Seedling Quality Program – A Tool For Improving Survival

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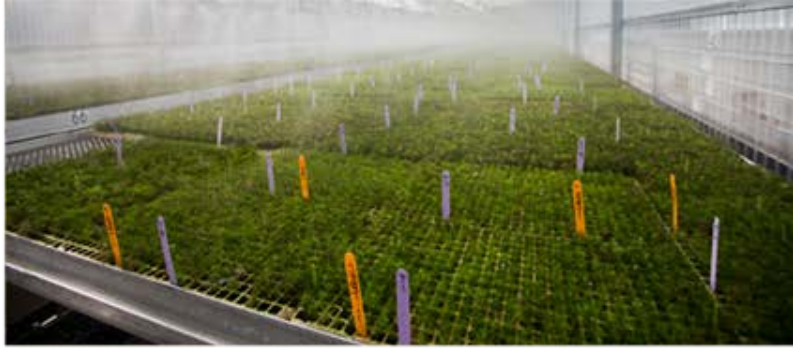
ArborGen

The Reforestation Advantage



Seedling Quality Assessment (SQA) Program

- Seedling Quality Assessment (SQA) Program
  - A high quality seedling is one that can survive prolonged environmental stress and produce vigorous growth following out planting
  - The definition of a quality seedling can vary based on a customers objective and can be affected by factors such as provenance, climatologically factors, planting site and time of planting
  - **No single factor has been shown to provide a perfect predictor for out-planting success, but each has been linked with seedling quality in some way**

Benefits of a SQA Program

- Provides a quantitative assessment that can be used to guide seedling management at the nursery level
  - Another tool for the nursery managers
  - Improve on predictors that lead to out-planting success
- Nurseries are always looking to control COGS
  - The lower the density, the higher the cost
- Provides a long-term benchmarking system for producing quality seedlings
- Quantitative support to help address issues that can occur after planting
- Increase in sales of higher genetics (“Education Factor”)
  - Customers are spending more on seedlings then ever before
  - Expectations are high given the price
  - More emphasis on seedlings meeting contract specs

General Measurements of a SQA Program

- Height
- Root Collar Diameter (RCD)
- Height:Diameter Ratio
- Seedling Grade Distribution
- Root Weight Ratio
- Shoot:Root Ratio
- Tap Root Length
- Number of First Order Lateral Roots
- Plug Fill Assessment (Container Programs)

General Outline - SQA Program

- Life History Plots (Growing Season)
  - Height
  - RCD
  - Height:Diameter Ratio
  - Plug Fill Assessments (Container Program)
- Finished Seedling Evaluations (Lifting Season)
  - Height
  - Root Collar Diameter (RCD)
  - Height:Diameter Ratio
  - Seedling Grade Distribution
  - Root Weight Ratio
  - Shoot:Root Ratio

LIFE HISTORY PLOTS (GROWING SEASON)

Life History Plots – A Tool for Nursery Managers

- Purpose:
  - Track survival and crop development throughout the growing season
  - Develop long term growth models

- Process:
  - Determine the number of plots to establish
    - Genetic Level (Open-Pollinated/Full-Sib/Varietal)
    - Provenance (Coastal/Piedmont/Texas/Arkansas)
  - Determine measurement schedule
  - Establish Permanent Plots
  - Audit Plots (Recommended)

Determine the Number of Plots & Plot Establishment

Develop a Measurement Schedule

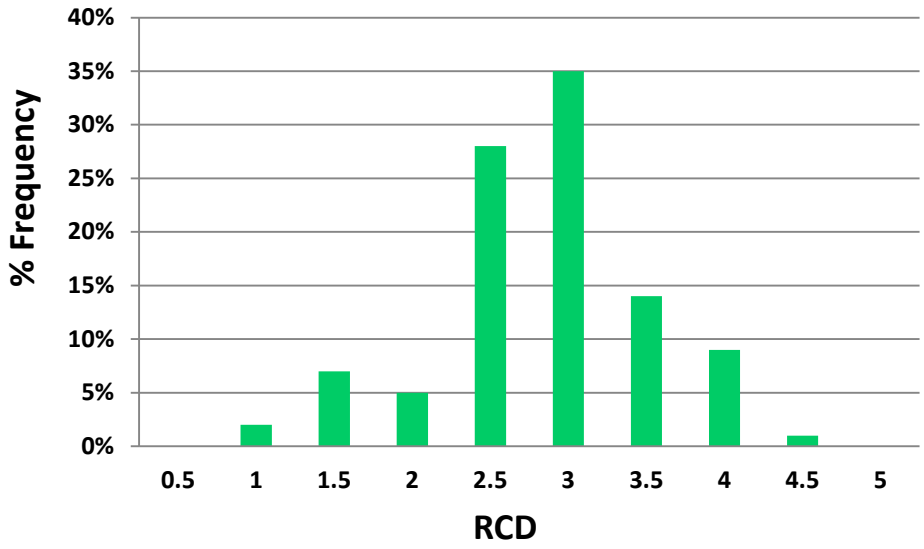
	Crop ID	IFMO-T12-10	IFMO-T12-11	IFMO-T12-12	IFMO-T12-12	IFMO-T12-13	IFMO-T12-14	IFLA-T12-14	IFMO-T12-15	IFMO-T12-15	IFMO-T12-16
Stock Type		128L	128L	110	128L	128/135	128/135	120S	128L	120S/128L	V93
Species		LL	LL	LL	LB	LL	LL	LB	LB	LB	LB/SHLF
5-Mar	10	Sown									
12-Mar	11		Sown								
19-Mar	12			Sown	Sown						
26-Mar	13					Sown					
2-Apr	14						Sown	Sown			
9-Apr	15								Sown	Sown	
16-Apr	16	WK 6									Sown
23-Apr	17		WK 6								
30-Apr	18			WK 6	WK 6						
7-May	19					WK 6					
14-May	20	WK 10					WK 6	WK 6			
21-May	21		WK 10						WK 6	WK 6	
28-May	22			WK 10	WK 10						WK 6
4-Jun	23					WK 10					
11-Jun	24	HT/RCD					WK 10	WK 10			
18-Jun	25		HT/RCD						WK 10	WK 10	
25-Jun	26			HT/RCD	HT/RCD						WK 10
2-Jul	27					HT/RCD					
9-Jul	28	HT/RCD					HT/RCD	HT/RCD			
16-Jul	29		HT/RCD						HT/RCD	HT/RCD	
23-Jul	30			HT/RCD	HT/RCD						HT/RCD
30-Jul	31					HT/RCD					
6-Aug	32	HT/RCD					HT/RCD	HT/RCD			
13-Aug	33		HT/RCD						HT/RCD	HT/RCD	
20-Aug	34	FI		HT/RCD	HT/RCD						HT/RCD
27-Aug	35		FI			HT/RCD					
3-Sep	36	HT/RCD		FI	FI		HT/RCD	HT/RCD			
10-Sep	37		HT/RCD			FI			HT/RCD	HT/RCD	
17-Sep	38			HT/RCD	HT/RCD		FI	FI			HT/RCD
24-Sep	39					HT/RCD			FI	FI	
1-Oct	40	HT/RCD					HT/RCD	HT/RCD			FI
8-Oct	41		HT/RCD						HT/RCD	HT/RCD	
15-Oct	42			HT/RCD	HT/RCD						HT/RCD
22-Oct	43					HT/RCD					
29-Oct	44	HT/RCD					HT/RCD	HT/RCD			
5-Nov	45		HT/RCD						HT/RCD	HT/RCD	
12-Nov	46			HT/RCD	HT/RCD						HT/RCD
19-Nov	47					HT/RCD					

SQA Sample Measurements

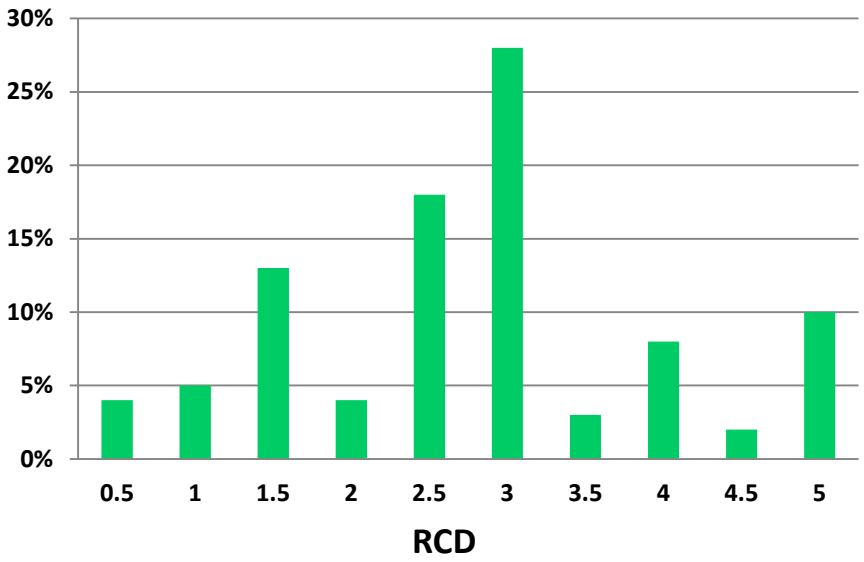
		Nursery X - August 2013			
AG Code	Prov	Avg HGT	St.Dev. HGT	Avg RCD	St.Dev. RCD
Family A	Coastal	8.80	0.24	3.03	0.22
Family B	Coastal	8.90	0.17	3.08	0.31
Family C	Coastal	9.00	0.21	3.32	2.60
Family D	Coastal	8.80	0.18	3.41	0.34
Family E	Coastal	9.00	0.16	3.12	0.29
Family F	Piedmont	8.80	0.27	3.04	0.22
Family G	Piedmont	8.50	0.21	3.02	0.28
Family H	Piedmont	8.80	0.18	2.79	0.19
Family I	Piedmont	7.80	0.16	3.28	0.35
Family J	Piedmont	7.40	1.70	3.61	0.34
Family K	Texas	8.90	0.26	3.49	0.30
Family L	Texas	8.90	0.19	3.22	0.26
Family M	Texas	7.90	0.11	3.43	0.33

