

FIELD-HARVESTED MAIZE “ROOT SYSTEM ARCHITECTURE” COMPARISONS UNDER DIFFERENT TREATMENTS AND TILLAGE CONDITIONS USING SOFT-TISSUE X-RAY IMAGING

2012 Annual Meeting of the Southern Branch of the
American Society of Agronomy
February 7, 2012

This Presentation Covers Collaborative Work With An Agri-Business Firm

- They want to include root system architecture performance in their agronomic studies.
- They are developing the tools and systems to extract and wash roots harvested in the field.
- They are using our X-ray based services to characterize their root systems and to provide feedback to them on their methods.

Can We Help Characterize These Roots?

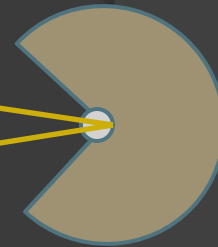


Basic X-ray Imaging Concept

X-ray
Camera



X-ray
Generator



Very low
energy X-rays
(10Kev) allow
for soft-tissue
imaging.

CPM Rep1



Root System Photograph



Root System Stereo X-ray Image

CPM Rep1

This image was modified electronically to reveal more structure and detail in dark areas of original X-ray image.

These roots have been broken in handling.



These portions of the root have a fine layer of soil along them that was not completely washed off. The same effect can be seen on other nodal roots in this area of the root system.

This is a corn kernel sized clump of soil embedded within the root system.

This area is dark in the original image because the stalk is thick and dense in this area.

