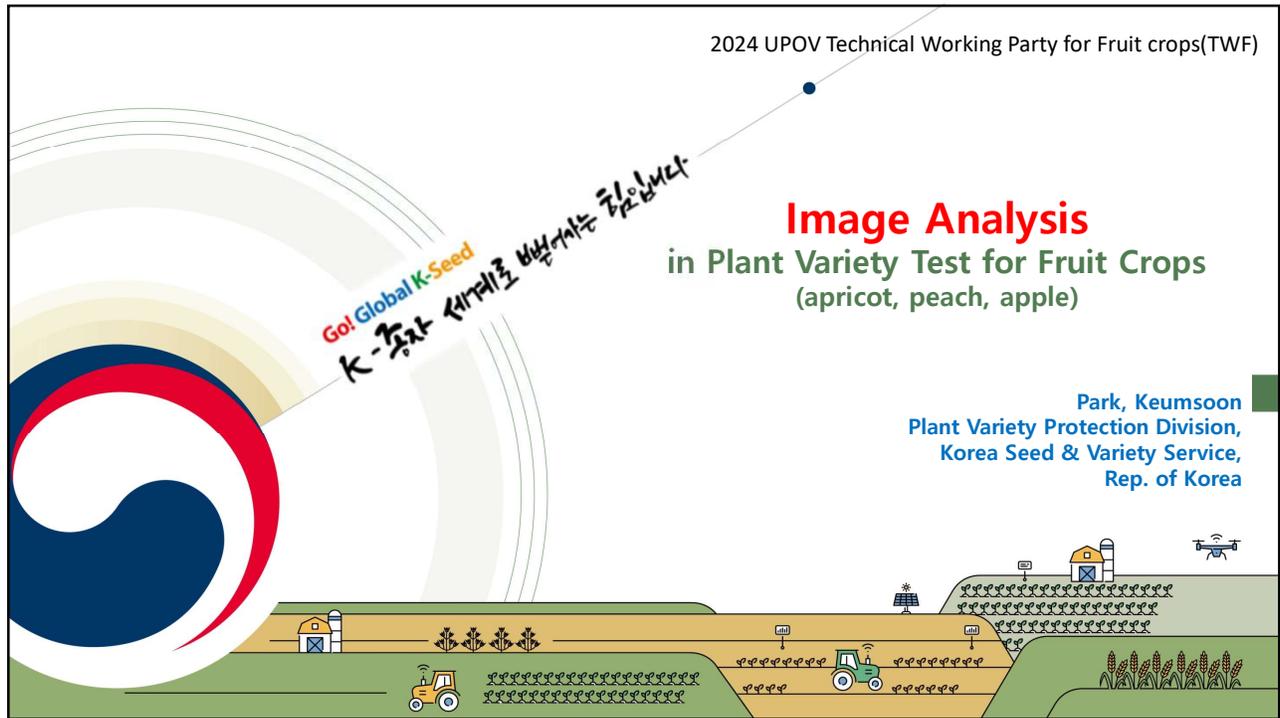


Technical Working Party for Fruit Crops**TWF/55/5****Fifty-Fifth Session****Original:** English**Virtual meeting, June 3 to 6, 2024****Date:** May 7, 2024

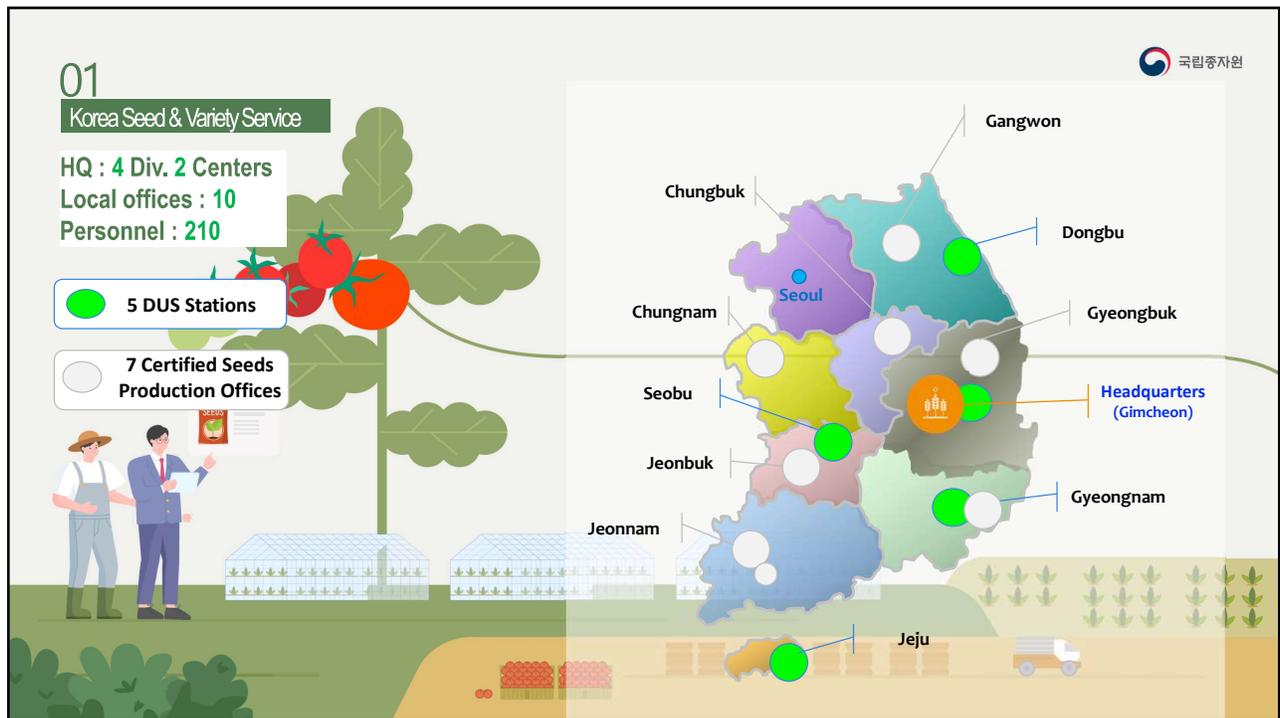
IMAGE ANALYSIS AND NEW TECHNOLOGIES IN DUS EXAMINATION*Document prepared by an expert from the Republic of Korea**Disclaimer: this document does not represent UPOV policies or guidance*

The annex to this document contains a copy of a presentation “Image Analysis in Plant Variety Test for Fruit Crops (apricot, peach, apple)”, to be made by an expert from the Republic of Korea, at the fifty-fifth session of the Technical Working Party for Fruit Crops (TWF).

