

# Excel Application for automation of Mensuration Exercise

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DEHRADUN

# FOREWORD

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# PART – I

## STUMP ANALYSIS

### INTRODUCTION

The analysis of a stump cross-section by counting and measuring the annual growth rings, in order to estimate the age of the tree and its past rates of radial growth. The final objective of this exercise is to establish the relationship between the Age of the Tree and DBH(OB) i.e. Over Bark Diameter at Breast Height.

### METHOD

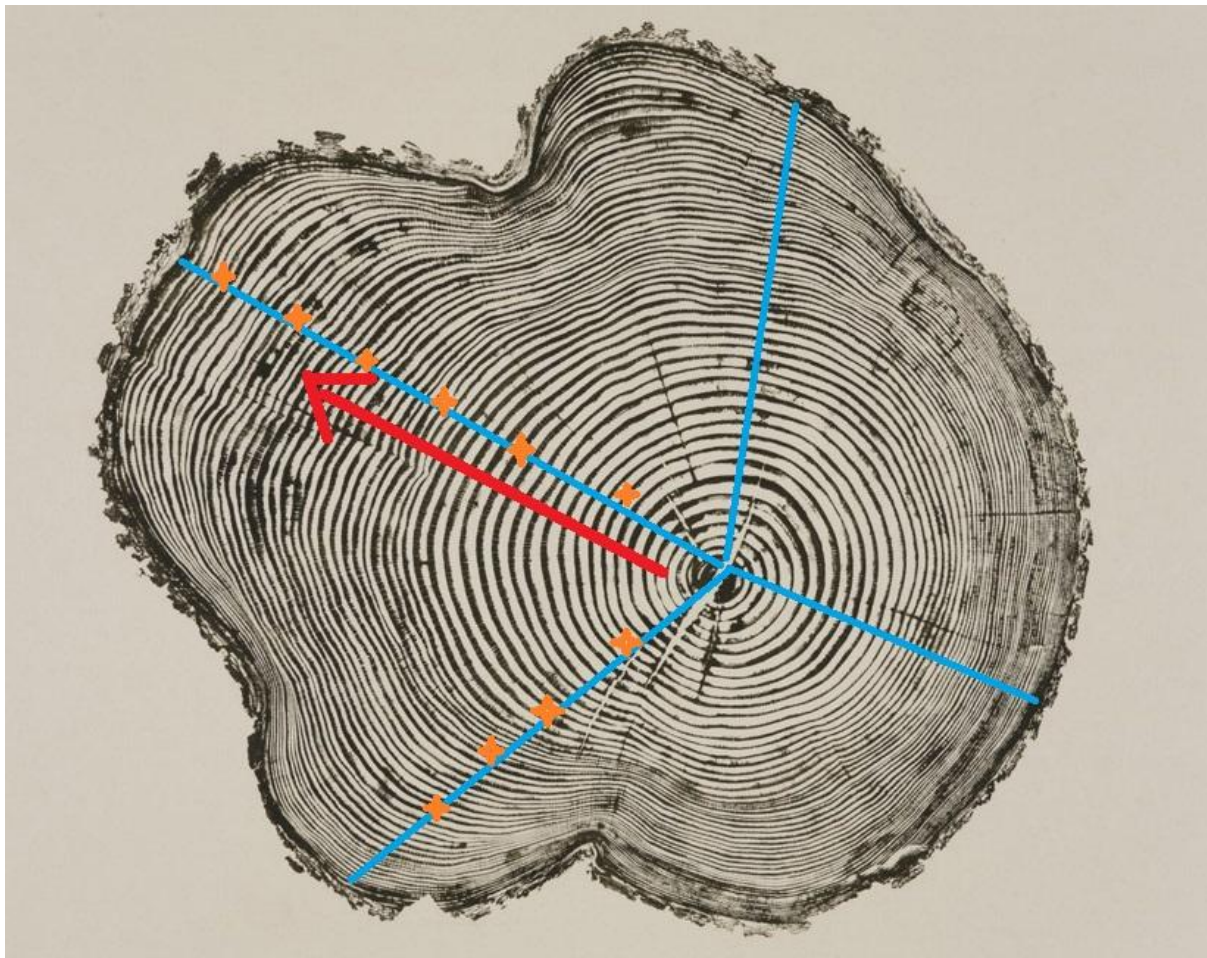
The method involves counting of annual rings on the cross section of a stump of the tree. Here, the counting of rings is not an easy task. The ease of counting annual rings on a cross section depends on the following factors:

- **Species** – The colour differentiation between late and early wood is different for different species. If this differentiation is very less then counting becomes difficult.
- **Age of the tree** – In older trees, the ring width is very small and therefore counting becomes difficult.
- **Environmental conditions:**
  - early or late frosts and drought sometimes promote formation of *false rings*;
  - under exceptionally good growing conditions, there may be little differentiation into early and late wood;
- **Extent of ring distortion** - due to branch whorls, defects, compression and tension in wood, the annuals rings may get distorted.

Therefore, in view of the factors above, the first important step is to identify a stump which is not damaged and has visible rings with least distortions and defects.

Identify the correct centre of the cross section and choose 4 different radial lines along which the radius will be measured subsequently (as represented by blue lines in the diagram shown below).

Start counting the rings from inside and place a pin on every 10<sup>th</sup> ring as shown in the figure (as shown by the orange pins in the diagram below).



The red arrow shows the direction of counting the rings along the 4 radial lines.

Since we are counting the rings along 4 different radii, we have 4 values of radius for each decade. Now we calculate the mean of these values and multiply by 2 to find out the mean diameter for each decade. This value for every decade is called decadal diameter and has to be entered into the sheet Stump Analysis Data (the data entry is explained further in the next section).

Other data such as the 'stump height' and 'girth' are also to be entered in the datasheet.

Using the collected data, a relationship is established between Age and DBH(UB) i.e. under bark diameter at breast height. All the processing is done by this excel application.

The relationship obtained by the process above has to be corrected in 2 aspects:

1. Correcting the Age determined by counting the rings of the stump, by adding the time required by the tree to reach the stump height.

For doing this correction, we need Age-Height relationship for the tree. For this, the data is collected by using 'Seedling Analysis' method. In this method, a seedling is cut at every 10 cms from the base till the height of 1 meter and at 20 cms thereafter (i.e. at 10cm, 20 cm, 30cm till 100 cms and after that 120 cms, 140 cms and so on). At each height the number of rings is counted. The data collected is entered into the sheet Seedling Data. This gives a relationship between age and height.

With this relation, age corresponding to our stump height is calculated and added to the age determined by counting the rings of the stump. All this process is done by this excel application itself.

2. Convert DBH(UB) to DBH(OB)

For doing this correction, we need relationship between DBH(UB) and DBH(OB). For this, the data is collected by using 'Taper Analysis' method.

The 'Taper Analysis' method involves 2 measurements:

- Measuring the DUB at 15cm, 45cm and 75cm from the ground
- Measuring DBH(OB)

The above readings are taken for 3 sample trees in each dia-class (0-10 class to 90-100 class). When we do the analysis manually, the DBH(OB) v/s DUB graph is plotted for each height i.e. 15cms, 45cms and 75 cms. After this, by using Lagrange Extrapolation / Interpolation method or linear extrapolation / interpolation method, a relationship between DBH (OB) and DUB is established for our stump height. Using this relation, the DUB is converted to DBH(OB) and a direct relationship between 'DBH(OB) and Age' is obtained by this excel application.

After these 2 corrections, the final relationship between DBH(OB) and Age is obtained.



Detailed instructions for using the excel application is given below where data for Stump Analysis, Seedling Analysis and Taper Analysis is entered in 3 different excel sheets.

# INSTRUCTIONS FOR USING THE APPLICATION

## 1. Install MS Office Plug-in

(This is required to export all the graphs generated by this excel application to pdf format. [Click here for downloading the plug-in](#))

project

Name	Date modified	Type	Size
 MS Office Imp Plugin	17-04-2017 16:52	File folder	
 Stem Analysis.xlsm	17-04-2017 16:28	Microsoft Office E...	181 KB
 Stump Analysis - Final.xlsm	12-04-2017 00:42	Microsoft Office E...	137 KB

## 2. Enable Macros (while starting the application)

Stump Analysis - Final.xlsm - Microsoft Excel

Security Warning: Macros have been disabled. Options...

