Mechanised Harvesting of Sugarcane:
Getting the Best Outcomes in the Field and at the Mill

Chris Norris
Chris@NorrisECT.com

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Energy Crop Technology

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STAB
Regional Sul

Overview

- The proportion of the Brazilian and global sugarcane crop which is machine harvested is increasing annually.
- Drivers for this change include:
  - availability of and health of labour,
  - environmental issues,
    - soil and moisture conservation
    - emissions / public health considerations
  - trash utilisation opportunities
    - primarily energy

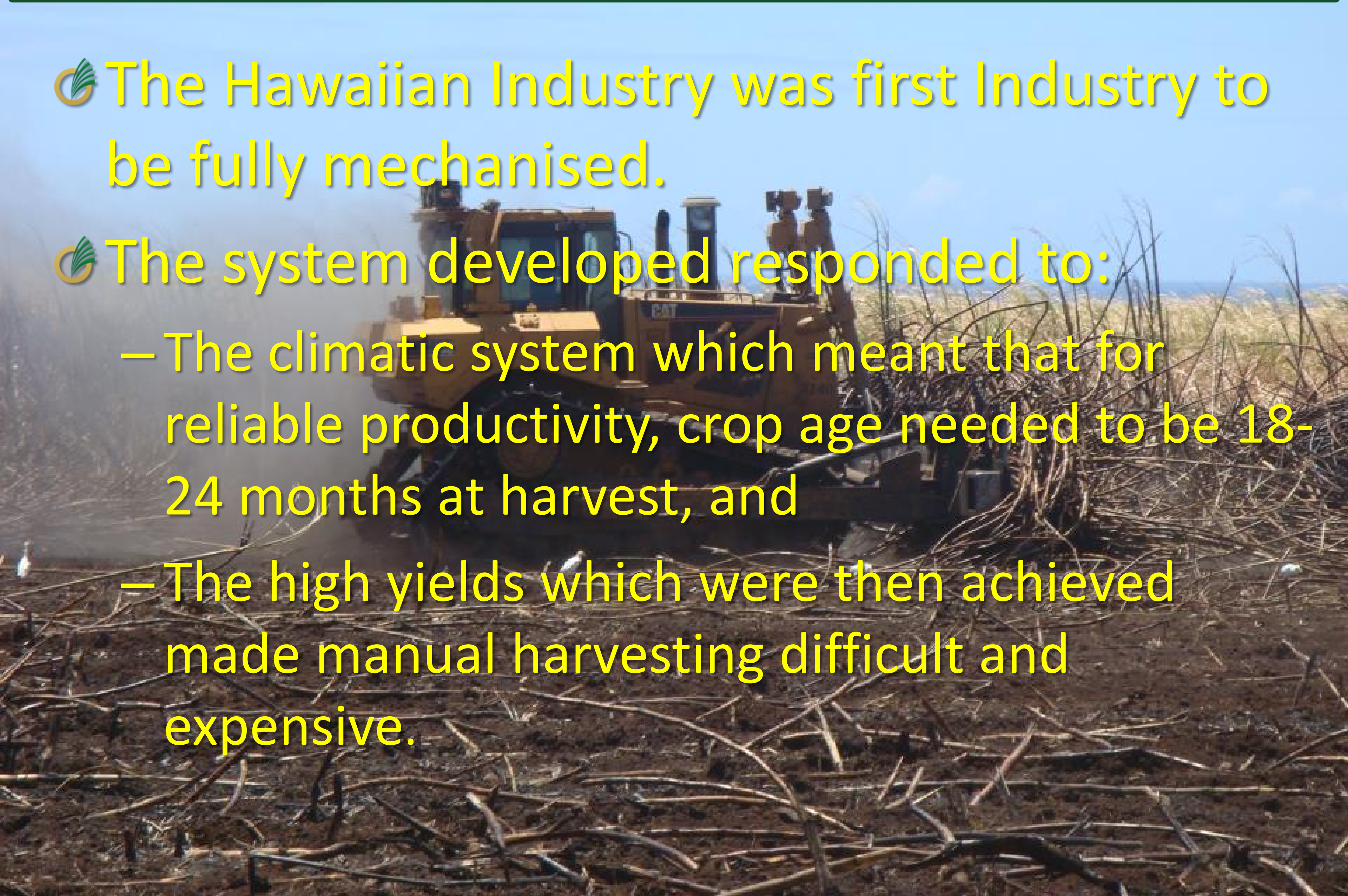
Adoption of Machine Harvesting

- Many major producers have achieved high levels of mechanisation in their harvesting operations.
- Not all countries which have adopted mechanised harvesting are doing it well:
  – Most (including Australia) have significant “room for improvement”
- This presentation focuses on optimising the harvest operation to maximise the sugar production value chain.

Overview: Harvesting

- All harvesting systems result in some “loss of value” between the crop in the field and the product delivered to the mill, including:
  - Loss of product
  - “Dilution” of the product with extraneous components
  - Deterioration of the product between harvesting and processing
- In sugarcane, harvesting systems can also impact directly on the crop ratooning performance and indirectly on soil health
- The relative importance placed on these issues can drive decisions relating to the harvesting strategies adopted.
- Compromise is inherent in all harvesting strategies.

Mechanisation of Sugarcane: The Compromises



- The Hawaiian Industry was first Industry to be fully mechanised.
- The system developed responded to:
  - The climatic system which meant that for reliable productivity, crop age needed to be 18-24 months at harvest, and
  - The high yields which were then achieved made manual harvesting difficult and expensive.

Mechanisation of Sugarcane

- The Industry argued that no other harvesting system can deliver the cane to mill as cheaply.
- Total cost of harvest loading & transport to mill < $5.00/t.
- This low harvesting cost was claimed to mitigate costs associated with low sugar recovery, and the cost of replanting, under Hawaiian conditions.
- The last mill closed in 2017

Mechanisation of Sugarcane

- The key issue was that the actual harvesting equipment and operations must be considered as only one part of the field to mill value chain;
- Excessive focus on the cost/efficiency of one component of the total production system can cause major losses in other parts of the system.

International Clients: Identified Losses

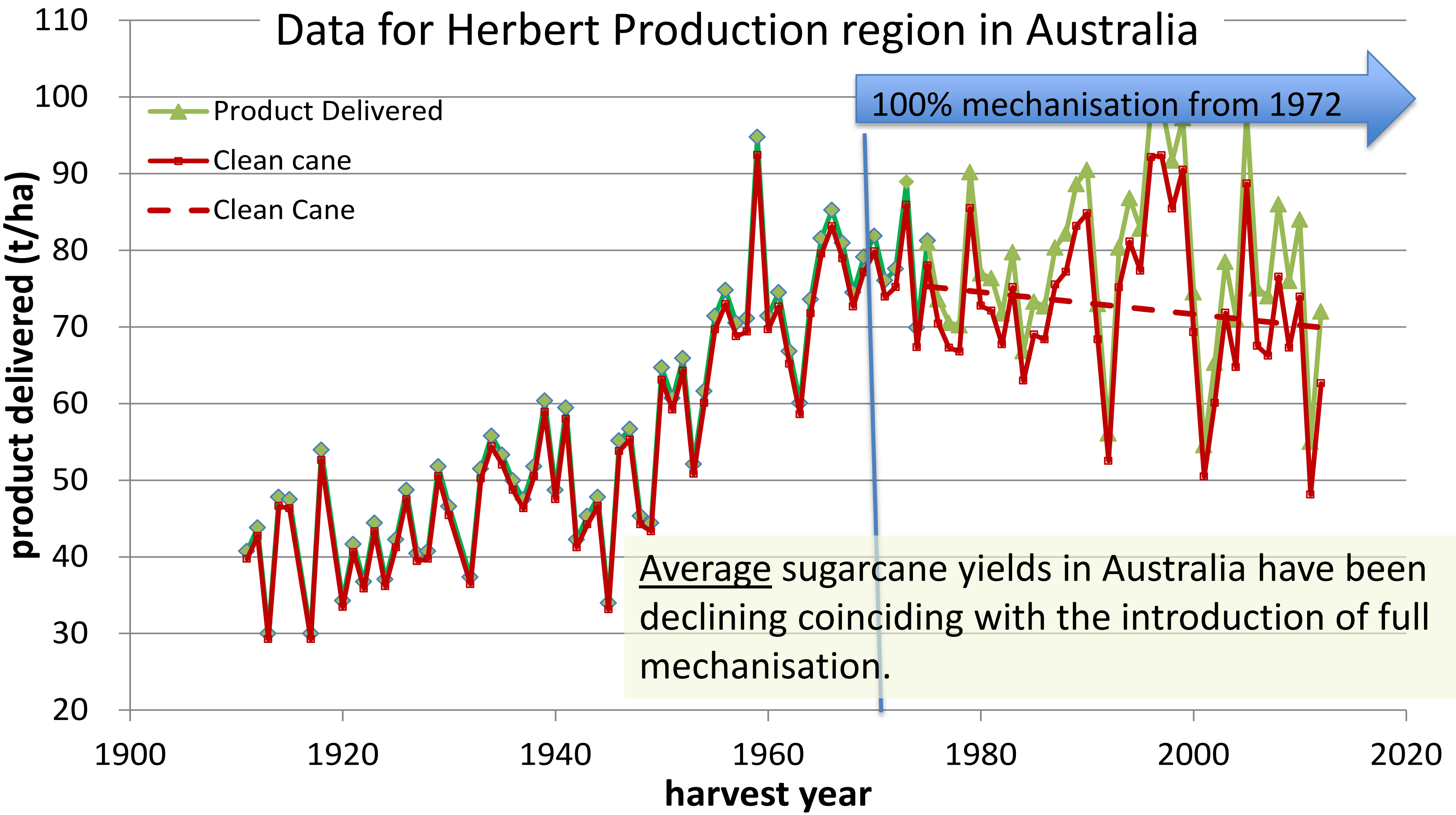
Much of the work undertaken by NorrisECT is for international clients who have recently introduced machine harvesting. Typically they have observed:

- Reduced Crop Cycle Yield:
  - Greater loss of stool after machine harvesting relative to their traditional manual cutting system;
  - Consequential accellerated yield decline;
- Gross Yield Loss:
  - Reduced t/ha delivered to mill with machine harvesting relative to manual cutting
- Reduced t_s/t_c in the delivered product and reduced overall sugar production.

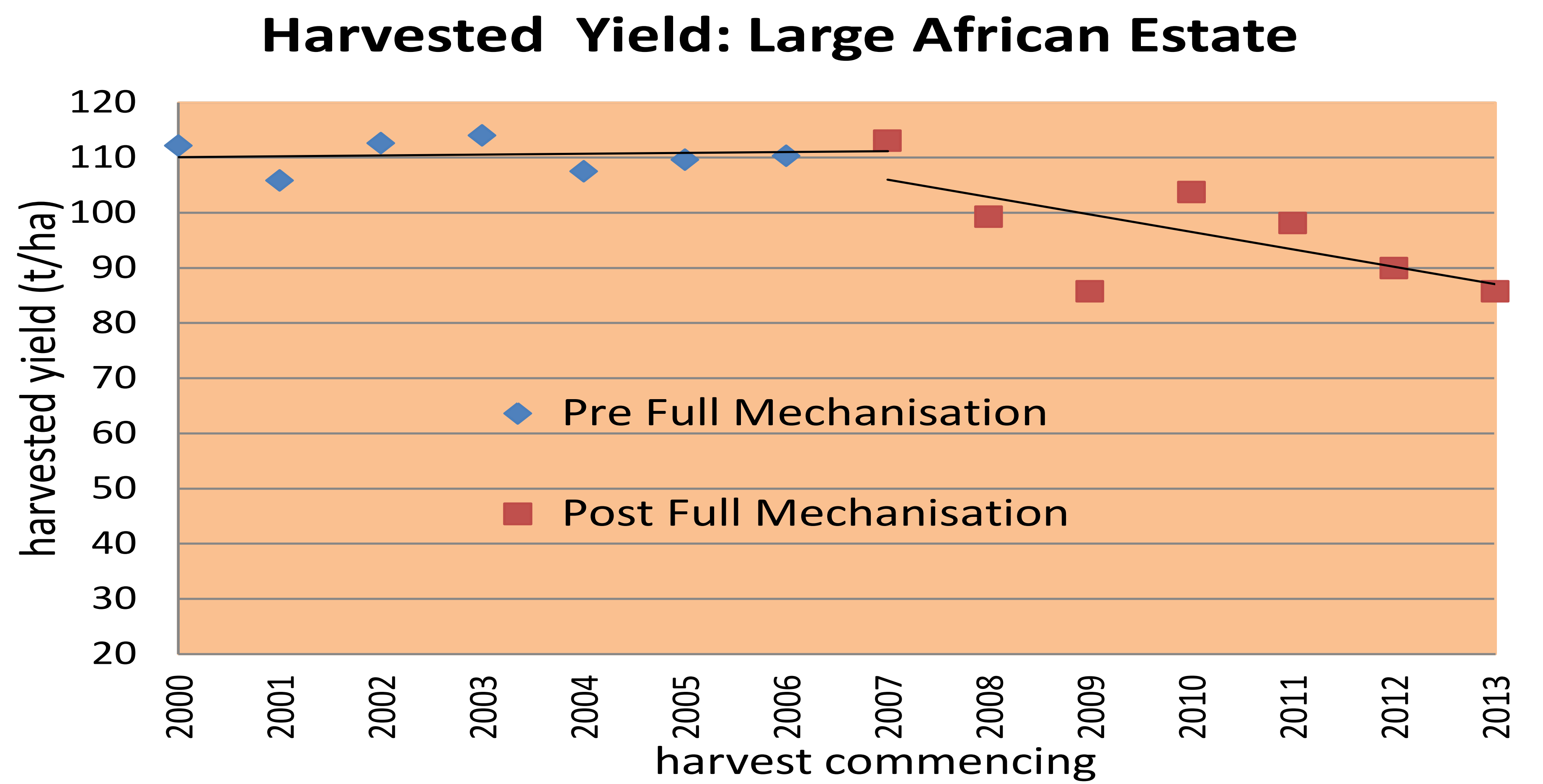
Reference Point: Australian Industry

The issues which have impacted on the Australian Industry are relevant to many other Industries as they move to full mechanisation, and in particular chopper harvesting.

Mechanisation Impact: Yield Decline?



Crop Cycle Yield Impacts



Production fell >20% from 2007/2008 to 2013/2014 despite an increase in farmed area

Reduced Crop Cycle

- Accelerated ratoon yield decline relative to hand cutting is nominally associated with:
  - Damage to cane stool from the harvester gathering, feeding and basecutting operations, e.g
    - Excessive harvesting speed, machine configuration and basecutter blade maintenance
  - Damage to cane stool from traffic on/near the row, e.g
    - “uncontrolled” traffic and row spacing mismatch
  - Soil compaction, e.g
    - Row spacing and dramatic increase in in-field traffic reducing available moisture storage
- These problems can all be managed.

Stool Damage by Harvester:

- In the past 20 years, the number of harvesters operating in Australia has reduced by approximately 50%* with area harvested remaining near constant.
- The primary strategy to manage this change has been to increase harvester operating speed.
- One reason for continuing ratoon yield decline is argued to be high levels of stool damage associated with the increasing harvesting speeds during this period.
- A move to thinner stalked varieties has also occurred because experience shows these varieties "survive" the harvester better.

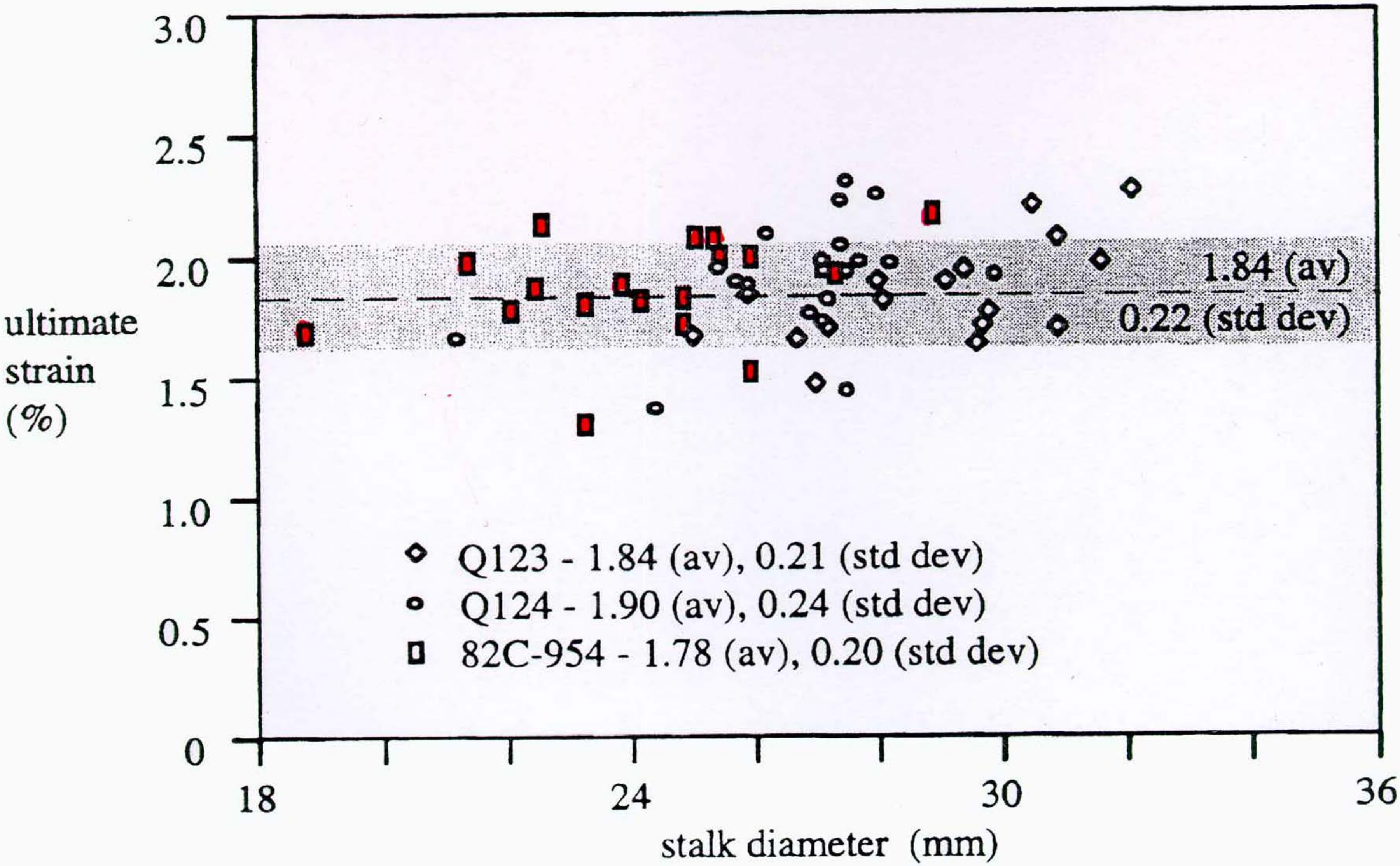
* SRA Harvest Best Practice Manual (anon 2014).

Varietal adoption for Machine Harvesting

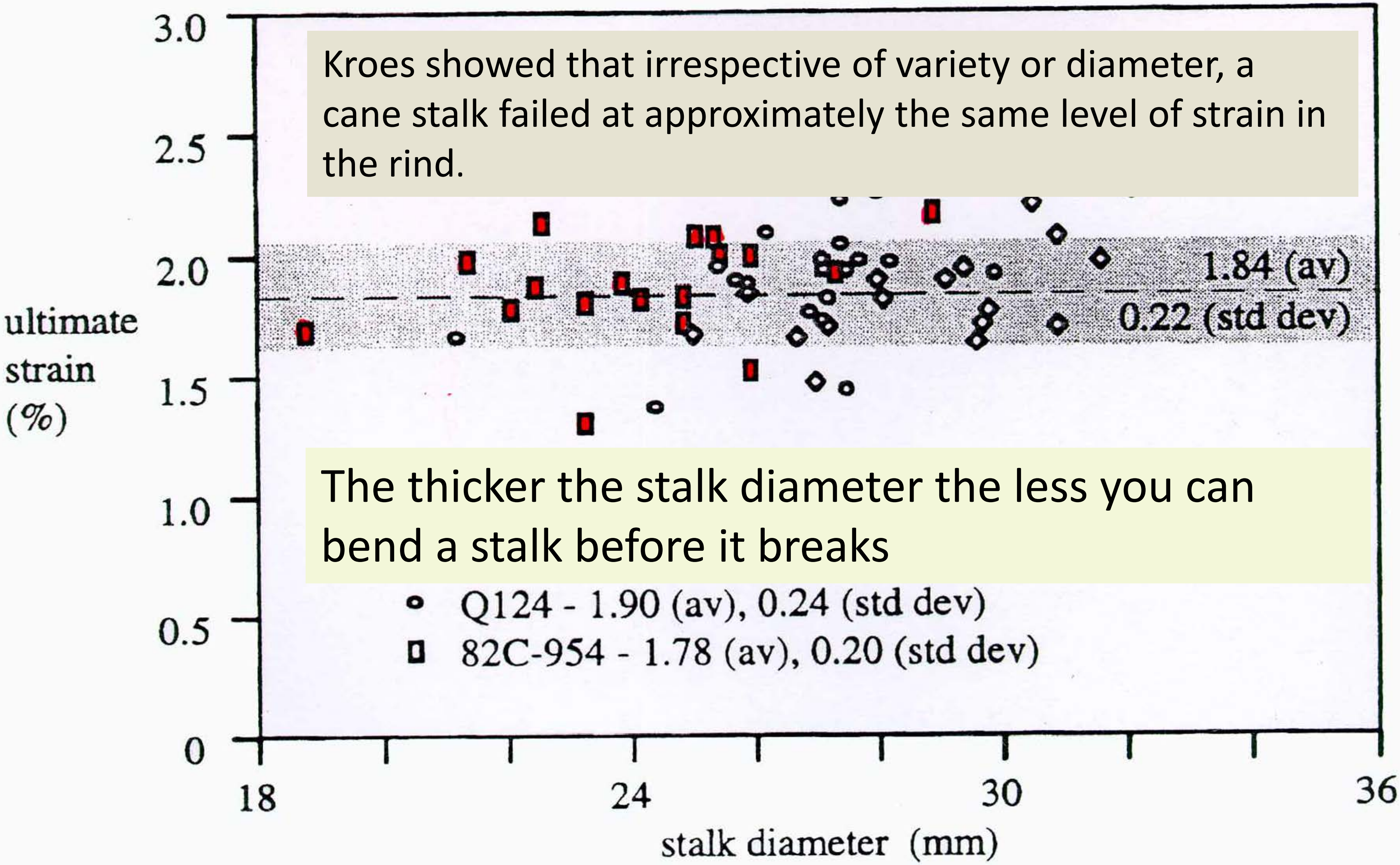
Varietal adoption for Machine Harvesting

As Industries mechanise they generally move to thinner varieties as these varieties “survive” machine harvesting better.

How much can you bend a cane stalk before it breaks? Kroes et.al.



How much can you bend a cane stalk before it breaks? Kroes et.al.

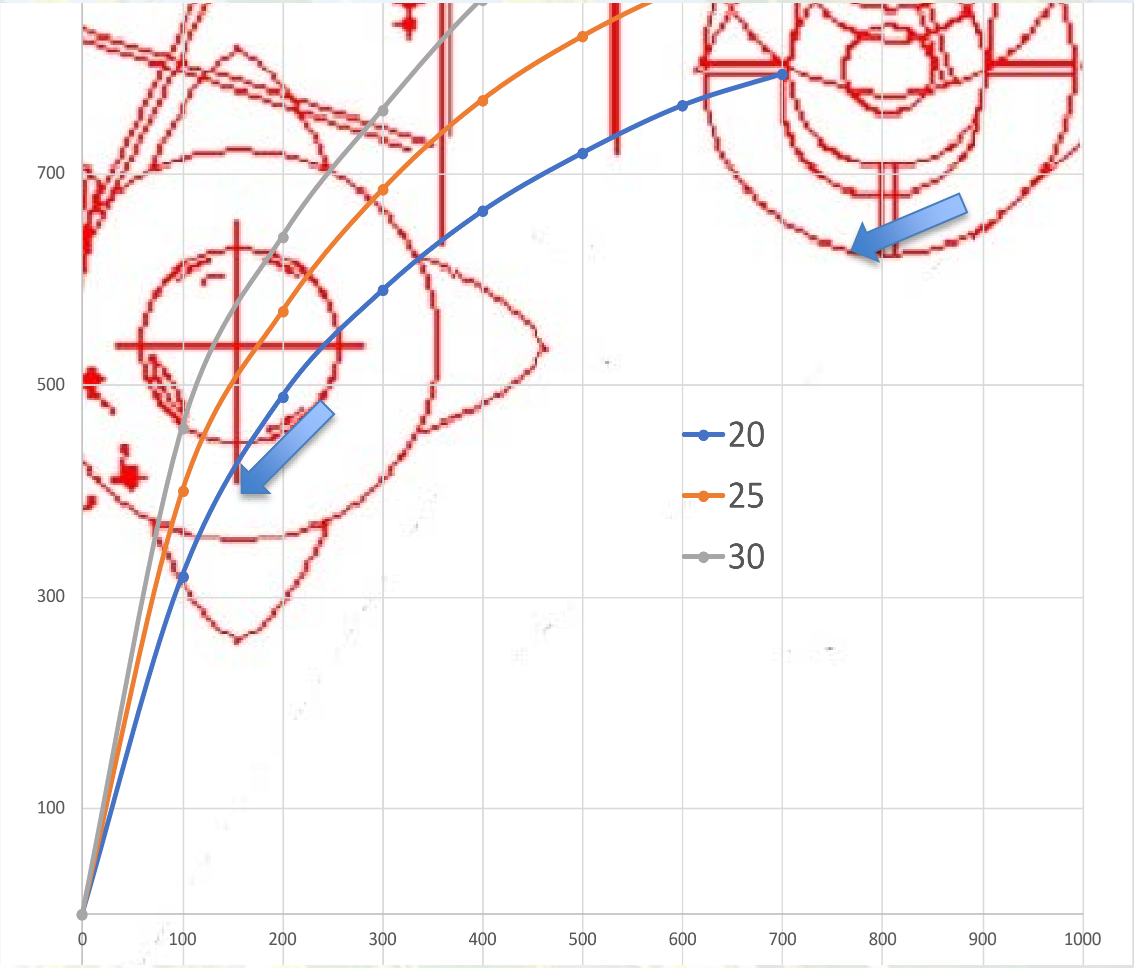


Kroes showed that irrespective of variety or diameter, a cane stalk failed at approximately the same level of strain in the rind.

The thicker the stalk diameter the less you can bend a stalk before it breaks

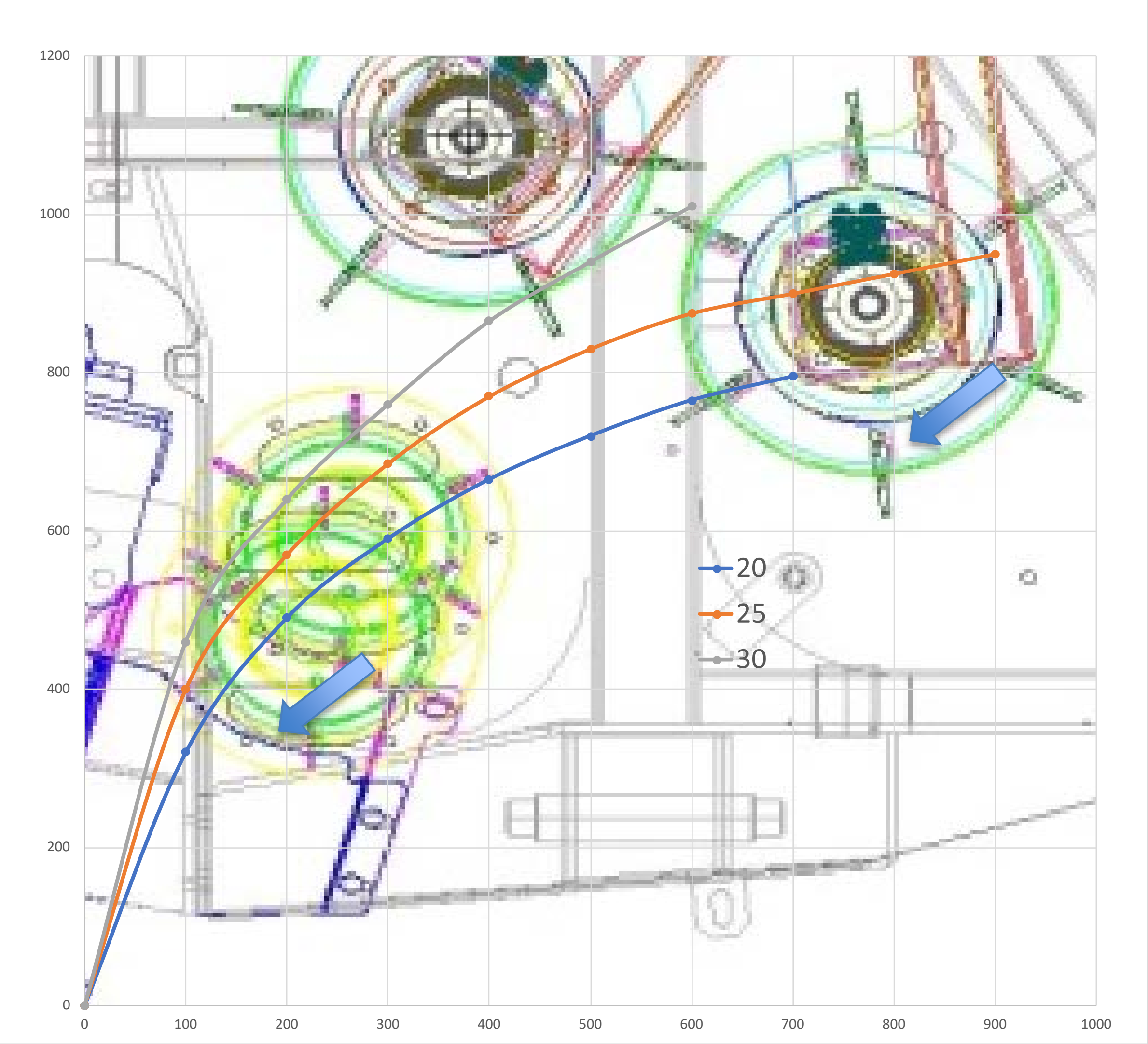
Knockdown: Current harvesters

- Kroes developed curves at which 50% of cane stalks would be broken if originally vertical stalks
- On this basis, most stalks fail before the base of the stalk reaches the basecutter blade.