[Annex follows]



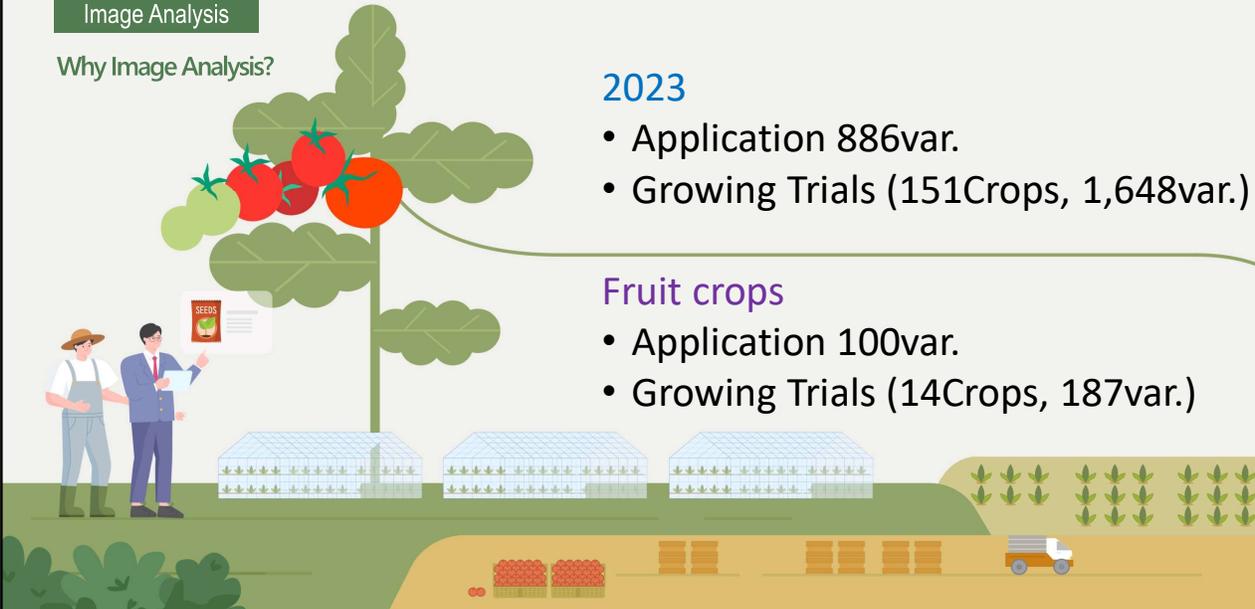
1



2

02
Image Analysis

Why Image Analysis?



2023

- Application 886var.
- Growing Trials (151Crops, 1,648var.)

Fruit crops

- Application 100var.
- Growing Trials (14Crops, 187var.)

국립중자원

3

02
Image Analysis

Why Image Analysis?



- Rose: 50 applications per year, 54 characters
- 6 hours per variety, depends on external conditions

국립중자원

4



02 Image Analysis

Strategy for Image Analysis

3 Target

➔

Program Development

➔

Reliability Check

➔

DUS Examination

Measurement (2020~2021)

1. LS: length between two Spots



Color (2021~2023)



Shape (2023~2024)

종류	형질	비율	비율	비율
종	종	종	종	종
종	종	종	종	종
종	종	종	종	종
종	종	종	종	종



5



02 Image Analysis

We will change

As-Is

- ✓ Avg. time per variety : 376min.(6 hrs)
- ✓ Personal per variety: 2~3 persons
- ✓ 4 steps for DUS examination
 - ▲ Measuring and manual documentation
 - ▲ Taking photos for reports
 - ▲ Manually data recording to the system
 - ▲ Data analysis

VS

To-Be

- ✓ 186min. (3 hrs)
- ✓ 1 persons
- ✓ 2 steps
 - ▲ Taking photos
 - ▲ Image analysis and data recording

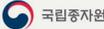
6

03
Image Analysis Program

Photos by Camera, Mobile

↓

Measurement







국립종자원
Korea Seed & Variety Service

KR-Image

작물 특성 분석 소프트웨어

사용자 명 : 실행 종료

ver. 0.9.4
beta test (이 버전은 테스트 버전임)

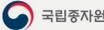
KETI 한국전자기술연구원
Korea Electronics Technology Institute



7

03
Image Analysis Program

Image Analysis for
Measurement

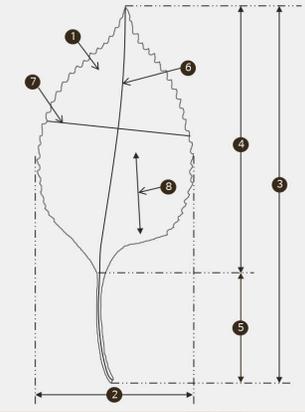




KR-Image

파일 분석 편집 도움말





Measurement (unit: mm)

1. A: leaf area
2. W: leaf width
3. L: total length, height
4. L1: length of leaf blade
5. L2: length of leaf petiole
6. LC: length of Center
7. LS: length between two Spots
8. LS2: length between two Spots 2
9. TH: Thickness



