

PHASAGE OF THE OPERATIONS OF MEASUREMENTS OF THE PALM TREES

1. BEFORE GOING ON THE FIELD:

Checking of the tools:

- 1.1 Metal stems intended to measure the angles for phyllotaxy and the tangent angle
- 1.2 Protractor provided with a light plumb line (4 to 5 metres of rope)
- 1.3 Triple or quintuple metal tape measure
- 1.4 Heavy plumb line with at least 2 meters of rope or, better, fluo yellow rope
- 1.5 Saw of nurseryman, shears, fine metal stem graduated or not (estimate length of the part remaining on the stipa)
- 1.6 Indelible markers (envisage 2 of them at least!), pen
- 1.7 Telescopic pole or handle of shears/ pruner saw
- 1.8 Eventually a painting bomb.

Checking of the supplies for data acquisitions:

- 1.9 Numeric camera of good quality (especially not a cellphone, nor a bottom-of-the-range compact camera), producing pictures of at least 8 million pixels whose objective must be one of focal length between 50 and 135 mm in order to minimize the deformations (a zoom whose characteristics make it possible to reach focal distances located in these boundaries is completely compatible). The pictures must be taken with the best possible definition and without compression
- 1.10 Pen and pencil
- 1.11 Form for measurements of Phyllotaxy and Growth
- 1.12 Form for nervure measurements (petiole and rachis)
- 1.13 Form for measurements sheets (general description) - NB: this form will be perhaps removed in its version paper (automatic acquisition from the Form for data leaflets measurements - provision and groups)
- 1.14 Form for measurements of offshoot leaves (general description)

2. ON THE FIELD:

- 2.1 Identification of the palm tree and the offshoots to be observed
- 2.2 Localization of the parastiche of order 8 on the principal palm tree
- 2.3 Counting of the petiolar bases in lower part of the lowest palm on the parastiche to which this palm belongs on the principal palm tree
- 2.4 Counting of the petiolar bases at 3 heights compared to the ground on the principal palm tree
- 2.5 Counting of the number of arrows
- 2.6 Estimate of the number of palms
- 2.7 Measurement of the stipa circumference at 3 heights compared to the ground on the principal palm tree
- 2.8 Localization of the 2 palms which will be used to measure the angle phyllotaxic (these palms can be different from those that one will sample for the characteristics of the vein and the leaflets)
- 2.9 Measurement of the angle between these 2 palms
- 2.10 Localization of the 2 palms which will be sampled for the characteristics of the vein and the leaflets

On each selected palm:

- 2.11 Measurement of insertion angle and angle at the point "C" using the protractor + plumb line
- 2.12 Measurement of the projection on the ground of the stem of 1 meter attached after the point "C"

- 2.13 Photographs of the angle of inflection at the end of the palm with the vertical reference mark provided by the heavy plumb line at the end of a pole
- 2.14 Photographs of the swing angle of the plan of the leaflets at the end, locates vertical provided by the heavy plumb line at the end of a pole
- 2.15 Localization of the horizontal deviation direction and photography of this deviation (position slept on the back, head against the stipa)
- 2.16 Localization of the beginning of the appreciable rotation of the plan of the leaflets, and also of the visible deviation
- 2.17 Localization of the highest point of the palm (painting the vein, photograph, etc...)
- 2.18 Section of the 2 palms as close as possible from insertion (saw of nurseryman)
- 2.19 Measurement of the remaining part on the stipa

On each selected offshoots

- 2.20 Localization of the order 8 parastiche
- 2.21 Counting of the petiolar bases in lower part of the lowest palm on the parastiche to which this palm belongs
- 2.22 Localization of 2 palms (low one and an average other)

On each palm of each rejection

- 2.23 Measurement of length of vein without pinnae (petiole) from the insertion to the first spine
- 2.24 Measurement of the spiny part length of the vein
- 2.25 Measurement of the foliolate part length of the vein
- 2.26 Length of the largest leaflet
- 2.27 Higher width of the largest leaflet

On each half-palm of each palm

- 2.28 Counting of the spine numbers
- 2.29 Counting of the intermediate pinnae number
- 2.30 Counting of the leaflet number including the end leaflet IN Technical premise or

3. LABORATORY:

On each selected palm:

- 3.1 Measurement of leaflets disposition and patterns, by noting on the vein the position of the first spine selected and by noting, on the pinnae, their row every 10 leaflets
- 3.2 To note positions $LR/10$, $2*LR/10$, ..., $9*LR/10$, on the rib according to the protocol
- 3.3 Choice of the sections around these positions for metric and angular measurements
- 3.4 Cut sections while avoiding modifying it

On each section of each selected palm

- 3.5 Measurements of widths and heights of the vein to these positions
- 3.6 On all the sections, measurements of the lengths of the pinnae and marking of the positions $1/3$ and $2/3$ (strip of 50 cm then a metre if they are longer)
- 3.7 Measurement of the leaflet openings at $1/3$ and $2/3$ with a caliper
- 3.8 Measurement of the $1/2$ widths of the leaflets at $1/3$ and $2/3$ with the strip (precision at $1/2$ mm if available)
- 3.9 Pictures (*) from top of the horizontal angles of insertion for later measurements
- 3.10 Pictures (*) in face of the angles of vertical insertion for later measurements - NB: if the relation vertical angle and rotation angle is proven and constant for this species, these pictures are not needed.
- 3.11 Section of the leaflets, clean and close to the vein, location of the sides and pictures (*) of the rotation angles of the pinnae at their insertions for later measurements

(*) remainder: The pictures must be realized (especially not a cellphone, nor a bottom-of-the-range compact camera), producing pictures of at least 8 million pixels whose objective must be

one of focal length between 50 and 135 mm in order to minimize the deformations (a zoom whose characteristics make it possible to reach focal distances located in these boundaries is completely compatible). The pictures must be taken with the best possible definition and without compression

4 AT THE OFFICE:

From the pictures taken in technical premise or laboratory (Mesurim software):

- 4.1 Measurements of the horizontal angles of the leaflets on the vein
- 4.2 Measurements of the vertical angles of the leaflets on the vein
- 4.3 Measurements of the rotation angles of the leaflets on the vein

From the checked cards "paper" data acquisitions in the Excel sorter Interfaces:

- 4.4 Form table measurements of stipa (phyllotaxy and growth)
- 4.5 Form table measurements of ribs (petiole and rachis)
- 4.6 Form table sheets measurements of offshoots (general description)
- 4.7 Form table measurements of leaflets (provision and groups)
- 4.8 Form table measurements sections rachis, lengths of the pinnae
- 4.9 Form table measurements sections rachis, openings of the pinnae
- 4.10 Form table measurements sections rachis, 1/2 widths of the pinnae
- 4.11 Form table angles measurements of the pinnae - NB: if the relationship between vertical angle and rotation angle is proven and constant for this species, only the acquisition of the horizontal angles and rotation will be necessary

5 SIMULATION:

After checking of the table "data for Principes":

- 5.1 Copy table in a new file (special copy: copy first widths of the columns, special copy: copy then values, special copy: endly copy format)
- 5.2 Then record this file identified with palm tree_year_month_day
- 5.3 Then check that the decimal symbol inside Excel is well a point and not a comma
- 5.4 Endly copy this file in format text with tabulation separator (take care: Excel does not always add the extension ".txt" by itself)

Simulation itself:

- 5.5 Launch Xplo and configure the characteristics of simulation
- 5.6 Load the recorded file and "enjoy your palm tree simulations"

