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Integrated Precision Harvesting System: A Promising Technology to Improve Berry Yield and Quality

Precision Agriculture Research Team

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DOUG BRAGG ENTERPRISES

Objectives

- Develop improved integrated harvesting management systems = coupling of mechanical, biological and environmental processes

- Increase the berry picking efficiency of blueberry harvester = LOWER cost of production

Improved Integrated Harvesting System

- Sensor Fusion System to Identify Sources of Error
- Quantification of Multiple Fruit Losses During Harvesting
- Effect of Crop Characteristics and Machine Parameters on Berry Losses
- Effect of Harvest Timings and Climatic Condition on Fruit Losses Design Analysis and Comparison of Different Harvester Heads
- Impact of Relative Velocity and Different Header Forces on Fruit Picking Efficiency
- Development of Bio-System Modeling for Coupling of Biological, Environmental and Mechanical Processes
- On-Line Computer Program for Precise Berry Harvesting Recommendations

Precision Agriculture Research Team





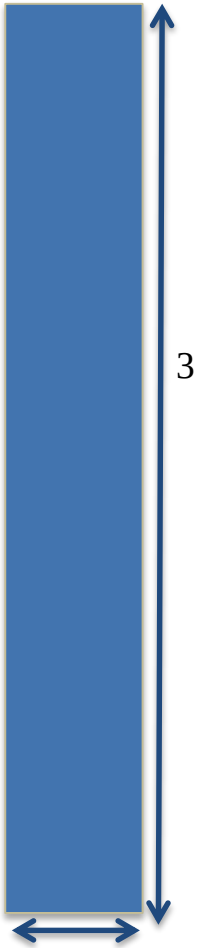








Quantification of Losses



Parameters

- Pre-Harvest Loss
- Fruit Yield
- Fruit on the Ground
- Fruit on the shoot
- Fruit in Debris from blower
- Fruit on Pan (Back side of head)
- Plant Height
- Fruit Zone
- Plant Density
- Stem Diameter
- Berry Sizes
- Leaf wetness
- Soil moisture
- Plant pull
- Slope
- GPS Location

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Quantification of Losses

Experiment Design Parameters

Speed (mile/hr)	Revolutions (rpm)	Sample Collection		
0.75, 1.0, 1.25	26			
	26			
	26			
0.75, 1.0, 1.25	28			
	28			
	28			
0.75, 1.0, 1.25	30			
	30			
	30			

Variables/Treatments:
Ground Speed: 0.75, 1.0 and 1.25 mph
Header Rotations: 26, 28 and 30 rpm

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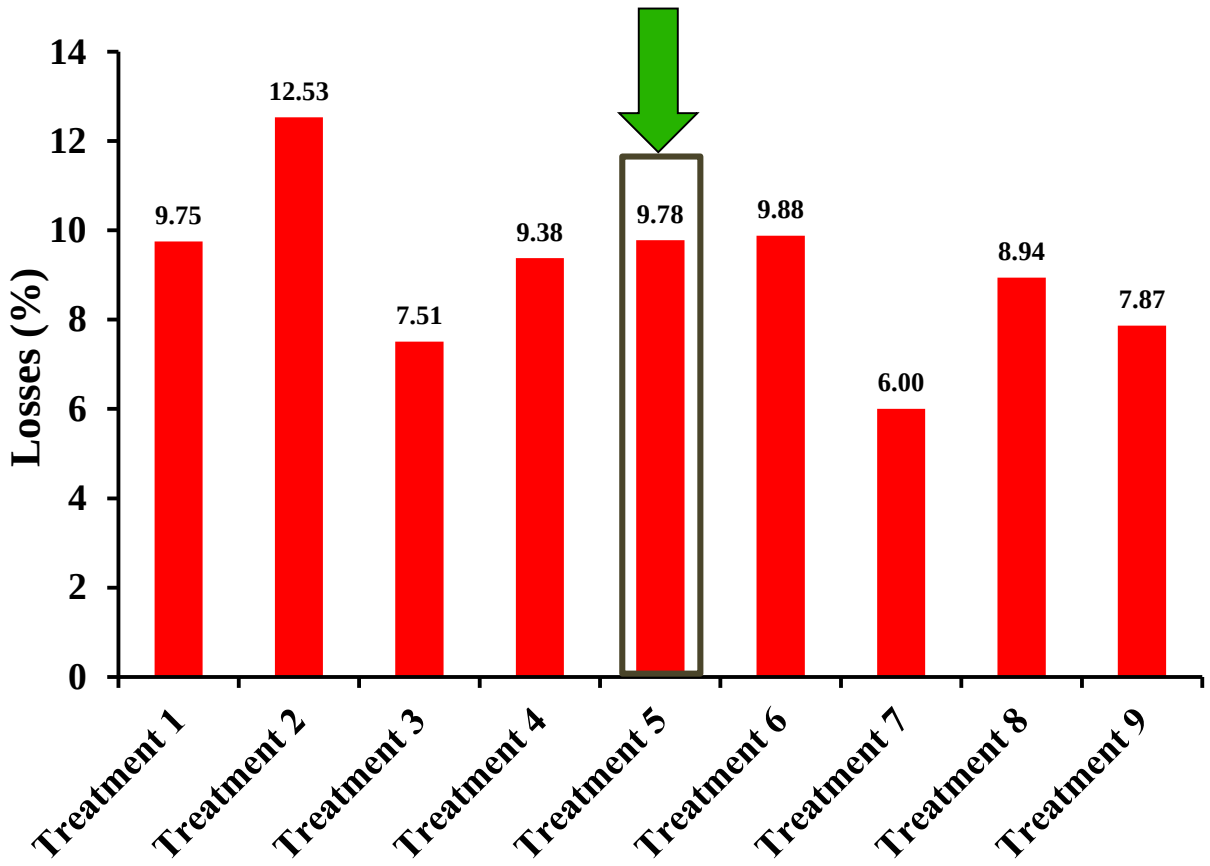
Quantification of Losses – Small Scott

Trt. 1: 0.75 mph and 26 rpm
Trt. 2: 0.75 mph and 28 rpm
Trt. 3: 0.75 mph and 30 rpm
Trt. 4: 1.0 mph and 26 rpm
Trt. 5: 1.0 mph and 28 rpm
Trt. 6: 1.0 mph and 30 rpm
Trt. 7: 1.25 mph and 26 rpm
Trt. 8: 1.25 mph and 28 rpm
Trt. 9: 1.25 mph and 30 rpm



