CID,Inc.

Root-Image Analysis Software for CI-600

Kuo-Chung Hsu
Application Scientist

Software Packages

Bundled Software

- Image capture software – CanoScan
  - Included with CI-600
- Image viewing software – ArcSoft PhotoStudio
  - Included with CI-600

Optional Software

- Image analyzing software
  - Regent WinRhizoTtron MF (sold separately)
  - SigmaScan Pro (sold separately)

Root Image Analysis

- **Qualitative Analysis:**
  - To observe root disease, development, etc. The included image capture and viewing software will be sufficient.

- **Quantitative Analysis:**
  - To measure root length, area, volume, branching, etc. One must purchase additional image analysis software.

Rhizosphere Fungus Image

Image provided by Dr. Dylan Fischer at Evergreeen State College. For more information, visit his web site at http://academic.evergreen.edu/f/fischerd/

Root Image Quantitative Analysis

- Users of Root Analysis software packages must identify roots prior to performing measurements. There are several tools available. We suggest one of the following programs:

1. **WinRhizoTron MF**: a program developed specifically for root image analysis and requires users to manually trace roots

2. **SigmaScan Pro**: a generic image processing program. No manual root tracing is required, but sophisticated image processing may be required

Root-Image Analysis Software Performance Review

	WinRhizo Tron	SigmaScan
Root-image specific	Y	N
Functionality	+++	++
Ease of use	++	+
Data Output	++	+
Price	+	++
Recommended	+++	+

Note: +++: most favorable for users, ++: more favorable for users, +: less favorable for users

WinRhizo Tron

Principle of Operation:

- Users manually trace the roots and then utilize built-in functions to perform measurements

Pros:

- Root tracing can be time consuming for certain root systems. This program eliminates the need to retrace each root image by offering a feature that saves previous root traces in a template. The template can be imported and overlapped onto the images taken at the same location, at a later time. This time saving feature is a major differentiator between WinRhizo Tron and its competition.
- Multi-image display for space/time sequencing (on MF version)
- Provides detailed root-branch analysis

Cons:

- Tracing each individual root is time consuming.
- Output data file is in text format with labels misaligned.

  (Excel compatible supplemental package (sold separately) solves this issue.)

SigmaScan

Principle of Operation:

- Uses image processing techniques to globally select the roots without manually tracing every root. This is Sigma Scan's main differentiator.

Pros:

- Many built-in image processing tools and measurements functions. Users have more flexibility to extract data from root images
- Less expensive than WinRhizo Tron

Cons:

- Needs multiple manipulations of the image to identify root structure without noise. Depending on the contrast of roots and soil color, it may be very difficult to isolate the roots only.
- This program does not calculate the total length of the roots. Users need to manually trace the roots of interest. Also, the results are not clearly indicated in the data file. It may be difficult to find the total length of a root.
- All the measurement data can be saved in Excel format. But the column titles (the measurement item names) will be lost in the saved file.