Instructions:

2. Enter the number of groups in the cell highlighted below
3. Prepare the sheet by using the button **Prepare Sheet**
4. Enter the data and move on to the next sheet *Seedling Data*

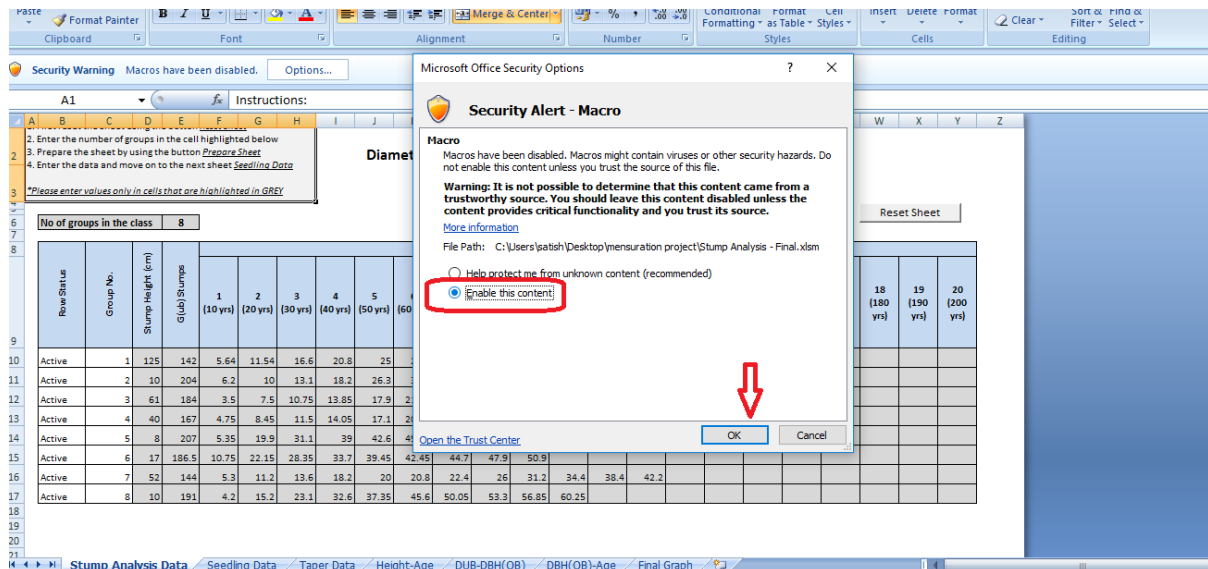
\*Please enter values only in cells that are highlighted in GREY

No of groups in the class: 8

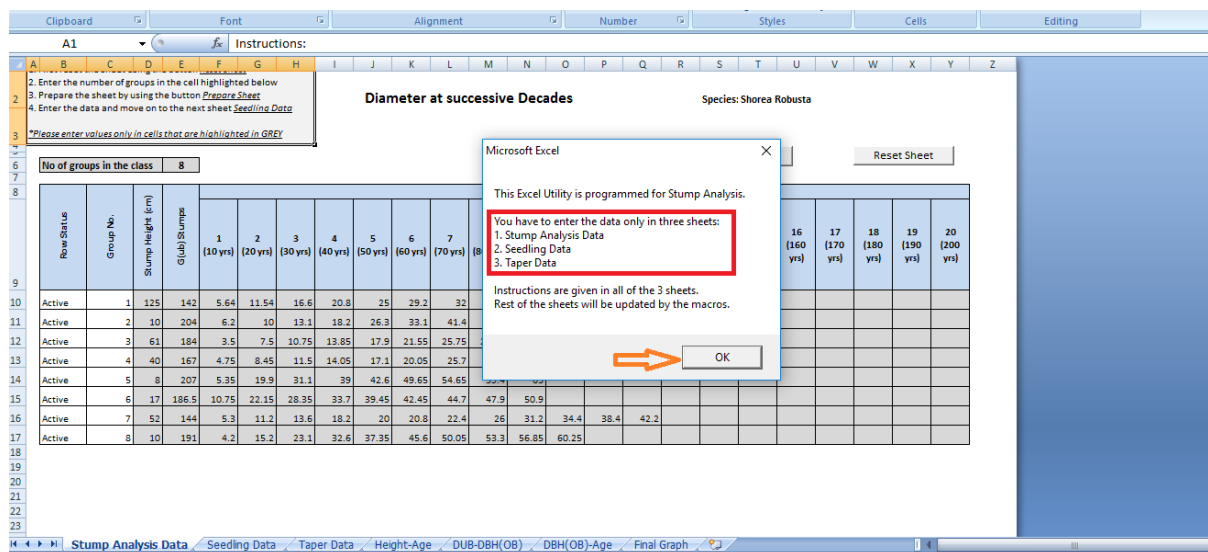
Species: Shorea Robusta

Prepare Sheet Reset Sheet

Row Status	Group No.	Stump Height (cm)	G (ub) Stumps	Average diameter of decades in cms																			
				1 (10 yrs)	2 (20 yrs)	3 (30 yrs)	4 (40 yrs)	5 (50 yrs)	6 (60 yrs)	7 (70 yrs)	8 (80 yrs)	9 (90 yrs)	10 (100 yrs)	11 (110 yrs)	12 (120 yrs)	13 (130 yrs)	14 (140 yrs)	15 (150 yrs)	16 (160 yrs)	17 (170 yrs)	18 (180 yrs)	19 (190 yrs)	20 (200 yrs)
Active	1	125	142	5.64	11.54	16.6	20.8	25	29.2	32	33.6	36	39.4	42.6	46.1								
Active	2	10	204	6.2	10	13.1	18.2	26.3	33.1	41.4	46.4	49	51	53.8	58.4	61.4							
Active	3	61	184	3.5	7.5	10.75	13.85	17.9	21.55	25.75	29.95	34.15	38.1	43.25	48.85	54.15							
Active	4	40	167	4.75	8.45	11.5	14.05	17.1	20.05	25.7	29	32.4	35.45	39.25	43.55	48.5	51.5	54.75					
Active	5	8	207	5.35	19.9	31.1	39	42.6	49.65	54.65	59.4	65											
Active	6	17	186.5	10.75	22.15	28.35	33.7	39.45	42.45	44.7	47.9	50.9											
Active	7	52	144	5.3	11.2	13.6	18.2	20	20.8	22.4	26	31.2	34.4	38.4	42.2								



A message box will appear giving some instructions to use the application.





### 3. Entering data in 'Stump Analysis' datasheet

(Please note that instructions are also given in each datasheet for entering the data)

First of all, the user has to reset the sheet as shown below. Also, the user will have to enter the number of groups performing the mensuration exercise.

The screenshot shows the 'Stump Analysis' Excel spreadsheet. The title bar indicates the file is 'Stump Analysis - Final.xlsm' in Microsoft Excel. The ribbon includes Home, Insert, Page Layout, Formulas, Data, Review, View, and Developer. The 'Instructions' box on the left contains the following steps:

1. First reset the sheet using the button **Reset Sheet**
2. Enter the number of groups in the cell highlighted below
3. Prepare the sheet by using the button **Prepare Sheet**
4. Enter the data and move on to the next sheet **Seedling Data**

A note below the instructions states: *\*Please enter values only in cells that are highlighted in GREY*

The main title of the sheet is **Data of Stump Analysis**. Below it, the text **Diameter at successive Decades** is displayed. The species is identified as **Shorea Robusta**. There are two buttons: **Prepare Sheet** and **Reset Sheet**. A black arrow points to the **Reset Sheet** button. A red box highlights the **Reset Sheet** button. A red arrow points to the input field for 'No of groups in the class', which contains the value **8**. The table below shows the average diameter of decades in cms.

Row Status	Group No.	Stump Height (cm)	G (ub) Stumps	1 (10 yrs)	2 (20 yrs)	3 (30 yrs)	4 (40 yrs)	5 (50 yrs)	6 (60 yrs)	7 (70 yrs)	8 (80 yrs)	9 (90 yrs)	10 (100 yrs)	11 (110 yrs)	12 (120 yrs)	13 (130 yrs)	14 (140 yrs)	15 (150 yrs)	16 (160 yrs)	17 (170 yrs)	18 (180 yrs)	19 (190 yrs)	20 (200 yrs)

After this, prepare the sheet for entering the data by pressing the button 'Prepare Sheet'. Then the data collected from the field is entered into the grey cells.

**Instructions:**

1. First reset the sheet using the button **Reset Sheet**
2. Enter the number of groups in the cell highlighted below
3. Prepare the sheet by using the button **Prepare Sheet**
4. Enter the data and move on to the next sheet **Seedling Data**

*\*Please enter values only in cells that are highlighted in GREY*

**No of groups in the class** 8

**Prepare Sheet** **Reset Sheet**

**Data of Stump Analysis**  
Species: Shorea Robusta

**Diameter at successive Decades**

Row Status	Group No.	Stump Height (cm)	G(ub) Stumps	Average diameter of decades in cms																			
				1 (10 yrs)	2 (20 yrs)	3 (30 yrs)	4 (40 yrs)	5 (50 yrs)	6 (60 yrs)	7 (70 yrs)	8 (80 yrs)	9 (90 yrs)	10 (100 yrs)	11 (110 yrs)	12 (120 yrs)	13 (130 yrs)	14 (140 yrs)	15 (150 yrs)	16 (160 yrs)	17 (170 yrs)	18 (180 yrs)	19 (190 yrs)	20 (200 yrs)
Active																							
Active																							
Active																							
Active																							
Active																							
Active																							
Active																							

Stump Analysis Data | Seedling Data | Taper Data | Height-Age | DUB-DBH(OB) | DBH(OB)-Age | Final Graph

**Instructions:**

1. First reset the sheet using the button **Reset Sheet**
2. Enter the number of groups in the cell highlighted below
3. Prepare the sheet by using the button **Prepare Sheet**
4. Enter the data and move on to the next sheet **Seedling Data**

