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UPOV

INTERNATIONAL UNION FOR THE PROTECTION OF NEW VARIETIES OF PLANTS
GENEVA

TECHNICAL WORKING PARTY ON AUTOMATION AND COMPUTER PROGRAMS

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IMAGE ANALYSIS FOR DUS IN THE UNITED KINGDOM

Document prepared by experts from the United Kingdom

Image analysis for DUS in the UK

Adrian Roberts & Graham Horgan, BioSS,
Niall Green , SASA & Haidee Philpott &
Carol Norris, NIAB

Overview

- Introduction
- Benefits of Image Analysis in DUS testing
- Some tips
- Introducing IA for measurement
- Software
- Hardware
- Characteristics in UK
- Examples

Introduction

- Currently we are using image analysis for measurement in some crops
  - Aim to save costs and improve quality
- Also has potential for reference collection management
  - Visually
  - By calculation of distance
  - Average images
  - As part of a database

Introduction – previous documents

Ref	Title
TWC/13/10	Plant variety color assessment using a still video camera
TWC/16/10	Visor - a plant variety image database
TWC/19/06	Matching of Plant Variety Images From Different Sowings
TWC/22/07	Automatic Measurement of Pea Characteristics
TWC/22/09-TWA/33/07	Image Analysis in DUS Testing in NIAB
TWC/26/21 Rev.	Measurement of Plant Characteristics Using Digital Images

Benefits of IA for measurement

- Greater reproducibility
- Often good repeatability
- May reduce costs
  - Automation
  - Making many measurements at once
    - Many plants – multiple characteristics per part
- Can help in development of new characteristics
- Digital image stored as a record of trial
  - Quality management
  - Can be used for reference collection management

Some tips

Set-up

- Avoid shadows
  - Diffuse lighting
  - Matt black or 'opposite' colour background can be good
- Objects not touching
- Scaling object

Colour measurement difficult

- Needs careful set up to ensure success
- We have avoided colour

Resolution requirements

- Depends on measurement
- E.g. length vs dentation

Introducing IA for measurement

- For existing characteristics
  - Need to prove performance vs "manual" measurement
  - Automated measurement often has greater precision and accuracy
  - Can often be more reproducible
  - Have to balance costs and benefit – a small time saving, better discrimination, image library, average shape can be derived
- For new characteristics
  - Has to fit rules on characteristics more generally
  - Must be beneficial to introduce
    - Helps to distinguish varieties
  - Beneficial to establish characteristics more widely
    - Crop guideline
    - Requires clear description

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Proof of performance vs manual methods

Evaluation for field pea based on …

- 2 or 3 years of data from Pea DUS trials
- trials with 2 replicates for each variety
- at least 40 varieties measured: automated and manual measurements on the same plant parts
- variety means for each year
- correlations between manual and automated measurement
- comparison of variety F-statistic from over-year ANOVA
- comparison of numbers of varieties distinct by 2% COYD criterion
- see TWC/22/7

Software

At the UK Vegetable DUS station

- Uses *Imagin* – in-house software
  - Fortran with Windows interface built using Visual Basic
  - Tailored to crop parts and characteristics

At the UK Combinable Crops DUS station

- Uses in-house software
  - C# with windows interface
  - Tailored to crop parts and characteristics

Hardware

At the UK Vegetable DUS station

- Camera at set distance above a fixed horizontal surface – distance varies with plant part
- Set lighting – photographic studio or bench
- Plant parts placed in fixed layout
- Matt black background (avoids shadows)
- Try to keep objects flat (glass used for leaflets/stipules)
- Label with plot info (may replace with 2d barcode)
- Scale given by coin

Image capture hardware: Pea

Canon EOS 450D digital camera linked to computer; IMAGIN programme; lens EF-S 18-55 IS Kit. Camera is 64 cms above plant parts. 4 x 11W energy saving light bulbs (ES/E27 Screw Cap).

Pea leaflets and stipules are flattened by acrylic sheet.

Hardware

At the UK Combinable Crops DUS station

- Camera at set distance above a fixed horizontal surface – distance varies with plant part
- Set lighting – studio lights or back lit
- Plant parts placed in fixed layout
- Acetate or 'opposite' colour background
- Try to keep objects flat
- Colour images converted to grey scale to cope with semi transparency of some characters
- Label with plot info
- Scale given by circular reference object

Image capture hardware: Oilseed

Olympus SLR to take the images linked to computer. A Windows 64 bit computer is needed to run the software