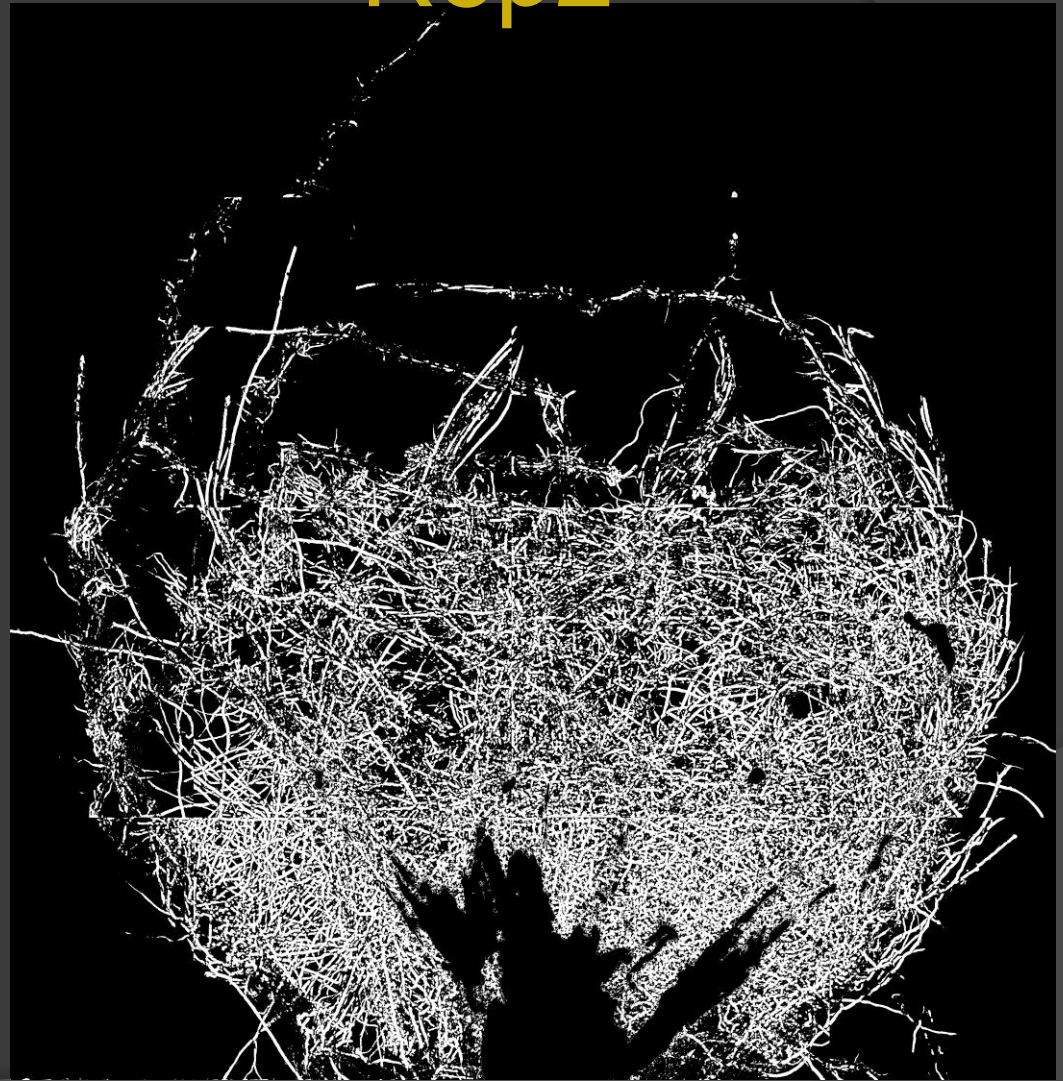
Maize Plant CPM Rep2



Coarse Root Portion $D = 1.58$

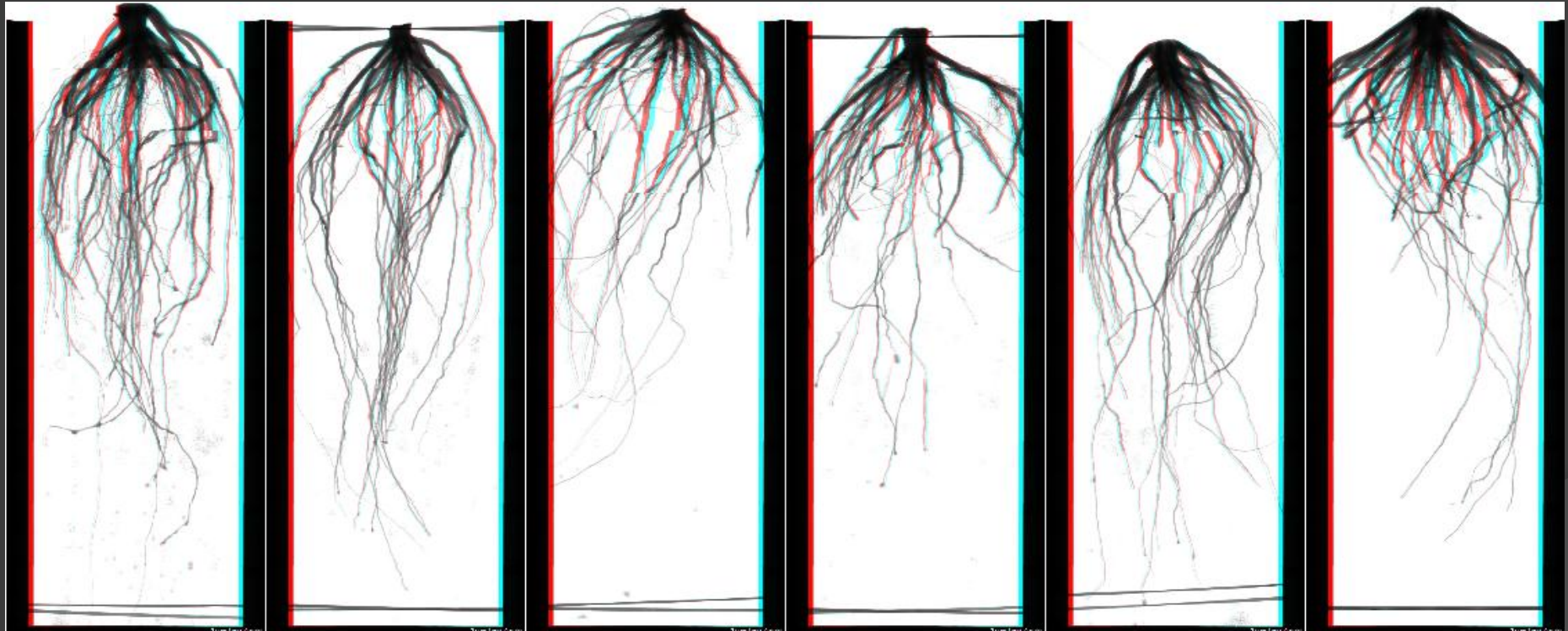


Medium Root Portion $D = 1.65$



Fine Root Portion $D = 1.78$

By Second Year There Were Improvements in Extraction & Washing



Maize Evaluations

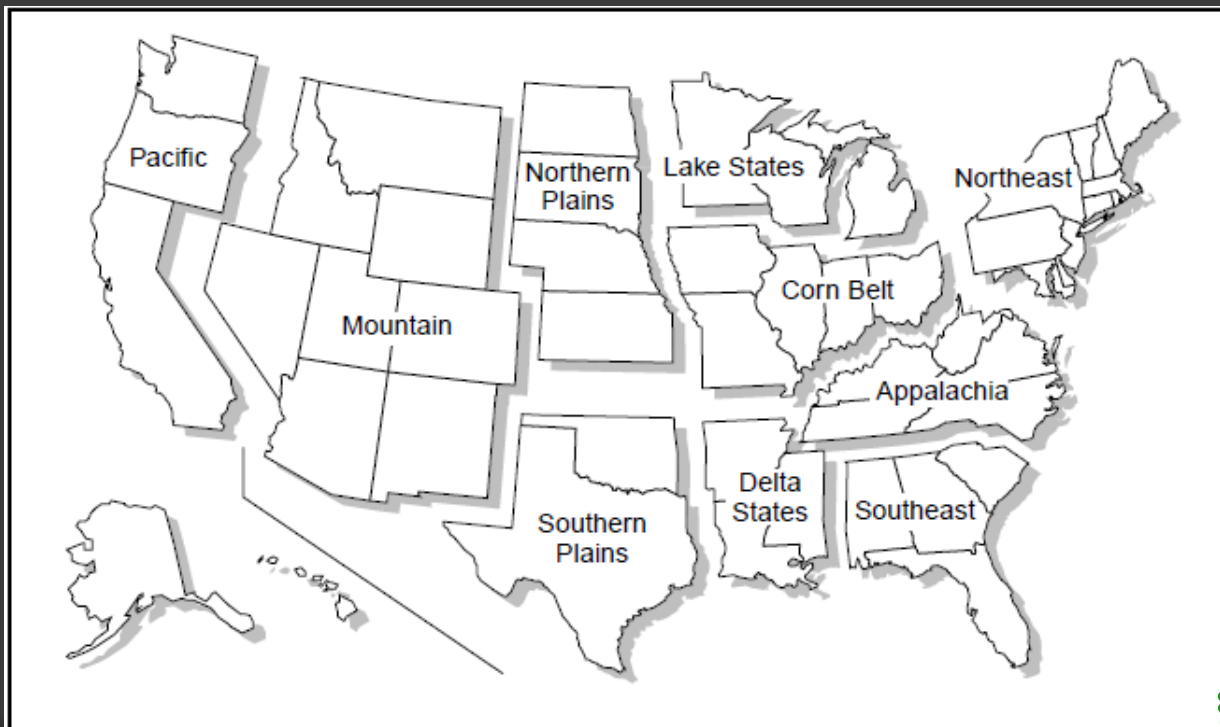
- Investigations began with a broad analysis of twenty-three maize root systems grown in Appalachia and in the Corn Belt in order to identify any statistical differences among Total-root-length and Projected-Area when the plants were grown under different tillage types and treatments.
- Total-root-length is the sum total of the length of all root segments lay end to end. It does not have a root diameter component.
- Projected-Area is a measure of the size of the root system. This trait includes contributions by both root lengths and root diameters.

Maize Evaluation (cont.)

- All image analysis was conducted individually on five separate root diameter size classes
 - Size Class Five 181u - 616u
 - Size Class Four 362u - 1,232u
 - Size Class Three 725u - 2,465u
 - Size Class Two 1,450u - 4,930u
 - Size Class One 2,900u - 9,860u
- Roots within different sizes are suspected of having different functions within the overall root system.

Washed Roots Background - Location

- CB – Corn Belt Production Region
- AP – Appalachia Production Region



Washed Roots Background - Treatment

- CPM = Comprehensive pest management treatment
- APM = Aggressive pest management treatment
- TPM = Traditional pest management treatment

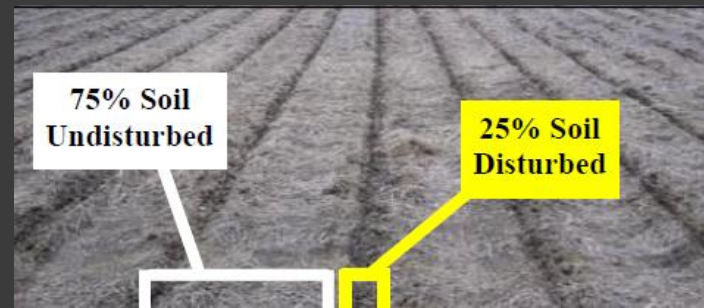
Washed Roots Background – Tillage Type

- CT – Conventional Tillage

- ST – Strip Tillage



- NT – No Tillage



There were relatively few plants in each category

Pest Management Treatment	NT (6)	ST (6)	CT (6)
Comprehensive	(2)	(2)	(2)
Aggressive	(2)	(2)	(2)
Traditional	(2)	(2)	(2)

Corn Belt Production Region

Pest Management Treatment	NT (5)	ST	CT
Comprehensive	(1)		
Aggressive	(2)		
Traditional	(2)		

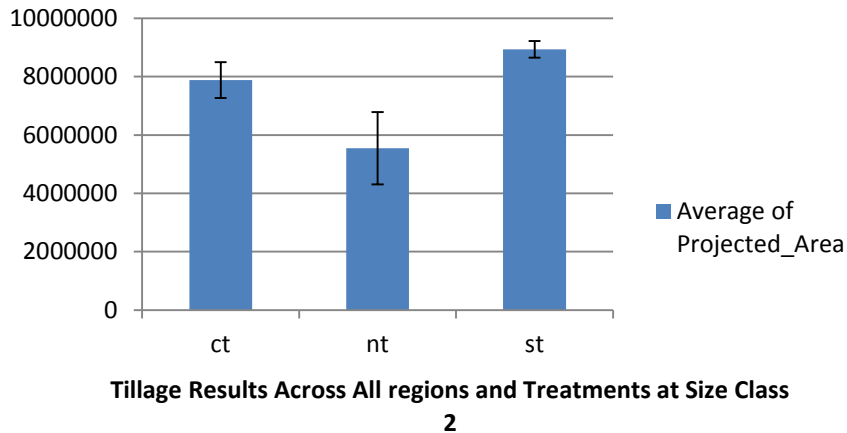
Appalachia Production Region

Analysis Across Regions

- There were statistical differences between tillage types across all treatments when comparing data with the Corn Belt and Appalachia together .
- Projected-Area gave significant differences between tillage types in size classes 2 and 3.
 - Size Class Two 1,450u - 4,930u
 - Size Class Three 725u - 2,465u