Knockdown: Current harvesters

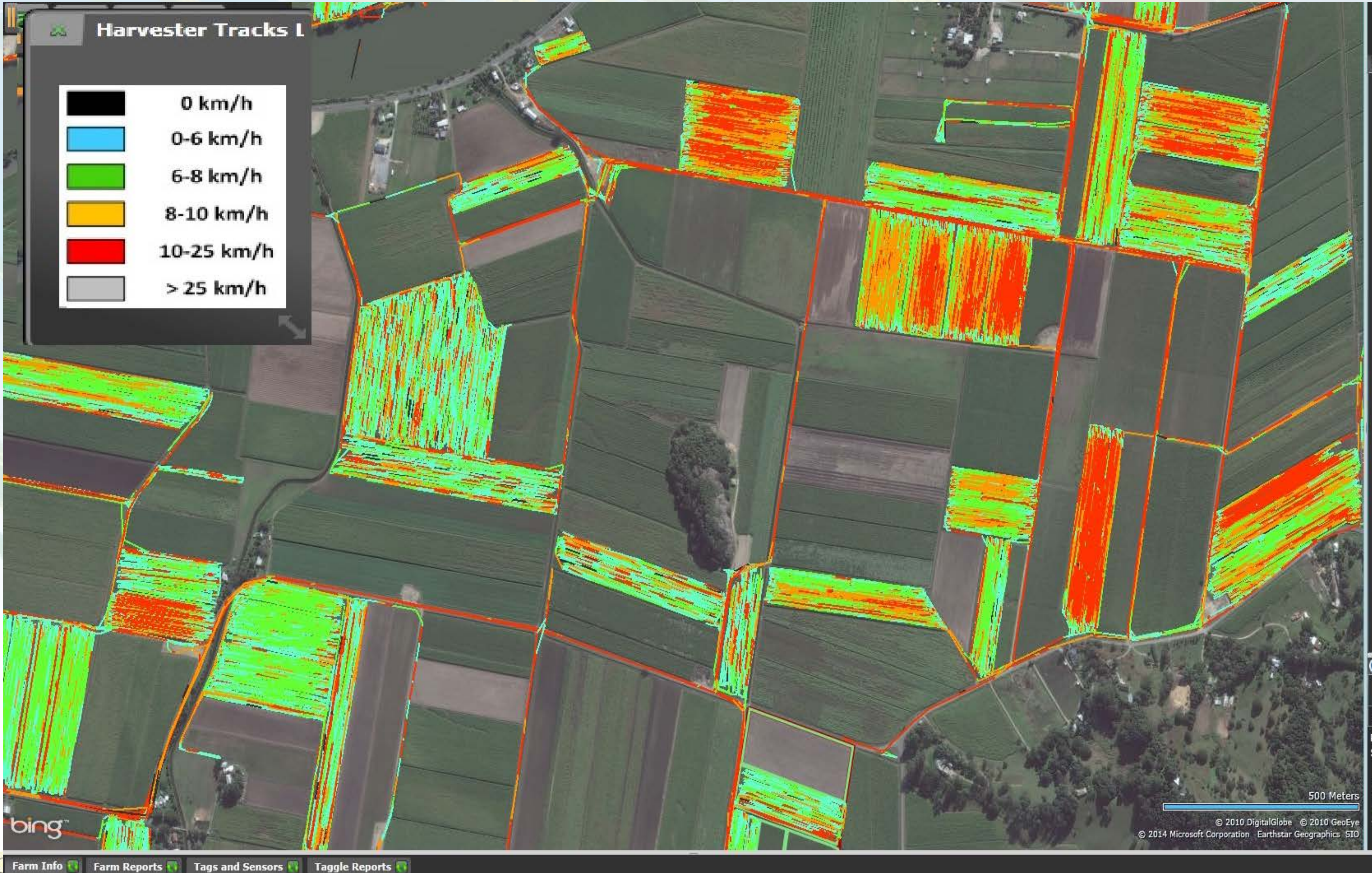
Again, failure of most stalks will have occurred before the basecutter severs the stalk.



Knockdown Damage: Summary

- The design of current harvester "front end" geometry is very aggressive, and can expect to cause the failure of a large proportion of the cane stalks prior to basecutting, particularly in erect crops;
- The move by Industries around the world has been to adopt thinner varieties as they "survive" the harvesting operation better;
- Agronomic strategies such as planting depth and depth of cover can impact on outcomes.

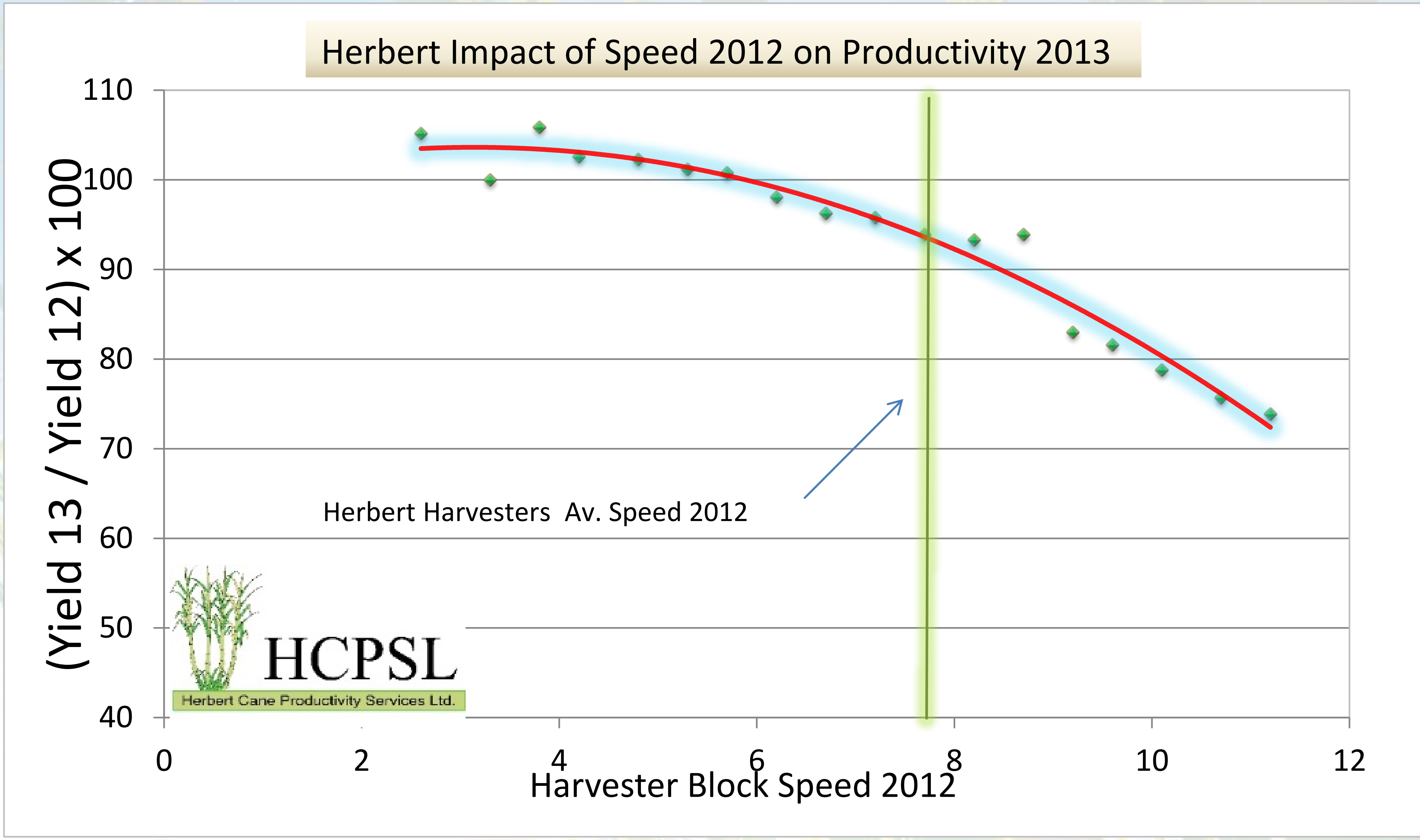
Harvesting Speed:



Harvesting Speed:

- In most mill areas in Australia, the location of the harvester is monitored in "near real time" for cane consignment purposes
- Harvesting speeds can now be derived and monitored
- This also allows the impact of harvesting speed to be correlated with rate of ratoon yield decline in individual fields and compare it with other fields.

Effect of Harvesting Speed on Subsequent Yield

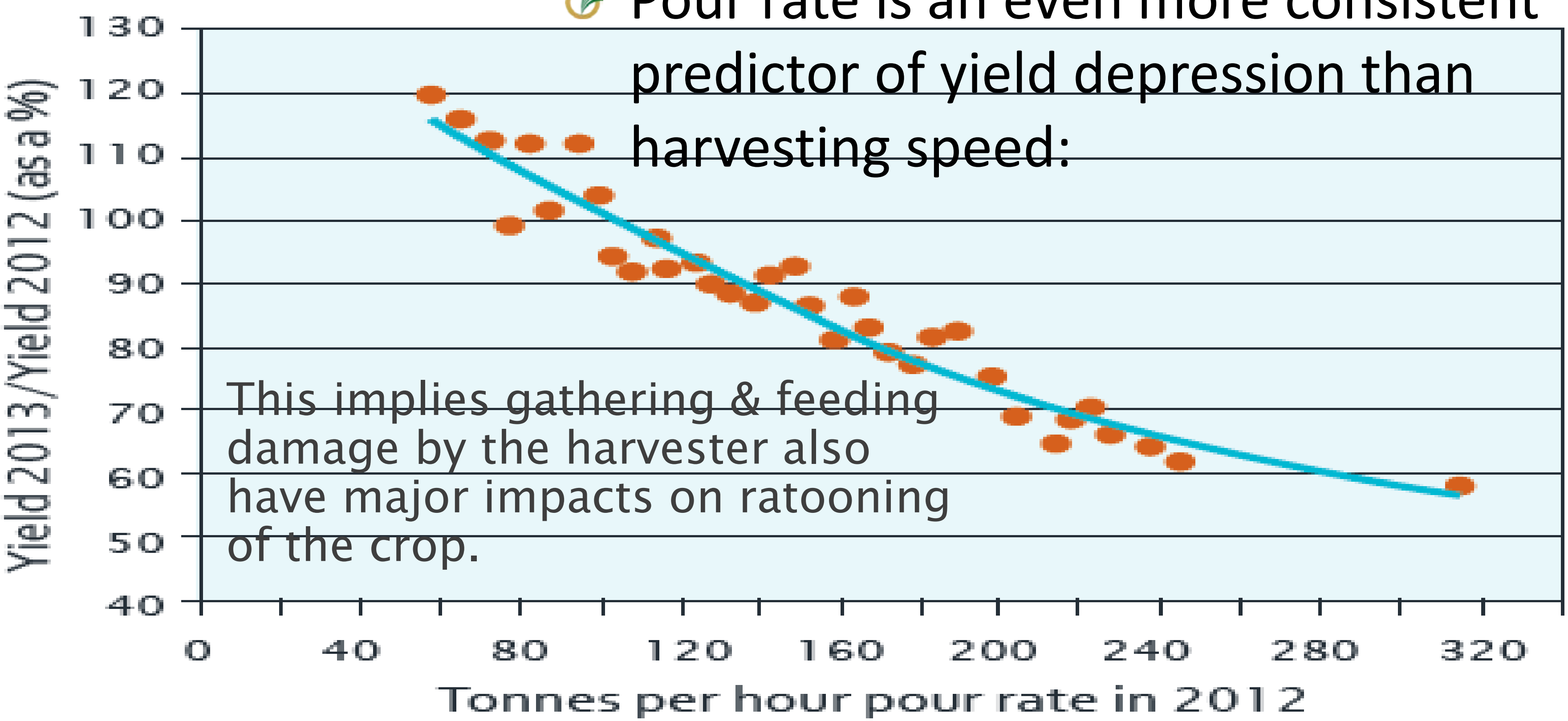


Key Observations

- Initially it was believed that the reduction in yield was primarily caused by an increase in damage associated with the basecutting process at higher harvesting speeds.
- Further analysis indicated that the problem was not this simple: A number of factors were involved, including:
  - Harvesting speed
  - Crop size (related also to degree of lodging)
  - Pour rate = speed x crop size
    - At the same harvesting speed, the larger the crop the higher pour rate and more damage was observed even at lower speeds;

Effect of Pour Rate on Subsequent Crop Yield

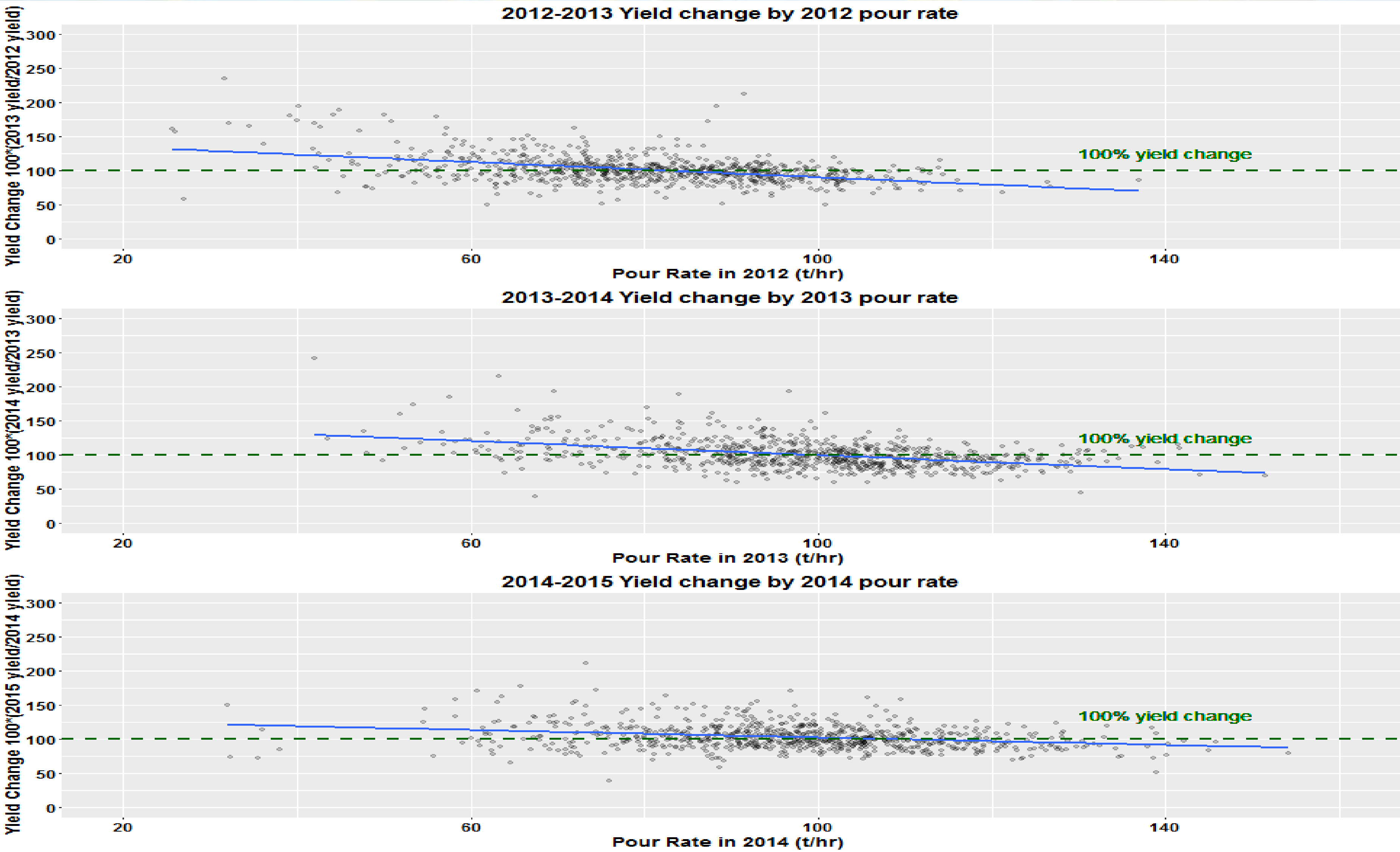
- Pour rate is an even more consistent predictor of yield depression than harvesting speed:



This implies gathering & feeding damage by the harvester also have major impacts on ratooning of the crop.

Figure 10: The impact of pour rate in 2012 on productivity in 2013—Burdekin region.

Yield change by pour rate – farm level



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Current Research

On the basis of recent data and previous research, three primary Issues were considered to impact on stool damage during the harvest operation:

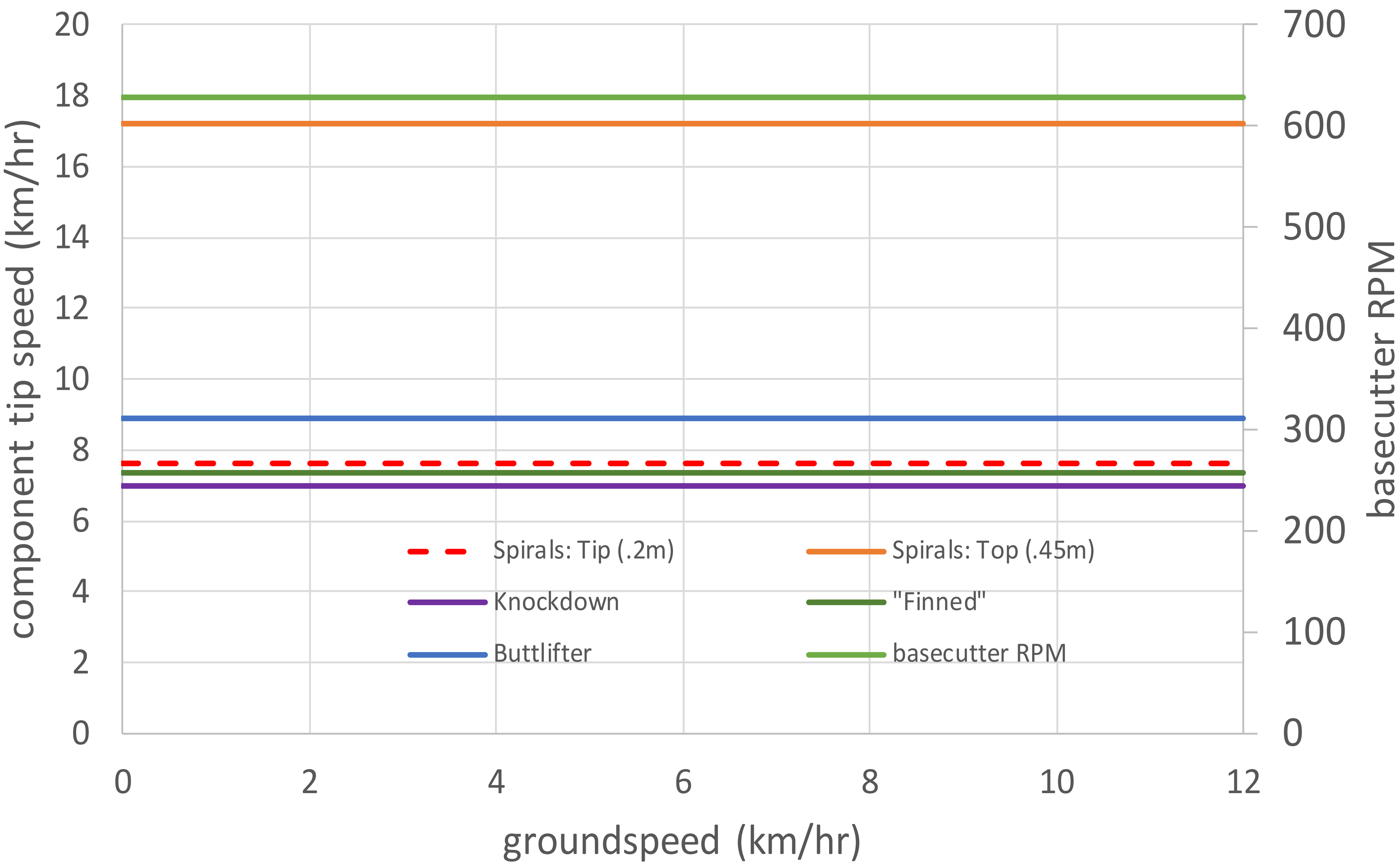
- Gathering damage
  - Schembri & Garson, Norris Davis etal, Davis & Norris, Davis & Schembri
- Feeding Damage
  - Davis & Norris, Kroes & Harrris, Kroes
- Basecutting Damage
  - Kroes & Harrris, Kroes

Current Research

A research project is currently being run by NorrisECT and Queensland University of Technology

- The fundamental hypothesis is that matching “front end” components tip/surface speeds to groundspeed is a necessary component of performance/design optimisation.
  - At lower groundspeeds component speeds are actually too high in standard machine configuration
- Once matched, more advanced machine cane interactions/strategies can be used to facilitate improvements in harvester performance.

JD 3520 Standard




JD 3520 Standard
working speed range
component tip speed (km/hr)
basecutter RPM
groundspeed (km/hr)
20
18
16
14
12
10
8
6
4
2
0
900
800
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
Spirals: Tip (.2m)
Spirals: Top (.45m)
Knockdown
"Finned"
Buttlifter
basecutter RPM

Typical Trial Treatments

Treatment	Basecutter Speed (RPM)	Harvesting Speed (km/hr)	Comment
1	450	4.5	Matched: low harvest speed / pour rate
2	800	8.0	Matched: high pour rate / harvest speed
3	620	4.5	Standard: low harvest speed/pour rate
4	620	8.0	Standard: high harvest speed / pour rate

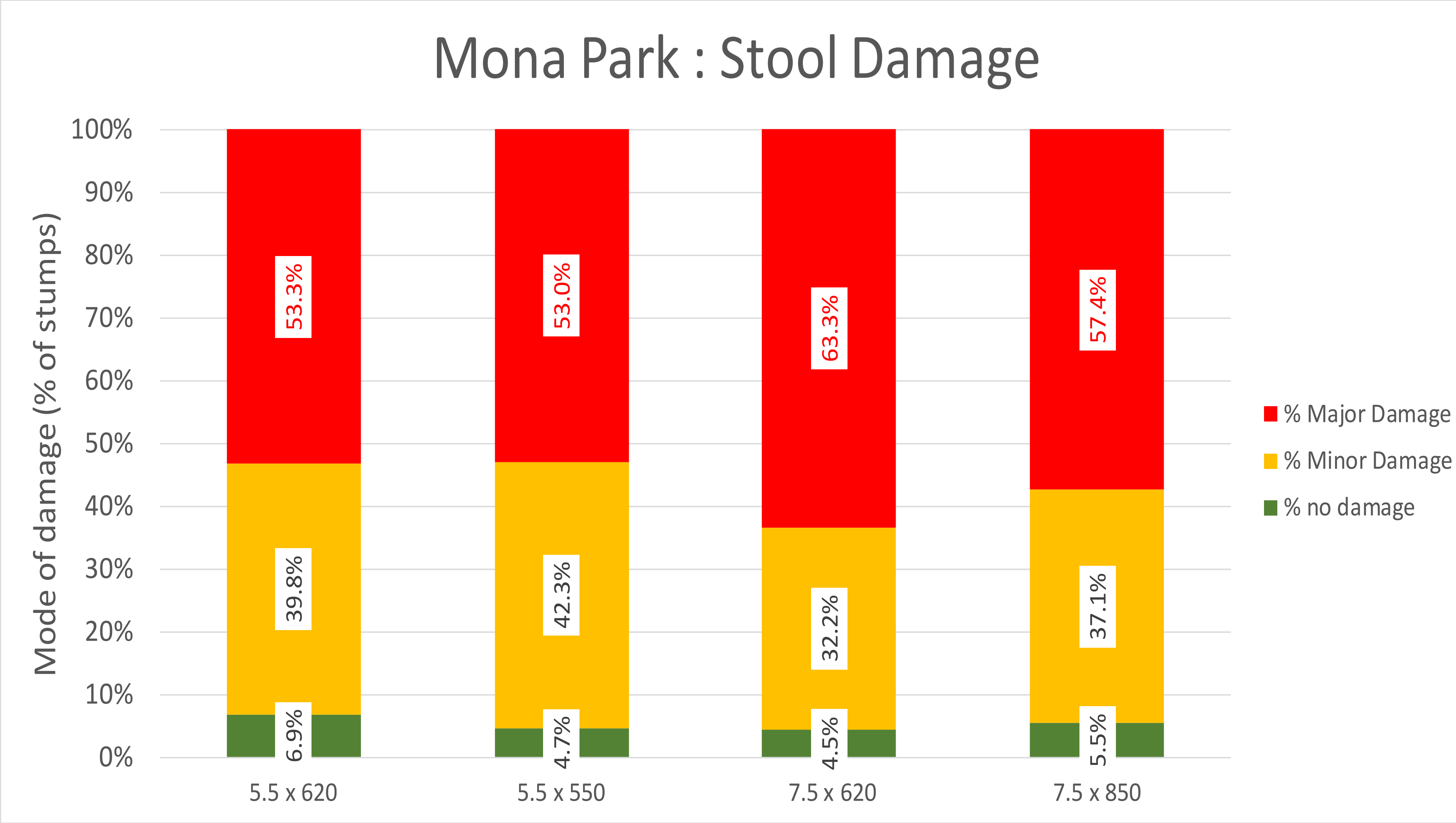
Clearing Observation Plots

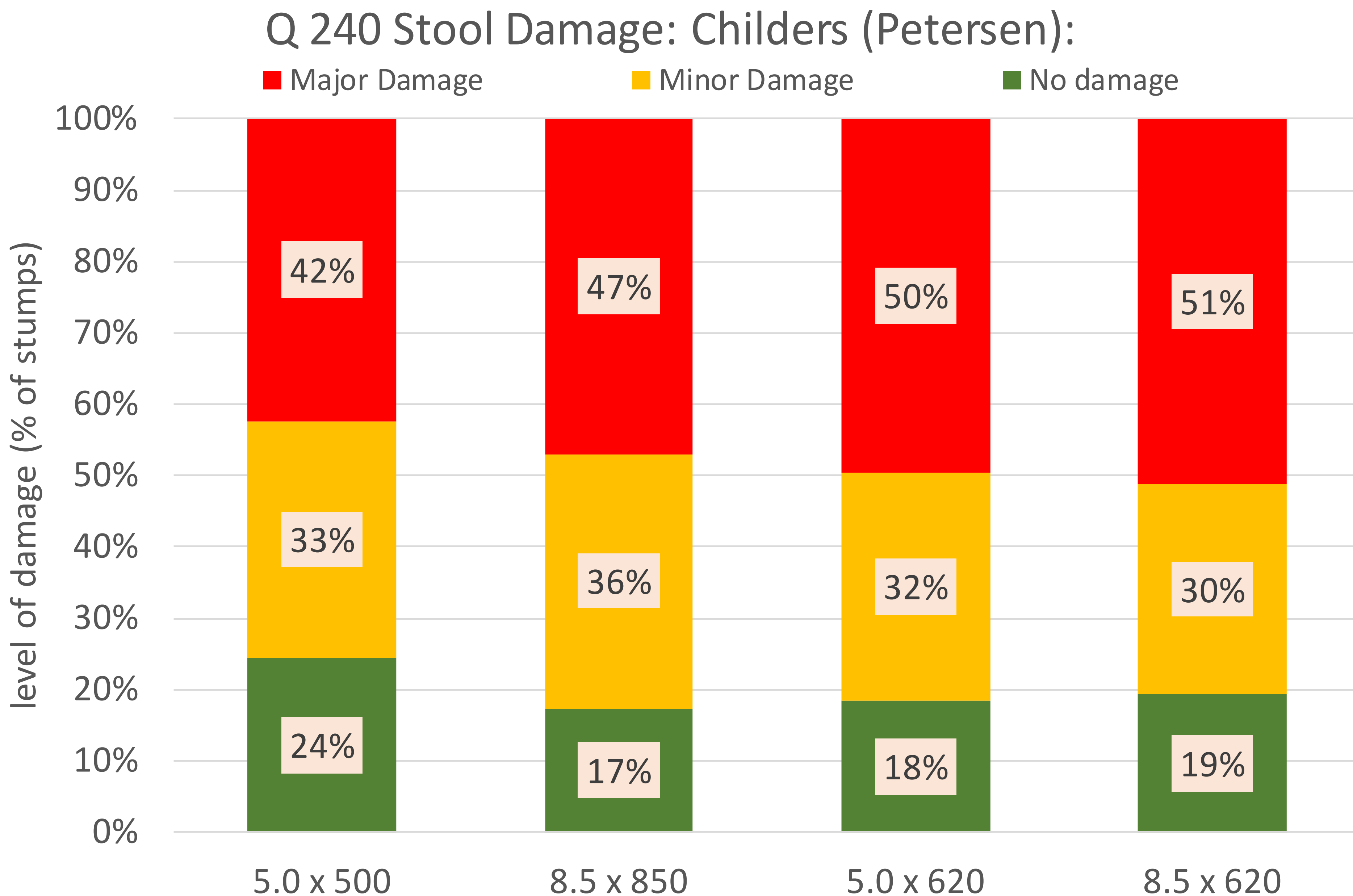
Analysis of damage

Initial Results

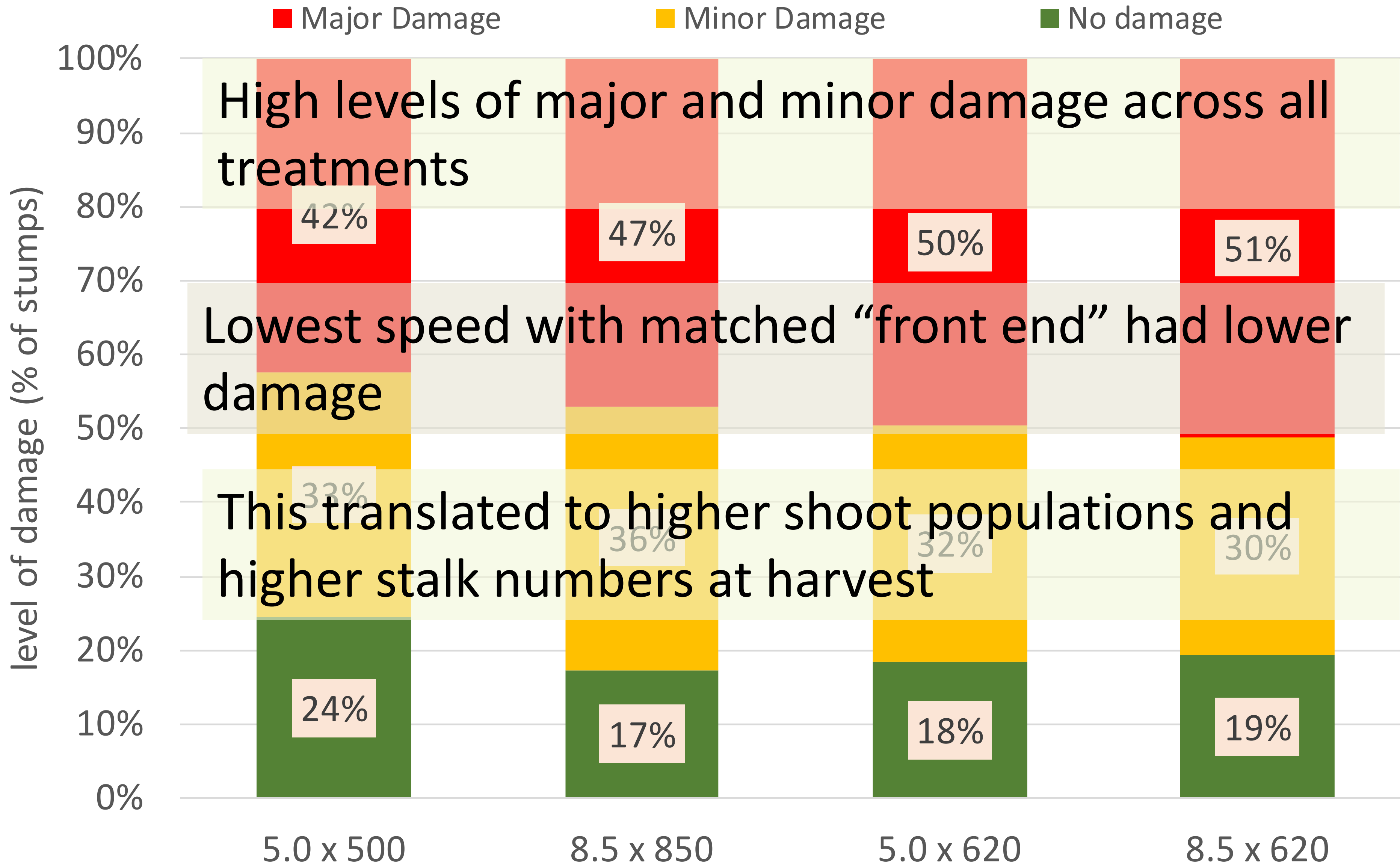
- Data from first years trials indicated that very high levels of damage were being inflicted by the harvesting operation;
- Similar results from all five trial sites in a range of crops;
  - Lodged and erect crops