RCD Distribution – Same Average RCD

Family A

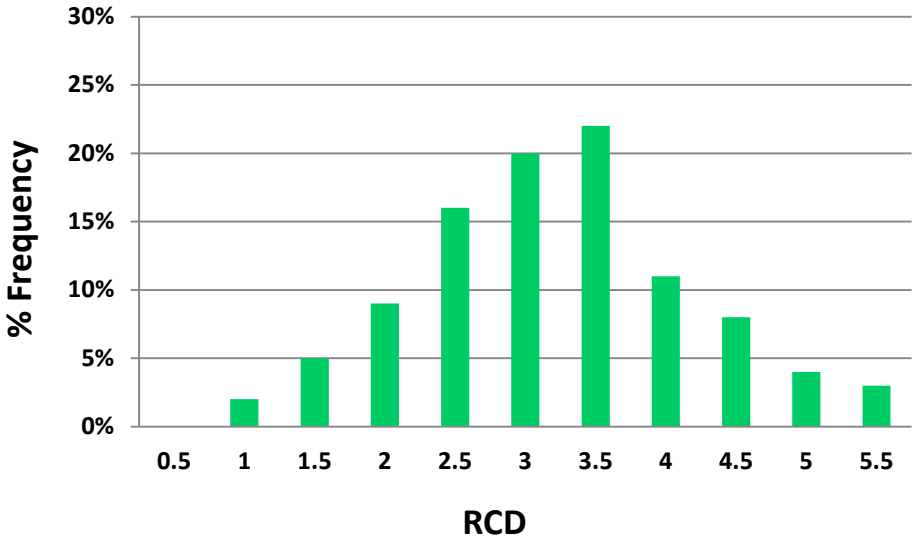


Family B

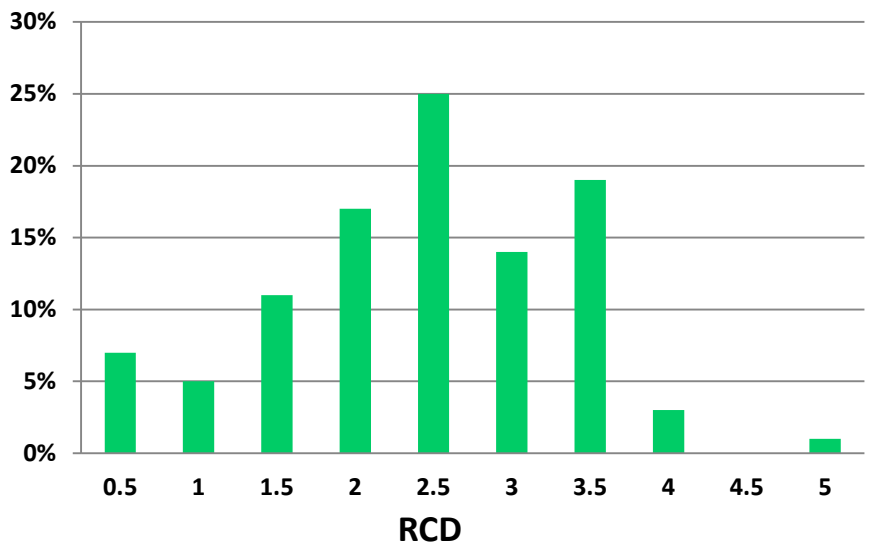


RCD Distribution – Effect of Density