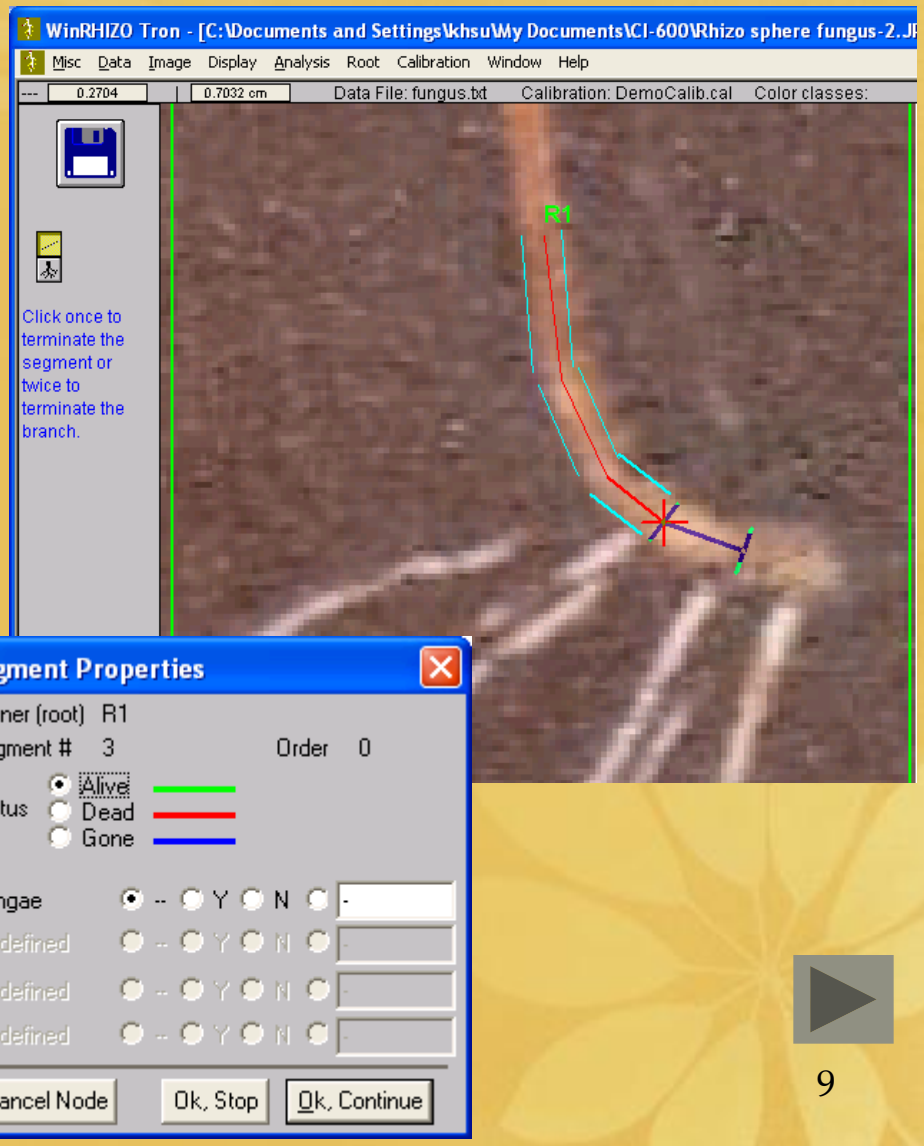
CID,Inc.

Supplementary Material

Root Tracing in WinRhizo Tron

- Roots of interest need to be manually traced by marking small segments along the root

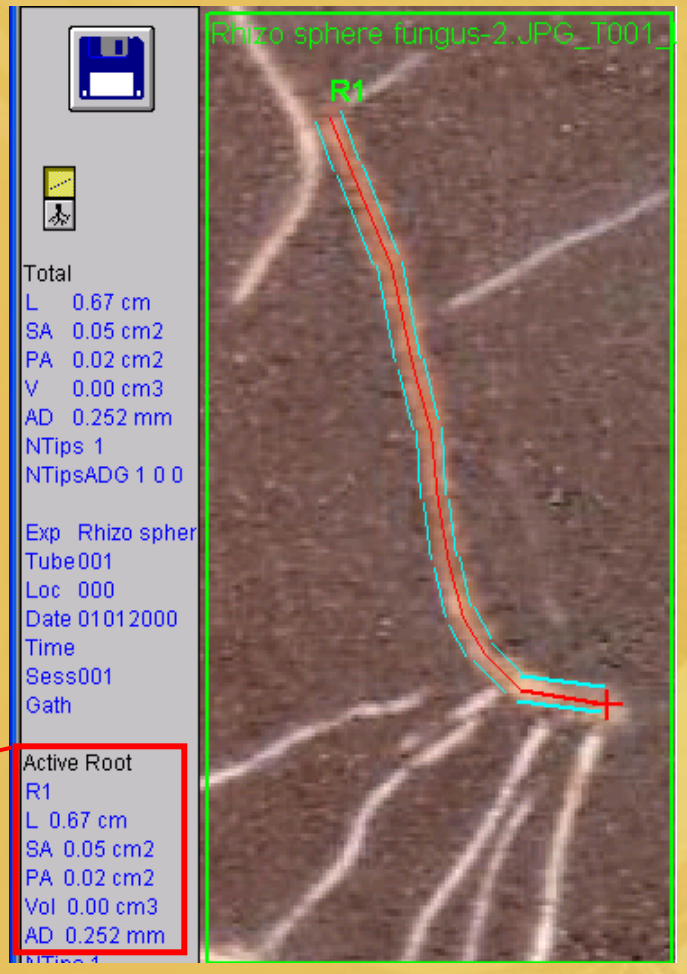
- Options of Alive, Dead, and Gone can be assigned to each segment.