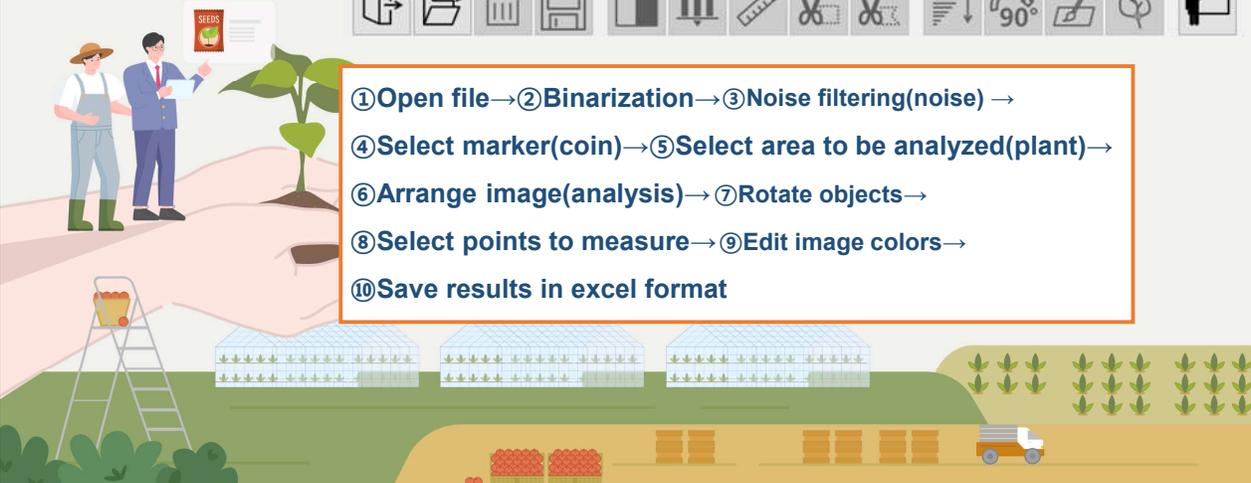
8

03
Image Analysis Program

Image Analysis for Measurement



① Open file → ② Binarization → ③ Noise filtering(noise) →
④ Select marker(coin) → ⑤ Select area to be analyzed(plant) →
⑥ Arrange image(analysis) → ⑦ Rotate objects →
⑧ Select points to measure → ⑨ Edit image colors →
⑩ Save results in excel format



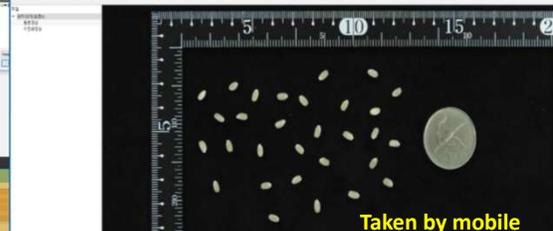
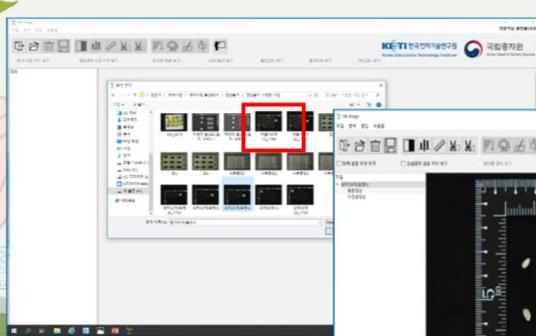
9

03
Image Analysis Program

Image Analysis for Measurement



① Open file (photo)



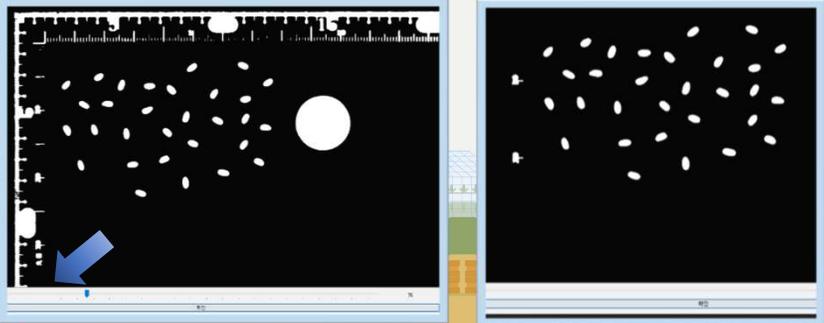
10

03
Image Analysis Program

Image Analysis for Measurement



② Binarization → ③ Noise filtering
- binarize the object to black and white and filtering to remove noise



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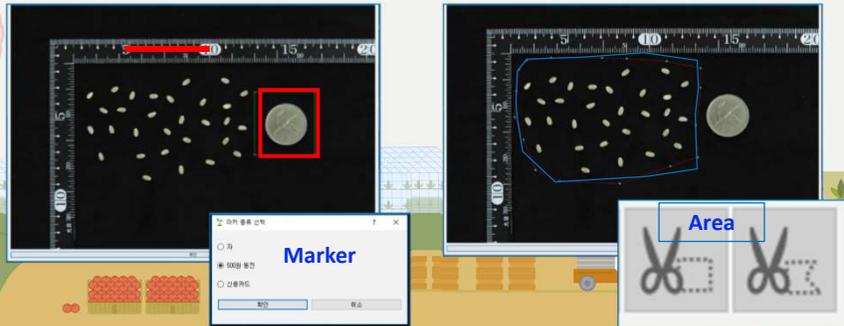
11

03
Image Analysis Program

Image Analysis for Measurement



④ Select marker (coin, ruler)
⑤ Define the area to be analyzed (square, polygone)