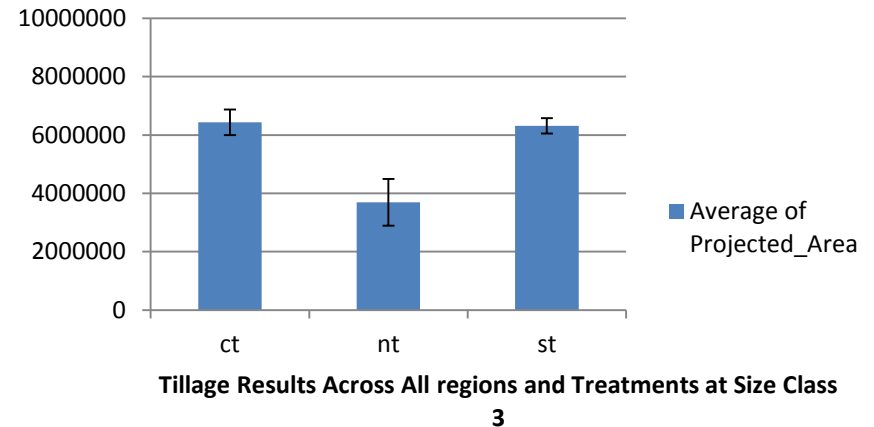
Analysis Across Regions (cont.)

Average Projected Area



Size Class Two; 1,450u - 4,930u
The three tillage types had significant effects on roots of this size. Strip-till favors roots of this size while no-till does not.

Average Projected Area



Size Class Three 725u - 2,465u
Only no-till had a significant effect on roots of this size. No-till does not favor roots of this size.

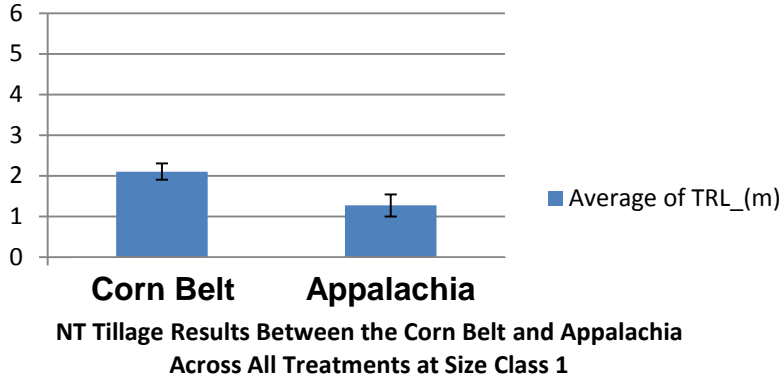
Analysis Across Regions (cont.)

- There were no statistical differences between the three treatments (Comprehensive, Aggressive, Traditional) when comparing across tillage types and across both the Corn Belt and Appalachia with respect to Projected-Area and Total-root-length.

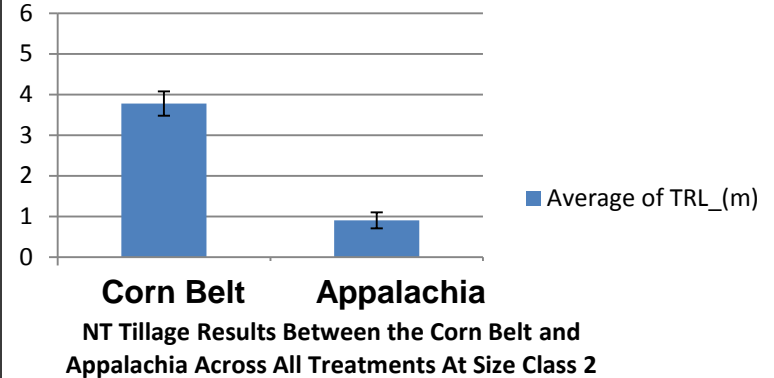
Analysis of Tillage Types

- Because Appalachia contained only the NT tillage type, NT was used to identify differences in NT between Appalachia and the Corn Belt.
- Statistical differences were identified among total-root-lengths when looking at size classes 1-4.

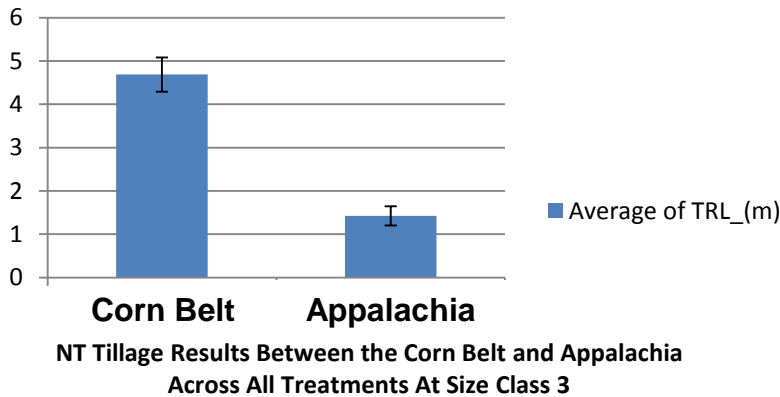
Average of TRL_(m)



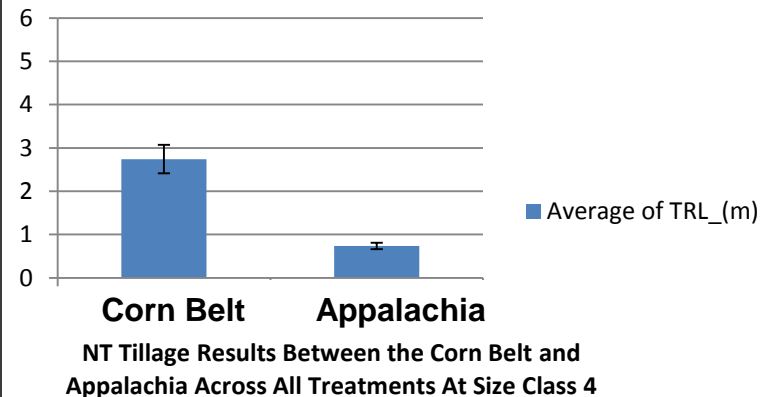
Average of TRL_(m)



Average of TRL_(m)



Average of TRL_(m)

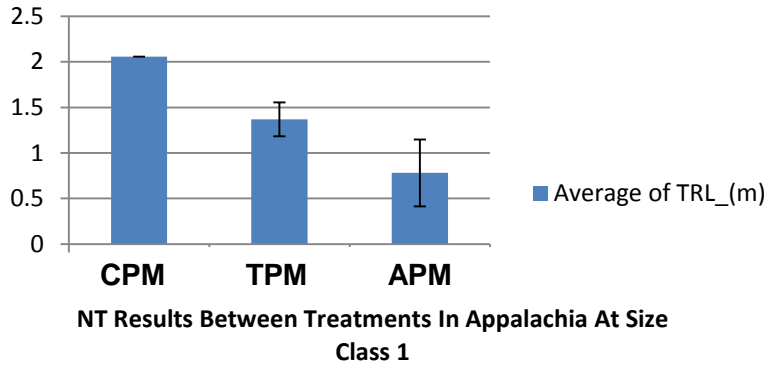


There were significantly shorter roots of all sizes in Appalachia than in the Corn Belt under no-till conditions.