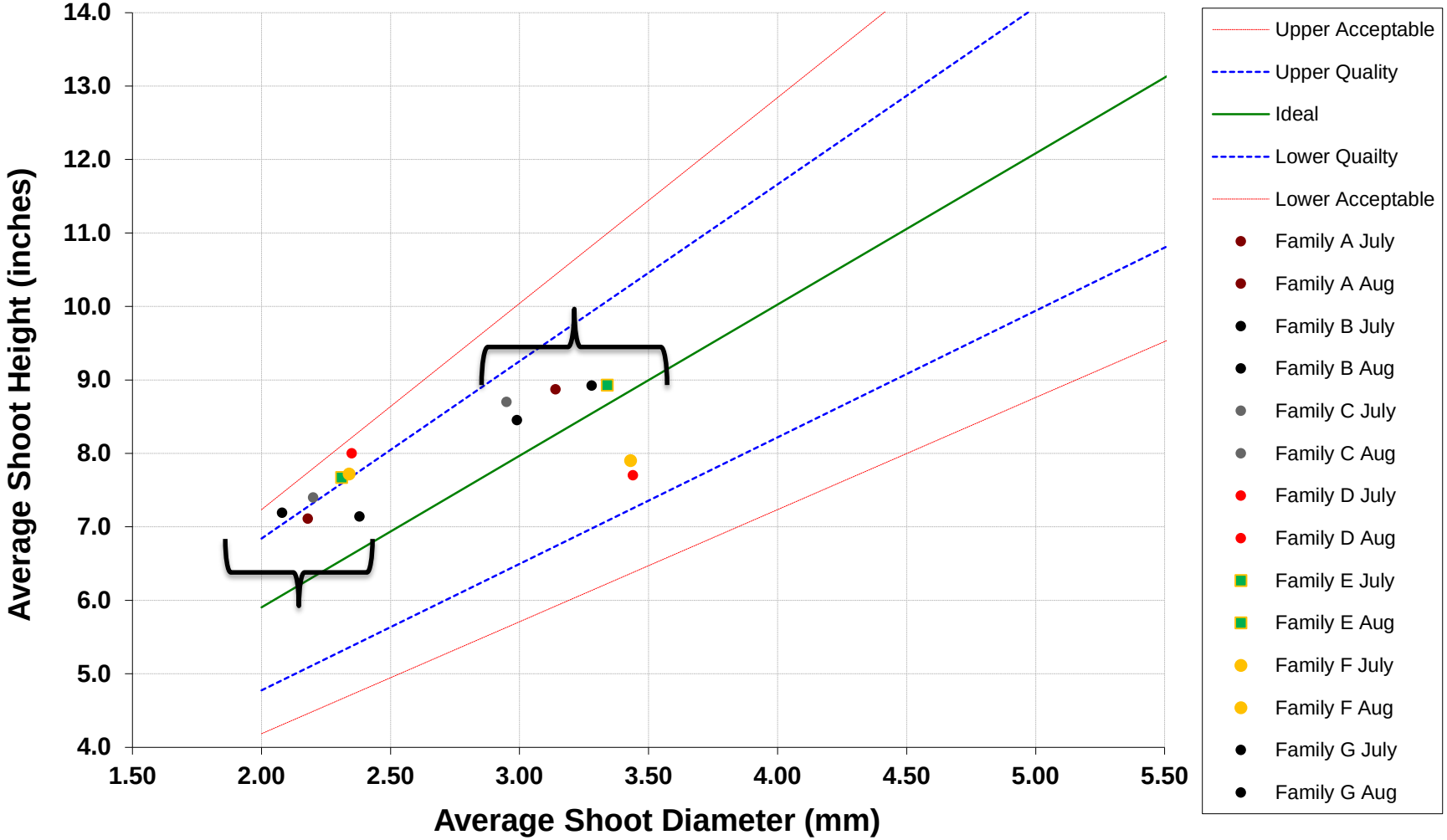
82 Seedlings/LBF



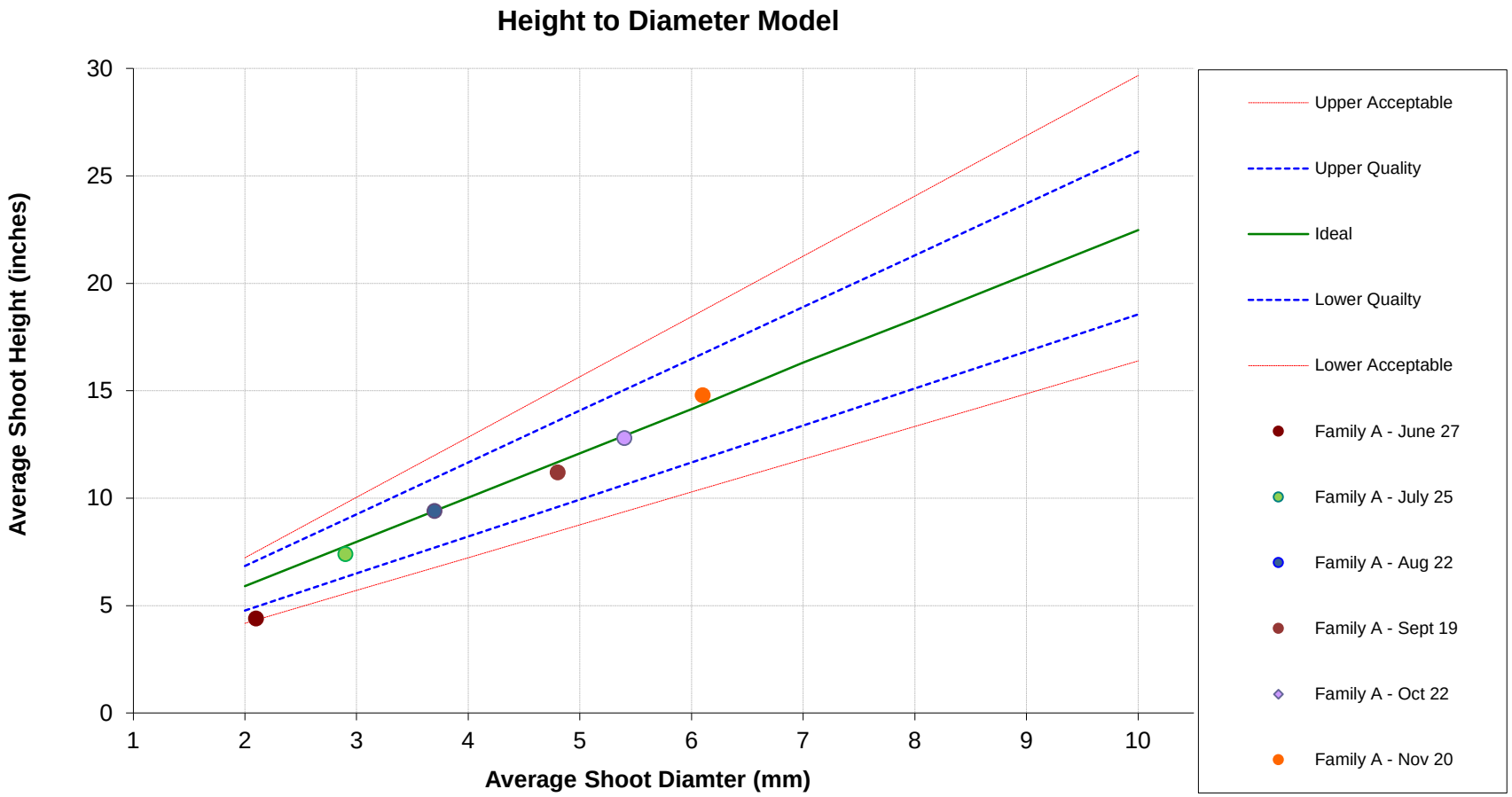
108 Seedlings/LBF



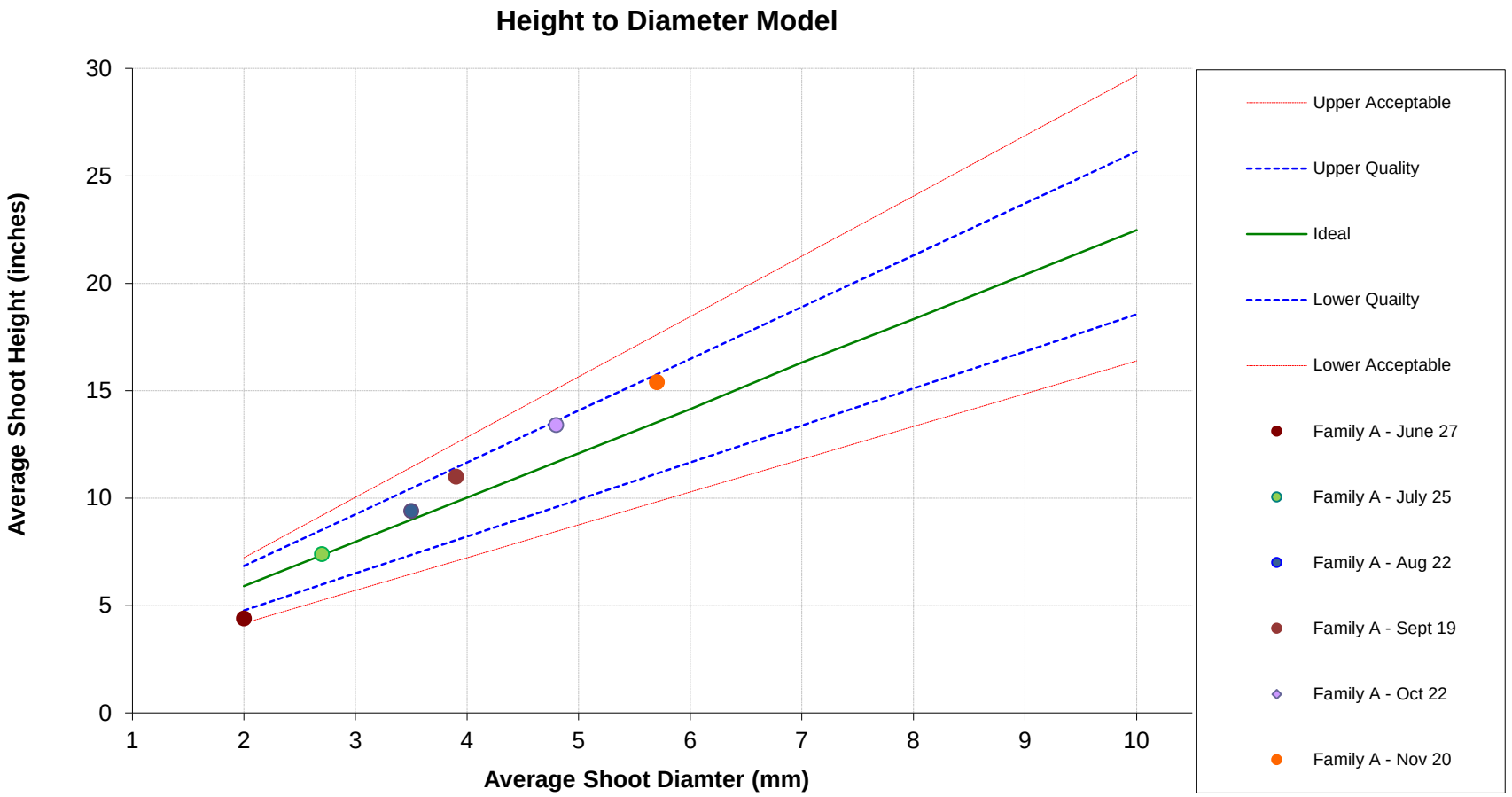
Monthly Crop Development – History Plots