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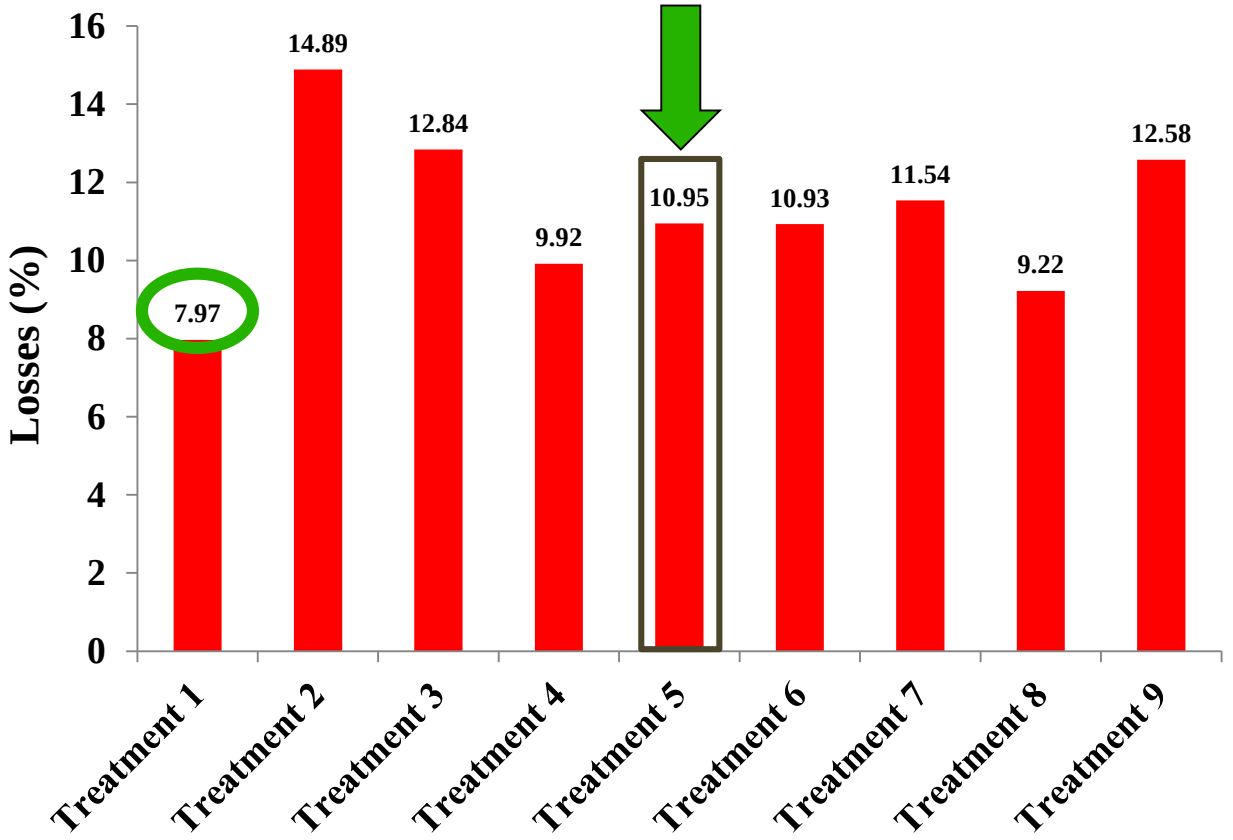
Avg. Plant Height = 23 cm
Avg. Density = 560 plants m^{-2}

Area = 4.6 acres
Fruit Yield = 2600 lb $acre^{-1}$

Quantification of Losses – Cooper Site

- Trt. 1: 0.75 mph and 26 rpm
- Trt. 2: 0.75 mph and 28 rpm
- Trt. 3: 0.75 mph and 30 rpm
- Trt. 4: 1.0 mph and 26 rpm
- Trt. 5: 1.0 mph and 28 rpm
- Trt. 6: 1.0 mph and 30 rpm
- Trt. 7: 1.25 mph and 26 rpm
- Trt. 8: 1.25 mph and 28 rpm
- Trt. 9: 1.25 mph and 30 rpm

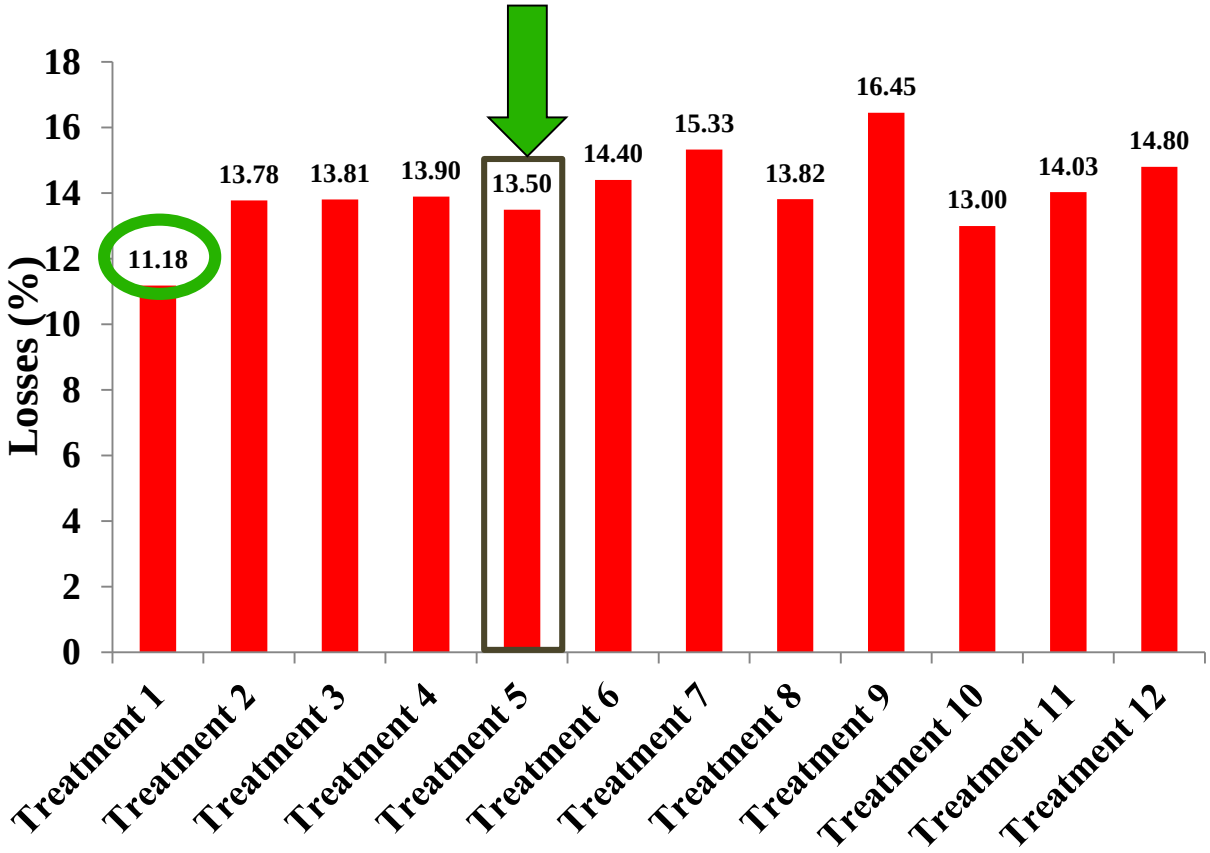


Avg. Plant Height = 24 cm
Avg. Density = 560 plants m^{-2}

Area = 47.9 acres
Fruit Yield = 3700 lb $acre^{-1}$

Quantification of Losses – Tracdie site

Trt. 1: 0.75 mph and 26 rpm
Trt. 2: 0.75 mph and 28 rpm
Trt. 3: 0.75 mph and 30 rpm
Trt. 4: 1.0 mph and 26 rpm
Trt. 5: 1.0 mph and 28 rpm
Trt. 6: 1.0 mph and 30 rpm
Trt. 7: 1.25 mph and 26 rpm
Trt. 8: 1.25 mph and 28 rpm
Trt. 9: 1.25 mph and 30 rpm
Trt. 10: 0.6 mph and 18 rpm
Trt. 11: 0.6 mph and 20 rpm
Trt. 12: 0.6 mph and 22 rpm