Observed Stool Damage after Harvest




Q 240 Stool Damage: Childers (Petersen):
Major Damage
Minor Damage
No damage
level of damage (% of stumps)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
42%
33%
24%
47%
36%
17%
50%
32%
18%
51%
30%
19%
5.0 x 500
8.5 x 850
5.0 x 620
8.5 x 620

Q 240 Stool Damage: Childers (Petersen):

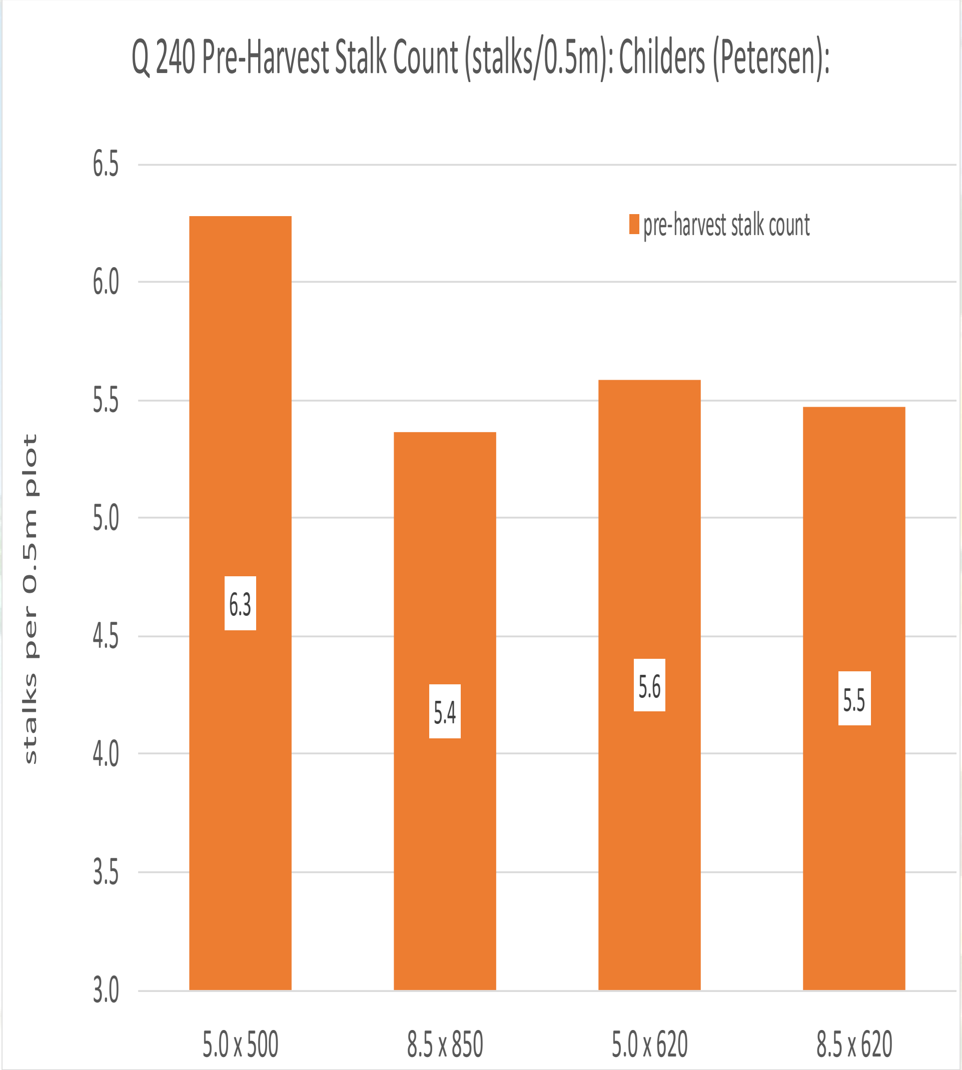


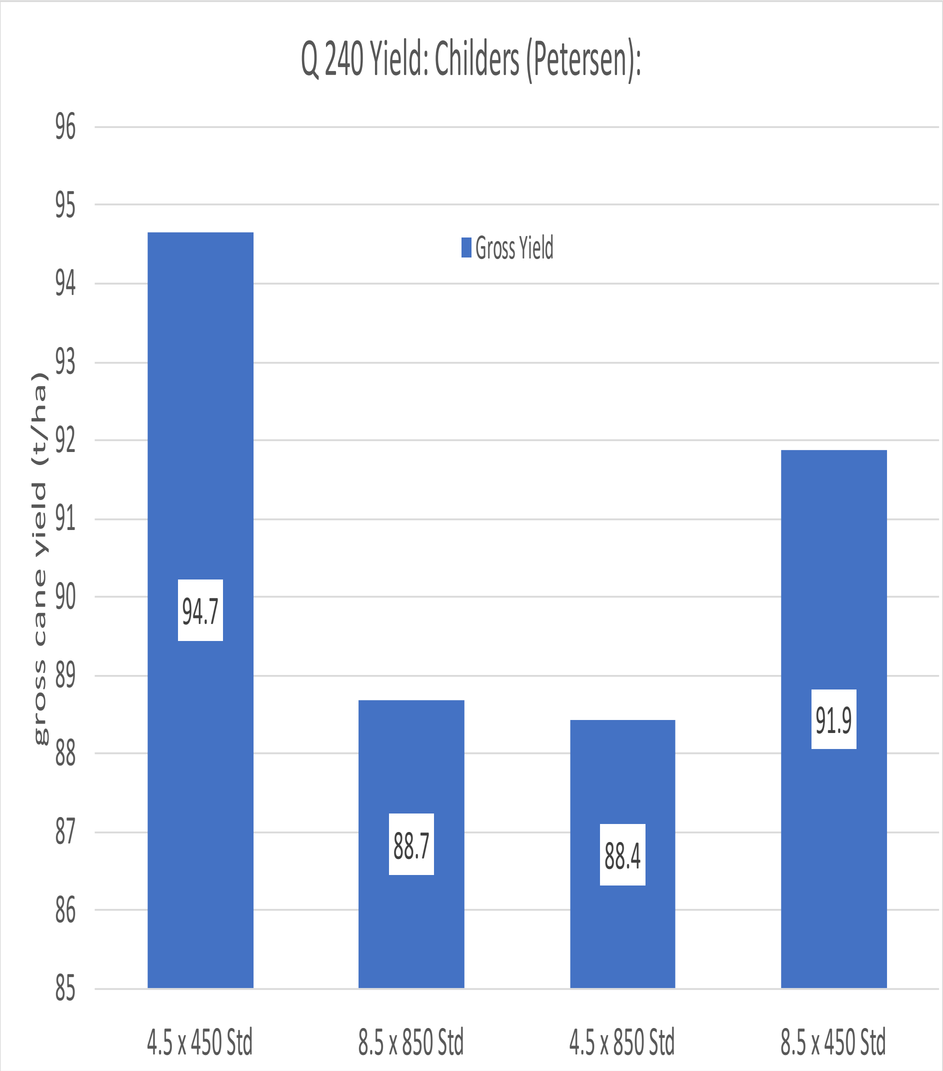
High levels of major and minor damage across all treatments

Lowest speed with matched “front end” had lower damage

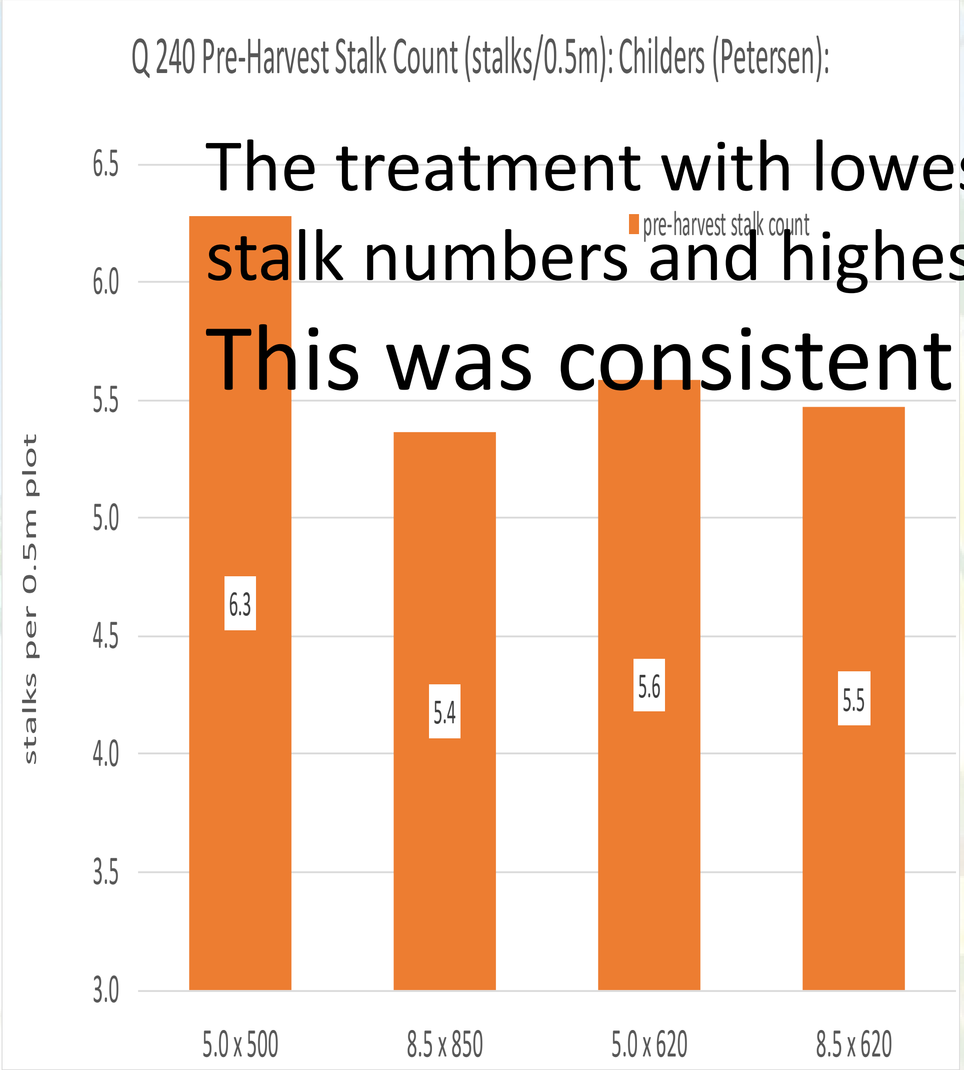
This translated to higher shoot populations and higher stalk numbers at harvest

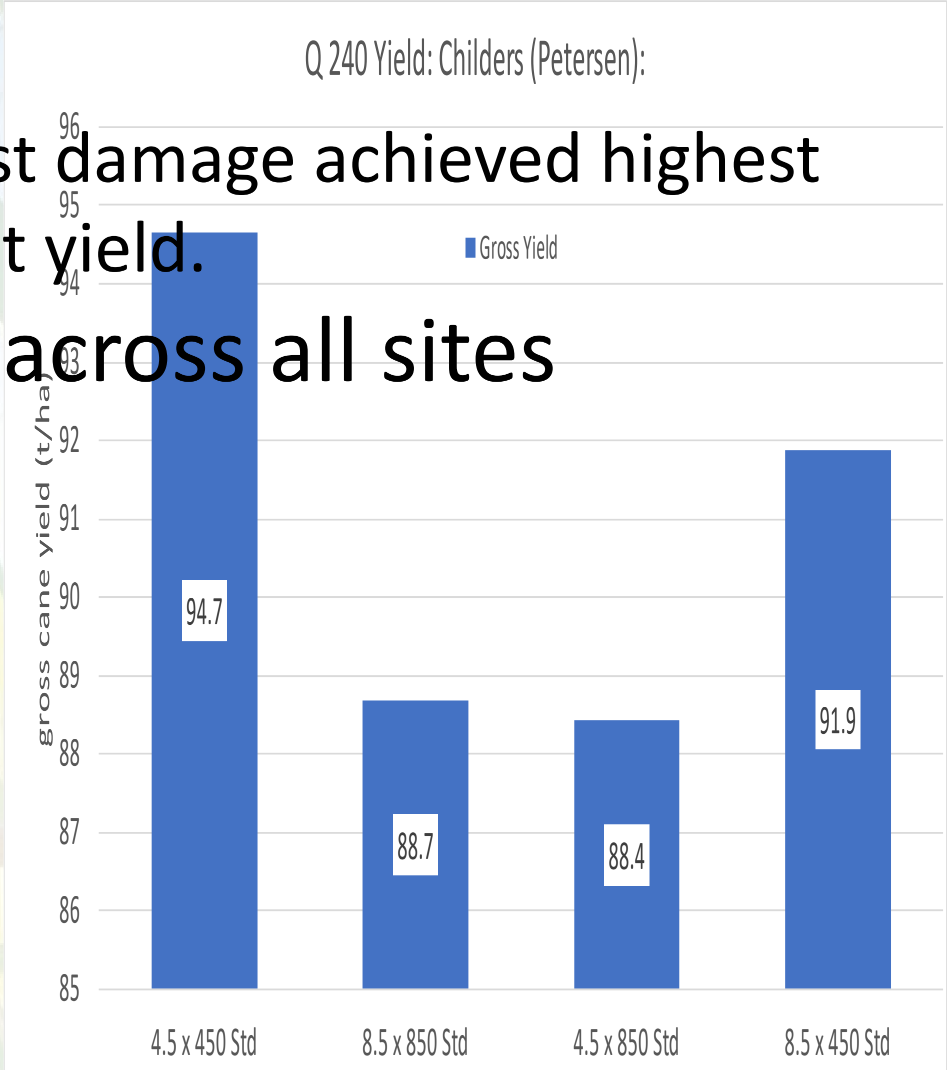
Population and Yield Impacts





Population and Yield Impacts





The treatment with lowest damage achieved highest stalk numbers and highest yield.

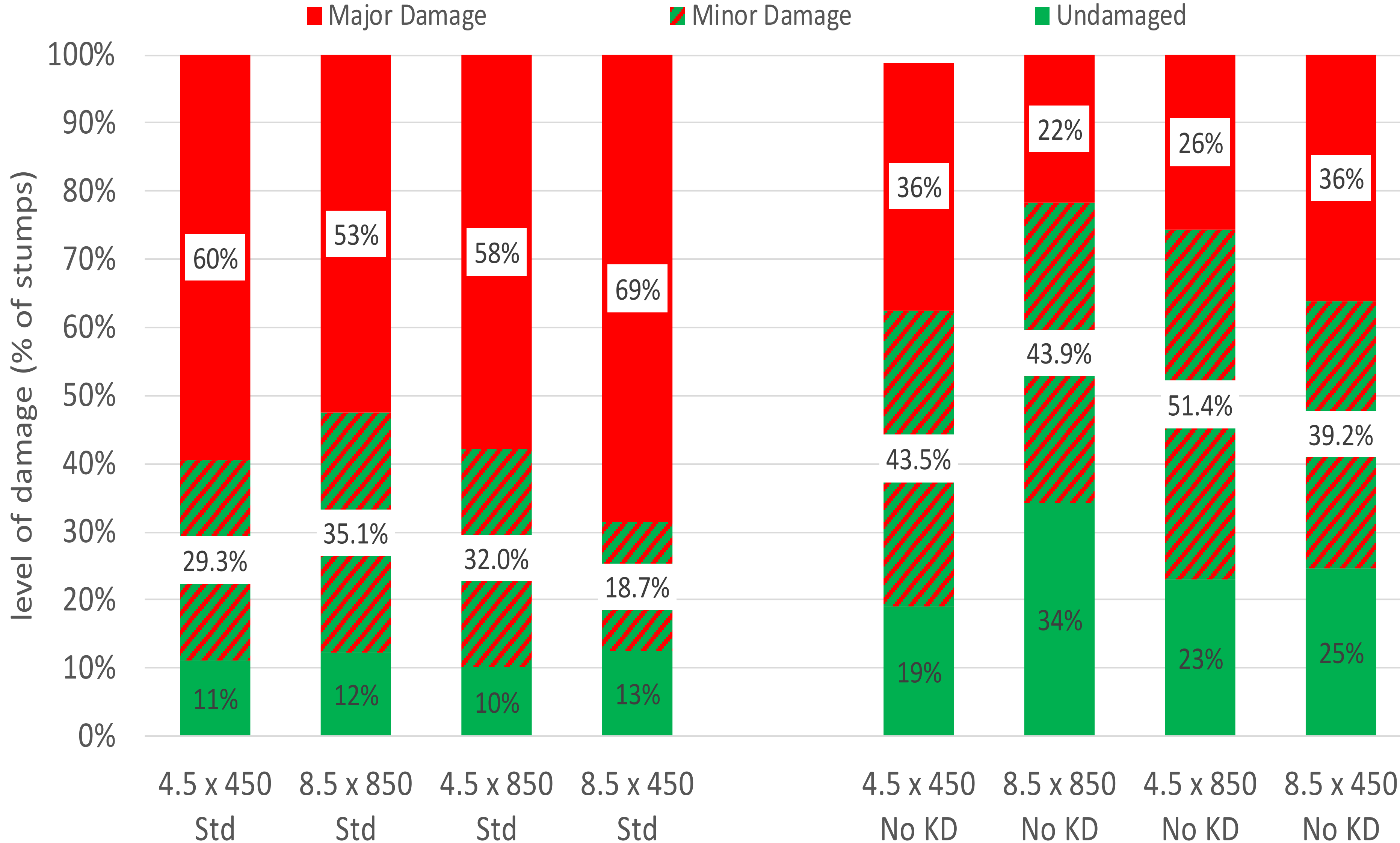
This was consistent across all sites

2018 Trials

- Because of the high levels of damage observed in all trials, an additional sub-treatment was introduced where the plot was manually harvested leaving stubble app 25 cm long
- This stubble length did not interact with the harvester forward feed rollers
- The only damage would then be that caused by the basecutters
- Any damage greater than this in the “standard plots” was then caused by the gathering and feeding processes

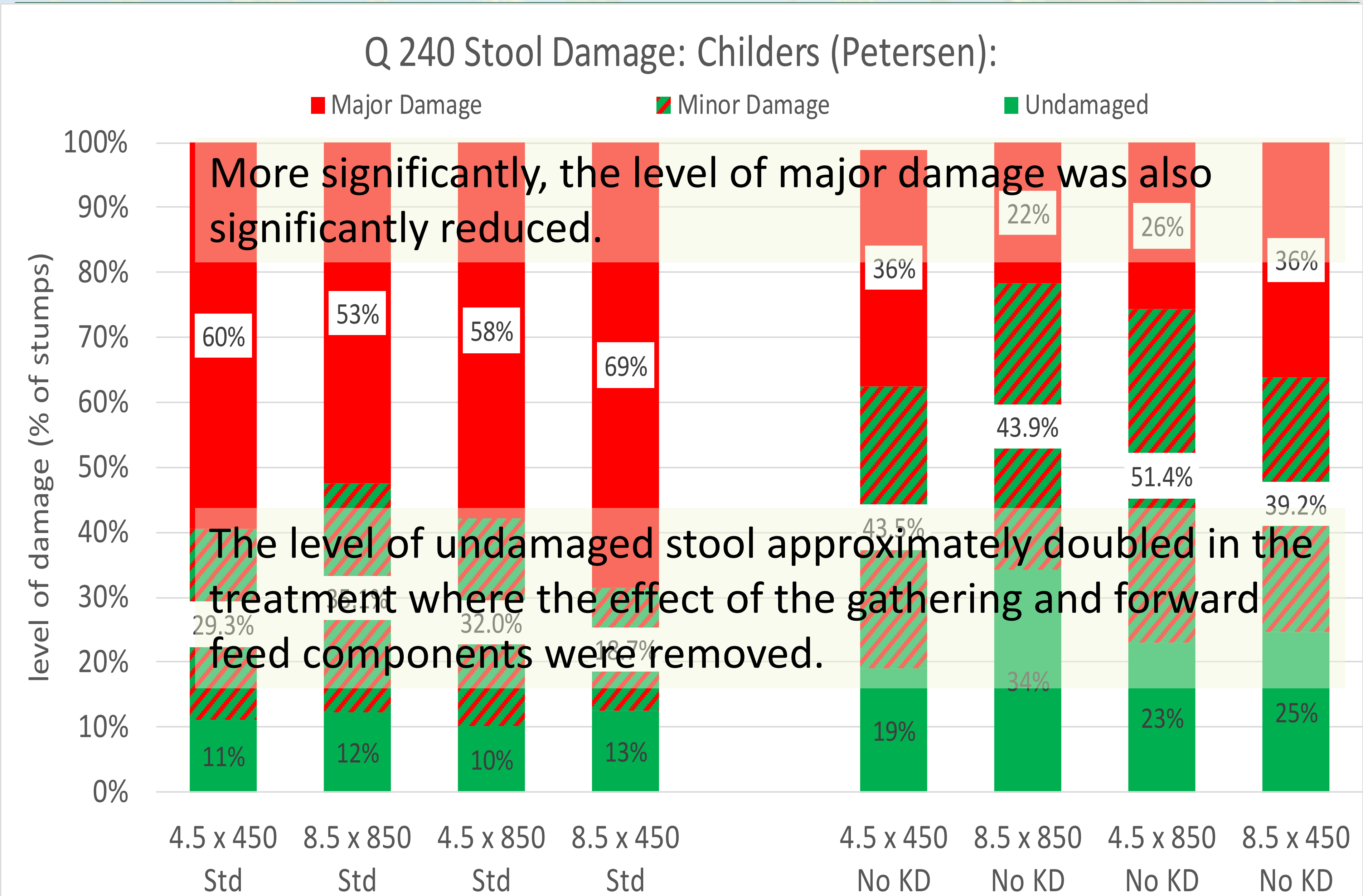
Harvesting Pre-cut Plots

Q 240 Stool Damage: Childers (Petersen):



More significantly, the level of major damage was also significantly reduced.

The level of undamaged stool approximately doubled in the treatment where the effect of the gathering and forward feed components were removed.



Summary: Harvester "Front End" Issues

- Damage to the crop stool during the harvesting operation is a major issue for mechanised sugar Industries:
- Aggressive "front end geometry" causes a significant proportion of the damage;
- To date, the Industry has pursued a "variety development" approach, i.e thinner varieties;
- This strategy has significant consequences for other aspects of the sugar cane harvesting value chain.

International Issues: Cane Loss

- "Where has the cane gone?"
  - As estates move into machine harvesting, mills insist on trash free cane:
  - Harvester suppliers respond by recommending high trash extractor fan speeds and short billet lengths.
- Cross referencing machine harvested yields with hand-cut yields often indicates significant "missing" cane.

Cane Loss at Harvest

Where is the missing cane?

- The monitoring of cane stalk left in the field by the harvester is a useful strategy for managing losses associated with many harvester operating parameters, e.g.
  - Basecutter height
  - Billet spillage etc

Monitoring Harvesting Losses

Monitoring Harvesting Losses

Harvest Loss Log

	Morning shift								
Block			H17-H19	H15-H16	H15-H16	i12-i13	i12-i13	i12-i13	
Harvester name	**H1**	**H4**	**H5**	**H6**	**H7**	**H8**	**H9**	**H10**	**Mean t/ha**
Chips (blown by primary fan)			0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Base cutter losses (debris)			0.3	0.3	0.3	0.8	0.8	0.3	**0.5**
High base cutting			0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Pick up losses (long loose cane)			0.5	0.6	0.7	1.5	1.1	1.2	**0.9**
Uncut stalks (attached to stool)			0.3	0.0	0.0	0.0	0.0	0.2	**0.1**
Sound Billets (from chopper drums)			0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Sound Billets (from elevator)			0.0	0.3	0.2	0.0	0.0	0.0	**0.1**
Uprooted stools			0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
TOTAL LOSSES T/ha	**0.0**	**0.0**	**1.0**	**1.1**	**1.2**	**2.3**	**1.9**	**1.8**	**1.5**

Cane Loss at Harvest

Where is the missing cane?

- Monitoring the billet fragments which are identified as coming from the extractor typically indicates extractor cane loss to be minimal, or in some trials, to actually reduce as extractor speed increases.
- The most significant losses, billeting losses and trash extractor losses, cannot be measured in this way.

“Invisible” Losses

The largest sources of losses are:

- The chopper systems (billeting the cane)
  - Predominantly juice loss, and
- The extractor (trash extraction)
  - Billets which are extracted by the extractor fans are effectively “dissociated”, the resulting product is difficult to identify or collect
- Both are significant sources of “invisible” losses and are often much higher than the total of the “visible” losses found on the ground after harvest.
- Look first at billet length and billeting losses.

Billet Length / Billeting Losses

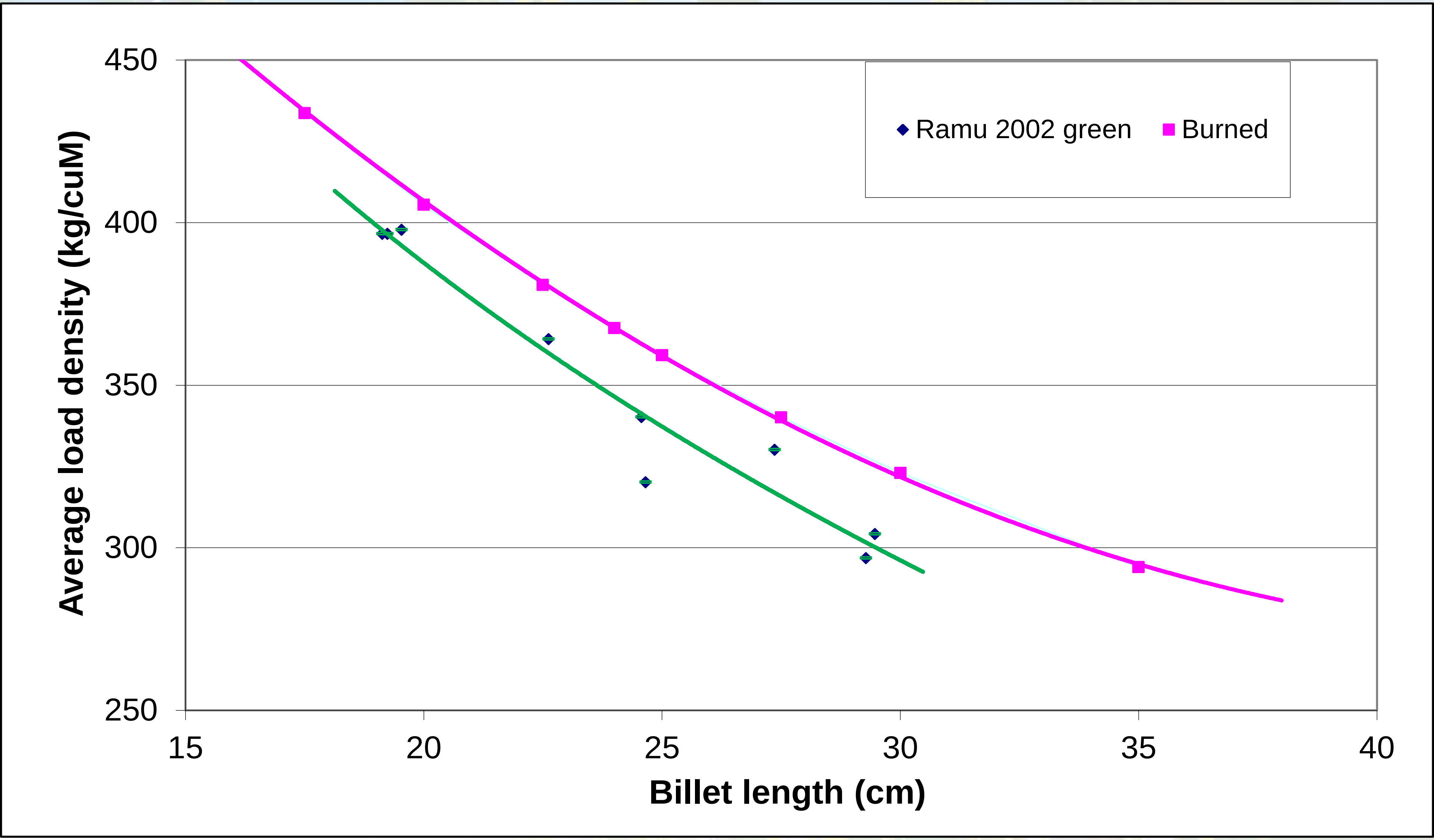
- The operator can change billet length by changing the speed of the feedtrain rollers.
- Reducing billet length improves load density:
    - Transport cost benefits
    - Mitigate the impact of increasing trash levels on load density
  - Manufacturers now option machines for very short billet length, based on client demand:
    - 4 & 5 blades/drum now common (8 & 10 blade systems), with 12 blade systems being available from aftermarket suppliers

Billet length: Which is best option?

