European Cooperative Programme for Plant Genetic Resources

ECP/GR

ECPGR Characterization and Evaluation Descriptors for Apple Genetic Resources

Apple (*Malus x domestica*)

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Introduction

Developing standards to collect and share information about plant genetic resources is vital for their conservation and use by farmers, gardeners, scientists, conservationists and breeders.

In recent years, the ECPGR *Malus/Pyrus* Working Group highlighted the need to synthesize, harmonize and prioritize an agreed set of characterization and evaluation descriptors for *Malus/Pyrus* cultivated species (Lateur et al., 2006; Lateur et al., 2013), and committed to filling this need. Common protocols and descriptors were consequently adapted, initially by a task force formed by representatives of the *Malus/Pyrus* Working Group (M. Lateur, D. Szalatnay, E. Dapena, M. Kellerhals). Further on, in the framework of an ECPGR Grant Scheme Activity named 'Common ECPGR protocols and tools available for Characterization & Evaluation of *Malus/Pyrus* genetic resources',and supported by the Federal Ministry of Food and Agriculture, Germany, it was planned to finalize a new updated version of the former Descriptor List for Apple (*Malus*) published 40 years ago.

This publication brings all the above efforts together and includes enhanced descriptions of methods/protocols and technical practical information.

As far as possible, it was attempted to retain descriptors already in use, and many of the descriptors proposed are the same as those previously published by, or adapted from ECPGR, UPOV, CPVO and/*or Obst-Deskriptoren NAP – Descripteurs de Fruits PAN* (Szalatnay 2006). Further descriptors are from protocols already developed and in use by collection curators, and a small number of novel descriptors have been added where no suitable descriptor was available.

Genetic resources, by their nature, contain a wide diversity of traits. Scales must be sufficiently open to include this range. A general rule has been to use 1–9 scales with extreme classes (1 and 9) described as 'Extremely…', which should be taken to mean outside of what is generally known. To maximize the accuracy of a trait description, in many tables, it is recommended to use the intermediate class types referenced in the descriptor tables as 'X'.

Describing colour can be challenging, and illustrations are presented in the document thanks to the work of Szalatnay (2006). It is recommend, when possible, to control the judgement of colour against a standard colour chart such as the Royal Horticultural Society Colour Chart,and reference to this is either included or will be included in due course in line with UPOV (2019).

Even for characterization traits, variability is observed among fruits, among sites and across years. It is therefore ideal to collect data during a sufficiently long period of time to be able to show the variability of the character and to define a 'median' relative value for each trait.

Most descriptors are based on comparison to reference cultivars. However, in some cases, illustrations or absolute values have been added for further clarity. For most descriptors, it is recommended that the list of reference cultivars is extended so that, for each category, at least one is available for comparison.

One very important objective in standardizing descriptors is to be able to compare and analyze data from different collections, and it is crucial to clearly describe the methodology used for each descriptor. To aid with the comparison across different collections, it is important to record experimental methods, numbers of replicates, ages of trees, rootstocks and management scheme (e.g. fungicide application), and to include reference cultivars as far as possible. Climatic data such as mean rainfall for each season can also be important to note.

It is hoped that the descriptors below will allow the potential ranking of accessions through relative classification; ranking will obviously need to be applied within specific contexts.
It is recommended that field observations on descriptions and/or descriptors should be maintained for later reference and/or consideration.

Further information on the concepts of crop descriptors is downloadable from:

- https://cgspace.cgiar.org/handle/10568/56589

Online information on apple descriptors can also be found at:

- https://hdl.handle.net/10568/72794
- http://www.upov.int/edocs/tgdocs/en/tg014.pdf
- https://cpvo.europa.eu/sites/default/files/documents/malus_domestica_2.pdf
- http://www.cpc-skek.ch/fileadmin/pdf/NAP_Beschreibungshandbuecher/deskriptoren-handbuch_nap.pdf

Methods and prioritized descriptors for *Malus*

The aim of the below is to recommend a range of descriptors, which will successfully describe and discriminate between key characters in most accessions. Ideally, characters should meet the criteria of being:

- Highly stable over time with low interaction with environmental factors
- Highly polymorphic
- Easy to score in practice
- Able to combine characterization and agronomic evaluation value where possible.