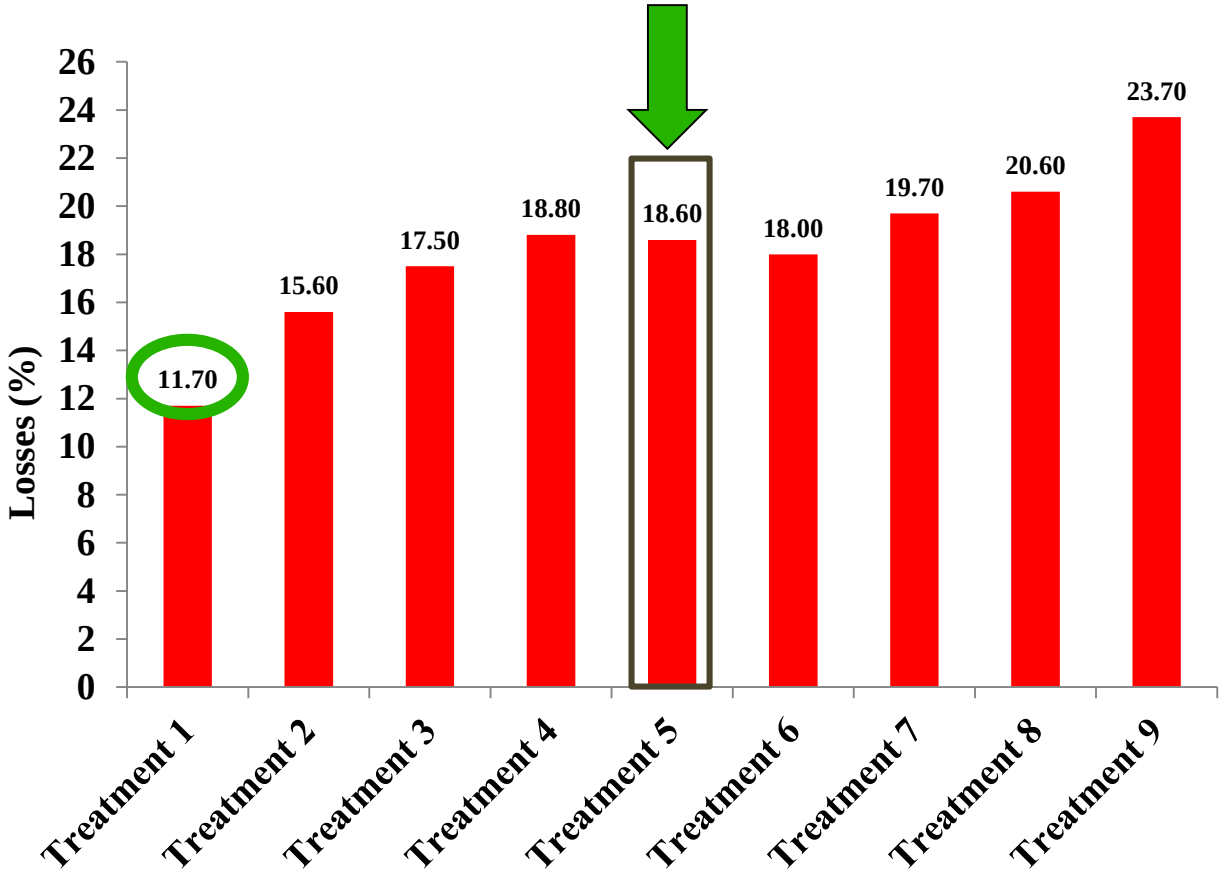


Avg. Plant Height = 27 cm
Avg. Density = 474 plants m^{-2}

Area = 4.0 acres
Fruit Yield = 5500 lb $acre^{-1}$

Quantification of Losses – Frankweb site

- Trt. 1: 0.75 mph and 26 rpm
- Trt. 2: 0.75 mph and 28 rpm
- Trt. 3: 0.75 mph and 30 rpm
- Trt. 4: 1.0 mph and 26 rpm
- Trt. 5: 1.0 mph and 28 rpm
- Trt. 6: 1.0 mph and 30 rpm
- Trt. 7: 1.25 mph and 26 rpm
- Trt. 8: 1.25 mph and 28 rpm
- Trt. 9: 1.25 mph and 30 rpm

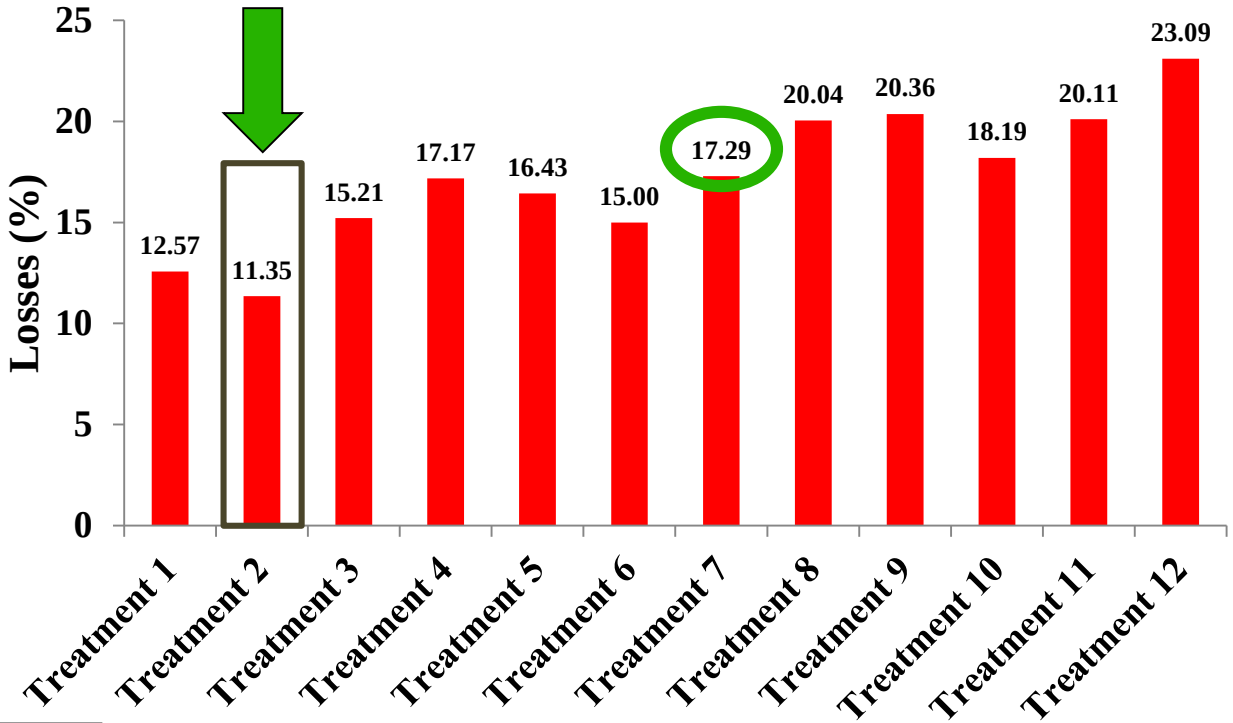


Avg. Plant Height = 22 cm
Avg. Density = 646 plants m^{-2}

Area = 11.4 acres
Fruit Yield = 8100 lb $acre^{-1}$

Quantification of Losses – Joe Slack's Site

Trt. 1	0.75 mph and 24 rpm
Trt. 2	0.75 mph and 26 rpm
Trt. 3	0.75 mph and 28 rpm
Trt. 4	0.75 mph and 30 rpm
Trt. 5	1.0 mph and 24 rpm
Trt. 6	1.0 mph and 26 rpm
Trt. 7	1.0 mph and 28 rpm
Trt. 8	1.0 mph and 30 rpm
Trt. 9	1.25 mph and 24 rpm
Trt. 10	1.25 mph and 26 rpm
Trt. 11	1.25 mph and 28 rpm
Trt. 12	1.25 mph and 30 rpm



