Root System Architecture (RSA) of Prairie Grasses Under Acidic Soil Conditions

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Three Types of Prairie Grasses Were Grown in Number 5 Pots

- Switchgrass (*Panicum virgatum* L.)

- Eastern Gamagrass (*Tripsacum dactyloides* (L.) L.)

- Big Bluestem (*Andropogon gerardii* Vitman)

Experimental Conditions

- Four seeds of each species were planted in each pot in TSU greenhouses.

- Soil pH for each pot was maintained at one of three acidity levels: 4.5pH, 5.5pH and 6.5pH.

- Plants were grown under same greenhouse conditions for over nine months.

Experimental Conditions (cont)

- Plants were extracted from pots, root systems were manually separated, soil was washed off with gentle water spray, individual roots were wrapped in moist towels and placed in sealed plastic bags, and shipped for overnight delivery to Phenotype Screening Corporation.

- Roots were left sealed until just prior to imaging. Roots were X-ray imaged over a period of 15 minutes each.

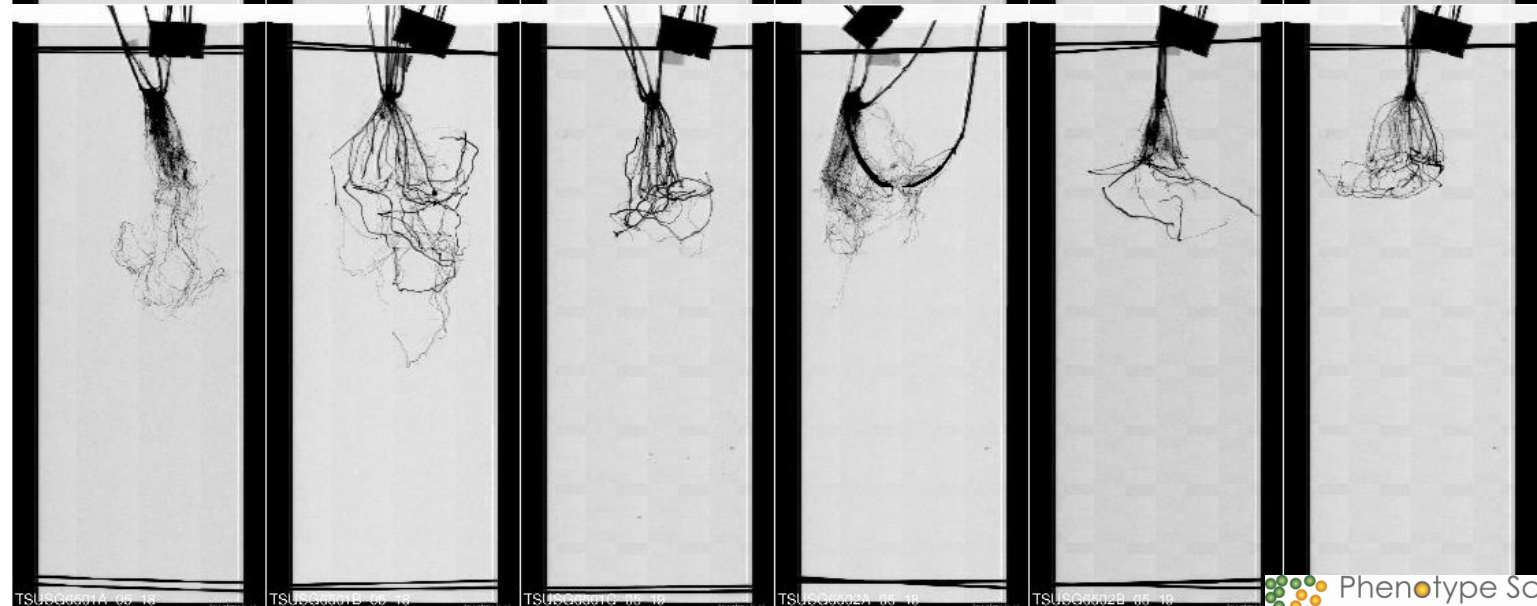- There were six replicates for each treatment.

Basic Imaging Concept

Camera

Plant roots

X-ray cone beam
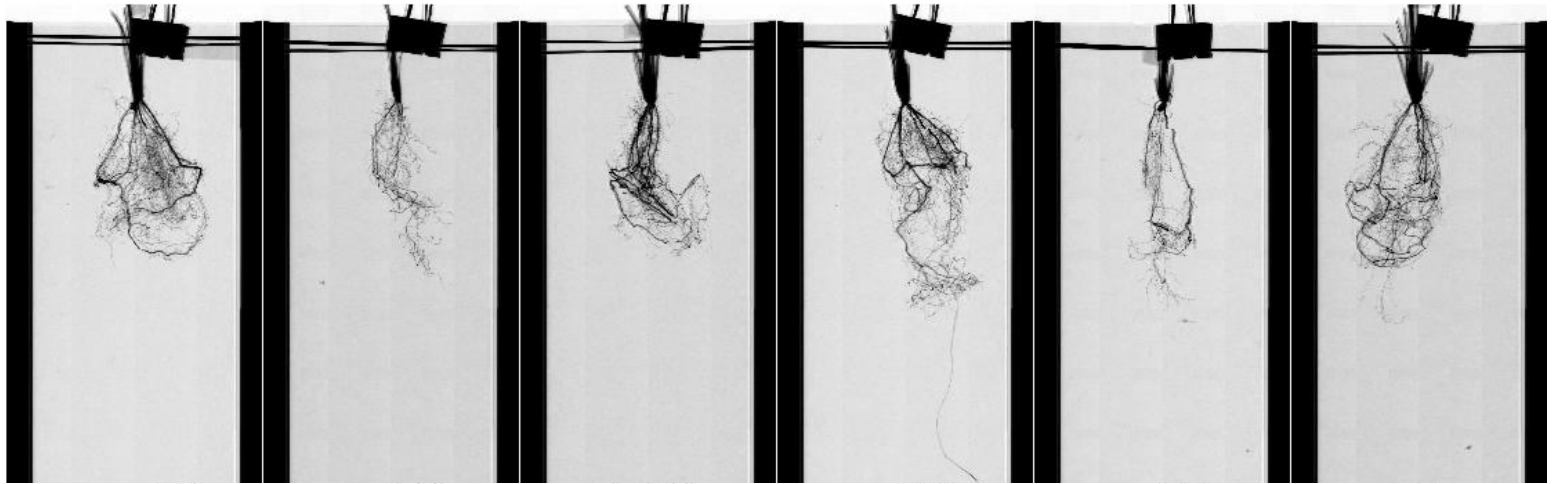
X-ray generator

Phenotype Screening
CORPORATION
enabling discovery
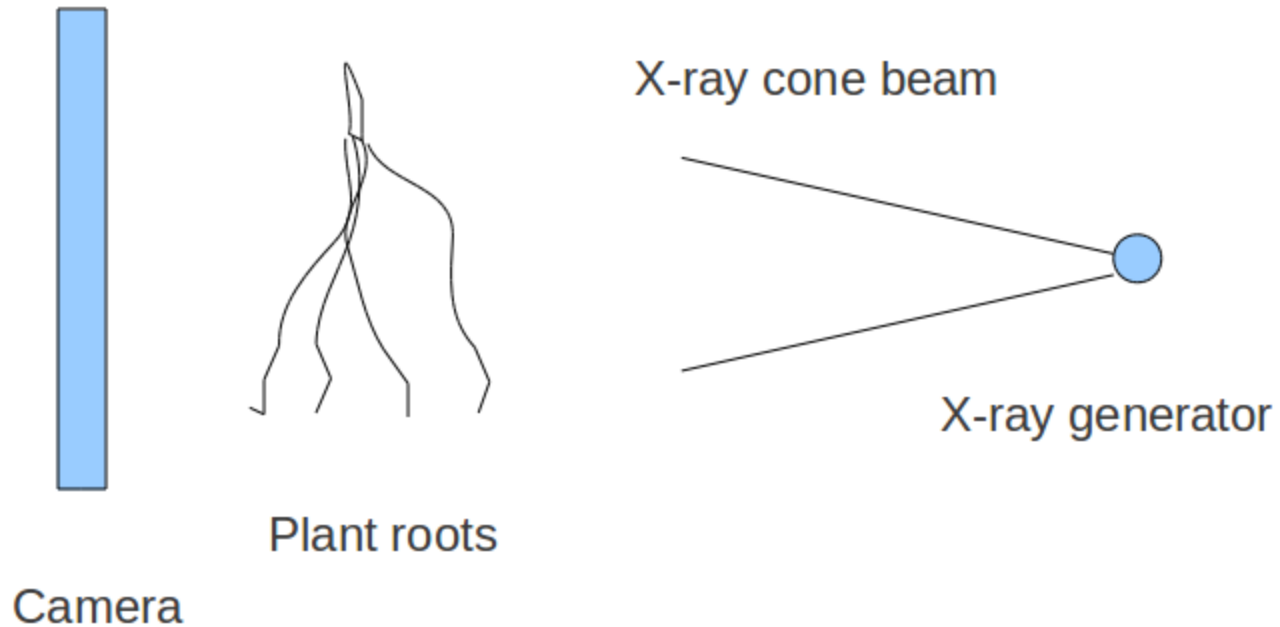
Switchgrass Root System X-ray Images
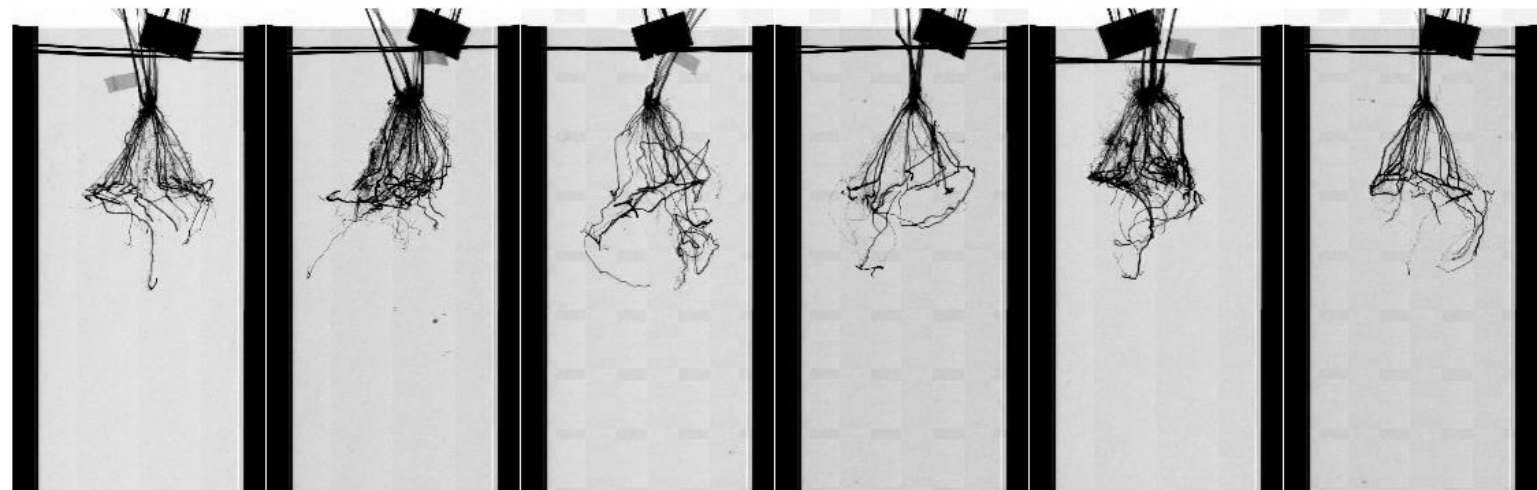
4.5 pH