*\*Please enter values only in cells that are highlighted in GREY*

**No of groups in the class** 8

**Prepare Sheet** **Reset Sheet**

**Data of Stump Analysis**  
Species: Shorea Robusta

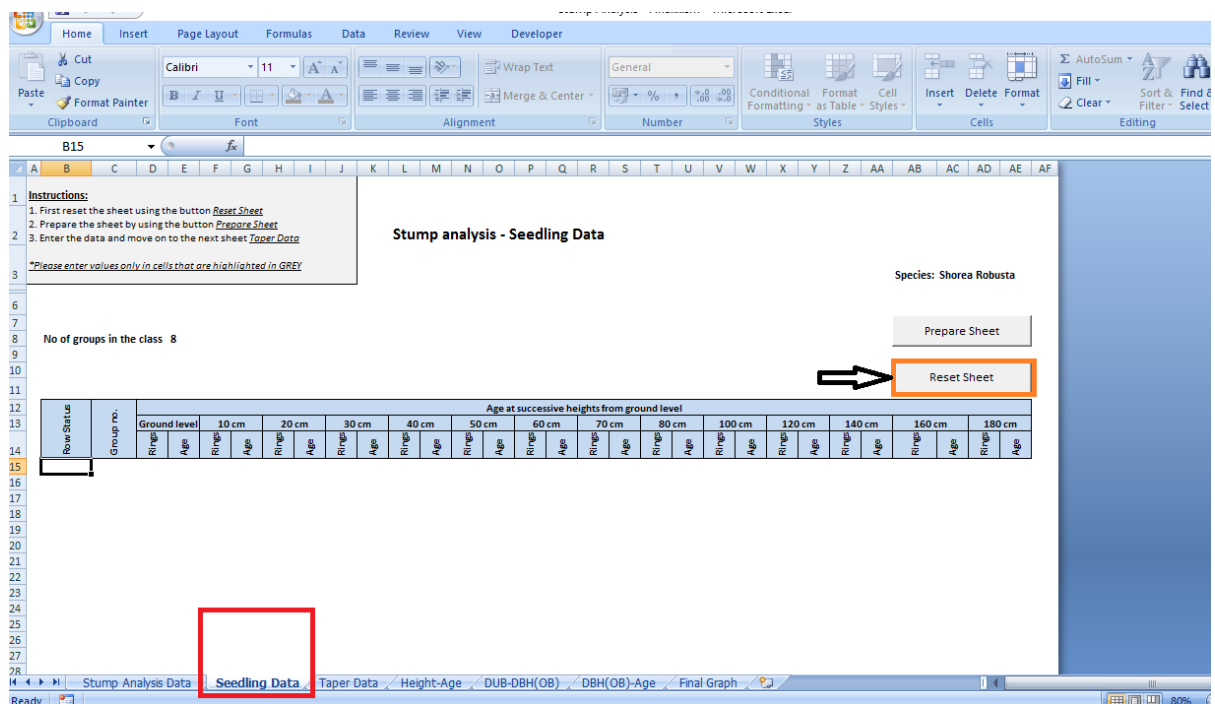
**Diameter at successive Decades**

Row Status	Group No.	Stump Height (cm)	G(ub) Stumps	Average diameter of decades in cms																			
				1 (10 yrs)	2 (20 yrs)	3 (30 yrs)	4 (40 yrs)	5 (50 yrs)	6 (60 yrs)	7 (70 yrs)	8 (80 yrs)	9 (90 yrs)	10 (100 yrs)	11 (110 yrs)	12 (120 yrs)	13 (130 yrs)	14 (140 yrs)	15 (150 yrs)	16 (160 yrs)	17 (170 yrs)	18 (180 yrs)	19 (190 yrs)	20 (200 yrs)
Active	1	125	142	5.64	11.54	16.6	20.8	25	29.2	32	33.6	36	39.4	42.6	46.1								
Active	2	10	204	6.2	10	13.1	18.2	26.3	33.1	41.4	46.4	49	51	53.8	58.4	61.4							
Active	3	61	184	3.5	7.5	10.75	13.85	17.9	21.55	25.75	29.95	34.15	38.1	43.25	48.85	54.15							
Active	4	40	167	4.75	8.45	11.5	14.05	17.1	20.05	25.7	29	32.4	35.45	39.25	43.55	48.5	51.5	54.75					
Active	5	8	207	5.35	19.9	31.1	39	42.6	49.65	54.65	59.4	65											
Active	6	17	186.5	10.75	22.15	28.35	33.7	39.45	42.45	44.7	47.9	50.9											
Active	7	52	144	5.3	11.2	13.6	18.2	20	20.8	22.4	26	31.2	34.4	38.4	42.2								
Active	8	10	191	4.2	15.2	23.1	32.6	37.35	45.6	50.05	53.3	56.85	60.25										

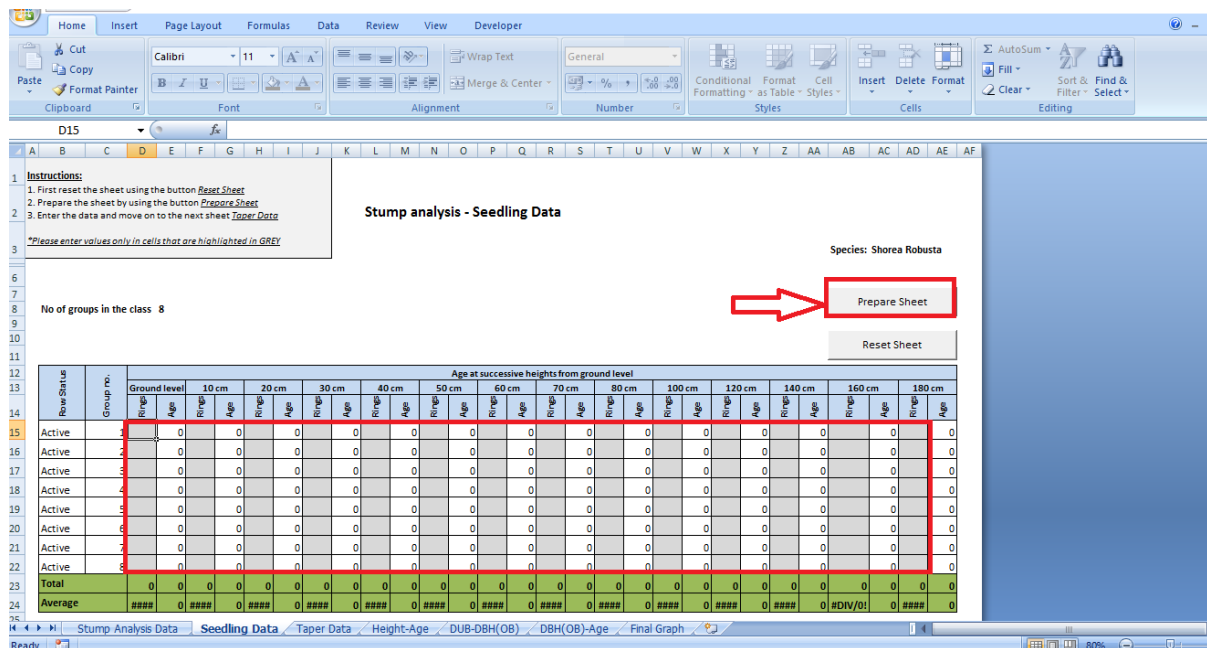
Stump Analysis Data | Seedling Data | Taper Data | Height-Age | DUB-DBH(OB) | DBH(OB)-Age | Final Graph

#### 4. Entering data in 'Seedling Data' datasheet

First of all, the user has to reset the sheet as shown below.

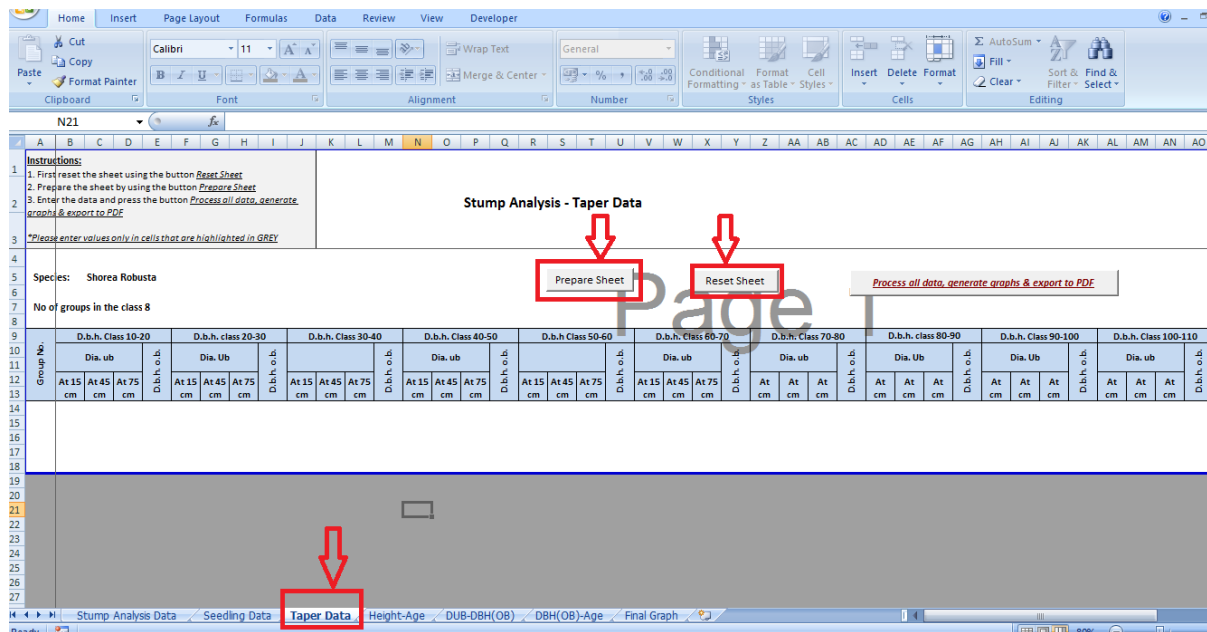


After this, prepare the sheet for entering the data by pressing the button 'Prepare Sheet'. Then the data collected from the field is entered into the grey cells.

