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INTERNATIONAL UNION FOR THE PROTECTION OF NEW VARIETIES OF PLANTS

Geneva

TECHNICAL WORKING PARTY FOR VEGETABLES

Forty-Eighth Session
Paestum, Italy, from June 23 to 27, 2014

ADDENDUM TO DOCUMENT TWV/48/20

REVISION OF DOCUMENT TGP/8: PART II: SELECTED TECHNIQUES USED IN DUS EXAMINATION, NEW SECTION12: EXAMINING CHARACTERISTICS USING IMAGE ANALYSIS

Document prepared by the Czech Republic, France, the Netherlands and the United Kingdom

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The annexes to this document contain copies of presentations made by experts from the Czech Republic, France, the Netherlands and the United Kingdom, at the forty-eighth session of the Technical Working Party for Vegetables (TWV), in relation to their use of image analysis in DUS examination, as follows:

ANNEX I: Image analysis in UKZUZ, Czech Republic

ANNEX II: Phenotyping by image analysis, France

ANNEX III: Image analysis of onion varieties, the Netherlands

ANNEX IV: Vegetable DUS image analysis in the United Kingdom, United Kingdom

[Annexes follow]

Image analysis in UKZUZ

UPOV

TWV, Forty-Eighth Session, Paestum, Italy

June, 2014

Radmila Šafaříková

Topics

- ✓ Main goals
- ✓ Hardware, software
- ✓ Practical experience
- ✓ Summary

Main goals

- **To replace visual observation or manual measurement by image analysis for appropriate crops and characteristics**
  - To save labour work
  - To eliminate human factor errors
  - To reach greater precision
- **To store and archive images of plant material**
- **To asses precisely characteristics which are difficult to observe visually or to measure**

3

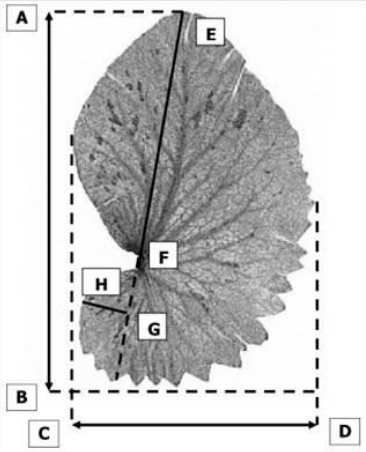
UPOV rule

Characteristics which may be examined by IA should be able to examined by visual observation or manual measurement, as appropriate

4

Difficult-to-measure characteristics

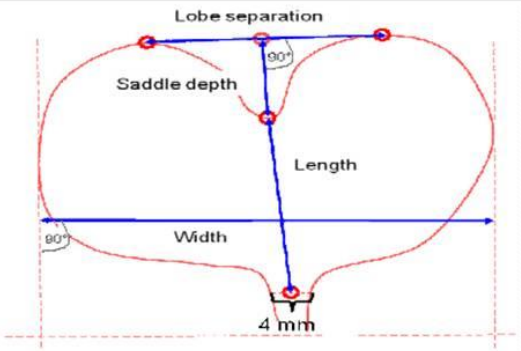
Stipule: length (15) A - B
Stipule: width (16) C - D
Stipule: length from axil to tip (18) E - F
Stipule: length of lobe below axil (19) G - H
(perpendicular to the line E – G)



5

Difficult-to-measure characteristics

Cotyledon characteristics:
- ratio length/width
- saddle depth
- ratio lobe separation/width
- ratio lobe separation/ saddle depth



6

Specifics in UKZUZ

- Image analysis is used in a fully automated way – the expert just scans of plant material and a computer calculates relevant characteristics without human interference
- Images of plant parts are recorded with scanner at three UKZUZ locations
- Scanned images are sent to the centre
- Image analysis is provided by biometrician

7

Software

MATLAB – computational system

- http://www.mathworks.com/
- Core + analysis toolbox
- Prepared functions completed by our expert for particular characteristics

8

Hardware

SCEYE

- Http://www.sceye.biz/
- Relatively cheap solution
- Quality of the device: shape analysis fully possible, colour analysis impossible

9

Problems in development

Main condition – to ensure harmonization and calibration

Light condition

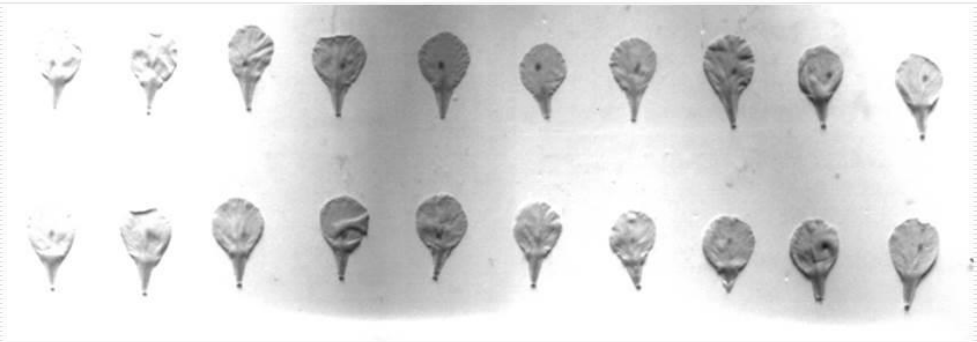
- Shade of coin
- Reflections
- Image burn

Identification of objects

- Plant material
- Coin
- Label

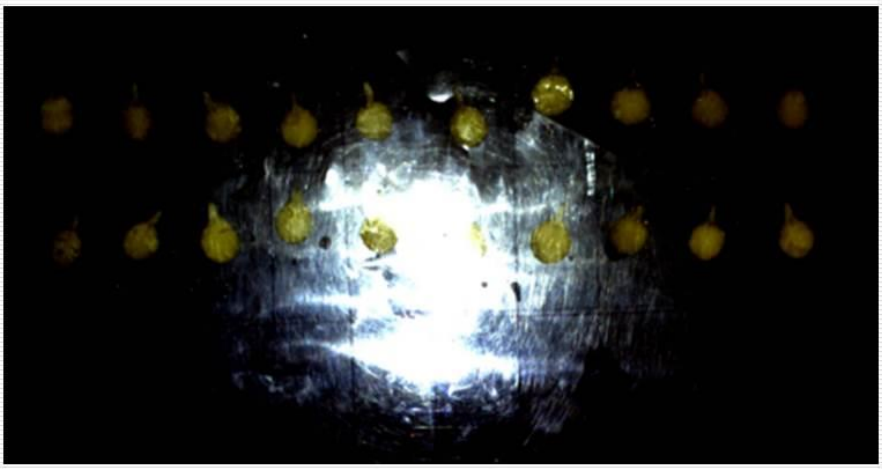
10

Problems in development



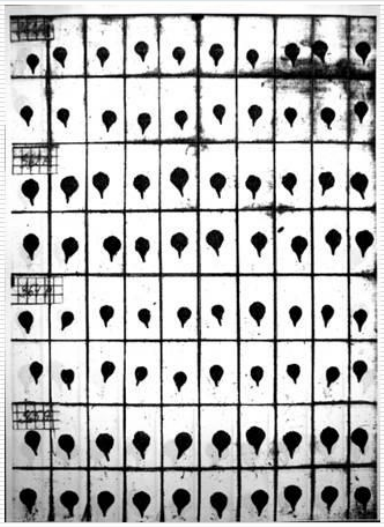
11

Problems in development



12

Problems in development



13

Problems in development

14

Solution

- ✓ Acquisition of the illuminative system Atlas
- ✓ Improvement of the blackout of the working room
- ✓ Better organization of the scanned area

Consistency between results from manual measurements or visual observations and IA result should be checked!

15

Preparation of the sample

16

Blackout

17

Better organisation

18

Application of IA

- Current
  - Pea
    - Leaflets, stipules and standard characteristics
  - Oil seed rape
    - Cotyledons and flower characteristics
- Preparation
  - Pea
    - Pods characteristics
  - Bean
    - Leaf and pods characteristics

19

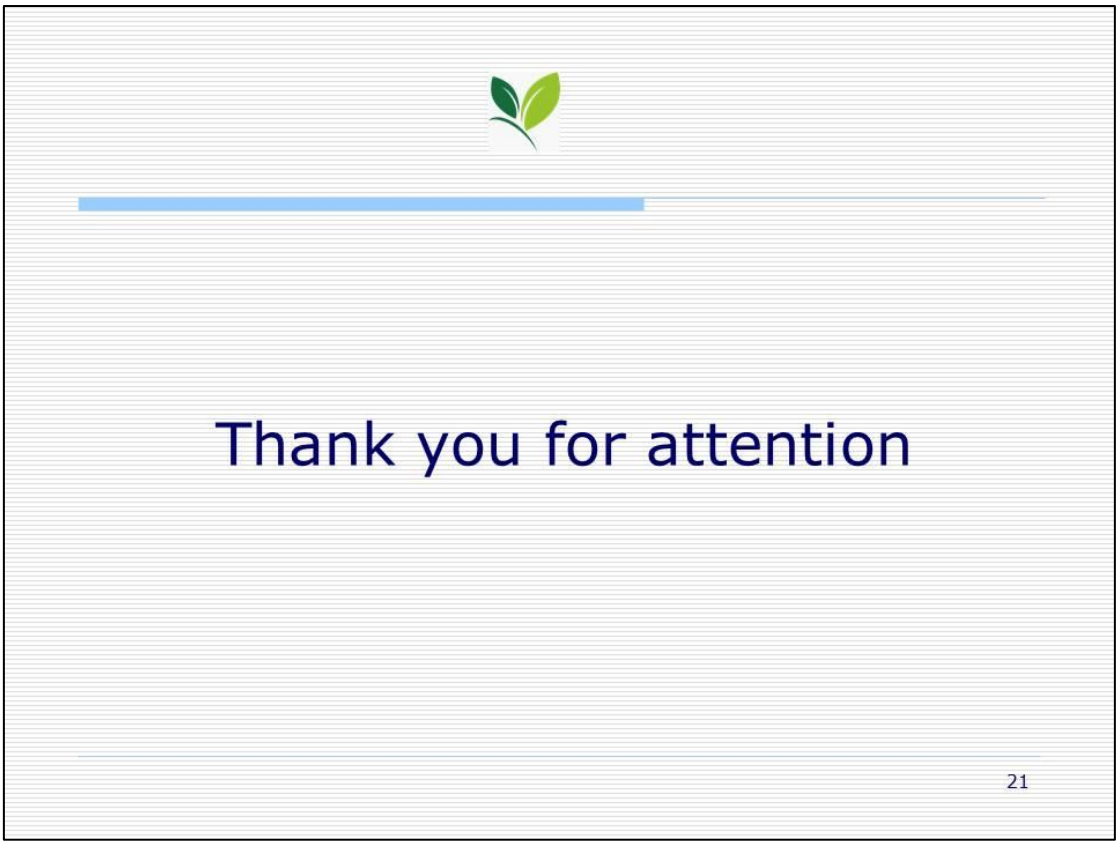
Conclusion

IA YES or NO?