6.5 pH

Gamagrass Root System X-ray Images

4.5 pH

6.5 pH

Big Bluestem Root System X-ray Images
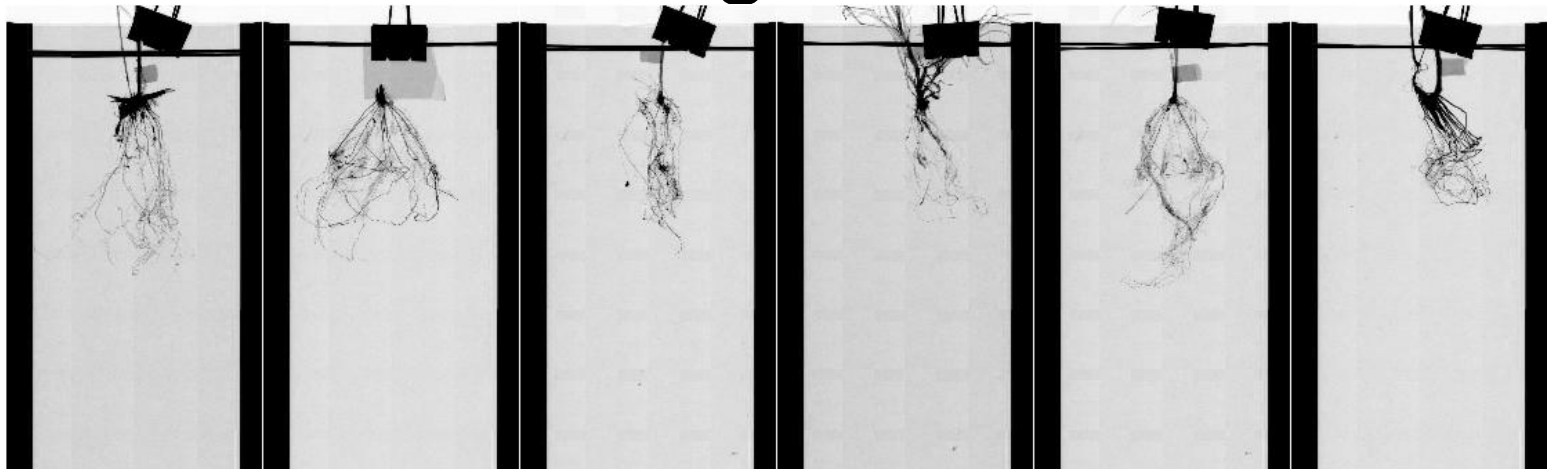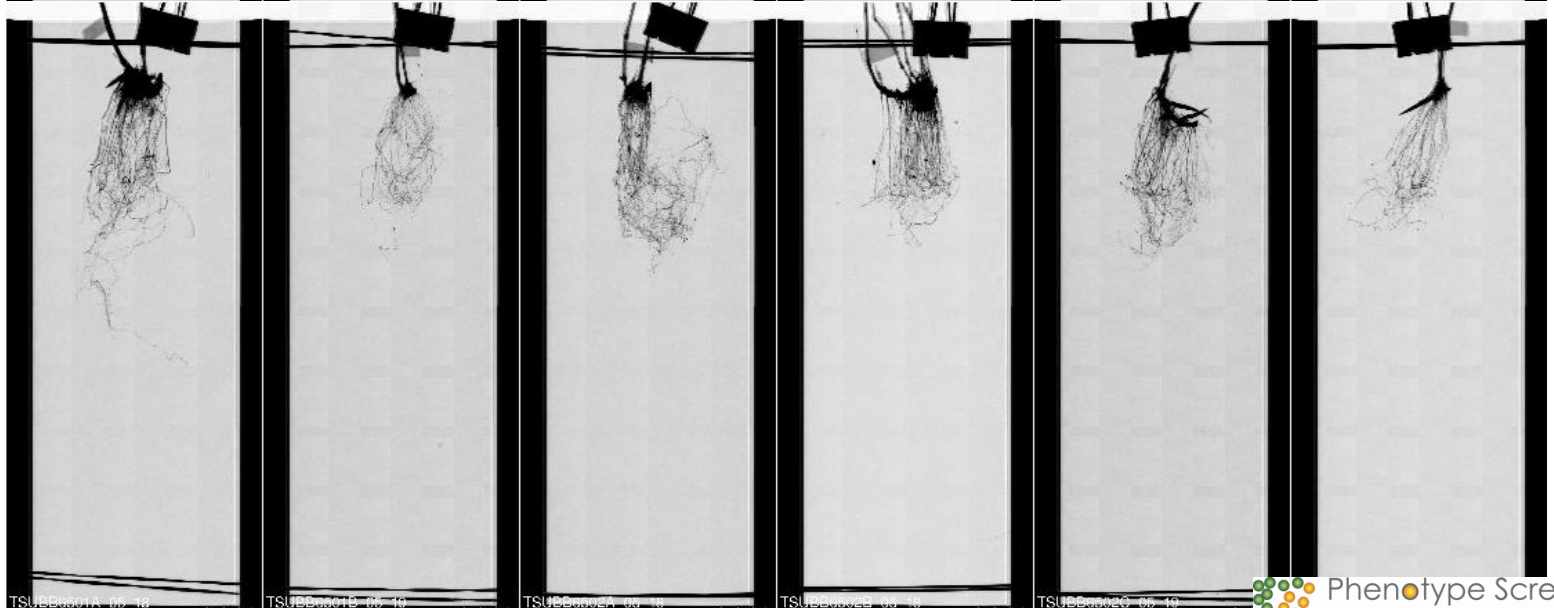
4.5 pH

6.5 pH

Stereo and Mono Images Were Generated of Each Plant

Switchgrass

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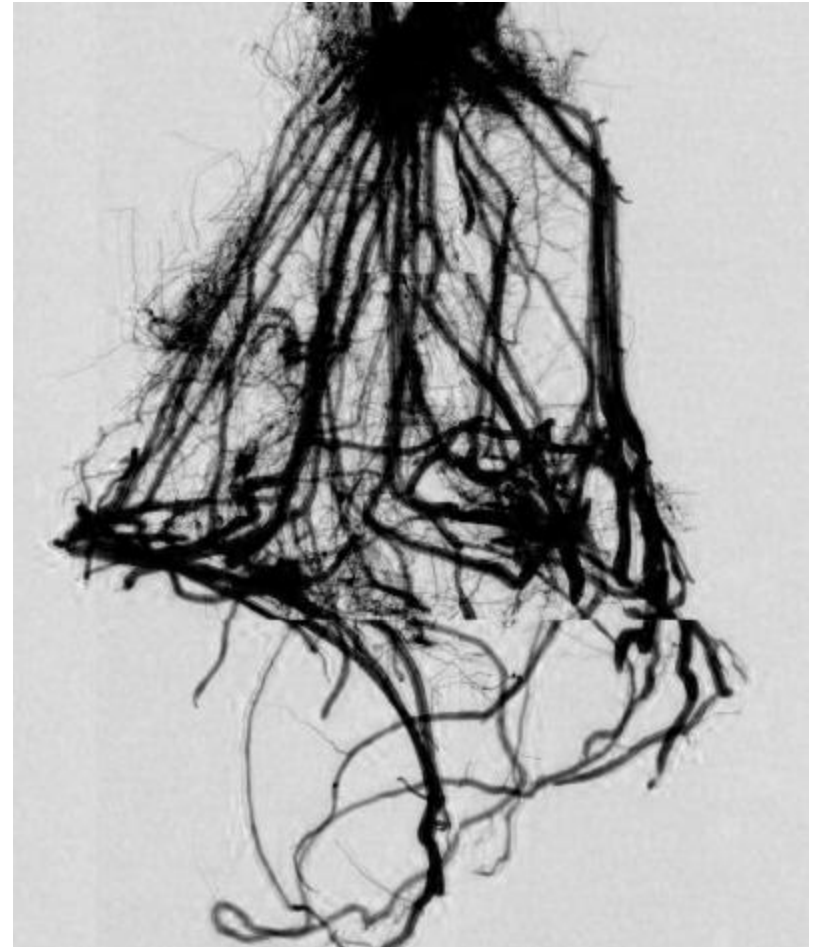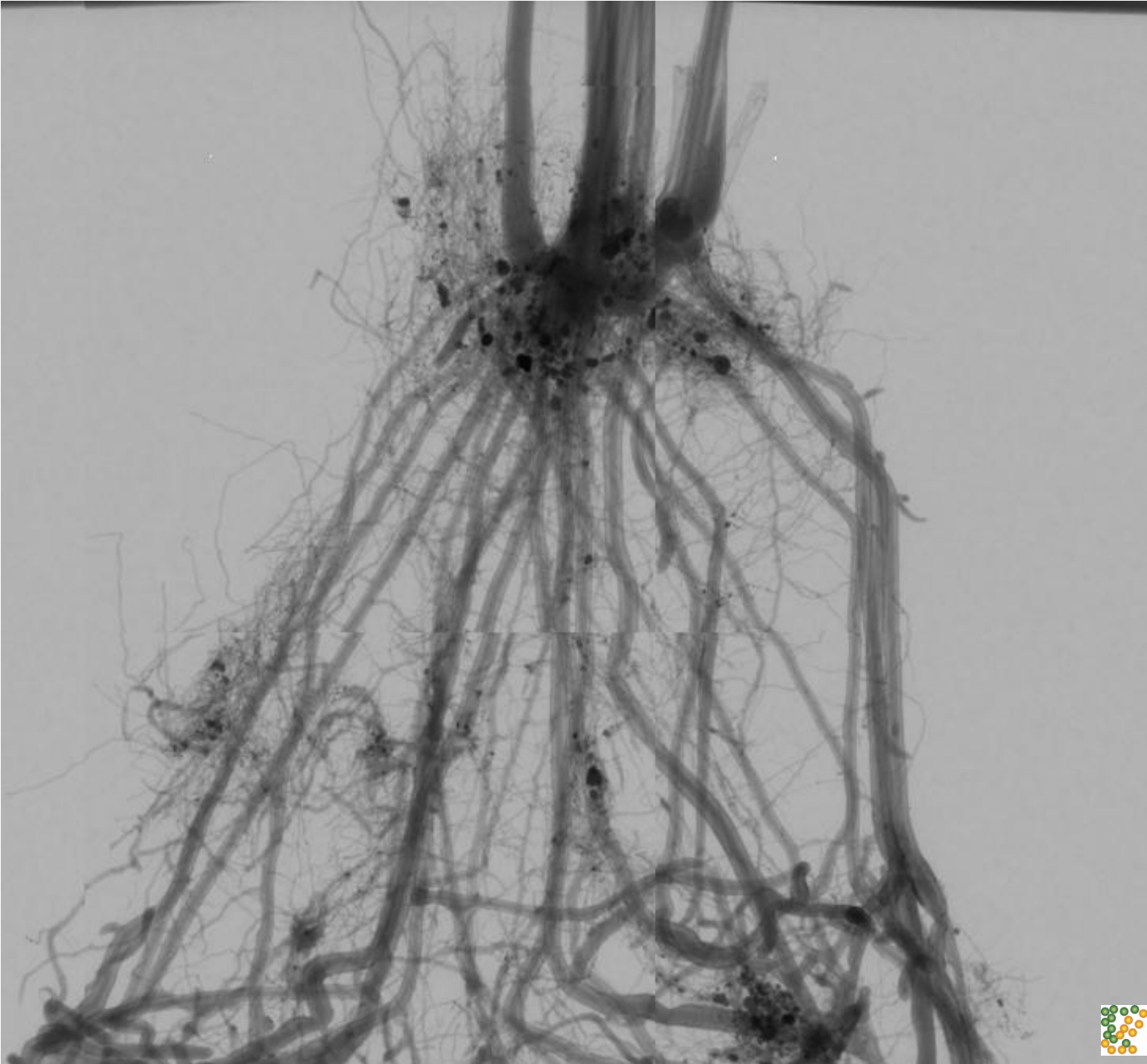
Very fine structure of RSA is captured in each plant root image.