Fruit yield increased = 474 lb acre^{-1}

Avg. Plant Height = 20 cm
Avg. Density = 603 plants m^{-2}

Area = 9.6 acres
Fruit Yield = 7900 lb acre^{-1}

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16 Bar Head
vs.
12 Bar Head

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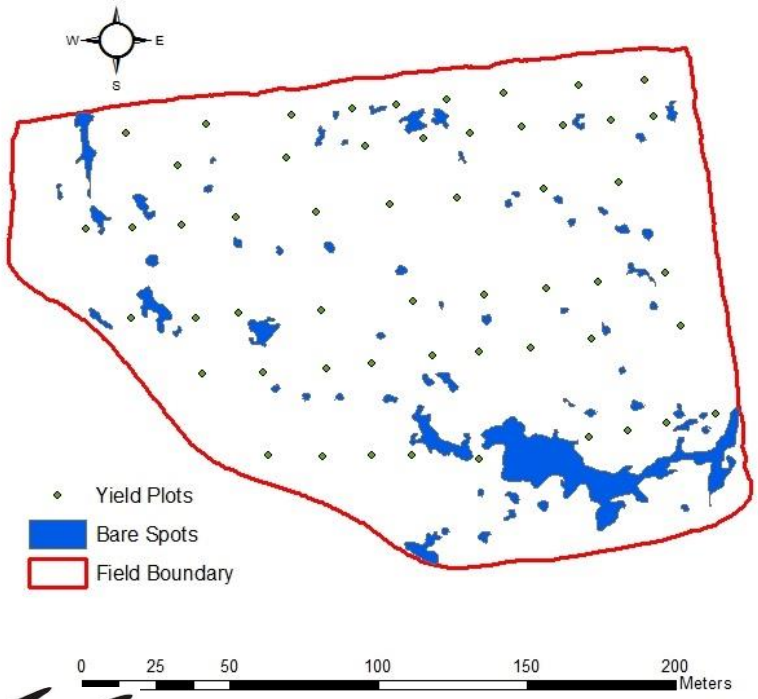
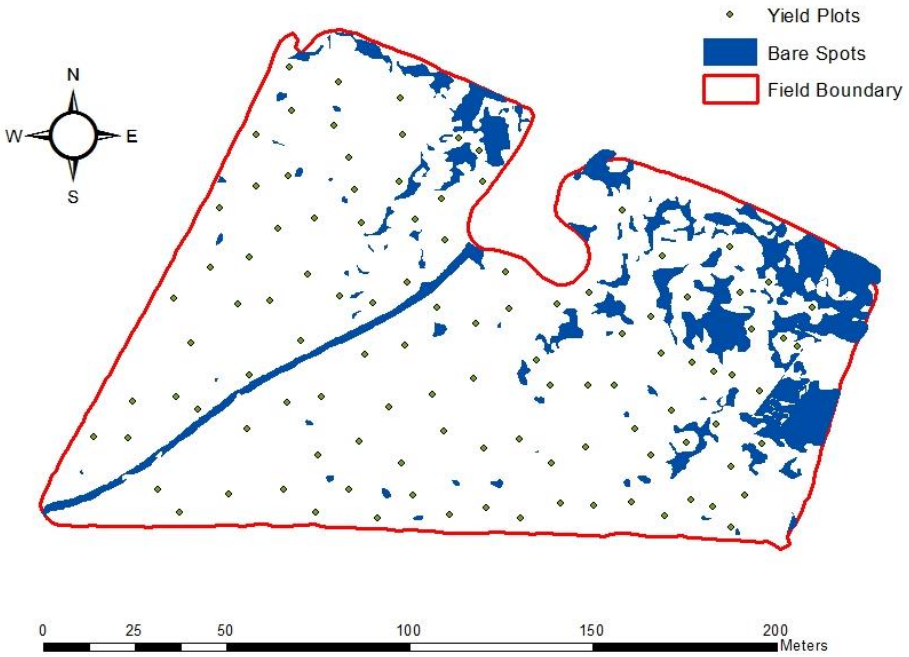
Site Selection

Area = 8.0 acres
Bare spots = 0.5 acres
Average yield = 3385 lb acre^{-1}



Robie Glenn Site

Area = 5.1 acres
Bare spots = 0.6 acres
Average yield = 6973 lb acre^{-1}

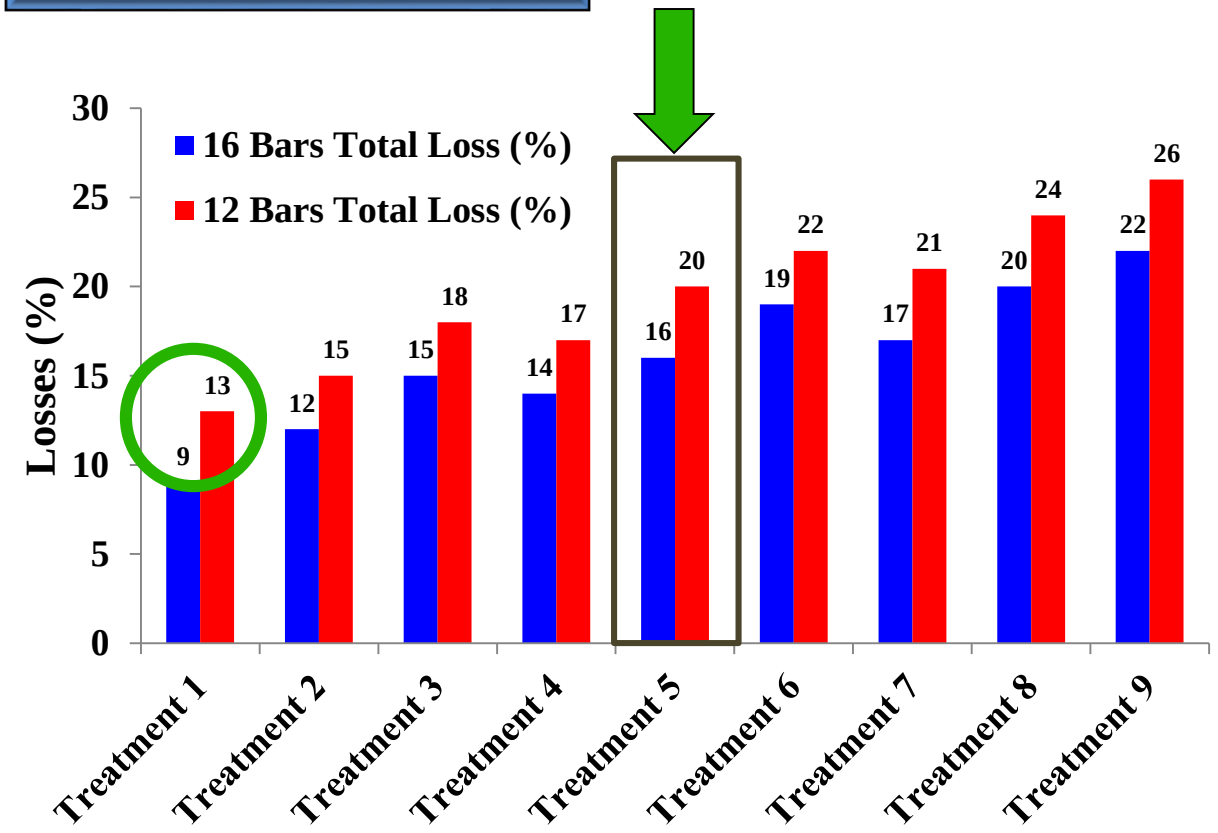


Hardwood Hill Site

16 Bars vs. 12 Bars – Total Losses

Hardwood Hill Site

Trt. 1: 0.75 mph and 26 rpm
Trt. 2: 0.75 mph and 28 rpm
Trt. 3: 0.75 mph and 30 rpm
Trt. 4: 1.0 mph and 26 rpm
Trt. 5: 1.0 mph and 28 rpm
Trt. 6: 1.0 mph and 30 rpm
Trt. 7: 1.25 mph and 26 rpm
Trt. 8: 1.25 mph and 28 rpm
Trt. 9: 1.25 mph and 30 rpm