국립중자원

12

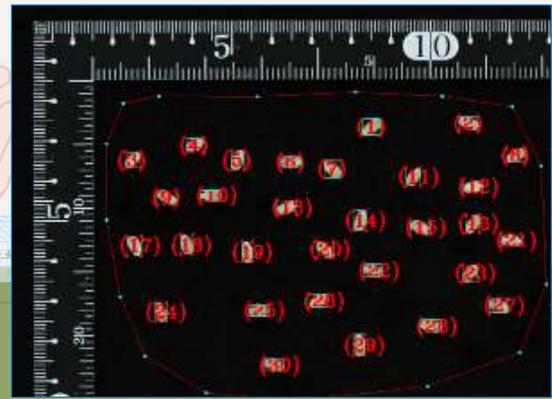
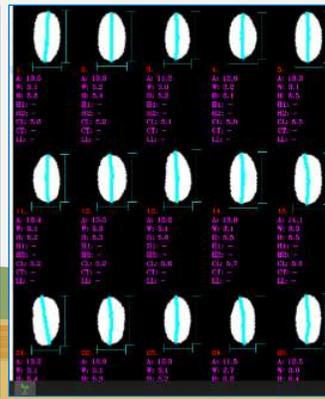
03 Image Analysis Program

Image Analysis for Measurement





⑥ Image Arrangement

13

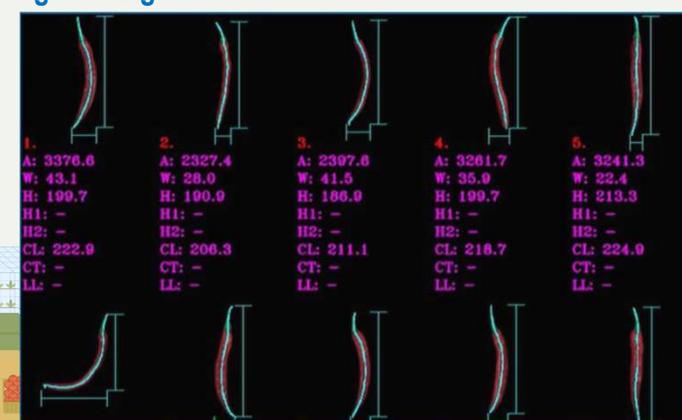
03 Image Analysis Program

Image Analysis for Measurement





⑥ Image Arrangement



1.	2.	3.	4.	5.
A: 3376.6	A: 2327.4	A: 2307.6	A: 3261.7	A: 3241.3
W: 43.1	W: 28.0	W: 41.5	W: 35.0	W: 22.4
H: 199.7	H: 190.0	H: 166.0	H: 199.7	H: 213.3
H1: -				
H2: -				
CL: 222.9	CL: 206.3	CL: 211.1	CL: 216.7	CL: 224.9
CT: -				
LL: -				

14

03
Image Analysis Program

Image Analysis for Measurement

국립중자원

KR-Image

파일 불러오기 ① ⑩ ② ③ ④ ⑤ ⑥ ⑦ ⑨ ⑧

⑥ Image Arrangement

Taken by camera, indoors

15

03
Image Analysis Program

Image Analysis for Measurement

국립중자원

KR-Image

파일 불러오기 ① ⑩ ② ③ ④ ⑤ ⑥ ⑦ ⑨ ⑧

⑩ Save results in excel file

	A	B	C	D
1	crop index	area(mm ²)	width(mm)	height(mm)
2	1	17.9	3.9	6.2
3	2	17.7	3.9	5.8
4	3	15.8	3.9	5.6
5	4	16.4	4.1	5.3
6	5	17.5	3.9	5.8
7	6	17.9	3.9	6.0
8	7	18.0	4.4	6.0
9	8	16.6	3.9	5.8
10	9	16.8	3.7	6.0
11	10	17.2	3.7	6.0
12	11	16.6	3.9	5.6
13	12	18.5	4.1	6.0
14	13	17.9	3.7	6.0
15	14	18.3	4.1	6.0
16	15	19.0	4.1	6.2
17	16	16.9	3.9	5.8
18	17	19.3	4.1	6.0
19	18	17.1	3.9	5.6
20	19	17.5	3.9	6.0
21	20	17.4	4.1	5.8
22	21	18.1	3.9	6.0
23	22	17.2	3.9	5.8
24	23	16.7	3.7	5.6
25	24	15.7	3.7	5.6
26	25	17.0	3.7	5.8
27	26	17.0	3.9	5.6
28	27	17.9	3.9	5.8
29	28	19.6	3.9	6.5
30	29	18.9	4.1	6.0
31	30	17.1	3.7	5.8
32	average	17.5	3.9	5.9

16

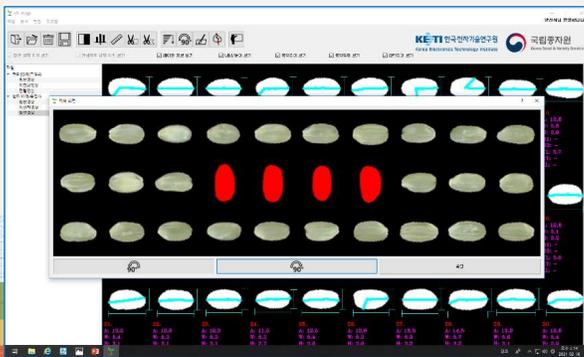
03
Image Analysis Program

Image Analysis for Measurement





⑦ Rotate objects- individually or entirely at an angle of 90°



17

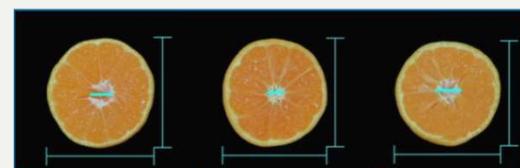
03
Image Analysis Program

Image Analysis for Measurement

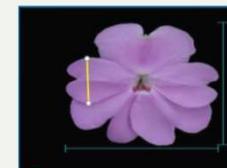




⑧ Select target points
- thickness and distance between two dots



1.	2.	3.
A: 3023.5	A: 2945.3	A: 2825.1
W: 61.5	W: 59.8	W: 60.2
H: 62.8	H: 61.8	H: 59.8
H1: -	H1: -	H1: -
H2: -	H2: -	H2: -
CL: 62.6	CL: 63.5	CL: 60.1
CT: -	CT: -	CT: -
LL: 12.2	LL: 8.3	LL: 13.6