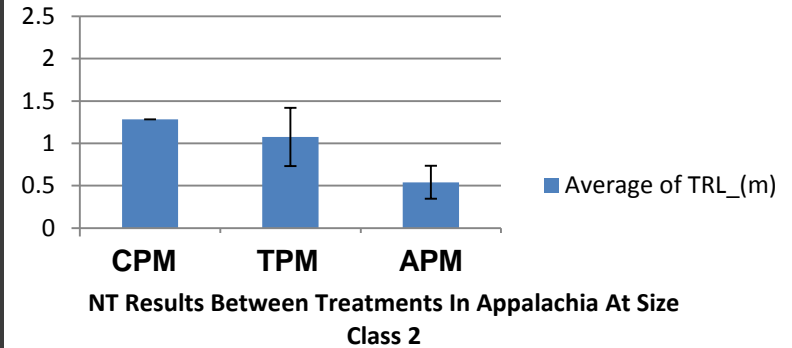
Treatment Effects Under NT Tillage in Appalachia

- There were significant differences between size classes 1, 2, 3, and 5 when comparing total-root-lengths among the different treatments in Appalachia.

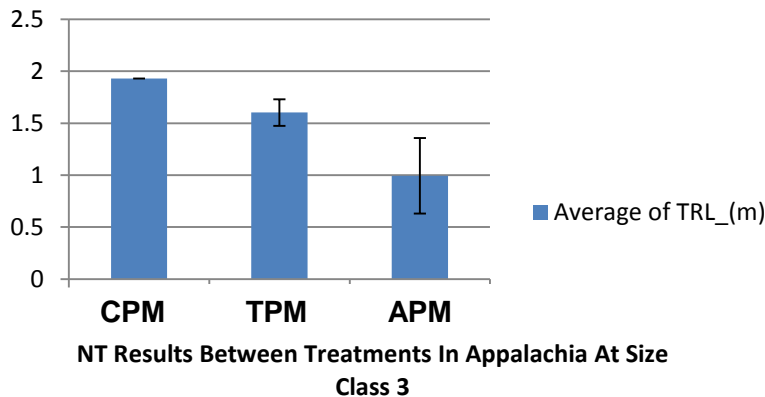
Average of TRL_(m)



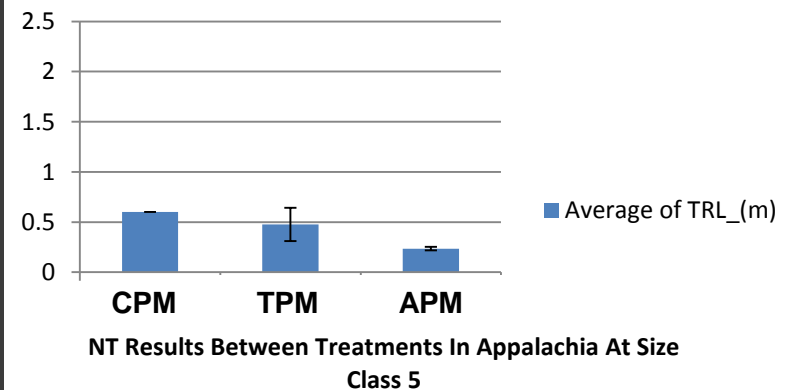
Average of TRL_(m)



Average of TRL_(m)



Average of TRL_(m)

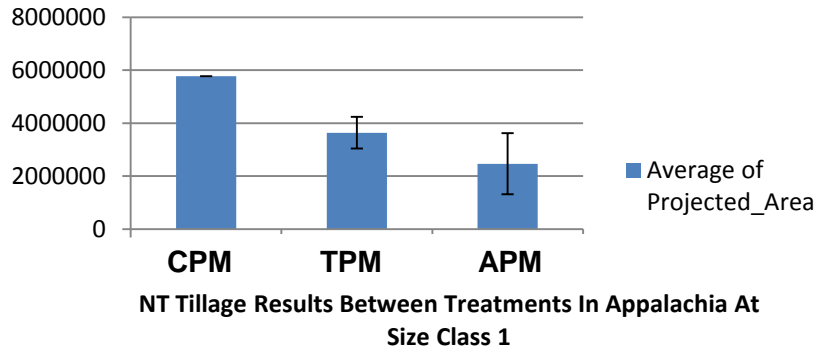


There were shorter roots in these size classes in Appalachia for the aggressive pest management treatment when the plants were grown under no-till.

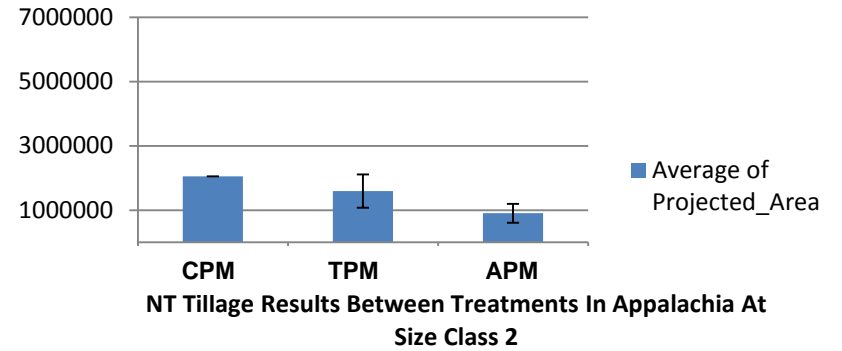
Treatment Effects Under NT Tillage in Appalachia (cont)

- Numerical differences were also observed when looking at projected-area in Appalachia. The statistical significance is less pronounced with this trait.
 - Note that projected-area has a contribution from the root diameters while total-root-length does not.