Root Measurment in WinRhizo Tron

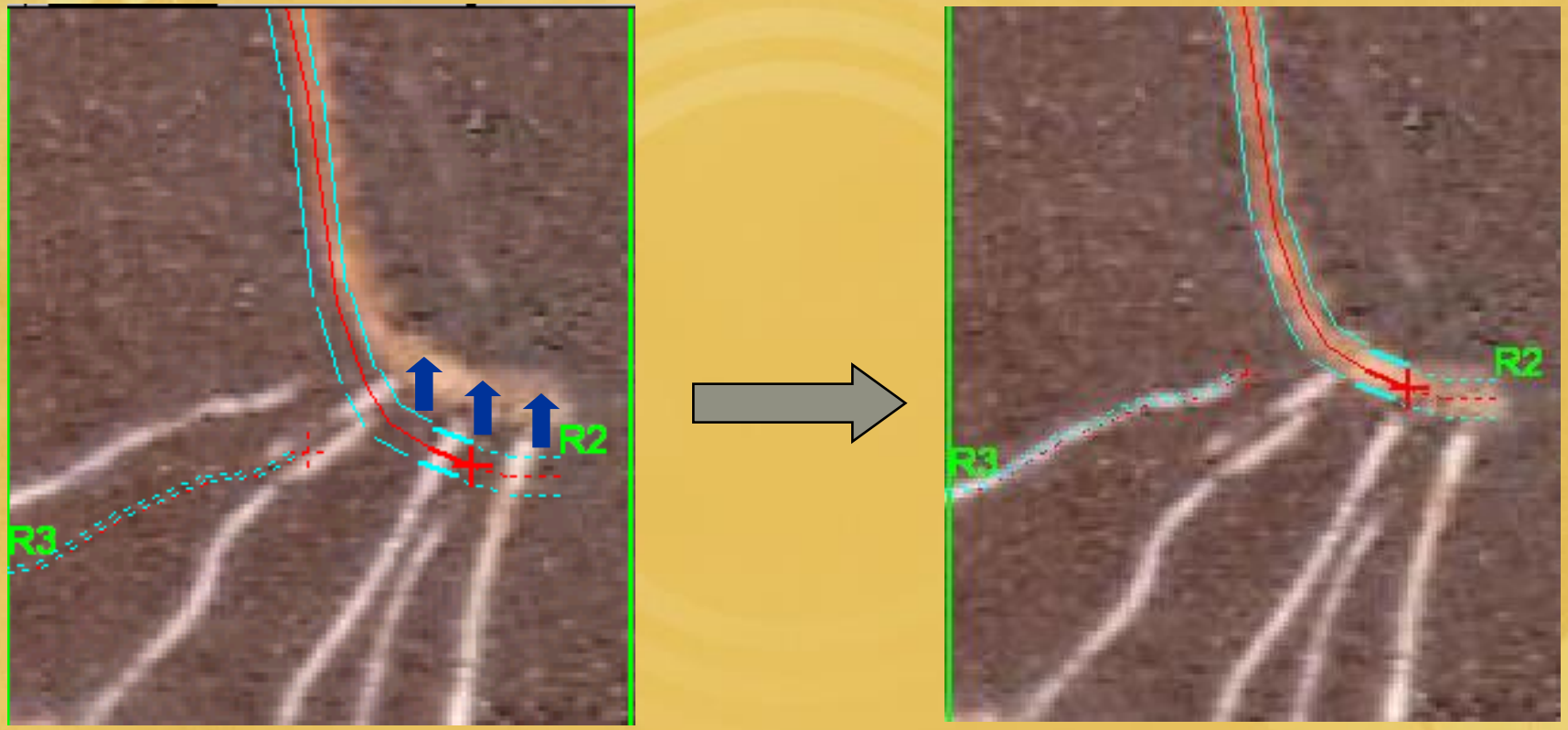
- Once a root is completely traced, the analysis of the root is displayed in the left panel. More complete data are saved in a data file.