- Number of variety in RC
- Number of individual measurements
- Size of observed organs
- Type of characteristics (difficult to measurement or observe)

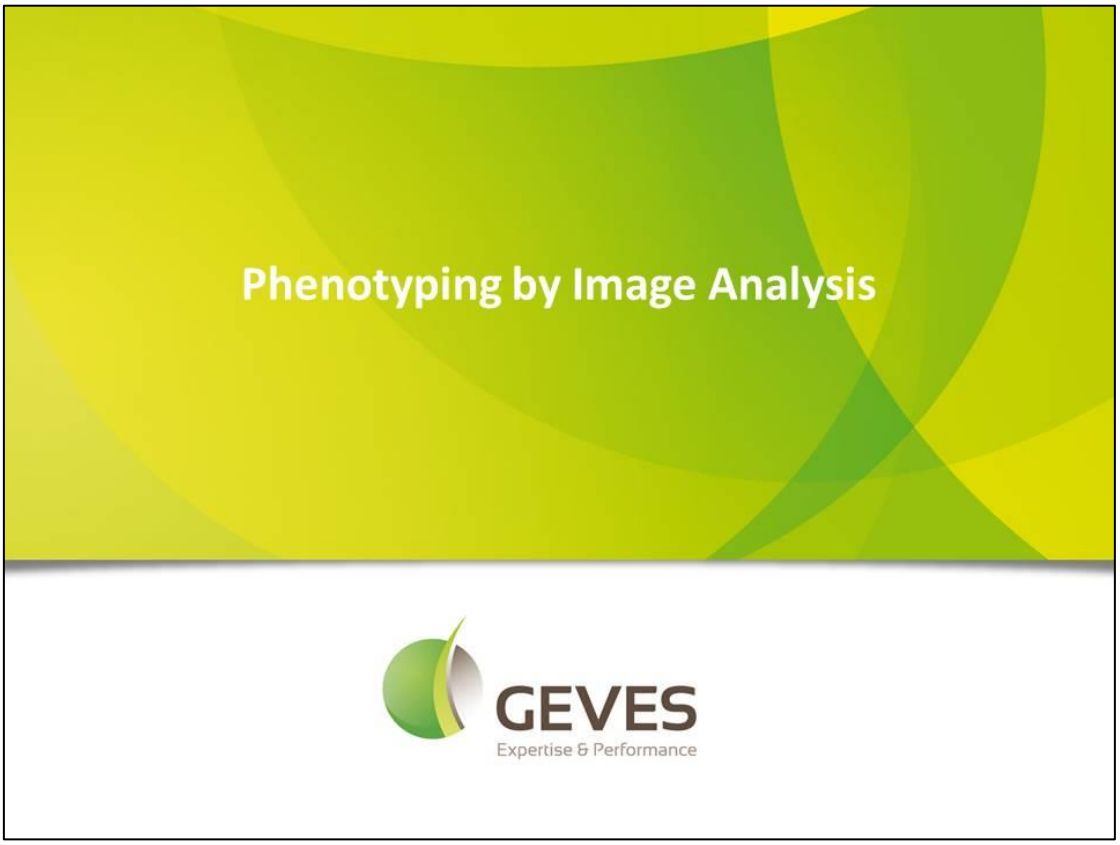
- Investment
  - hardware, software, experts, precise definition of char., time consuming preparation of samples, calibration with already existing results…)

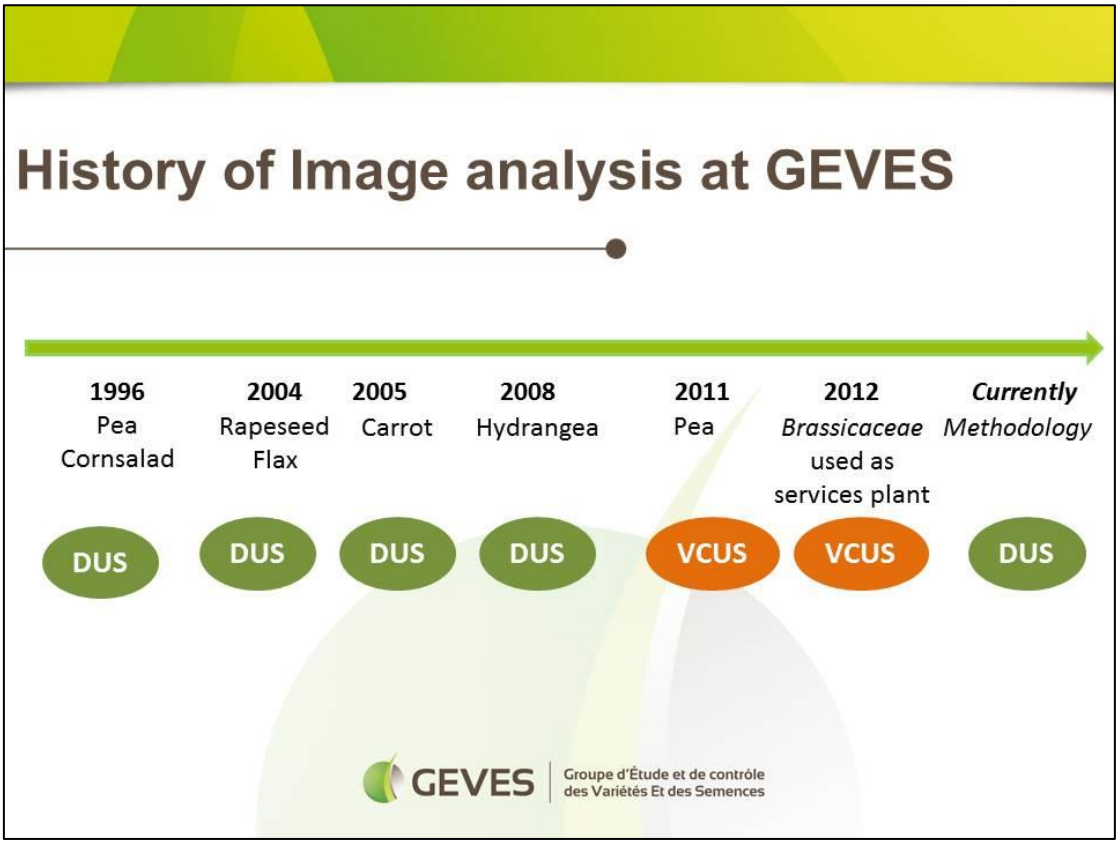
20



[Annex II follows]

ANNEX II


Phenotyping by Image Analysis
GEVES
Expertise & Performance


History of Image analysis at GEVES
1996
Pea
Cornsalad
DUS
2004
Rapeseed
Flax
DUS
2005
Carrot
DUS
2008
Hydrangea
DUS
2011
Pea
VCUS
2012
Brassicaceae
used as
services plant
VCUS
Currently
Methodology
DUS
GEVES
Groupe d'Étude et de contrôle
des Variétés Et des Semences

1996 Pea Cornsalad | 2004 Rapeseed Flax | 2005 Carrot | 2008 Hydrangea | 2011 Pea | 2012 Brassicaceae used as services plant | *Currently Methodology*

Measure of length, width, surface, perimeter on stipules

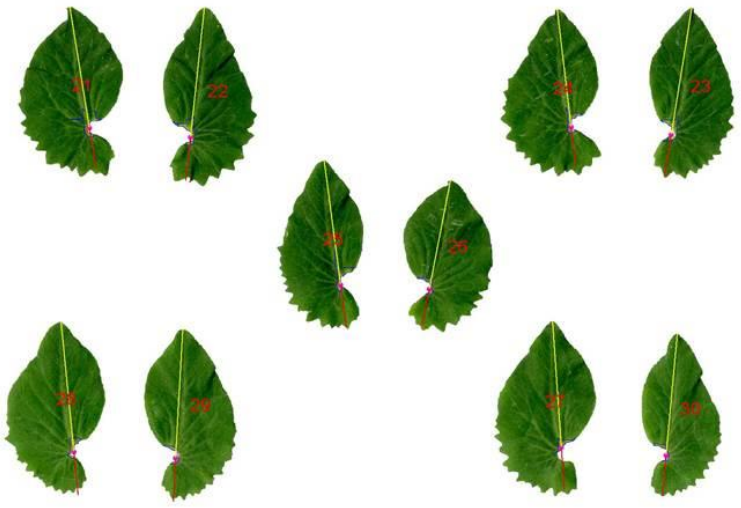
- Scanner : shape A3, A4 - 9600 dpi
- ImageJ
  - ➔ Free software (http://rsb.info.nih.gov/ij/)