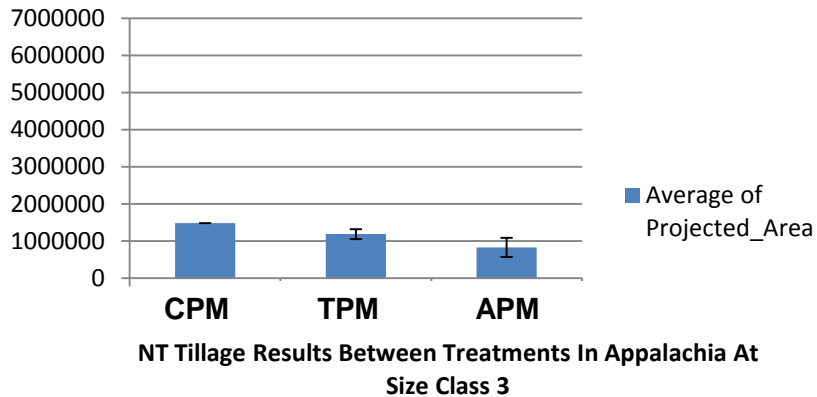
Average of Projected Area



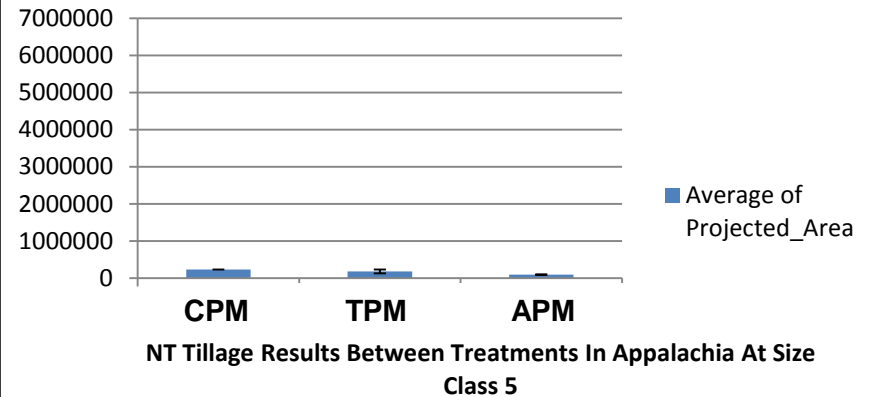
Average of Projected Area



Average of Projected Area



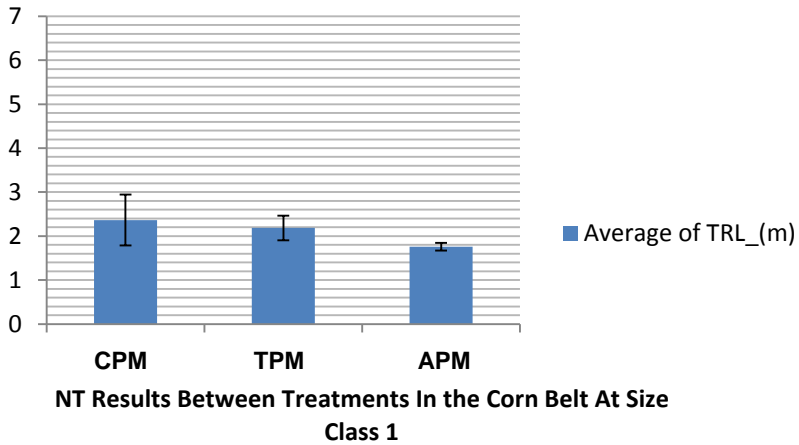
Average of Projected Area



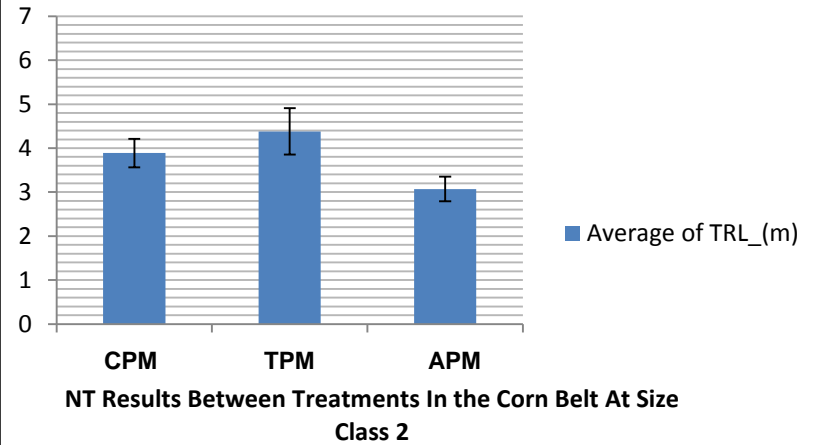
Treatment Effects Under NT Tillage in the Corn Belt

- Differences among treatments were also observed in the Corn Belt when looking at NT tillage type across all treatments.
- With respect to Total-root-length, differences were identified in size classes 1, 2, 3, and 5.

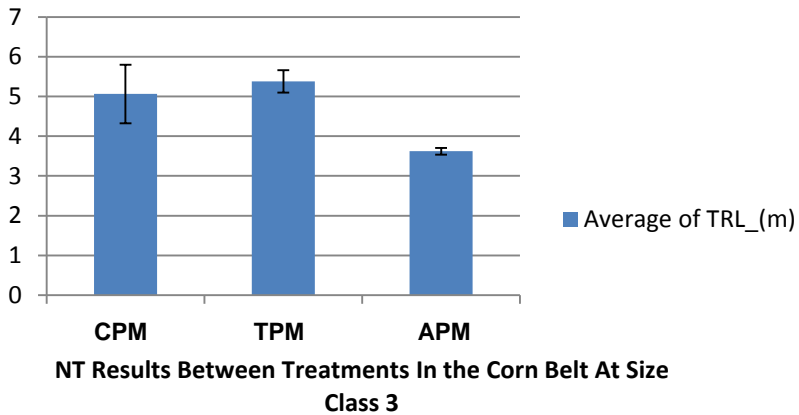
Average of TRL (m)



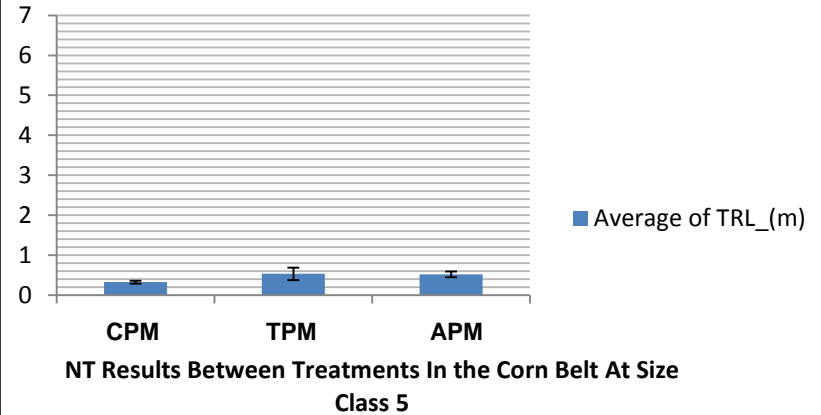
Average of TRL (m)



Average of TRL (m)



Average of TRL (m)

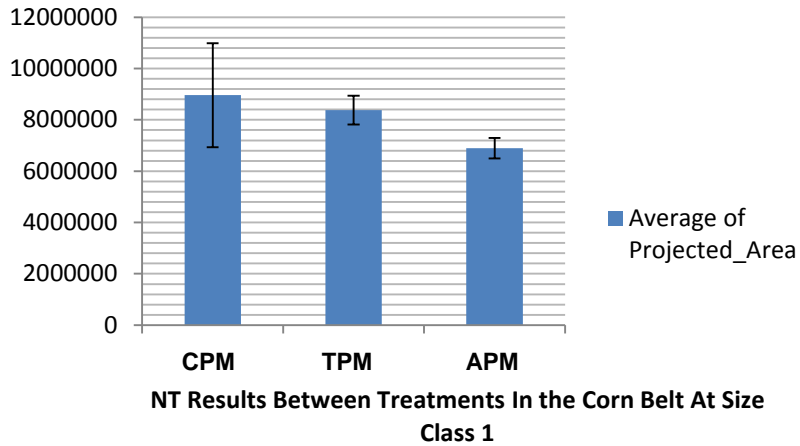


There were no differences in root lengths between the comprehensive and traditional treatments but there were under the aggressive treatment.