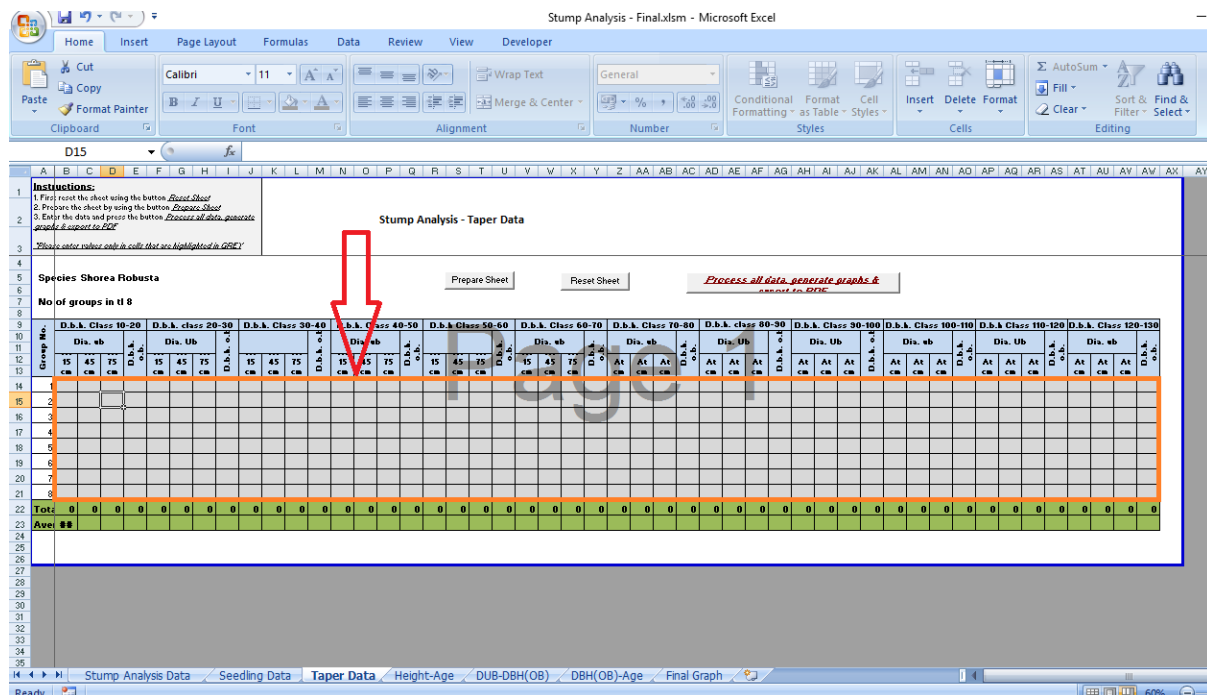


## 5. Entering data in 'Taper Data' datasheet

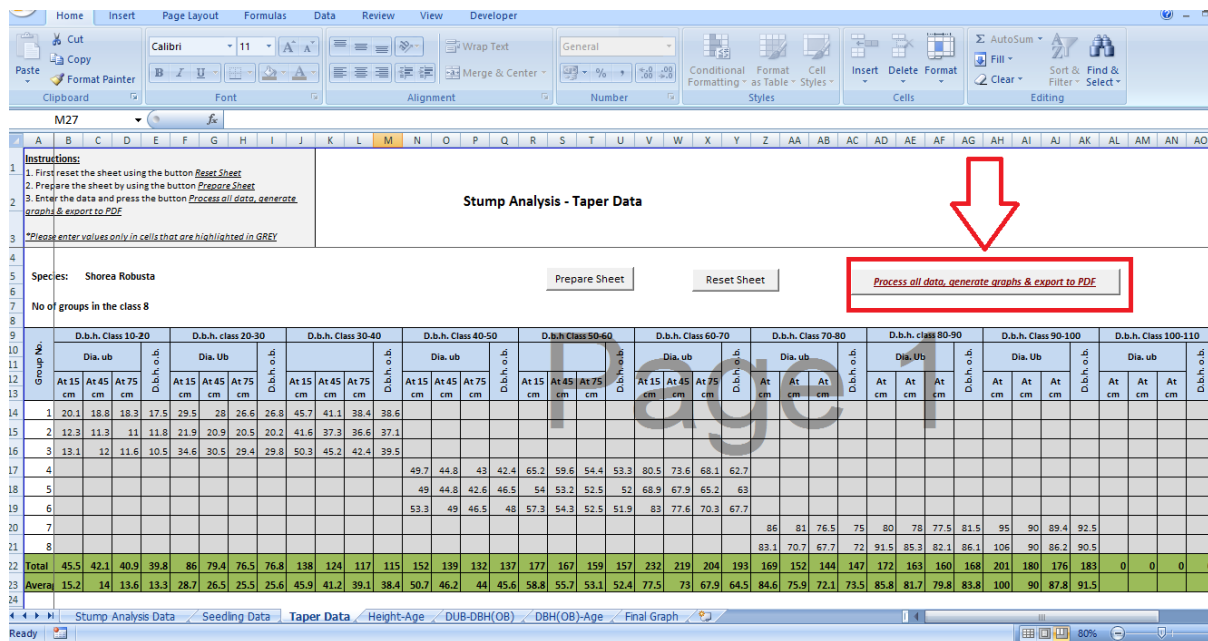
First of all, the user has to reset the sheet as shown below.



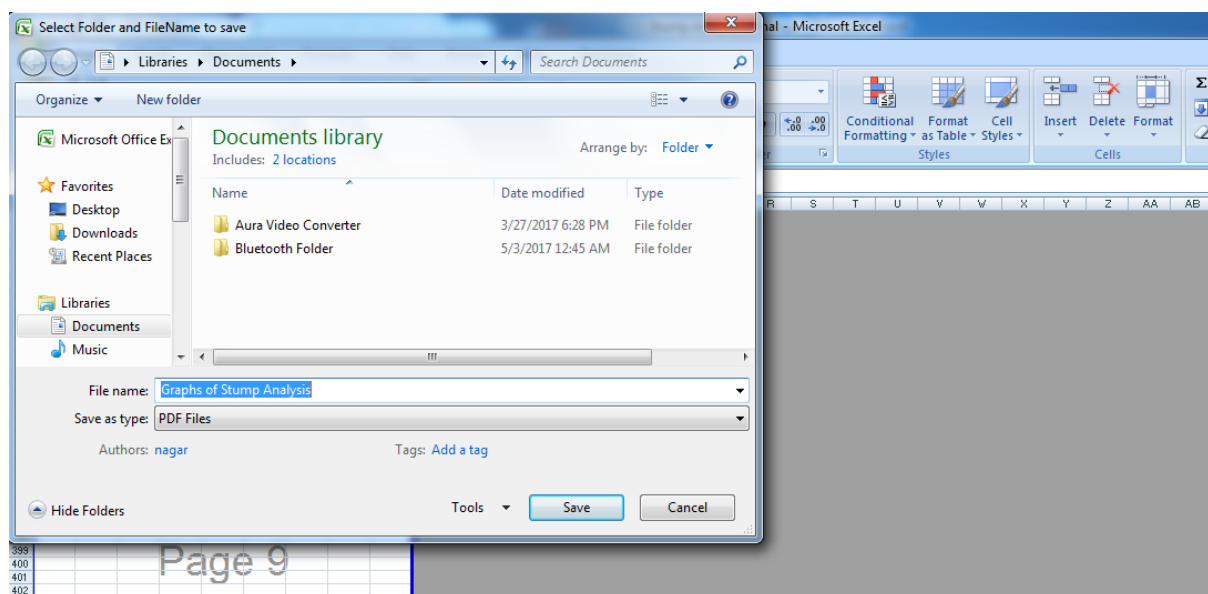
After this, prepare the sheet for entering the data by pressing the button 'Prepare Sheet'. Then the data collected from the field is entered into the grey cells.



Click on the button 'Process All Data, Generate Graphs and Export to PDF'.



A PDF will be created with all the graphs of stump analysis. The program will ask the user to save the PDF to any location of his choice.



The output PDF will be saved to the location entered by the user.

# PART – II

## STEM ANALYSIS

### INTRODUCTION

Stem Analysis is a method of analysing the complete stem instead of a stump at a particular height. It helps determining the past growth rate of the tree by studying the cross sections of the stem at various heights of the tree. However, in this method the tree has to cut down.