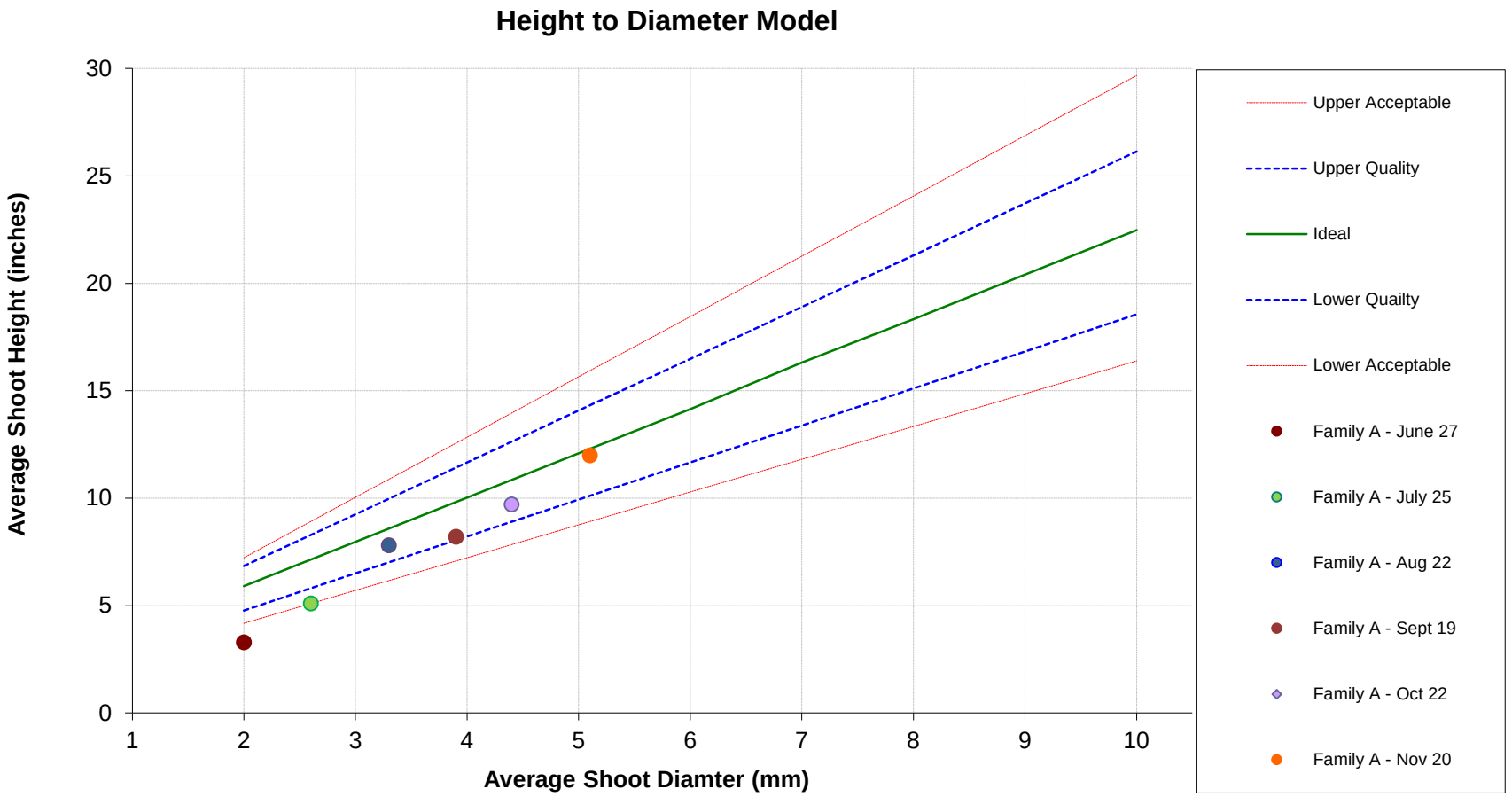
Example History Plot – Ideal



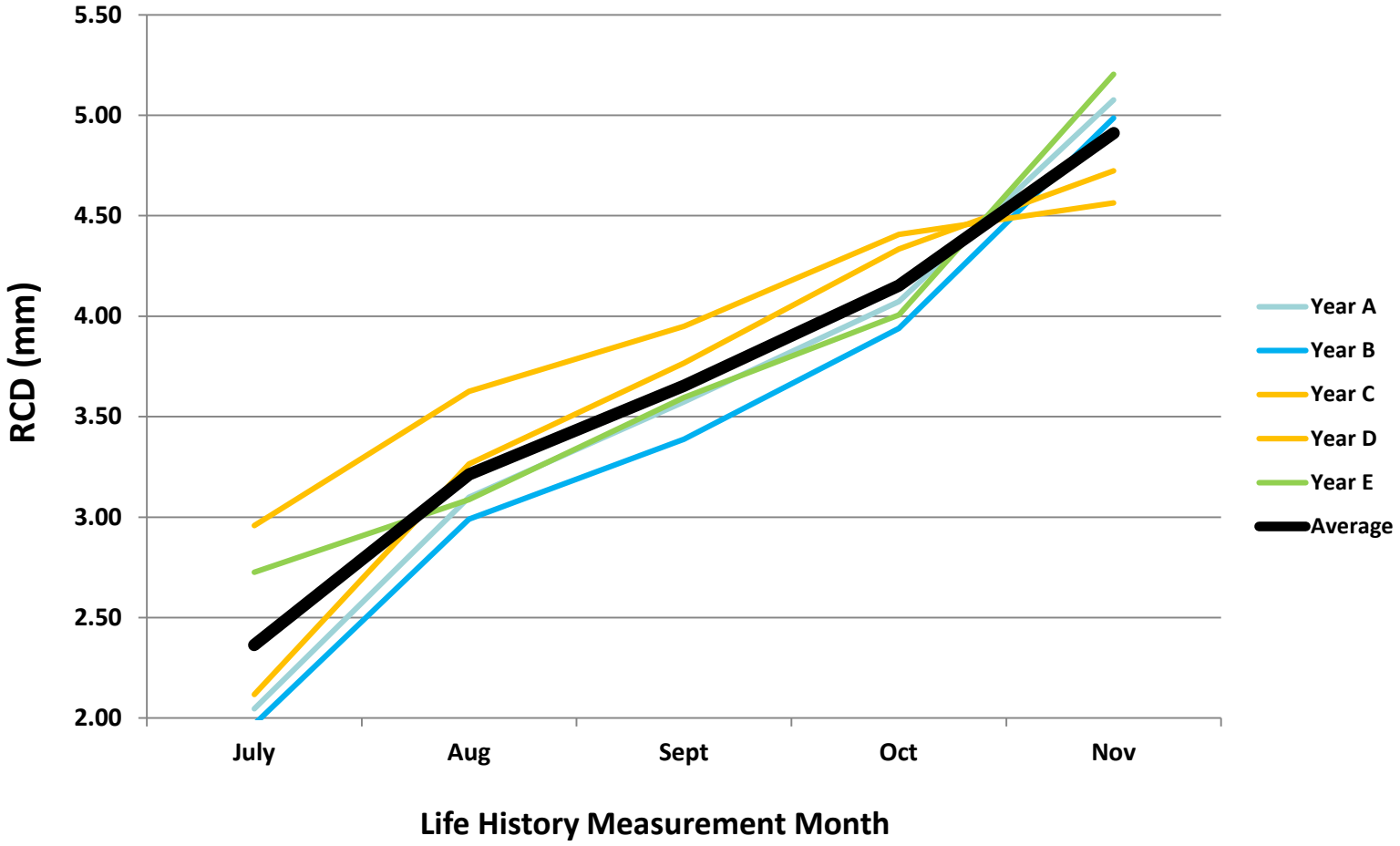
Example History Plot – Top-Clipping Needed?



Example History Plot – Detecting a Problem?



Developing a Long Term Model



Plug Fill Assessment – A Tool for Nursery Managers

- Tool to guide cultural practices and assess seedling development (typically start mid-Summer)
- **1** – Plug fully intact with no loose media (90 – 100% plug capture)
- **2** – 75% of the plug captured
  - Container plug holds together when extracted but the center of the plug is loose
- **3** – 50% of the plug captured
  - Typically see the bottom portion of the plug captured, but a portion of the media falls apart when extracted
- **4** – Root development is present but upon extraction most, if not all, of the media falls off

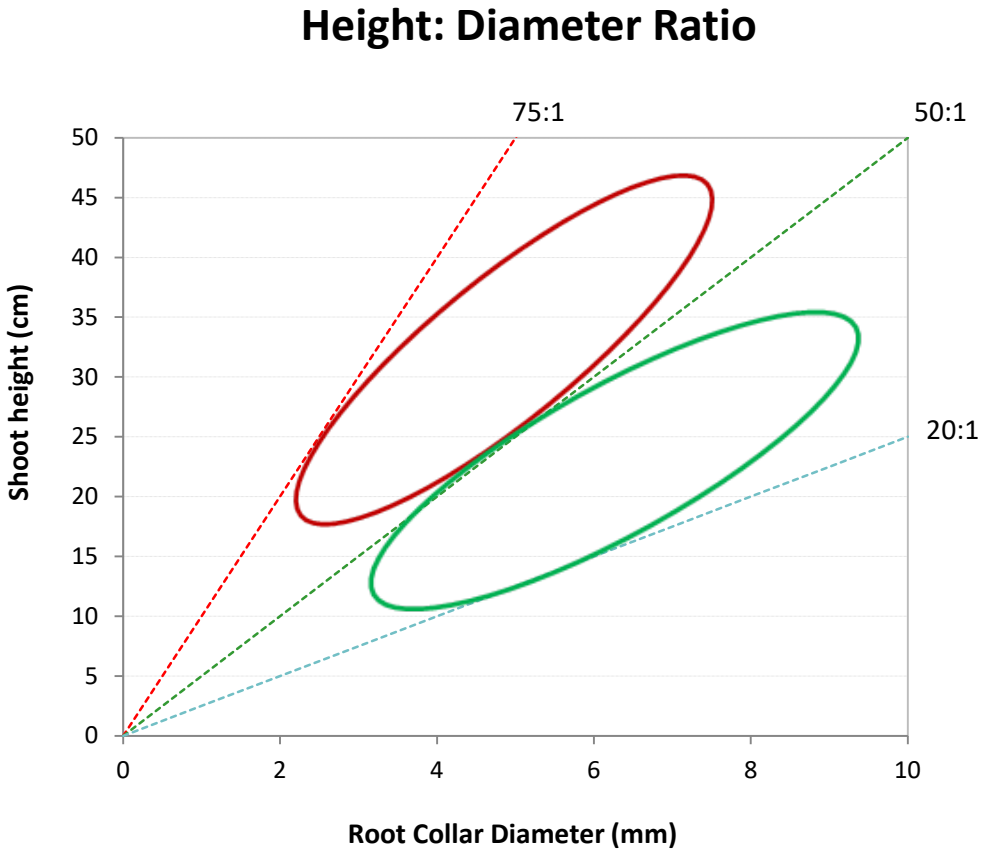
FINISHED SEEDLING EVALUATIONS (LIFTING SEASON)

Finished Seedling Evaluation – Improving Out-planting Success

- Purpose:
  - Quantitative assessment of predictors that lead to out-planting success
    - Effect of cultural practices
    - Effect of density
  - Quantitative support to help address issues that can occur after planting
  - Evaluate “Operational Research” questions
- Process:
  - Determine the number of plots to collect
    - Genetic Level (Open-Pollinated/Full-Sib/Varietal)
    - Provenance (Coastal/Piedmont/Texas/Arkansas)
  - Determine collection schedule
  - Determine measurement facilities

Height:Diameter Ratio

- Assessment of above ground seedling balance
- Measurements
  - Height (cm)
  - RCD (mm)
- Acceptable Range - 25:1 to 75:1
  - **Desired Ratio - 50:1**



Green = Ideal
Red = Acceptable

Root Weight Ratio

- Root Weight Ratio (RWR) is a measure of the total amount of root biomass relative to seedling biomass
- RWR = Root Weight (g) ÷ (Root Weight (g) + Shoot Weight (g))