PROTOCOLE DESCRIPTIF 3D

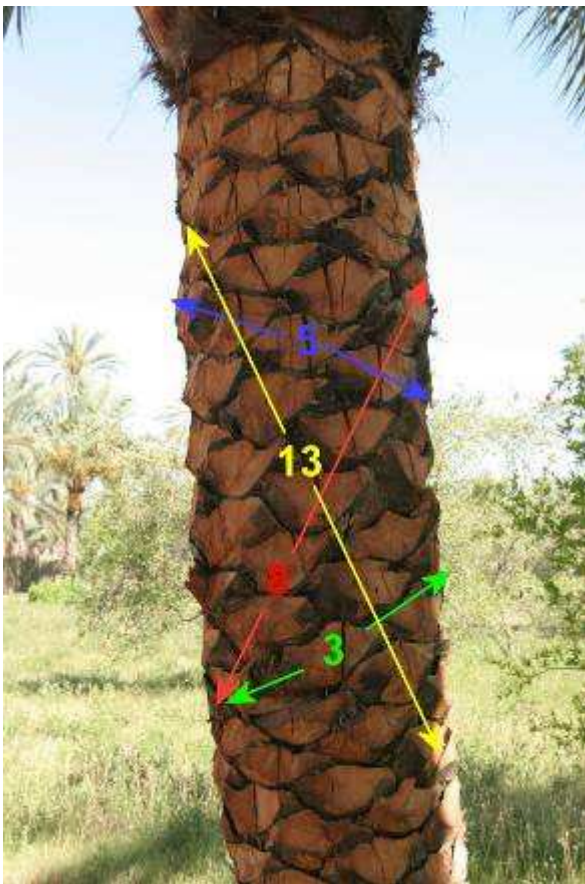
1 IDENTIFICATION OF THE SPECIMEN

Date	
Identification number	
Morphotype or cultivar	

2 DESCRIPTION OF THE PALM TREE (IN-SITU)

2.1 Location of the whorl of order 8 and classification of the palms

2.1.1 Determination of the phyllotaxic direction (right or left) and of the order 8 parastiche (in red in these 2 cases)..



2.1.2 Classification of the palms starting from palm 1 (emergent palm just being in deployment)

Possible pruning (the most moderate as possible) of the palms in order to reach the central part.



2.2 Counting of the fronds

2.2.1 Number of present fronds (exact counting or estimation)

2.2.2 Number of arrows

2.2.3 Number of fronds presenting a different lateral deviation

2.3 Counting of the petiolar bases (stumps) on order 8 parastiche

2.3.1 Counting of the stumps present under the lowest frond on the order 8 parastiche to which this palm belongs.

Direction of the parastiches (1=trigo dir., -1 clockwise dir.)		Number of stumps on order 8 parastiche at 20cm Number of stumps on order 8 parastiche at 50cm Number of stumps on order 8 parastiche at à 100cm Stipa circumference at 20cm Stipa circumference at 50cm Stipa circumference at 100cm	
Number of visible arrows			
Estimated number of fronds			
Number of fronds with a different lat. deviation/generality			
Height of the higher stump under the fronds (cm)			
Number of stumps on order 8 parastiche			
Stipa circumference			

2.3.2 Counting of the stumps at 3 heights compared to the ground on the principal palm tree (20cm, 50cm and 100cm).

2.3.3 Measurement of the stipa circumference at 3 heights over to the ground on the principal palm tree (20cm, 50cm and 100cm).

2.3.4 Height in cm of the upper stump under fronds.

2.3.5 Circumference of the stipa at the height of this last stump under fronds.

Establishment angle at the stipa base (id. offshoot)	
Beginning of stipa straightening zone (number of fronds)	
End of stipa straightening zone (number of fronds)	

2.4 Measurement of phyllotaxic angle

2.4.1 Installation of the gauges on two palms chosen on order 8, with at least 3x8 rows of distance.

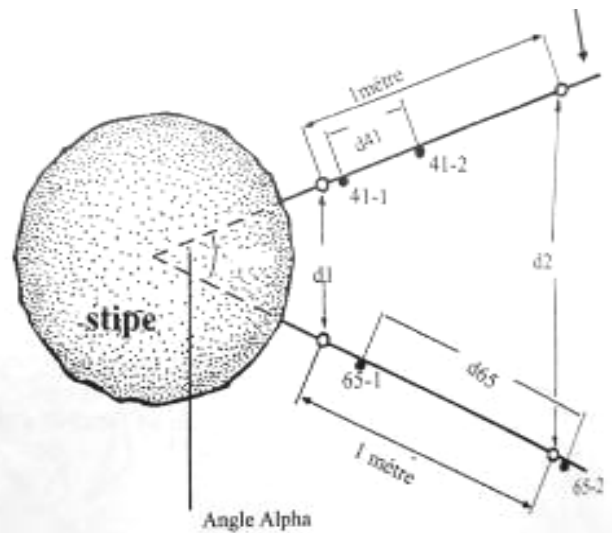


Figure 17. Mesures de l'angle phyllotaxique

The first reference mark of the gauge is as close as possible to the first spine ("C" point) but always after this one. The gauge must be fixed rather firmly but in such way that it is tangent in a point located at 50cm (medium of the gauge) of the "C" point

2.4.2 For each selected palm, locate the plumb line balances on the ground for the 2 braces of the gauge by using small stakes, (one will always measure on the same side of the palm and one lets descend the plumb line by having the brace between the stipa and the rope.

- 2.4.3 Align the eyed gauges against the location stakes, all of the 2 on the same side of the stakes. Insert a fixing stake in each eye.
- 2.4.4 One will check with the spirit level that the eyed gauges. One will check with a spirit level that the eyed gauges are well in a horizontal plane, if not, correct by using hold thickness under the eyed gauges.
- 2.4.5 If the selected palms are also those intended to be pruned for the continuation of the observations, note the distances on the ground between the stakes of location of the brace gauge reference marks. In this case, also locate the position of the first point of the gauge on the frond rib.
- 2.4.6 Note the distances D1 and D2 between the fixing stakes of the eyed gauges (axis to axis)

Frond row	Distances on the ground between reference marks of the gauge	D1	D2

2.5 Measurement of the characteristic angles of the rib (rachis)

(on the two selected palms for the continuation of the observations on the rachis and the leaflets)

- 2.5.1 Measurement of the rachis angle compared to the vertical closest to its insertion with a plum lined protractor.
- 2.5.2 Measurement of the rachis angle at the "C" point with a plum lined protractor.



- 2.5.3 Measurement, using the brace gauge, of the balances projection on the ground like in the case of measurements for the angle of phyllotaxy, report the metric position of the first point of the gauge

Frond row		
Basal petiol angle/verticale		
Petiol angle at "C" point /verticale		
Metric position of the first point of the gauge		