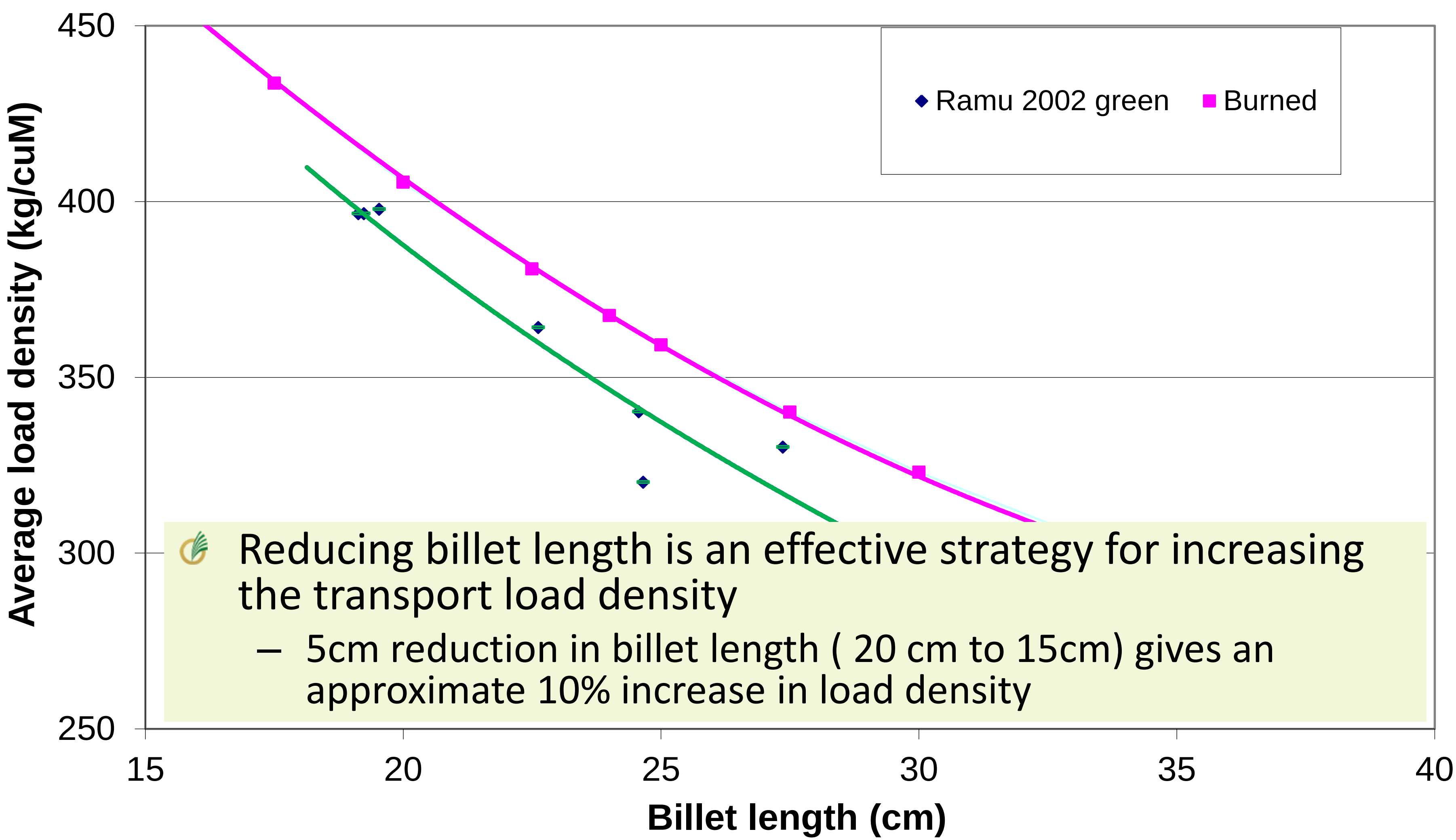
4 blades/drum: 150-170mm billets

2 blades/drum: 380mm billets
Côte d'Ivoire

Billet Length v's Load Density

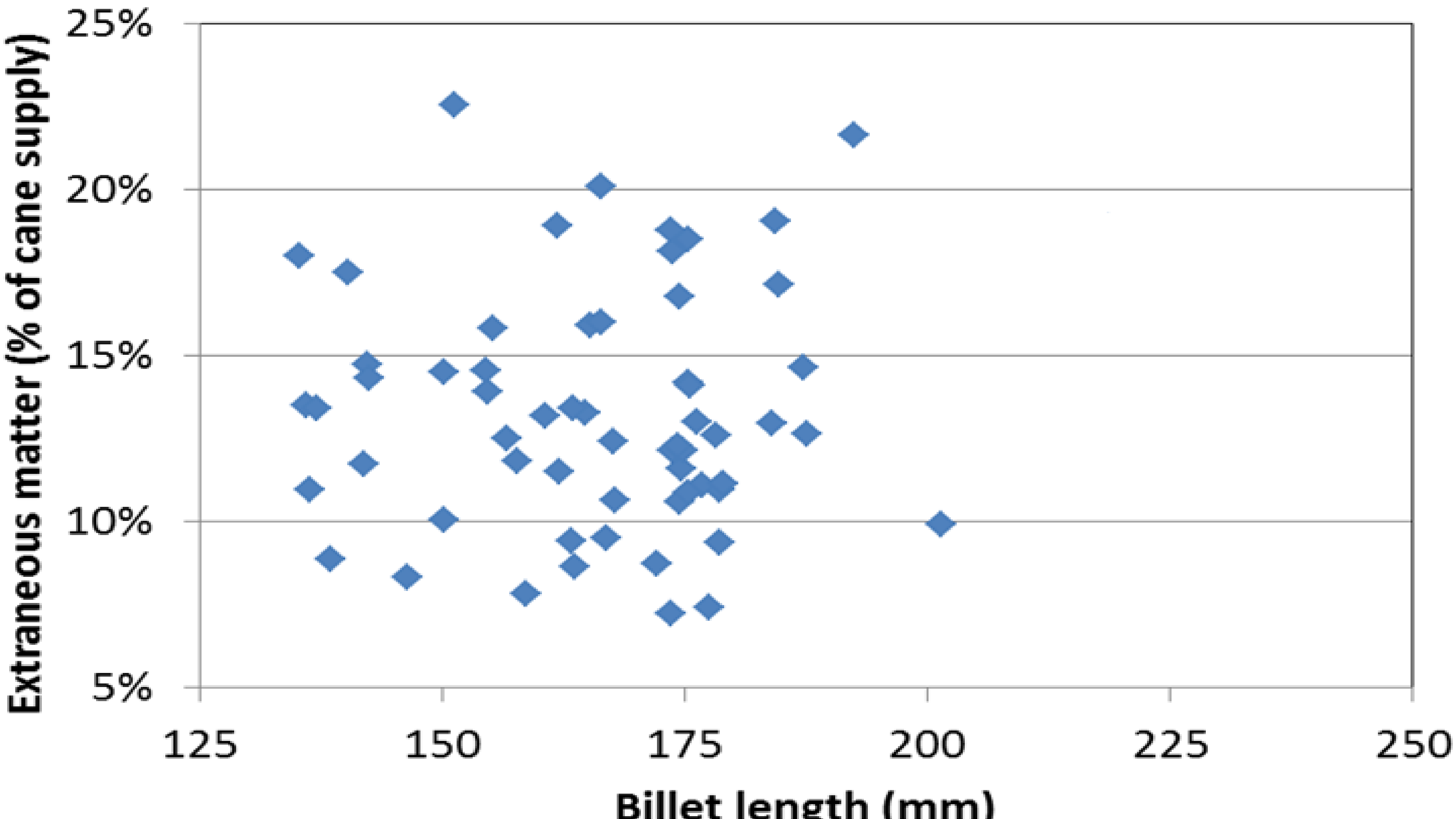


Billet Length v's Load Density



- Reducing billet length is an effective strategy for increasing the transport load density
  - 5cm reduction in billet length (20 cm to 15cm) gives an approximate 10% increase in load density

Billet length v's EM:

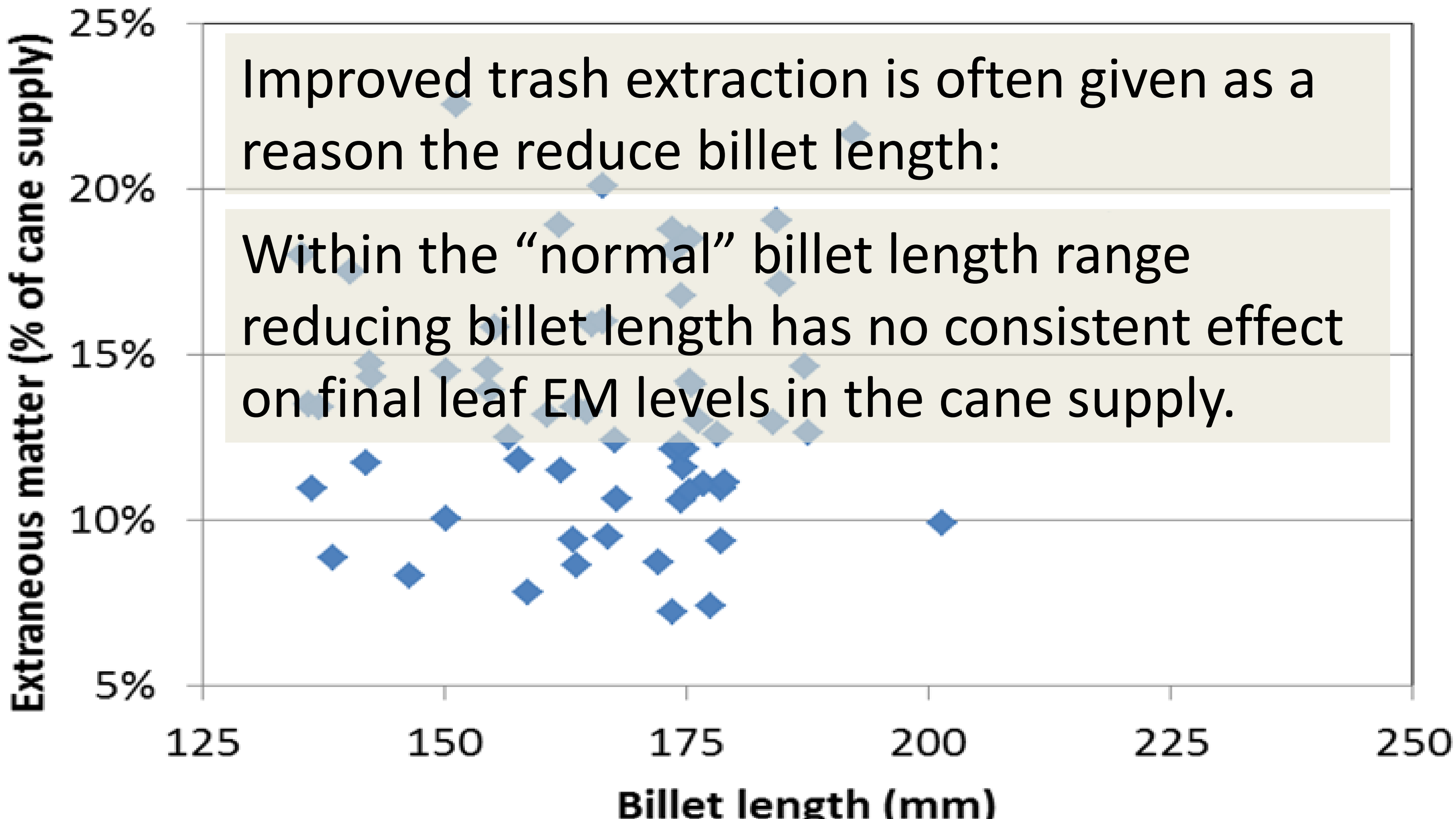


PL LARSEN; PA PATANE; I ASAMOAH, (2017) BENCHMARKING CANE SUPPLY QUALITY IN THE HERBERT, BURDEKIN, PROSERPINE AND PLANE CREEK REGIONS Proc of ASSCT .

Billet length v's EM:

Improved trash extraction is often given as a reason the reduce billet length:

Within the "normal" billet length range reducing billet length has no consistent effect on final leaf EM levels in the cane supply.



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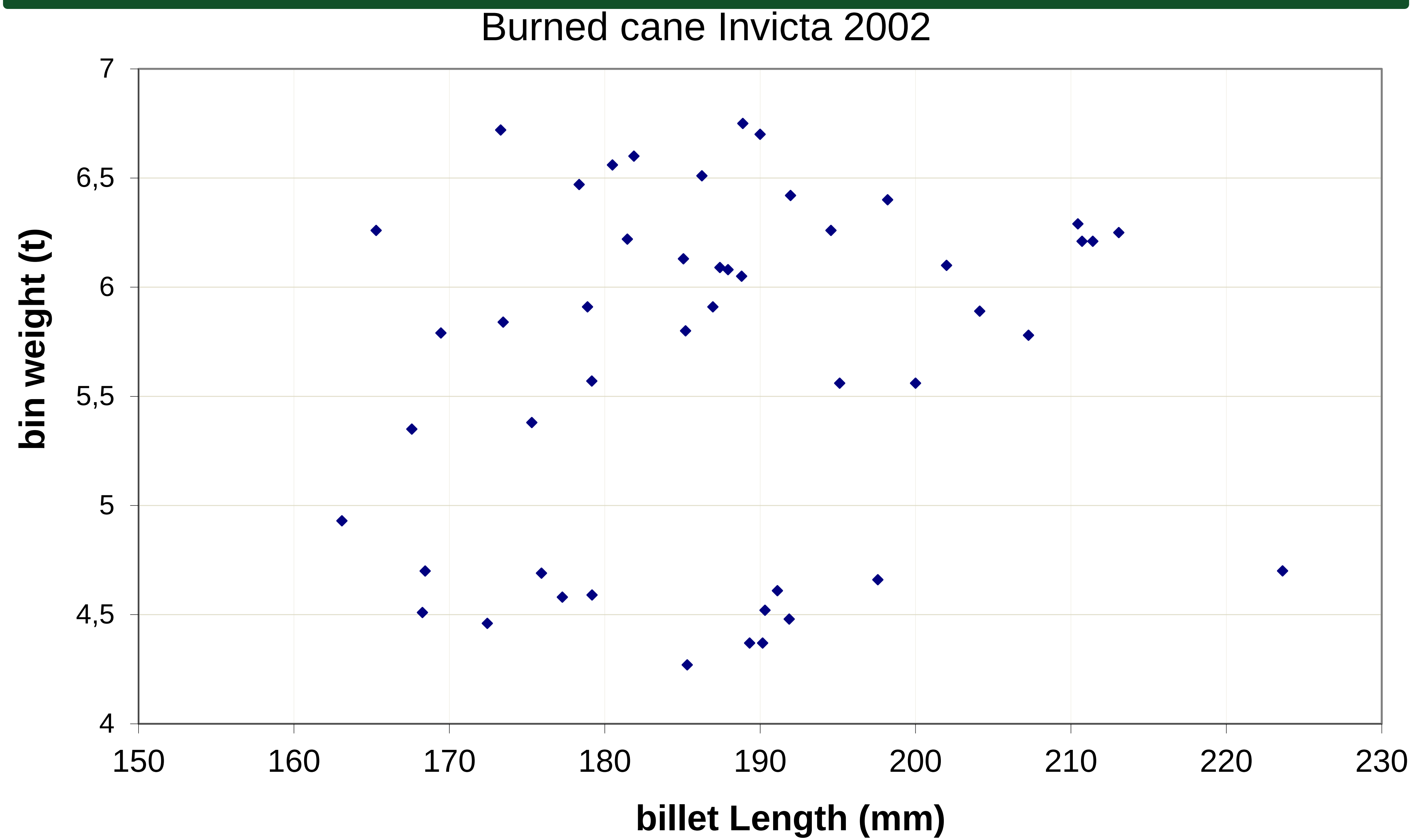
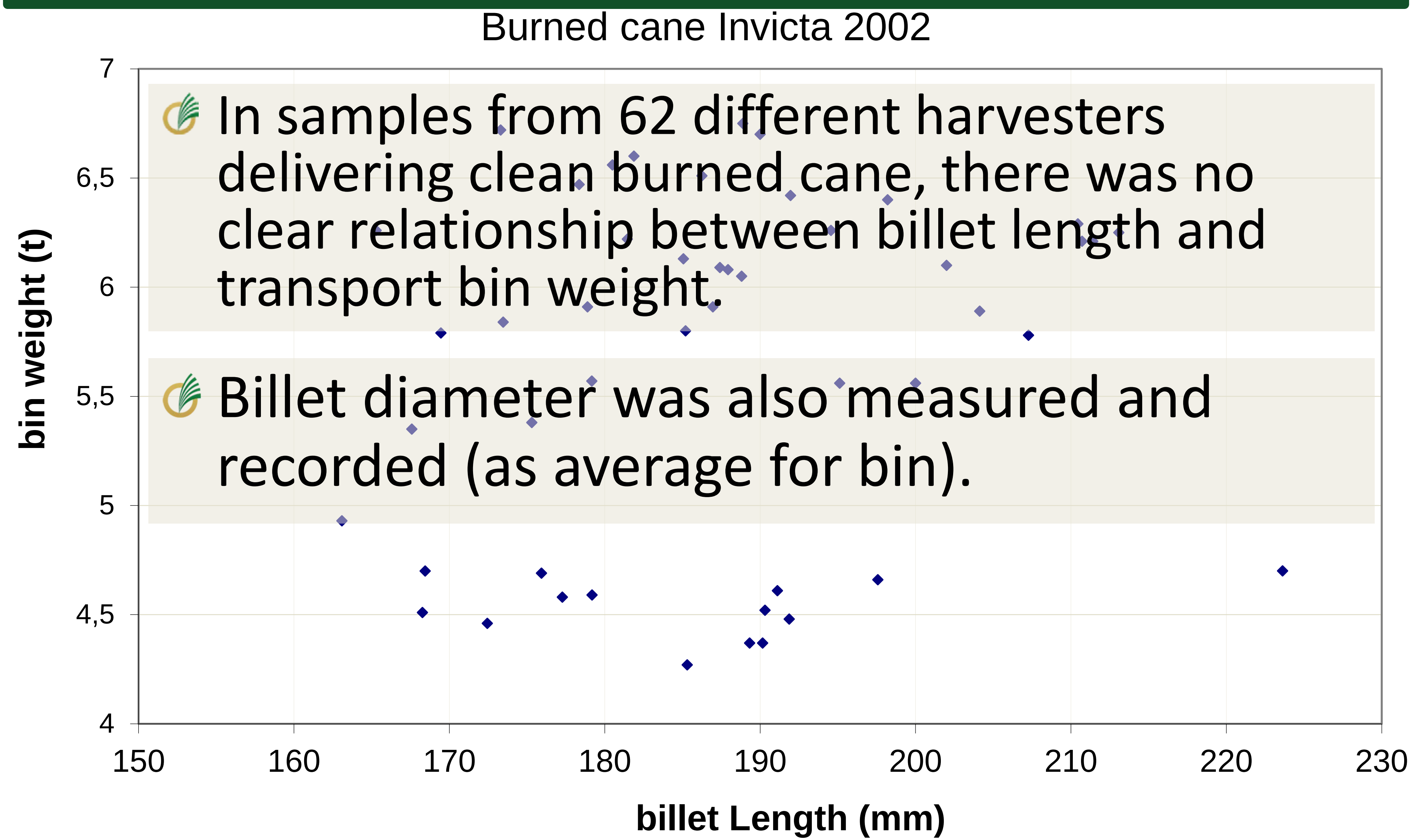
Billet Length v's Load Density/Binweight

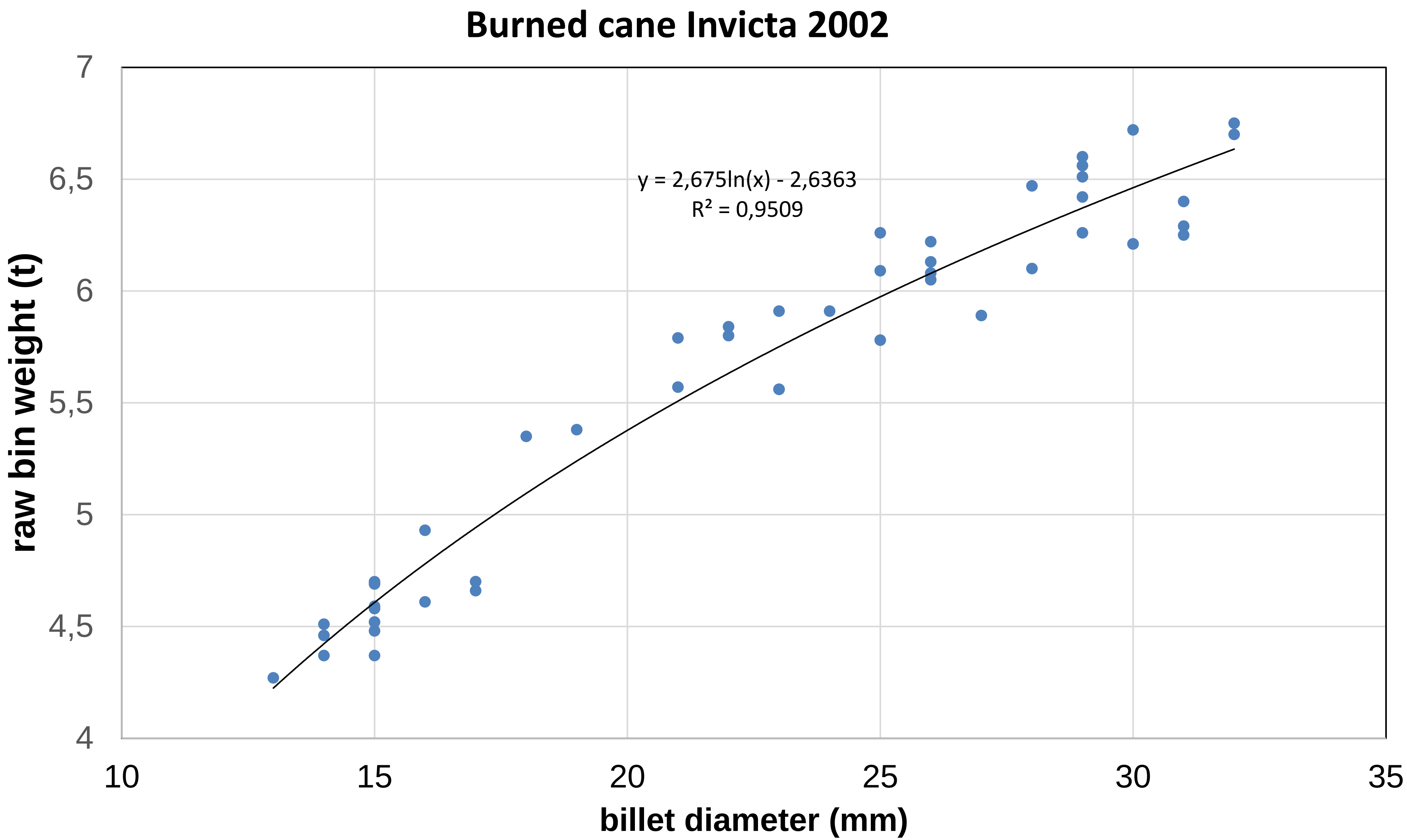


Billet Length v’s Load Density/Binweight

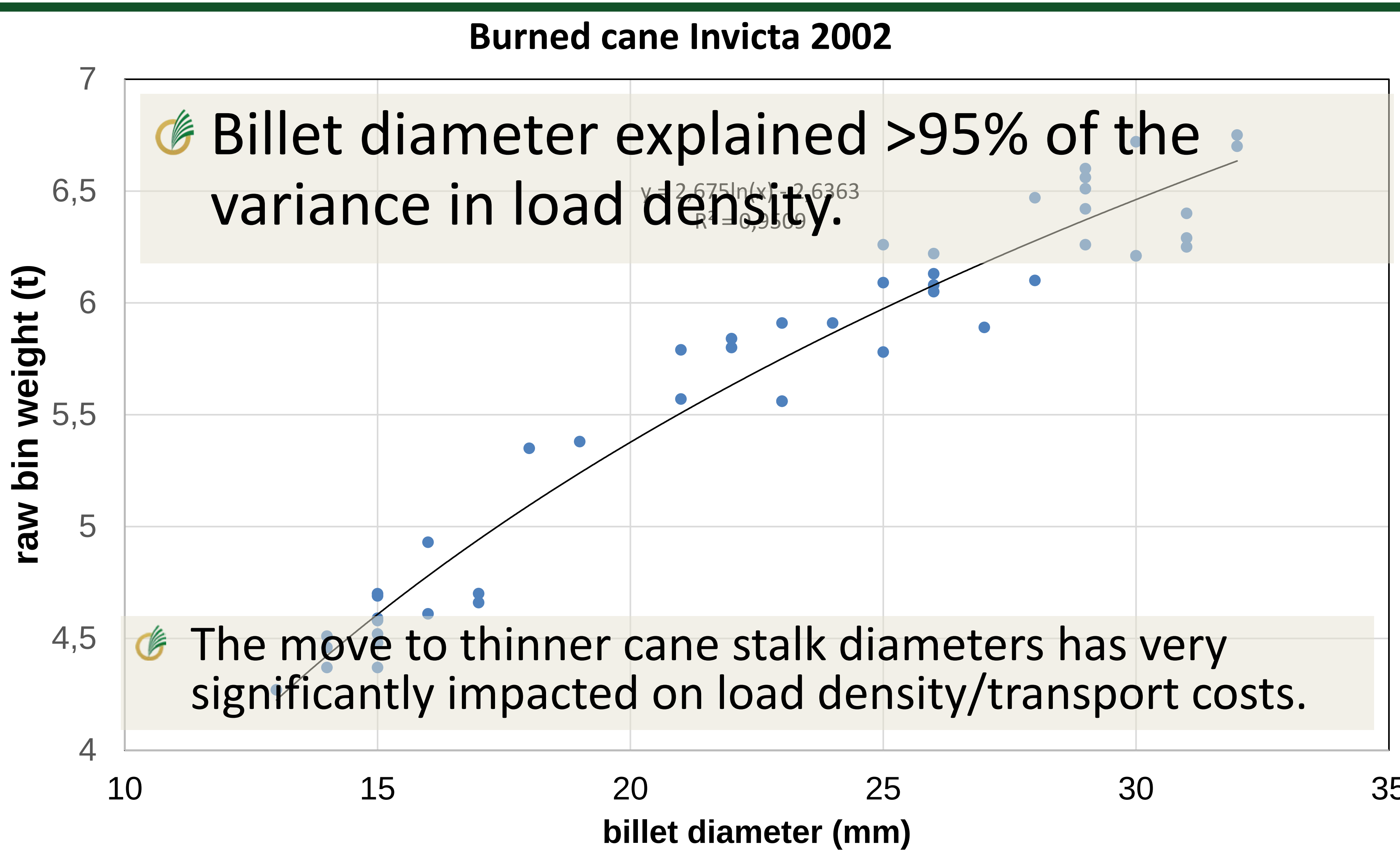
- In samples from 62 different harvesters delivering clean burned cane, there was no clear relationship between billet length and transport bin weight.
- Billet diameter was also measured and recorded (as average for bin).