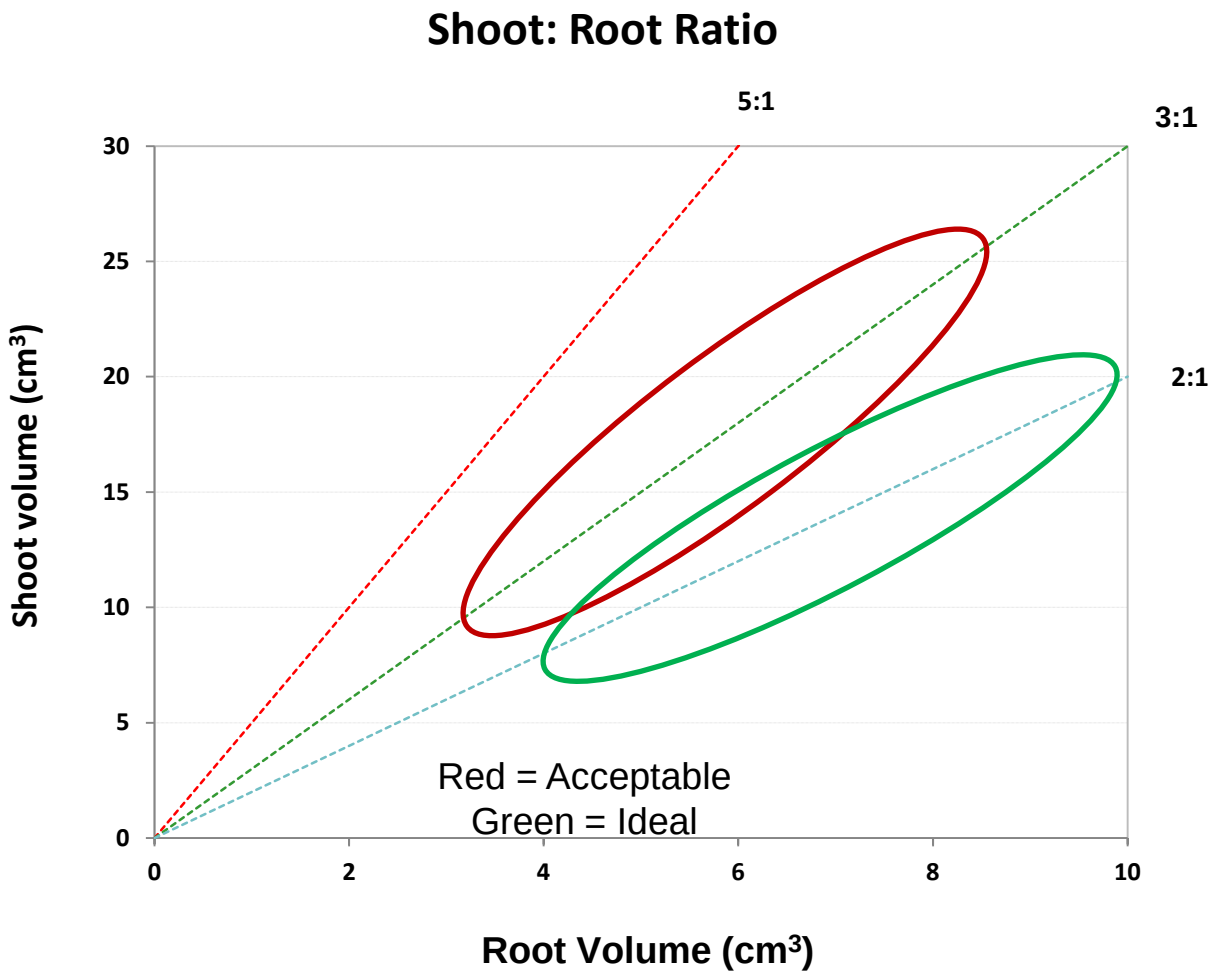
- RWR provides a good comparison between genetic lines (when examined at same time)

- Acceptable Range: 20% to 30%
  - Range: 20% to 24%
  - Target Ratio: 22%

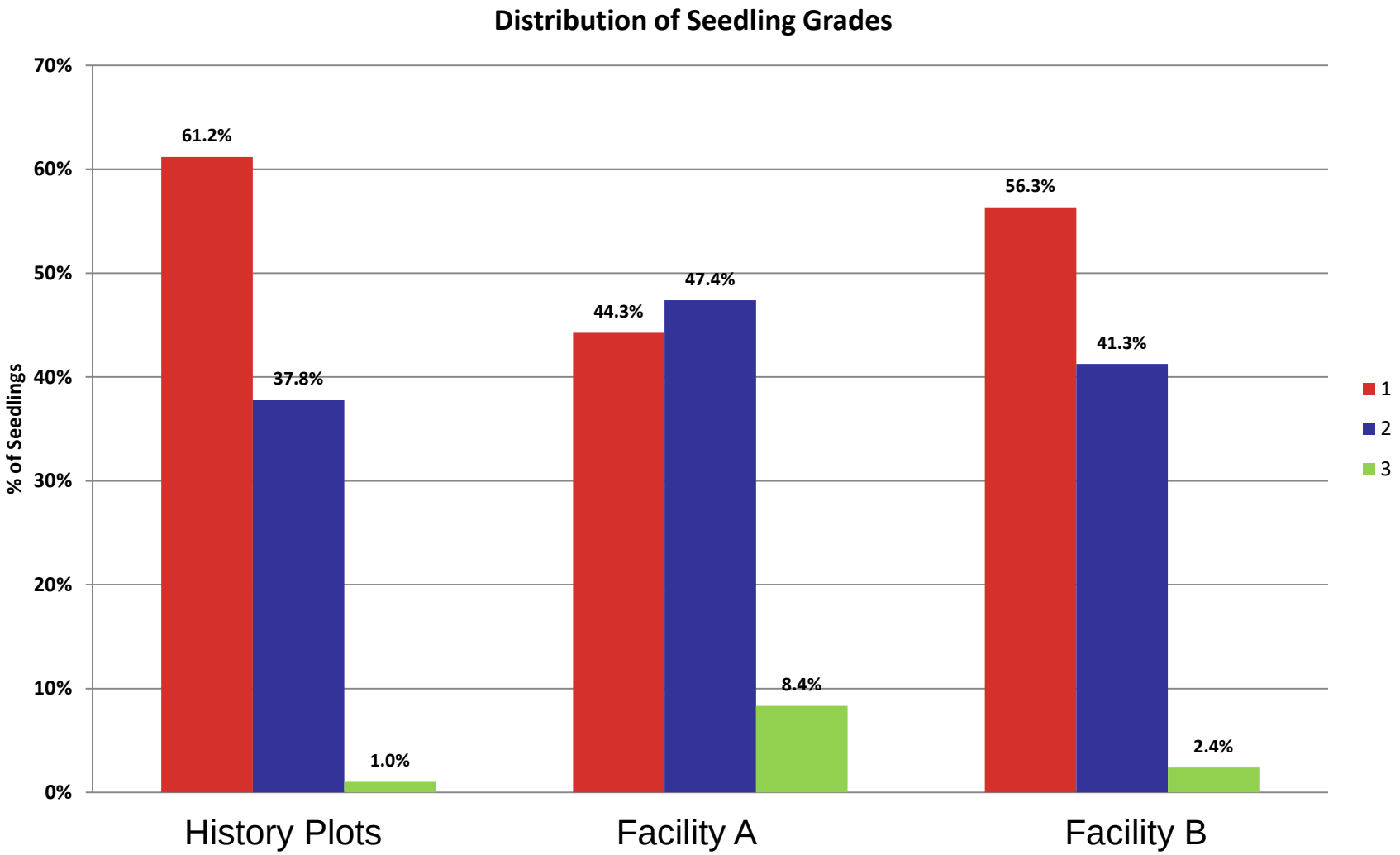
Shoot:Root Ratio

- The shoot-root ratio (S/R) was devised as a measure of balance between the transpirational area (shoot) and the water absorbing area (root) of a seedling.
- Measurements
  - Dry Weight (grams)
  - Volume Displacement (cm^3)
- Typically use Volume Displacement
  - Allows for single seedling measurements
  - Highly correlated to dry weight measurements
- S/R = Shoot Volume (cm^3) ÷ Root Volume (cm^3)
  - Not Shoot length ÷ Tap Root Length
- Acceptable Range - 2:1 to 5:1
  - Desired Ratio - 2.5:1

Shoot:Root Ratio



Seedling Grade Distributions



RELATIONSHIP BETWEEN SEEDLING QUALITY AND SEEDLING SURVIVAL

Addressing Landowner Concerns using SQA Program

- Concerns with survival due to seedling imbalance (seedlings to tall)
- Chilling Hours vs Time of Lifting
- Comparison in past has been with different genotypes from different nurseries
- Established a study using the same genotypes grown at different nurseries to compare out-planting success

