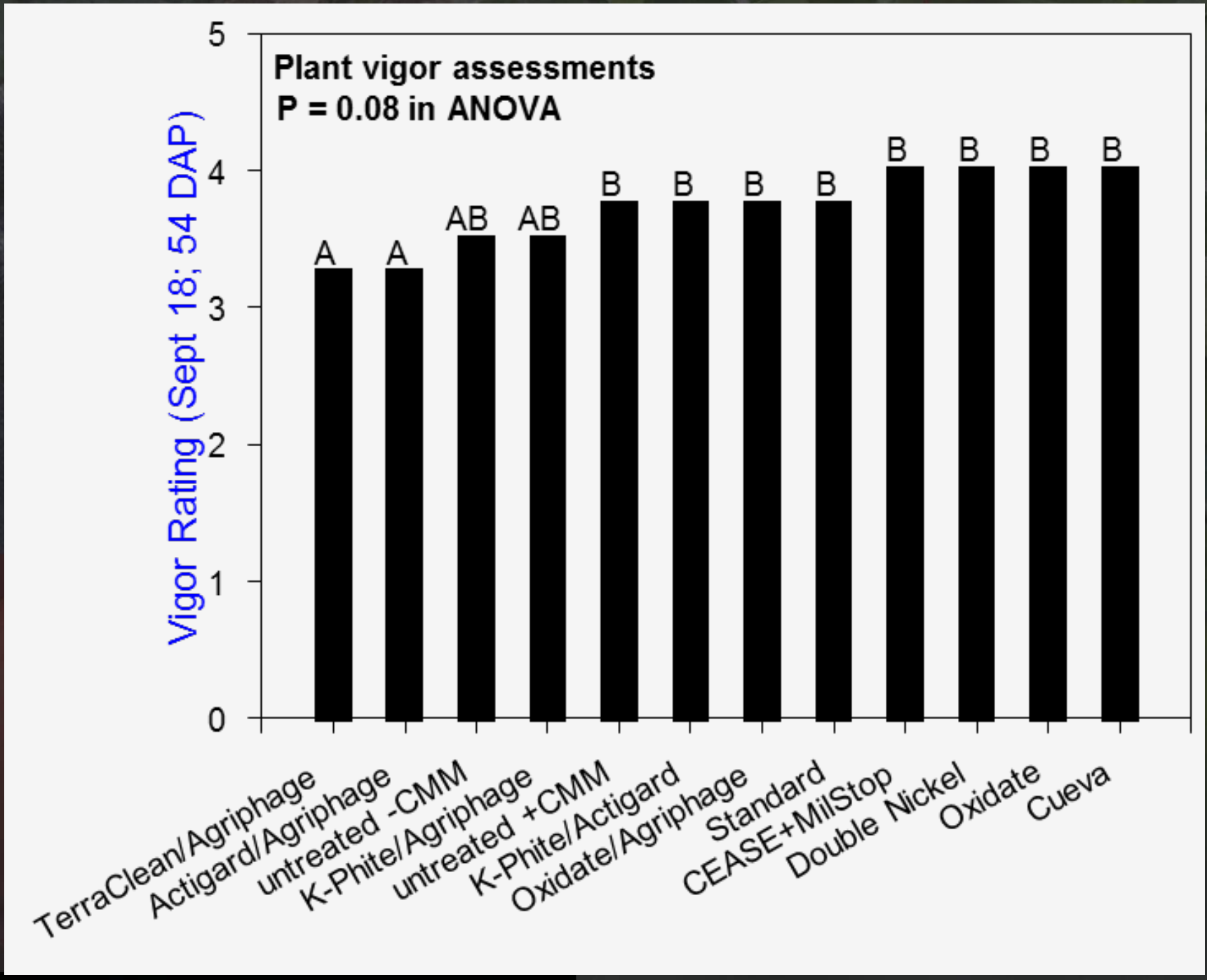
1	**no spray (water)**	negative control
2	**no spray (water)**	Non-inoculated control
3	Actigard (0.25 oz/100gal) drench	
	K-Phite (3.0 qt/A)	
4	Cease (6.0 qt/100 gal)	
	Milstop (2.0 lb/100 gal)	
5	Double Nickel (2.0 qt/A)	
6	Terra Clean (12.8 fl oz/100 gal/A) drench 1,3,5,7	
	AgriPhage CMM 2 pt/50 gal	
7	Oxidate 2.0 (1 .0 gal/100gal)	
8	AgriPhage CMM 2 pt/50 gal	
	Oxidate 2.0 (1.0 gal/100gal)	
9	Actigard (0.25 oz/100gal) drench	
	AgriPhage CMM 2 pt/50 gal	
	K-Phite (3.0 qt/A)	
10	AgriPhage CMM 2 pt/50 gal	
	K-Phite (3.0 qt/A)	
11	Cueva (2.0 qt/A)	
12	**Industry Standard**	Industry Standard
	Copper (1.25 lb/100gal)	
	Actigard (0.75 oz/100gal) 1,3,5,7	