1.
A: 690.6
W: 29.1
H: 32.2
H1: -
H2: -
CL: 33.2
CT: -
LL: 11.4

18

03
Image Analysis Program

Image Analysis for Measurement

국립중자원

⑨ Edit colors - object, number, background

1.	2.	3.	4.	5.
A: 432.1	A: 420.7	A: 478.3	A: 415.2	A: 416.7
W: 11.3	W: 10.8	W: 13.4	W: 10.8	W: 11.5
H: 58.2	H: 55.5	H: 56.4	H: 54.4	H: 54.0
H1: -				
H2: -				
CL: 58.8	CL: 57.2	CL: 58.6	CL: 57.1	CL: 55.4
CT: 10.8	CT: 10.5	CT: 12.4	CT: 11.7	CT: 11.4
U: -				

19

03
Image Analysis program

Measurement Reliability

국립중자원

Diameters of coins (Source: Bank of Korea)

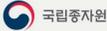
* 10 won : 18.0 mm
50 won : 21.6 mm
100 won : 24.0 mm
500 won: 26.5 mm

7.	4.	3.	2.
A: 246.1	A: 373.6	A: 459.5	A: 556.8
W: 17.7	W: 21.3	W: 24.1	W: 26.5

20

04
DUS test

Image Analysis for
Fruit crops
(Apricot)



Apricot: 59 characteristics(QN: 39)

- **Measurement : 14 characteristics**
- **Measure 11 characteristics with 4 Images**

1. **Leaf 1 image: 5 characteristics**
 - * Leaf blade: Length, Leaf blade: width, Leaf blade: ratio length/width, Petiole: length, Leaf: ratio length of blade /length of petiole
2. **Fruit 3 images: 6 characteristics**
 - * Fruit: height , Fruit: width in lateral view, Fruit: width in ventral view , Fruit: ratio height /ventral width, Fruit: ratio lateral width/ventral width, Fruit: depth of stalk
3. **3 characteristics NOT available**
 - * Flower: diameter, Fruit: weight, Fruit: ratio weight of fruit/weight of stone



21

04
DUS test

Image Analysis for
Fruit crops
(Apricot)



Leaf

1.	2.	3.	4.	5.
A: 6012.1	A: 5742.5	A: 6296.2	A: 6186.3	A: 6544.1
W: 89.4	W: 80.8	W: 86.3	W: 92.5	W: 91.9
H: 147.4	H: 151.7	H: 152.3	H: 147.4	H: 151.1
L1: 96.8	L1: 102.4	L1: 103.0	L1: 97.4	L1: 102.4
L2: 50.6	L2: 49.3	L2: 49.3	L2: 50.0	L2: 48.7
LC: 155.8	LC: 149.1	LC: 150.2	LC: 118.6	LC: 152.2
LS: -				
TH: -				

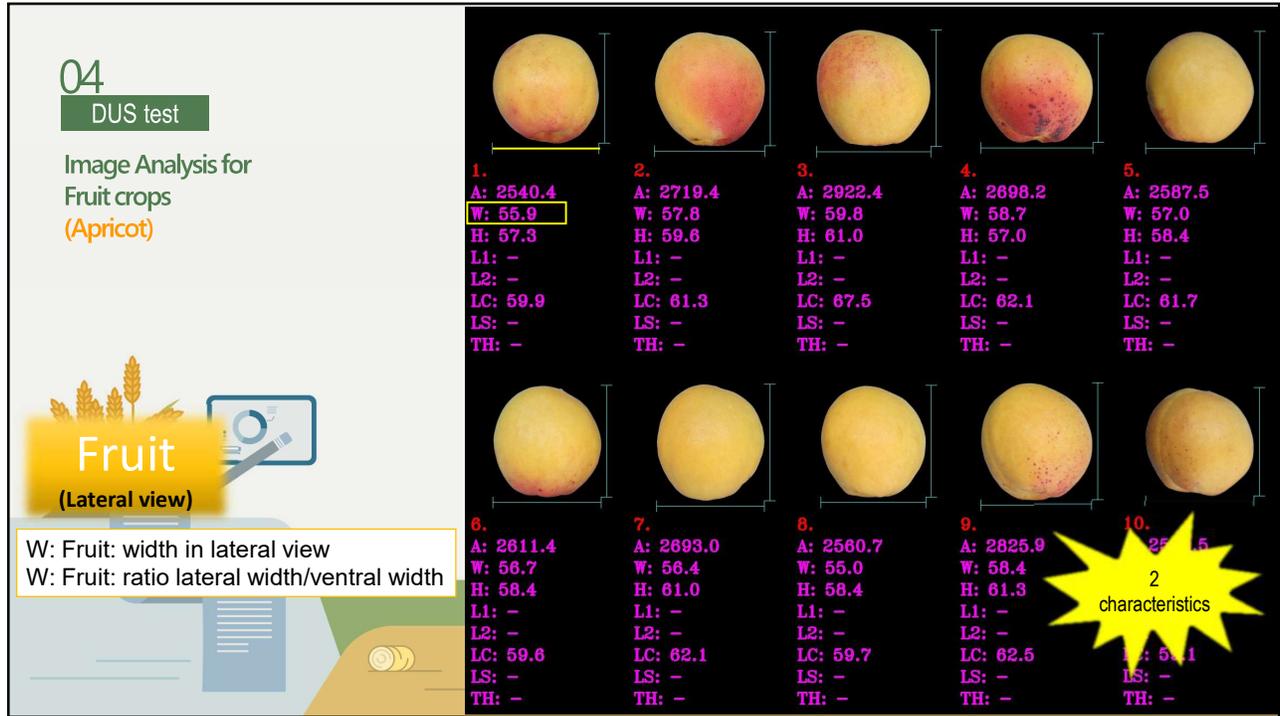
6.	7.	8.	9.
A: 5596.0	A: 5270.5	A: 5674.0	A: 6281.3
W: 82.0	W: 80.8	W: 82.6	W: 90.7
H: 145.5	H: 138.8	H: 150.5	H: 149.2
L1: 90.7	L1: 89.4	L1: 97.4	L1: 100.5
L2: 54.9	L2: 49.3	L2: 53.0	L2: 48.7
LC: 145.3	LC: 138.3	LC: 151.8	LC: 158.1
LS: -	LS: -	LS: -	LS: -
TH: -	TH: -	TH: -	TH: -