The objectives of this analysis are to plot the following growth curves:

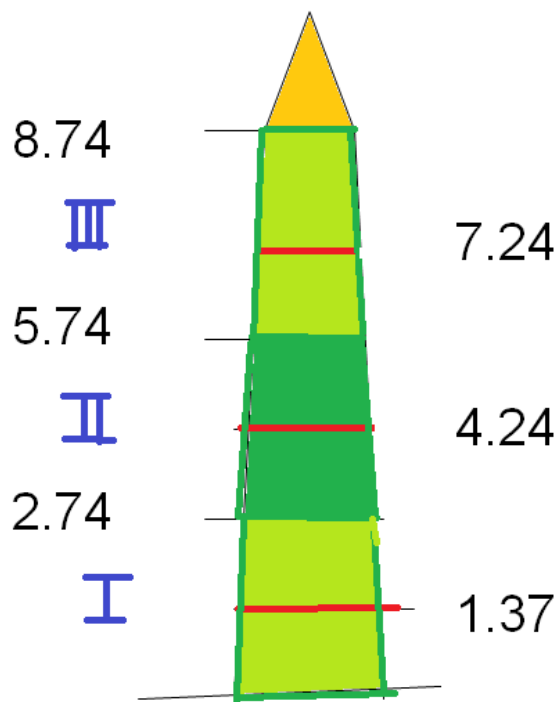
1. Age – Height relationship
2. Age – DBH(OB) i.e. Over Bark Diameter at Breast Height
3. Age – Volume relationship

This will enable us to find the average incremental rate of diameter, height and volume. The data collected from stem analysis is helpful in the creation of the Local Volume Table (LVT).

### METHOD

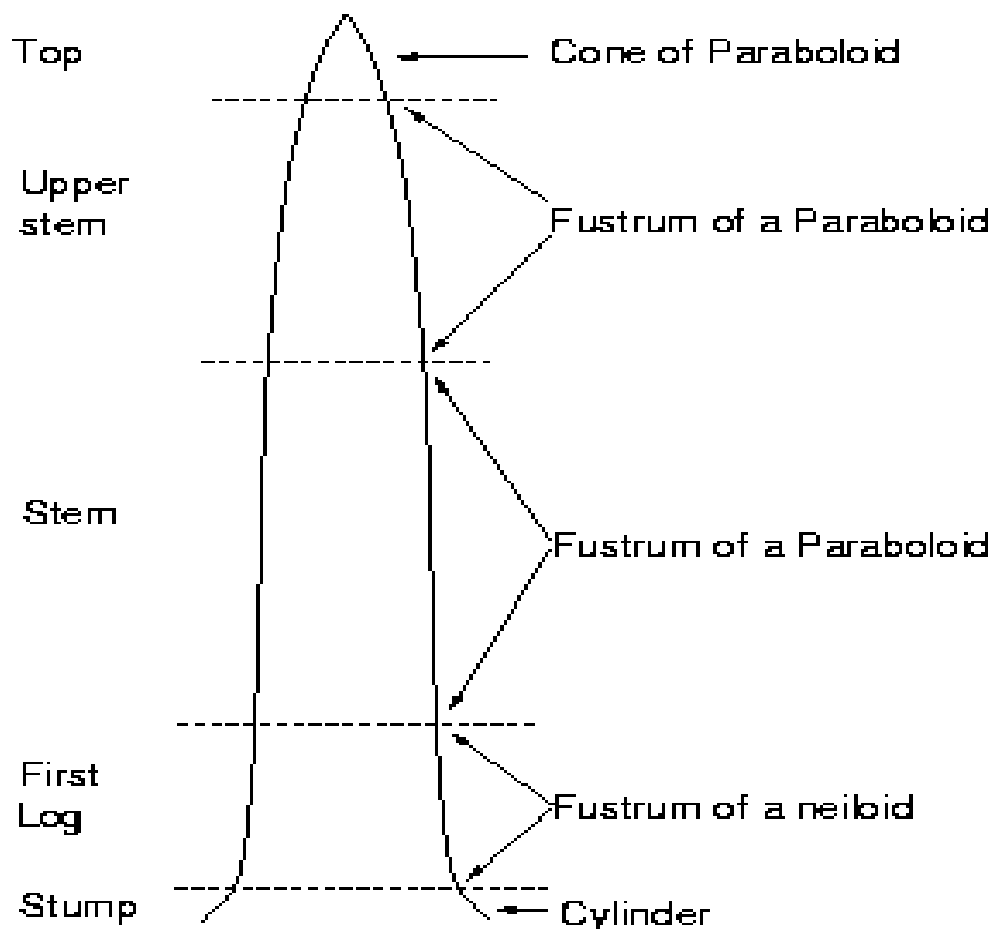
The stem analysis method involves cutting the whole stem at various heights which is described as follows:

- a. The tree is divided into sections so that the first section is of 2.74 m and all other sections except the top most section are of 3 m each. If the last section is greater than 1.5 m then it will be treated as a separate conic section, otherwise, it will be included in the previous section itself.
- b. Now the tree is cut at the mid points of all the sections.
- c. Therefore, the first cut is at breast height (1.37 m). The first section is of length 2.74 m ( as shown in figure below as section I)
- d. The second cut is at 4.24 m (i.e. twice the breast height + 1.5 m = 4.24m) (as shown in figure below as section II)
- e. The third cut is at 4.24 + 3 m i.e. ( 7.24m) ( as shown in figure as section III). The rest cuts are made at 3 m intervals.
- f. The last section is decided as per the details given in the point (a).



For the purpose of calculation of the volume of the different sections the following diagram is referred which considers:

- The first section as frustum of a neloid
- The middle sections as frustum of paraboloid
- The last section as cone of a paraboloid



The first step is to establish the relationship between Age and Height. First of all, we assume the age at breast height to be '0'. Age of subsequent sections is determined by counting the rings at all sections and subtracting them with rings in the first section i.e. at breast height. Please note that, here, we have calculated the age of all sections based on the assumption that the age at breast height is '0'. Therefore, we need to do an age correction by using the data of seedling analysis (*collected during stump analysis*).

The second step is to derive a curve between Age and DBH(OB). Here, we use 2 types of relationships:

- a. Relationship between DBH(UB) and Age from the data entered by the user
- b. Relationship between over-bark diameter and under-bark diameter

The third step is to establish the relationship between age and volume using smoothened decadal diameters at each section.






# INSTRUCTIONS FOR USING THE APPLICATION

## 1. Install MS Office Plug-in

(This is required to export all the graphs generated by this excel application to pdf format. [Click here for downloading the plug-in](#))

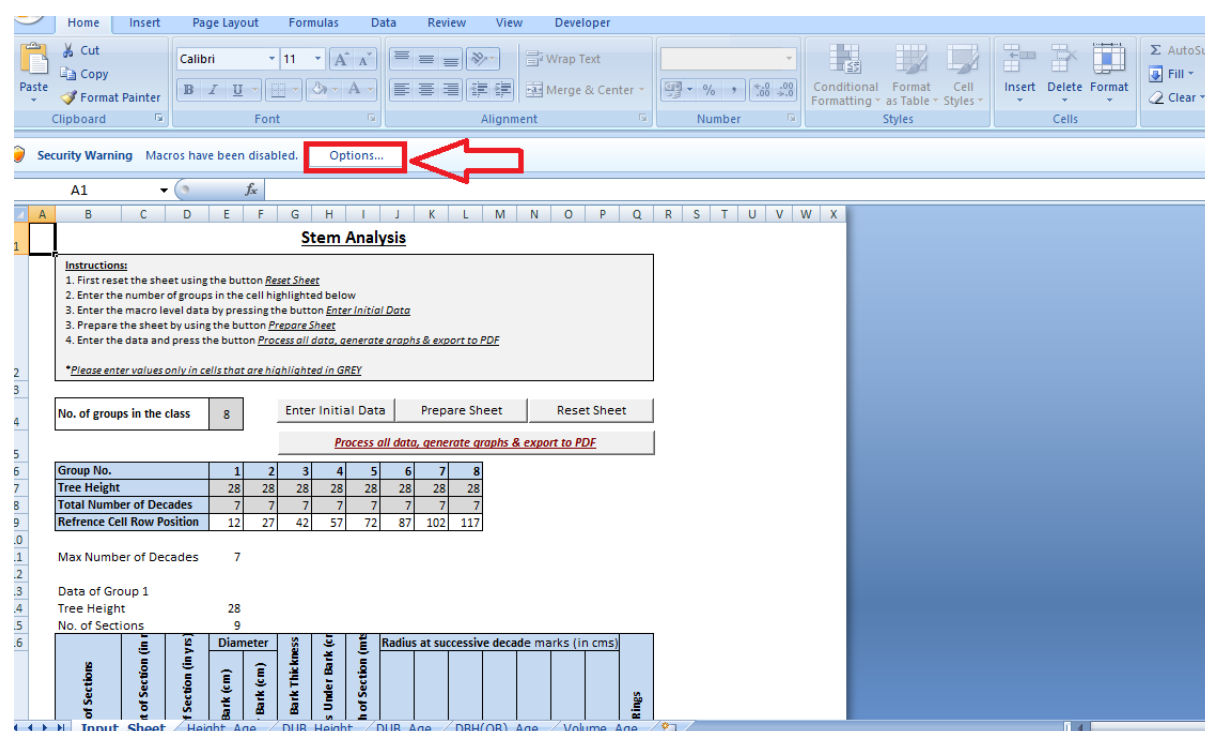
project

Name	Date modified	Type	Size
 MS Office Imp Plugin	17-04-2017 16:52	File folder	
 Stem Analysis.xlsm	17-04-2017 16:28	Microsoft Office E...	181 KB
 Stump Analysis - Final.xlsm	12-04-2017 00:42	Microsoft Office E...	137 KB

2. It is advisable to save the processed Stump Analysis – Final file in the same folder as this Stem Analysis – Final. This helps the program to pull necessary information from Stump Analysis – Final file itself. Otherwise, the program will ask the user to fill the required information as and when required.