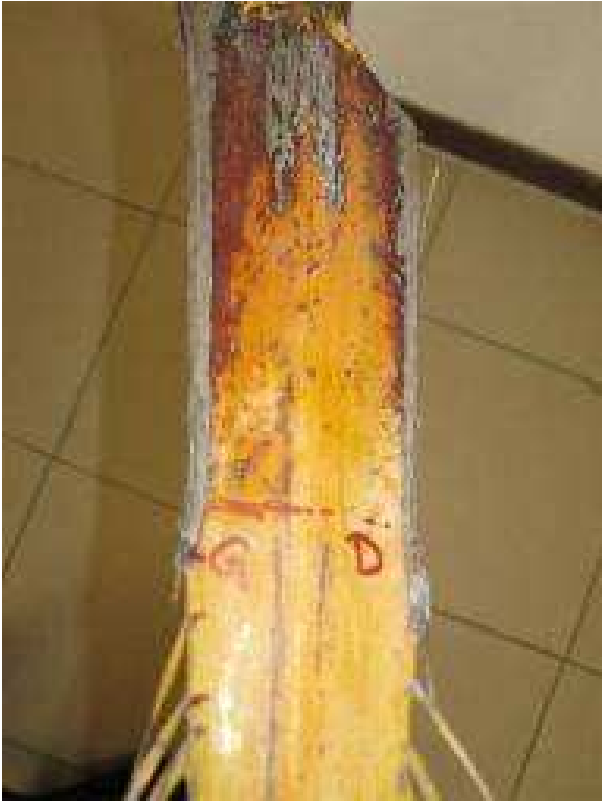
- 2.5.4 Location of the highest point of (of the rib of) the palm either by drawing a mark there, or by taking a sufficiently clear photograph which will make it possible to count the leaflets between the end and this point
- NB: if this point is not the end, the angle of the rib with the vertical is 90° there
- 2.5.5 Picture of the rachis end angle with the vertical: the vertical must be referenced by a heavy plumb line on white or yellow fluo rope (this angle is the inflection angle at the end)
- NB: this point may be confused with the highest point
- 2.5.6 Location of the frond deviation direction, back to the stipa
-1 the frond is deviated on the left hand of observer
+1 the frond is deviated on the right hand of the observer
- 2.5.7 Location of the point from which the frond rotation becomes sensitive (distance to the stipa of the beginning of the rachis significant rotation)
- 2.5.8 Location of the point from which the frond deviation becomes sensitive (distance to the stipa of the beginning of the rachis significant deviation)
- 2.5.9 Picture of the rachis rotation at the end of the frond: the vertical must be referenced by a heavy plumb line on white or yellow fluo rope (this angle is the swing angle at the end)
- 2.5.10 Photographs, in a down to up manner, of all the rachis, from insertion to the end, to reconstitute the deviation (this angle is the final deviation angle at the end)

Frond row		
Deviation direction (back to stipa)		
Distance to stipa of rachis sensitive deviation beginning		
Final deviation angle at the frond end		
Distance to stipa of rachis sensitive rotation		
Orthogonal angle of leaflet plan at the frond end		

3 LEAF DESCRIPTION (in technical premise or laboratory)

3.1 General description

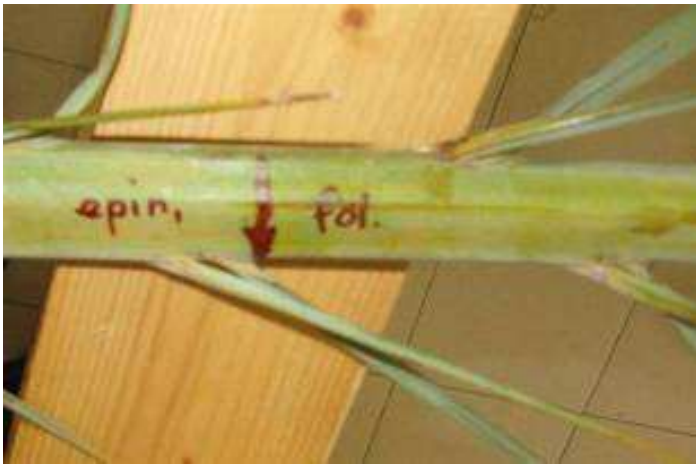
- 3.1.1 The right left orientation is done in reference to the ventral face of the palm ("upper" face), the feet towards the insertion of the palm
- 3.1.2 Location of the first spine on each side
- 3.1.3 Location of the last spine on each side
- 3.1.4 Location of the first leaflet on each side
- 3.1.5 Location of the 5 last leaflets on each side + final leaflet
- 3.1.6 Installation of the tape measure along the rachis by positioning the graduation which corresponds to the value of the part remained on the stipa when cutting the frond, measurement of length of the rachis: LR
- 3.1.7 Location of the positions LR/10, 2*LR/10, 3*LR/10,....., 8*LR/10, 9*LR/10.



L R Orientation of the frond on ventral face

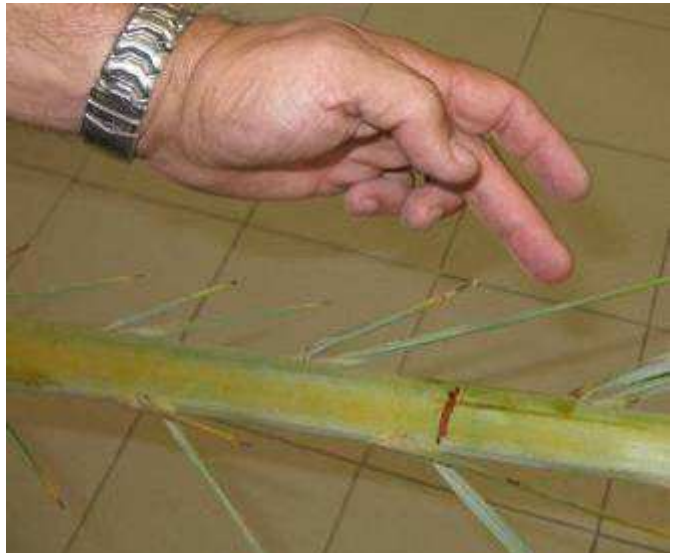


Installation of the tape measure



Transition spine/leaflet location

Location of every LR/10 positions



3.2 Description of foliar plans

For each side of palm (one will indicate "left half-palm" and "right half-palm")



3.2.1 Location of the metric position of each pinnae on the rib



3.2.2 Determination of the position of the pinnae forming the groups:

- + or sup : the pinnae is directed upwards
- o or med : the pinnae is quite in the foliar plane
- or inf : the pinnae is directed downwards

NB : It is important (quite essential) to note the sequence number of the pinnae every 10 pinnae, this helps to be located for the possible checks..

Pinnae row	Position + 0 - (sup med inf)	Distance insertion	1st leaflet position (note "F")
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

⋮
⋮
⋮

⋮
⋮
⋮

⋮
⋮
⋮

⋮
⋮
⋮

40			
41			
42			
43			
44			
45			
46			
47			
48			
49			

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⋮

109			
110			
111			
112			
113			

⋮
⋮

⋮
⋮

⋮
⋮

⋮
⋮

Pinnae row	Position + 0 - (sup med inf)	Distance insertion	1st leaflet position (note "F")
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
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15			
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17			
18			
19			
20			

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40			
41			
42			
43			
44			
45			
46			
47			
48			
49			

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109			
110			
111			
112			
113			

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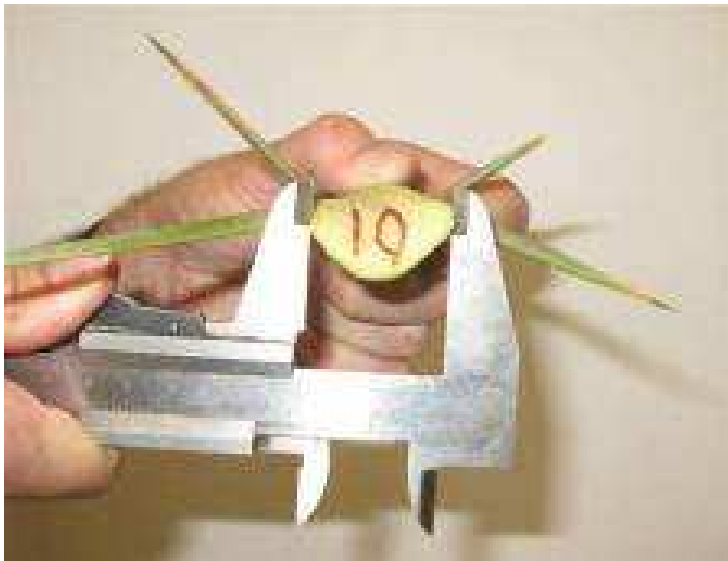
3.3 Description by section

- 3.3.1 Cutting out groups close to each section mark in order to get a maximum of pinnae with different positions (+, 0, -), it is appropriate to have at least a complete group on each side, a group consists of 1 to 4 leaflets, rarely 5.