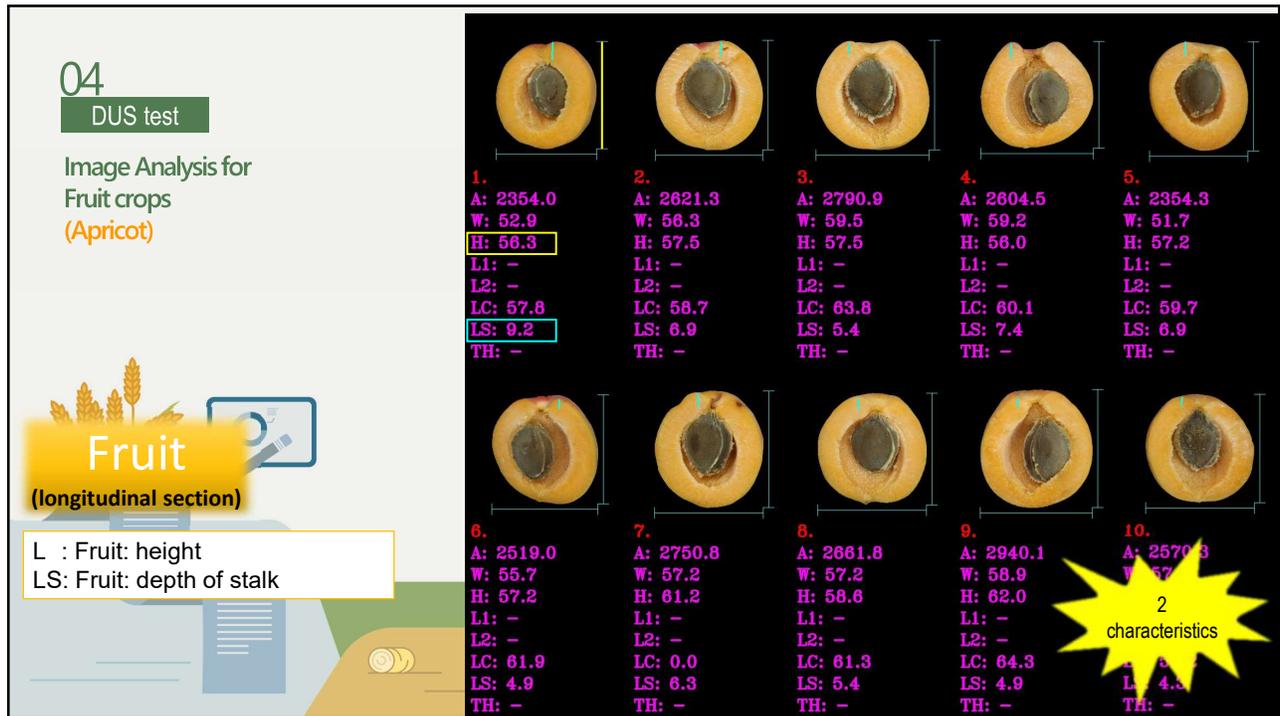
5
characteristics

L1 : Leaf blade: Length
L2 : Petiole: length
W : Leaf blade: width
L1/W: Leaf blade: ratio length/width
L1/L2: Leaf: ratio length of blade /length of petiole

22



23



24

04
DUS test

Image Analysis for
Fruit crops
(Apricot)

Fruit
(ventral view)

W: Fruit: width in ventral view
W: Fruit: ratio height /ventral width

1. A: 2320.1 W: 52.5 H: 55.5 L1: - L2: - LC: 58.9 LS: - TH: -	2. A: 2380.1 W: 50.4 H: 58.8 L1: - L2: - LC: 58.4 LS: - TH: -	3. A: 2617.8 W: 53.6 H: 60.2 L1: - L2: - LC: 62.8 LS: - TH: -	4. A: 2255.1 W: 50.6 H: 57.2 L1: - L2: - LC: 57.2 LS: - TH: -	5. A: 2412.0 W: 53.6 H: 56.4 L1: - L2: - LC: 61.5 LS: - TH: -
6. A: 2511.6 W: 53.1 H: 59.4 L1: - L2: - LC: 61.5 LS: - TH: -	7. A: 2610.8 W: 55.0 H: 60.2 L1: - L2: - LC: 59.2 LS: - TH: -	8. A: 2333.9 W: 50.8 H: 59.1 L1: - L2: - LC: 57.9 LS: - TH: -	9. A: 2593.5 W: 55.5 H: 59.4 L1: - L2: - LC: 58.8 LS: - TH: -	10. A: 2329.8 W: 53.1 H: 56.4 L1: - L2: - LC: 61.5 LS: - TH: -

2 characteristics

25

04
DUS test

Image Analysis for
Fruit crops
(Peach)

Peach: 70 Characteristics(QN: 44)