The proposed list was mostly compiled using:

- Characters suggested by members of the *Malus/Pyrus* Working Group and compiled by a Task Force headed by M. Kellerhals (Lateur et al., 2010)
- Results of a study on selected common cultivars in the UK, France, Belgium and Italy (Janes and Jones, 1998)
- Apple Descriptors (Watkins and Smith, 1982)
- Protocol for distinctness, uniformity and stability tests – *Malus domestica* Borkh. – APPLE, CPVO-TP/14/2 Final (14/03/2006).
- UPOV Guidelines for the conduct of tests for distinctness, uniformity and stability (Apple – Fruit Varieties): TG/14/8 (1995) and TG/14/9 (2005).
- *Obst-Deskriptoren NAP – Descripteurs de Fruits PAN* (Szalatnay, 2006).
- Dapena, E., Fernández, M. (2009). Guía de descriptores de caracteres. In : Dapena, de la Fuente E, Blazquez, Noguero MD. 2009. Description de las variedades de Manzana de la D.O.P Sidra de Asturias. Villaviciosa. 69pp.

A priority ranking of the descriptors is included. It is acknowledged that capability will depend upon time and resources. The primary characterization and evaluation traits are recommended for prioritization. First priority descriptors are indicated in the document with "**Priority 1**"; second and third priority descriptors with a "**Priority 2/3**". Second and third priority descriptors represent useful tools that can be used by curators who have the capacity to do the further evaluation and/or characterization work.

Since many scores are relative, it is important to have representatives from a minimum set of common reference cultivars (ideally, a minimum of 2/3) in each characterization/evaluation site. Recommended cultivars for general comparison are listed below and are based on a survey of the members of the ECPGR *Malus/Pyrus* Working Group:

- Alkmene
- Åkerö
- Ananas Reinette (syn. Reinette Ananas)
- Discovery
- Golden Delicious
- Ingrid Marie
- James Grieve
- Jonathan
- King of the Pippin (syn. Reine des Reinettes, Winter Goldparmäne)
- Reinette de Champagne
- Winter Banana
- White Transparent (syn. Transparente Blanche)

General notes on methodology for characterization

Data should be recorded on representative trees and ideally, data should be recorded in representative years.

Extreme climatic conditions such as high spring temperature, severe spring frost or hail are known to affect floral phenology and fruit set/quality.

Ideally, data from several **representative** years should be recorded before accessions can be fully classified.

All recorded dates should be transformed into number of days from the first of January. Phenological classifications can then be expressed as '+' or '–' (X) day differences from the reference cultivars classified in the medium period.

It is important to organize training for technicians and field workers who will perform the evaluation. It is recommended to check the reproducibility of data (between data collected on the same object by different observers) and the repeatability (between observations made by the same observer at different times).

1. Flowers

Assessment of trees two to three times per week is generally recommended in order to observe the correct moment when flowers open. The primary stages that need at least to be observed are: E2 (BCCH: 59), F (BCCH: 61), F2 (BCCH: 65) and H (BCCH: 69), (according to Fleckinger and Meier, 2001 – **Figure 1)**. For further detail, it is recommended to follow the BBCH flowering stages codes (Anonym, 1989, Meier, 2001). As a general rule, assessment of flowers should not include those appearing on one-year shoots.

Some cultivars tend to produce a second flowering phase a few months after the spring flowering period. The intensity of this flowering is much less important, but incidence represents a risk of infection by fire blight (*Erwinia amylovora*). Independent descriptors relating to secondary flowering are proposed.