Severity AUDPC Values due to Cmm
AUDPC Cmm (severity)
400
350
300
250
200
150
100
50
0
A
B
BC
BC
BC
BC
BC
BC
CD
CD
D
untreated -CMM
Double Nickel
Actigard/Agriphage
K-Phite/Actigard
Oxidate/Agriphage
CEASE+MilStop
Oxidate
Cueva
TerraClean/Agriphage
K-Phite/Agriphage
Standard
untreated +CMM


Severity AUDPC Values due to Bsp
AUDPC Bsp Severity
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
A
AB
AB
ABC
ABC
ABC
ABC
ABC
BC
BC
C
C
CEASE+MilStop
Double Nickel
Cueva
Oxidate/Agriphage
Oxidate
Standard
Actigard/Agriphage
K-Phite/Actigard
untreated -CMM
TerraClean/Agriphage
K-Phite/Agriphage
untreated +CMM


Treatment effect on fruit numbers
Number of Fruit/6 plants
0
100
200
A
AB
AB
AB
AB
AB
ABC
ABC
BC
BCD
CD
D
Oxidate/Agriphage
Double Nickel
untreated +CMM
untreated -CMM
TerraClean/Agriphage
Cueva
Oxidate
CEASE+MilStop
Actigard/Agriphage
K-Phite/Actigard
Standard
K-Phite/Agriphage


Relationship between number and weight of fruit.
Y = 27.6128X
R2 = 0.811
Number of fruit/6 plants
320
280
240
200
160
120
80
3
4
5
6
7
8
9
10
11
Weight (kg) of fruit/6 plants


Plant vigor assessments
P = 0.08 in ANOVA
Vigor Rating (Sept 18; 54 DAP)
0
1
2
3
4
5
A
A
AB
AB
B
B
B
B
B
B
B
B
TerraClean/Agriphage
Actigard/Agriphage
untreated -CMM
K-Phite/Agriphage
untreated +CMM
K-Phite/Actigard
Oxidate/Agriphage
Standard
CEASE+MilStop
Double Nickel
Oxidate
Cueva