GEVES | Groupe d'Étude et de contrôle des Variétés Et des Semences

1996 Pea Cornsalad

Measure of len

- Scanner
- ImageJ
  - ➔ Free



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1996
Pea
Cornsalad

Measure of le

- Scanner
- ImageJ
  - ➔ Free
-

	Label	Surface	Périmètre	Longueur	Largeur	Long_Aisselle	Long_Lobe
1	1011.08a	1097.57	151.65	54.7	28.12	40.29	1.84
2	1011.08a	1138.97	149.62	53.43	30.74	38.57	0
3	1011.08a	1190.16	162.33	59.59	26.25	44.48	1
4	1011.08a	1021.92	142.66	51.3	30.13	38.68	0
5	1011.08a	1042.34	149.72	54.81	26.7	40	1.5
6	1011.08a	1103.04	152.16	53.86	29.04	38.79	2.34
7	1011.08a	1247.84	163.44	58.34	31.74	45.15	1
8	1011.08a	1124.46	153.05	56.43	28.73	43.12	1.34
9	1011.08a	871.23	135.64	50.46	24.33	38.23	1.67
10	1011.08a	897.92	134.72	47.71	26.39	33.8	2.34
11	1011.08b	1003.81	150.97	53.19	25.86	38.84	1.5
12	1011.08b	1056.51	151.61	55.75	26.18	40.76	1.34
13	1011.08b	957.51	142.85	53.41	25.32	39.02	1.67
14	1011.08b	1033.22	148.3	51.6	27.87	36.6	3.17
15	1011.08b	1147.28	158.97	58.7	26.93	42.5	2.67
16	1011.08b	1015.75	141.52	50.12	27.97	35.02	2
17	1011.08b	1005.57	147.65	54.52	26.87	38.66	2.17
18	1011.08b	1048.34	145.06	53.2	29.13	40.14	0
19	1011.08b	1020.33	149.1	53.52	26.97	39.37	3.84
20	1011.08b	935.22	141.78	52.61	25.33	39.09	1.84
21	1012.01a	1297.19	180.52	59.19	30.74	42.13	6.51
22	1012.01a	1195.96	177.03	61.47	27.48	44.74	5.68
23	1012.01a	1097.74	165.84	58.98	25.81	44.06	4.51
24	1012.01a	1199.25	177.82	57.43	26.54	40.69	8.52
25	1012.01a	1079.69	168.71	58.51	25.61	43.13	4.84
26	1012.01a	1031.37	153.98	52.29	27.82	37.9	5.01
27	1012.01a	1251.86	176.86	59.99	29.88	43.3	4.34
28	1012.01a	1227.42	165.87	59.14	30.41	44.79	3.17
29	1012.01a	1139.58	162.79	58.63	27.48	44.34	4.01
30	1012.01a	940.58	154.68	56.02	24.35	41.93	4.01
31	1012.01b	1087.47	167.44	54.3	26.27	40.63	4.18

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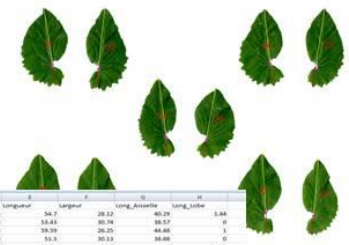
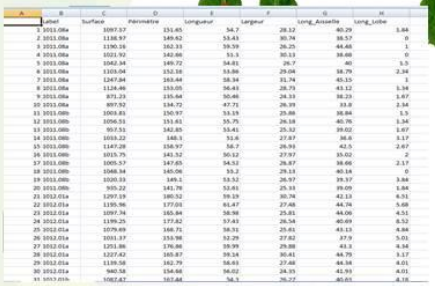


30 000 to 40 000 data per year
200 to 300 images stored per year



GEVES

1996 Pea Cornsalad | 2004 Rapeseed Flax | **2005 Carrot** | 2008 Hydrangea | 2011 Pea | 2012 Brassicaceae used as services plant | *Currently Methodology*

Measure surface, perimeter and ratio to assess the division of the leaf

- Scanner : shape A3, A4 - 9600 dpi
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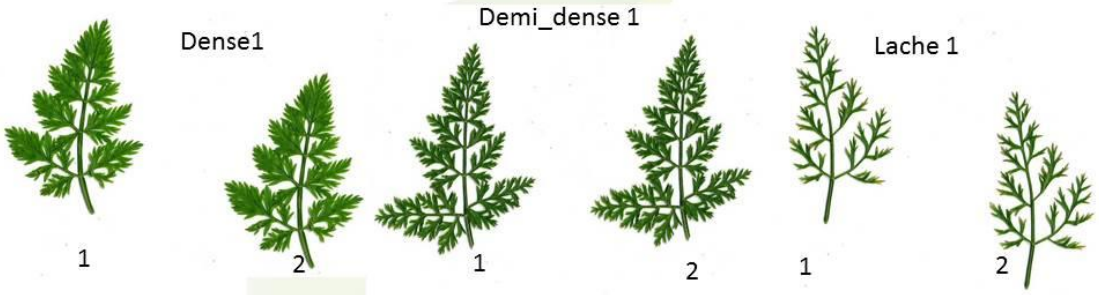

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	A	B	C	D	E
1	Count	Label	Area	Perim.	Aera/Perim
2	1	dense1.jpg	3134.77002	890.77002	3.52
3	2	dense1.jpg	3141.55005	887.97998	3.54
4	1	demi_dense1.jpg	3346.40991	1345.52002	2.49
5	2	demi_dense1.jpg	3346.48999	1335.31995	2.51
6	1	lache1.jpg	1390.14001	1114.69995	1.25
7	2	lache1.jpg	1394.34998	1122.90002	1.24
8					
9					

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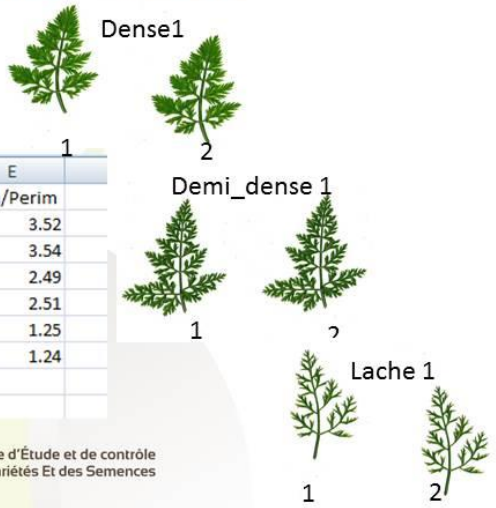

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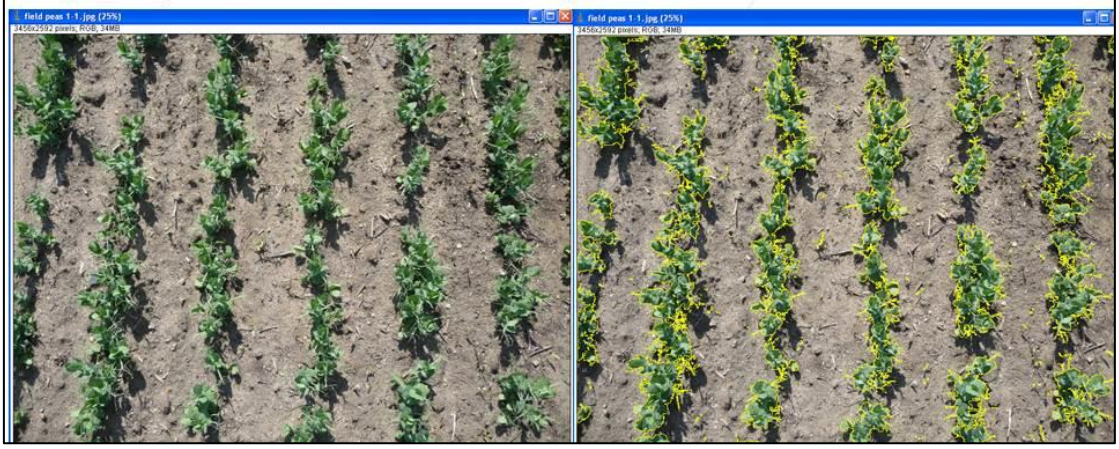
1996 Pea Cornsalad | 2004 Rapeseed Flax | 2005 Carrot | 2008 Hydrangea | **2011 Pea** | 2012 Brassicaceae used as services plant | *Currently Methodology*

Calculation of covering power

- Digital camera (high resolution not necessary)
- ImageJ



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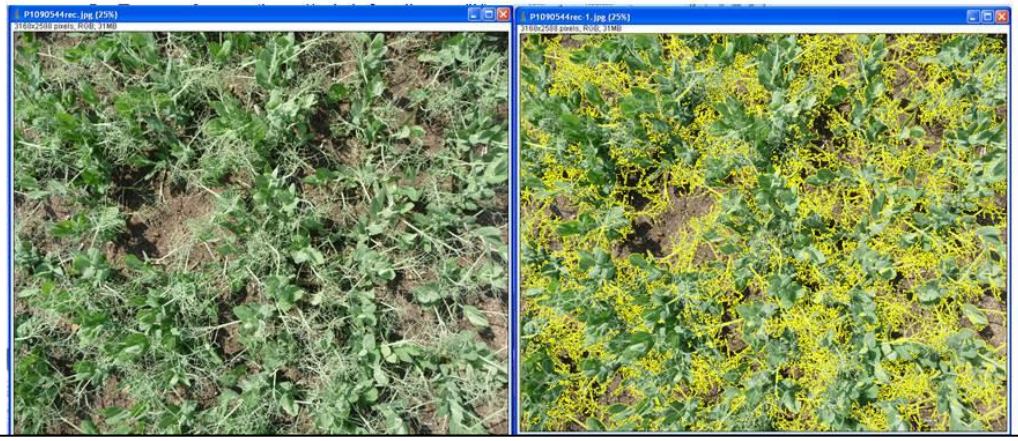