## 3. Enable Macros

### First Screen



Security Warning: Macros have been disabled. Options...

**Stem Analysis**

**Instructions:**

1. First reset the sheet using the button **Reset Sheet**
2. Enter the number of groups in the cell highlighted below
3. Enter the macro level data by pressing the button **Enter Initial Data**
4. Prepare the sheet by using the button **Prepare Sheet**
5. Enter the data and press the button **Process all data, generate graphs & export to PDF**

\*Please enter values only in cells that are highlighted in GREY

No. of groups in the class: 8

Buttons: Enter Initial Data, Prepare Sheet, Reset Sheet

**Process all data, generate graphs & export to PDF**

Group No.	1	2	3	4	5	6	7	8
Tree Height	28	28	28	28	28	28	28	28
Total Number of Decades	7	7	7	7	7	7	7	7
Reference Cell Row Position	12	27	42	57	72	87	102	117

Max Number of Decades: 7

Data of Group 1

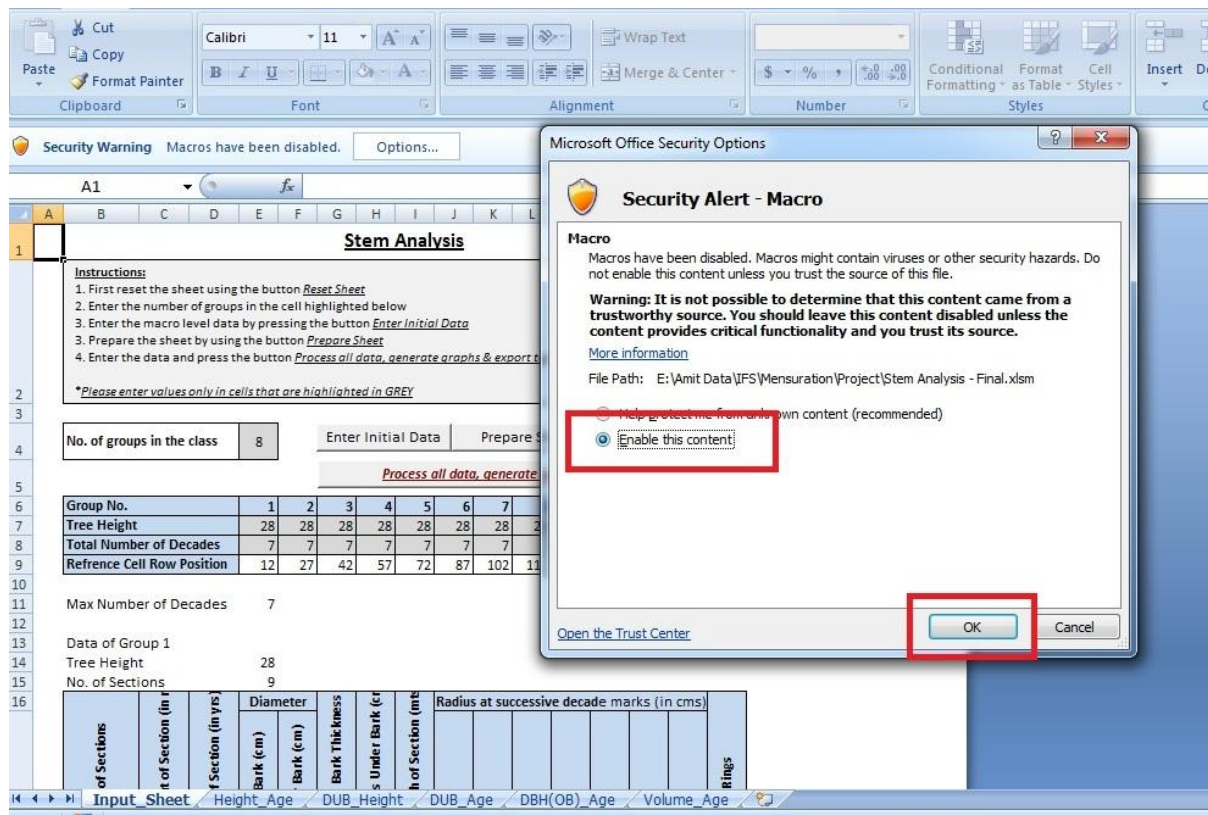
Tree Height: 28

No. of Sections: 9

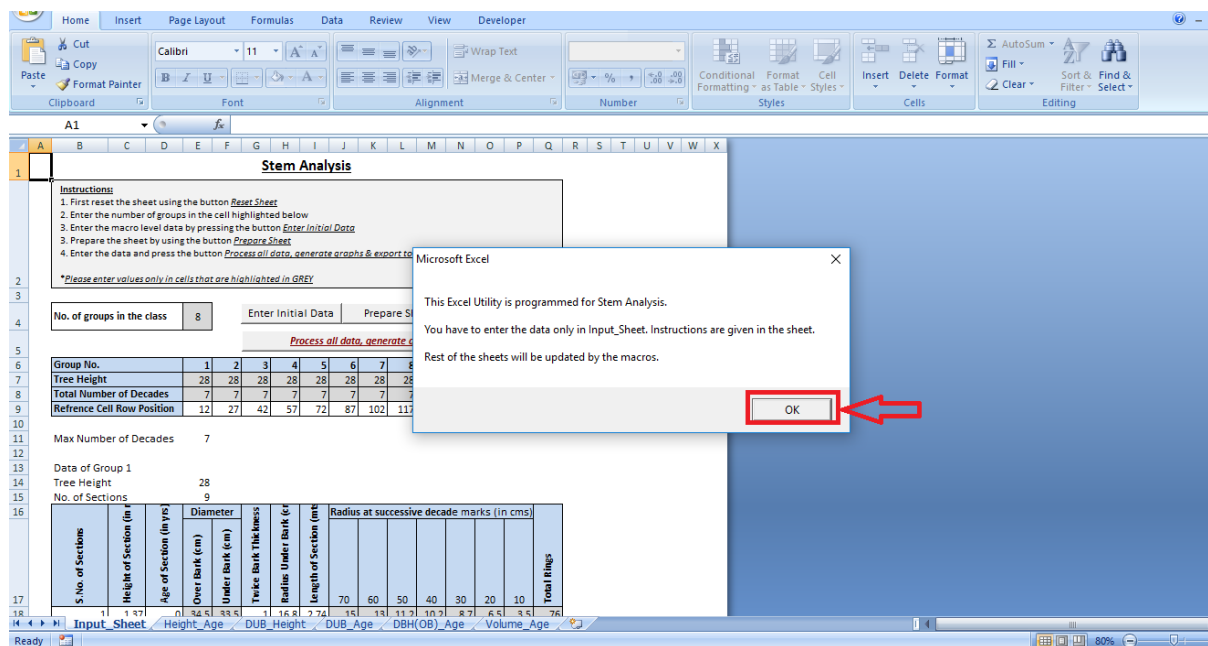
of Sections	of Section (in ft)	Section (in yrs)	Diameter	Bark Thickness	Bark (cm)	Bark (cm)	Bark Thickness	Under Bark (cm)	Radius at successive decade marks (in cms)	Rings