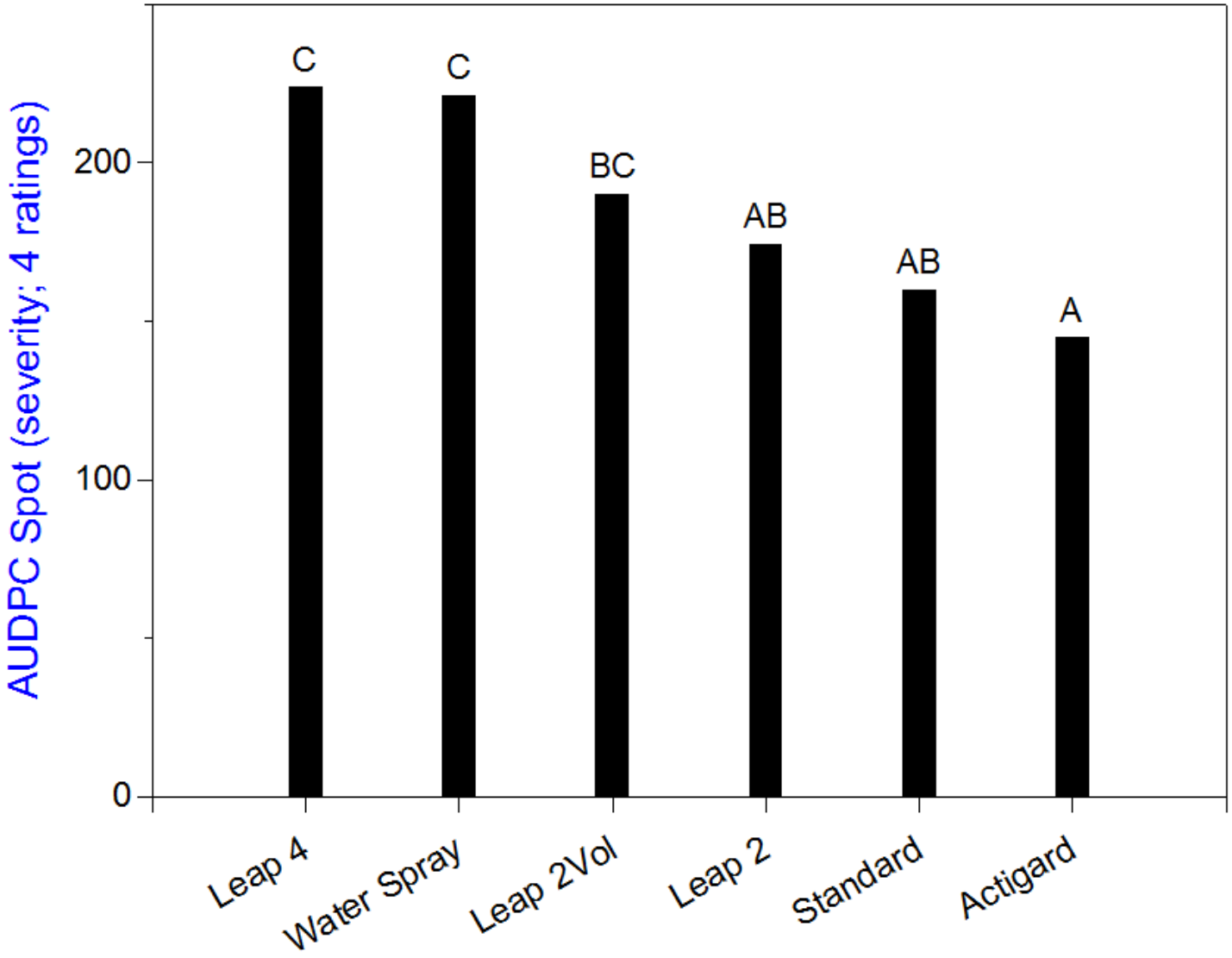
Experiment # 2 2015
Same Site; Similar Design

	Treatment	Rate
1	Water Spray	---
2	Standard	See footnote
3	Actigard	0.75 oz/100 gal
4	Leap 2	2 pt/A
5	Leap 4	4 pt/A
6	Leap 2Vol	2 pt/A/100gal