Data Summary

Nursery A

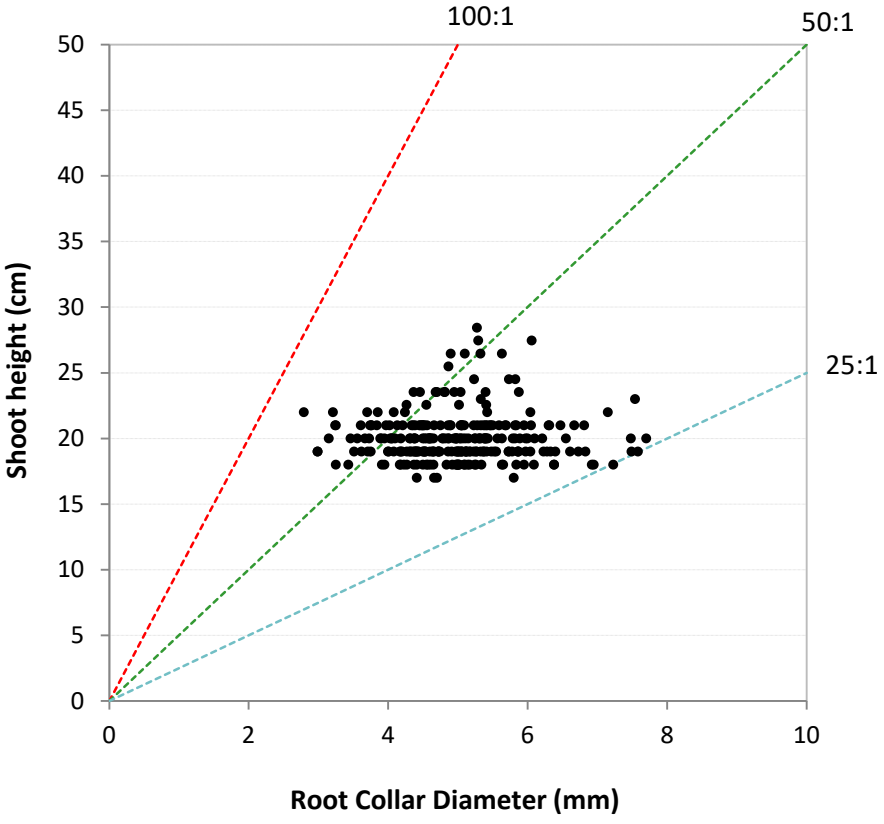
	Height, cm	Caliper, mm	Ht:Diam Ratio	Shoot vol, cc	Root vol, cc	Shoot: Root Ratio	Root Dry Weight (g)	Shoot Dry Weight (g)	Root Weight Ratio
MEAN	20.07	4.99	41.51	11.05	3.74	3.05	30.54	95.56	24.28%
MIN	17.00	2.79	24.90	5.00	1.00	1.20	27.76	89.24	22.04%
MAX	28.42	7.70	78.85	38.00	8.00	6.00	33.87	106.02	27.51%
STDEV	1.88	0.88	8.33	4.38	1.11	0.94	2.54	7.49	2.35%

Nursery B

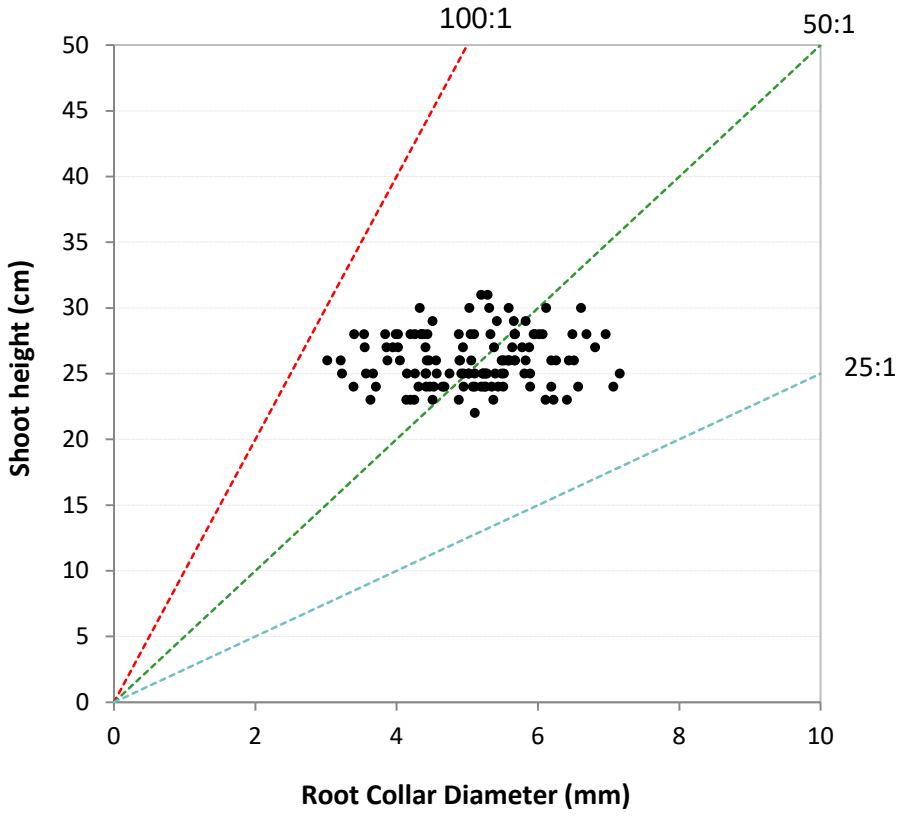
	Height, cm	Caliper, mm	Ht:Diam Ratio	Shoot vol, cc	Root vol, cc	Shoot: Root Ratio	Root Dry Weight (g)	Shoot Dry Weight (g)	Root Weight Ratio
MEAN	26.03	5.21	48.84	14.78	4.40	3.48	30.75	119.50	20.27%
MIN	22.00	3.22	30.14	9.00	2.00	1.83	24.58	106.23	18.79%
MAX	31.00	7.90	82.35	29.00	9.00	6.67	37.14	133.26	21.80%
STDEV	1.71	0.94	10.47	4.36	1.22	1.05	6.34	13.64	1.52%