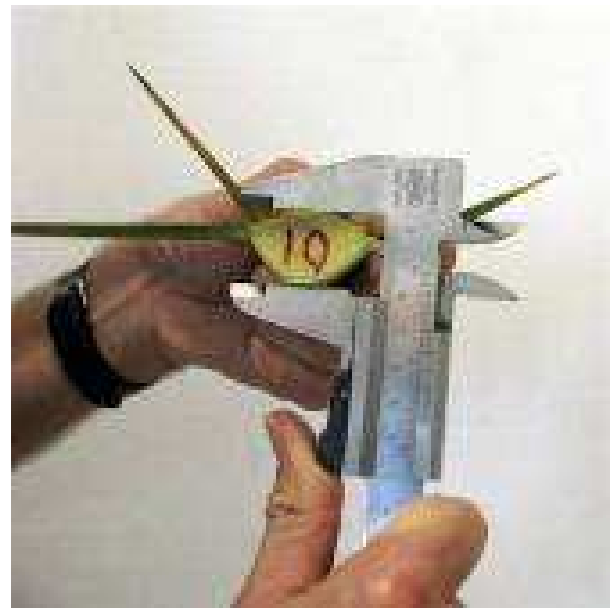


- 3.3.2 Constitute a section "1st spine"
3.3.3 To constitute a section "last spine → 1st leaflet" including sometimes an intermediate pinnae
3.3.4 It is advisable to constitute a section "Terminal Group" made up of the 5 last leaflets on each side and of the final leaflet

3.4 Dimensions of the rachis sections



3.4.1 Measurement of the rachis width, using a slide caliper, for each reference mark (LR/10, 2*LR/10, 3*LR/10, ..., LR)



3.4.2 Measurement of the rachis thickness (height), using a slide caliper, for each reference mark (LR/10, 2*LR/10, 3*LR/10, ..., LR)

Length of the remaining part on the stipa

Metric position	Width	Thickness
X		
LR/10		
2*LR/10		
3*LR/10		
4*LR/10		
5*LR/10		
6*LR/10		
7*LR/10		
8*LR/10		
9*LR/10		
LR		

3.5 Dimensions of the pinnae: lengths and location of positions 1/3 and 2/3

For each side of each section, including the possible special sections (1st spine, transition spine → leaflet, terminal group)

3.5.1 Measurement of each pinnae length from insertion to the end, using a graduated strip of 50 with 60cm length or a metal tape measure

3.5.2 Location of positions 1/3 length and 2/3 the length of each leaflet

	Metric position	1/2 left frond			
		+ or sup	0 or med	0 or med	- or inf
1st spine	X spine 1				
last spine	X lst. spine				
1st leaflet	X leaflet 1				
	X on stipa				
	LR/10				
	2*LR/10				
	3*LR/10				
	4*LR/10				
	5*LR/10				
	6*LR/10				
	7*LR/10				
	8*LR/10				
	9*LR/10				
TG1	X TG1				
TG2	X TG2				
TG3	X TG2				
TG4	X TG2				
TG5	X TG2				
FT	LR				

3.6 Dimensions of pinnae : aperture

For each side of each section, including the possible special sections (1st spine, transition spine → leaflet, terminal group)

3.6.1 Measurement of aperture, at the position 1/3 of length, using a slide caliper

3.6.2 Measurement of aperture, at the position 2/3 of length, using a slide caliper



	Metric position	1/2 left frond							
		1st third				2 nd third			
		+ or sup	0 or med	0 or med	- or inf	+ or sup	0 or med	0 or med	- or inf
1st spine last spine 1st leaflet	X spine 1								
	X lst. spine								
	X leaflet 1								
	X on stipa								
	LR/10								
	2*LR/10								
	3*LR/10								
	4*LR/10								
	5*LR/10								
	6*LR/10								
	7*LR/10								
	8*LR/10								
	9*LR/10								
TG1	X TG1								
TG2	X TG2								
TG3	X TG2								
TG4	X TG2								
TG5	X TG2								
FT	LR								

3.7 Dimensions of pinnae : half-width

For each side of each section, including the possible special sections (1st spine, transition spine → leaflet, terminal group)



3.7.1 Measurement of half-width, at the pinnae insertion, using a slide caliper or a half-millimeter graduate strip

3.7.2 Measurement of half-width, at the position 1/3 of length, using a graduate strip or a metal tape measure

3.7.3 Measurement of half-width, at the position 2/3 of length, using a graduate strip or a metal tape measure



	Metric position	1/2 palme gauche							
		insertion				2 nd third			
		+ or sup	0 or med	0 or med	- or inf	+ or sup	0 or med	0 or med	- or inf
1st spine	X spine 1								
last spine	X lst. spine								
1st leaflet	X leaflet 1								
	X on stipa								
	LR/10								
	2*LR/10								
	3*LR/10								
	4*LR/10	:	:	:	:	:	:	:	:
	5*LR/10	:	:	:	:	:	:	:	:
	6*LR/10								
	7*LR/10	:	:	:	:	:	:	:	:
	8*LR/10	:	:	:	:	:	:	:	:
	9*LR/10								
TG1	X TG1								
TG2	X TG2								
TG3	X TG2								
TG4	X TG2								
TG5	X TG2								