Switchgrass

Sophisticated Processing Is Applied to Enhance Features of Interest
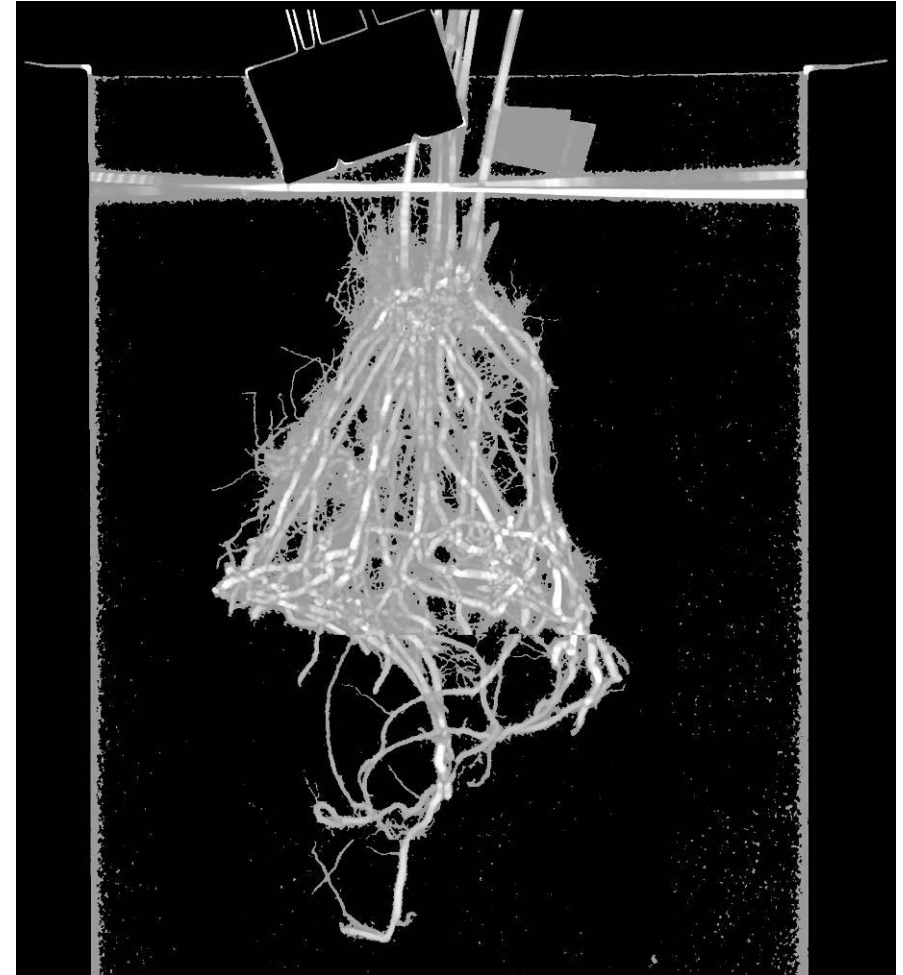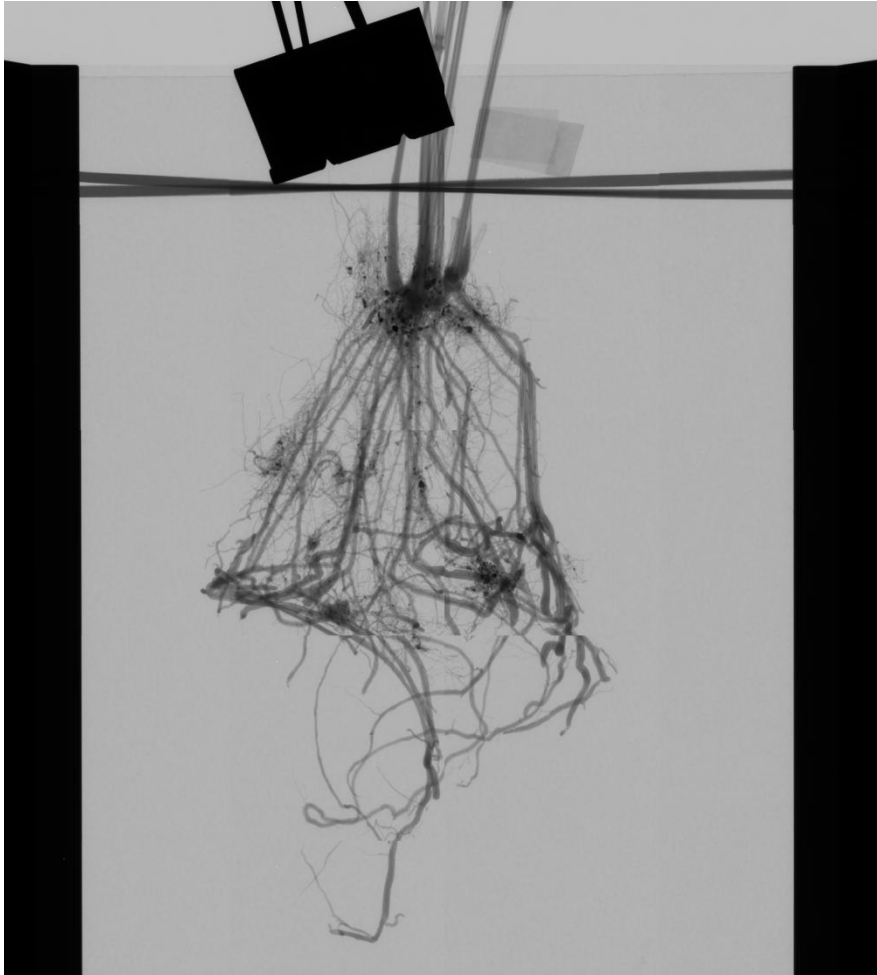
Switchgrass

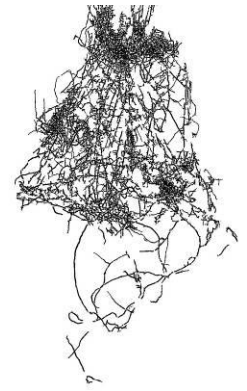# Image Analysis Techniques Were Used to Characterize the RSA by Root Size Classes
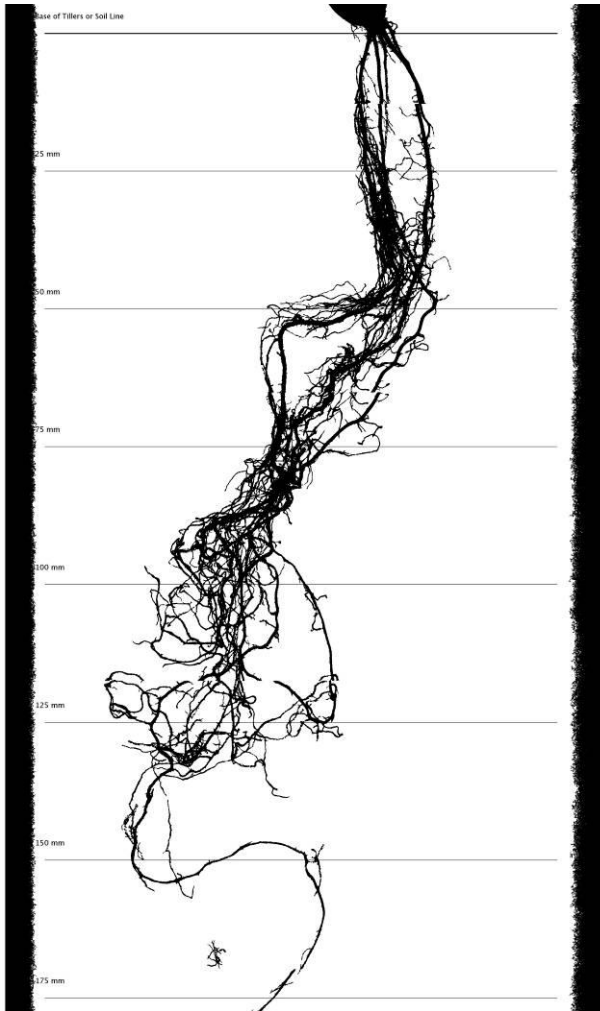

Original Image

Coarse Roots
< 2.9 mm

Medium Roots
725u to 2.5 mm

Fine Roots
181u to 620u

Global RSA traits were independently determined at each root class size.

# Transect Analysis was Used to Assess RSA Distribution by Depth

The image is analyzed at specific depths. The number of roots crossing each transect is counted and the position and diameter of each root at the crossing is determined.

The square of the root diameter is considered proportional to mass. The sum of all of the areas of roots gives a value proportional to total mass at that depth.
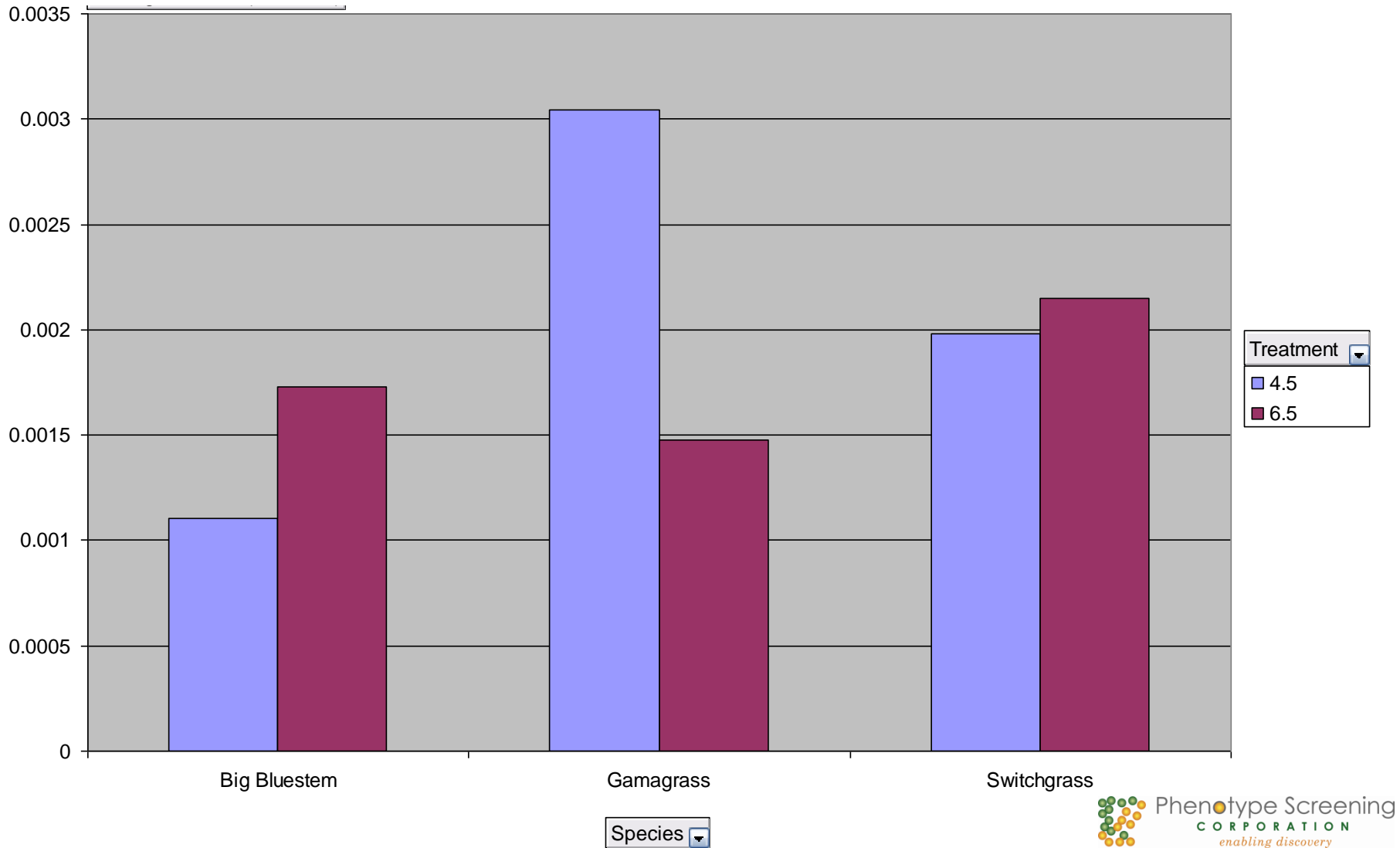
The width of the root system is also determined at each transect depth. We can then determine the "count density" and the "mass density" at each depth.