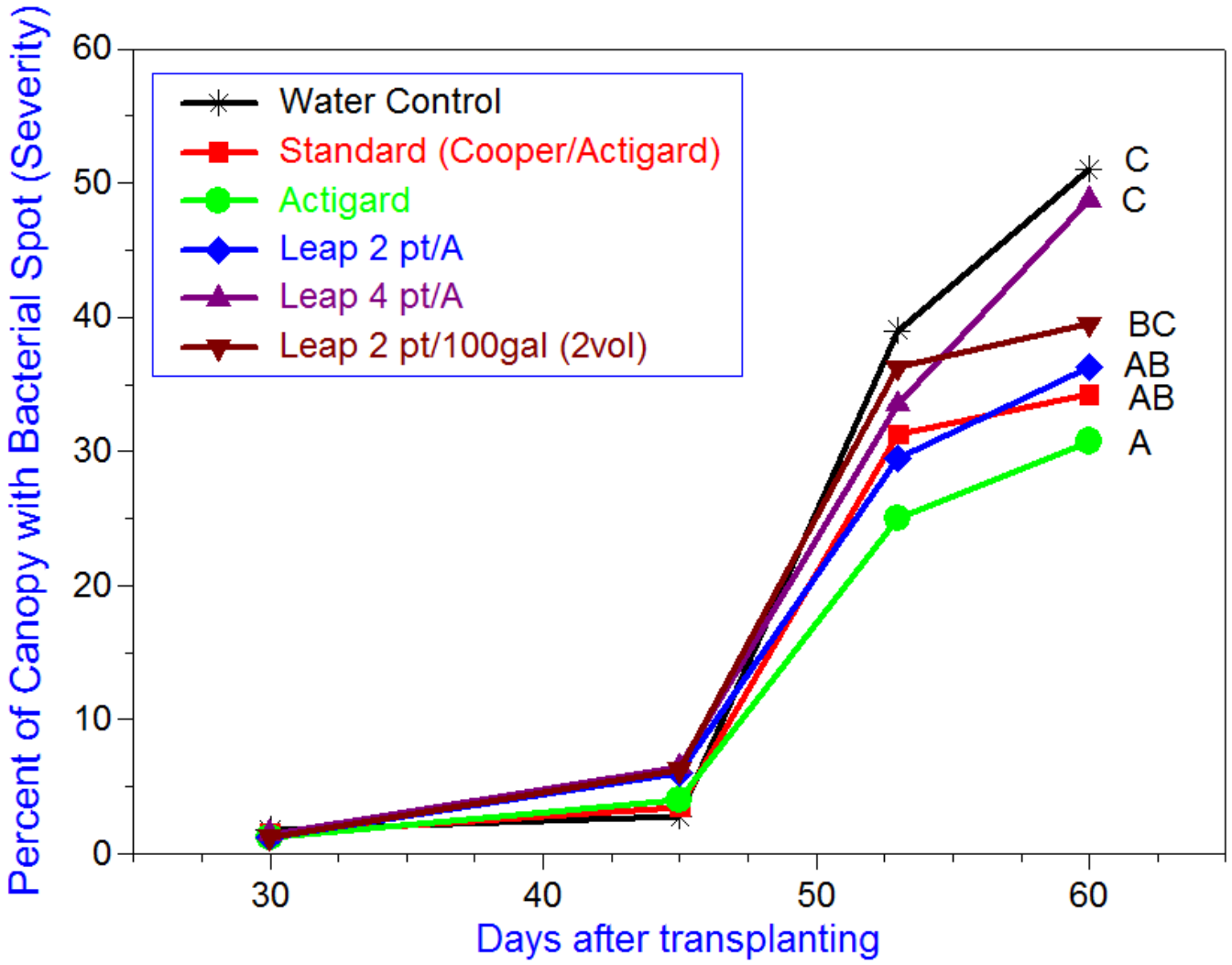
Standard is the combination of copper (Kocide 3000 1.25 lb/100 gal) plus Actigard (50WG 0.75 oz/100gal)

Note: Induce was included at 0.25% V/V in the Leap and Actigard treatments; not in the water and standard controls.