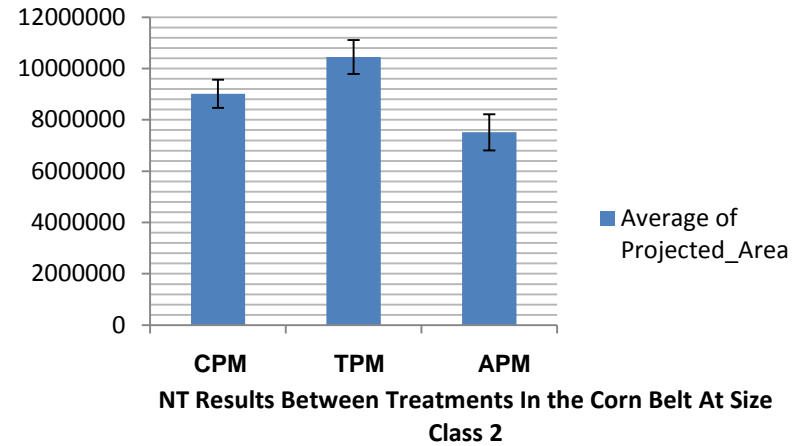
Treatment Effects Under NT Tillage in the Corn Belt (cont)

- There were also significant differences in projected area between treatments when looking at NT tillage type in the Corn Belt.
- Differences were observed in size classes 1, 2, 3, and 5.

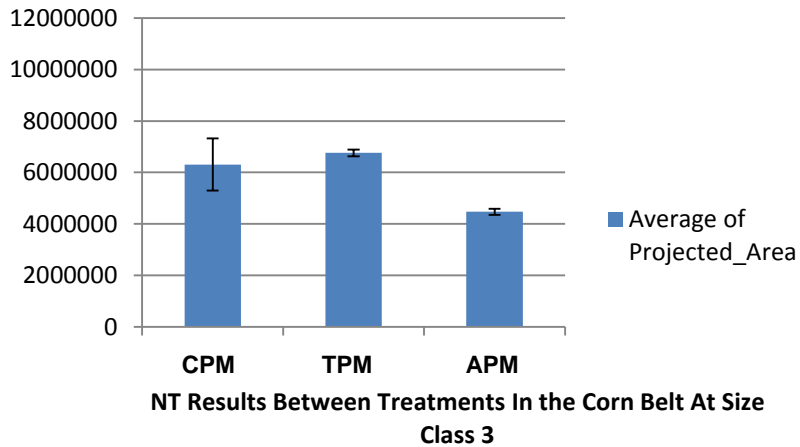
Average of Projected Area



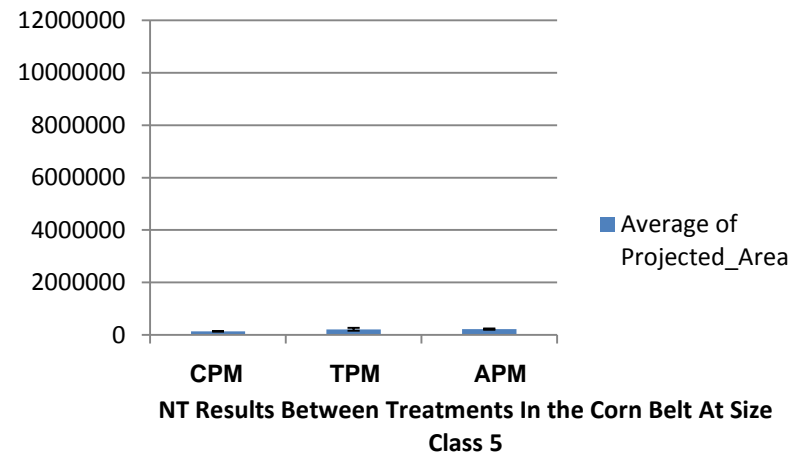
Average of Projected Area



Average of Projected Area



Average of Projected Area

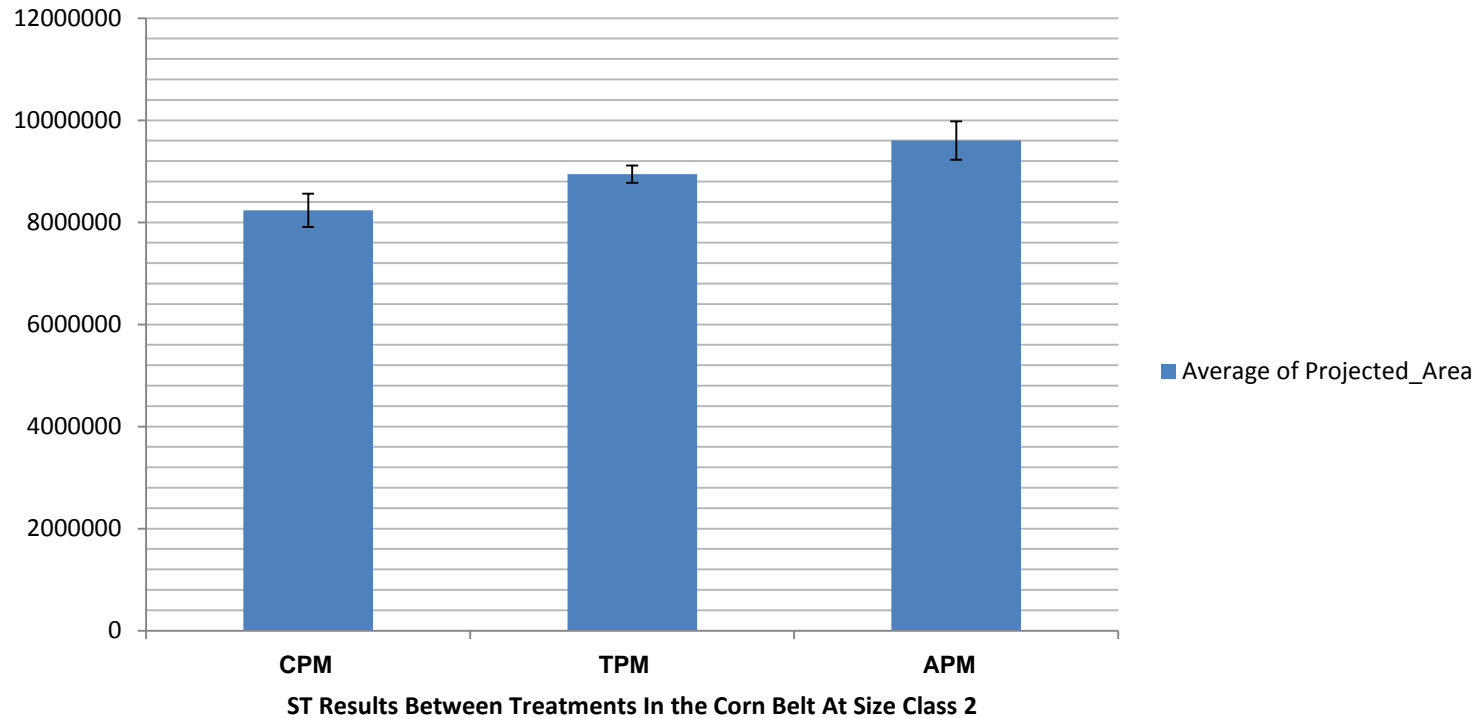


In the corn belt, the significance between the aggressive treatment is more pronounced than in Appalachia for this projected-area trait.