  (ASCII format)



Analysis of the root:
L: total length, SA: surface area
PA: projected area, V: volume
AD: average diameter

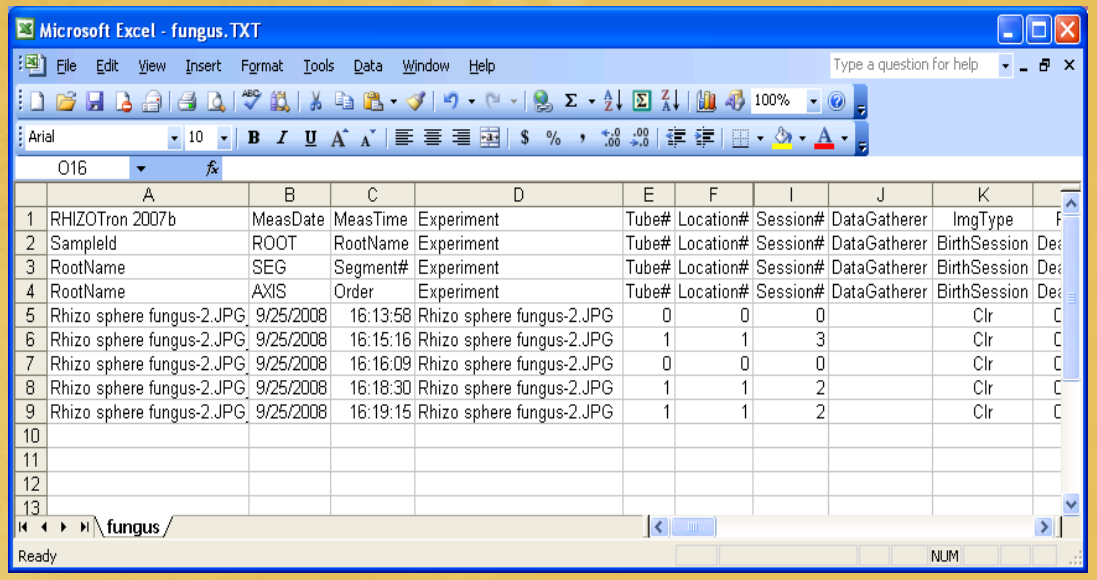
WinRhizo Tron – Root Template



The root template can be imported and be moved to match the root image. This feature is beneficial to CI-600 users as the scanner head is often times inserted into the scanning tube at different orientations.