Billet Diameter v's Load density/Binweight



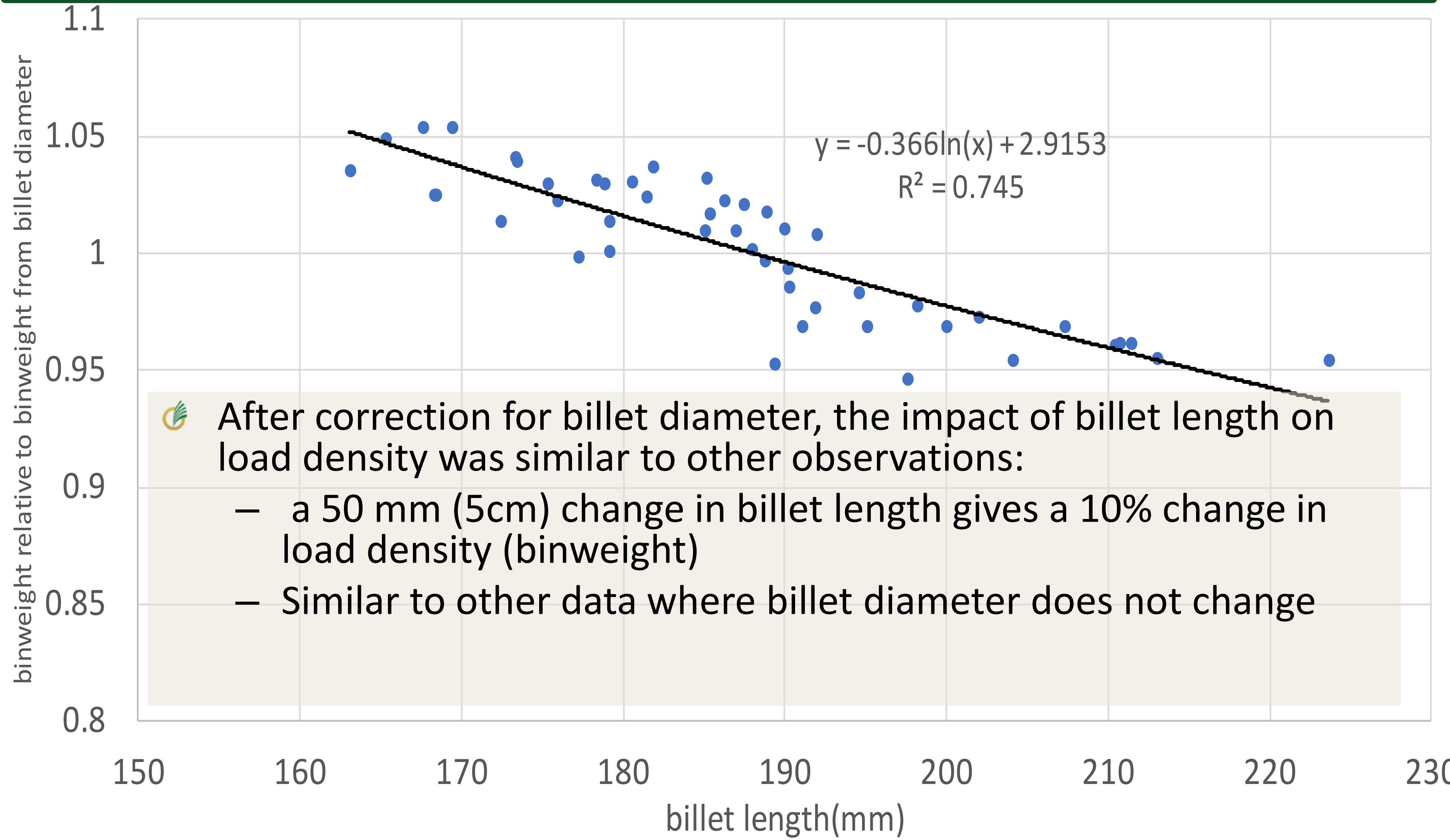
Billet Diameter v's Load density/Binweight



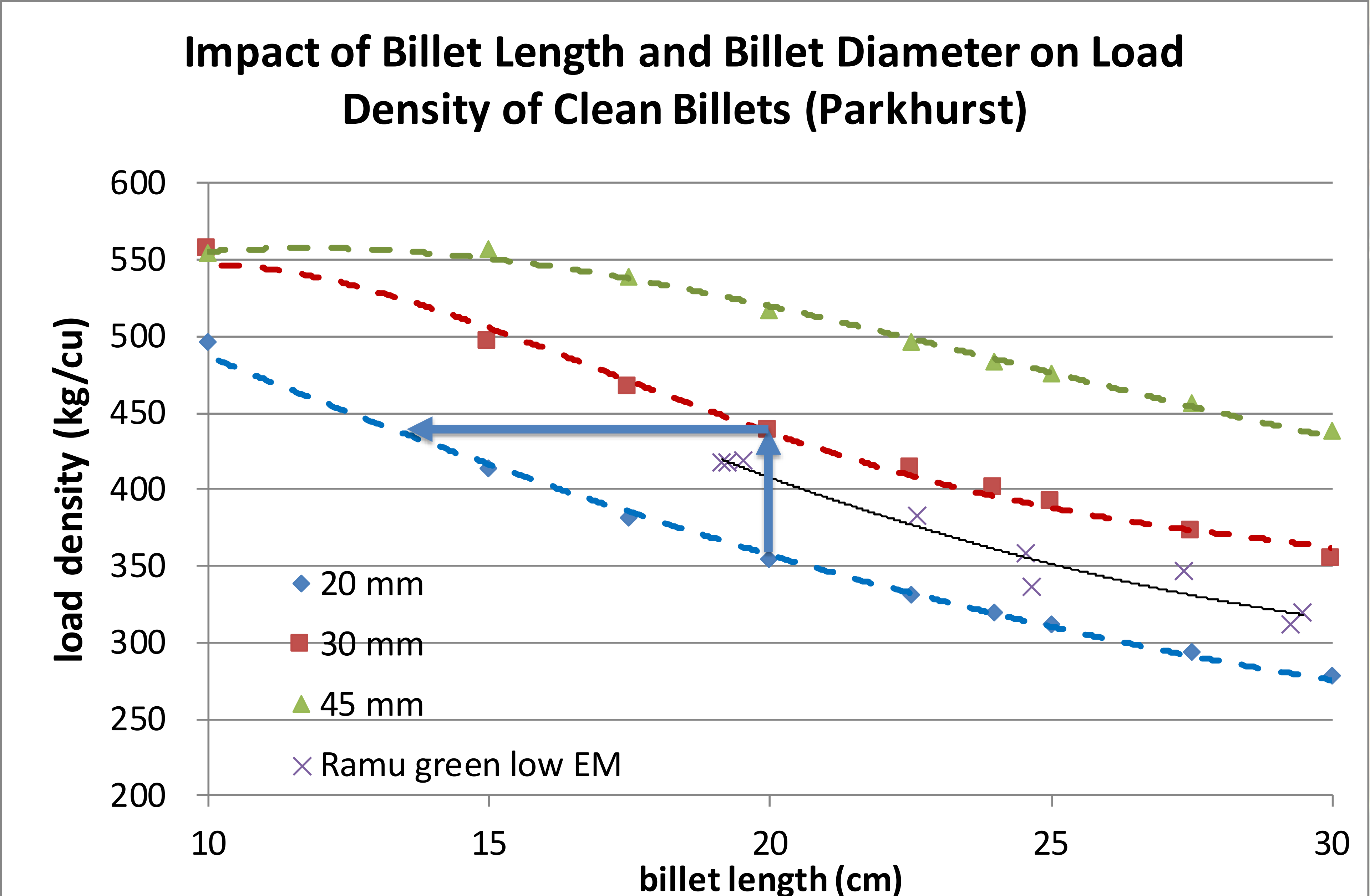
- Billet diameter explained >95% of the variance in load density.
- The move to thinner cane stalk diameters has very significantly impacted on load density/transport costs.

Billet Length v's Load Density

(corrected to average billet diameter)



- After correction for billet diameter, the impact of billet length on load density was similar to other observations:
  - a 50 mm (5cm) change in billet length gives a 10% change in load density (binweight)
  - Similar to other data where billet diameter does not change



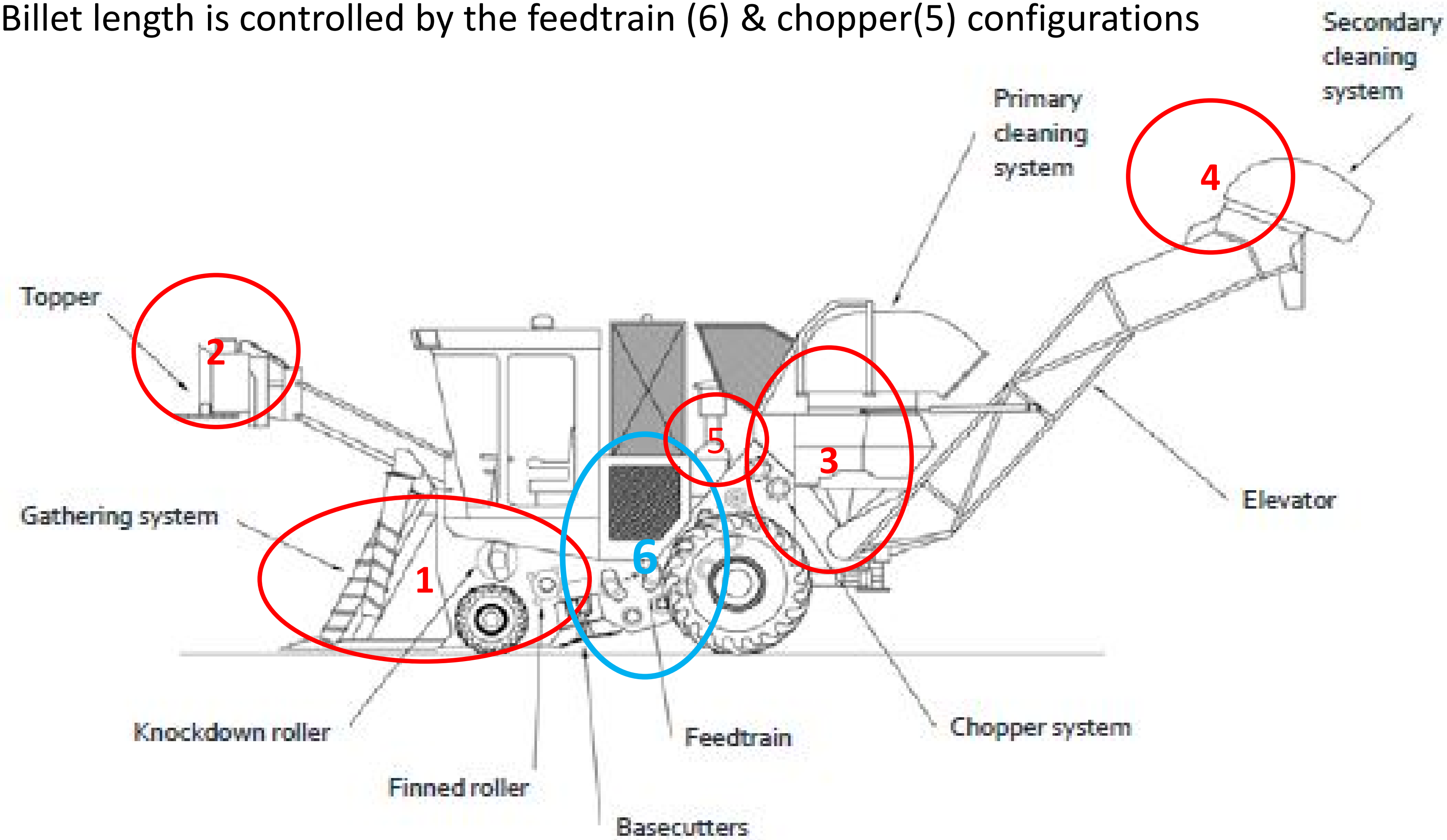
In thicker varieties there is much less advantage in shortening billet length than in thin varieties:

Billet Length, Diameter & Binweight

- Industries have moved to cane varieties with thinner diameters
- In an attempt to manage the impact on transport load density, billet length has been reduced.
- This has impacted on billeting losses

Harvester Components

Billet length is controlled by the feedtrain (6) & chopper(5) configurations



Billet Length v's Chopper Losses

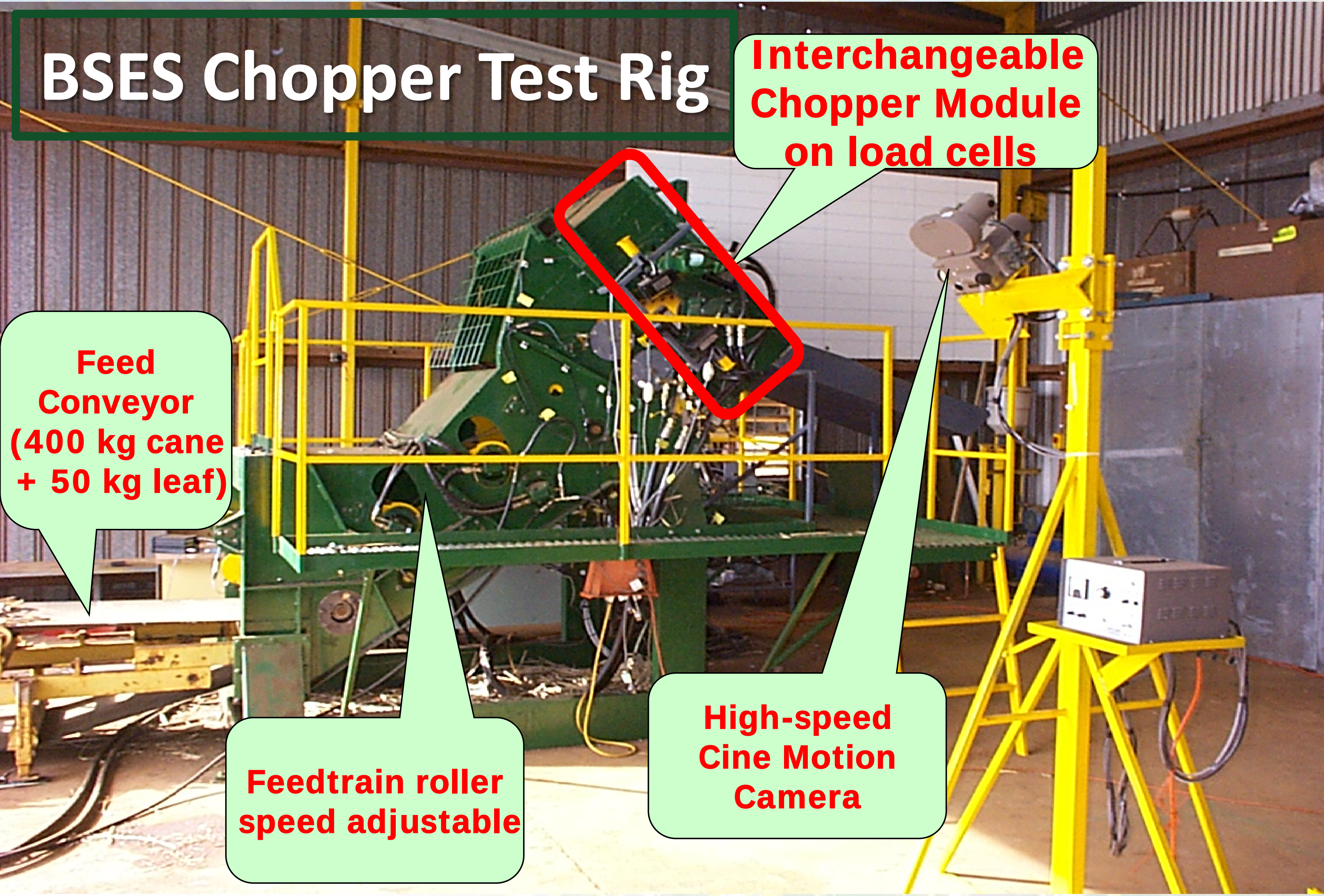
- The chopper system billets the cane, which is presented by the harvester feedtrain
- It is important to understand the process to manage losses and damage
- BSES Chopper Test Rig gave useful reference data which is still relevant:
  - Design of common chopper systems (Differential) has not significantly changed

Billet Length v's Chopper Losses

- Trials conducted at realistic processing rates to represent "real operating conditions"
  - 120 & 240 t/hr cane processing rates
- Chopper test rig represents "ideal" conditions, and therefore underestimates the true magnitude of loses which occur.

BSES Chopper Test Rig

BSES Chopper Test Rig



Billet Length v's Chopper Losses

- Test Rig Operation:
  - Feed-rate controlled by speed of feed conveyor;
  - Chopper speed was fixed but different feedtrain roller speed settings were used to achieve different billet lengths.
  - Only mass loss was measured, not deterioration effects;
    - 400 kg cane stalk on conveyor
    - 390 kg billets and visible pieces sorted from the billeted cane and trash
    - 2.5% loss of cane mass
- A total of 127 tests were undertaken.

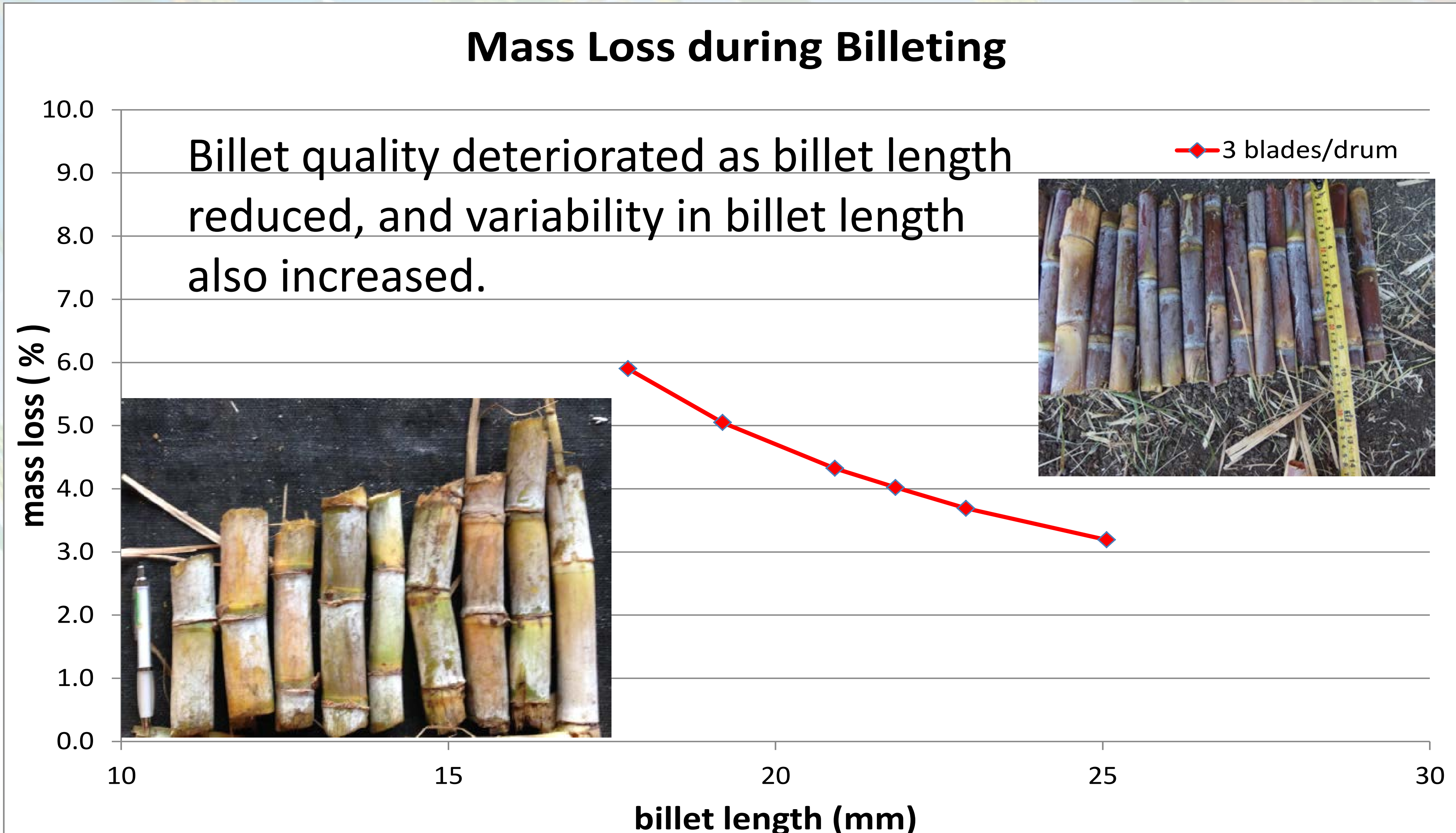
TEST No. 9

Austoft 15" diff (3)

240 t/hr, 185 rpm

Q141

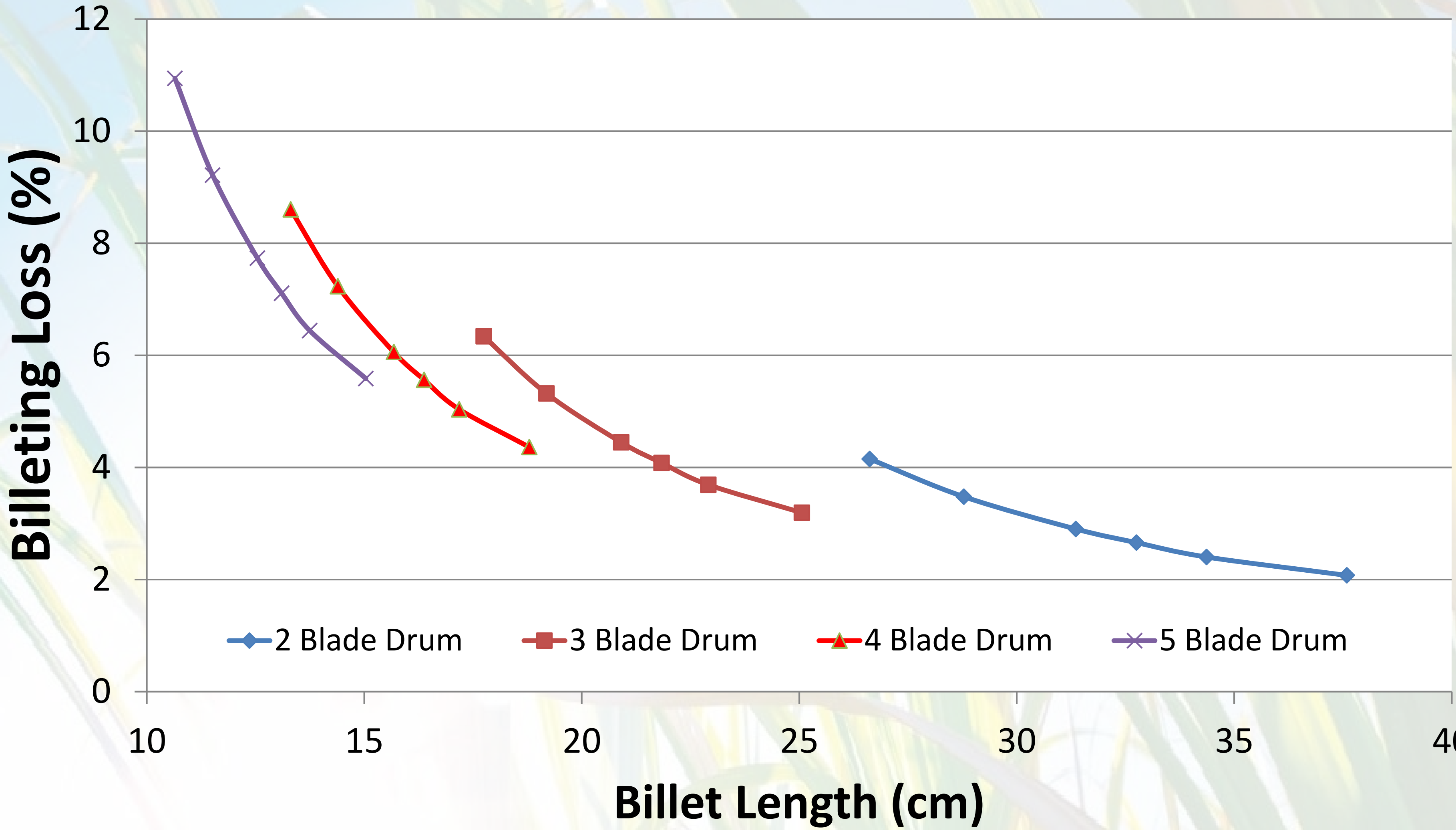
Results: Mass Loss 3 blade/drum



Billeting Loss Results: General

- Billeting mass loss is:
  – loss per cut x number of cuts/m length of stalk
- The minimum loss *per cut* was achieved at the maximum billet length setting used for any chopper system,
  – Losses increases as billet length is shortened
- Billet damage lowest at maximum billet length setting
  – Damage increased as billet length was shortened

Billet Mass Losses: Other Configurations

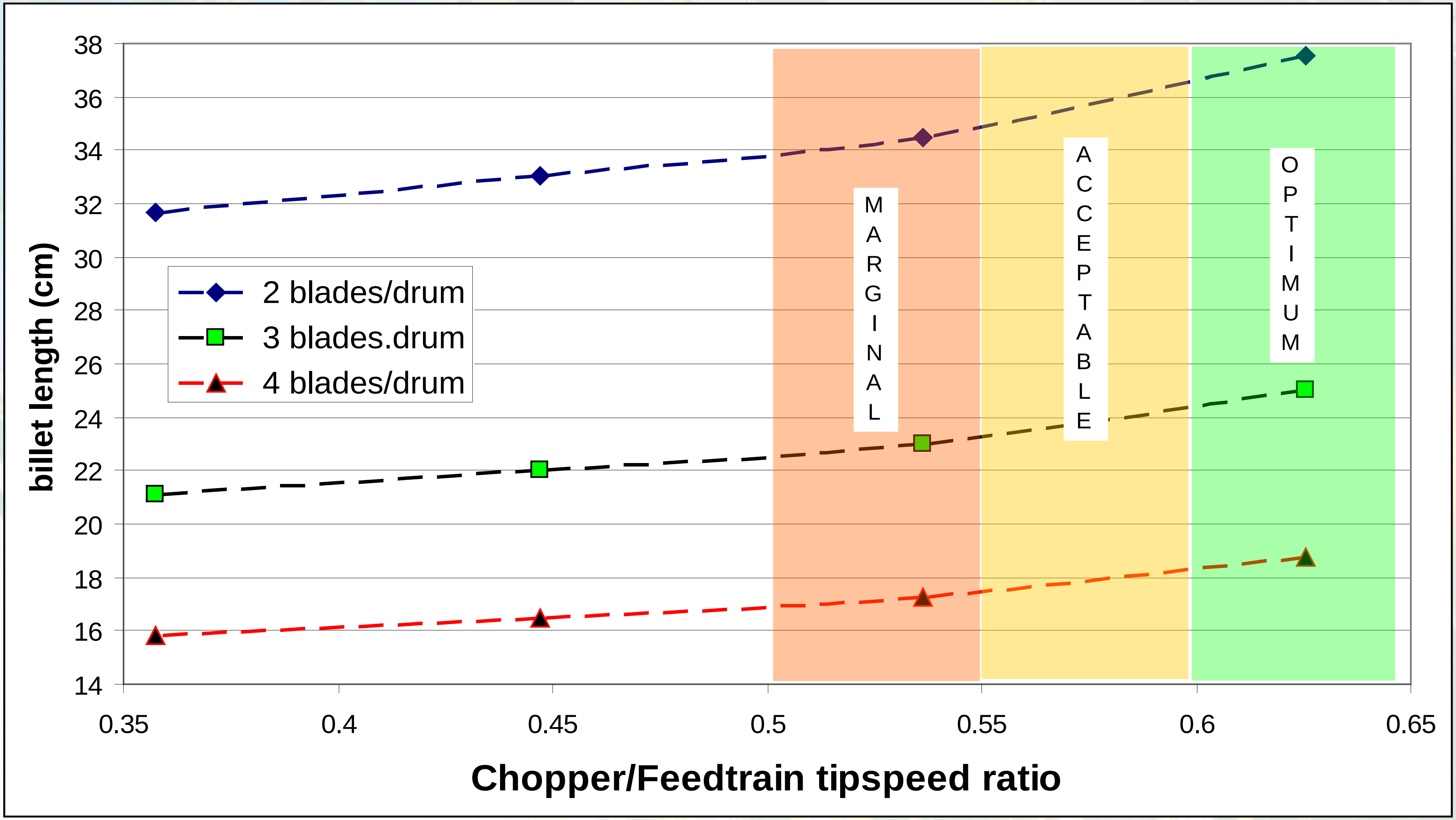


Optimising Chopper Performance

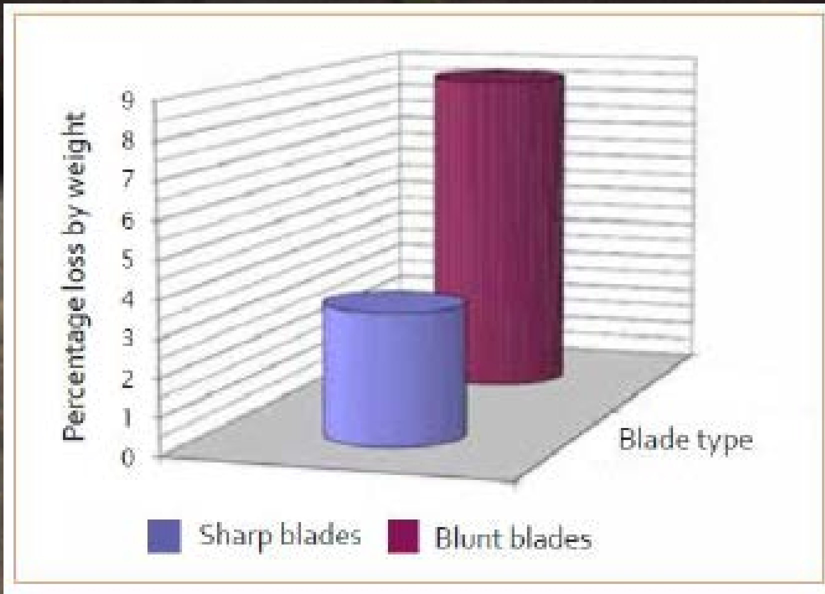
Further analysis showed that for all chopper systems tested:

- Billeting losses, billet damage and power consumption were all minimised when the tip speed of the rollers was 60-65% of the tip speed of the chopper blades.
- At this ratio, the blades were not applying any tension to the cane bundle as they severed the stalks
- At lower ratios, the blades generated high tension in the cane bundle as they attempted to pull the cane stalk through the feedtrain, increasing losses and damage.