Height:Diameter Ratio

Nursery A

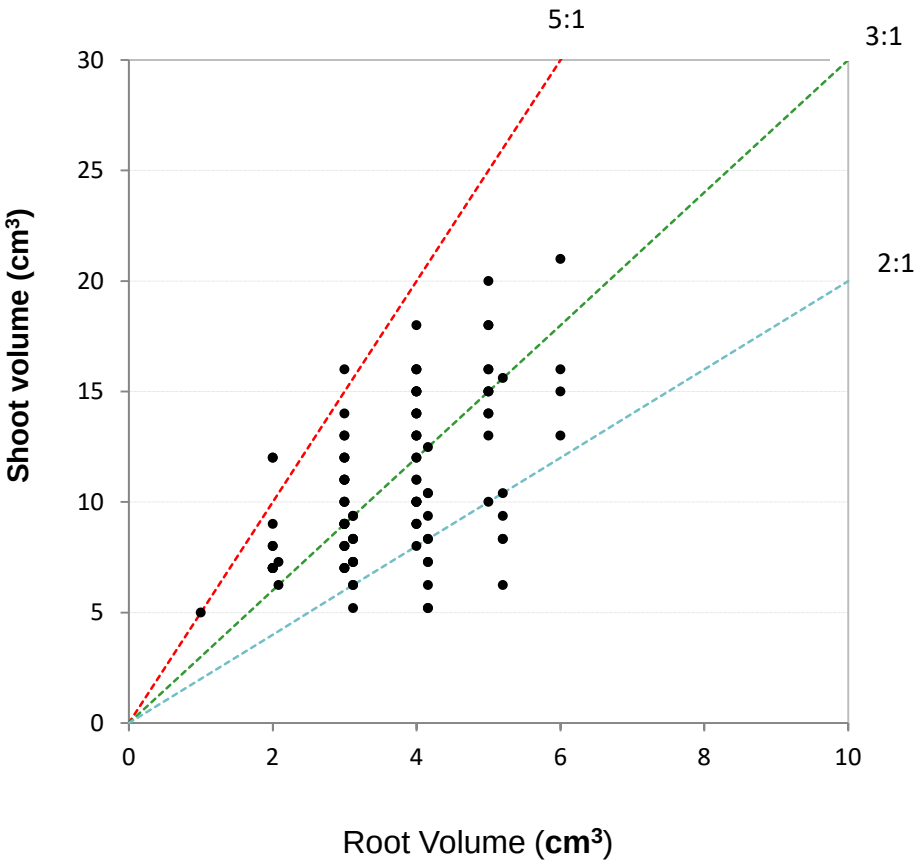


Nursery B

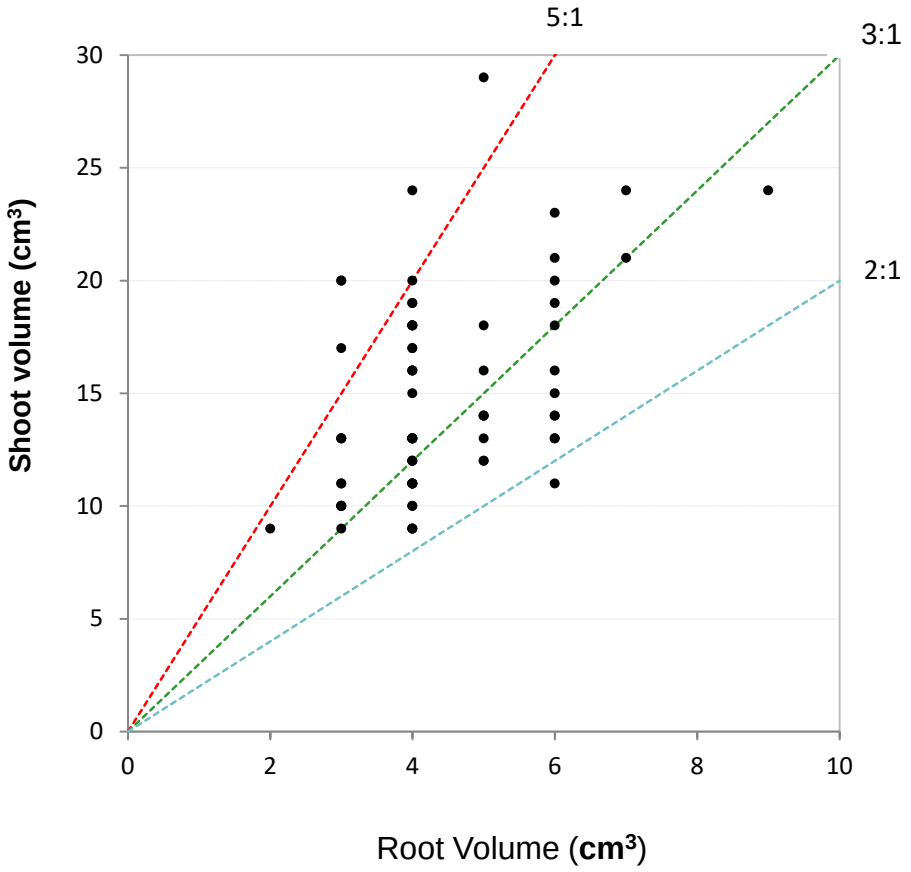


Shoot:Root Ratio

Nursery A



Nursery B



Landowner Concerns assisted by Seedling Quality

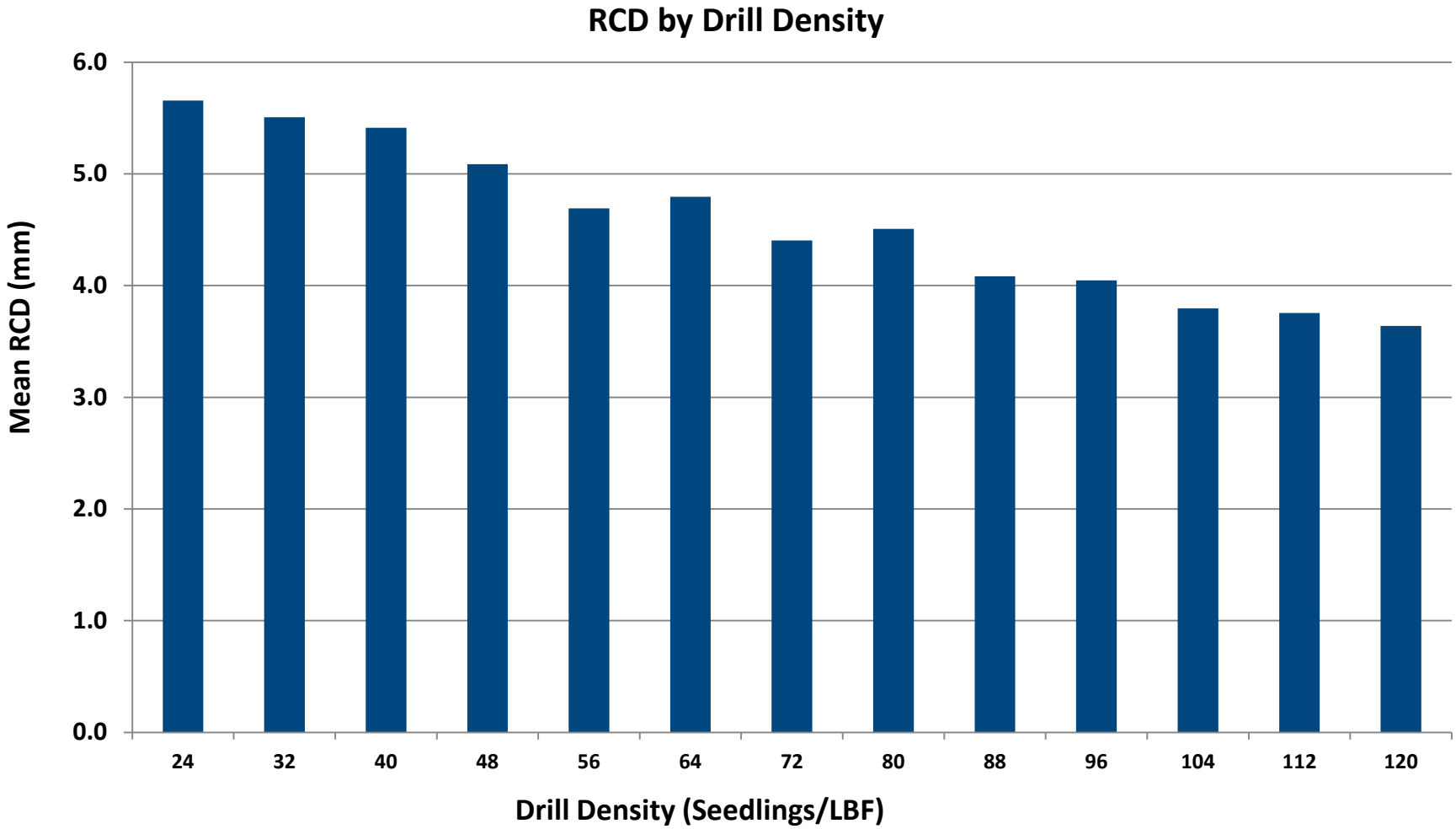
- "Nursery A" produced a more uniform seedling
  - Height:Diameter Ratio
  - Root:Shoot Ratio
  - Root Weight Ratio
- "Nursery B" produced a larger seedling on average, but with a lot more variation
  - Height
  - RCD
- First Year Seedling Survival Assessment
  - Nursery A – 92%
  - Nursery B – 77%

EFFECT OF SEEDLING DENSITY ON SEEDLING QUALITY

SQA Research Study – Effect of Density on Seedling Survival

- Study established to look at the effect of seedling density on seedling quality traits and seedling survival
- The same full-sib family was grown as two densities:
  - 78 seedlings/LBF (Low Density)
  - 111 seedlings/LBF (High Density)
- Seedlings measurements were collected by drill in December
- Seedlings were established in replicated block plots in two locations
  - Only Grade 1/Grade 2 seedlings planted

Effect of Density on Seedling Grade



HIGH DENSITY: Least Square Means, Standard Errors, Simple Means and Tukey Means groupings for nursery drill RCD.

Drill	LS Mean	Std Err	Mean	Tukey's	
1	0.886	0.035	0.939	A	
7	0.801	0.035	0.851	A	B
8	0.798	0.038	0.894	A	B
6	0.796	0.035	0.842	A	B
2	0.776	0.033	0.788	A	B
3	0.767	0.032	0.774	A	B
5	0.758	0.035	0.831		B
4	0.725	0.034	0.778		B

LOW DENSITY - Least Square Means, Standard Errors, Simple Means and Tukey Means groupings for nursery drill RCD.

Drill	LS Mean	Std Err	Mean	Tukey's
8	5.76	0.094	6.14	A
1	5.52	0.086	5.60	A
6	4.95	0.085	4.92	B
2	4.88	0.080	4.76	B
7	4.85	0.087	5.00	B
5	4.77	0.087	4.88	B
4	4.71	0.084	4.69	B
3	4.70	0.078	4.71	B

Data Summary

HD

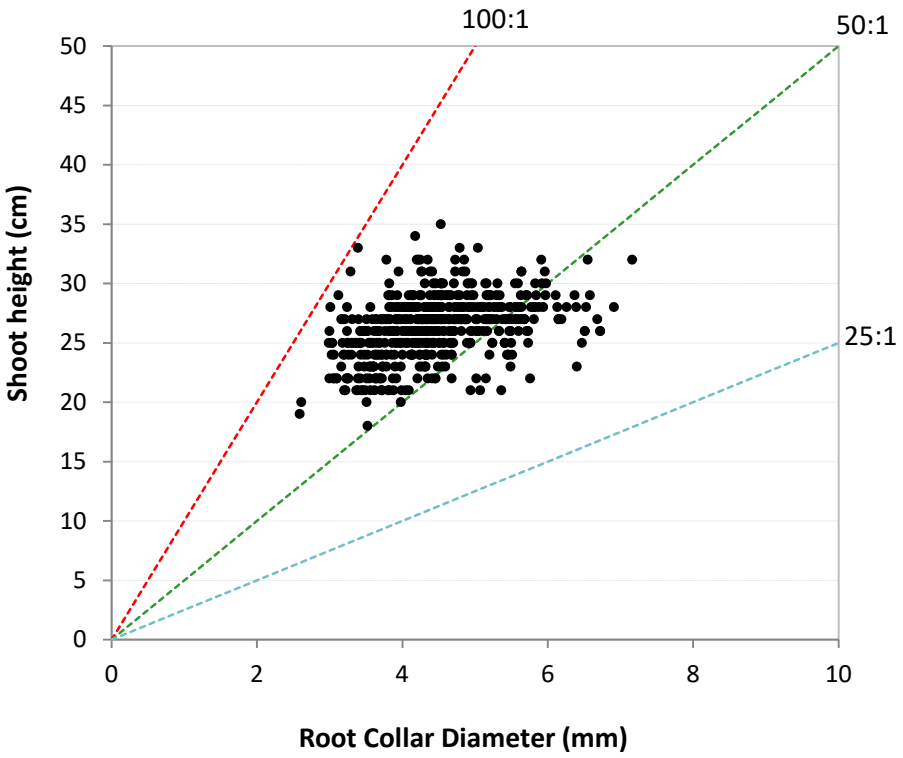
n=560	Height, cm	Caliper, mm	Ht:Diam Ratio	Shoot vol, cc	Root vol, cc	Shoot: Root Ratio	Root Dry Weight (g)	Shoot Dry Weight (g)	Root Weight Ratio	Tap Root Length (cm)	FOLR
MEAN	26.34	4.44	60.74	10.69	3.37	3.21	24.06	100.59	19.31%	15.24	11.64
MIN	18.00	2.59	35.94	4.00	0.98	1.13	18.73	66.85	16.91%	11.00	5.00
MAX	35.00	7.16	97.35	25.00	10.00	7.00	32.09	125.86	23.12%	19.00	23.00
STDEV	2.57	0.79	9.81	4.03	1.17	1.03	4.26	18.22	1.92%	1.29	3.01