WinRhizo Tron – Data File

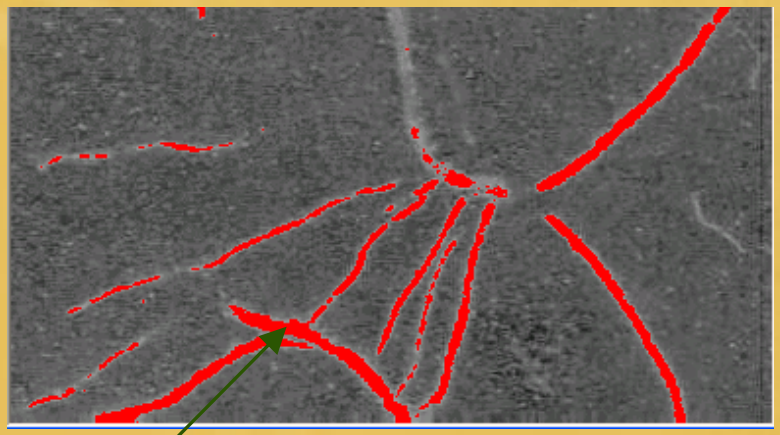
RHIZOTron 2007b	MeasDate	MeasTime	Experiment	Tube#	Location#	Date	Time	Session#	DataGatherer	ImgType	PxSizeH
<=3.500	3.500<.PA.<=4.000	4.000<.PA.<=4.500	.PA.>4.500	0.000<.V.<=0.500		0.500<.V.<=1.000		1.000<.V.<=1.500			1.500<.
SampleId	ROOT	RootName	Experiment	Tube#	Location#	Date	Time	Session#	DataGatherer	BirthSession	DeathSe
RootName	SEG	Segment#	Experiment	Tube#	Location#	Date	Time	Session#	DataGatherer	BirthSession	DeathSe
RootName	AXIS	Order	Experiment	Tube#	Location#	Date	Time	Session#	DataGatherer	BirthSession	DeathSession
root1.JPG_T001_L000_01012000__001_.jpg		9/23/2008			15:16:21	root1.JPG	1	0	01012000	001	Clr
root1.JPG_T001_L000_01012000__001_.jpg	ROOT	R1			root1.JPG	1	0	01012000	001	1	0 0.7285
root1.JPG_T001_L000_01012000__001_.jpg	ROOT	R2			root1.JPG	1	0	01012000	001	1	0 0.3223
root1.JPG_T001_L000_01012000__001_.jpg		9/24/2008			11:28:44	root1.JPG	1	0	01012000	001	Clr
root1.JPG_T001_L000_01012000__001_.jpg	ROOT	R1			root1.JPG	1	0	01012000	001	1	0 0.7286
root1.JPG_T001_L000_01012000__001_.jpg	ROOT	R2			root1.JPG	1	0	01012000	001	1	0 0.3223
root1.JPG_T001_L000_01012000__001_.jpg	ROOT	R3			root1.JPG	1	0	01012000	001	1	0 0.1760



	A	B	C	D	E	F	I	J	K
1	RHIZOTron 2007b	MeasDate	MeasTime	Experiment	Tube#	Location#	Session#	DataGatherer	ImgType
2	SampleId	ROOT	RootName	Experiment	Tube#	Location#	Session#	DataGatherer	BirthSession
3	RootName	SEG	Segment#	Experiment	Tube#	Location#	Session#	DataGatherer	BirthSession
4	RootName	AXIS	Order	Experiment	Tube#	Location#	Session#	DataGatherer	BirthSession
5	Rhizo sphere fungus-2.JPG	9/25/2008	16:13:58	Rhizo sphere fungus-2.JPG	0	0	0		Clr
6	Rhizo sphere fungus-2.JPG	9/25/2008	16:15:16	Rhizo sphere fungus-2.JPG	1	1	3		Clr
7	Rhizo sphere fungus-2.JPG	9/25/2008	16:16:09	Rhizo sphere fungus-2.JPG	0	0	0		Clr
8	Rhizo sphere fungus-2.JPG	9/25/2008	16:18:30	Rhizo sphere fungus-2.JPG	1	1	2		Clr
9	Rhizo sphere fungus-2.JPG	9/25/2008	16:19:15	Rhizo sphere fungus-2.JPG	1	1	2		Clr
10									
11									
12									
13									

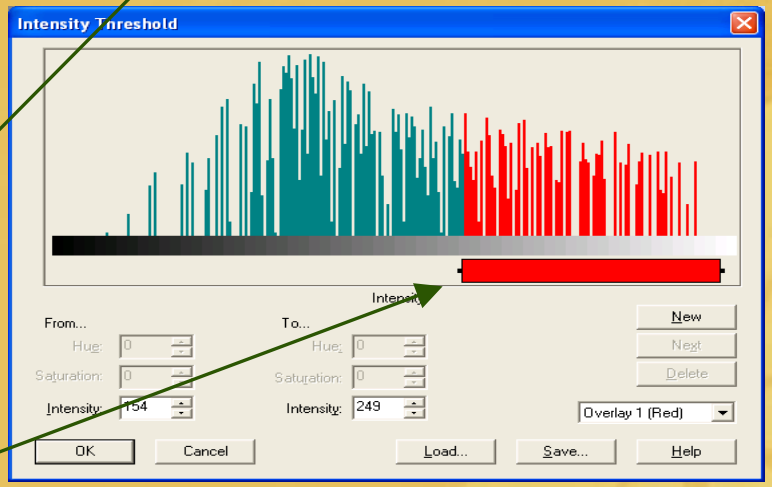
Measurement results are saved in text format, however, the labels are misaligned. The labels are better aligned when imported to Excel. Users may purchase XLRhizo Tron that exports data in Excel. (sold separately)