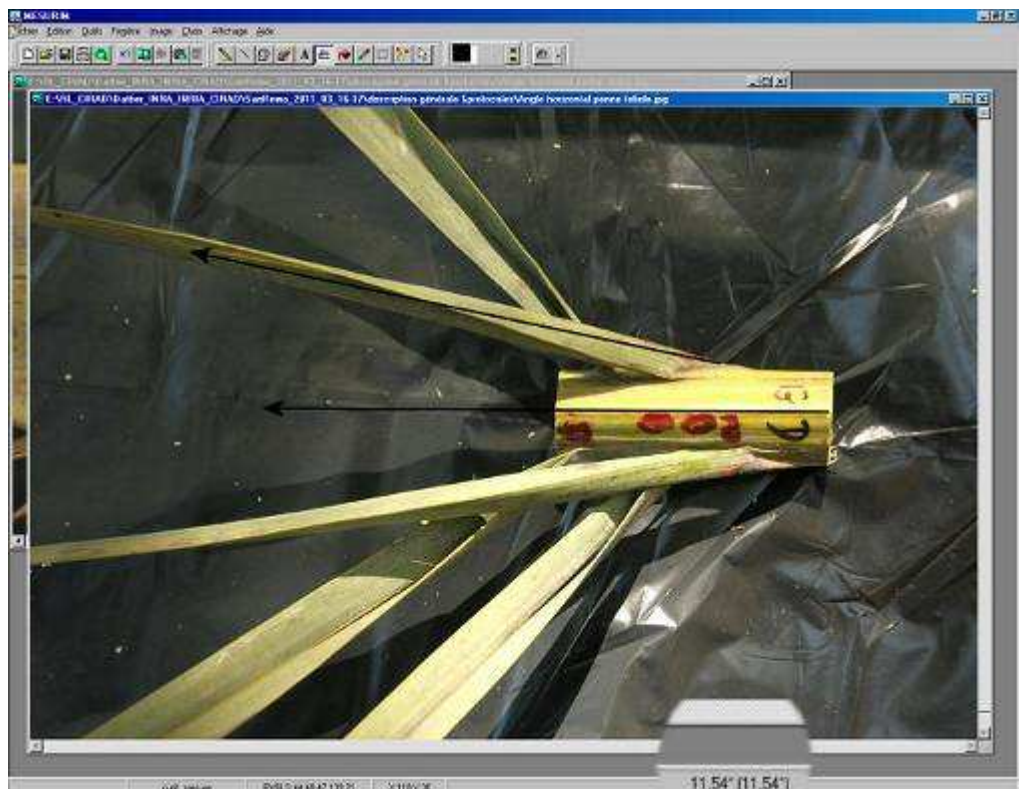
4 CHARACTERITIC ANGLES OF PINNAE

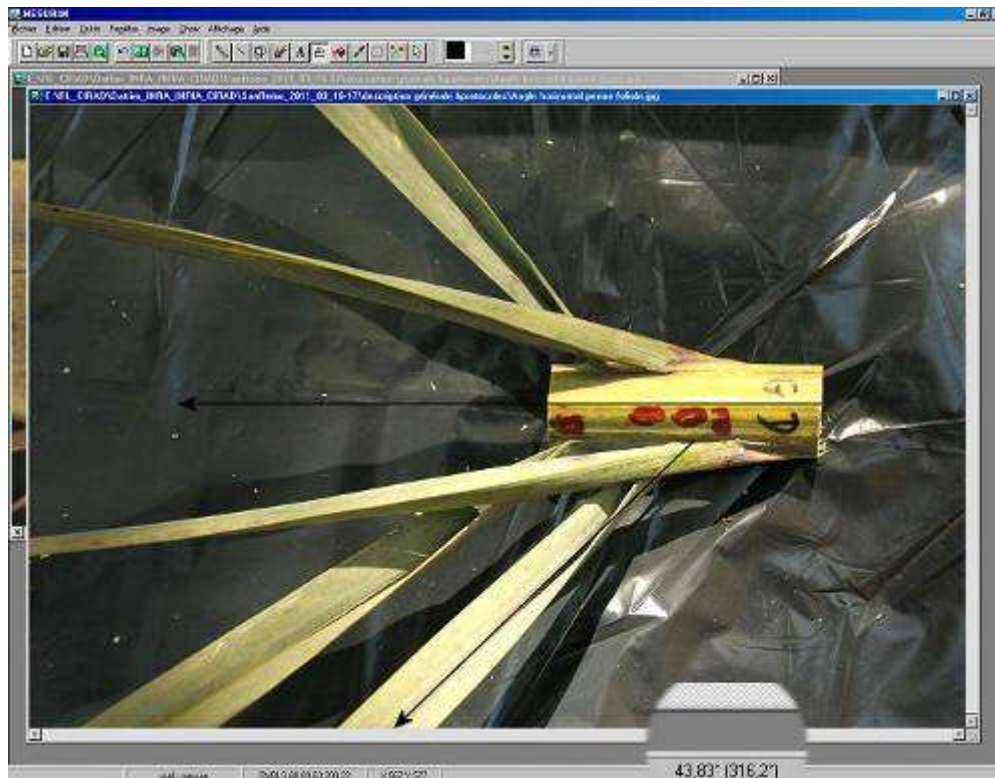
To carry out these series of measure, Pictures are taken after preceding metric measurements (length, openings, half-widths) for carrying out these series of measurements.

These photographs are then treated using an image software to put them at the "screen" format (1200X800), one also adds to it the layout of the axis which will be used as reference for the measurement of the considered angle.

4.1 Horizontal insertion angle

The measurement of the horizontal angle of the left upper leaflet is around 11,54°, taking into account the precision the value 11,5° will be recorded



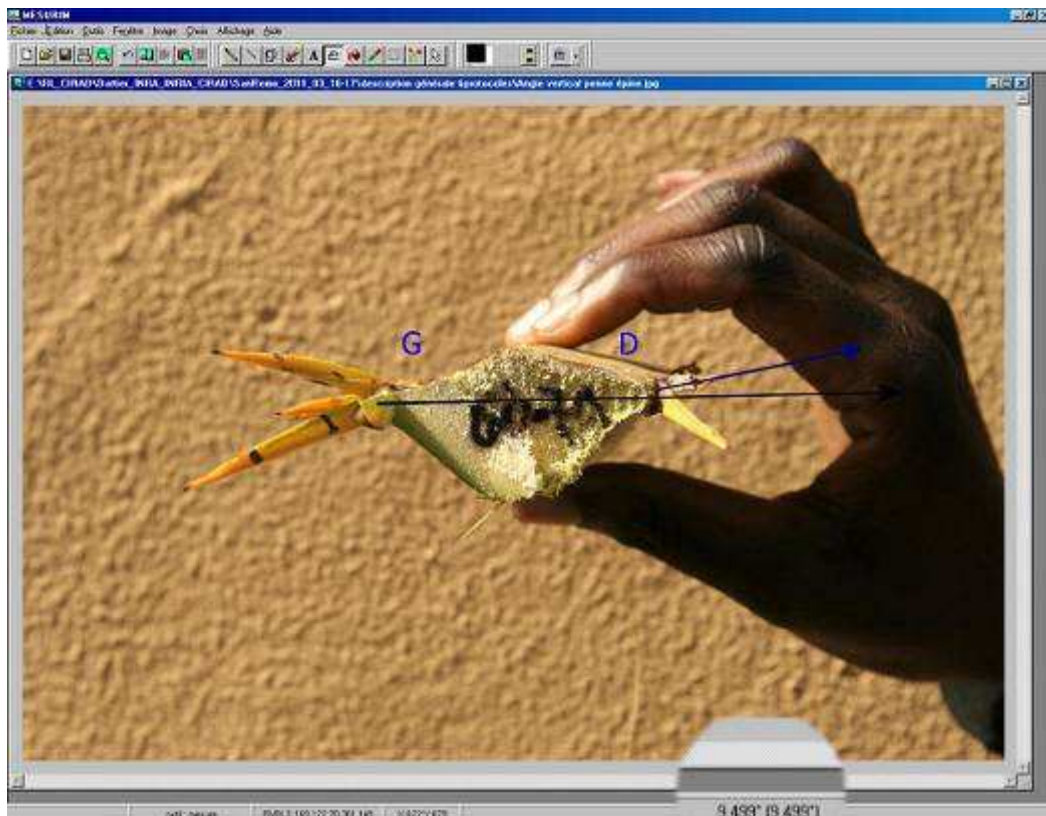
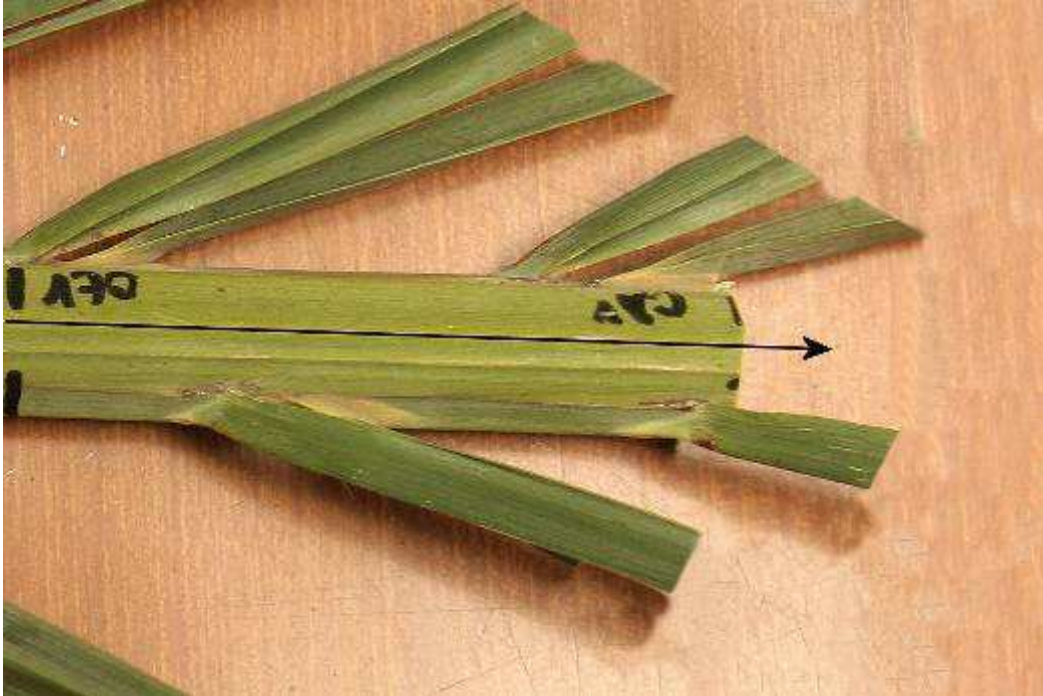