Avg. Plant Height = 19 cm
Avg. Density = 646 plants m^{-2}

Area = 5.1 acres
Fruit Yield = 6973 lb $acre^{-1}$

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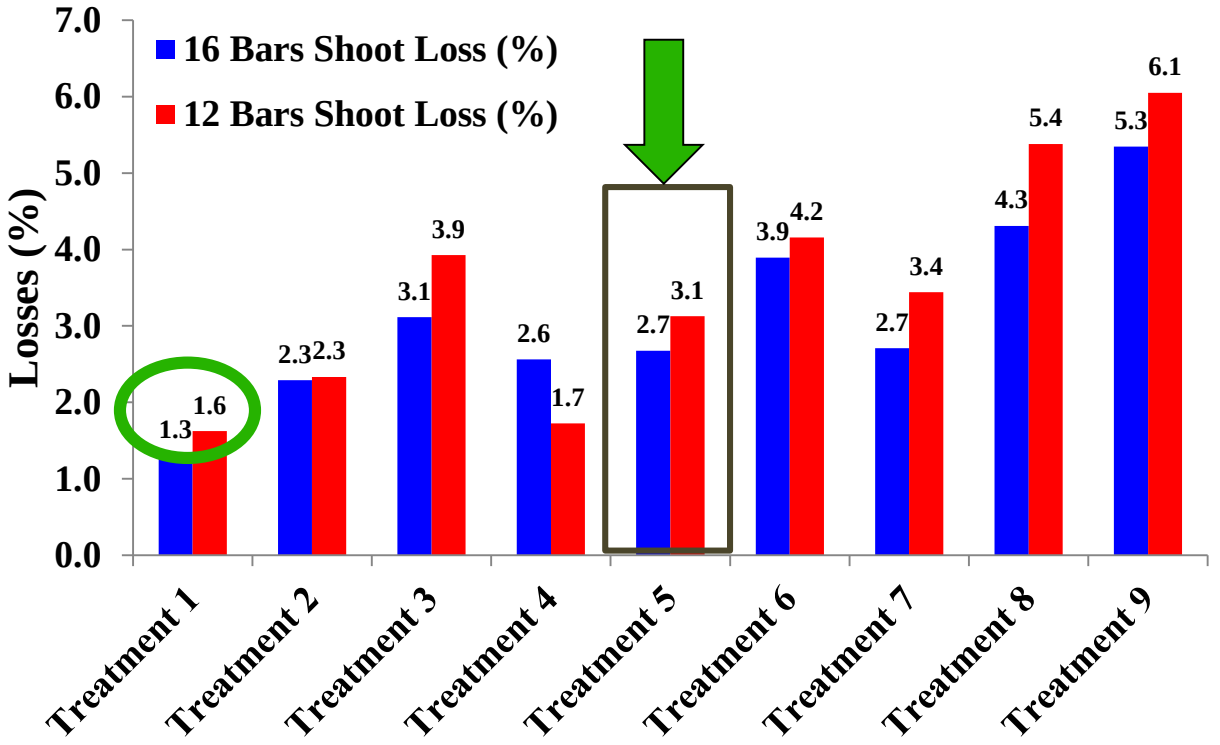
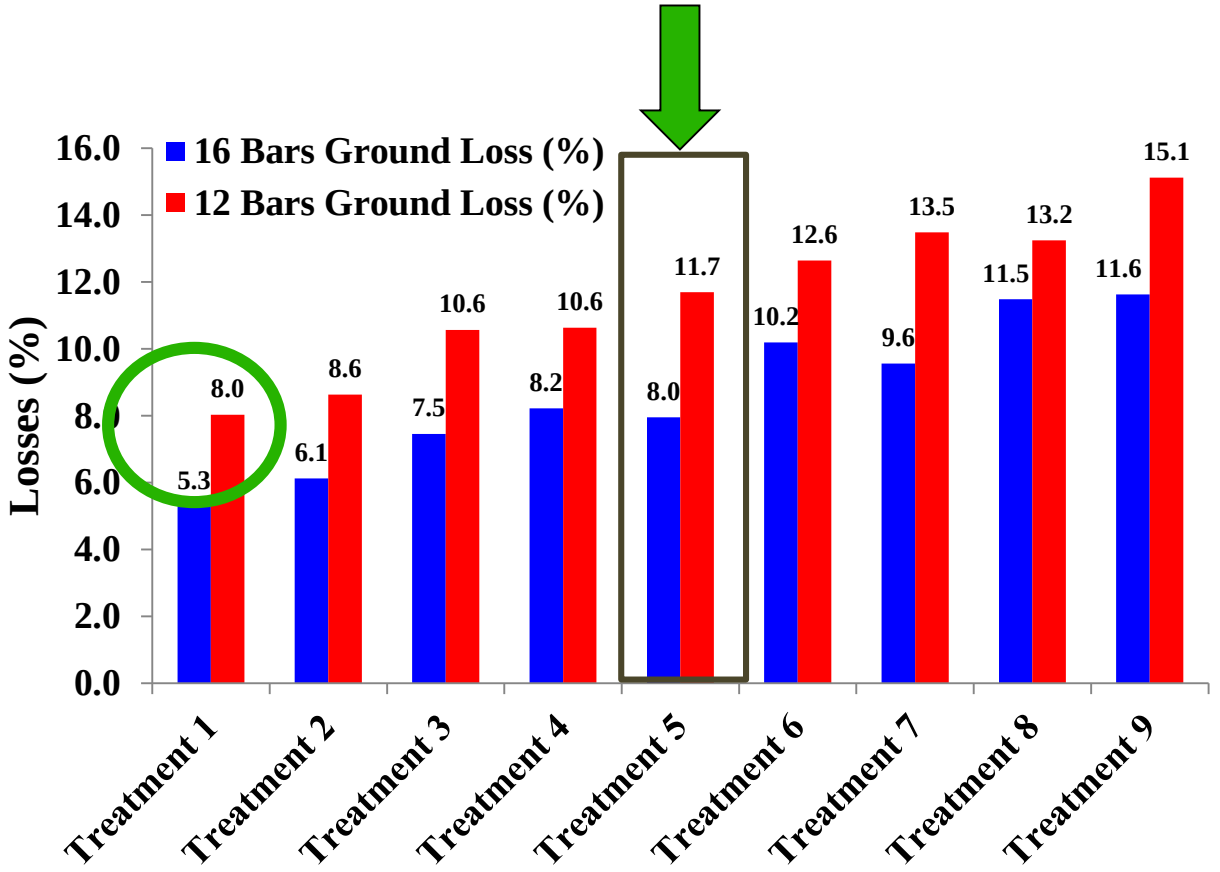
16 Bars vs. 12 Bars – Shoot Loss

Trt. 1: 0.75 mph and 26 rpm
Trt. 2: 0.75 mph and 28 rpm
Trt. 3: 0.75 mph and 30 rpm
Trt. 4: 1.0 mph and 26 rpm
Trt. 5: 1.0 mph and 28 rpm
Trt. 6: 1.0 mph and 30 rpm
Trt. 7: 1.25 mph and 26 rpm
Trt. 8: 1.25 mph and 28 rpm
Trt. 9: 1.25 mph and 30 rpm