- **Measurement: 13 characteristics**
- **Measure 7 characteristics with 3 Images**
 - 1. **Petal 1 image: 1 characteristic**
* Petal: width
 - 2. **Leaf 1 image: 4 characteristics**
* Leaf blade: length, Leaf blade: width, Leaf blade: ratio length/width, Petiole: length
 - 3. **Fruit 1 image: 2 characteristics**
* Fruit: depth of stalk cavity, Fruit: width of stalk cavity
 - 4. **6 characteristics NOT available**
* Fruit: size, Fruit: firmness of flesh, Fruit: sweetness, Fruit: acidity

26

05
DUS test

Image Analysis for
Fruit crops
(Peach)



Petal

W: Petal: width

1. A: 273.0 W: 16.7 H: 22.5 L1: - L2: - LC: 21.1 LS: - TH: -	2. A: 260.4 W: 16.1 H: 23.4 L1: - L2: - LC: 24.2 LS: - TH: -	3. A: 291.2 W: 17.0 H: 24.4 L1: - L2: - LC: 25.6 LS: - TH: -	4. A: 237.4 W: 15.4 H: 21.6 L1: - L2: - LC: 21.4 LS: - TH: -	5. A: 265.5 W: 16.0 H: 23.4 L1: - L2: - LC: 24.4 LS: - TH: -
6. A: 268.1 W: 16.6 H: 23.2 L1: - L2: - LC: 23.5 LS: - TH: -	7. A: 253.4 W: 16.6 H: 22.0 L1: - L2: - LC: 0.0 LS: - TH: -	8. A: 277.8 W: 17.3 H: 22.6 L1: - L2: - LC: 21.2 LS: - TH: -	9. A: 273.2 W: 16.4 H: 24.0 L1: - L2: - LC: 25.6 LS: - TH: -	10. A: 269.7 W: 16.0 H: 24.4 L1: - L2: - LC: 24.4 LS: - TH: -

2 characteristics

27

05
DUS test

Image Analysis for
Fruit crops
(Peach)



Leaf

L1 : Leaf blade: length
L2 : Petiole: length
W : Leaf blade: width
L1/W: Leaf blade: ratio length/width

1. A: 3114.4 W: 35.6 H: 152.9 L1: 140.6 L2: 12.3 LC: 168.8 LS: - TH: -	2. A: 3587.2 W: 36.8 H: 155.8 L1: 145.9 L2: 9.9 LC: 168.6 LS: - TH: -	3. A: 3014.7 W: 33.8 H: 158.1 L1: 149.4 L2: 8.8 LC: 169.0 LS: - TH: -	4. A: 3432.7 W: 36.2 H: 154.6 L1: 141.2 L2: 13.4 LC: 178.3 LS: - TH: -	5. A: 2920.7 W: 31.5 H: 163.9 L1: 147.6 L2: 16.3 LC: 176.9 LS: - TH: -
6. A: 3596.1 W: 34.4 H: 167.4 L1: 151.7 L2: 15.8 LC: 179.0 LS: - TH: -	7. A: 3711.8 W: 33.3 H: 168.6 L1: 154.6 L2: 14.0 LC: 178.6 LS: - TH: -	8. A: 3653.3 W: 36.2 H: 166.9 L1: 154.0 L2: 12.8 LC: 183.0 LS: - TH: -	9. A: 3889.5 W: 37.9 H: 155.2 L1: 141.2 L2: 14.0 LC: 164.9 LS: - TH: -	

4 characteristics

28

05

DUS test

Image Analysis for
Fruit crops
(Peach)



Fruit
(longitudinal section)

LS : Fruit: depth of stalk cavity
LS2: Fruit: width of stalk cavity

1.	2.	3.	4.	5.
A: 5529.8	A: 3828.1	A: 4425.0	A: 4344.2	A: 4024.4
W: 87.9	W: 72.0	W: 73.6	W: 76.0	W: 75.2
H: 80.3	H: 67.2	H: 74.8	H: 72.0	H: 67.2
L1: -				
L2: -				
LC: 99.4	LC: 71.9	LC: 76.6	LC: 77.9	LC: 74.2
LS: 8.4	LS: 9.0	LS: 11.6	LS: 8.4	LS: 8.4
LS2: 34.6	LS2: 30.4	LS2: 31.2	LS2: 33.0	LS2: 31.7
TH: -				

6.	7.	8.	9.	10.
A: 4665.9	A: 4162.5	A: 4711.7	A: 5609.4	A: 5554.8
W: 78.7	W: 72.4	W: 77.5	W: 84.7	W: 85.0
H: 73.2	H: 71.2	H: 74.0	H: 81.5	H: 81.5
L1: -				
L2: -				
LC: 80.8	LC: 75.1	LC: 81.2	LC: 86.0	LC: 86.0
LS: 10.7	LS: 9.2	LS: 9.7	LS: 13.1	LS: 13.1
LS2: 30.2	LS2: 35.8	LS2: 34.2	LS2: 37.0	LS2: 34.3
TH: -				



2
characteristics

29

06

DUS test

Image Analysis for
Fruit crops
(Apple)





Apple: 51 Characteristics(QN: 40)

- **Measurement: 13 characteristics**
- **Measure 11 characteristics with 2 Images**
 - 1. Leaf 1 image: 5 characteristics**
 - * Leaf blade: length, Leaf blade: width, Leaf blade: ratio length/width, Petiole: length,
Leaf: ratio length of leaf blade / length of petiole
 - 2. Fruit 1 image: 7 characteristics**
 - * Fruit: height, Fruit: diameter, Fruit: ratio height/diameter, Fruit: length of stalk,
Fruit: depth of stalk cavity, Fruit: depth of eye Basin, Fruit: width of eye basin
 - 3. 3 characteristics NOT available**
 - * Flower: diameter, Fruit: weight, Fruit: firmness of flesh