The measurement of the horizontal angle of the right median leaflet is around 43,83°, taking into account the precision the value 43,8° will be recorded

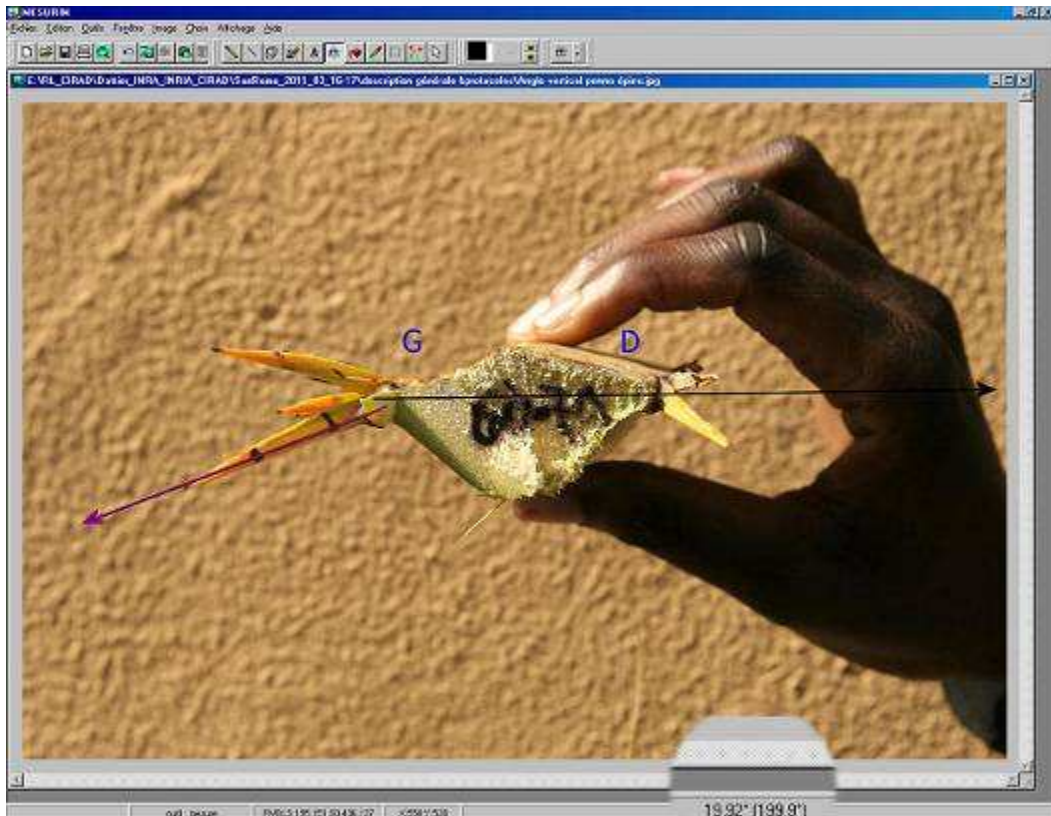
	Metric position	1/2 left frond			
		+ or sup	0 or med	0 or med	- or inf
1st spine	X spine 1				
last spine	X lst. spine				
1st leaflet	X leaflet 1				
	X on stipa				
	LR/10				
	2*LR/10				
	3*LR/10				
	4*LR/10				
	5*LR/10				
	6*LR/10				
	7*LR/10				
	8*LR/10				
	9*LR/10				
TG1	X TG1				
TG2	X TG2				
TG3	X TG2				
TG4	X TG2				
TG5	X TG2				
FT	LR				

4.2 Vertical insertion angle

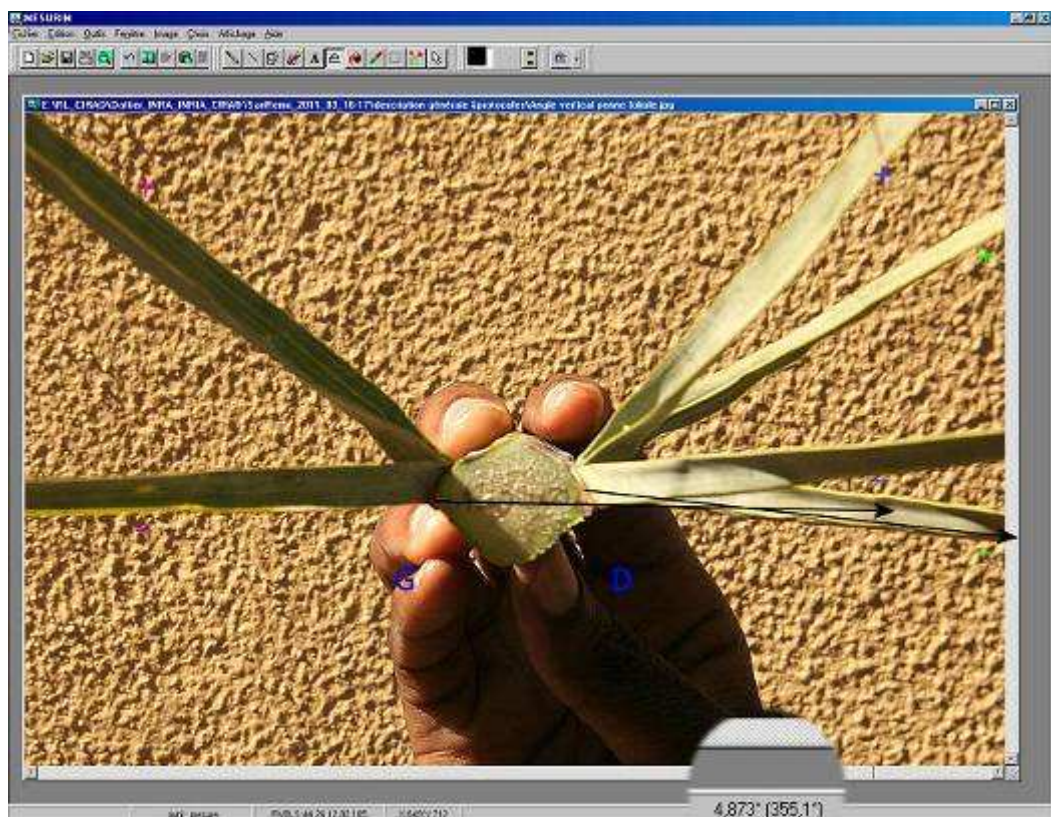
In order to prevent that the pinnae located towards the camera do not hide those located further, it is advisable to proceed to a gradually decreasing length-cutting of the pinnae which will be photographed (closest being shortest), as on the example below