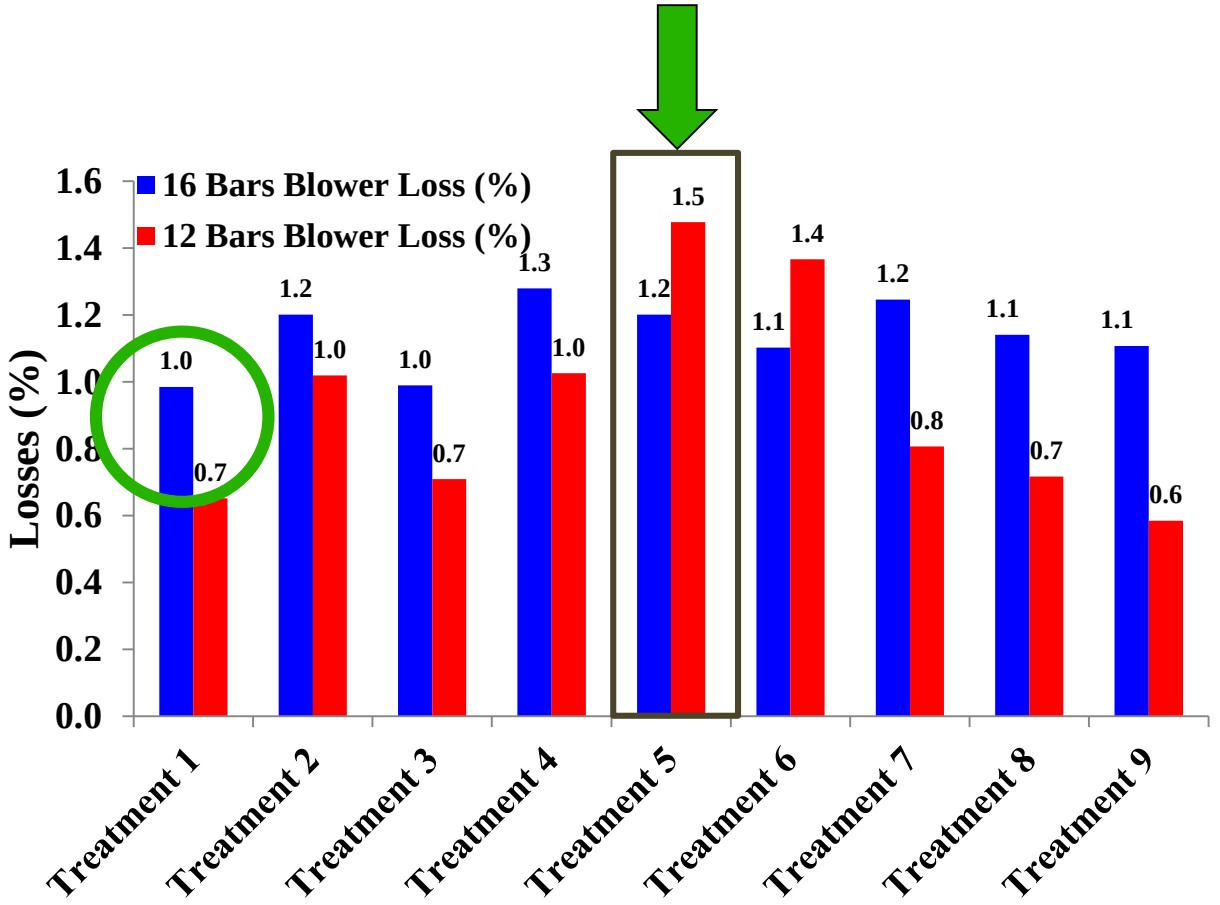
16 Bars vs. 12 Bars – Ground Loss

Trt. 1: 0.75 mph and 26 rpm
Trt. 2: 0.75 mph and 28 rpm
Trt. 3: 0.75 mph and 30 rpm
Trt. 4: 1.0 mph and 26 rpm
Trt. 5: 1.0 mph and 28 rpm
Trt. 6: 1.0 mph and 30 rpm
Trt. 7: 1.25 mph and 26 rpm
Trt. 8: 1.25 mph and 28 rpm
Trt. 9: 1.25 mph and 30 rpm



16 Bars vs. 12 Bars – Blower Loss

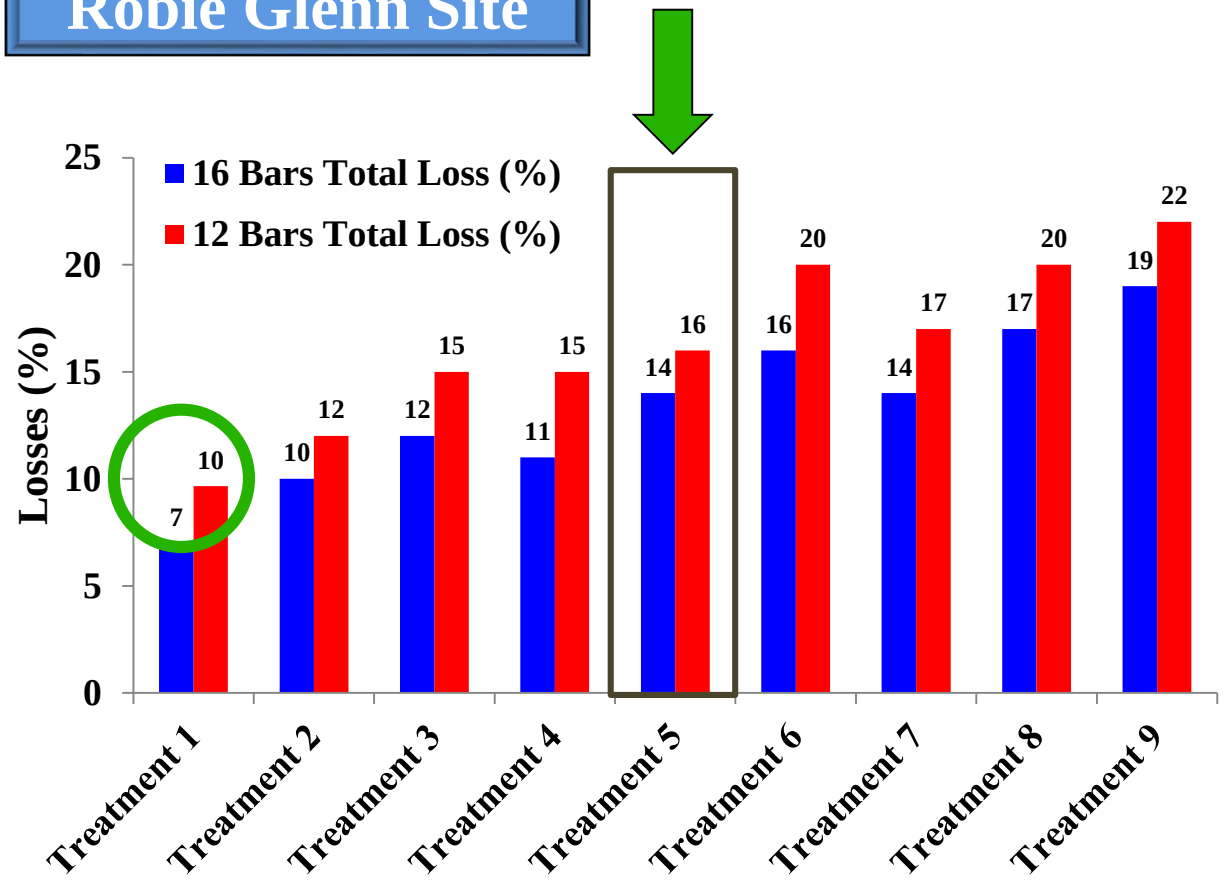
Trt. 1: 0.75 mph and 26 rpm
Trt. 2: 0.75 mph and 28 rpm
Trt. 3: 0.75 mph and 30 rpm
Trt. 4: 1.0 mph and 26 rpm
Trt. 5: 1.0 mph and 28 rpm
Trt. 6: 1.0 mph and 30 rpm
Trt. 7: 1.25 mph and 26 rpm
Trt. 8: 1.25 mph and 28 rpm
Trt. 9: 1.25 mph and 30 rpm



16 Bars vs. 12 Bars – Total Losses

Trt. 1: 0.75 mph and 26 rpm
Trt. 2: 0.75 mph and 28 rpm
Trt. 3: 0.75 mph and 30 rpm
Trt. 4: 1.0 mph and 26 rpm
Trt. 5: 1.0 mph and 28 rpm
Trt. 6: 1.0 mph and 30 rpm
Trt. 7: 1.25 mph and 26 rpm
Trt. 8: 1.25 mph and 28 rpm
Trt. 9: 1.25 mph and 30 rpm