30

06

DUS test

Image Analysis for
Fruit crops
(Apple)



Leaf

L1 : Leaf blade: length
L2 : Petiole: length
W : Leaf blade: width
L1/W: Leaf blade: ratio length/width
L1/L2: Leaf: ratio length of leaf blade / length of petiole

				
1. A: 3647.2 W: 58.4 H: 113.6 L1: 83.7 L2: 29.9 LC: 95.1 LS: - LS2: - TH: -	2. A: 4005.2 W: 61.2 H: 114.5 L1: 86.4 L2: 26.2 LC: 118.3 LS: - LS2: - TH: -	3. A: 3182.6 W: 51.0 H: 110.3 L1: 85.1 L2: 25.2 LC: 118.6 LS: - LS2: - TH: -	4. A: 3409.7 W: 57.0 H: 109.4 L1: 83.2 L2: 26.2 LC: 121.0 LS: - LS2: - TH: -	5. A: 3863.6 W: 61.7 H: 114.5 L1: 83.7 L2: 30.9 LC: 130.1 LS: - LS2: - TH: -
				
6. A: 3198.2 W: 51.9 H: 112.7 L1: 85.5 L2: 27.1 LC: 70.0 LS: - LS2: - TH: -	7. A: 3763.0 W: 57.0 H: 120.1 L1: 90.7 L2: 29.5 LC: 128.3 LS: - LS2: - TH: -	8. A: 2871.2 W: 45.8 H: 109.9 L1: 80.9 L2: 29.0 LC: 118.7 LS: - LS2: - TH: -	9. A: 3556.7 W: 53.8 H: 118.3 L1: 86.0 L2: 32.3 LC: 127.1 LS: - LS2: - TH: -	10. A: 4068.8 W: 59.4 H: 114.5 L1: 83.7 L2: 30.9 LC: 130.1 LS: - LS2: - TH: -



31

06

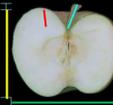
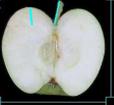
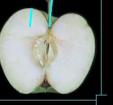
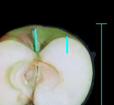
DUS test

Image Analysis for
Fruit crops
(Apple)



Fruit
(longitudinal section)

L2 : Fruit: height
W : Fruit: diameter
L2/W: Fruit: ratio height/diameter
LS : Fruit: length of stalk
LS2 : Fruit: depth of stalk cavity

				
1. A: 5134.5 W: 86.7 H: 74.0 L1: 4.9 L2: 69.1 LC: 93.6 LS: 19.8 LS2: 14.7 TH: -	2. A: 4827.5 W: 83.0 H: 74.9 L1: 7.4 L2: 67.5 LC: 84.4 LS: 17.7 LS2: 11.5 TH: -	3. A: 4941.9 W: 83.0 H: 76.5 L1: 6.5 L2: 69.9 LC: 107.2 LS: 18.4 LS2: 11.5 TH: -	4. A: 4512.7 W: 78.1 H: 78.9 L1: 11.5 L2: 67.5 LC: 88.2 LS: 22.6 LS2: 12.3 TH: -	5. A: 4719.0 W: 83.0 H: 72.0 L1: 7.0 L2: 65.0 LC: 80.8 LS: 16.8 LS2: 11.5 TH: -
				
6. A: 4886.7 W: 83.9 H: 89.2 L1: 22.9 L2: 66.3 LC: 102.7 LS: 35.6 LS2: 13.5 TH: -	7. A: 4534.0 W: 81.8 H: 87.5 L1: - L2: - LC: 0.0 LS: 12.1 LS2: 12.3 TH: -	8. A: 5254.6 W: 88.4 H: 72.0 L1: 5.7 L2: 66.3 LC: 90.1 LS: 17.9 LS2: 13.9 TH: -	9. A: 4440.0 W: 76.5 H: 70.4 L1: 8.2 L2: 62.2 LC: 84.9 LS: 19.6 LS2: 14.7 TH: -	10. A: 4719.0 W: 83.0 H: 72.0 L1: 7.0 L2: 65.0 LC: 80.8 LS: 16.8 LS2: 11.5 TH: -



32

06
DUS test

Image Analysis for
Fruit crops
(Apple)

Fruit
(longitudinal section)

LS : Fruit: width of eye basin
LS2: Fruit: depth of eye basin

1.	2.	3.	4.	5.
A: 5118.4	A: 4810.7	A: 4929.2	A: 4497.2	A: 4701.5
W: 86.6	W: 82.9	W: 82.9	W: 78.0	W: 82.9
H: 73.9	H: 75.1	H: 75.9	H: 78.8	H: 71.9
L1: -				
L2: -				
LC: 93.9	LC: 80.9	LC: 102.5	LC: 98.3	LC: 81.3
LS: 35.2	LS: 35.6	LS: 36.0	LS: 32.3	LS: 34.3
LS2: 10.2	LS2: 11.0	LS2: 11.1	LS2: 12.2	LS2: 16.9
TH: -				
6.	7.	8.	9.	10.
A: 4862.9	A: 4514.9	A: 5234.1	A: 4422.1	A: 5260.5
W: 83.7	W: 81.3	W: 87.8	W: 76.4	W: 86.9
H: 89.0	H: 87.4	H: 71.9	H: 70.2	H: 83.9
L1: -				
L2: -				
LC: 88.1	LC: 80.5	LC: 92.6	LC: 85.7	LC: 83.9
LS: 36.9	LS: 32.7	LS: 34.0	LS: 33.1	LS: 33.9
LS2: 11.8	LS2: 11.4	LS2: 15.5	LS2: 15.2	LS2: 12.3
TH: -				

2 characteristics

33

2024 UPOV Technical Working Party for Fruit crops(TWF)

Image Analysis
in Plant Variety Test for Fruit Crops
(apricot, peach, apple)

34