Global characteristics such as "projected area," "total-root-length," "total-root-length-density" are also determined for each plant.
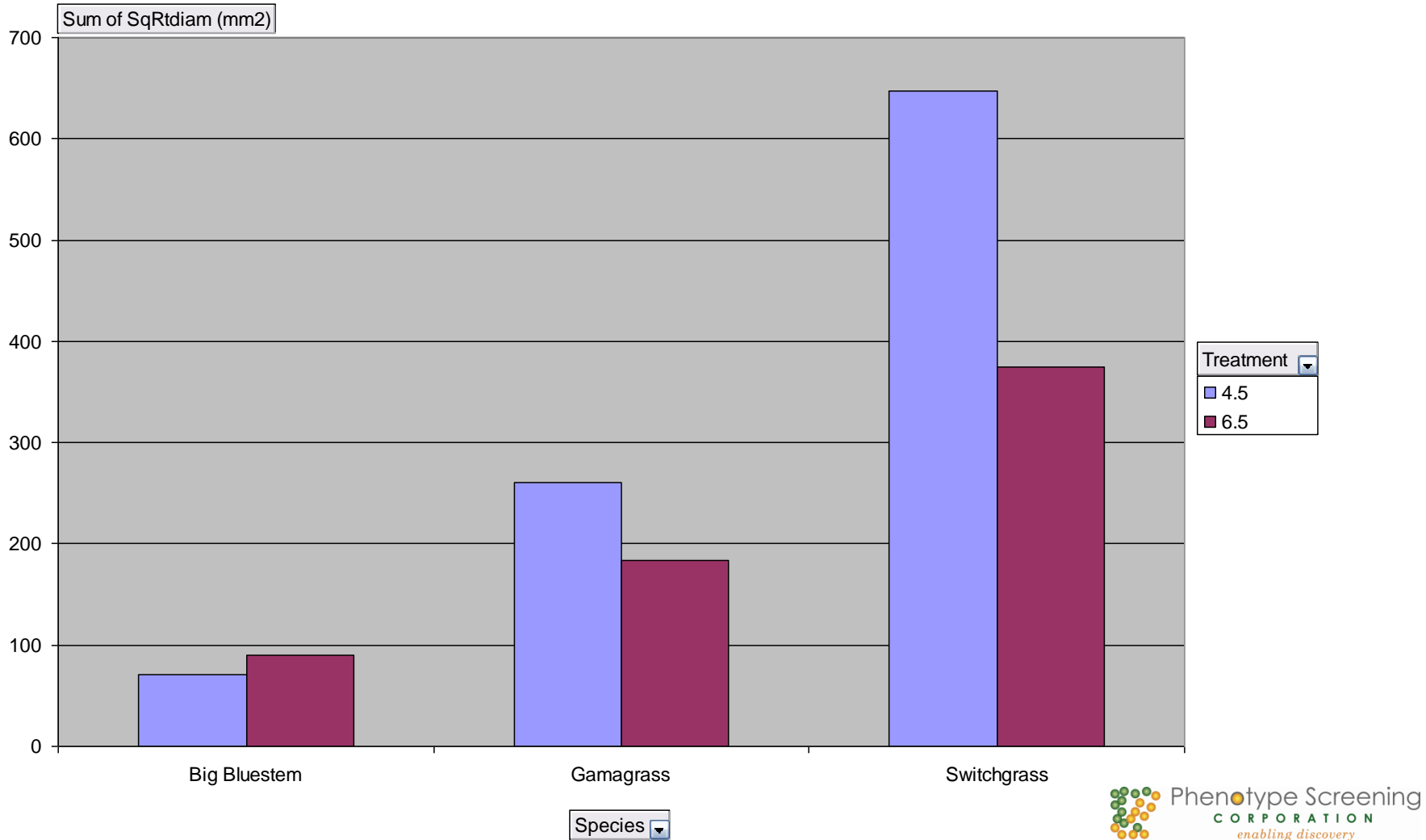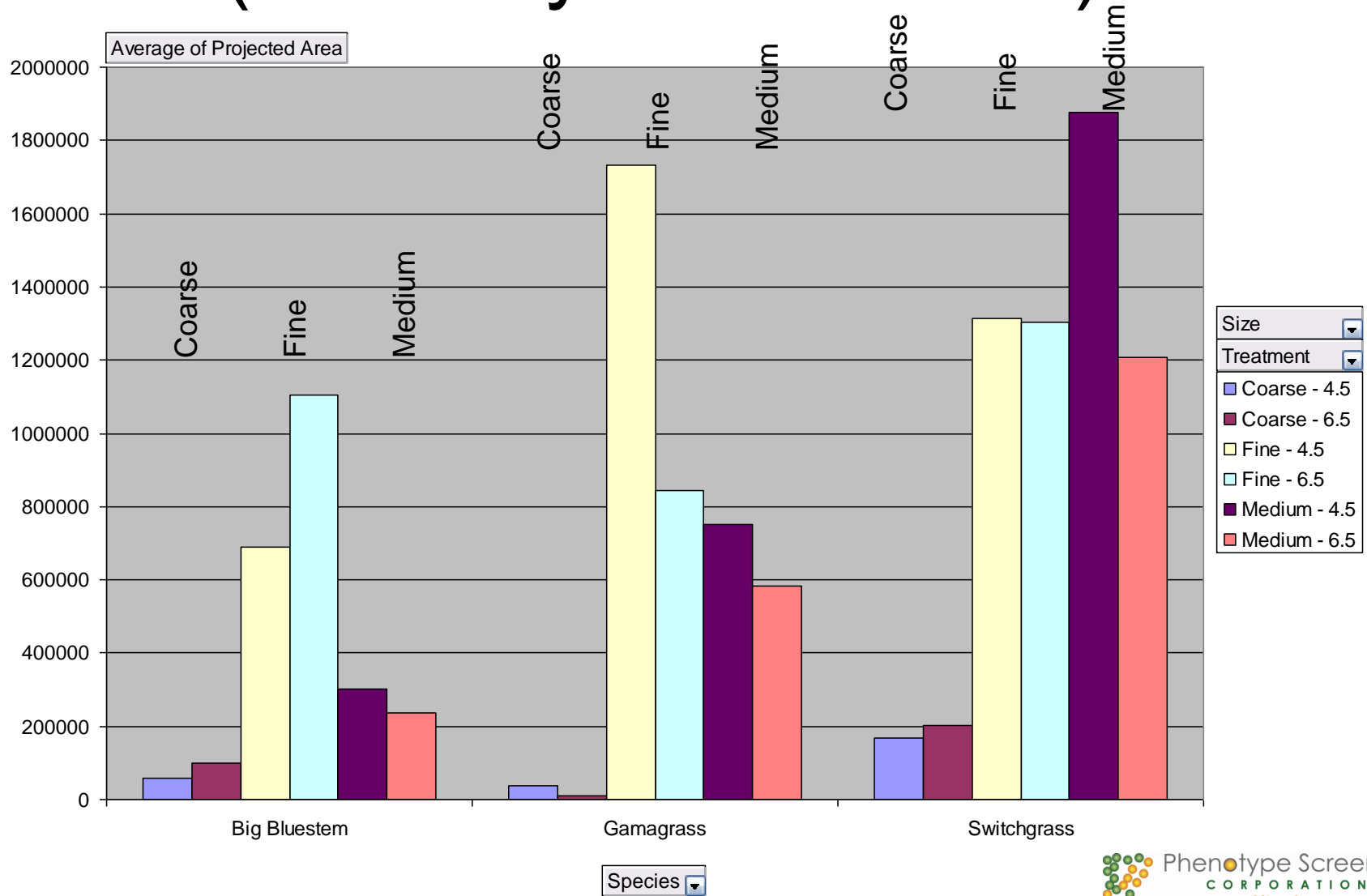
Average "Total-Root-Length"
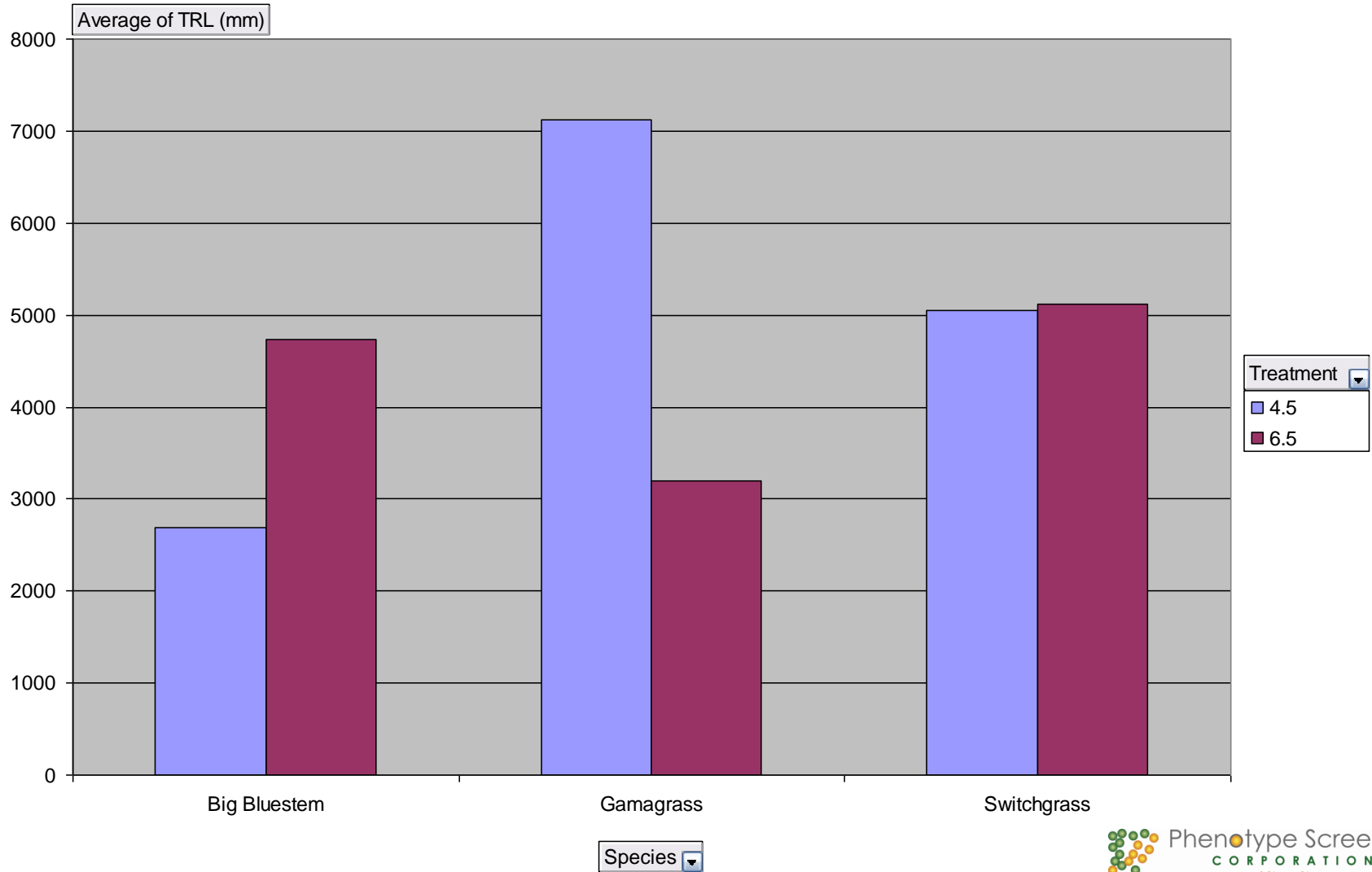
Average "Total Root Length Density"