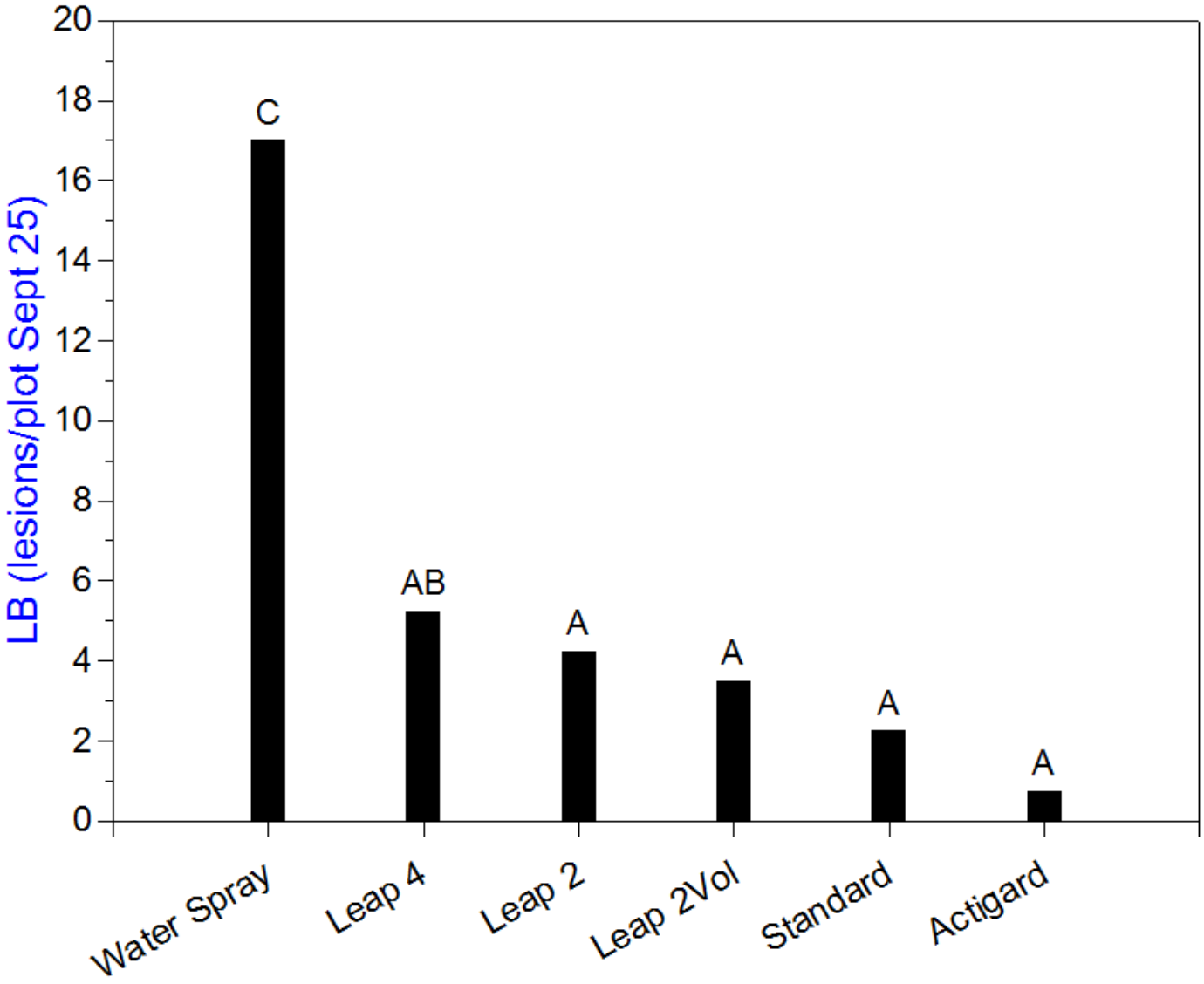
Severity of bacterial spot over the course of the season; area under the disease progress curve values