Optimising Chopper Performance



- Blunt /poorly adjusted chopper blades had losses 200-300% of losses for sharp blades



Juice + Soil = Mud

Billet Length Field Trials

- Field trials in association with Chopper Test Rig program indicated that total recoverable sucrose losses were approximately twice the mass loss indicated by the test rig*.
  - Higher actual losses in field v's test rig
  - Higher proportions of damaged & mutilated billets
  - Increased rates of deterioration
- Further trials in Nicaragua (December 2014)** gave similar results.
  - Significantly reduced CCS% with reduced billet length

* James, M (2003) **FINAL REPORT – SRDC PROJECT MCB001 LIFTING THE VIABILITY OF THE MOSSMAN SUGAR INDUSTRY BY IMPROVING THE CANE SUPPLY**

**NorrisECT Visit Report to Client

Billet Length Field Trials

- A series of four field trials in association with Chopper Test Rig used billet length adjustment in harvester to give long and shorter billets

- Large trial also conducted in Nicaragua in December 2014, comparing harvesters with 3 blades/drum and 4 blades/drum

Billet Length Field Trials:

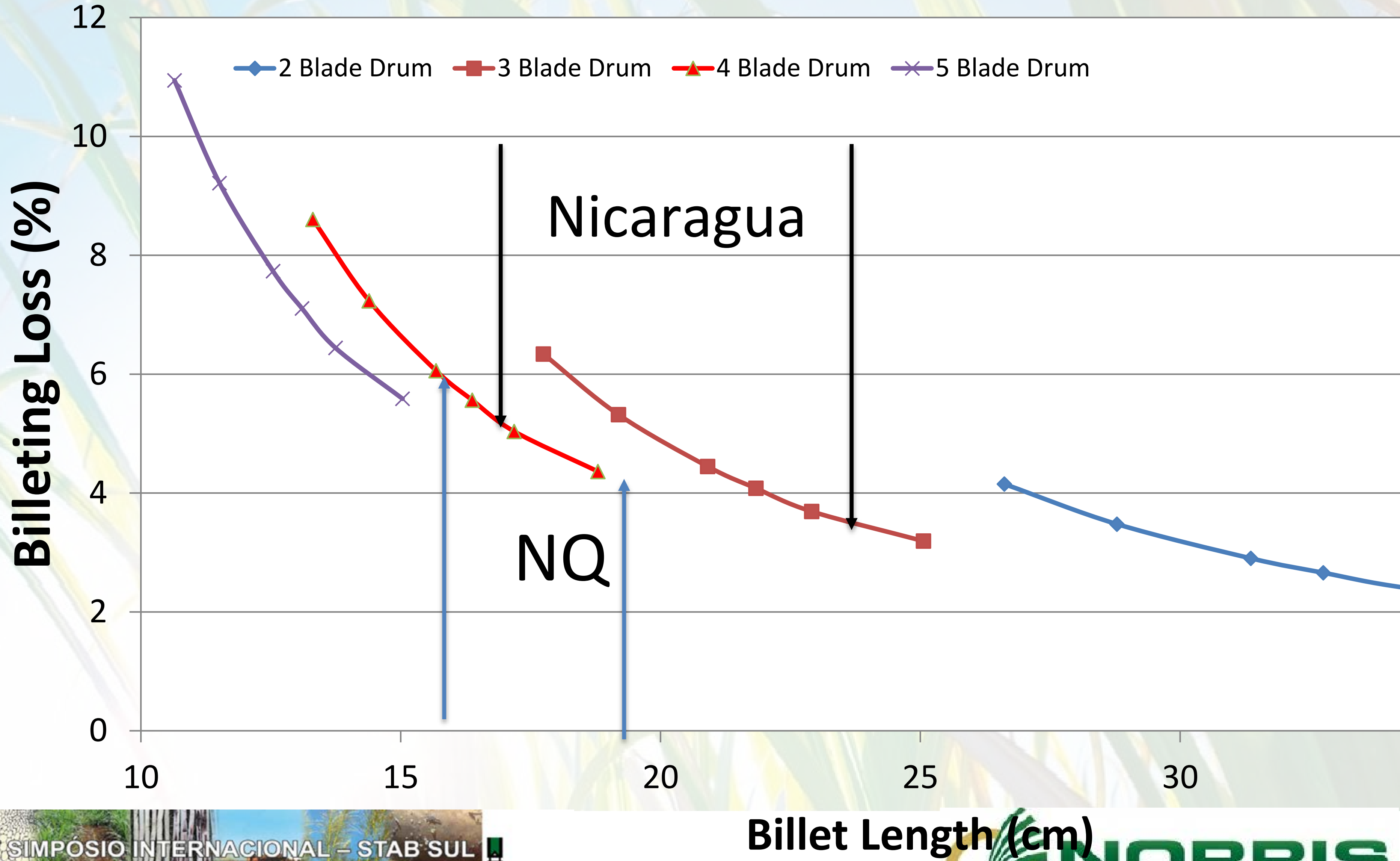
	Billet Lengths (mm)		TCH		TCH Field	Test Rig Losses		
	Short	Long	Short	Long	% Change	% loss	% loss	%
Trial 1	140	175	100.9	103.2	2.28%	7.5	4.2	3.3
Trial 2	170	200	80.75	85.4	5.76%	6.25	4.7	1.55
Trial 3	174	204	56	58.3	4.11%	6.2	4.65	1.55
Trial 4	150	180			1.30%	7	4.2	2.8
Average	**159**	**190**			**3.36%**			2.30%
Nicaragua	**6 blade**	**8 blade**						
	170	**230**	**estimated**		**1.90%**	5	3.8	1.2%

Change in crop yield with change from 159-190mm = 3.36%

Billet Length Field Trials

	Billet Lengths (mm)		TCH		TCH Field	Test Rig Loss		
						Short	Long	Difference
	Short	Long	Short	Long	% Change	% loss	% loss	%
Trial 1	140	175	100.9	103.2	2.28%	7.5	4.2	3.3
Trial 2	170	200	80.75	85.4	5.76%	6.25	4.7	1.55
Trial 3	174	204	56	58.3	4.11%	6.2	4.65	1.55
Trial 4	150	180	(from report)		1.30%	7	4.2	2.8
Average	**159**	**190**			**3.36%**			**2.30%**
Nicaragua	**170**	**230**	**estimated**		**1.90%**	**5**	**3.8**	**1.2%**

Billet Losses (120 tph pour rate)



Billet Length Field Trials: CCS

	CCS		
	Short	Long	% Change
Trial 1	13.9	14.1	1.6%
Trial 2	13.5	13.2	-2.2%
Trial 3	14.8	15.2	2.7%
Trial 4	NA		2.90%
Average			**1.24%**
Nicaragua	**12.3**	**12.6**	**2.4%**

Tonnes Sugar/ha: Long v's Short

	CCS	TC/ha	TS/ha
	Change	Change	Change
Trial 1	1.6%	2.3%	103.9%
Trial 2	-2.2%	5.8%	103.4%
Trial 3	2.7%	4.1%	106.9%
Trial 4	2.9%	1.3%	104.2%
Average	**1.2%**	**3.4%**	**104.6%**
30mm change in billet length setting changed recovery by almost 5%			
Nicaragua	**2.43%**	**1.90%**	**104.4%**

60mm change with different choppers (each at maximum billet length setting) gave a similar change in recovery

Binweight

	Short (160 mm)	Long (190 mm)	Change
Trial 1	11.80	11.30	-4.2%
Trial 2 (more trashy)	10.60	9.10	-14.2%
Trial 3	9.78	8.82	-9.8%
Trial 4	NA	NA	-4.7%
Average			-8.2%
Nicaragua (170 & 230mm)	42.0	37.0	-12%

Billet length reduction of 30mm increased binweight by 8.9% (12% Nicaragua for 60mm change)

Billet Length Field Trials

- The loss of recoverable sucrose associated with a moderate change in billet length (30mm) is in the order of 5%, with a similar difference by changing from “6 blade” to “8 blade” chopper systems.
- The reduction in transport costs associated with the two changes were 8% (billet length adjustor on harvester) to 12% (changing chopper drums).
- Depending on relative sugar and transport costs, the loss in sugar recovery typically significantly outweighs reductions in transport costs gained by shorter billets*.
  - By factor of x4 to x8.
- Short billets can be an un-recognised but *very significant* source of loss for many Industries .

* Value Chain Modelling for Clients, NorrisECT

Harvester Cleaning Systems:

- **Size and weight issues constrain the size of the separation system;**

- **Feed of material from the choppers is always variable, making efficient separation difficult;**

- **Proximity to fan of billet trajectory is because of height restrictions;**

- **Air velocity profiles are variable across the chamber.**

Harvester Performance: Leaf Extraction

Harvester extractor system aims to separate trash from billets.

- 100% separation efficiency is never possible, there will always be:
  - Trash left in the cane , and
  - Cane extracted with the trash
- Harvesters have relatively poor selectivity due to design constraints.
- Best demonstrated in trials under controlled conditions:
  - “Workshop trials”.

Monitoring Extraction Performance

C. Whiteing, R.J. Davis, E.J. Schmidt. Evaluation Of Cane Loss Monitoring Systems. (2004) Proc Aust. Soc. Sugar Cane Technol., Vol. 26, 2004.

Collection & weighing of all material

Inputs - Weighing Cane Before Test

- 2 varieties
- Cane stripped & weighed
- Weighed trash added to get 10% & 15% leaf EM levels
- Cane and trash recombined on conveyor which fed material into harvester throat.
- Pour rate (80 tph & 140 tph) controlled by amount of cane/trash on conveyor (typ 400 kg) and conveyor feed rate
- 120 tests run

Conveyor system into harvester

- 6-8 seconds (effective) /run

Collection & weighing of all material

Results – Cane Loss Trends 3 blade fan

Fan Speed RPM (old) (RPM modern)	**Cane Loss**		
	80 TPH	**140 TPH**	**Mean**
1000 (675)	1.9%	2.9%	**2.4%**
1200 (810)	4.6%	4.2%	**4.4%**
1400 (950)	10.4%	7.8%	**9.1%**

Results – Cane Loss Trends

- Cane loss increases substantially as fanspeed increases from 1000rpm to 1400rpm
- For 17 test runs, cane billets, pieces and tiny fragments were separated from the material extracted by the fan as in a field “tarp test”
- *On average, < 25% of cane lost could be found, which explains why “tarp tests” in the field significantly underestimate cane loss*

Results – Cane loss mechanism

- In an effort to better understand the interaction between airflow and cane/trash in the cleaning chamber different coloured cane stalks were placed in the top and bottom layers of the conveyor
- 8.5% of cane on top layer was lost through the fan and only 3.1% of cane on bottom layer. This also supports the case that trash flow is the mechanism by which billets are carried out the extractor.
- Going further, any increase in trash flow creates an increase in cane flow out the extractor through the same mechanism.
  - Reducing trash flow by topping can be expected to reduce cane loss

Results – Extraneous Matter

- Pour rate had a significant effect on EM levels

	Extraneous Matter	
Fan Speed (rpm)	**80 TPH**	**140 TPH**
1000	3.1%	7.6%
1200	2.3%	5.5%
1400	1.1%	3.1%

Results – Extraneous Matter

- At 80 TPH, increasing fan speed from 1000rpm to 1400 rpm only reduced EM by 2%, but at the same time cane loss increased by 8%.
- This supports field trial results which indicated there were significant losses at high fan speeds with only marginal improvements in quality.
- *The data also indicates that a significant proportion of the material being ejected by the extractor is sugarcane, reflecting high sugar levels in trash recorded by other researchers.*

Cane Loss Trends: Modern Machines

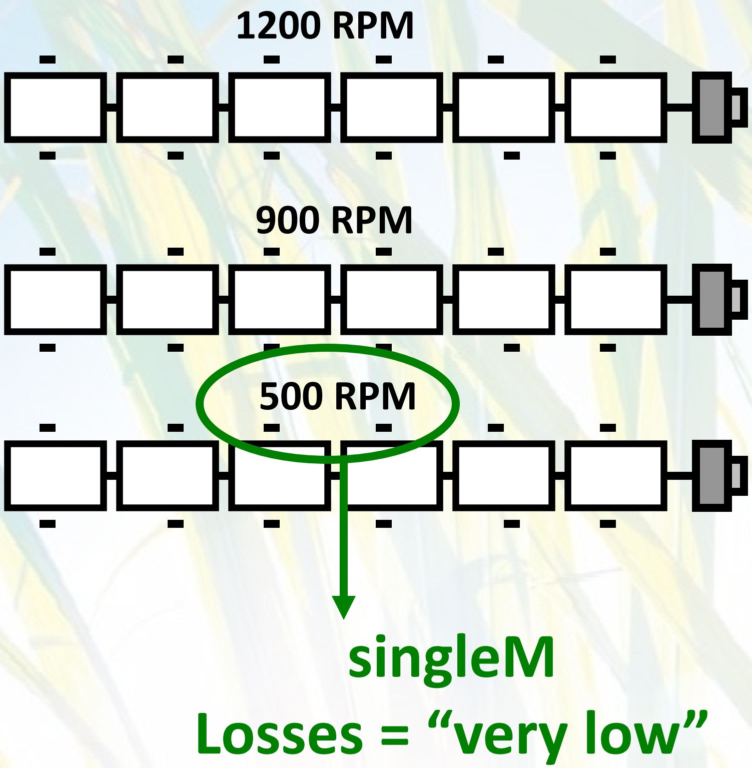
- Larger diameter and/or more aggressive fan blade design
  - Increased airflow at lower extractor fanspeeds
- Cane loss/fanspeed and EM / fanspeed characteristics remain similar, however
- High cane loss can now be achieved at lower extractor fanspeeds.

Cane Loss Measurement: Field Trials

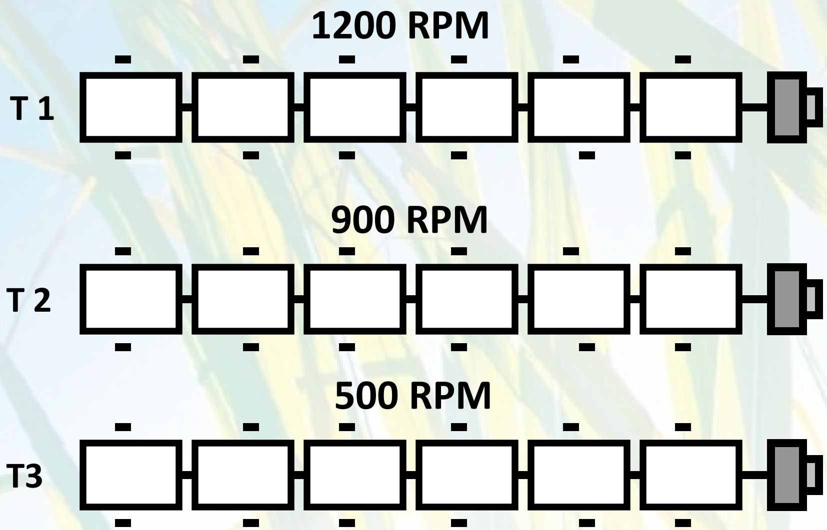
Mass Balance: Protocol

<u>Objectives:</u>
Measure losses, by comparisson between net TCH or TSH,
delivered at different RPM, where 500 RPM (low fan) is considered
"**<u>losses = very low</u>**" situation.

Mass Balance: Protocol

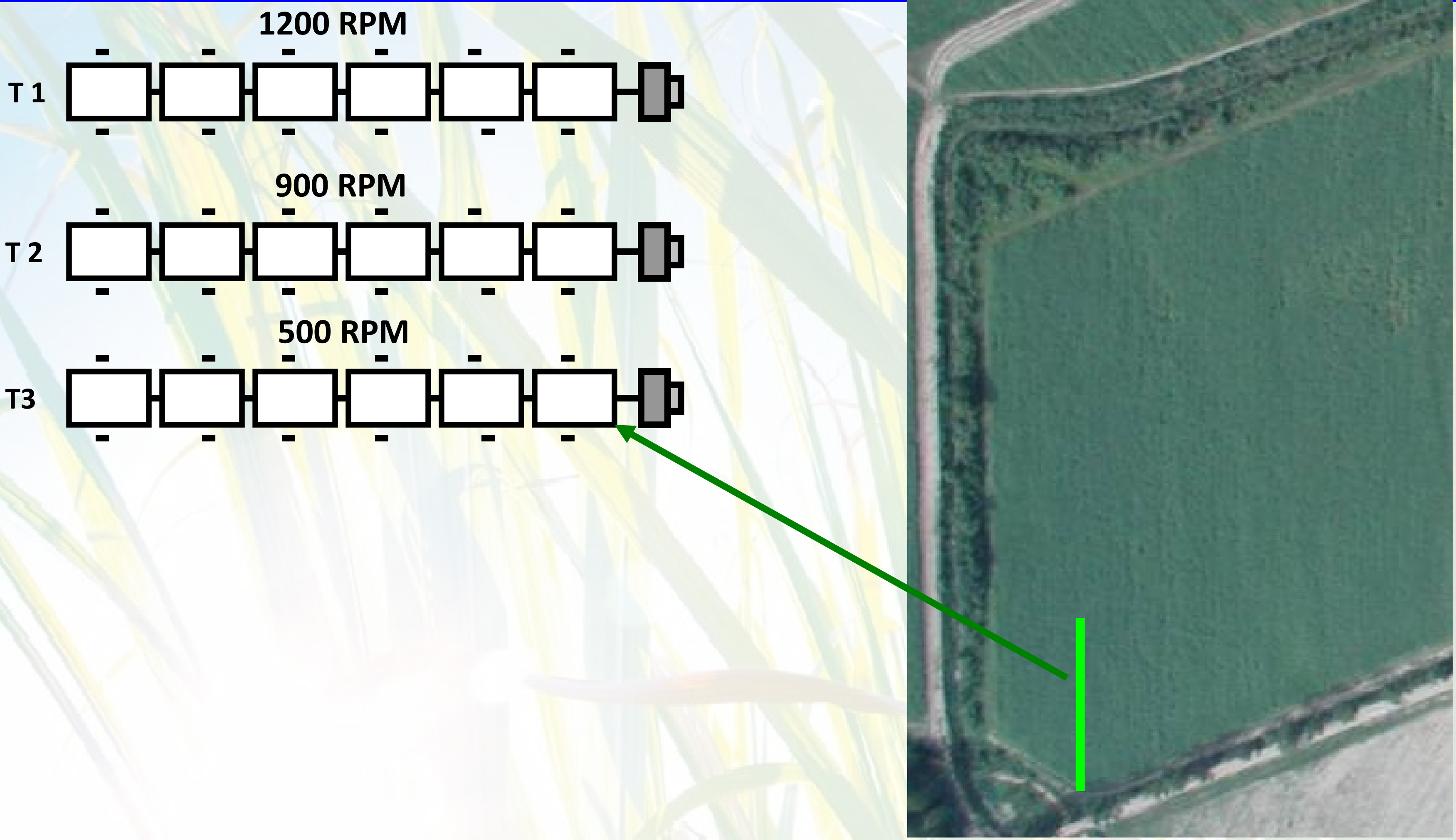


Mass Balance: Protocol

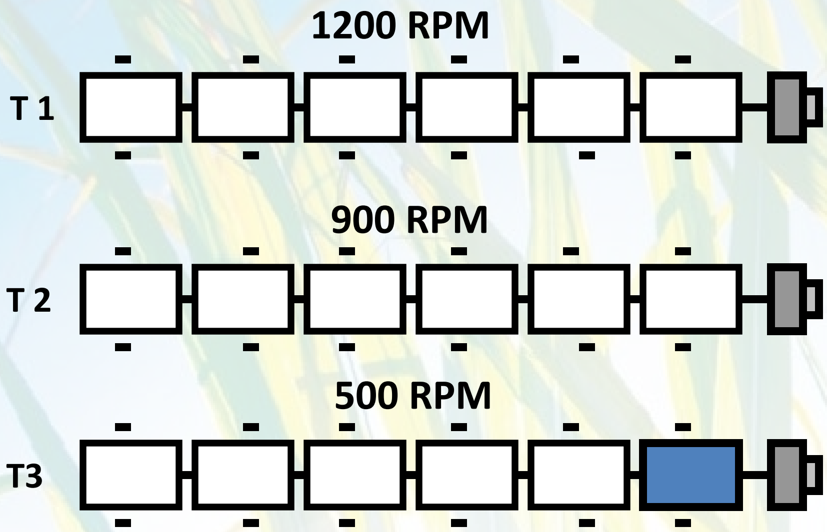


1 Self tipping haulout
Row lenght was measured

Mass Balance: Protocol



Mass Balance: Protocol



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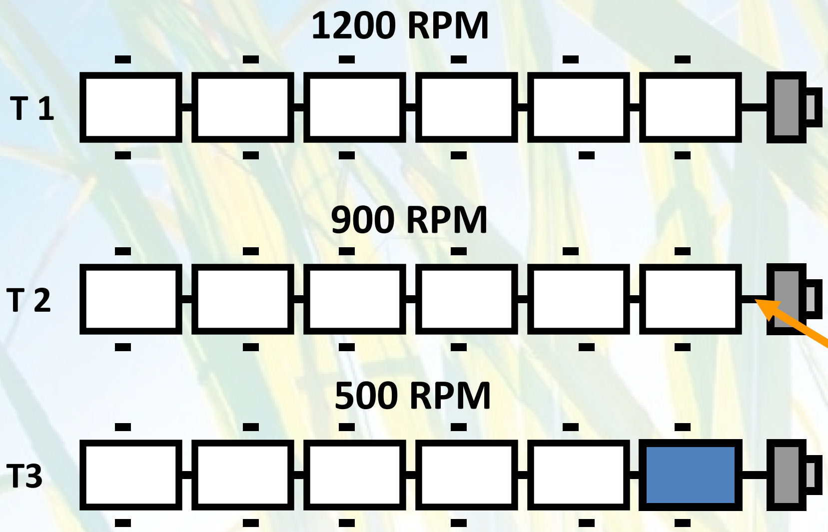

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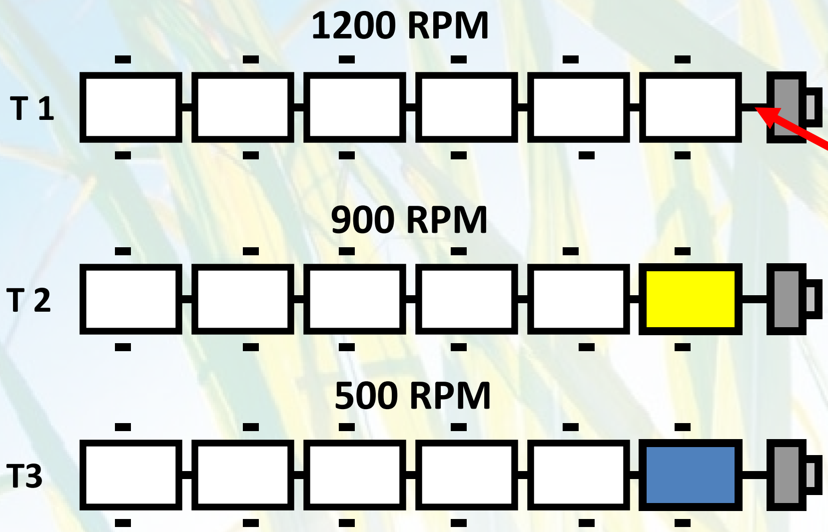
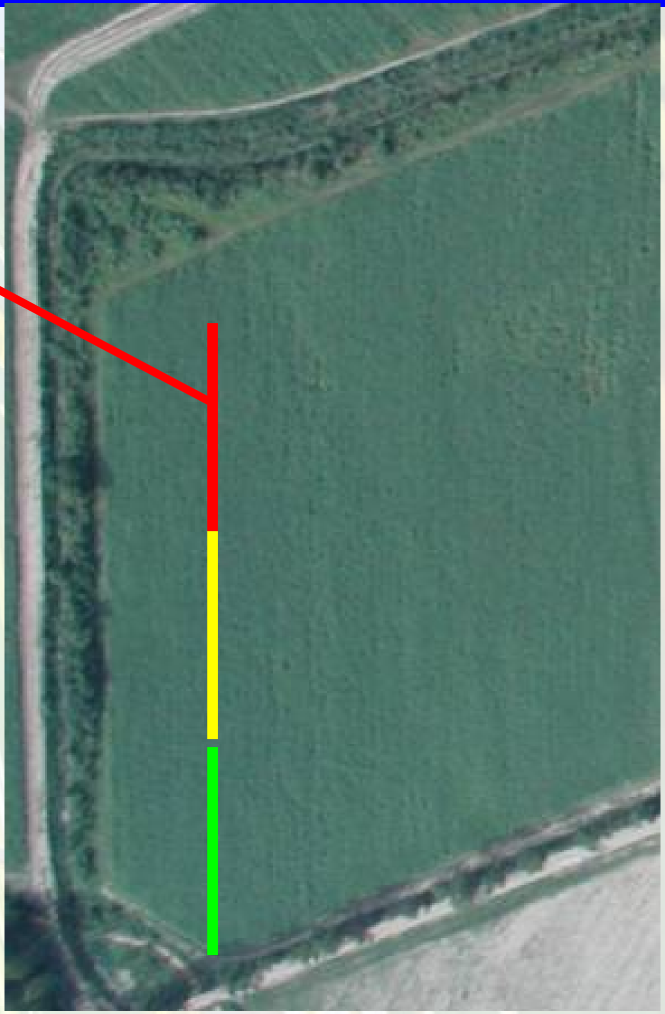
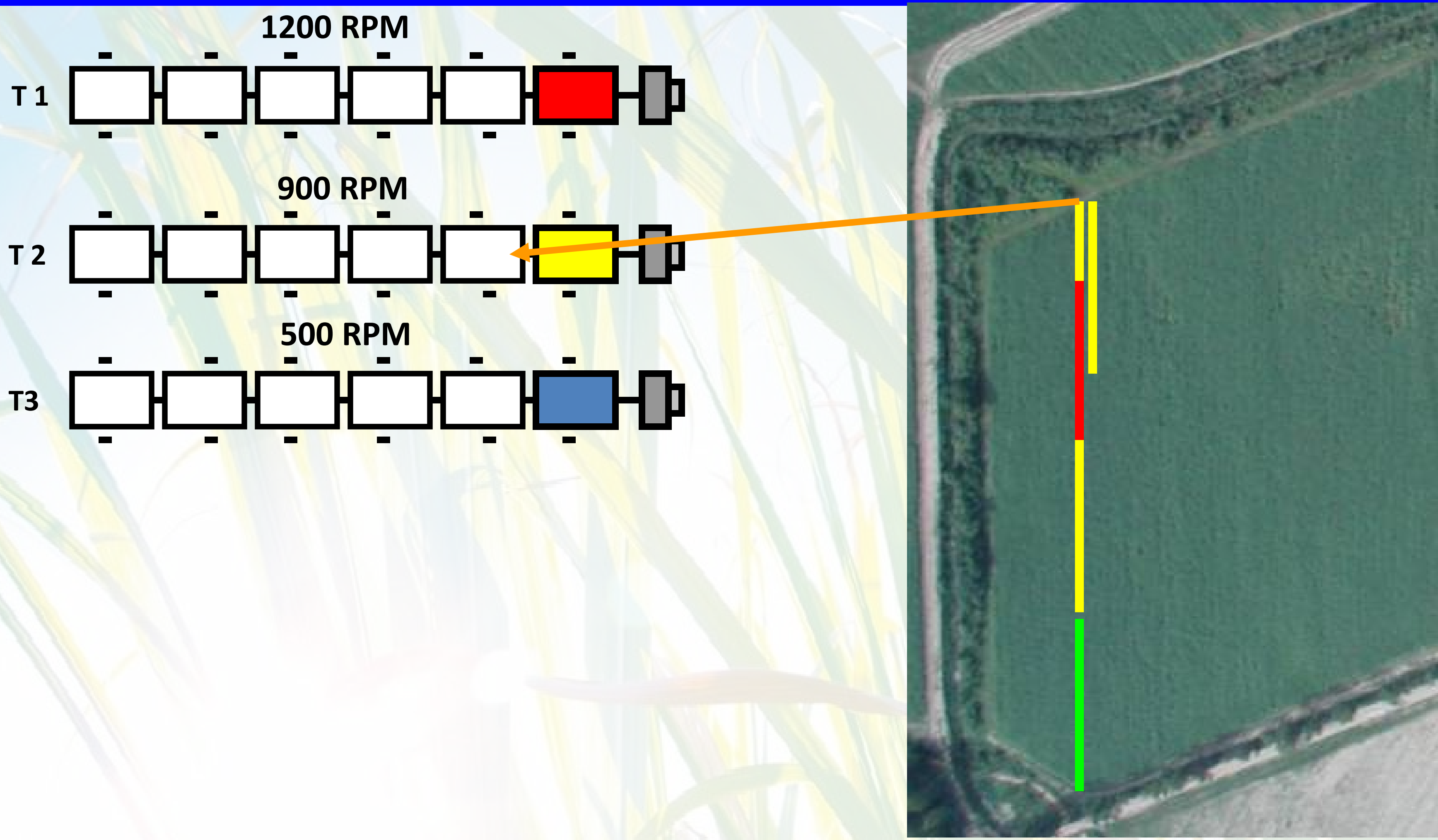
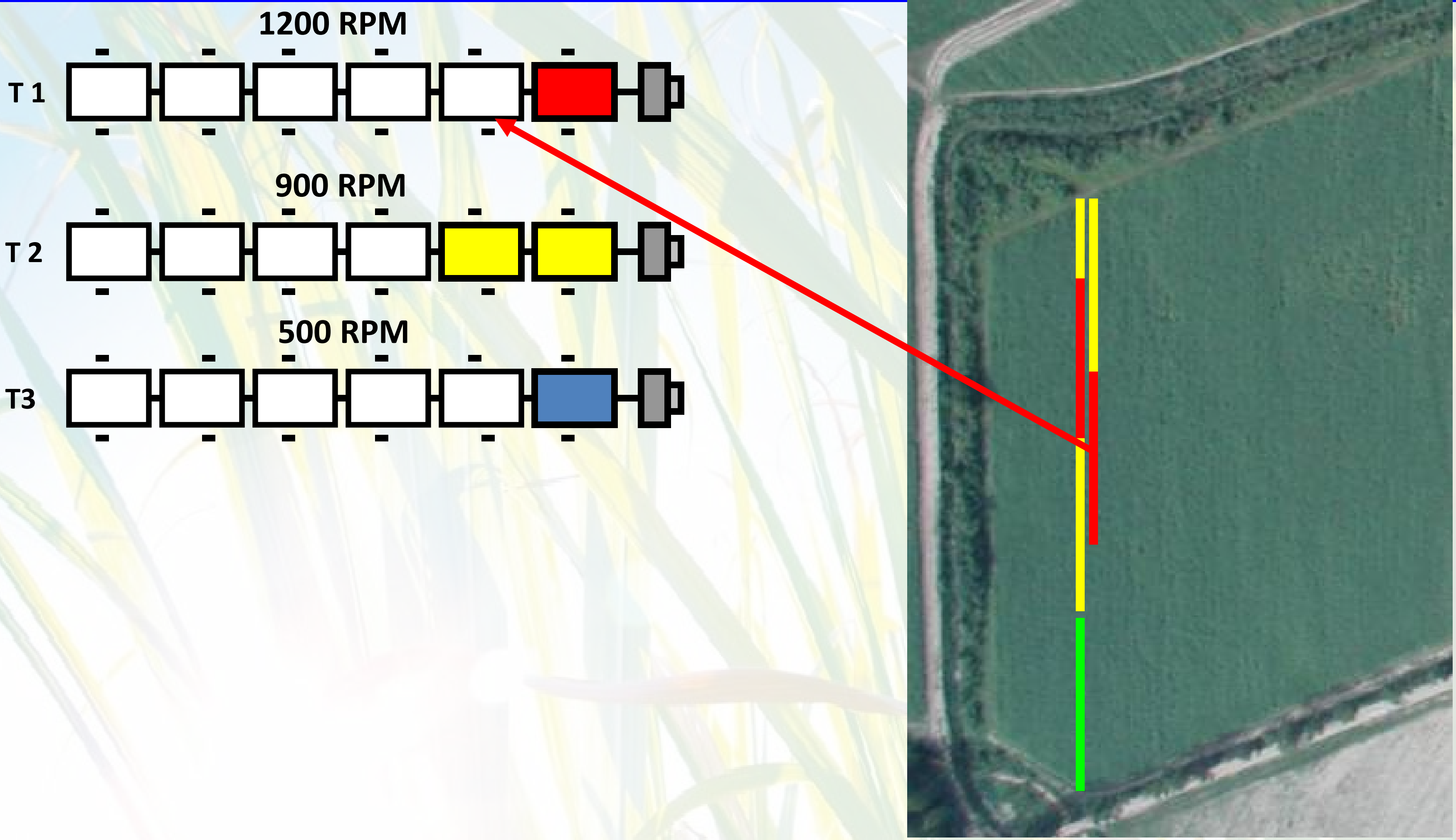