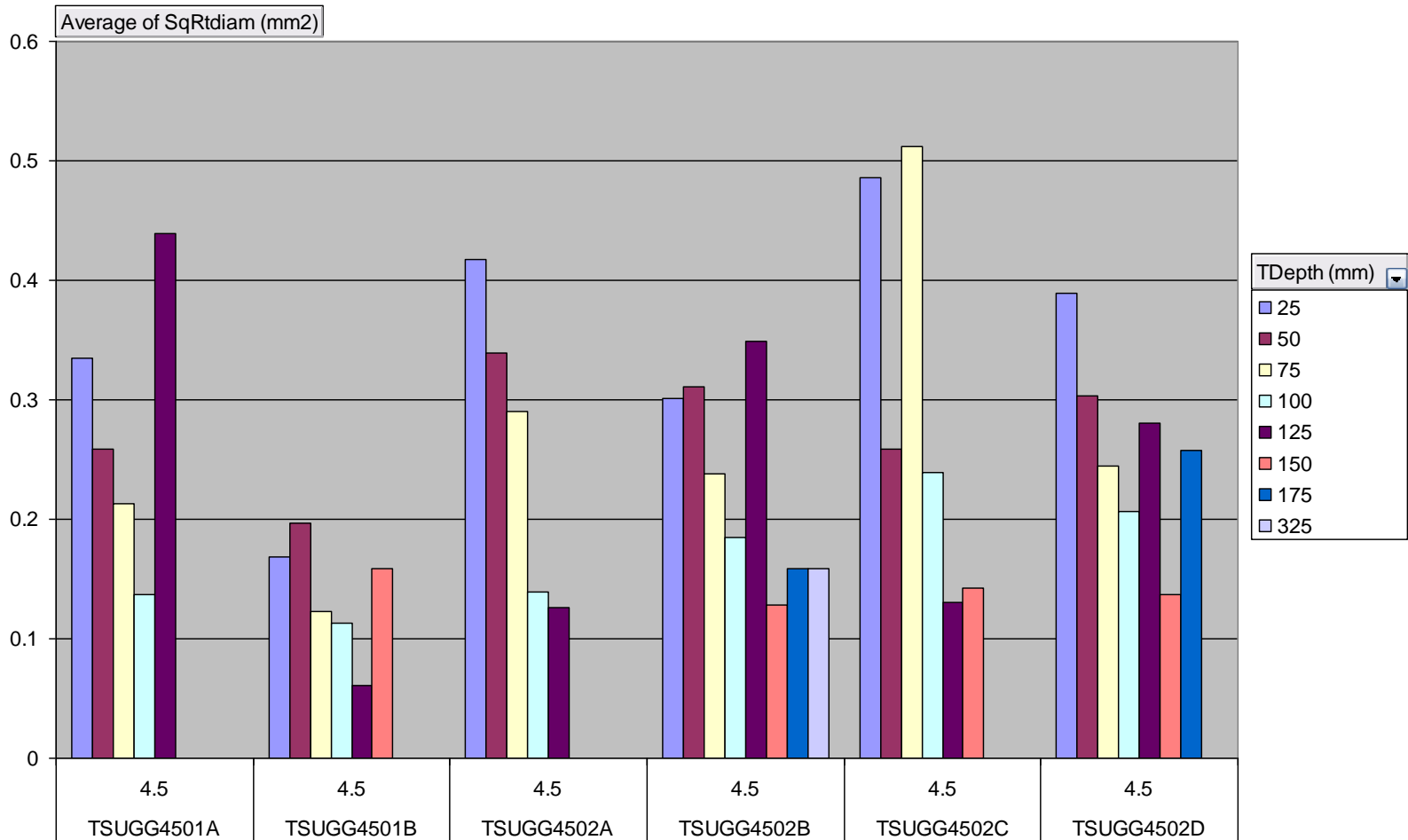# Approximate Root Mass Extracted from X-ray Images (arbitrary units)

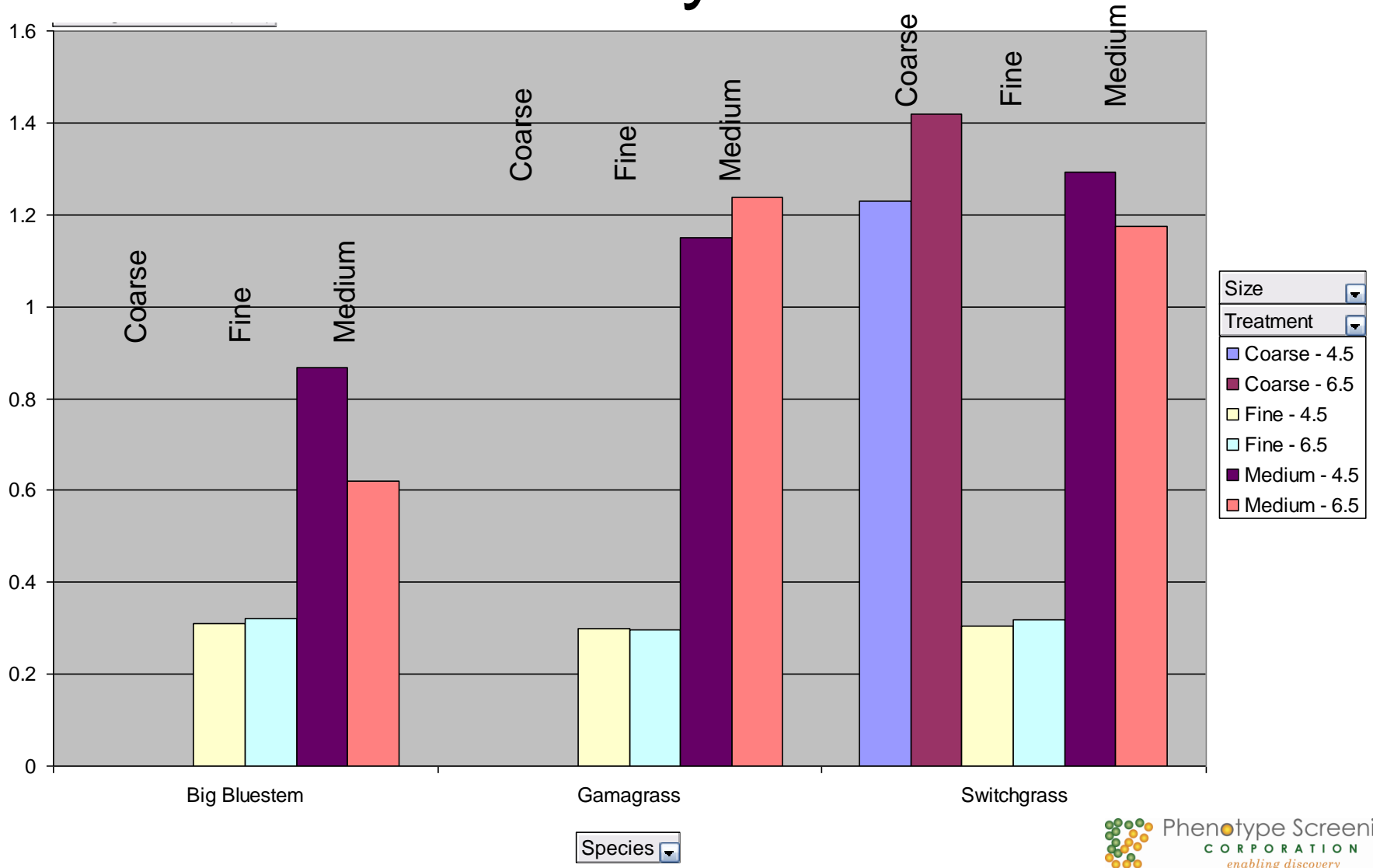# Silhouette Area of Root System ("Root System Extent")

Approximate Root Mass Distribution by Individual Gamagrass Plant

Species | Gamagrass ▾

Average of SqRtdiam (mm2)