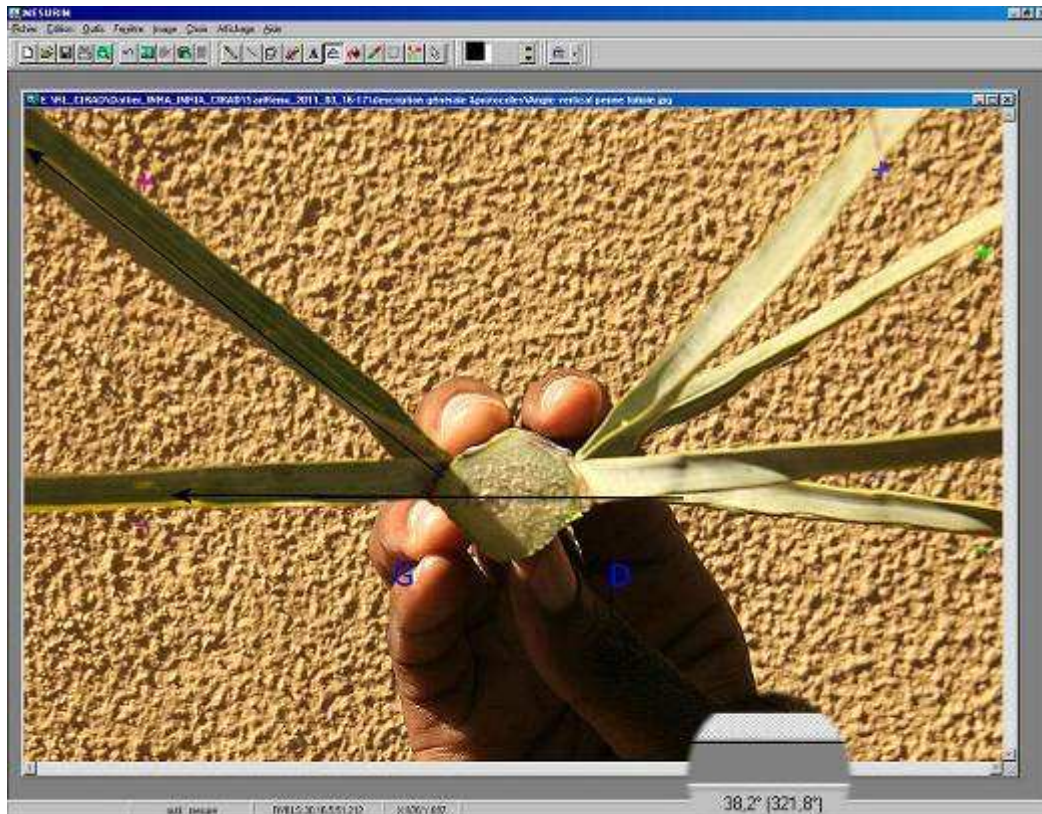
The measurement of the vertical angle of the right upper spine is around $9,499^\circ$, taking into account the precision and of the position, the value $9,5^\circ$ will be recorded



The measurement of the vertical angle of the left lower spine is around $19,92^\circ$, taking into account the precision and of the position the value $-19,9^\circ$ will be recorded



The measurement of the vertical angle of the right lower leaflet is around $4,873^\circ$, taking into account the precision and of the position the value $-4,9^\circ$ will be recorded



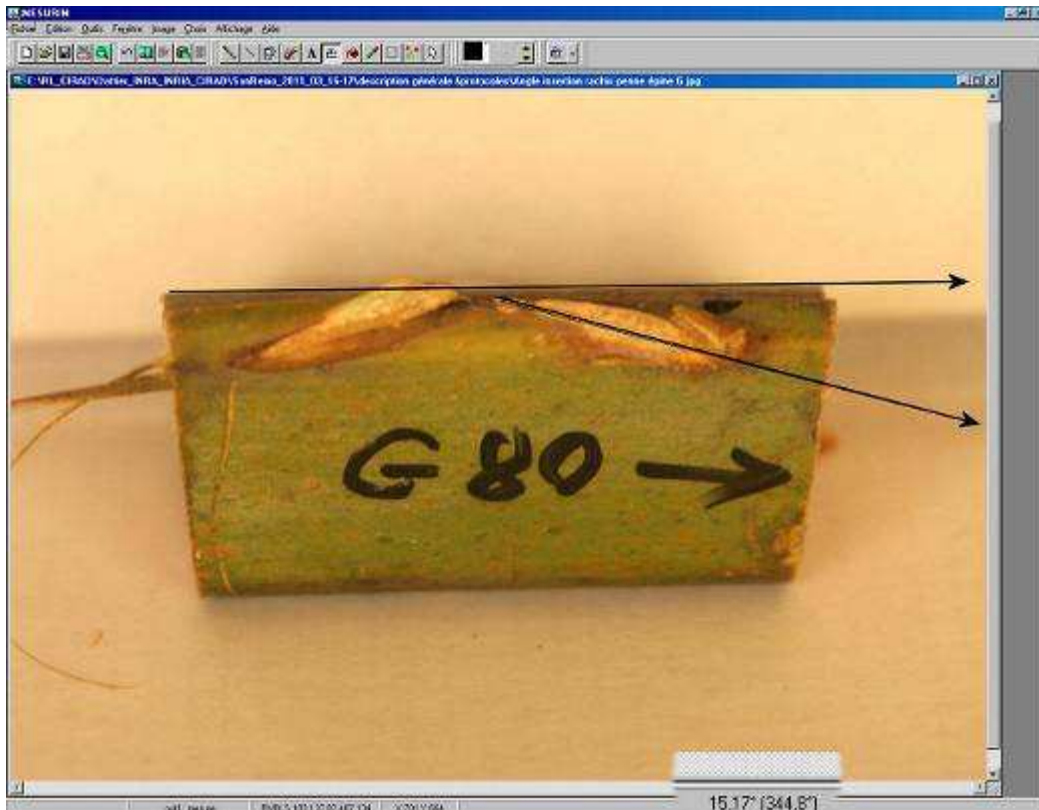
The

measurement of the vertical angle of the left higher leaflet is around 38,2°, taking into account the precision and of the position the value 38,2° will be recorded

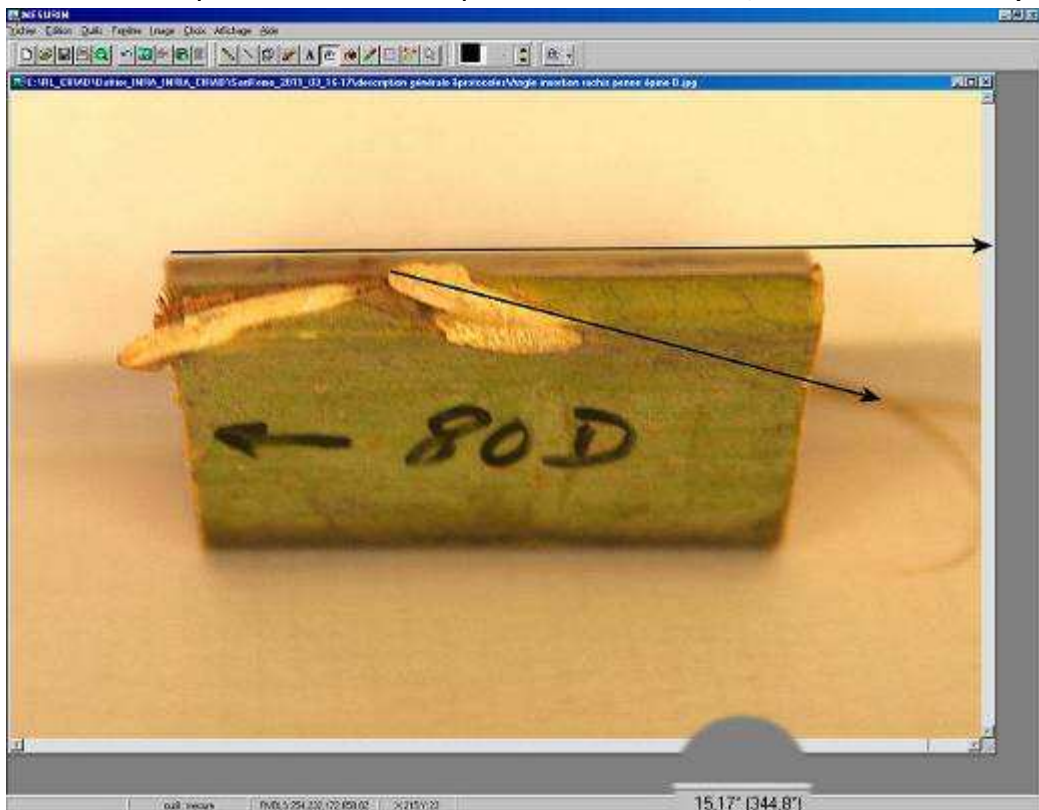
4.3 Rotation angle at the insertion on rachis