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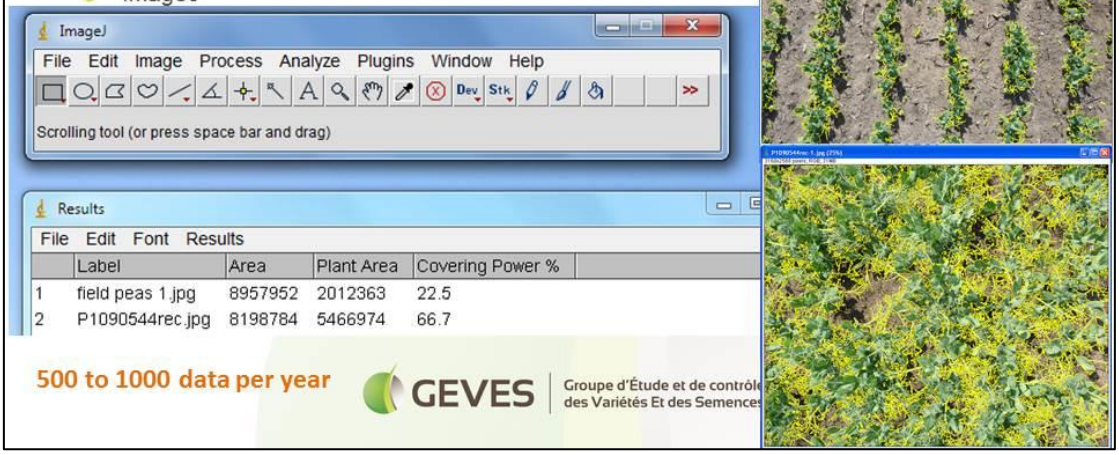

500 to 1000 data per year

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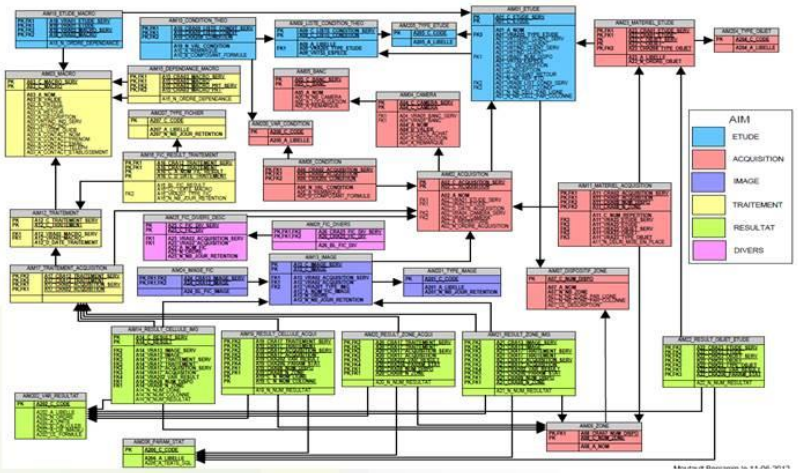
1996 Pea Cornsalad | 2004 Rapeseed Flax | 2005 Carrot | 2008 Hydrangea | 2011 Pea | 2012 Brassicaceae used as services plant | ***Currently Methodology***

Assessment of the colours

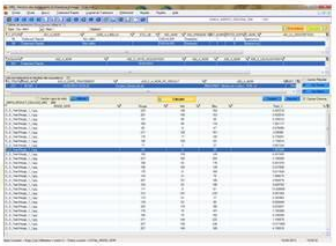
- Digital camera (high resolution not necessary)
- AIM application

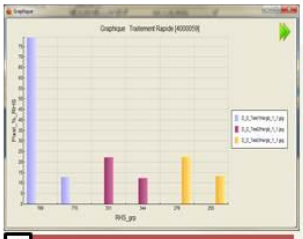


1996 Pea Cornsalad | 2004 Rapeseed Flax | 2005 Carrot | 2008 Hydrangea | 2011 Pea | 2012 Brassicaceae used as services plant | ***Currently Methodology***

Assessment of the colours

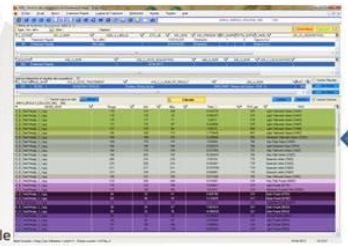
1 Run Macro ImageJ to get RGB Combination for each variety





4 raphic representation of the two main color for each variety

3 Get main colors of each variety



2 Link with color classification

[Annex III follows]

nak tuinbouw

Image analysis of onion varieties

Marian van Leeuwen

UPOV TWV 2014

nak tuinbouw

Method: Image analysis

An image analysis system is developed for a number of characteristics which at the moment are observed only visually, but then also can be analysed statistically:

- 13: Bulb: height
- 14: Bulb: diameter
- 15: Bulb: ratio height/diameter
- 16: Bulb: position of maximum diameter
- 17: Bulb: width of neck
- 18: Bulb: shape (in longitudinal section)
- 19: Bulb: shape of stem end
- 20: Bulb: shape of root end

nak tuinbouw

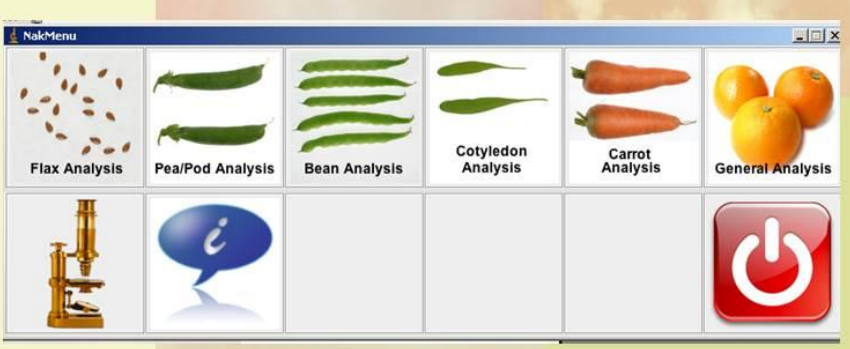
Equipment

nak tuinbouw

Software developed by Biometris, (in testing phase)

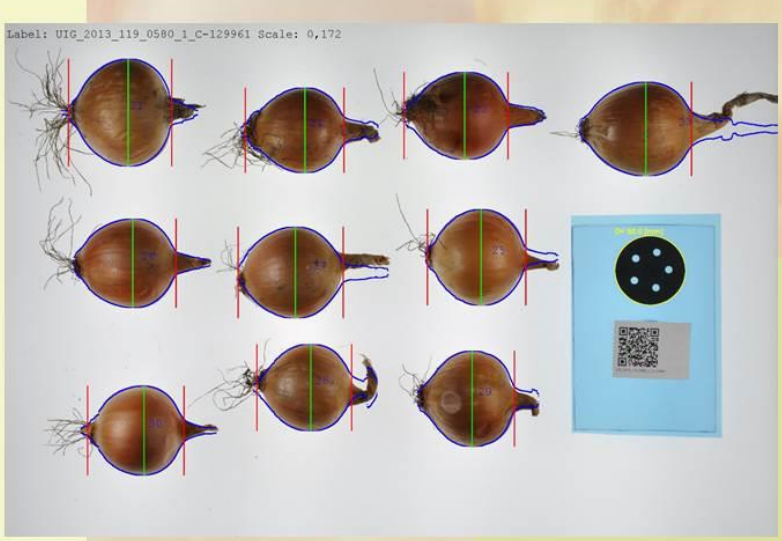
C:\Program Files\ImageJ versie 2\imagej\Imagej.exe
Click on