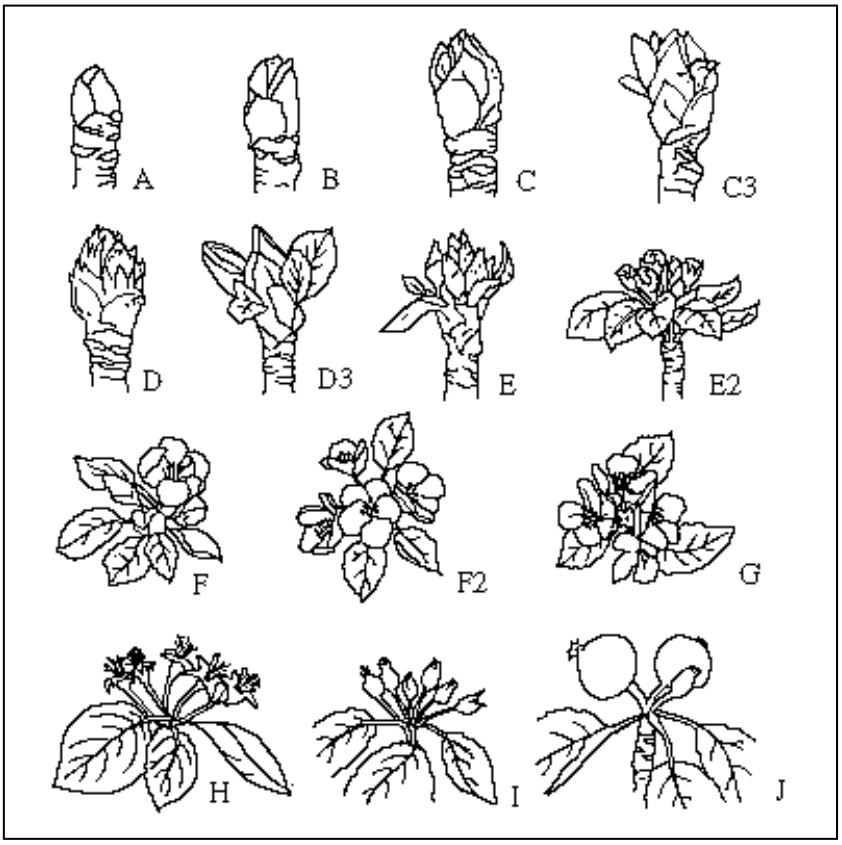


Figure 1. Fleckinger's phenological flower stages for apple.

1.1 Flowering phenology (*Priority 1*)

When flowering intensity is very low (fewer than 5% of the buds are flower buds), it is not representative to evaluate the flowering season. It is useful to note and/or assess the flowering intensity of the trees by using the assessment key defined in **Table 1**. The relative flowering season of a cultivar (**Table 2**) can then be assessed by comparison against the flowering period of reference cultivars. It is recommended that for standardization, Golden Delicious is considered as a central point for all areas. For this comparison; the reference flower stage can be either 'F' (BCCH: 61), or 'F2' (BCCH: 65).

Table 1. Flowering intensity (developed from Lateur and Populer, 1996)

State	Flowering intensity	Field observations
1	No flower	Absence of any flower
2	Extremely low	Flower clusters represent up to 5% of all buds
3	Low	Flower clusters represent approx. 10% of all buds
4	Low to medium	X
5	Medium	Flower clusters represent approx. 30% of all buds
6	Medium to high	X
7	High	Flower clusters represent approx. 50% of all buds
8	High to extremely high	X
9	Extremely high	Over 90% of all buds are floral

'X': Intermediate rating.

Table 2. Relative flowering season (adapted from Lateur and Populer, 1996)

State	Flowering period	Indicative difference in average days	Example of reference cultivars
1	Extremely early		
2	Very early	-9	White Transparent, Gravensteiner, Stark Earliest, Sobena, Princesa
3	Early	-6	Boskoop, Idared, Alkmene, Rosy Glow, James Grieve, Discovery
4	Early/medium	-3	Granny Smith, Tydemans Early Worcester, Jonathan, Cox's Orange Pippin
5	Medium	0	Jacques Lebel, Elstar, Golden Delicious, Glockenapfel, Jonagold, King of the Pippin, Ingrid Marie
6	Medium/late	+3	Reinette Etoilée (syn. Rote Sternreinette), Belle-Fleur de France, Gala, Golden Orange
7	Late	+6	Court-Pendu Rouge (syn Court-Pendu Plat, Königlicher Kurzstiel), Belle-Fleur de Brabant, Rome Beauty
8	Very late	+9	Reinette de France, Spätblühender Taffetapfel
9	Extremely late		

1.2 Regularity of flowering *(Priority 3)*

Following the assessment of flowering intensity over four to six representative years, accessions can be placed in categories of flowering regularity. It is important that thinning methods are not in place as these will act to mitigate this characteristic.

Table 3. Relative regularity of flowering (adapted from Watkins and Smith, 1982)

State	Regularity of flowering	Example of reference cultivars
1	Very Irregular	
2	X	
3	Irregular	
4	X	
5	Regular	Golden Delicious

'X': Intermediate rating.

1.3 Occurrence of secondary flowering during summertime *(Priority 3)*

Secondary flowering should initially be assessed in terms of intensity as per **Table 4**. Following at least 5–6 seasons, accessions can be classified into different levels of frequency of secondary flowering (**Table 5**).

Table 4. Intensity of secondary flowering

State	Secondary flowering intensity	Field observations
1	Low	Absence of any secondary flowering
2	Medium	Flower clusters represent up to 5% of all buds
3	High	Flower clusters represent more than 5% of all buds

Table 5. Frequency of secondary flowering (Watkins and Smith, 1982)

State	Frequency of secondary flowering	Example of reference cultivars
1	Rare	Reinette de France
2	Intermediate	
3	Frequent	Pinova

1.4 Flower colour at balloon stage (BBCH 59, E2) *(Priority 3)*

1 = white

1 = weiss

1 = blanche

(Cox's Pomona)

2 = yellowish and pink

2 = gelb und rosa

2 = jaune et rose

(Herrenhut, Worcester Pearmain)