Robie Glenn Site



Avg. Plant Height = 23 cm
Avg. Density = 560 plants m^{-2}

Area = 8.0 acres
Fruit Yield = 3385 lb $acre^{-1}$

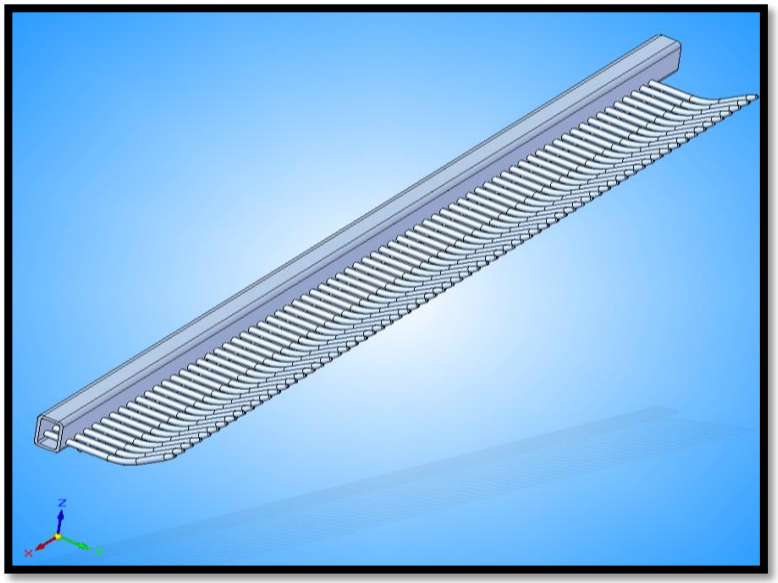
Teeth Bar Spacing

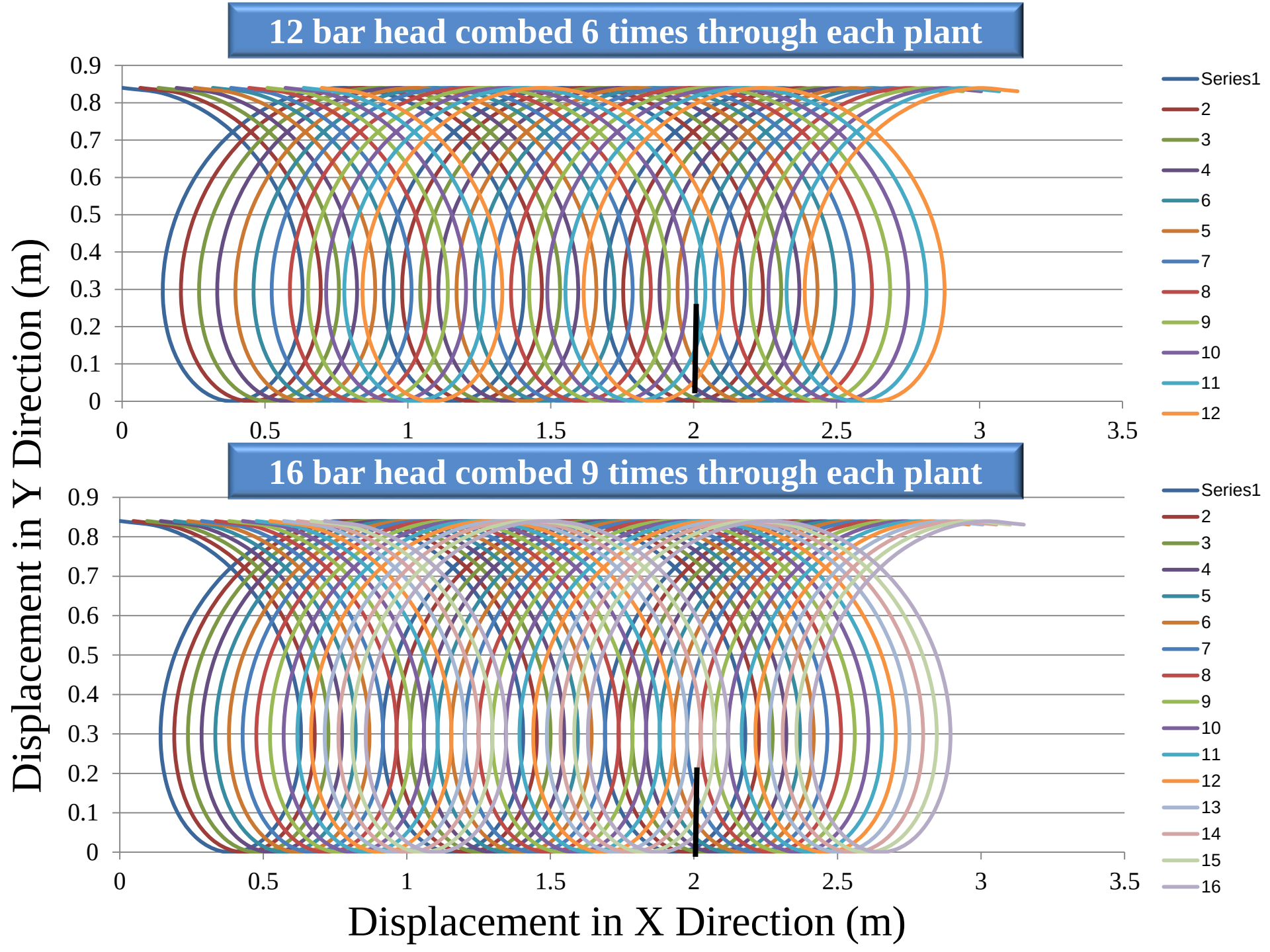
16 Bar Head

Spacing between the bars = 1.37 inches

12 Bar Head

Spacing between the bars = 1.83 inches




12 bar head combed 6 times through each plant
16 bar head combed 9 times through each plant
Displacement in Y Direction (m)
Displacement in X Direction (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
0.5
1
1.5
2
2.5
3
3.5
Series1
2
3
4
6
5
7
8
9
10
11
12
13
14
15
16

Head Capacity Comparison

16 Bar Head	
Max Yield Harvestable (Kg /Ha)	25568
5% Leaves by Volume	24290
10% Leaves by Volume	23011
15% Leaves by Volume	21733

12 Bar Head	
Max Yield Harvestable (Kg /Ha)	19176
5% Leaves by Volume	18217
10% Leaves by Volume	17259
15% Leaves by Volume	16300

The capacity for the 12 bars head is 25% lower than 16 bars head

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Slow video of 16 Bars and 12 Bars (Back view)

16 bars vs. 12 bars

Aug.21 (1 mph/28 rpm)

Slow video of 16 Bars and 12 Bars (Front view)