Imagej.exe.
The following screen will be open



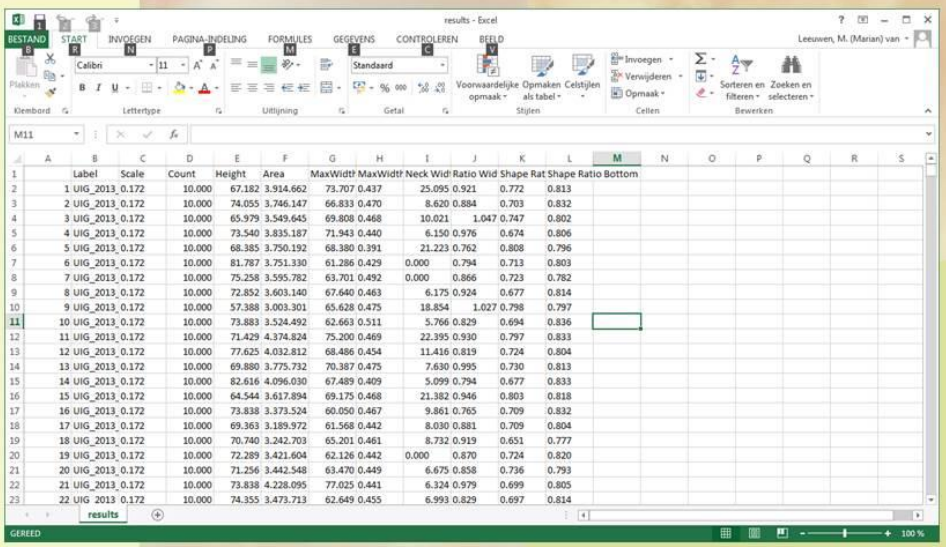
nak tuinbouw

Analysed Picture



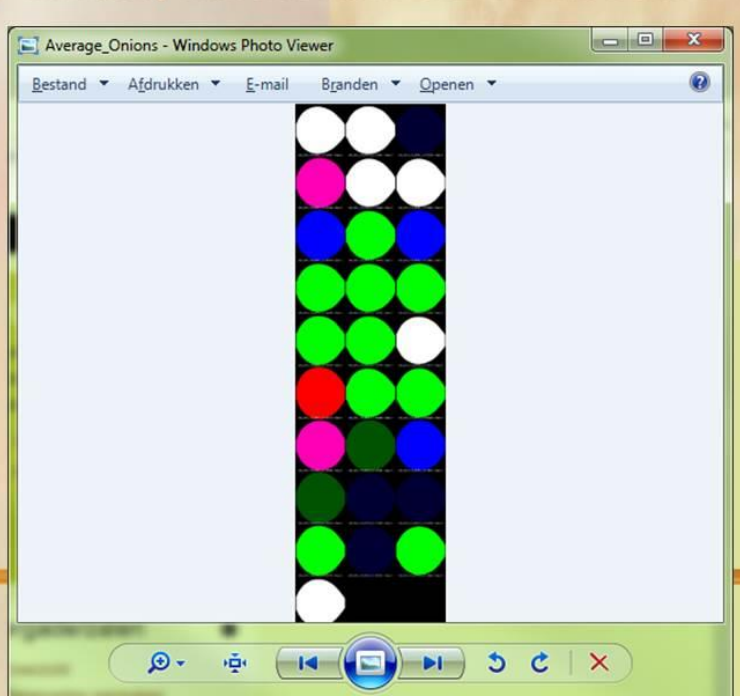
nak tuinbouw

Table with results in Excel spread sheet

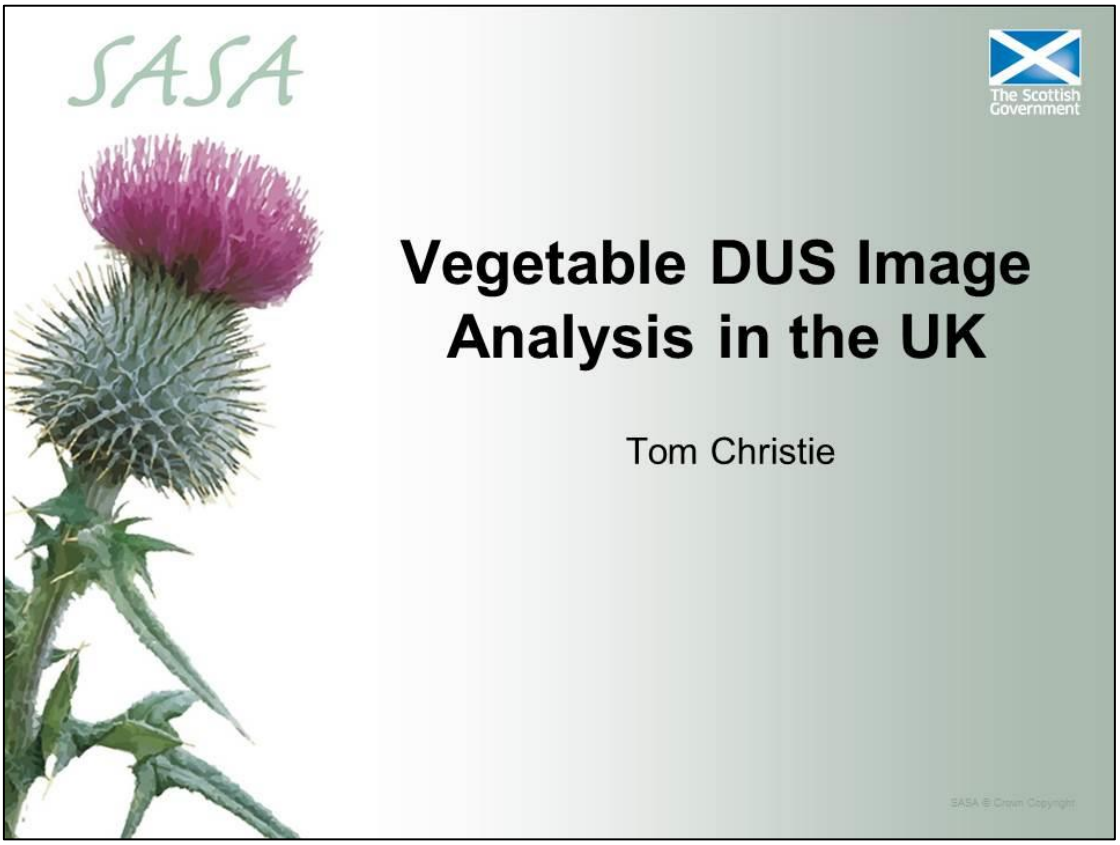


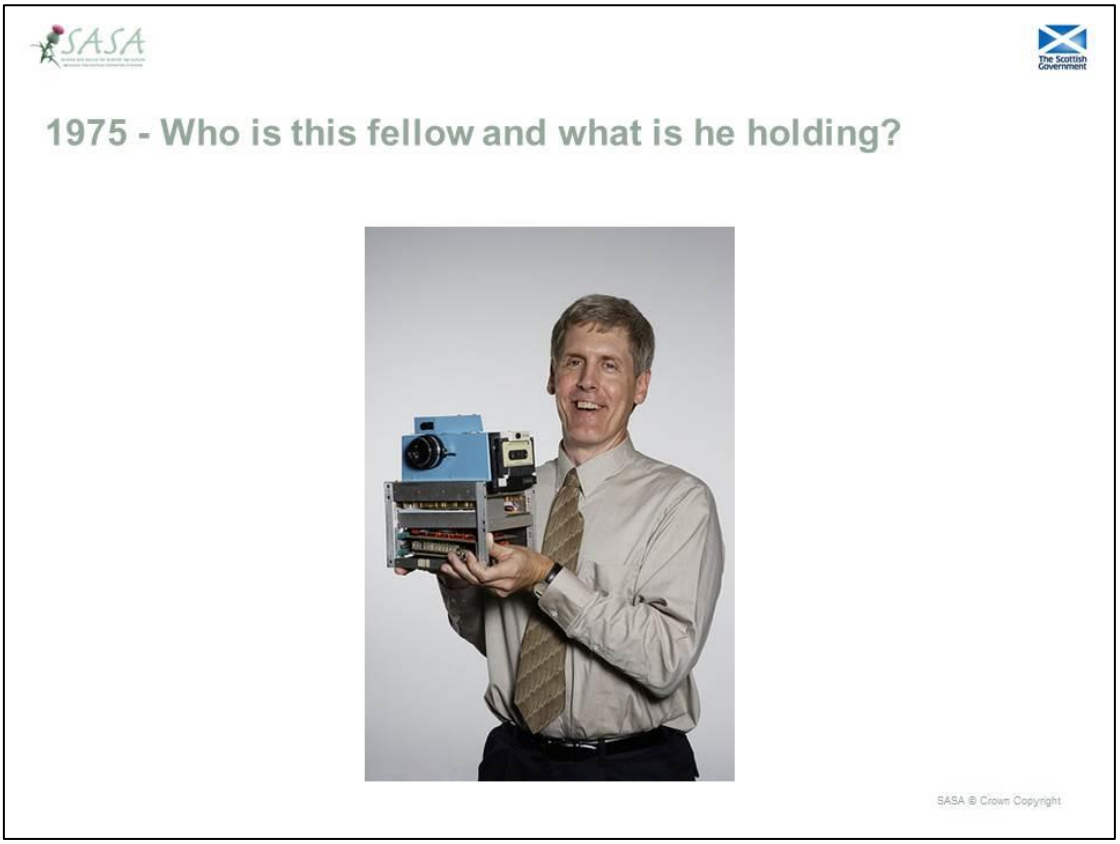
	Label	Scale	Count	Height	Area	MaxWidth	MaxWidth	Neck Wid	Ratio Wid	Shape Rat	Shape Ratio Bottom
1	1 UIG_2013_	0.172	10.000	67.182	3.914.662	73.707	0.437	25.095	0.921	0.772	0.813
2	2 UIG_2013_	0.172	10.000	74.055	3.746.147	66.833	0.470	8.620	0.884	0.703	0.832
3	3 UIG_2013_	0.172	10.000	65.979	3.549.645	69.808	0.468	10.021	1.047	0.747	0.802
4	4 UIG_2013_	0.172	10.000	73.540	3.835.187	71.943	0.440	6.150	0.976	0.674	0.806
5	5 UIG_2013_	0.172	10.000	68.385	3.750.192	68.380	0.391	21.223	0.762	0.808	0.796
6	6 UIG_2013_	0.172	10.000	81.787	3.751.330	61.286	0.429	0.000	0.794	0.713	0.803
7	7 UIG_2013_	0.172	10.000	75.258	3.595.782	63.701	0.492	0.000	0.866	0.723	0.782
8	8 UIG_2013_	0.172	10.000	72.852	3.603.140	67.640	0.463	6.175	0.924	0.677	0.814
9	9 UIG_2013_	0.172	10.000	57.388	3.003.301	65.628	0.475	18.854	1.027	0.798	0.797
10	10 UIG_2013_	0.172	10.000	73.883	3.524.492	62.663	0.511	5.766	0.829	0.694	0.836
11	11 UIG_2013_	0.172	10.000	71.429	4.374.824	75.200	0.469	22.395	0.930	0.797	0.833
12	12 UIG_2013_	0.172	10.000	77.625	4.032.812	68.486	0.454	11.416	0.819	0.724	0.804
13	13 UIG_2013_	0.172	10.000	69.880	3.775.732	70.387	0.475	7.630	0.995	0.730	0.813
14	14 UIG_2013_	0.172	10.000	82.616	4.096.030	67.489	0.409	5.099	0.794	0.677	0.833
15	15 UIG_2013_	0.172	10.000	64.544	3.617.894	69.175	0.468	21.382	0.946	0.803	0.818
16	16 UIG_2013_	0.172	10.000	73.838	3.373.524	60.050	0.467	9.861	0.765	0.709	0.832
17	17 UIG_2013_	0.172	10.000	69.363	3.189.972	61.568	0.442	8.030	0.881	0.709	0.804
18	18 UIG_2013_	0.172	10.000	70.740	3.242.703	65.201	0.461	8.732	0.919	0.651	0.777
19	19 UIG_2013_	0.172	10.000	72.289	3.421.604	62.126	0.442	0.000	0.870	0.724	0.820
20	20 UIG_2013_	0.172	10.000	71.256	3.442.548	63.470	0.449	6.675	0.858	0.736	0.793
21	21 UIG_2013_	0.172	10.000	73.838	4.228.095	77.025	0.441	6.324	0.979	0.699	0.805
22	22 UIG_2013_	0.172	10.000	74.355	3.473.713	62.649	0.455	6.993	0.829	0.697	0.814

Picture of 'average onions' on which the average shape and the class of each variety is shown. The number of classes can be decided, classes have a different color.