TDepth (mm) ▾
- 25
- 50
- 75
- 100
- 125
- 150
- 175
- 325

4.5 — TSUGG4501A
4.5 — TSUGG4501B
4.5 — TSUGG4502A
4.5 — TSUGG4502B
4.5 — TSUGG4502C
4.5 — TSUGG4502D

Plant ID ▾ | Treatment ▾

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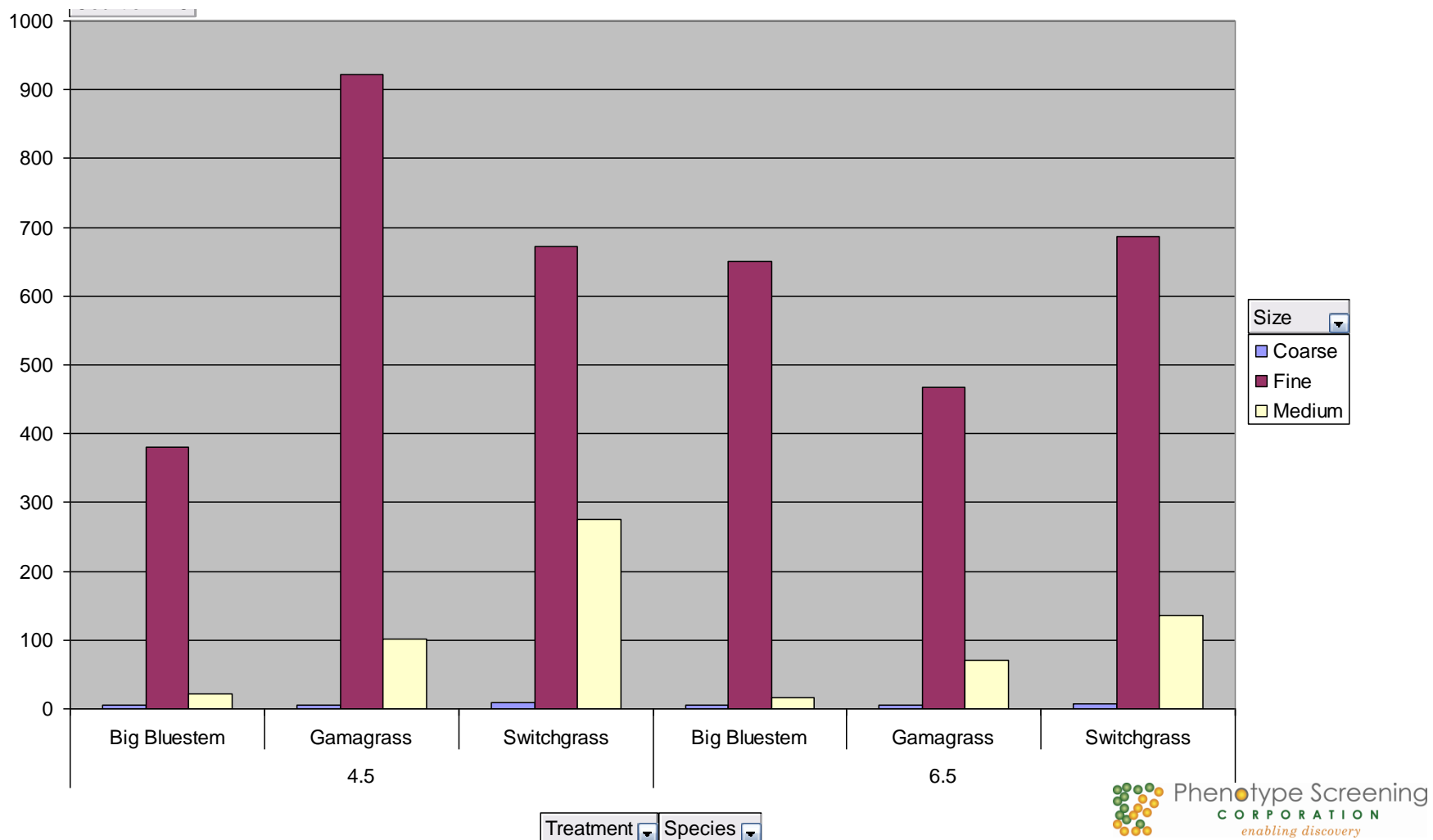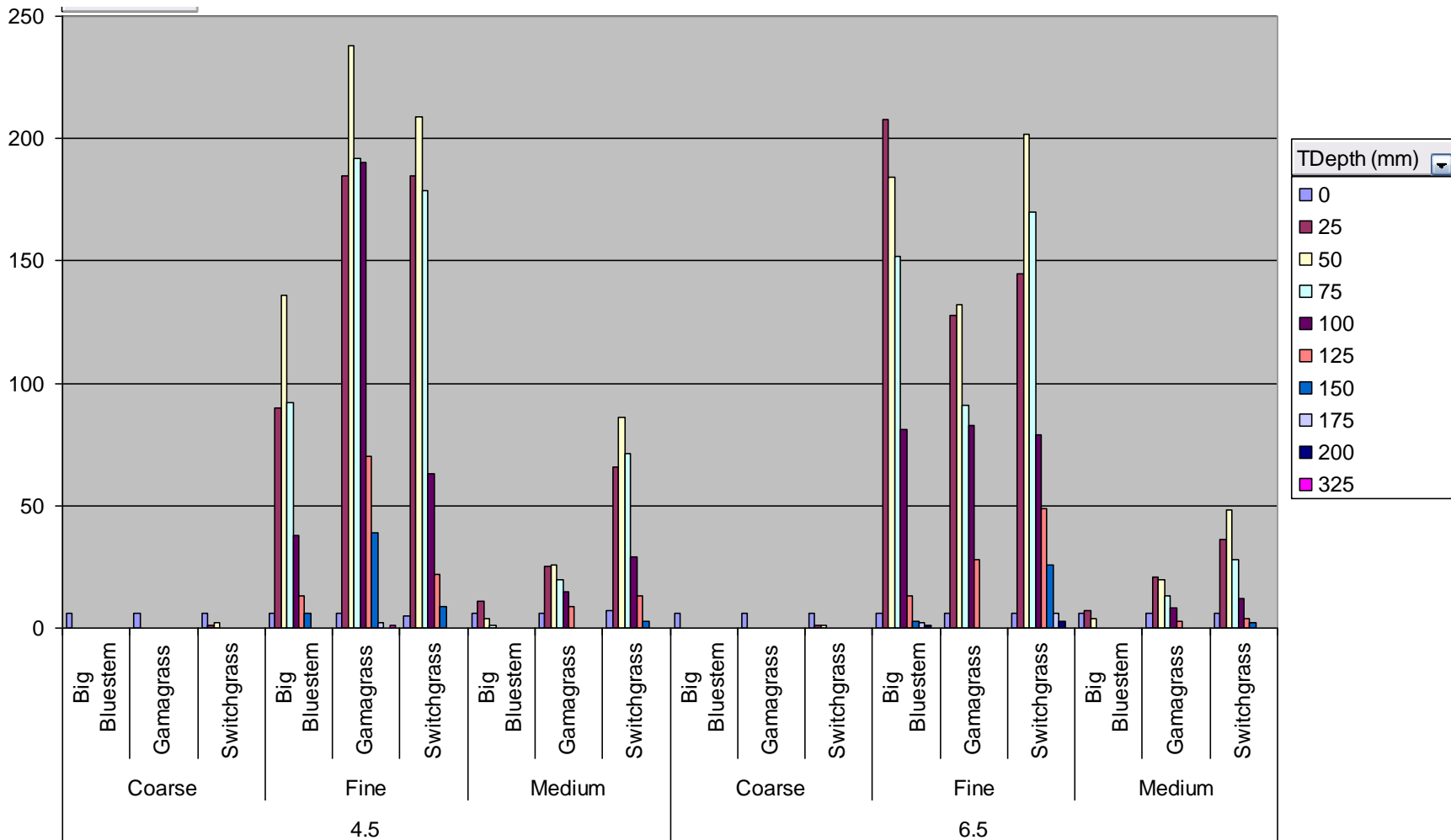
Average Root Diameter by Size-Class and by Treatment

Number of Root Crossings Over All Transect Depths by Root-Size-Class

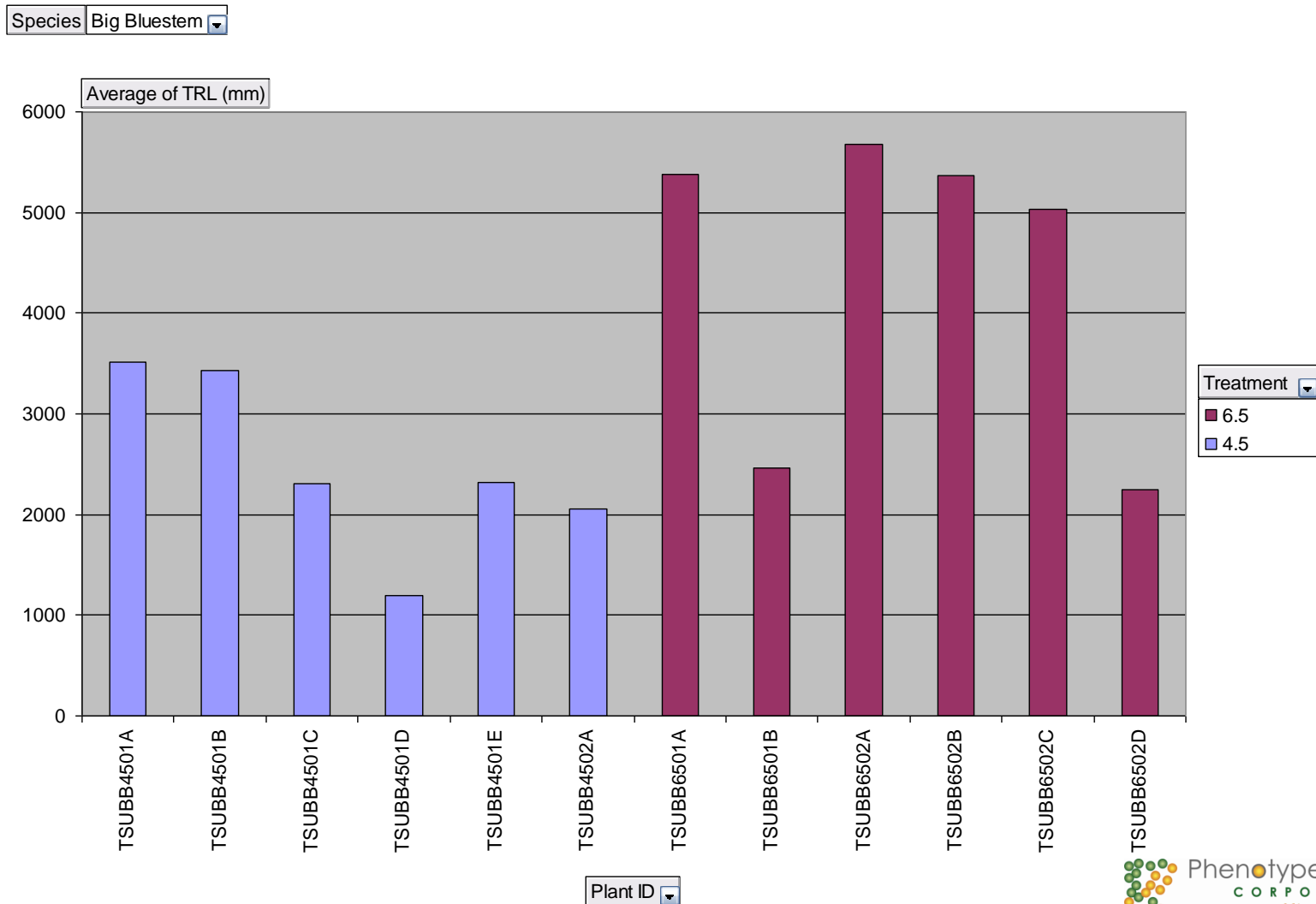# Number of Root Crossings at Measured Transect Depths
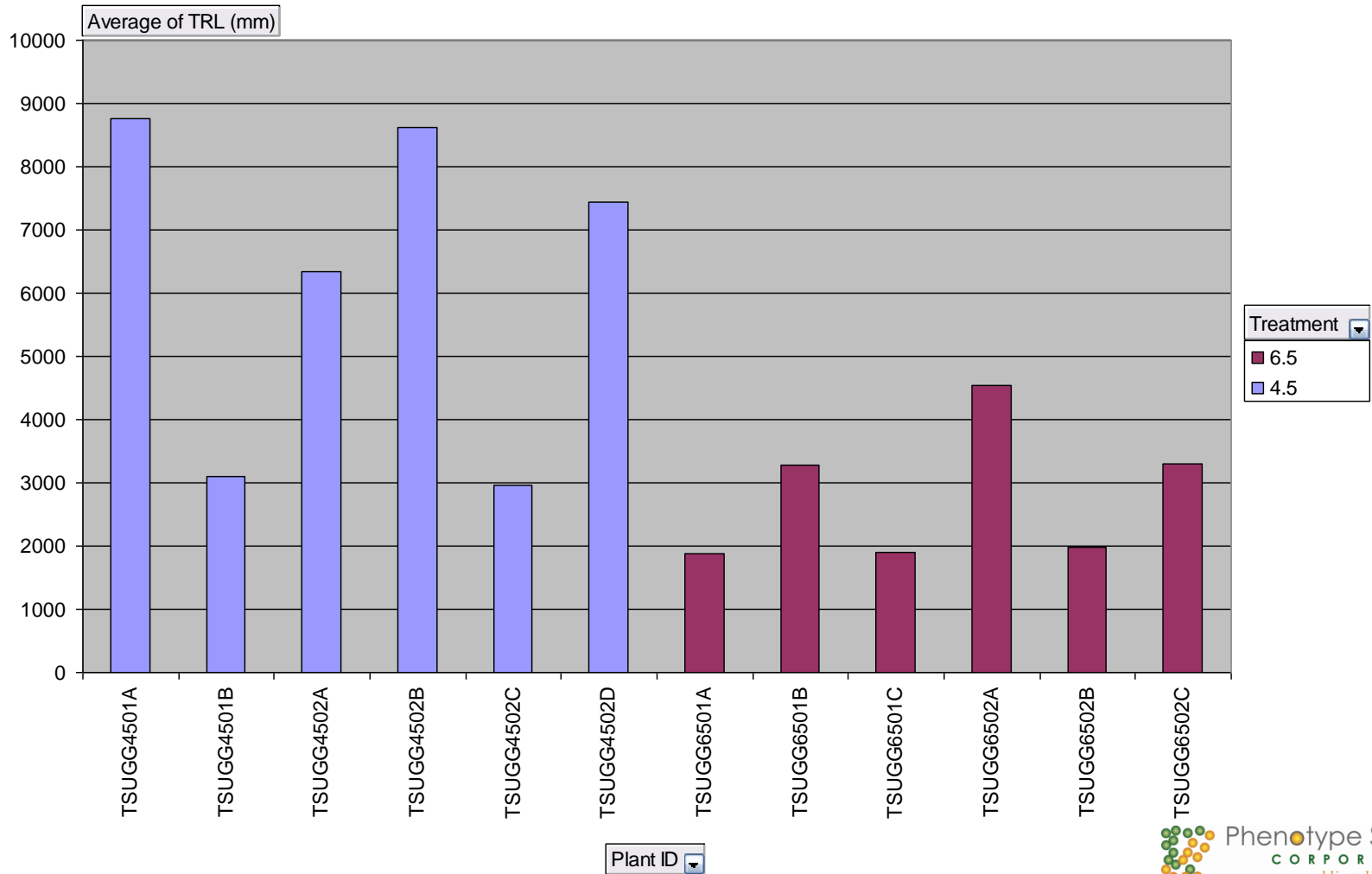
TRL by Individual Big Bluestem Plant