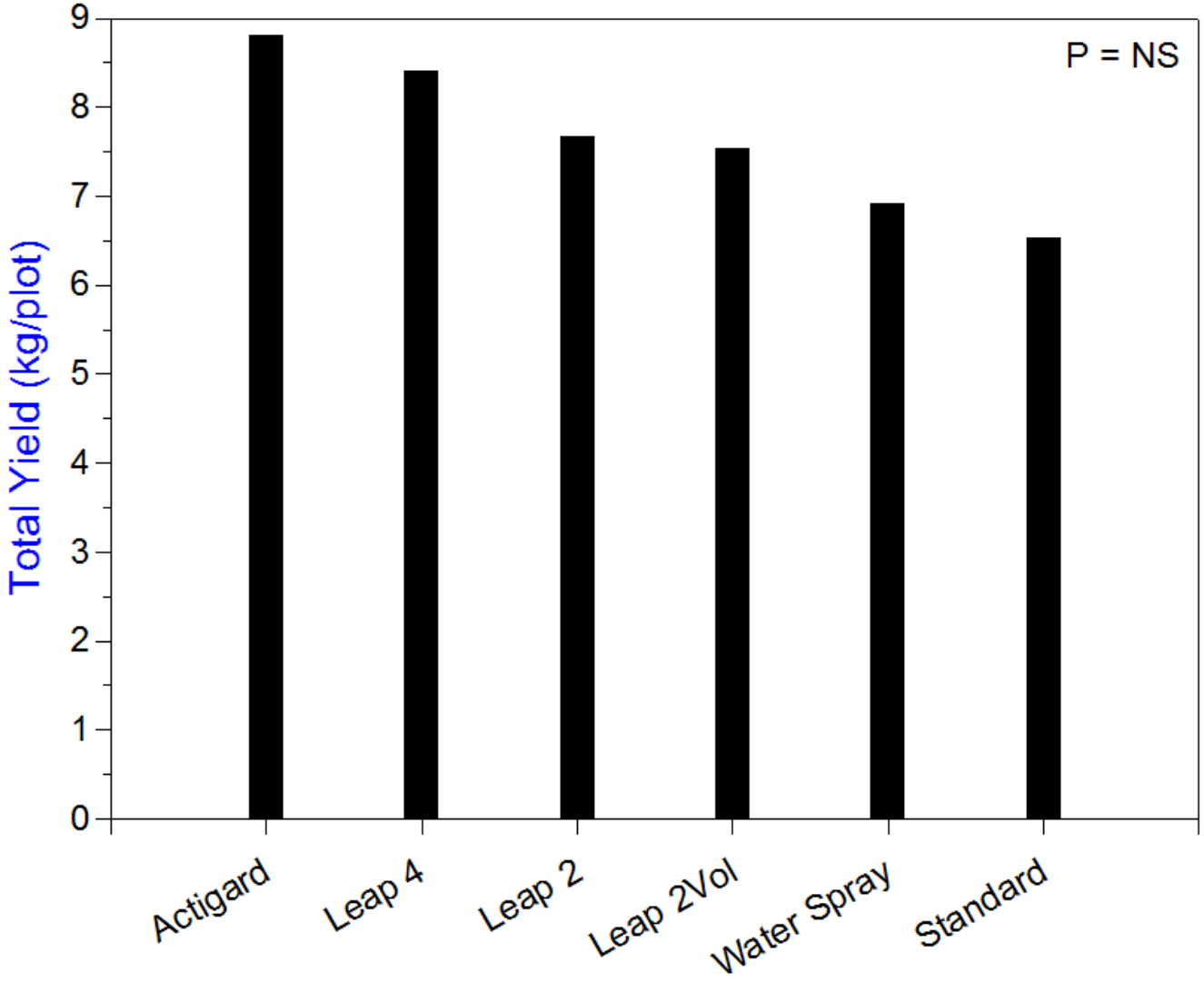
Severity of bacterial spot over the course of the season; disease progress curves.