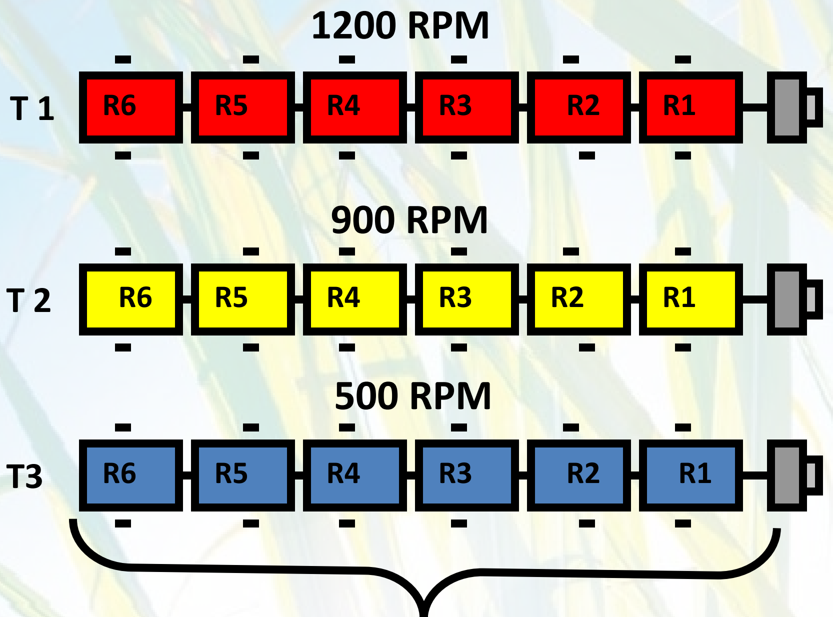
Mass Balance: Protocol



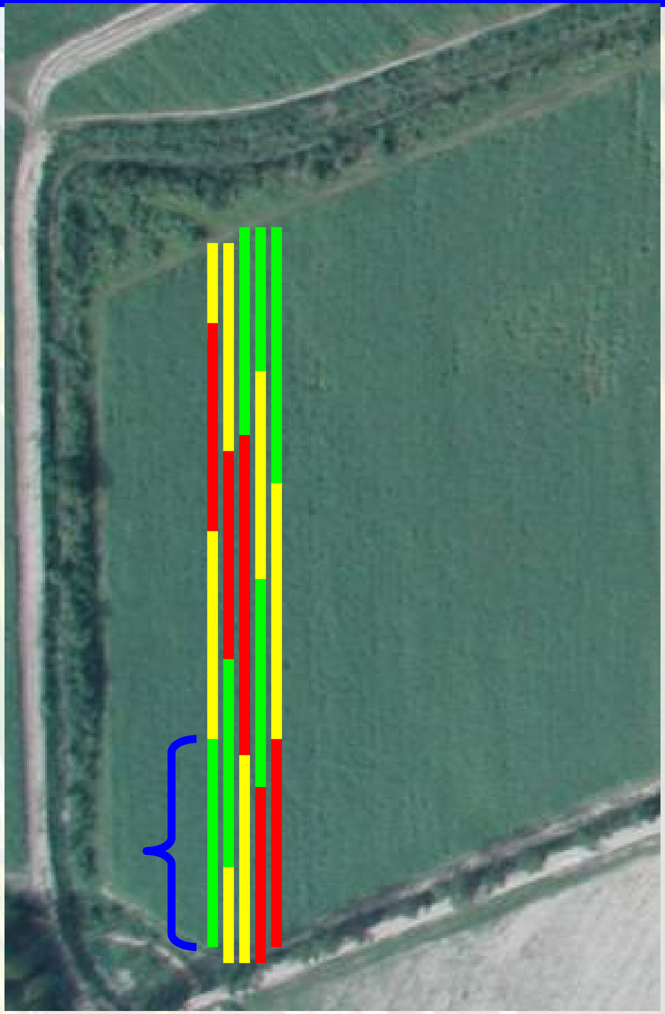
Mass Balance: Protocol



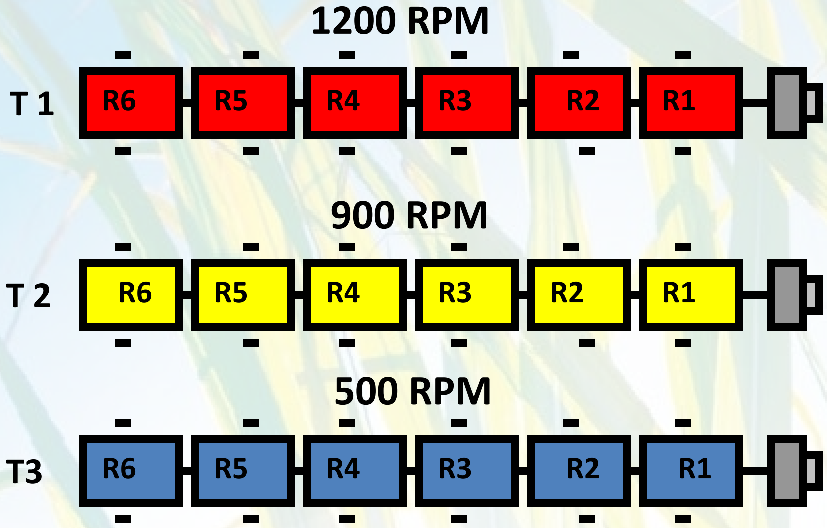
Mass Balance: Protocol

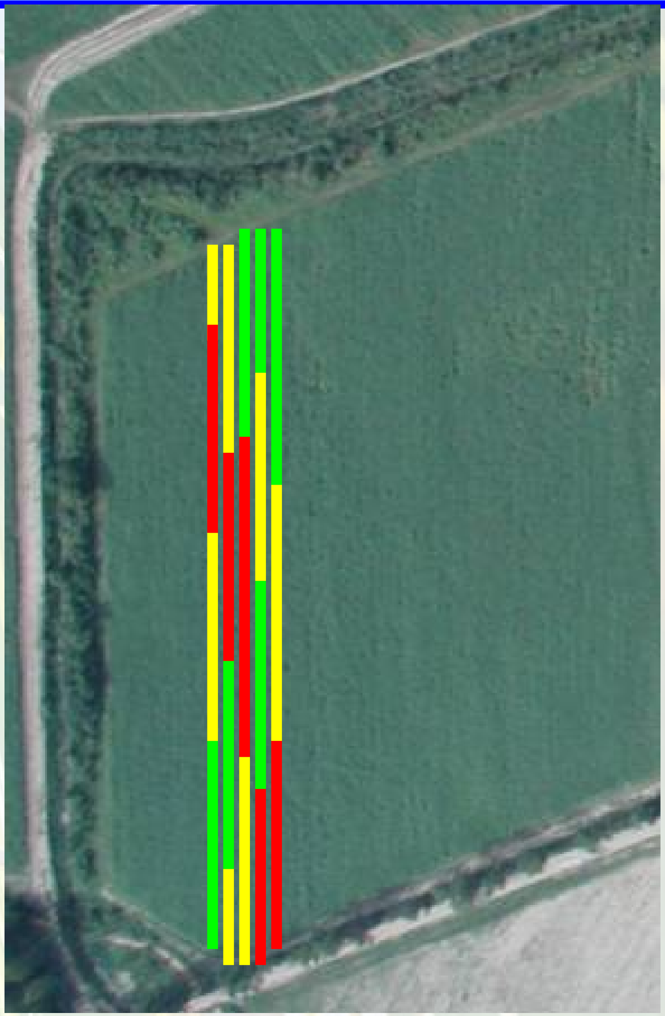


Wagons are weighted (by pairs of bins)
%Trash and CCS (Hidraulic Press) are determined



Mass Balance: Protocol

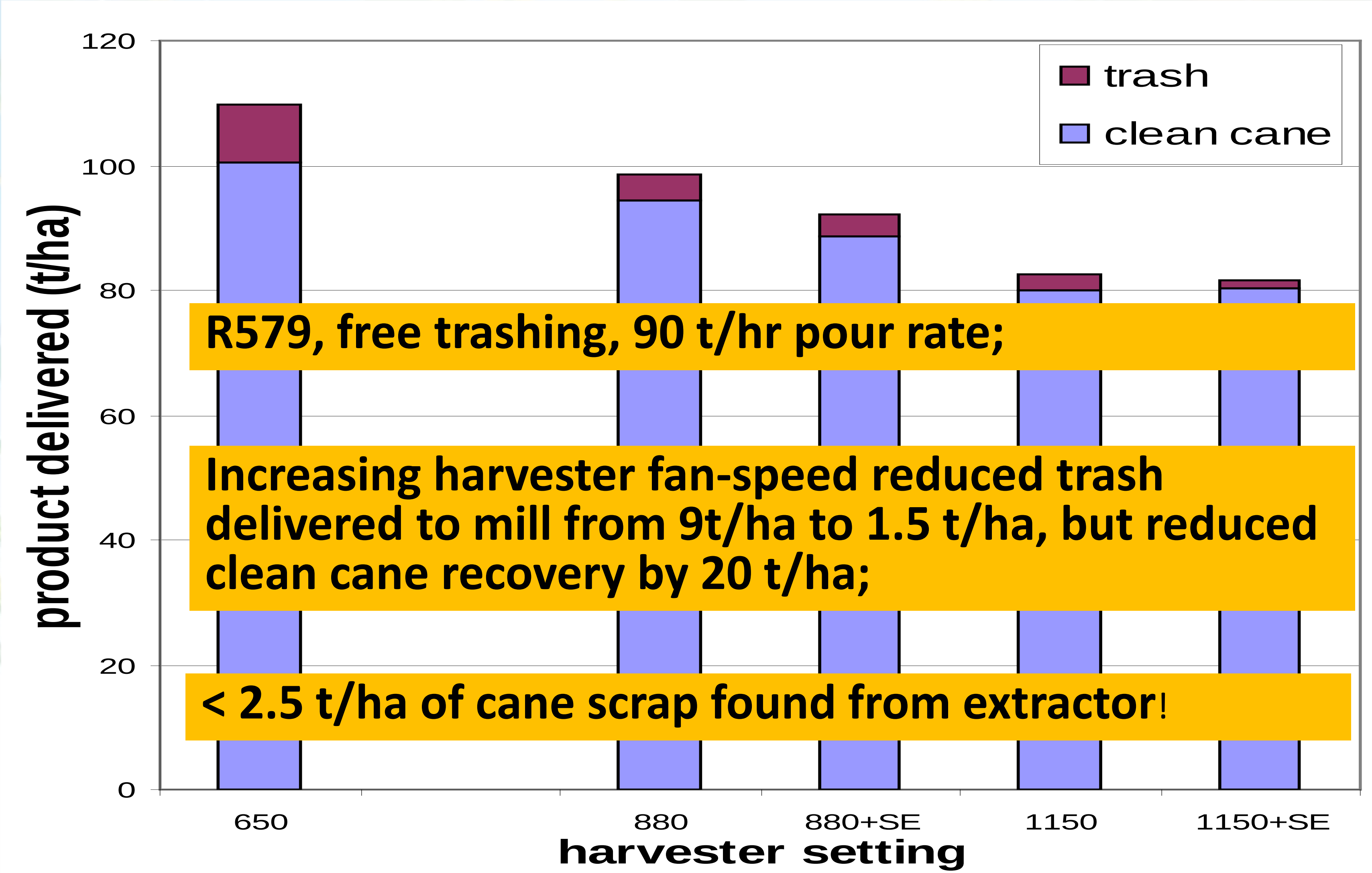




Calculations :

- **Net Cane =** Gross Cane - Trash
- **TCH :** Wagon Weight / (row lenght x row spacing)
- **TAH : TCH x Recov Sugar**

Cane Loss Trials: New Guinea May 2010

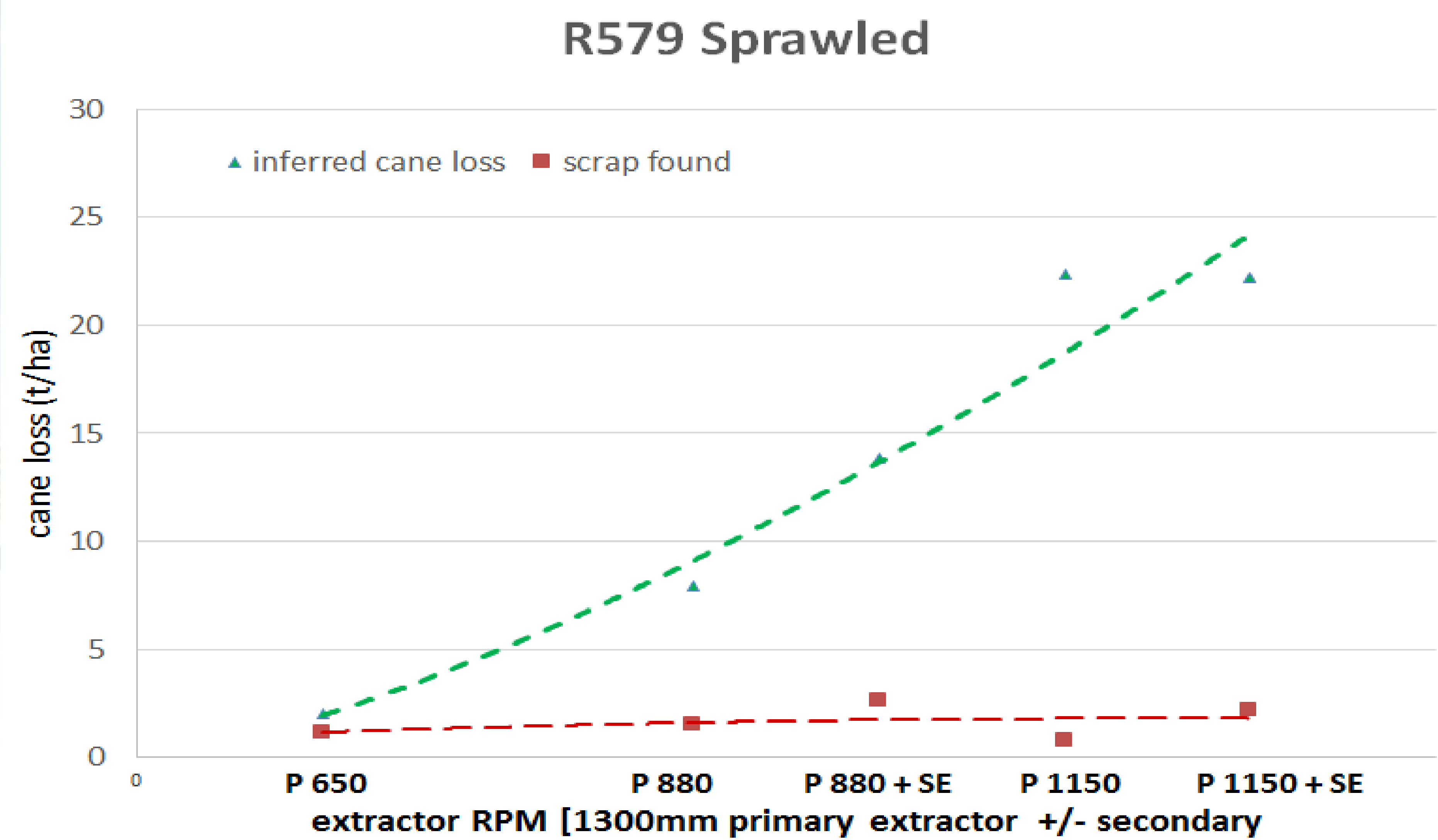


R579, free trashing, 90 t/hr pour rate;

Increasing harvester fan-speed reduced trash delivered to mill from 9t/ha to 1.5 t/ha, but reduced clean cane recovery by 20 t/ha;

< 2.5 t/ha of cane scrap found from extractor!

Cane loss Trial: Visible v's Invisible Losses



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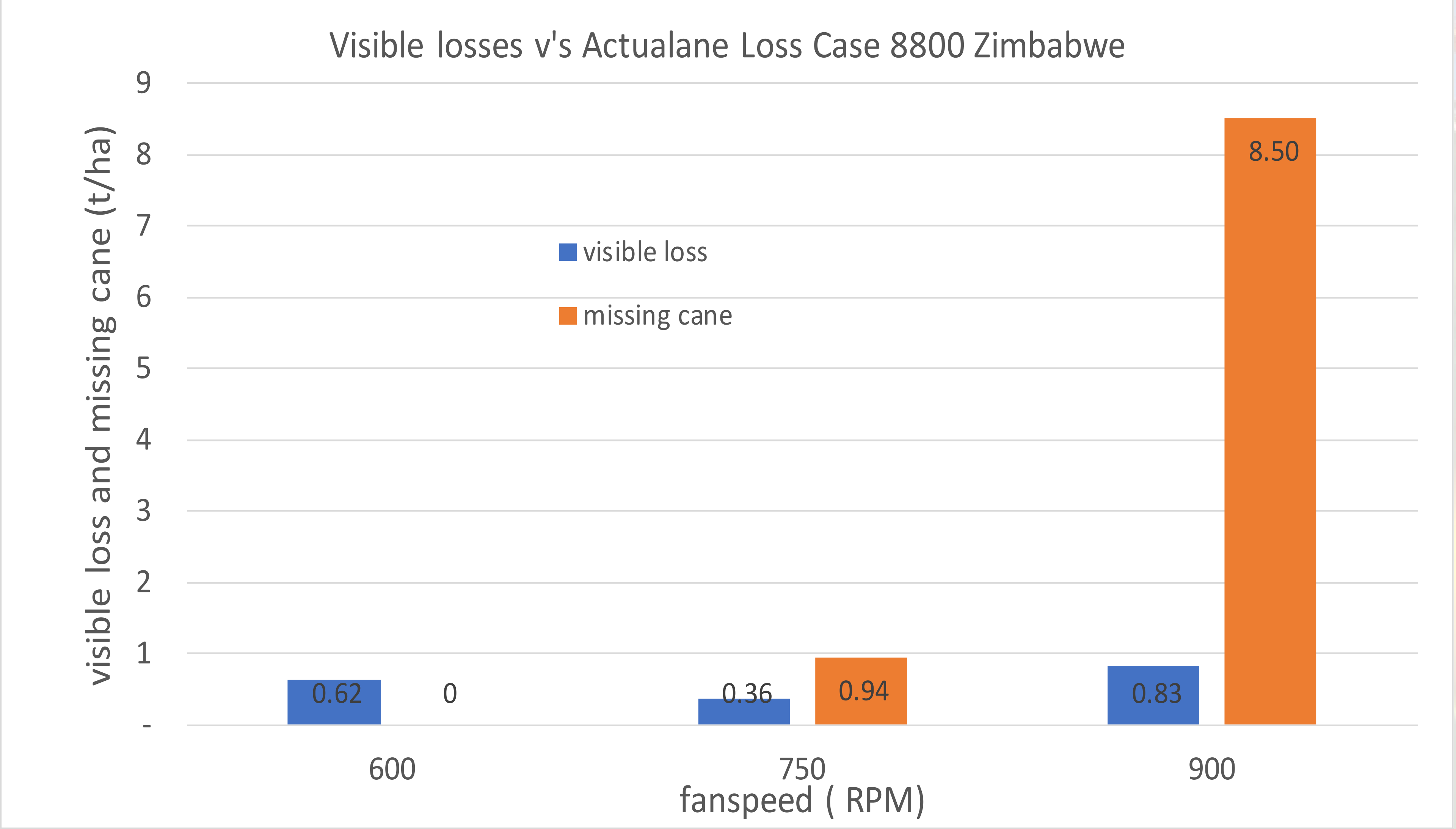


IV SIMPÓSIO INTERNACIONAL – STAB SUL
26 e 27 de Fevereiro de 2019
Hotel Mont Blanc - Av. Maurílio Biagi, 1577 - Ribeirânia - Ribeirão Preto - SP

STAB Regional Sul

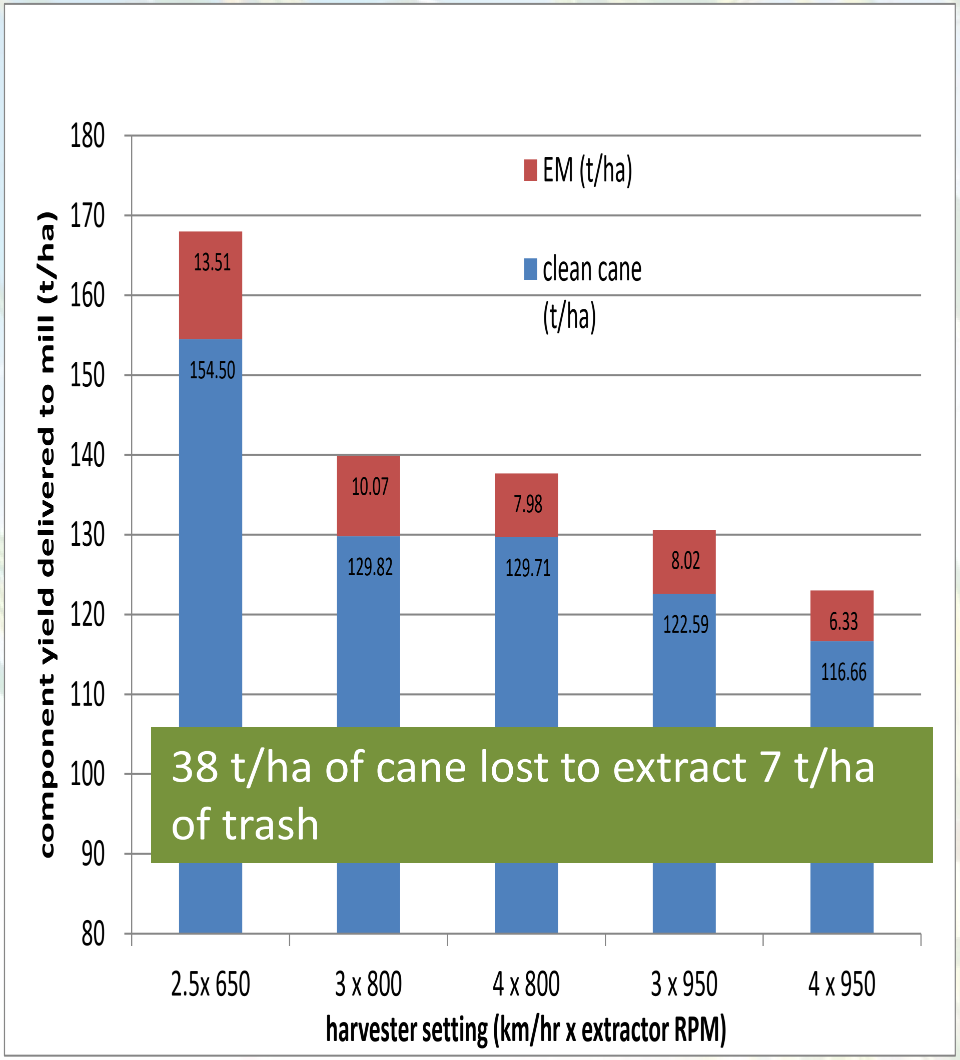
NORRIS Energy Crop Technology

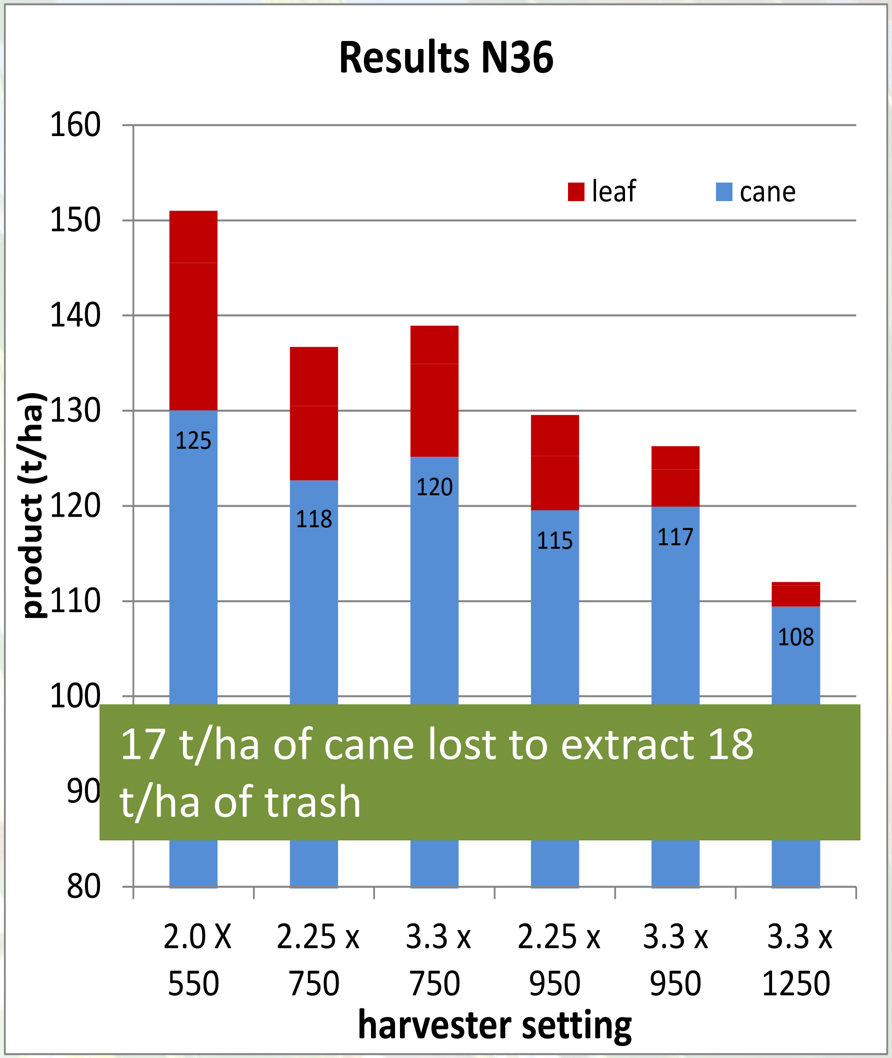
Factors Impacting on Cane Loss

Key factors impacting on cane loss for a particular harvest event include:

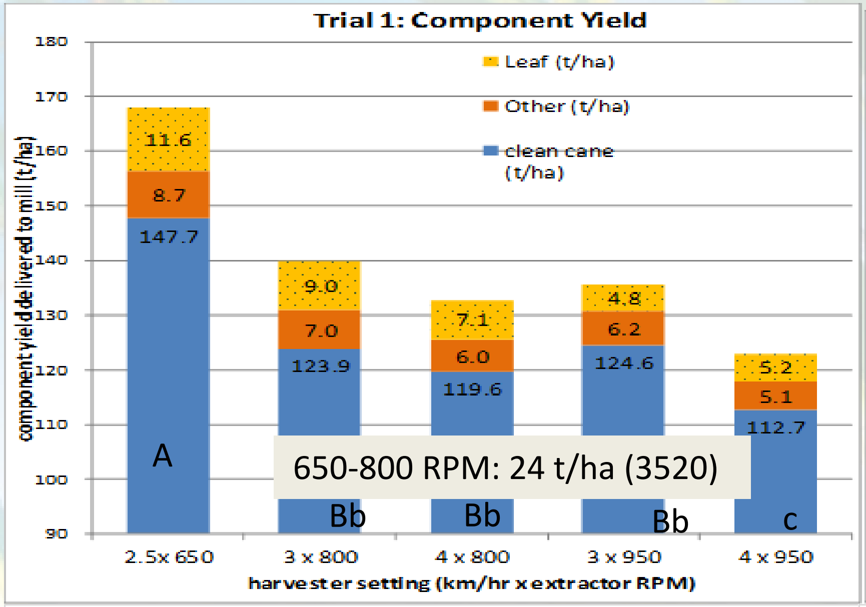
- Presentation of crop:
  - Lodged v's erect
- Level of trash and harvesting conditions
  - Variety
  - Damp v's dry
- Billet Length & Billet Diameter

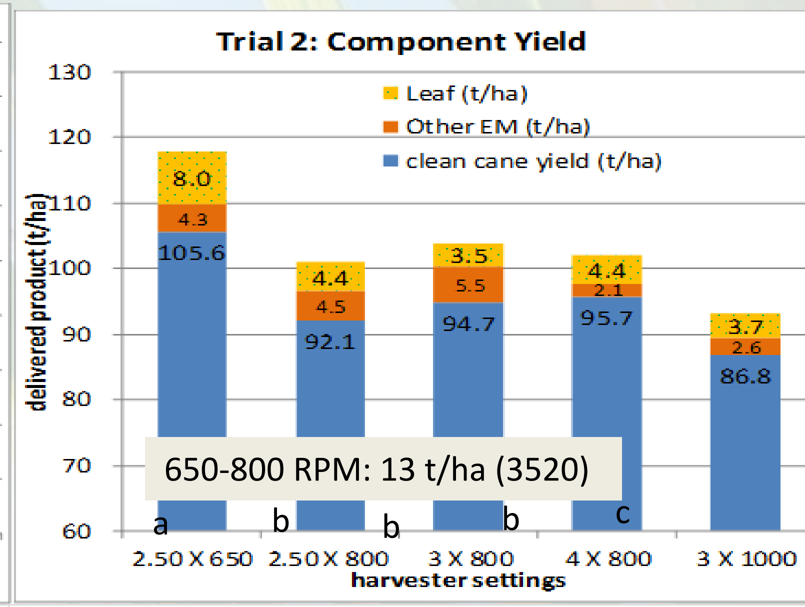
Nicaragua (Lodged) / Sth Africa (Erect)