TRL by Individual Gamagrass Plant

TRL by Individual Switchgrass Plant

Species | Switchgrass ▾

Average of TRL (mm)

Treatment ▾
- 6.5 (maroon)
- 4.5 (purple)

Plant ID ▾

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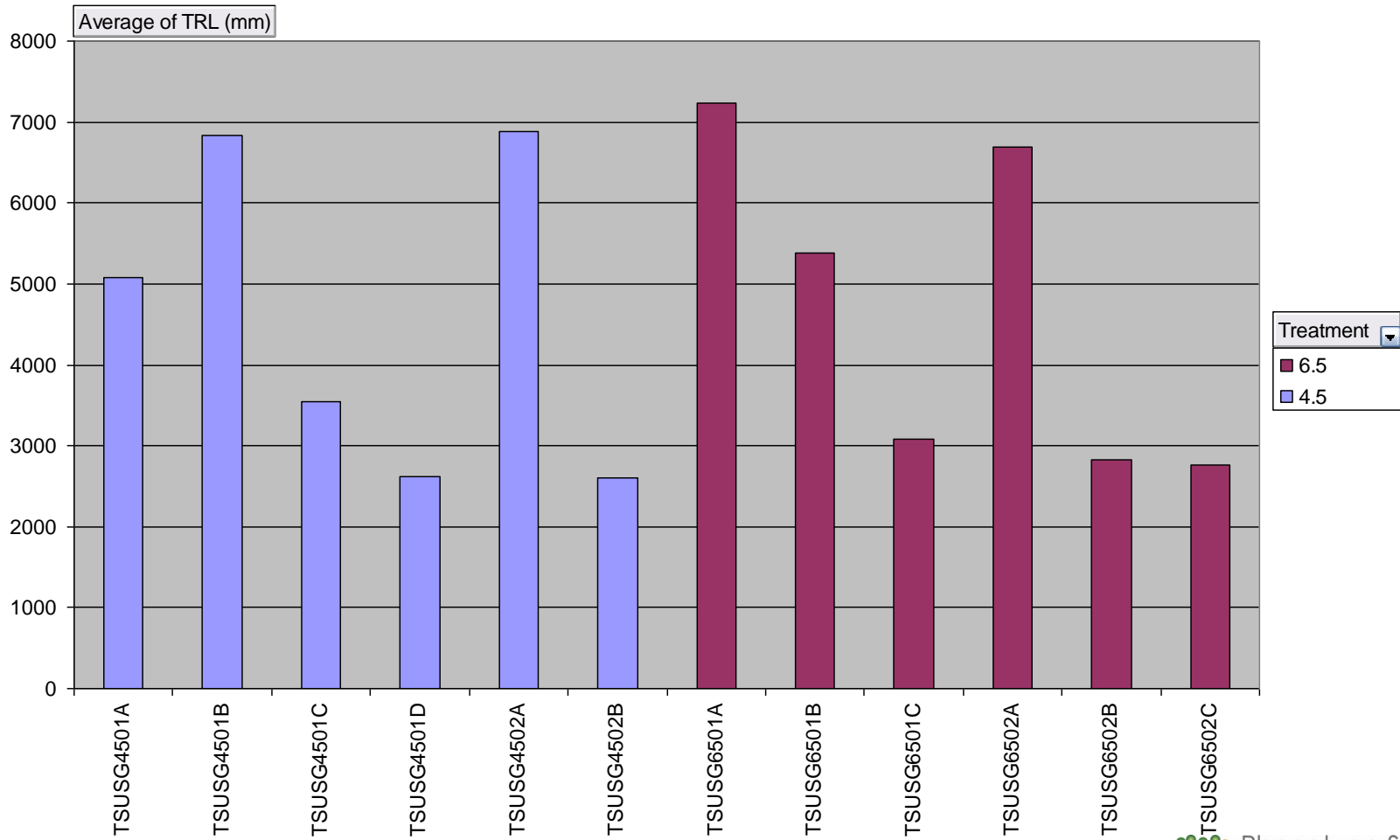
Root System Width at Increasing Depths of TSUBB4501A
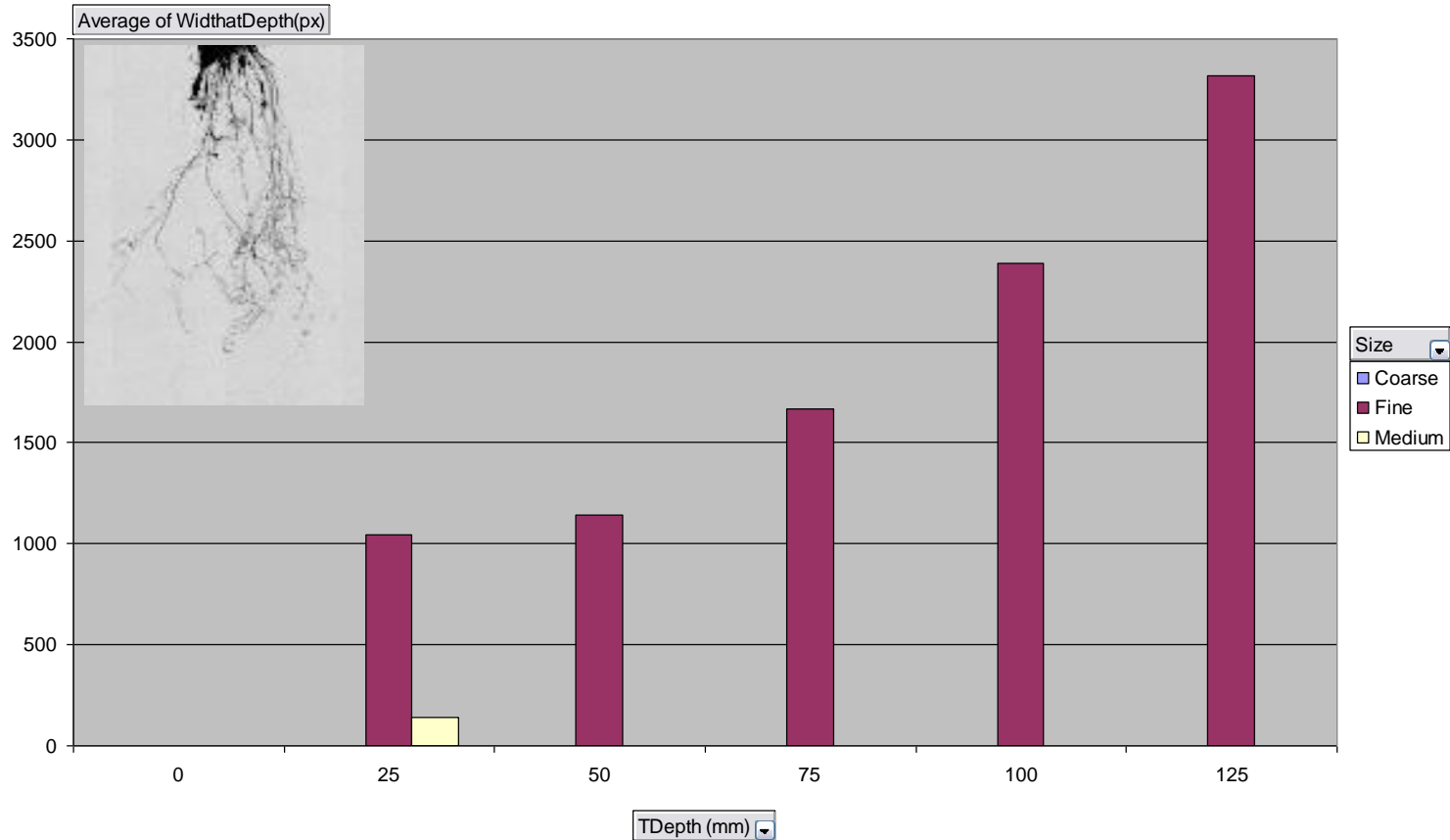
Number of Root Crossings per Root System Width (Count Density) at Increasing Depths of TSUBB4501A
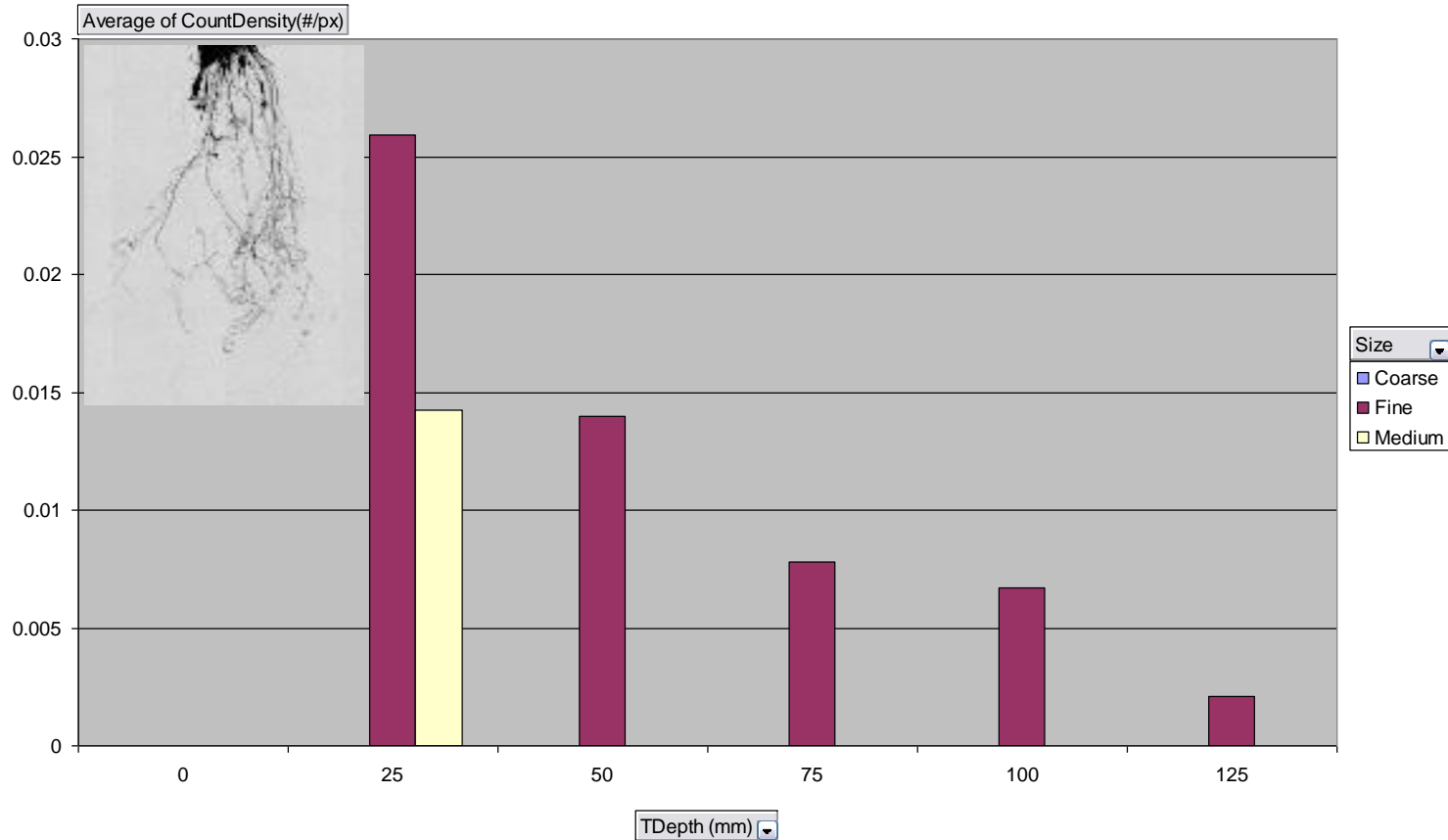
Approximate Root Mass Density Distribution at Increasing Depths of TSUBB4501A