SigmaScan – Global Root Identification



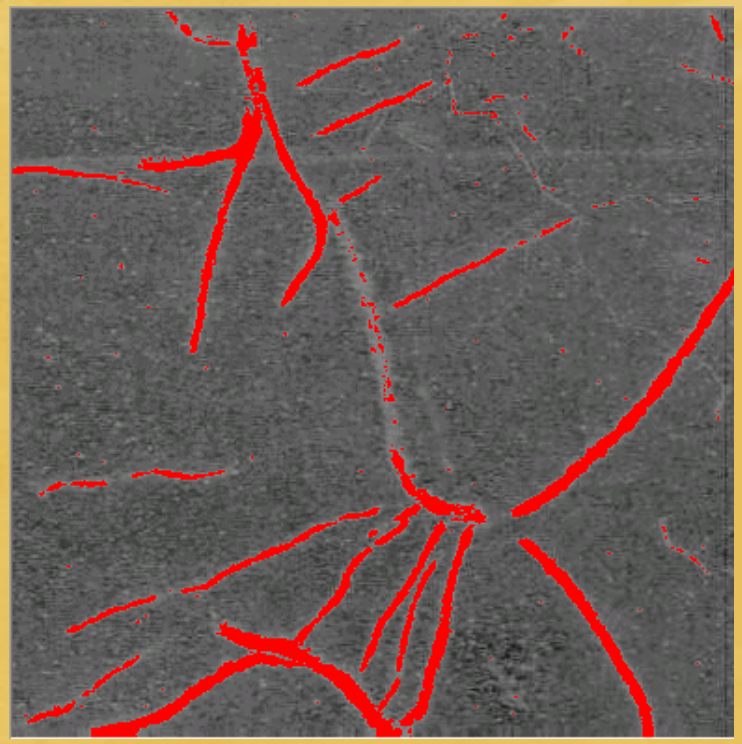
- Users can mark the area of roots by adjusting intensity/color threshold

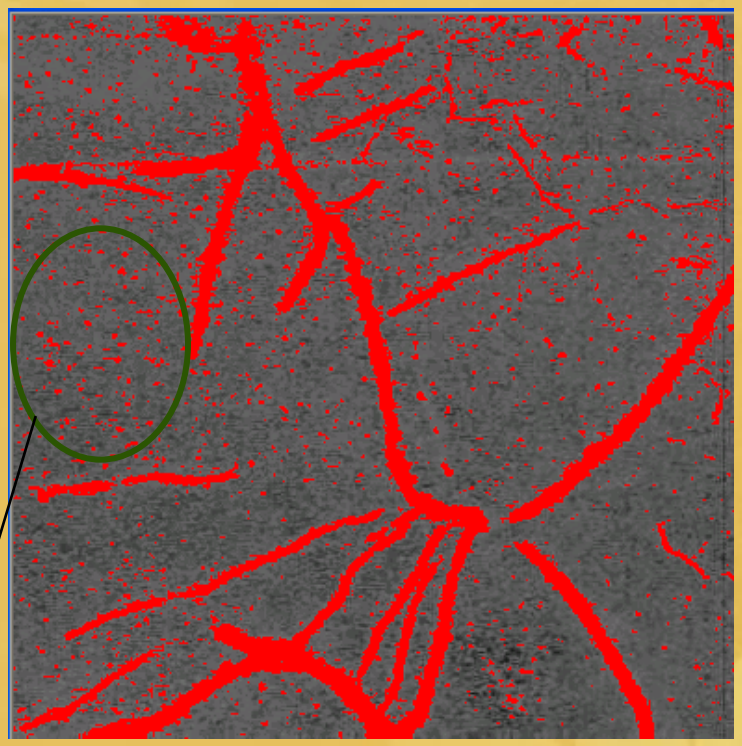
  Areas of roots can be marked with a proper level of threshold adjustment. Various measurements can be done on the marked areas.