Input\_Sheet | Height\_Age | DUB\_Height | DUB\_Age | DBH(OB)\_Age | Volume\_Age

## Second Screen



## Third Screen:

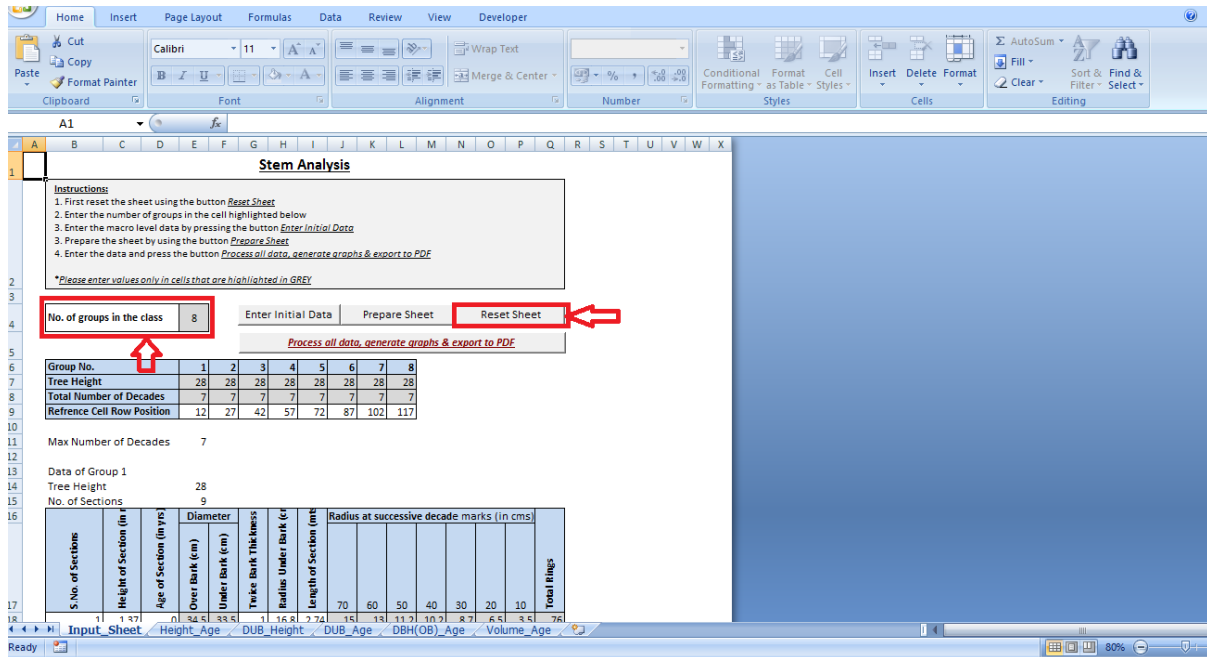


#### 4. Entering data in 'Input\_Sheet'

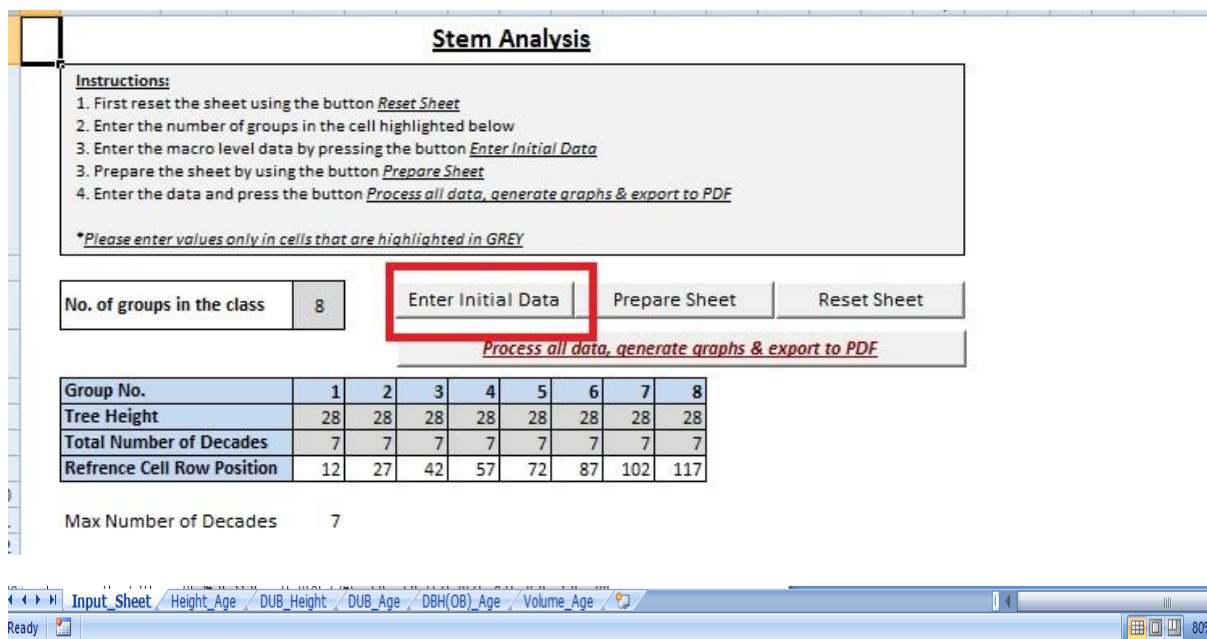
(Please note that instructions for entering the data are also given in Input\_Sheet)

First Screen – First reset the sheet

After resetting the sheet enter the Number of Groups as shown in the picture.



Second Screen: Enter 'Initial Data' by pressing the button as shown below. On pressing this button, a table will be created for entering the initial data. User will have to enter the data only in grey cells.



### Stem Analysis

**Instructions:**

1. First reset the sheet using the button [Reset Sheet](#)
2. Enter the number of groups in the cell highlighted below
3. Enter the macro level data by pressing the button [Enter Initial Data](#)
3. Prepare the sheet by using the button [Prepare Sheet](#)
4. Enter the data and press the button [Process all data, generate graphs & export to PDF](#)

*\*Please enter values only in cells that are highlighted in GREY*

No. of groups in the class

8

Enter Initial Data

Prepare Sheet

Reset Sheet

[Process all data, generate graphs & export to PDF](#)

Group No.	1	2	3	4	5	6	7	8
Tree Height	28	28	28	28	28	28	28	28
Total Number of Decades	7	7	7	7	7	7	7	7
Reference Cell Row Position	12	27	42	57	72	87	102	117

Max Number of Decades

7

**Third Screen:** Press 'Prepare Sheet' button and enter the data in the Grey cells

### Stem Analysis

**Instructions:**

1. First reset the sheet using the button [Reset Sheet](#)
2. Enter the number of groups in the cell highlighted below
3. Enter the macro level data by pressing the button [Enter Initial Data](#)
3. Prepare the sheet by using the button [Prepare Sheet](#)
4. Enter the data and press the button [Process all data, generate graphs & export to PDF](#)

*\*Please enter values only in cells that are highlighted in GREY*

No. of groups in the class

8

Enter Initial Data

Prepare Sheet

Reset Sheet

[Process all data, generate graphs & export to PDF](#)

Group No.	1	2	3	4	5	6	7	8
Tree Height	28	28	28	28	28	28	28	28
Total Number of Decades	7	7	7	7	7	7	7	7
Reference Cell Row Position	12	27	42	57	72	87	102	117

Max Number of Decades

7



Enter the data here.

No. of groups in the class	8	Enter Initial Data	Prepare Sheet	Reset Sheet
<b>Process all data, generate graphs &amp; export to PDF</b>				

Group No.	1	2	3	4	5	6	7	8
Tree Height	28	28	28	28	28	28	28	28
Total Number of Decades	7	7	7	7	7	7	7	7
Reference Cell Row Position	12	27	42	57	72	87	102	117

Max Number of Decades      7

Data of Group 1  
 Tree Height                      28  
 No. of Sections                 9

S.No. of Sections	Height of Section (in m)	Age of Section (in yrs)	Diameter		Twice Bark Thickness	Radius Under Bark (cm)	Length of Section (m)	Radius at successive decade marks (in cms)								Total Rings
			Over Bark (cm)	Under Bark (cm)				70	60	50	40	30	20	10		
1	1.37	0	34.5	33.5	1	16.8	2.74	15	13	11.2	10.2	8.7	6.5	3.5	76	
2	4.24	1	31.2	29.2	2	14.6	2.74	13.5	11.5	9.9	8.9	7.5	5.6	2.9	71	
3	7.24	2	31	29.6	1.4	14.8	2.74	11.8	9.8	8.7	7.7	6.3	4.6	2.1	68	
4	10.24	3	29.4	27.6	1.8	13.8	2.74	10.3	8.1	7.5	6.7	5.3	3.5	1.5	64	
5	13.24	4	26	23.6	2.4	11.8	2.74	8.9	6.5	5.9	5.8	3.8	2.1		58	
6	16.24	5	22.6	19.8	2.8	9.9	2.74	7.5	5.6	4.9	4.3	2.8			51	
7	19.24	6	18	14.5	3.5	7.25	2.74	6	4.5	3.8	3.1	1.9			44	
8	22.24	7	12	11	1	5.5	2.74	4.7	3.9	2.8	1.6				38	

5. Processing data by pressing the button 'Process all data, generate graphs & export to PDF'

### Stem Analysis

**Instructions:**

1. First reset the sheet using the button [Reset Sheet](#)
2. Enter the number of groups in the cell highlighted below
3. Enter the macro level data by pressing the button [Enter Initial Data](#)
3. Prepare the sheet by using the button [Prepare Sheet](#)
4. Enter the data and press the button [Process all data, generate graphs & export to PDF](#)

*\*Please enter values only in cells that are highlighted in GREY*

No. of groups in the class	8	Enter Initial Data	Prepare Sheet	Reset Sheet
<b>Process all data, generate graphs &amp; export to PDF</b>				