LD

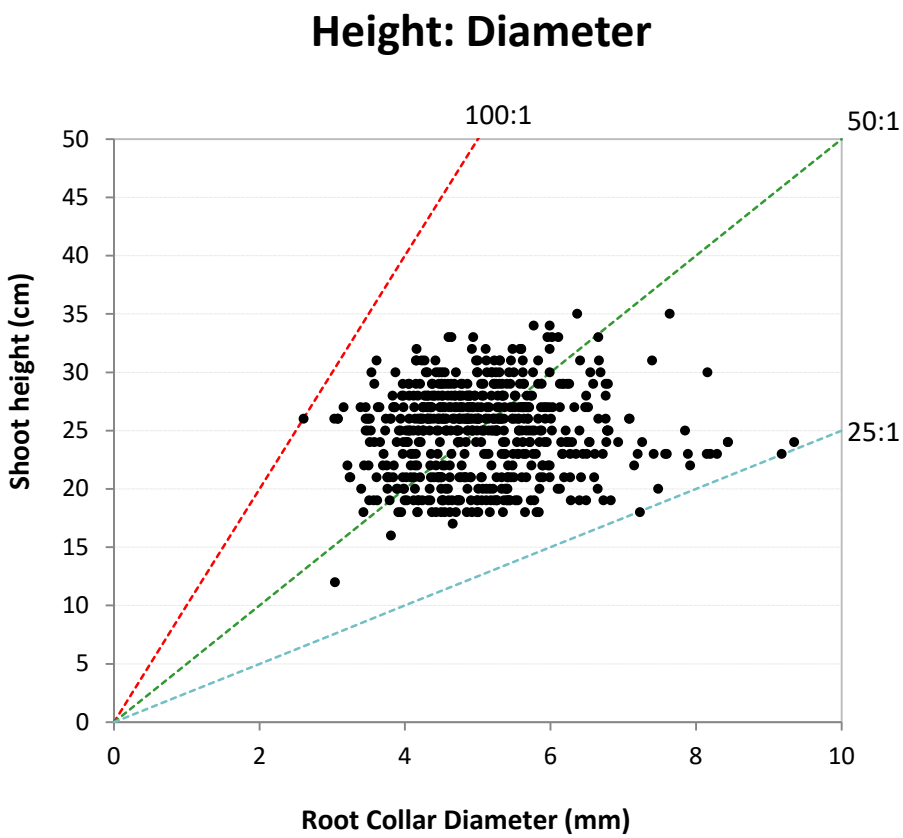
n=560	Height, cm	Caliper, mm	Ht:Diam Ratio	Shoot vol, cc	Root vol, cc	Shoot: Root Ratio	Root Dry Weight (g)	Shoot Dry Weight (g)	Root Weight Ratio	Tap Root Length (cm)	FOLR
MEAN	24.91	5.66	44.96	13.06	4.16	2.79	30.43	111.67	23.38%	15.17	14.43
MIN	12.00	2.61	22.84	3.00	1.00	1.13	23.77	91.43	18.23%	11.00	6.00
MAX	35.00	10.07	99.62	40.00	13.00	7.00	30.70	134.93	23.29%	20.00	22.00
STDEV	3.77	1.01	11.84	5.07	2.03	0.91	2.10	11.15	1.67%	1.55	3.02

Height:Diameter Ratio

High Density

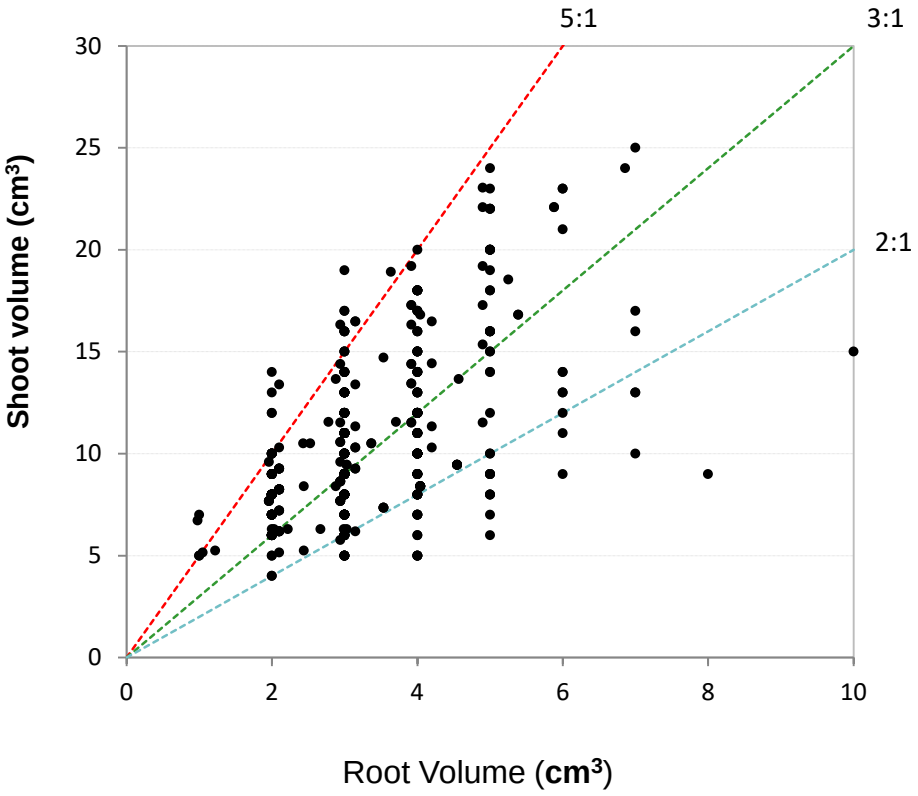


Low Density

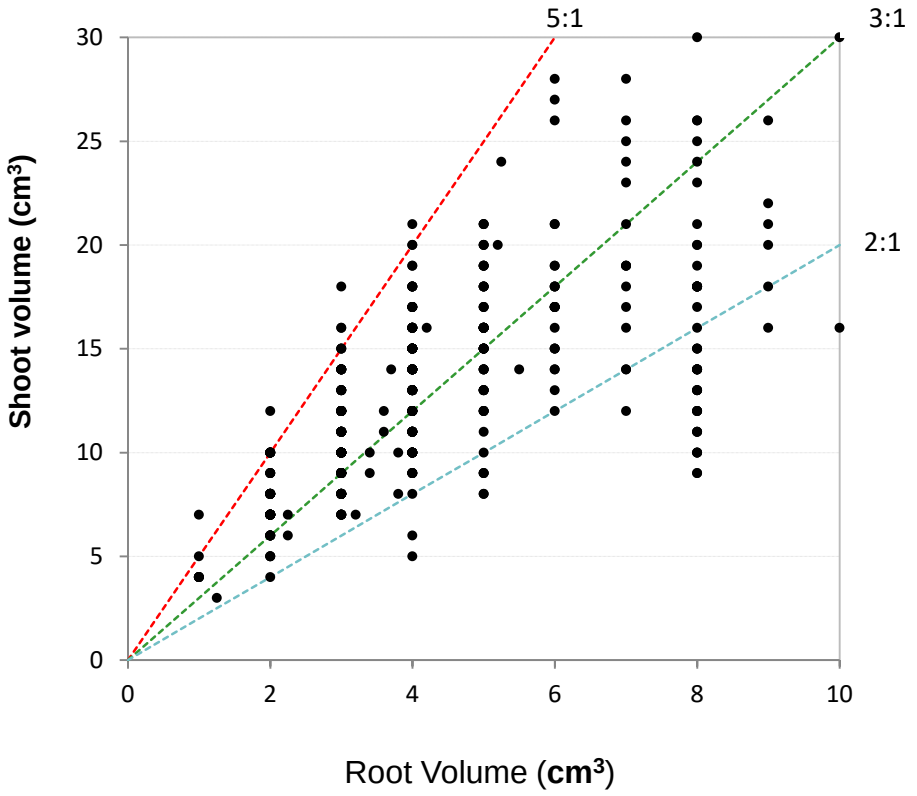


Root:Shoot Ratio

High Density



Low Density



First Year Assessment and Observations

- Survival:
  - Site A:
    - High Density: 72%
    - Low Density: 96%
  - Site B
    - High Density: 78%
    - Low Density: 95%
- Phonotypic Assessments:
  - High Density Seedlings put on little top/root growth
  - High Density Seedlings were more effected by a freeze event
  - Block plots more variable with high density seedlings

Summary Comments

- **No single factor has been shown to provide a perfect predictor for out-planting success, but each has been linked with seedling quality in some way**
- **Life History Plots** are another tool for nursery managers
  - Track crop development throughout the growing season
  - Help with nursery management decisions
- Quality seedlings make nursery managers, sales managers and customers happy!!!
  - Better growth
  - Better Survival
- Seedling Bed Density is important
  - Nursery managers have to balance quality with cost
  - Higher bed densities typically produce a lower quality seedling and a more variable crop

QUESTIONS?