Intensity threshold adjustment

SigmaScan – Root Identification





Unwanted areas

Lower threshold level = less noise, but missing some root segments

Higher threshold level = more roots identified, but more unwanted areas are marked

SigmaScan – Root Length

Worksheet3 *

A12 39.1152144312159

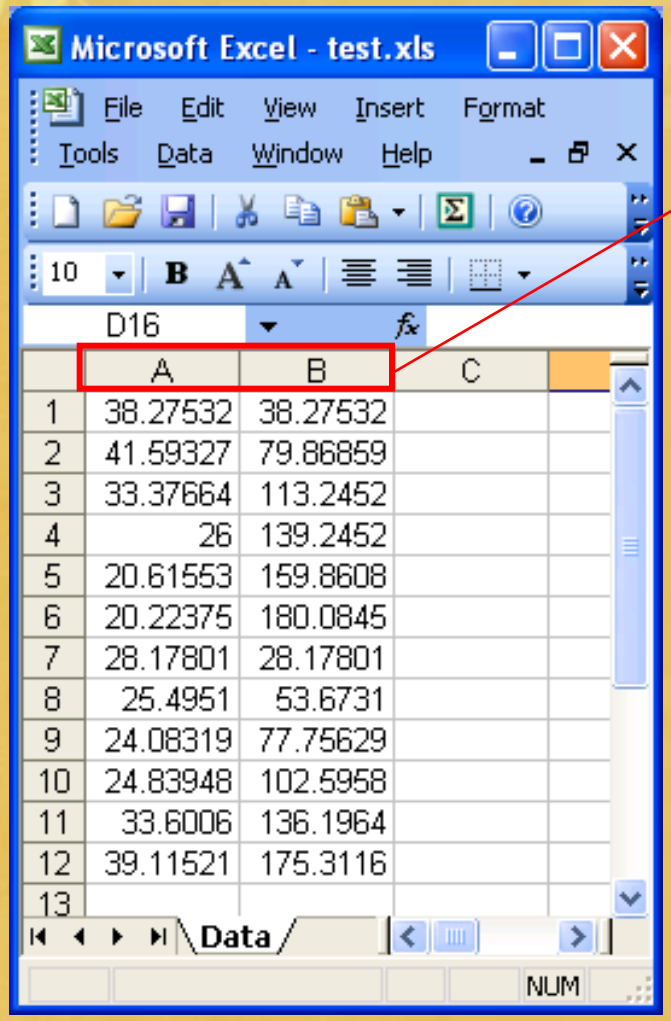
	B Distance	C C Dist	D	E
1	38.275318	38.275318		
2	41.593269	79.868587		
3	33.376639	113.24523		
4	26	139.24523		
5	20.615528	159.86075		
6	20.223748	180.0845		
7	28.178006	28.178006		
8	25.495098	53.673103		
9	24.083189	77.756292		
10	24.839485	102.59578		
11	33.600595	136.19637		
12	39.115214	175.31159		
13				

Data | Statistics

The length of each root segment is shown in the worksheet *(Column B)* and the cumulative length is shown in *(Column C)*.

The length of a root is calculated and shown in the C Dist (cumulative length) column as users are tracing the root. But the total length is not clearly indicated.

SigmaScan – Root Length



	A	B	C
1	38.27532	38.27532	
2	41.59327	79.86859	
3	33.37664	113.2452	
4	26	139.2452	
5	20.61553	159.8608	
6	20.22375	180.0845	
7	28.17801	28.17801	
8	25.4951	53.6731	
9	24.08319	77.75629	
10	24.83948	102.5958	
11	33.6006	136.1964	
12	39.11521	175.3116	
13			

The data file is saved in Excel format. However, the column labels are gone when the data file is opened in Excel. Users may have trouble reading the data at a later time.

CID,Inc.

Thank you for choosing CID products !!