Treatment Effects Under ST Tillage in the Corn Belt

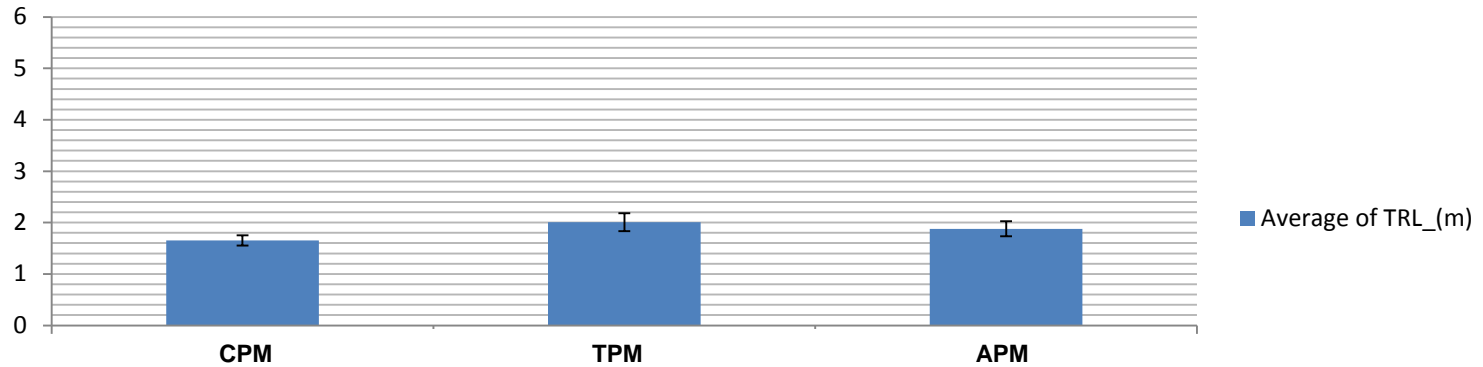
- There were significant differences in Projected-Area under ST tillage between treatments in the corn belt only for Size class 2 (1,450u - 4,930u).
- Significant differences were observed in Total-root-length under ST tillage treatments in the corn belt for Size classes 1 (2,900u - 9,860u) and 2 (1,450u - 4,930u).
- In the corn belt, under strip-till, the traditional and aggressive treatments seem to encourage larger diameter roots over the comprehensive treatment.

Average of Projected_Area



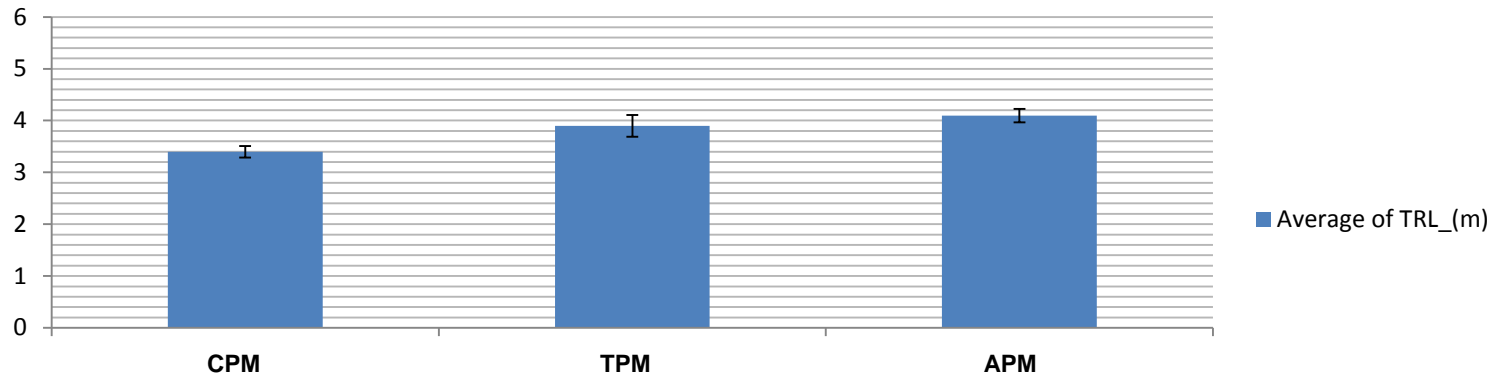
The impact of the various treatments were quite different under strip till than they were under no till.

Average of TRL_(m)



ST Results Between Treatments In the Corn Belt At Size Class 1

Average of TRL_(m)

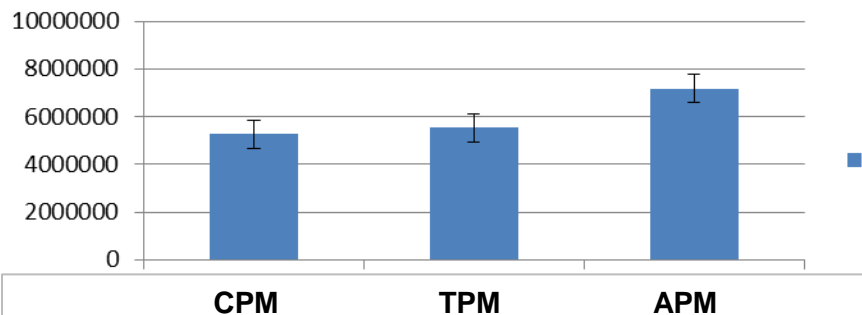


ST Results Between Treatments In the Corn Belt At Size Class 2

Treatment Effects Under CT Tillage in the Corn Belt

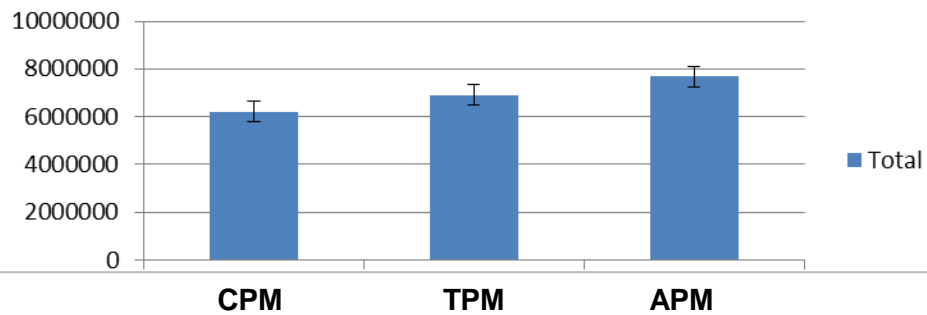
- There were significant differences in Projected-Area under ST tillage between treatments in the corn belt only for several size classes.
- Significant differences were observed in Total-root-length under CT tillage treatments in the corn belt all for size classes.
- In the corn belt, under conventional-till, each treatment had unique effects on each size class.