Number of late blight lesions per plot assessed on 25 Sep 2015 and one week after a cover spray was omitted

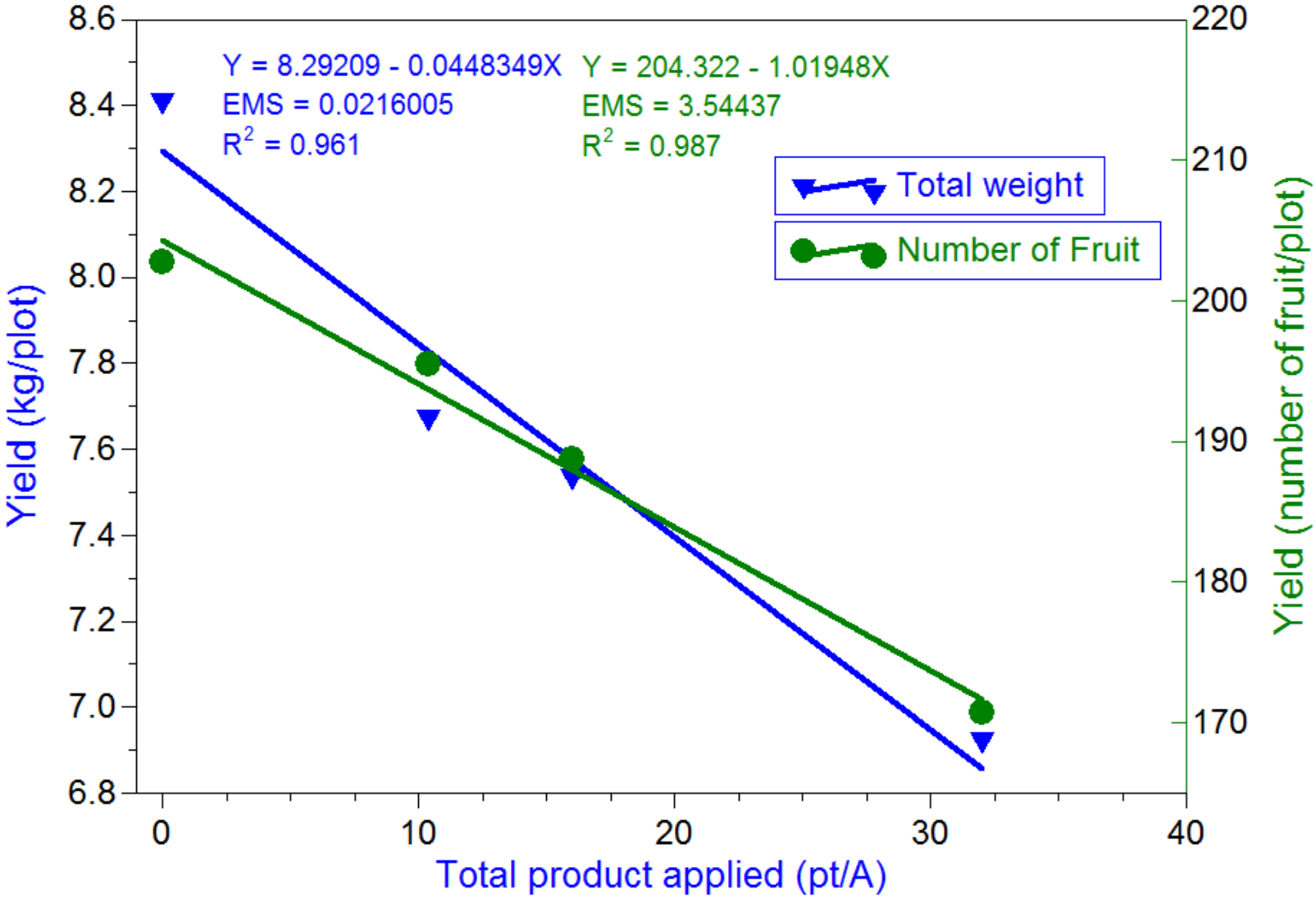


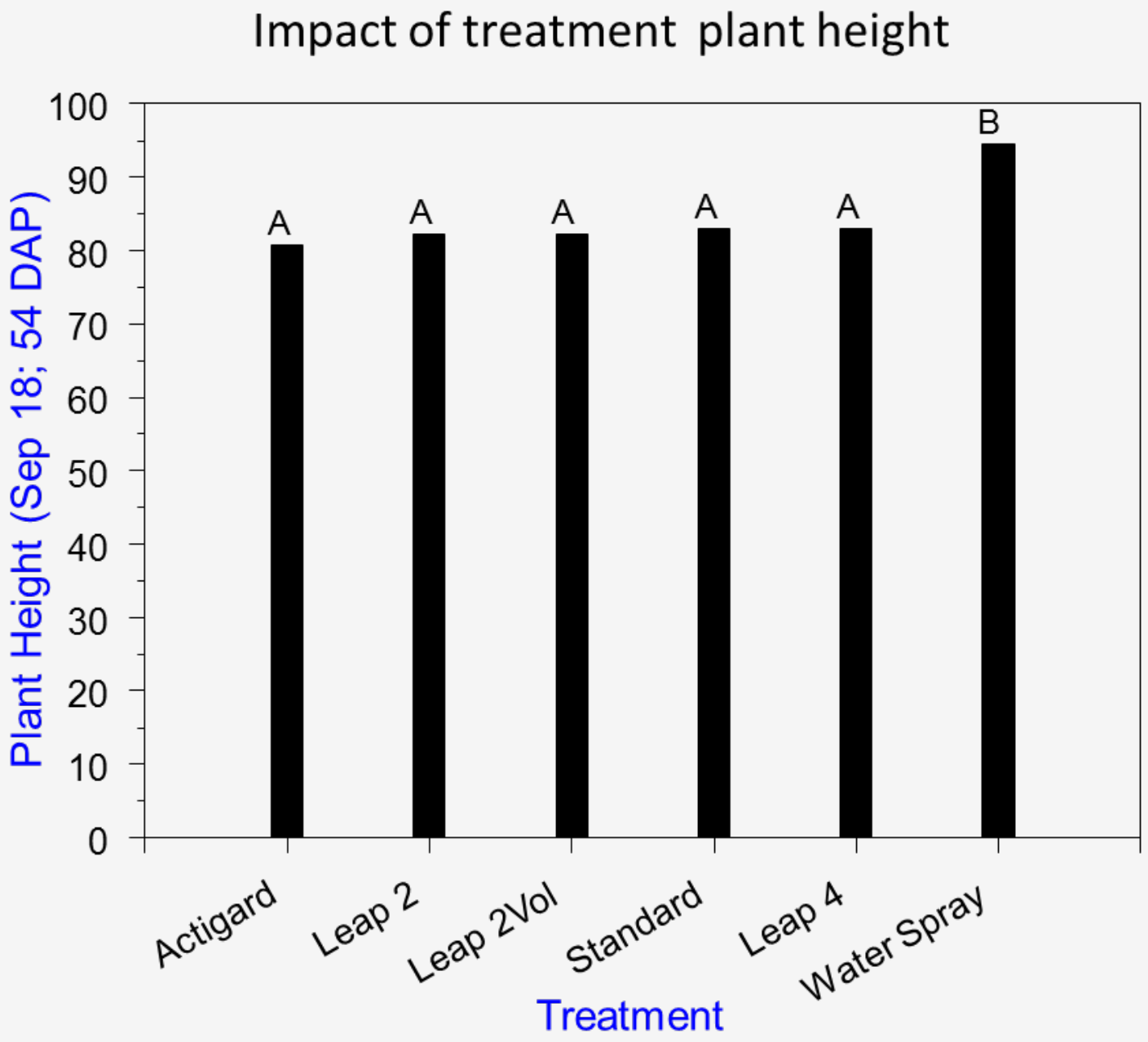
Impact of treatment on yield (kg/plot)



(multiply by 1911 to get lbs/A)

Impact of LEAP concentration on yield parameters




Impact of treatment plant height
Plant Height (Sep 18; 54 DAP)
100
90
80
70
60
50
40
30
20
10
0
A
A
A
A
A
B
Actigard
Leap 2
Leap 2Vol
Standard
Leap 4
Water Spray
Treatment

Thank You