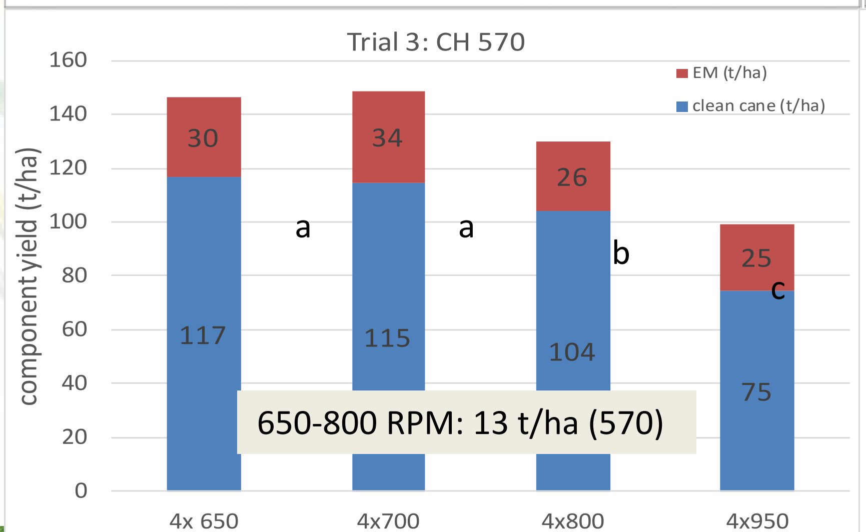


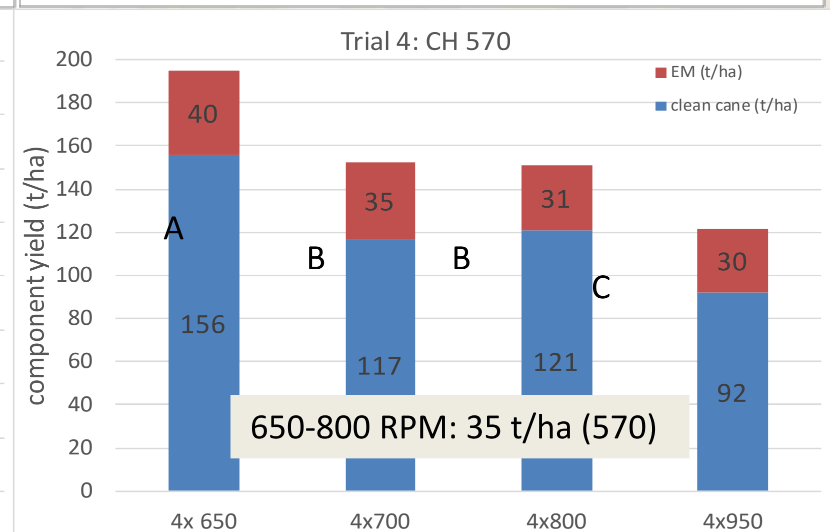


Cane Loss: Different Conditions & Harvesters, Nicaragua



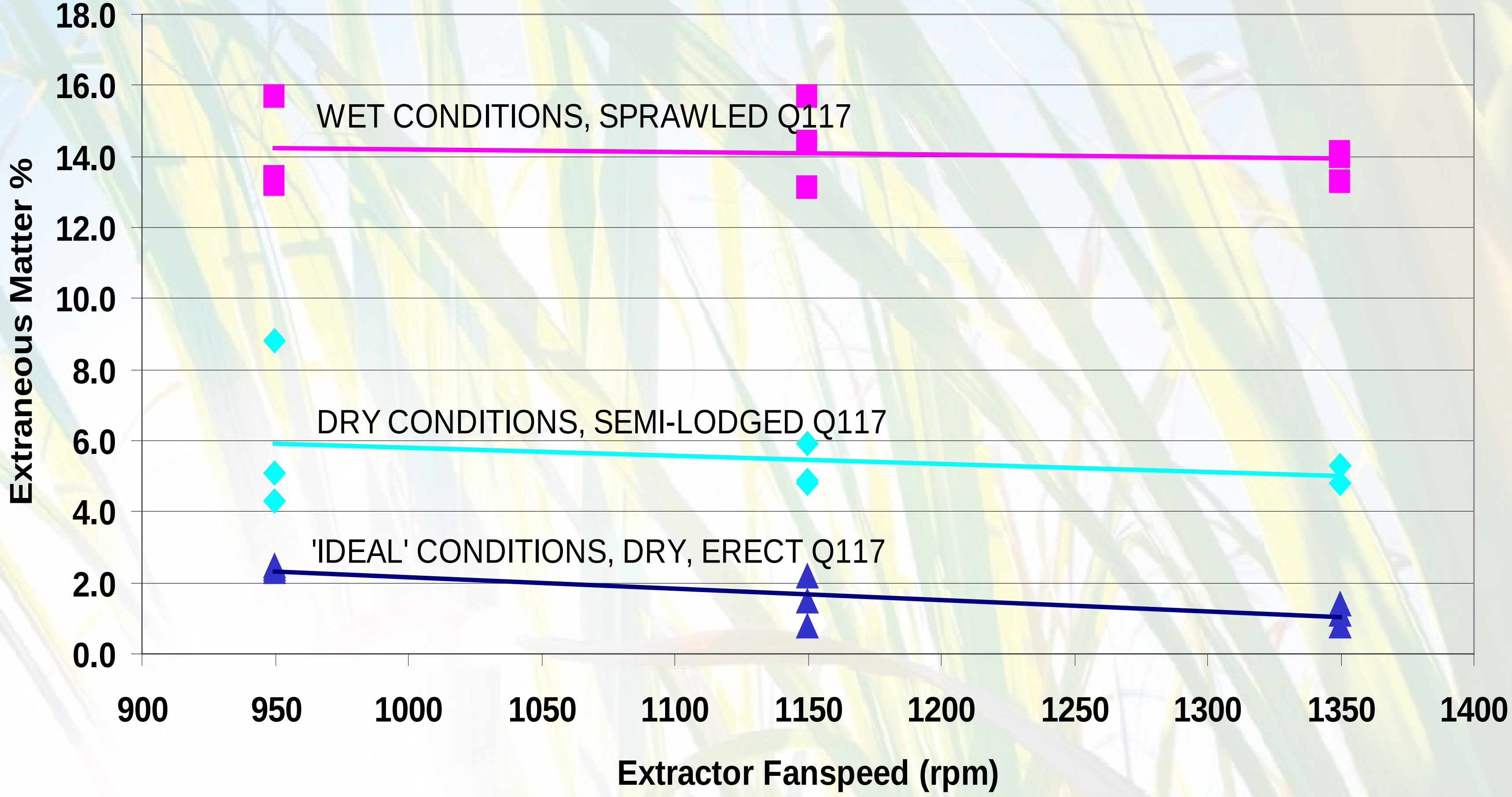






EM V's Field Conditions

- Field conditions dictate EM levels not fanspeed

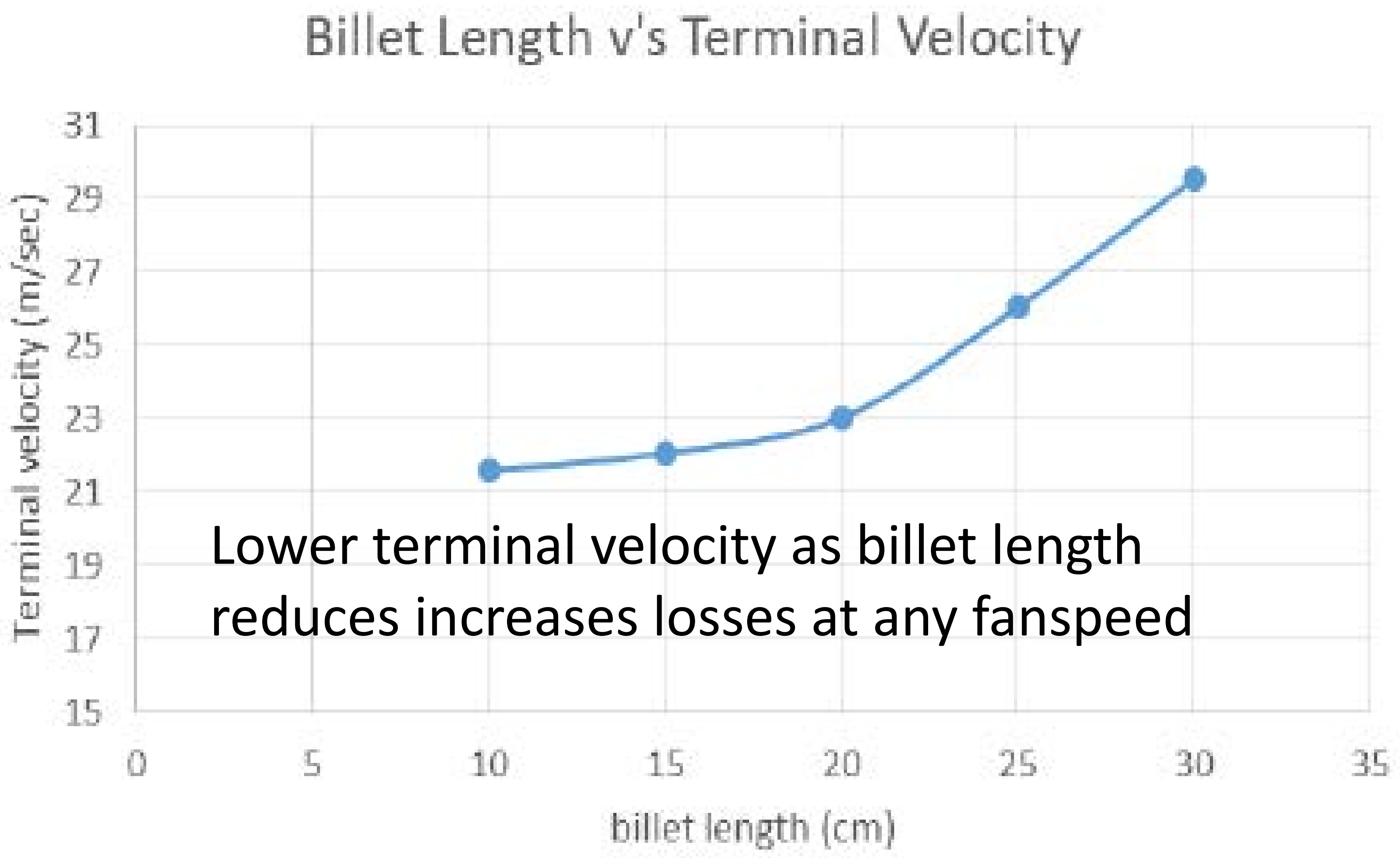


Cane Loss: Field Conditions (Tully 2013)

*   Damp conditions, wet trash in morning
** Same field being harvested in afternoon.

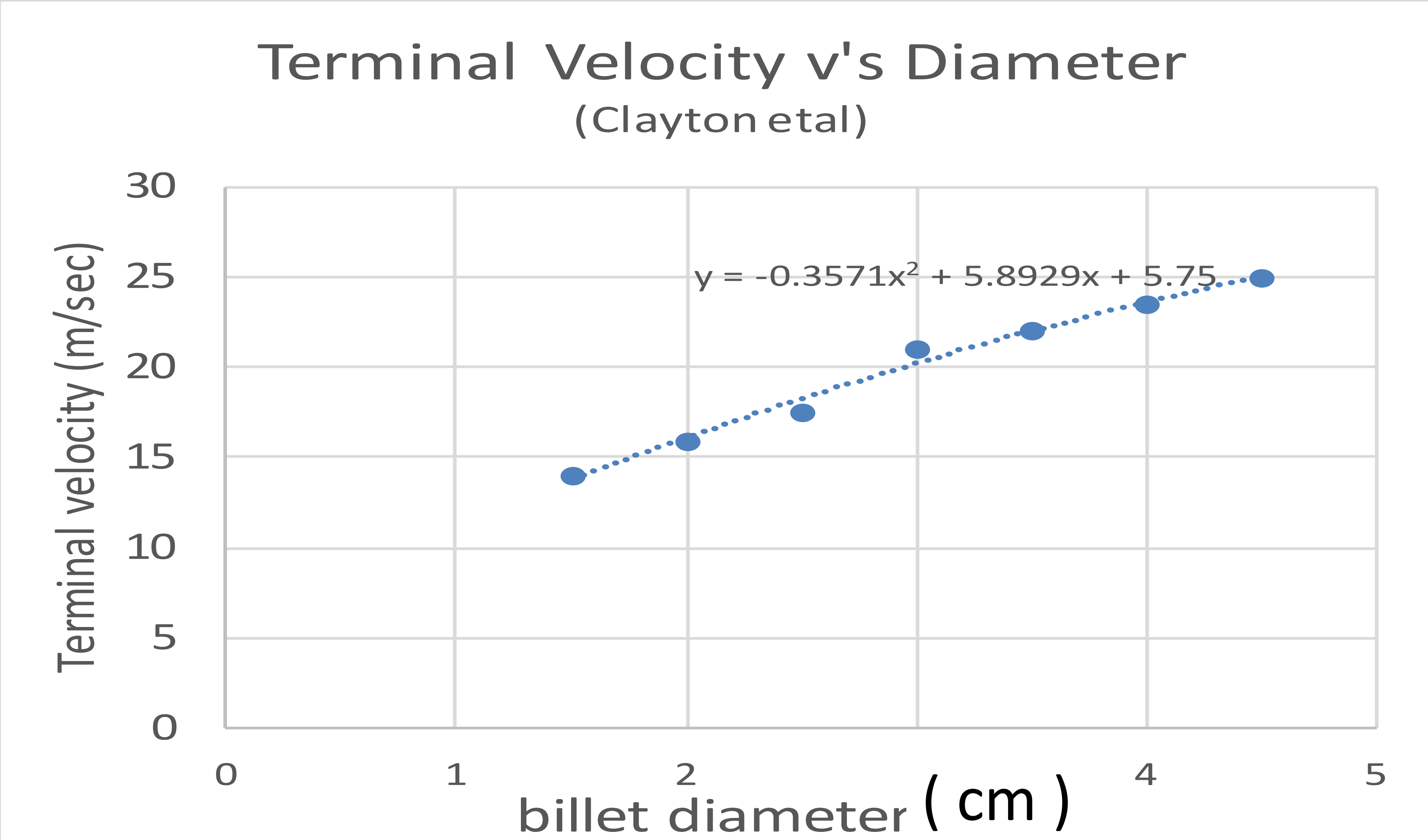
Fanspeed rpm	% Loss
780JD*	9.5%
800JD**	4.4%
710JD	6.4%
760JD	6.1%
800JD	10%

Billet length V’s Loss Potential



Lower terminal velocity as billet length reduces increases losses at any fanspeed

Billet Diameter v' Loss Potential

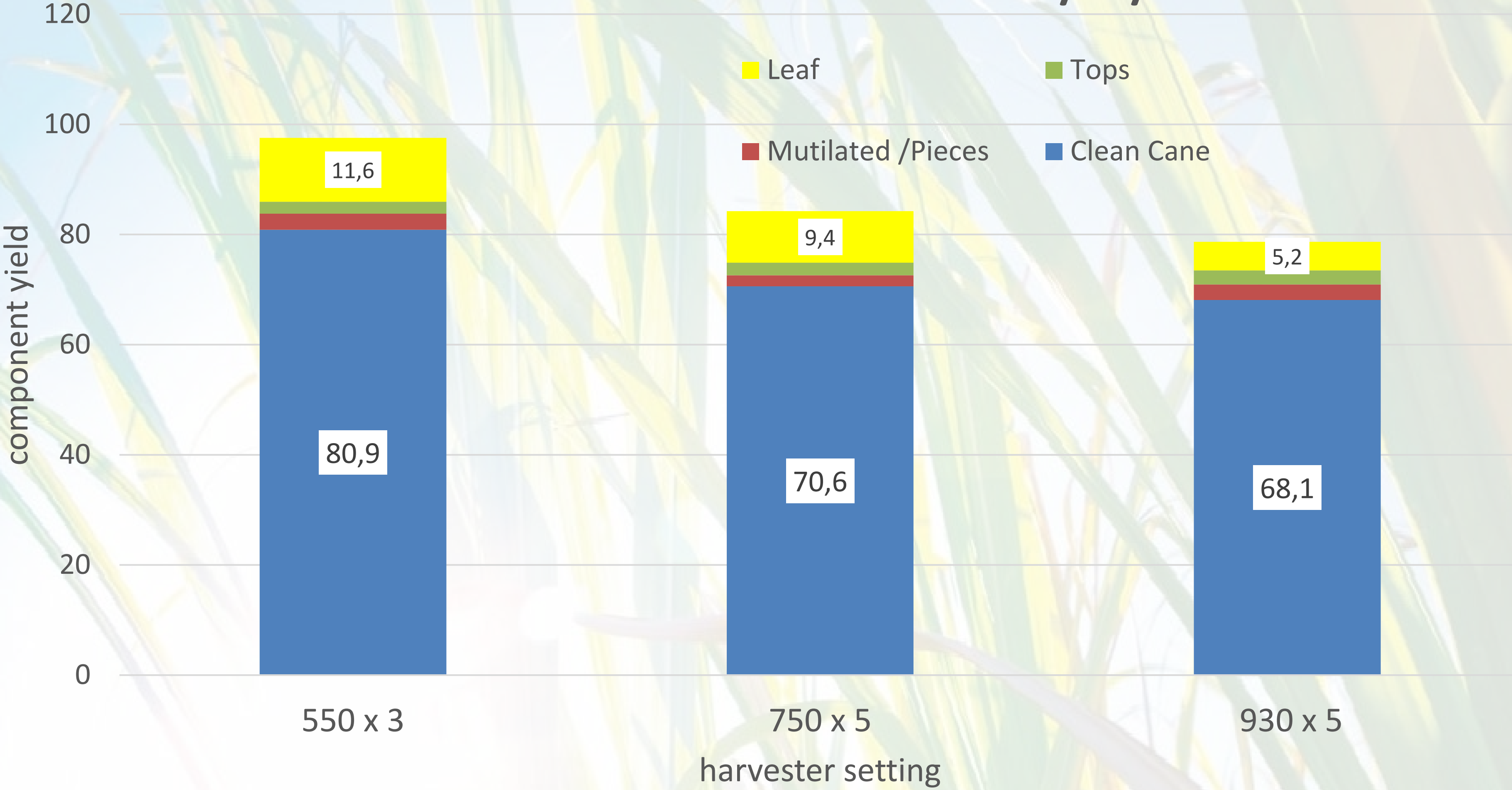


Sugar Loss: Billet Length and Diameter

- In an analysis of 45 cane loss trials, SRA researchers assessed the impact of :
  - Long (> 180mm) v’s short (< 180mm) billets
  - Thick (> 21 mm diameter) v’s (< 21 mm diameter)
- Over the trial program, the combination of short billets and thin diameter had, on average 50% higher cane loss than longer billets and thicker stalk diameter, at the same harvester settings.

CANE LOSS TRIAL: Ivory Coast

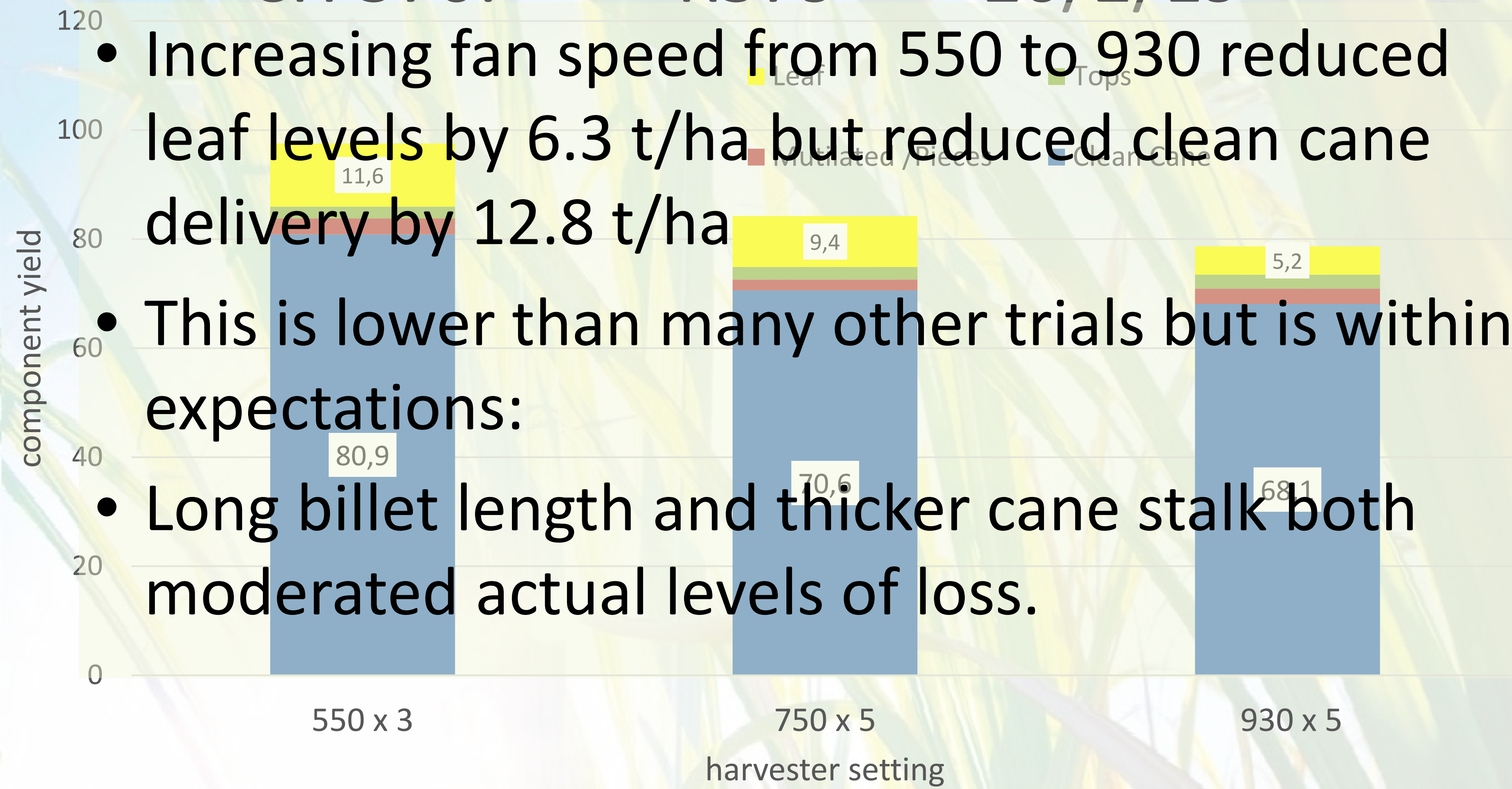
CH 570: R579 20/2/19



CANE LOSS TRIAL: Ivory Coast

CH 570: R579 20/2/19

- Increasing fan speed from 550 to 930 reduced leaf levels by 6.3 t/ha but reduced clean cane delivery by 12.8 t/ha
- This is lower than many other trials but is within expectations:
- Long billet length and thicker cane stalk both moderated actual levels of loss.



Cane loss trial:

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- Long billet length and thicker cane stalk both moderated actual levels of loss.

Harvester Performance: Cane Loss & Trash Extraction

- Cane Loss is real, and is mainly “invisible”.
- As fan speed and pour rate increase, extraction systems become less selective with respect to trash extraction and cane loss increases dramatically.
  - Typically, up to 500-600 RPM cane loss is low, but maximum 50% trash extraction
  - After 500-600 RPM, each additional tonne of trash removed by the harvester takes increasing amounts of cane with it.
    - Up to 5 tonnes cane/tonne of leafy trash
  - At maximum fan speeds, cane loss can exceed 30%.
- Poor harvesting conditions and high pour rates increase both EM and cane loss

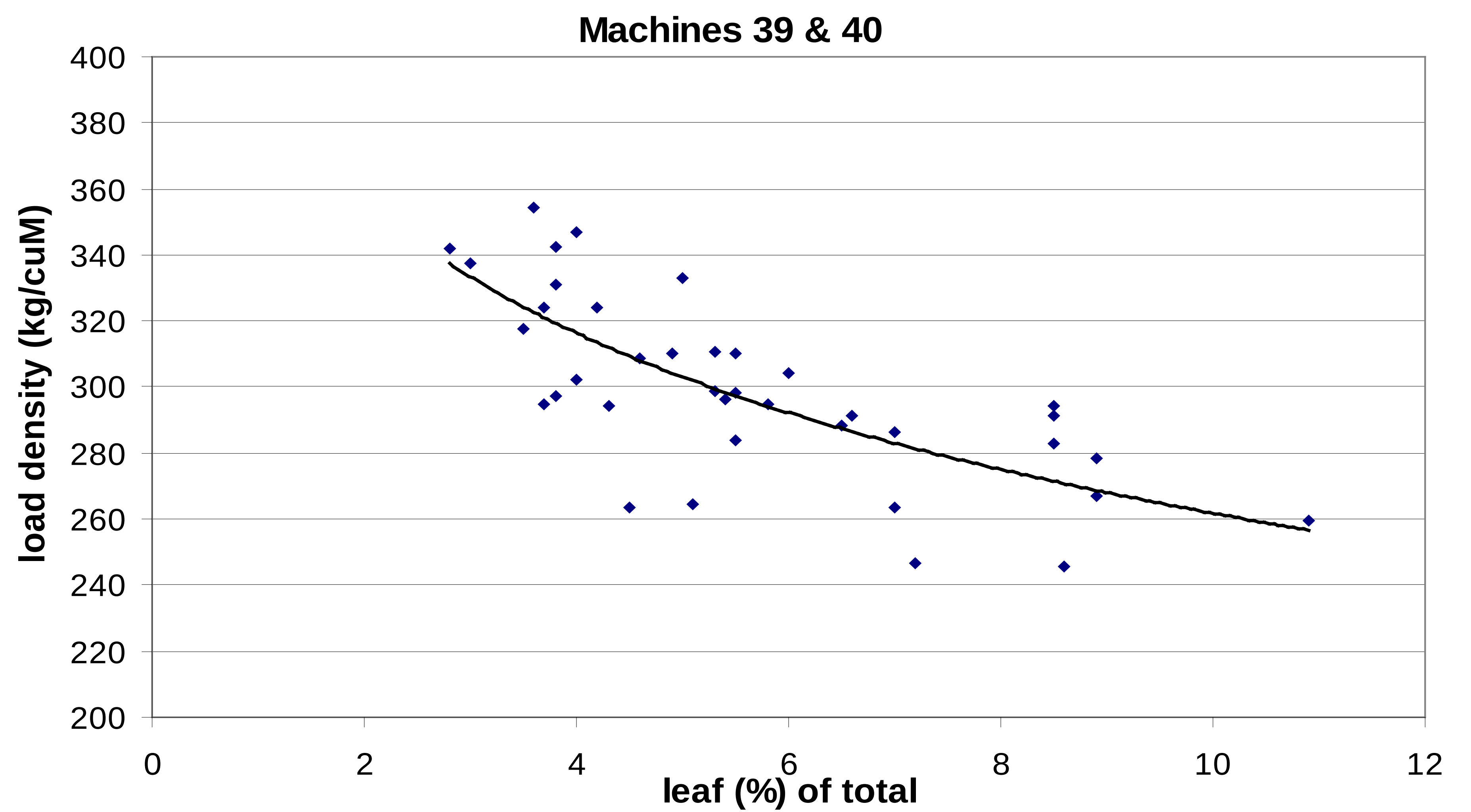
Impact of Increasing Trash Levels

Increasing trashy EM levels

- Reduce transport density
  - Transport costs
  - Unloading system capacity

- Increased fibre and impurities:
  - Reduced mill extraction, milling rate and increased boiling house losses
    - Reduced sugar quality

Impact of leaf % on load density:
(Ramu Fan speed trial May 2010, 2 harvesters)



Yield v's transport payload: Mauritius

Impact of Trash on Mill Performance:

Work at Mossman & Condong Mills by Kent [1] indicated:

- **"The results showed sugar recovery reduced by 0.9 units for each 1.0 unit increase in cane fibre content caused by increased trash content.**
- **The sugar analysis showed increased ash and colour, and some evidence of decreased filterability.**
- **The results indicated that the reduced sugar recovery was caused by greater Pol losses in molasses, bagasse and mud, in that order of importance."**

- [1] Kent,G.A., Moller, D.J., Scroope, P.D., Broadfoot, R., (2010) The Effect of Whole Crop Processing on Sugar Recovery and Sugar Quality. Proc of Aust Soc Sugarcane Technol V32, pp 559-572.

EM Levels v's Sugar Recovery

Viator demonstrate that the reduction in cane loss can be negated by increased milling losses associated with higher trash levels.

Harvester fanspeed	650	850	1050
Measured cane loss	Control	6.1 t/ha	16.4 t/ha
ERC of delivered cane	Control	+ 0.7 units	+ 1.4 units
Recovered Sugar	10.6 ts/ha	10.6 ts/ha	10.0 ts/ha

"Less than 15% of known cane loss could be found"

Viator, R.P. Richard, E.P., Viator, B.J. Jackson, W., Waugespack, H.L., Birkett, H.S. (2007). "Sugarcane Chopper Harvester Extractor Fan and Groundspeed Effects on Sugar Yield, Cane Quality and Field Losses". Applied Engineering in Agriculture. Vol 23 No 1.

Maximising Sucrose Recovery:

- Because of the negative impact of increasing leafy EM on sucrose recovery, the optimum operating point still occurs at concerning levels of cane loss (typically >5 t/ha).
- The implementation of strategies such as post harvest cleaning can facilitate further significant increases in total sucrose recovery, by allowing the harvester to operate at low cane loss settings whilst then supplying the mill with very clean cane.

Review of Losses

- Tangible costs drive many decisions.
  - Harvesting speed and pour rate
    - Maximise harvester output
  - Billet length & extractor speed
    - Transport costs and milling concerns
- Most Industries are unaware of the destruction in Industry value which is occurring, because of the lack of knowledge of magnitude of losses

Maximising Sugar & Value Recovery

Value Destruction is minimised by:

- Minimising losses on the harvester
  - Reduced extractor fan speed of “fans off”
- Minimising losses during the milling process
  - Post harvest cane cleaning
- Additional income can be achieved by utilisation of the proportion of the trash resource which comes to the mill with the cane.
  - Additional transport costs more than covered by increased sucrose recovery
  - Trash available as a “no cost” resource for further value adding.
- Alternative strategy is “field edge” cane cleaning.

“Field Edge” Cane Cleaning

Cleaner Operating

Trash exiting trash chute

Cleaned cane in elevator of cleaner

"Field Edge" Cane Cleaning

“Field Edge” Cane Cleaning

Questions & Comments