Average of Projected Area



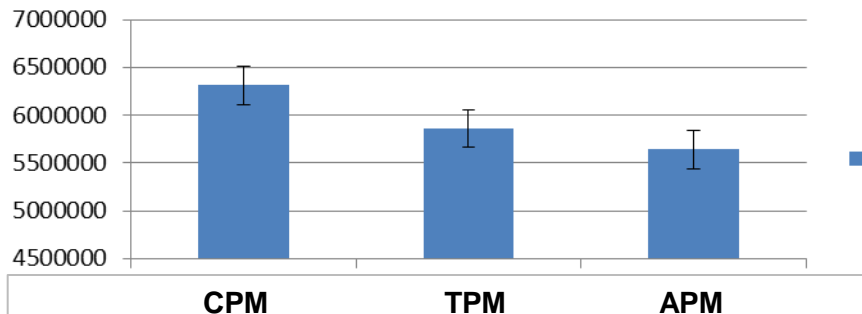
CT Results between treatments in the Corn Belt at SizeClass 1

Average of Projected Area



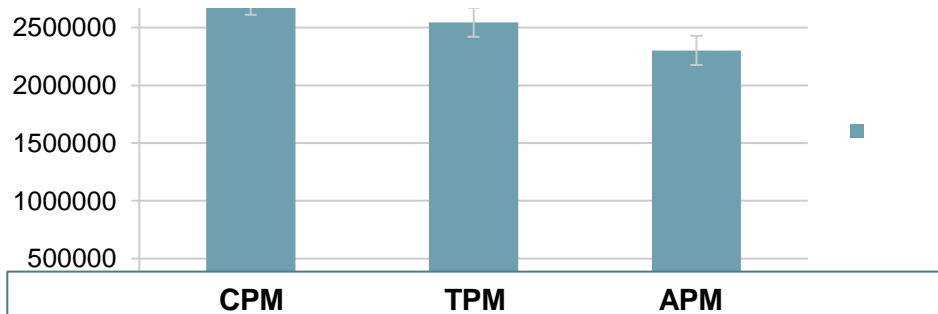
CT Results between treatments in the Corn Belt at SizeClass 2

Average of Projected Area



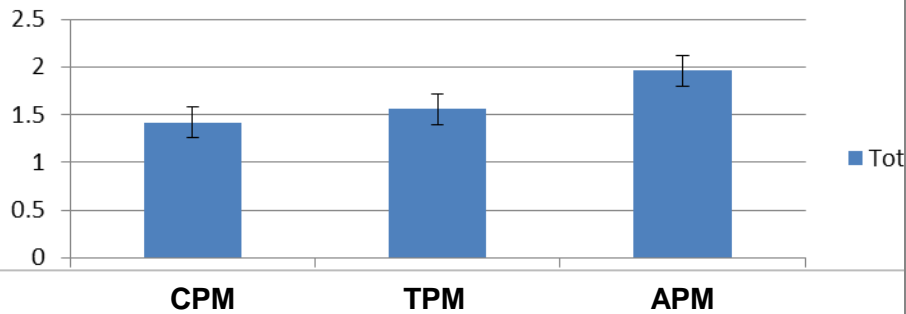
CT Results between treatments in the Corn Belt at SizeClass 3

Average of Projected Area



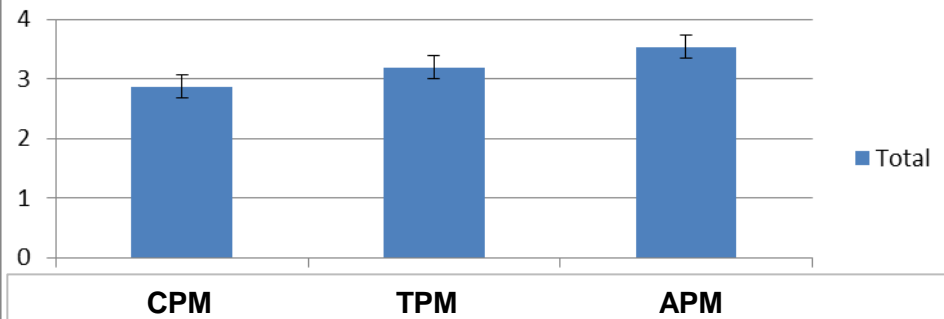
CT Results between treatments in the Corn Belt at SizeClass 4

Average of TRL



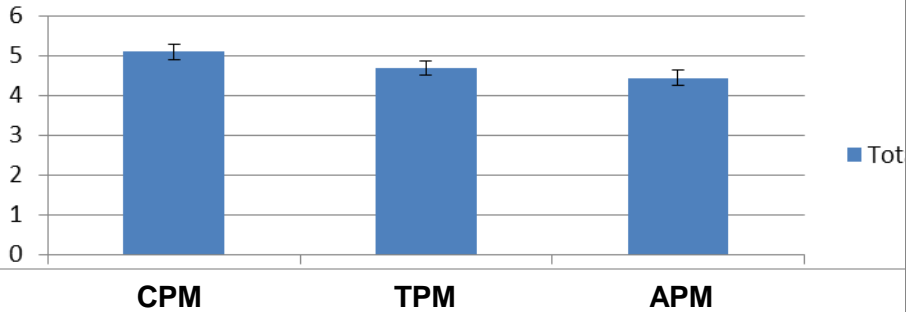
CT Results between treatments in the Corn Belt at SizeClass 1

Average of TRL



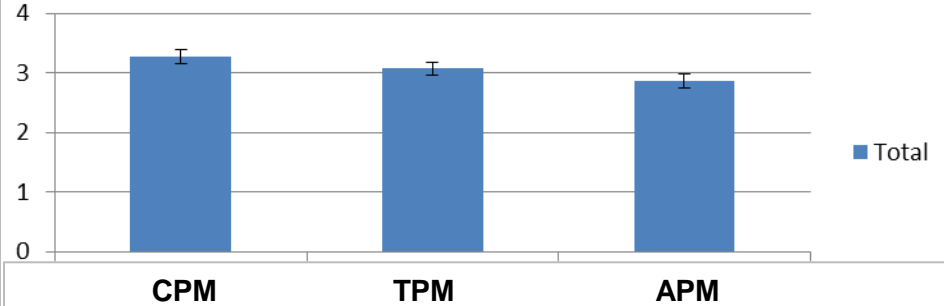
CT Results between treatments in the Corn Belt at SizeClass 2

Average of TRL



CT Results between treatments in the Corn Belt at SizeClass 3

Average of TRL



CT Results between treatments in the Corn Belt at SizeClass 4

Maize Summary

- Statistical differences were discovered under different treatments and tillages for specific root size classes. Each size class had a unique response to these conditions.
- For this growing season, under no-till, the lengths of roots in each size class were less in Appalachia than in the Corn Belt.
- When analyzing the Corn Belt and Appalachia data separately the effects of treatments under NT tillage indicated that roots tended to be consistently shorter under the aggressive pest management treatment for most root diameter sizes.
- When analyzing the Corn Belt and Appalachia data separately the effects of treatments under NT tillage indicated that root extent behaved differently under the treatments depending upon root diameter sizes.
- TPM and APM treatments in the Corn Belt under strip-till encouraged larger diameter roots.
- In the Corn Belt under conventional tillage the various treatments had unique impacts on each root diameter size.