[Annex IV follows]


SASA
The Scottish Government
Vegetable DUS Image Analysis in the UK
Tom Christie
SASA © Crown Copyright


SASA
The Scottish Government
1975 - Who is this fellow and what is he holding?
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Then in 1991 the first commercial digital camera becomes available

for only $13,000!

SASA © Crown Copyright

And in 1998 (while we waited for the price to come down) work begins at BioSS

Automatic measurement of pea pod, leaflet and stipule characteristics

Graham W. Horgan[1], Alec D. Mann & Adrian M. I. Roberts.

Biomathematics & Statistics Scotland

December 2000

BioSS

Summary

This aim of this project was to develop methods for automated measurement of the characteristics of pea pods, leaflets and stipules.

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The advantages of image analysis were projected to be:

- *Greater accuracy*
- *Greater consistency*
  - *Leading to greater discrimination*
- *Data would be captured which is only available digitally*
- *Decreased cost per character*
- *Generation of an image archive - DIGITISATION*
- *Generation of a data archive - DATAFICATION*

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So in 1999 - SASA buys a camera

- 3.2 Megapixels!

(My phone now has 13)

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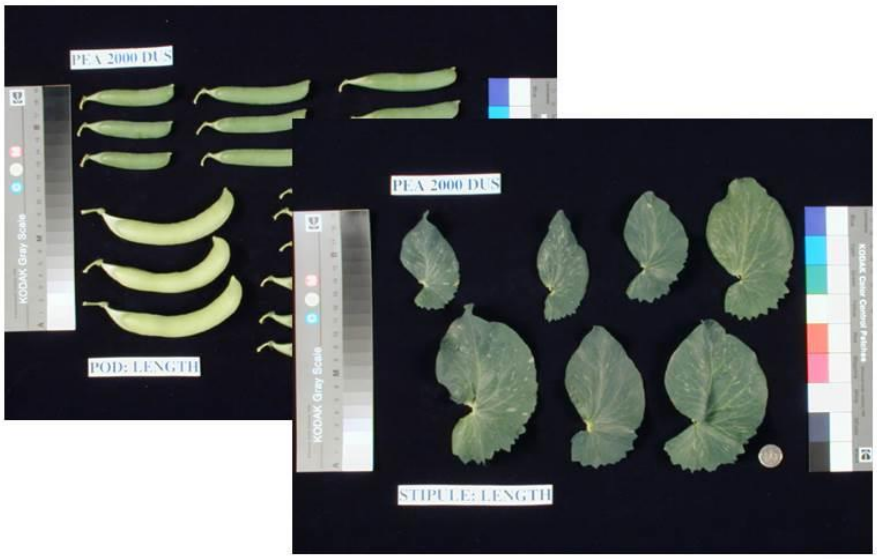
And in 2000 the first images were captured.



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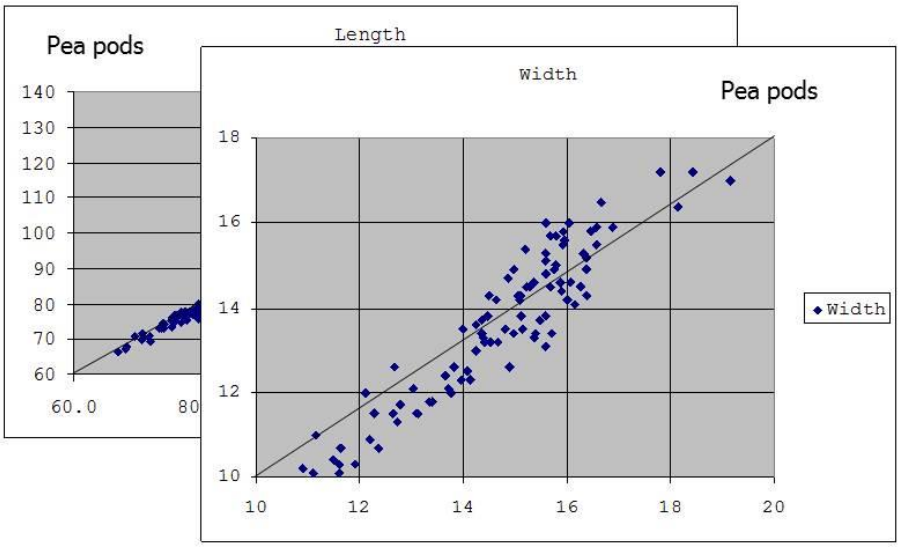
Followed by a period of testing and calibration



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… and of course, the Cost-Benefit Analysis

MANUAL RECORDING	time (mins.)	AUTOMATED RECORDING	time (mins.)
Set up Data Capture machine	35	Produce labels for photography	35
Recording time	1314	Photography including preparation and lay out time	2002
Download and check data; transfer to spreadsheet	180	Download and check data	120
Total time	1529	Total time	2157
Characters measured	12	Characters measured	55
Time per character	127	Time per character	39
Total Cost @ 2003/4 rates	£911	Total Cost @ 2003/4 rates	£1612
Cost per character	£76	Cost per character (£)	£29

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In 2005 DUS uses imaging for the first time for peas

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Pea imaging – the current setup

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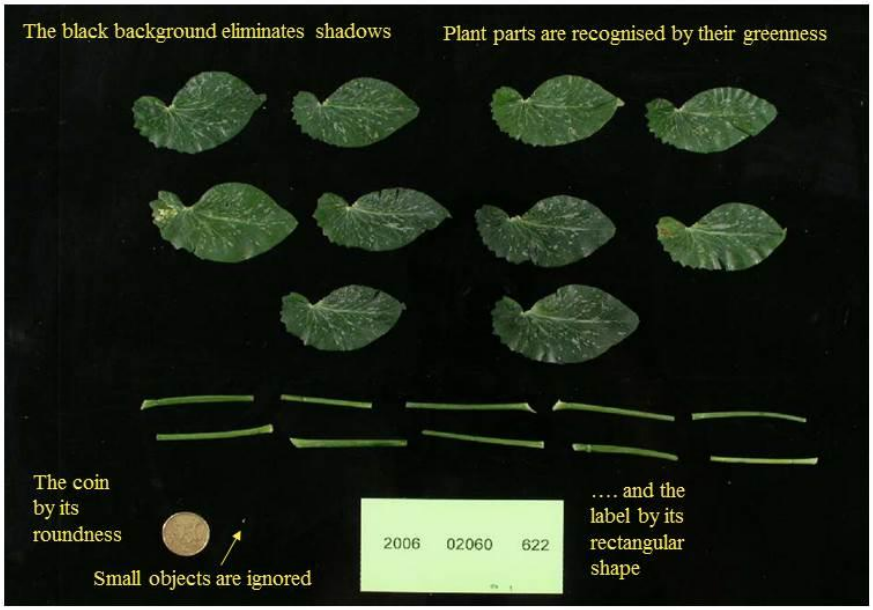
There are some basic principles:



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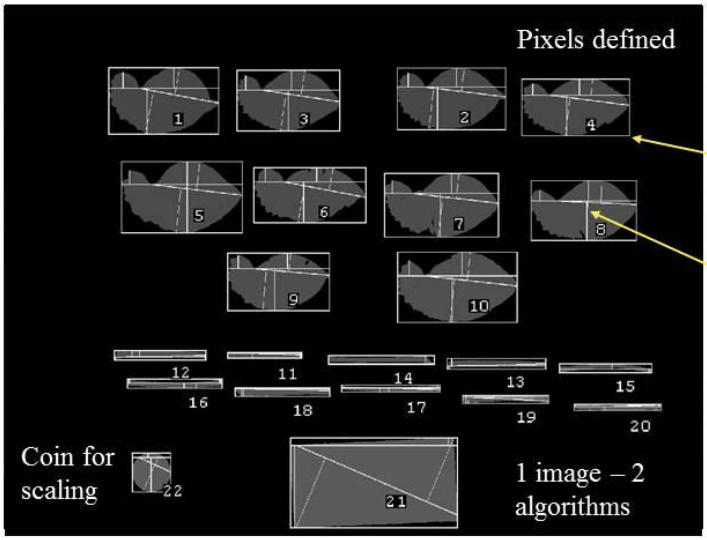
Images are analysed using *Imagin* software