16 bars vs. 12 bars

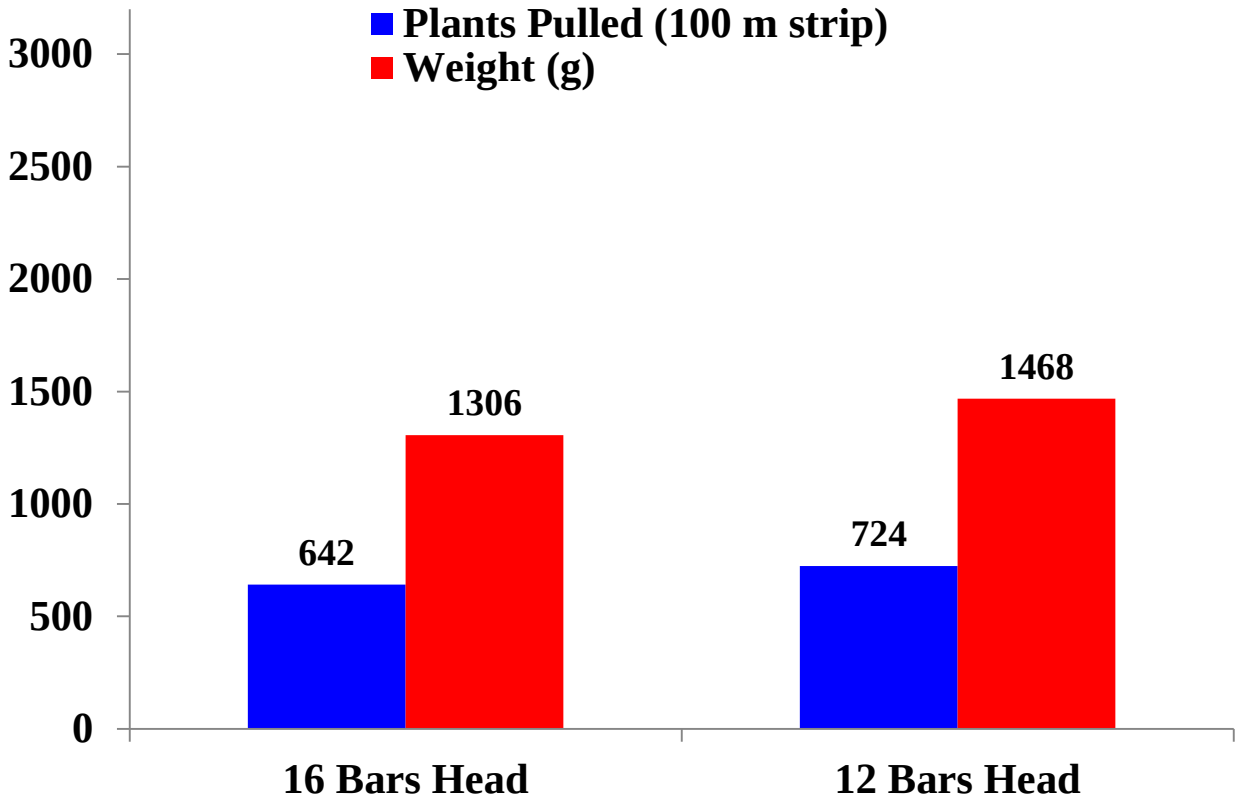
Aug.21 (1 mph/28 rpm)

Slow video of 16 Bars and 12 Bars (Side view)

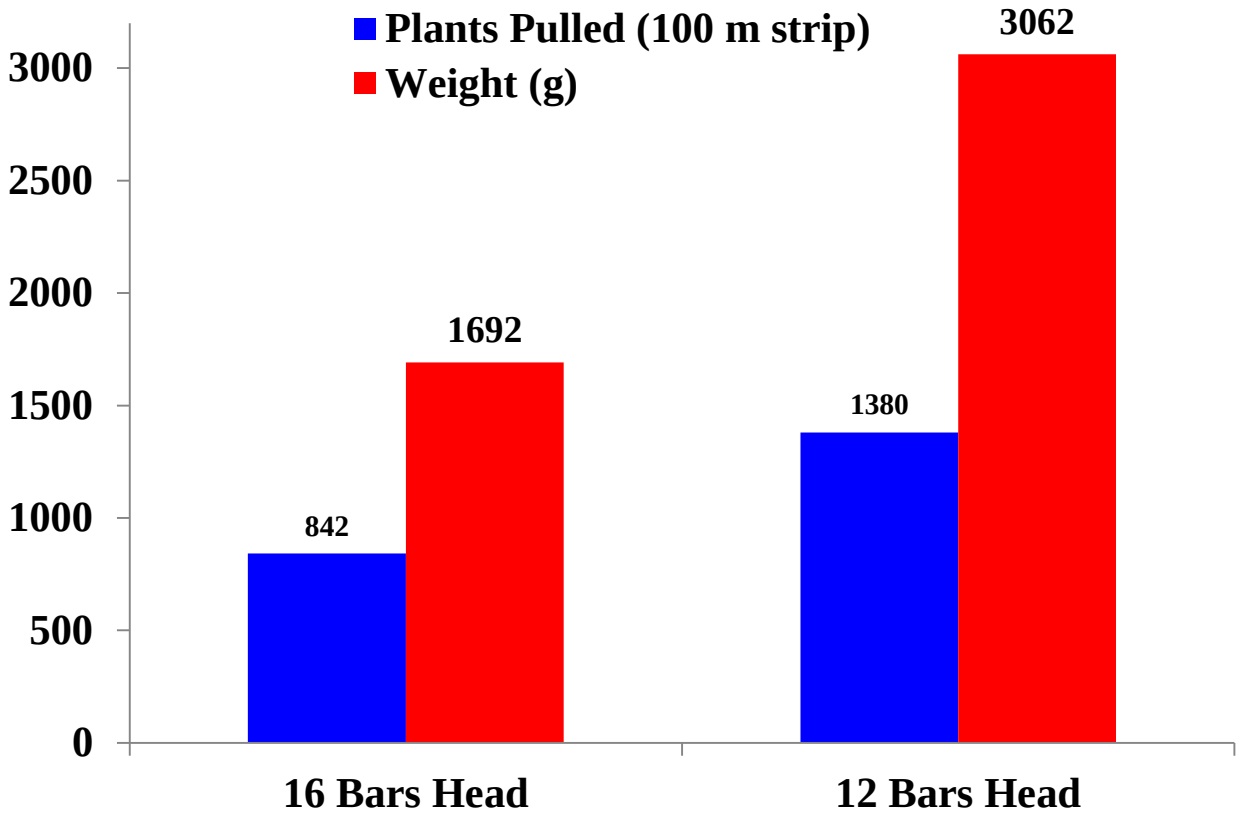
16 bars vs. 12 bars

Aug.21 (1 mph/28 rpm)

16 Bars vs. 12 Bars – Plants Pulled (Before Rain)



16 Bars and 12 Bars – Plants Pulled (After Rain)



Slow video of 16 Bars and 12 Bars (Before rain)

16 bars vs. 12 bars

Aug.22 (1 mph/28 rpm)

Slow video of 16 Bars and 12 Bars (After rain)

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Economic Impact

Additional Revenues		Additional Expenses	
Avg. yield per ha = 3360 kg	$	No additional expenses will be required	$
Avg. revenue per ha = $2.1/kg *3360 kg	$ 7056		$
improved yield/ha (say min. increase 5%) =168 kg	$		$
Increase in revenue/ha with improved systems	$ 353		$
Increase in NS revenue = 16,000 ha* $353	$ $5.5 mill		$
Total A:	$ 5.5 mill	Total D:	$
Reduced Expenses		Reduced Revenues	
Labor expenses might be reduced with automation	$	No reduction in revenue	$
	$		$
	$		$
	$		$
	$		$
Total B:	$	Total E:	$
C: (Total A + Total B)	$ 5.5 mill	F: (Total D + Total E)	$
Net Gain: C: $ 5.5 mill – F: $ _____ = $ 5.5 million			

Conclusions

- ✓ The 12 bar head provides more space for plants which causes the head to take bigger bites
- ✓ The 12 bar head combed through each plant 6 times, while the 16 bar head combed through each plant 9 times
- ✓ The capacity of the 12 bar head is 25% lower than 16 bar head
- ✓ The 16 bar head keep the berries more securely inside the header
- ✓ The 12 bar head pulled 12% and 39% more plants when compared with 16 bar head during dry and wet conditions, respectively
- ✓ Field experimentation, visual observations and video clips proved that there were significantly higher losses with 12 bar head

We propose harvester should be operated at a combination of 0.75 mph and 26 rpm in wild blueberry fields with yield over 3000 kg ha^{-1} to reduce berry losses

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ACKNOWLEDGEMENTS

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Nova Scotia's Provincial Berry
the Wild Blueberry
Wild Blueberry Producers Association of Nova Scotia

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