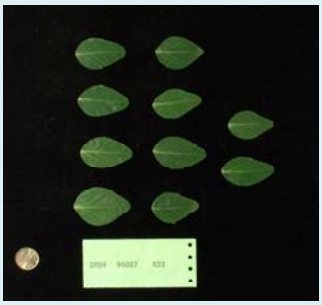
Example crop – field pea

Pea/Field Pea

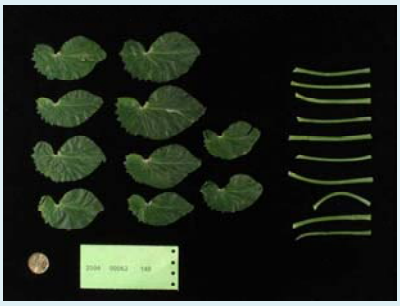
DUS characteristics (UPOV)	R&D characteristics
10. Leaflet: size	leaflet: tip shape
11. Leaflet: length	leaflet: shape
12. Leaflet: width	leaflet: dentation
13. Leaflet: position of broadest part*	leaflet: distance from widest point to base
15. Stipule: length	stipule: basal dentation
16. Stipule: width	pod: curvature at stem end
17. Stipule: size	pod: curvature at tip end
18. Stipule: length from axil to tip	pod: type of curvature
19. Stipule: length of lobe below axil	pod: degree of curvature
22. Petiole: length from axil to first leaflet	leaflet: average shape
34. Peduncle: length from stem to first pod	stipule: average shape
37. Pod: length	pod: average shape
38. Pod: width	

* Derived from Leaflet: length and Leaflet: distance from widest point to base

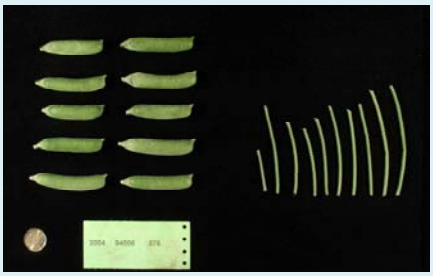
Image capture layout: Pea



Leaflets

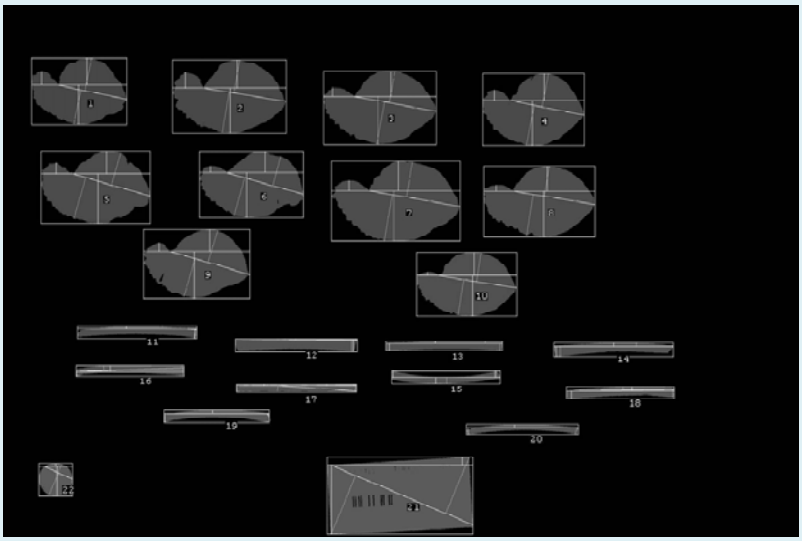


Stipules and petioles



Pods and peduncles

Examples – field pea



Example crop – parsnip

Automated measurement used in UK – Characteristic by crop

Parsnip

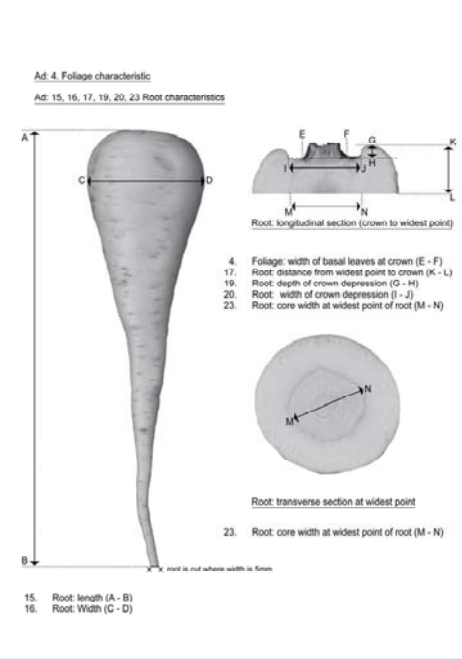
DUS characteristics (UPOV)

4. Foliage: width of basal leaves at crown
15. Root: length
16. Root: width
17. Root: distance from widest point to crown,
19. Root: depth of crown depression
20. Root: width of crown depression
23. Root: core width at widest point of root