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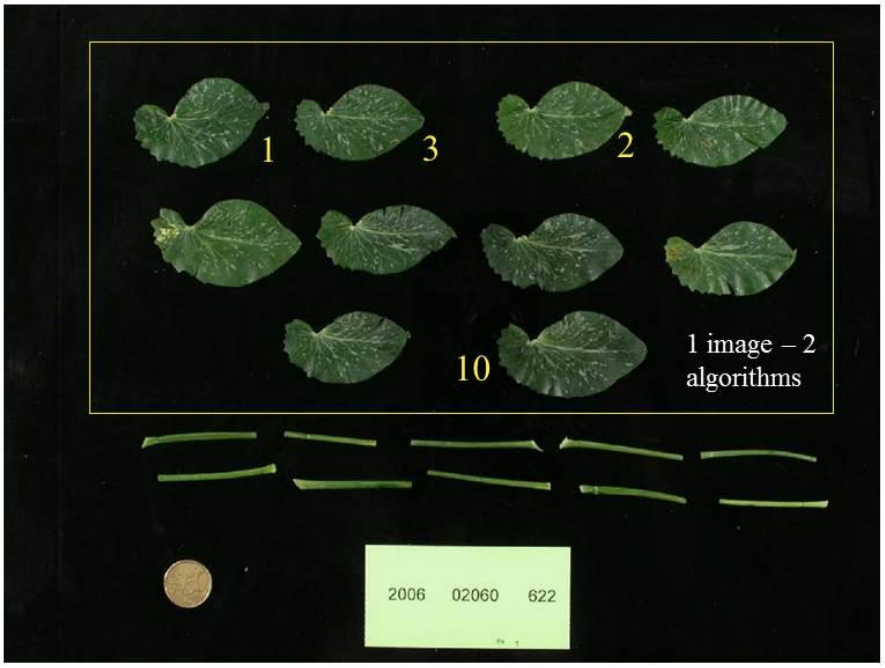

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Analysis output – pea stipules

Stipule	Length	Width	MaxWPos	GreenDv	Area	Blue	Red	Fleck	Den1	Den2	Xcen	Ycen	LJ	JB	MK	FG	IE	AB	File
1	69.4	41.3	52	31	1961	56	63	7.4	6	2.1	359	217	19.8	50	9.9	13	28.4	22	PICT0398.JPG
2	68.6	38.3	53	36	1830	55	69	7.2	21	2.6	1018	213	17.4	51	8.8	11.8	26.5	17.9	PICT0398.JPG
3	65	37.8	54	31	1708	55	64	6.2	14	2.4	649	217	16.3	49	8.8	12.4	25.4	19.6	PICT0398.JPG
4	68.1	35.3	54	34	1687	61	73	6.9	19	2.2	1306	230	17.1	51	6.9	9.9	25.4	16.3	PICT0398.JPG
5	76.3	44.4	55	36	2266	56	72	6.5	10	1.9	406	435	18.7	58	8.5	14.3	30	20.9	PICT0398.JPG
6	70.8	34.2	55	27	1703	56	64	7.1	18	2	693	427	19	52	8.5	8.8	25.4	18.5	PICT0398.JPG
7	71.9	39.4	59	23	1957	52	58	5.7	22	2.7	1003	453	17.6	54	7.7	12.4	27	18.5	PICT0398.JPG
8	66.7	37.2	57	33	1733	64	78	7.2	12	2.2	1329	466	16	51	6.6	12.7	24.5	14.9	PICT0398.JPG
9	64.2	35.8	55	26	1622	55	62	6.1	19	2	624	625	16.8	47	8.3	9.6	26.2	13.8	PICT0398.JPG
10	75.5	43.5	56	23	2277	52	59	6.2	16	2.3	1037	639	16.8	59	9.4	14.6	28.9	20.9	PICT0398.JPG
11	46.8	3.6	98	50	141	44	84	13.7	9	1.9	597	792	15.7	31	0.3	0.6	3	1.7	PICT0398.JPG
12	57.9	5.8	4	48	209	39	71	14.3	8	1.8	353	789	0.3	58	0	4.1	1.7	3	PICT0398.JPG
13	62.6	6.6	5	47	202	51	89	13.4	12	1.7	1121	810	0.3	62	0	4.7	1.9	3.3	PICT0398.JPG
14	67	5.5	91	45	197	46	76	13.1	10	1.7	863	802	67	0	5.2	0	0.3	0	PICT0398.JPG
15	58.4	5.5	4	50	163	52	87	12.9	8	1.8	1372	820	56.2	2	3.3	0.3	2.2	1.4	PICT0398.JPG
16	59.8	5.8	98	53	208	45	86	15.6	5	1.8	392	857	22.3	37	2.2	2.5	3.3	2.5	PICT0398.JPG
17	62.6	4.1	98	51	179	40	81	14.1	5	1.7	893	868	24.5	38	0.8	1.7	2.5	2.8	PICT0398.JPG
18	59.8	5.2	8	46	235	46	78	13.2	7	1.7	632	875	5.5	54	0.6	0	4.7	1.1	PICT0398.JPG
19	54.3	5	11	49	195	40	76	13.1	0	1.7	1145	890	3.6	51	0.3	1.1	3.9	3.3	PICT0398.JPG
20	55.1	3.9	96	52	157	70	122	13.3	6	1.9	1408	910	20.9	34	1.1	1.4	2.5	0.3	PICT0398.JPG
21	105.5	55.9	58	45	5371	181	210	5.2	11	1.7	847	1080	3.9	102	0.3	4.7	51.3	47.9	PICT0398.JPG
22	24.3	24.3	49	12	473	93	162	5	0	1.2	336	1056	4.1	20	0	2.8	21.5	11.8	PICT0398.JPG
Coin	24.3	24.3	49	12	473	93	162	5	0	1.2	336	1056	4.1	20	0	2.8	21.5	11.8	PICT0398.JPG

CPVO 15 Stipule: length

CPVO 16 Stipule: width

CPVO 17 Stipule: size

CPVO 18 Stipule: axil to tip

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Analysis output – pea petioles

Petiole	Length	Width	Curv2	GreenDV	Area	File
11	47	3.3	0	50	141	2006PICT0398.JPG
12	59	4.4	-2.2	48	209	2006PICT0398.JPG
13	63	4.4	-1.4	47	202	2006PICT0398.JPG
14	68	4.4	-1.1	45	197	2006PICT0398.JPG
15	59	3.3	-2.2	50	163	2006PICT0398.JPG
16	60	4.4	1.4	53	208	2006PICT0398.JPG
17	63	3.9	0	51	179	2006PICT0398.JPG
18	60	5	1.7	46	235	2006PICT0398.JPG
19	55	4.4	-0.8	49	195	2006PICT0398.JPG
20	55	3.9	1.4	52	157	2006PICT0398.JPG

CPVO 21
Petiole: length from axil to first leaflet or tendril

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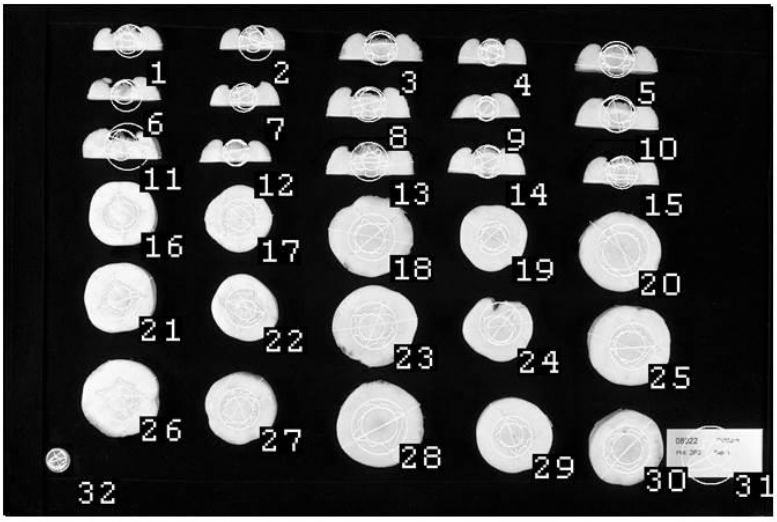
At SASA we also use image analysis for DUS Parsnips



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Parsnip characters recorded automatically

DUS characteristics (CPVO)

14. Root: length
15. Root: width
16. Root: distance from widest point to crown,
18. Root: depth of crown depression
19. Root: width of crown depression
22. Root: core width

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Which yields the now familiar data format

Slice	Isort	Length	Width	Acore	Area	Radrat	Arearat	Feret	InRad	OutRad	Xpos	Ypos	MaxD	File
16	16	110.1	107.2	2267	9259	59	25	66	30	45	174	297	90	Parsnip_024_2010.jpg
17	17	97.7	95.5	1265	7445	57	17	55	21	38	338	301	75	Parsnip_024_2010.jpg
18	18	85.2	80.8	918	5425	51	17	44	19	31	538	306	59	Parsnip_024_2010.jpg
19	19	80.8	77.8	978	4874	54	21	44	21	30	703	312	60	Parsnip_024_2010.jpg
20	20	119	116	2376	10692	61	23	72	31	49	892	338	98	Parsnip_024_2010.jpg
21	21	108.7	113.8	1848	9722	58	19	69	26	47	176	459	95	Parsnip_024_2010.jpg
22	22	96.2	94	1854	7229	58	26	60	26	41	343	457	82	Parsnip_024_2010.jpg
23	23	79.3	82.2	1231	5124	57	25	47	23	32	531	456	64	Parsnip_024_2010.jpg
24	24	94	90.3	1084	6615	54	17	51	19	35	696	474	70	Parsnip_024_2010.jpg
25	25	109.4	106.5	2018	9053	57	23	65	28	44	896	501	88	Parsnip_024_2010.jpg
26	26	124.8	119.7	2284	10870	53	21	68	29	47	172	630	93	Parsnip_024_2010.jpg
27	27	95.5	96.9	1621	6838	59	24	54	25	37	347	624	73	Parsnip_024_2010.jpg
28	28	94.7	94.7	2330	7203	73	33	68	28	47	522	627	93	Parsnip_024_2010.jpg
29	29	85.9	86.6	1478	5836	59	26	53	25	36	700	633	72	Parsnip_024_2010.jpg
30	31	83	85.9	997	5576	57	18	43	19	31	880	652	59	Parsnip_024_2010.jpg