Plant ID | TSUBB4501A ▼ | Species | Big Bluestem ▼

Average of ApproxMassDensity(mm2/px)

Size ▼
- ■ Coarse
- ■ Fine
- □ Medium

TDepth (mm) ▼

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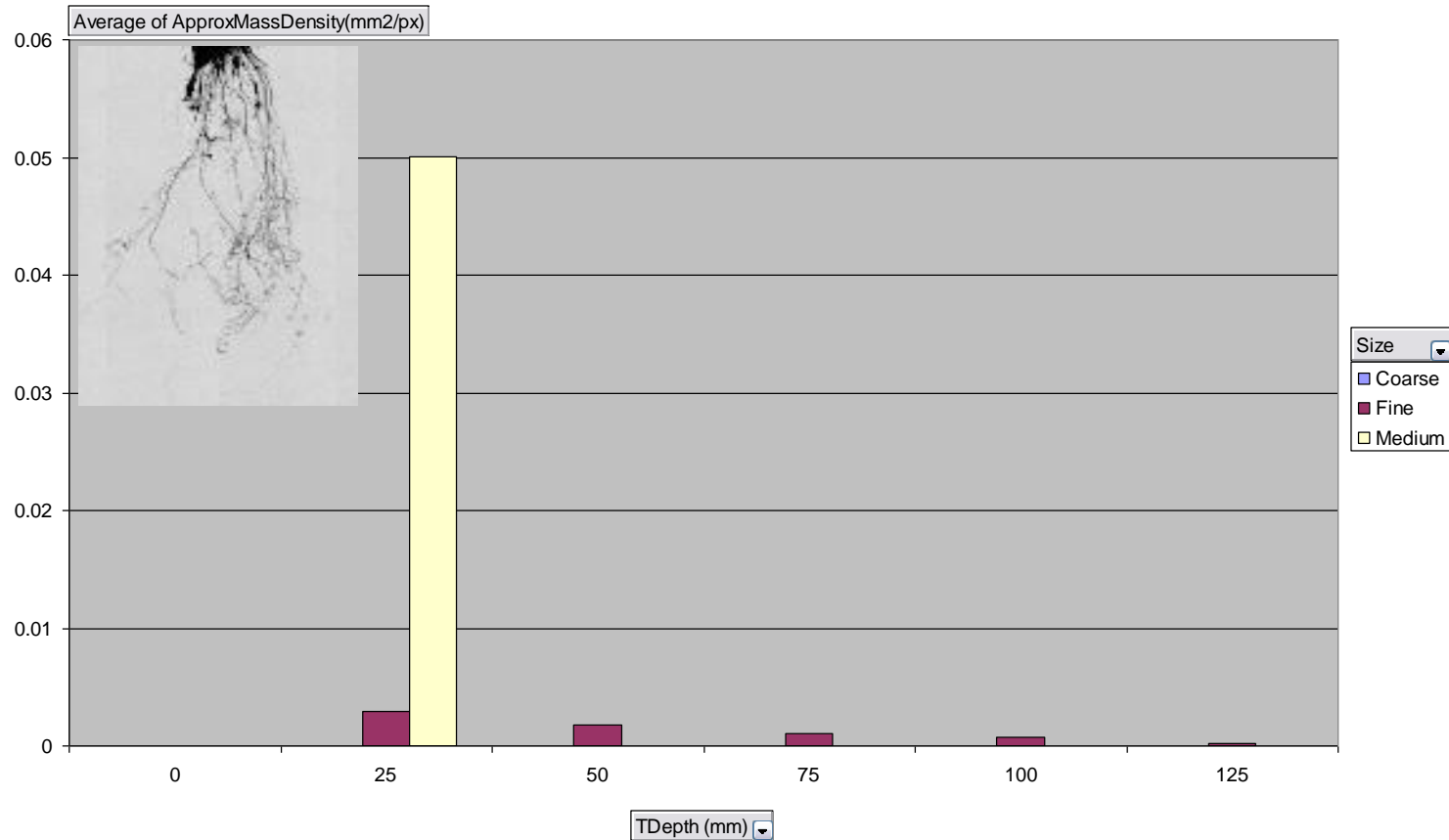
Approximate Root Mass Density Distribution at Increasing Depths of TSUBB4501A
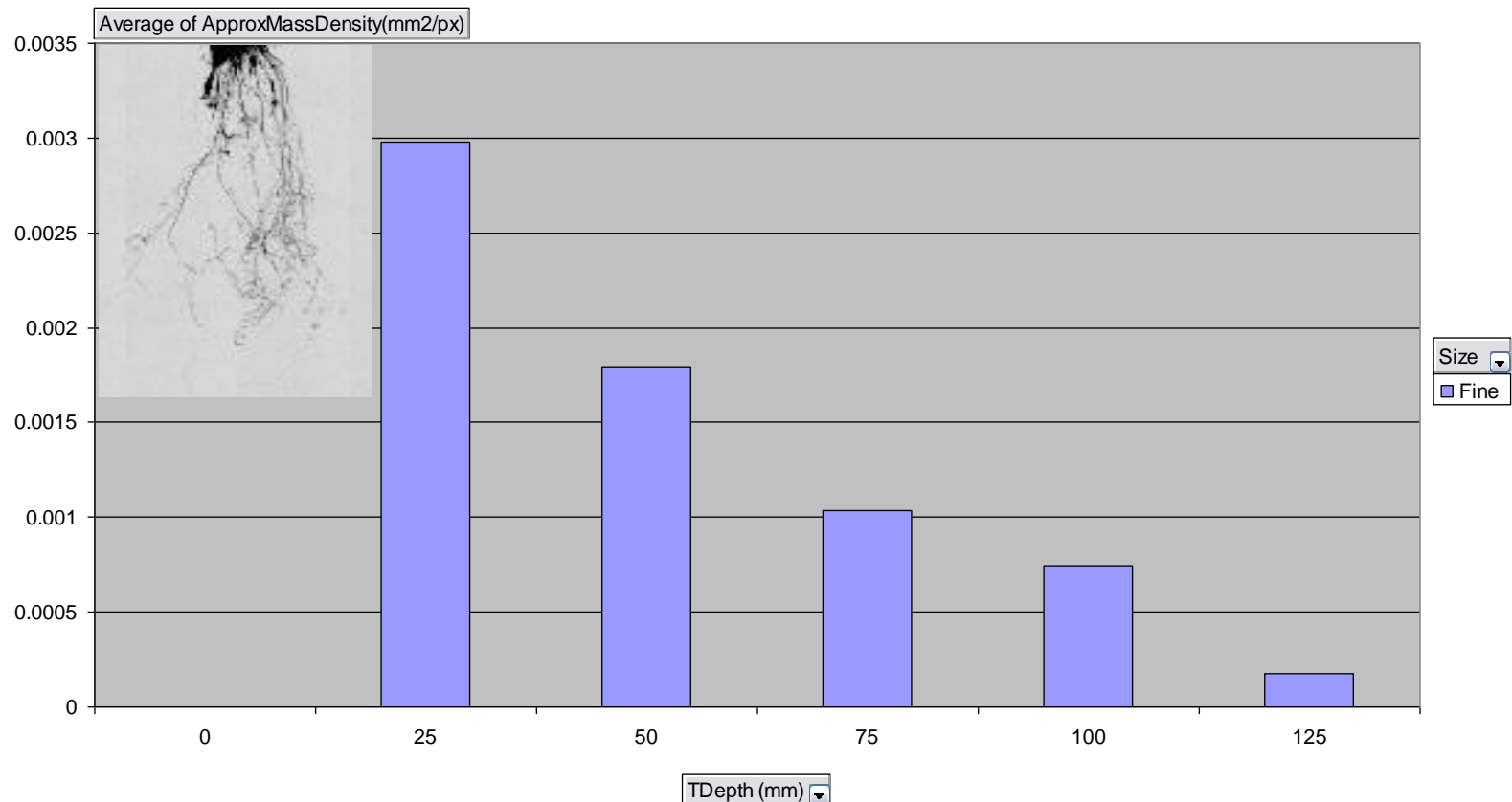
Plant ID | TSUBB4501A ▾ | Species | Big Bluestem ▾

Fine Roots Only!!!

Average of ApproxMassDensity(mm2/px)

Size ▾
□ Fine

TDepth (mm) ▾

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Conclusions

- Detailed, clear, high-resolution images are possible with pot-grown or field harvested washed root systems.

- Global descriptors of RSA can be automatically extracted from X-ray Images.

- Global descriptors of RSA can be determined independently for each root size class.

- RSA distribution as a function of root depth can also be derived and gives unique insight into root system morphology.

- Image analysis can differentiate root system growth between species and between treatments within and between species.

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