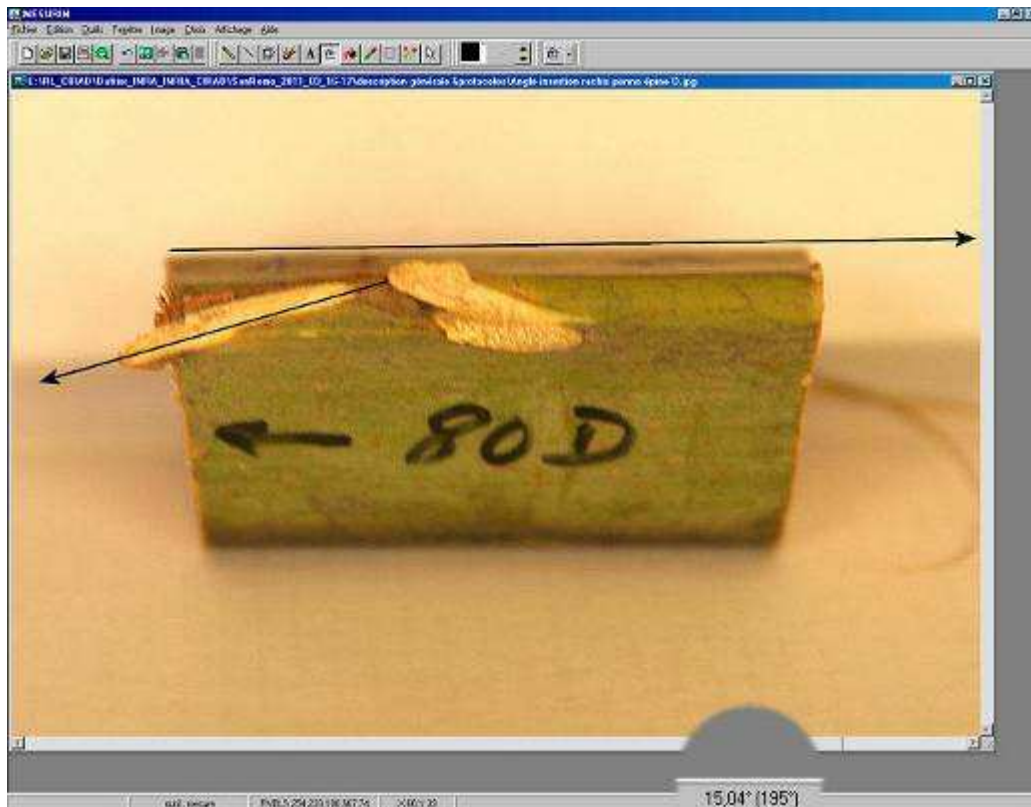
The measurement of the rotation angle at the insertion of the left upper leaflet is around 20,11°, taking into account the precision and the position the value 20,1° will be recorded



The measurement of the rotation angle of the left lower leaflet is around 15,17°, taking into account the precision and of the position the value 164,8° will be recorded (180-15,2)



The measurement of the rotation angle at the insertion of the left upper leaflet is around 15,17°, taking into account the precision and of the position the value 15,2° will be recorded



The measurement of the rotation angle of the left lower leaflet is worth 15,04°, taking into account the precision and of the position the value 165,0° will be recorded (180-15)

5 CHARACTERISTIC ANGLES OF FRONDS

Measurements on photographs of the inflection angle at the end of the frond, deviation angle at the end of the frond and torsion of the average plane of the leaflets at the end of the frond

5.1 Flexion angle



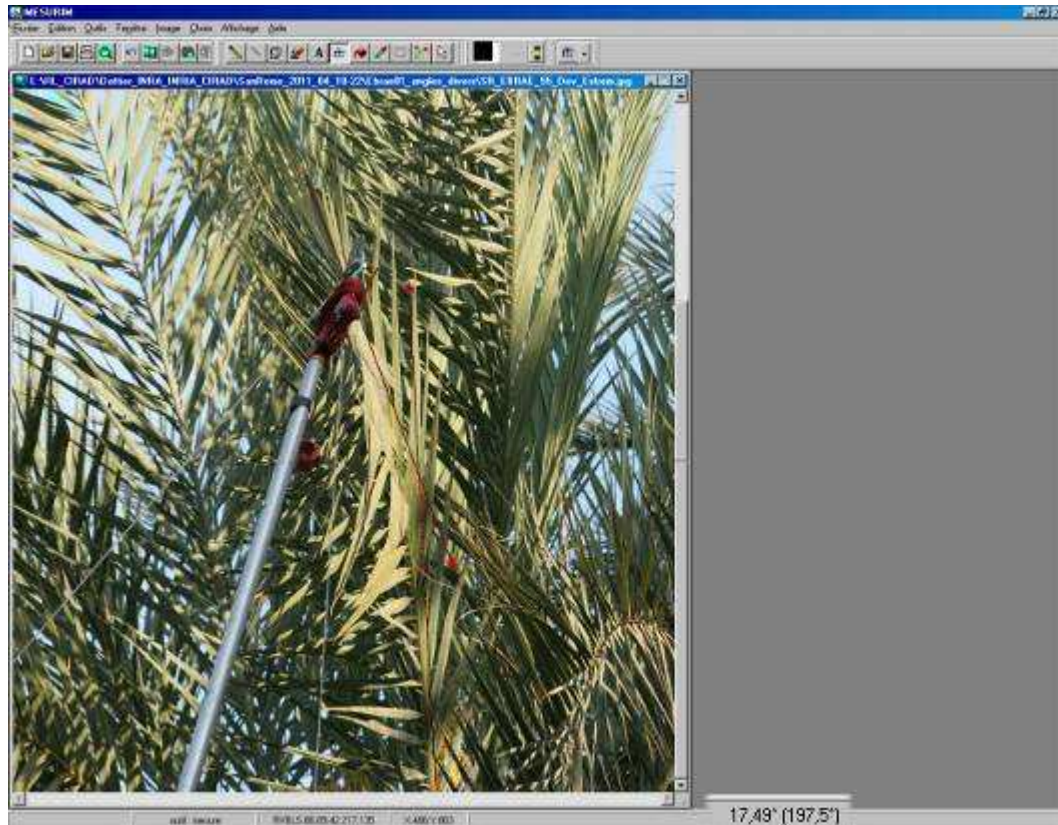
The measurement given by the software is around $46,77^\circ$, taking into account the precision the value $133,2^\circ$ will be recorded ($180-46,8$)



The measurement given by the software is around $82,65^\circ$, taking into account the precision the value $97,2^\circ$ will be recorded ($180-82,7$)

	Fronde row	
Rachis angle / verticality at the frond end		

5.2 Deviation angle



The measurement given by the software is around 17,49°, taking into account the precision the value 17,5° will be recorded

Fronde row		
Deviation direction (back to stipa)		
Distance to stipa of rachis sensitive deviation beginning		
Final deviation angle at the frond end		
Distance to stipa of rachis sensitive rotation		
Orthogonal angle of leaflet plan at the frond end		

5.3 Rotation angle of the average plane of the leaflets at the end of the frond



The measurement given by the software is around $28,6^\circ$, taking into account the precision the value $118,6^\circ$ will be recorded ($28,6+90$)