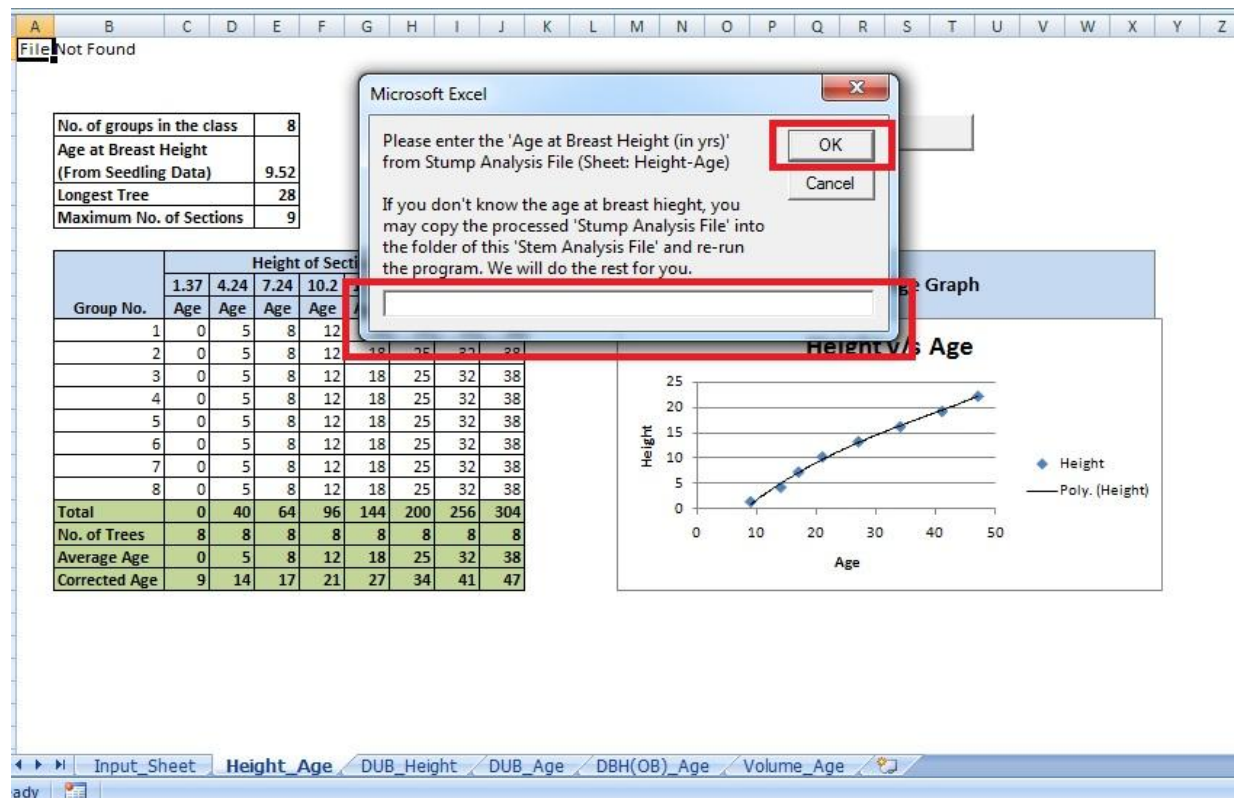
Group No.	1	2	3	4	5	6	7	8
Tree Height	28	28	28	28	28	28	28	28
Total Number of Decades	7	7	7	7	7	7	7	7
Reference Cell Row Position	12	27	42	57	72	87	102	117

Max Number of Decades      7

Data of Group 1  
 Tree Height                      28  
 No. of Sections                 9

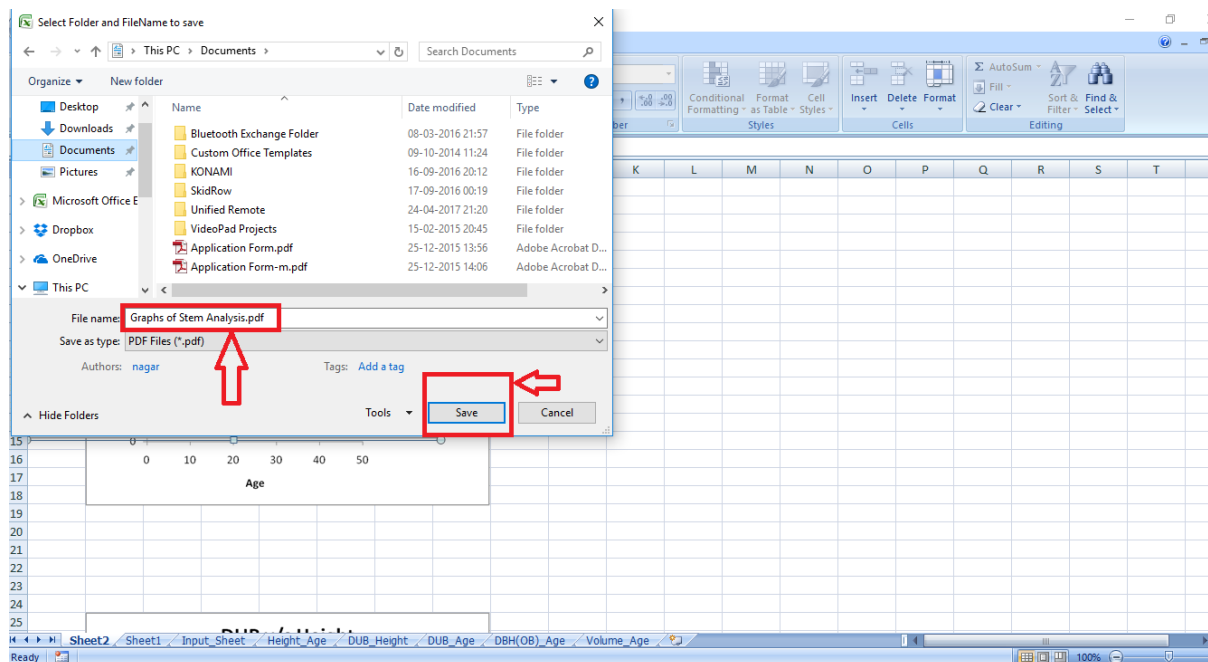
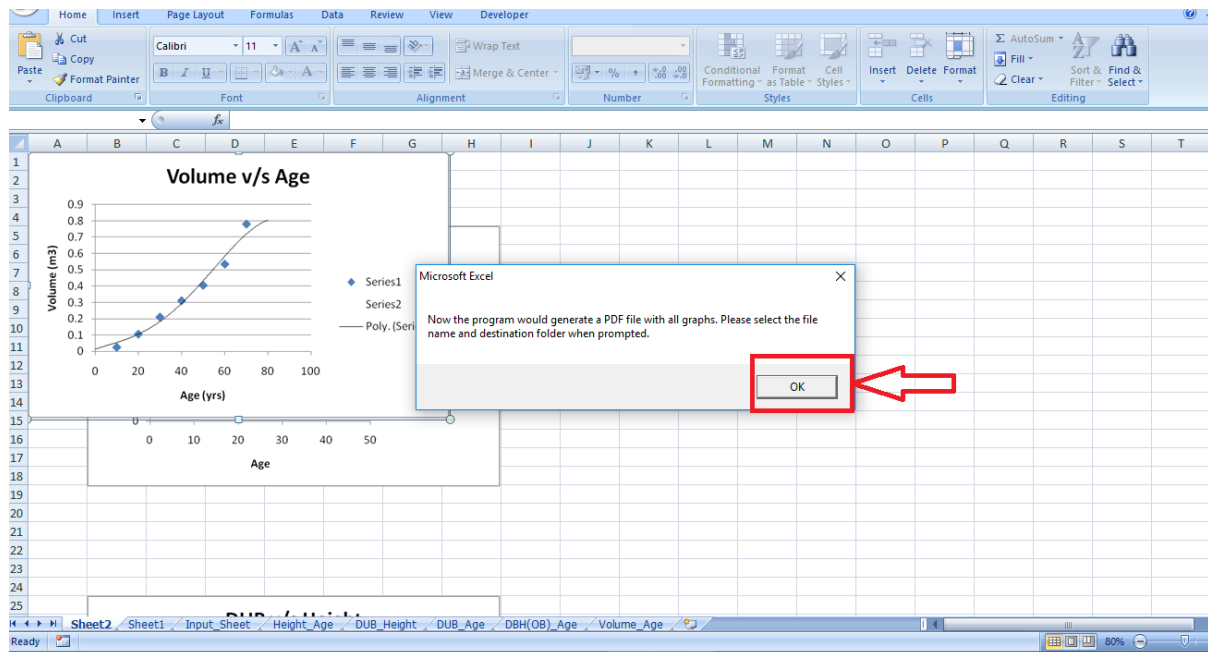
S.No. of Sections	Height of Section (in m)	Age of Section (in yrs)	Diameter		Twice Bark Thickness	Radius Under Bark (cm)	Length of Section (m)	Radius at successive decade marks (in cms)								Total Rings
			Over Bark (cm)	Under Bark (cm)				70	60	50	40	30	20	10		
1	1.37	0	34.5	33.5	1	16.8	2.74	15	13	11.2	10.2	8.7	6.5	3.5	76	

6. It may prompt, asking 'Age at Breast Height' from Stump Analysis File. Enter the same from Stump Analysis File (File name: *Stump Analysis-Final*, Sheet: *Height-Age*, Cell- Q4). Press OK after entering the data.



(If you save the processed *Stump Analysis - Final* file in the same folder as the Stem Analysis file, then it doesn't prompt for this value. In that case, the program pulls the required information from the *Stump Analysis - Final* file itself.)

7. After this, the program will generate a PDF file with all the graphs of stem analysis. User will be asked to select the location for saving the PDF.



Lastly, the output PDF will be saved at the location given by the user.