These values are the result of the root core character algorithm

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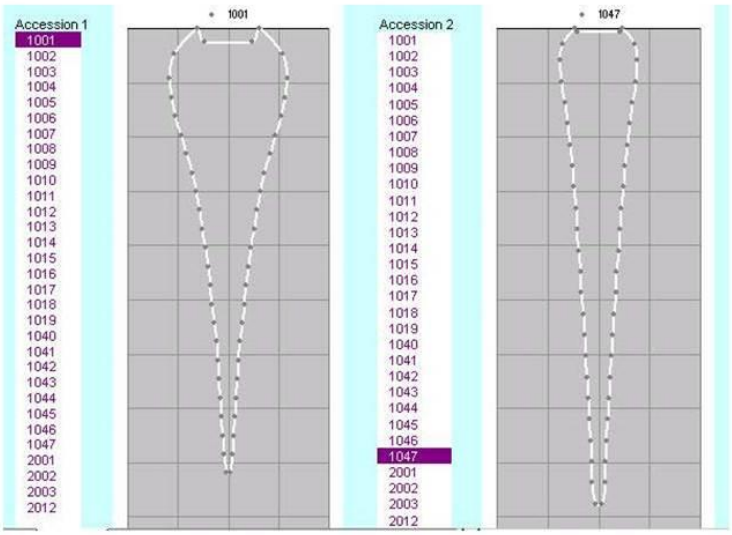
Average root shapes can also be generated from image data



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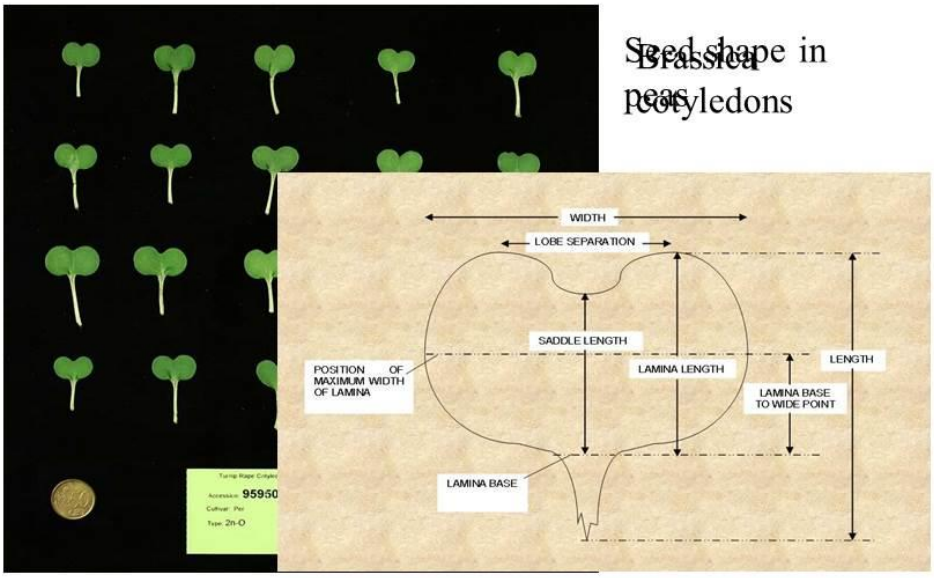
Other areas of interest / development:



Seed shape in peas

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The advantages of image analysis were projected to be:

Stipule	Length	Width	MaxWPos	GreenDv	Area	Blue	Red	Fleck	Den1	Den2	Xcen	Ycen	LJ	JB	MK	FG	IE	AB	File
1	69.4	41.3	52	31	1961	56	63	7.4	6	2.1	359	217	19.8	50	9.9	13	28.4	22	PICT0398.JPG
2	68.6	38.3	53	36	1830	55	69	7.2	21	2.6	1018	213	17.4	51	8.8	11.8	26.5	17.9	PICT0398.JPG
3	65	37.8	54	31	1708	55	64	6.2	14	2.4	649	217	16.3	49	8.8	12.4	25.4	19.6	PICT0398.JPG
4	68.1	35.3	54	34	1687	61	73	6.9	19	2.2	1306	230	17.1	51	6.9	9.9	25.4	16.3	PICT0398.JPG
5	76.3	44.4	55	36	2266	56	72	6.5	10	1.9	406	435	18.7	58	8.5	14.3	30	20.9	PICT0398.JPG
6	70.8	34.2	55	27	1703	56	64	7.1	18	2	693	427	19	52	8.5	8.8	25.4	18.5	PICT0398.JPG
7	71.9	39.4	59	23	1957	52	58	5.7	22	2.7	1003	453	17.6	54	7.7	12.4	27	18.5	PICT0398.JPG
8	66.7	37.2	57	33	1733	64	78	7.2	12	2.2	1329	466	16	51	6.6	12.7	24.5	14.9	PICT0398.JPG
9	64.2	35.8	55	26	1622	55	62	6.1	19	2	624	625	16.8	47	8.3	9.6	26.2	13.8	PICT0398.JPG
10	75.5	43.5	56	23	2277	52	59	6.2	16	2.3	1037	639	16.8	59	9.4	14.6	28.9	20.9	PICT0398.JPG
11	46.8	3.6	98	50	141	44	84	13.7	9	1.9	597	792	15.7	31	0.3	0.6	3	1.7	PICT0398.JPG
12	57.9	5.8	4	48	209	39	71	14.3	8	1.8	353	789	0.3	58	0	4.1	1.7	3	PICT0398.JPG
13	62.6	6.6	5	47	202	51	89	13.4	12	1.7	1121	810	0.3	62	0	4.7	1.9	3.3	PICT0398.JPG
14	67	5.5	91	45	197	46	76	13.1	10	1.7	863	802	67	0	5.2	0	0.3	0	PICT0398.JPG
15	58.4	5.5	4	50	163	52	87	12.9	8	1.8	1372	820	56.2	2	3.3	0.3	2.2	1.4	PICT0398.JPG
16	59.8	5.8	98	53	208	45	86	15.6	5	1.8	392	857	22.3	37	2.2	2.5	3.3	2.5	PICT0398.JPG
17	62.6	4.1	98	51	179	40	81	14.1	5	1.7	893	868	24.5	38	0.8	1.7	2.5	2.8	PICT0398.JPG
18	59.8	5.2	8	46	235	46	78	13.2	7	1.7	632	875	5.5	54	0.6	0	4.7	1.1	PICT0398.JPG
19	54.3	5	11	49	195	40	76	13.1	0	1.7	1145	890	3.6	51	0.3	1.1	3.9	3.3	PICT0398.JPG
20	55.1	3.9	96	52	157	70	122	13.3	6	1.9	1408	910	20.9	34	1.1	1.4	2.5	0.3	PICT0398.JPG
21	105.5	55.9	58	45	5371	181	210	5.2	11	1.7	847	1080	3.9	102	0.3	4.7	51.3	47.9	PICT0398.JPG
22	24.3	24.3	49	12	473	93	162	5	0	1.2	336	1056	4.1	20	0	2.8	21.5	11.8	PICT0398.JPG
Coin	24.3	24.3	49	12	473	93	162	5	0	1.2	336	1056	4.1	20	0	2.8	21.5	11.8	PICT0398.JPG

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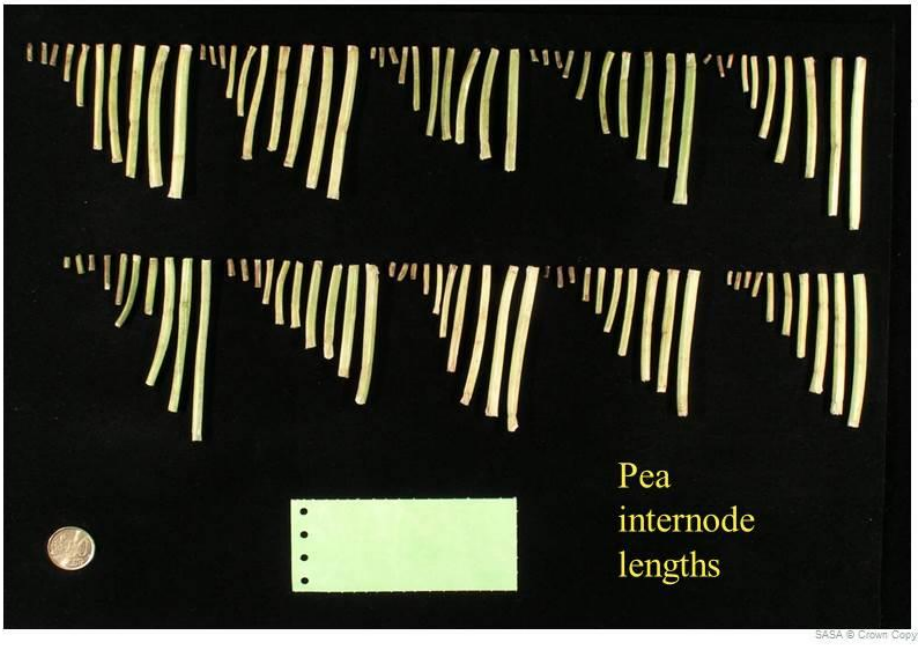
And some disadvantages we found:



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SASA

The Scottish Government

Thank you for your attention.

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SASA

The Scottish Government

And thank you Steve!

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Imagin – in-house software

Imagin may be obtained from the authors at Biomathematics & Statistics Scotland

BioSS

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[End of Annex IV and of document]