R&D characteristics

Root: average shape

Parsnip: root characteristics



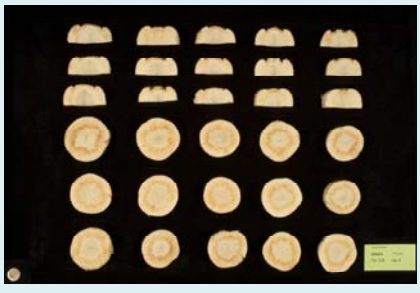


Image capture: Parsnip roots

- Selection of 15 representative roots per plot
- Roots are washed and root hairs removed
- 15 roots laid on floor and photographed (*for larger plant parts, alternative would be images of single roots on a conveyor system*)
- Roots cut at widest point: transverse section for core measurement
- Longitudinal section for crown measurements
- Coordinated layout of TS and LS sections

Example crop - Oilseed Rape

WOSR Characteristics (CPVO TP 36/1)

2. Cotyledon: length
3. Cotyledon: width
11. Flower: length of petals
12. Flower: width of petals
16. Siliqua: length (between peduncle and beak)
17. Siliqua: width
18. Siliqua: length of beak
19. Siliqua: length of peduncle

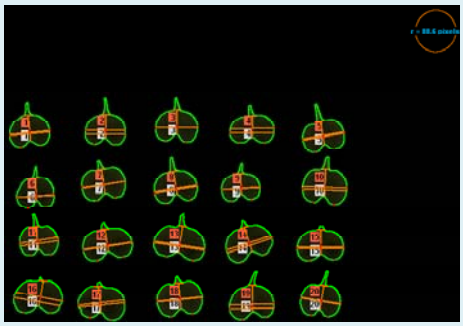
Additional characteristics approved by the President of CPVO

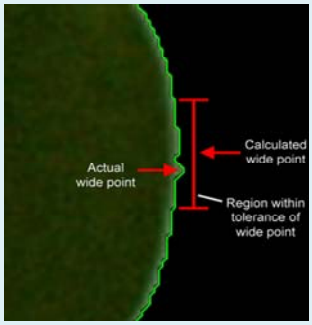
Cotyledon: lobe separation/width ratio
Cotyledon: saddle depth
Cotyledon: width/length ratio
Cotyledon: lobe separation/saddle depth ratio
Cotyledon: lamina base to wide point (lbtwp)
Cotyledon: saddle length/lamina length ratio
Cotyledon: lbtwp/width ratio

Additional characteristics approved in the UK for National Listing

Cotyledon: lobe separation
Cotyledon: lamina length
Cotyledon: lobe separation/lamina length ratio
Cotyledon: lbtwp/lamina length ratio
Petal: width/length ratio

Image capture layout: Cotyledon





- In order to smooth the edge and avoid noise from skewing a measurement, a tolerance is used.
- To find the calculated wide point, the actual widest point is first found.
- Suppose the tolerance is set at 1mm. The calculated widest point is then the middle of the region where the width is within 1mm of the actual widest point.

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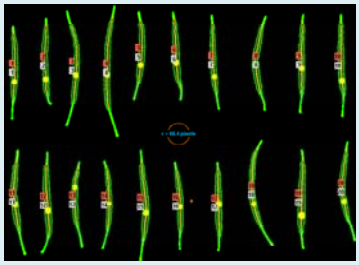
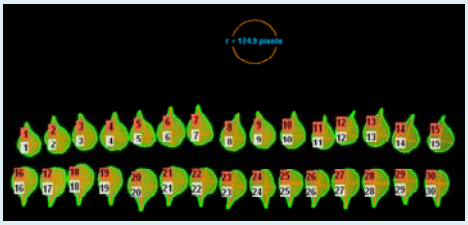
Image capture layout: Oilseed Rape



Siliquas



Petals

- For 3D objects like oilseed rape siliquas, placing circles at 100 points along the length to find the largest circle provides a solution to calculating the width of the siliqua
- The beak and peduncle cut-off points are automatically located by analysing the siliqua radius values along the midline

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Thank you for your attention

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Orientation for measurement: Pea

1. Leaflets
- Centre line from tip to base (along main vein)
- Lines are drawn at right angles for width
- Parallel lines to the above are drawn for box

2. Stipules
- 'Line of balance' is drawn along the length of the stipule
- Parallel lines are drawn for box
- Lines are drawn at right angles for width
- Line drawn from axil to tip
- Line drawn from axil to base (parallel to box line)
- Line drawn at right angle for length of lobe below axil

3. Pods
- Central line is drawn along length of pod
- Midpoint of central line is midpoint of pod
- Line drawn for pod width at centrepoint
- Right angle and parallel lines are drawn for box
- Maximum width measured by 'fitted circle'

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