3 = light pink

3 = hellrosa

3 = rose pâle

(Gravensteiner, Jonathan)

4 = dark pink

4 = dunkelrosa

4 = rose foncé

(Sylvia, Elstar)

5 = red

5 = rot

5 = rouge

(Kidd's Orange Red)

6 = purple

6 = violett

6 = violette

(Rafzubin, Melba)

7 = dark red

7 = dunkelrot

7 = rouge foncé

(Weirouge)
(Dapena et al., 2009)

Figure 2. Colour of flower petals at E2 stage (CPVO, 2006, Szalatnay, Dapena et al., 2009)

2. Fruit

A sample of at least 6 to 12 representative fruits should be evaluated. Having identified the most representative fruits on the tree, the same protocol should be used for each accession, e.g. fruits taken from the sunny side at ¾ of the height of the tree. It is important to avoid the terminal (king) fruits. In general, it is recommended to perform fruit assessments in the orchard, in front of the tree where possible.

As per the CPVO Protocol (2006), it is recommended that all descriptions of fruit quality should be carried out at an optimal stage of ripening for fresh consumption. Unfortunately, there are no simple criteria to define an accession's good state of ripening, and this will remain a subjective judgement based on the expertise of the curators; frequent observation of the trees is recommended. Some factors offer useful indications e.g. first pre-harvest drop of healthy fruit, change in ground- and over-colour of the fruit, and taste of the fruit (acidity, starchiness, sugar level, firmness) but it is noted that these are themselves characterization/evaluation characters. Iodine starch index can be also a good indicator but this is not always the case. It is generally recommended to not pick before reaching the 6–7 starch index score (Vaysse, Landry, 2004). For extremely late-ripening cultivars, it may be necessary to either analyze samples of fruit picked as late as possible or after a period of post-harvest ripening.

Since ripening time is difficult to accurately predict, and it is often not practical to finely monitor each accession, it is recommended that the level of eating maturity at the date of picking is noted against the scale in **Table 6**. It should be noted that the stage of ripening for harvest and consumption would differ for many cultivars, apart from the ‘summer-ripening’ apples. Scores of 1 or 5 should indicate that fruits are not suitable for assessment. However, except for those stated as to be measured at eating maturity, many of the characters below would be able to be assessed at harvest maturity.

Table 6. Assessment of the ripening stage (for consumption) of the fruits when picked

State	Optimal ripening stage (eating maturity) assessment
1	Much before optimal ripening stage
2	Just before optimal ripening stage
3	Optimal ripening stage
4	Just after optimal ripening stage
5	Much after the optimal ripening stage

2.1 Time of fruit ripening for harvest (harvest maturity) (*Priority 1*)

It is recommended that the optimal date of picking be recorded during at least four to six representative seasons. It should be possible to estimate the average optimal harvest date and classify accessions as per **Table 7**.

It is noted that the range below may not be wide enough to represent the full range of ripening times across Europe and this descriptor should be optimized further accordingly in the future.

Table 7. Relative harvest maturity

State	**Harvest maturity**	**Examples of reference cultivars**	**Approximate and indicative periods of picking for north-western Europe** (Lateur)	**Approximate difference to south-western Europe** (days, based on cv. Golden Delicious)
1	Extremely early	Earlier than White Transparent	July–August	More than -55
2	Very early	White Transparent	Early August	-55 to -40
3	Early	Jerseymac, Discovery, Tydeman's Early Worcester, Melba	End August	-39 to -26
4	X	James Grieve, Gravenstein, Alkmene, Transparente de Croncels, Auksis	Early September	-25 to -11
5	Medium	Gala, Elstar, Cox's Orange Pippin	Mid-September	± 10
6	X	Golden Delicious, Jonagold	End Sept–Early October	+11 to +25
7	Late	Idared, Melrose	Early October	+26 to +39
8	Very late	Fuji, Glockenapfel, Granny Smith	Mid-October	+40 to +55
9	Extremely late	Later than Fuji, Glockenapfel, Granny Smith	End October–November	> +55

'X': Intermediate rating.

2.2 Tendency to drop fruit at harvest time (*Priority 2*)

Assessment should be specific to healthy fruits (i.e. avoiding those that drop due to damage or factors other than ripening) and should be carried out at the judged time of optimal harvest as above.

Table 8. Tendency to drop fruit at harvest period.

State	Drop observed	Proportion of fruit drop at harvest (%)
1	No drop observed	0
2	Very low drop	1–10
3	Low	approx. 25–30%
4	Low to medium	X
5	Medium	approx. 50%
6	Medium to high	X
7	High	approx. 75%
8	High to very high	X
9	Very high	> 90

'X': Intermediate rating.

2.3 Precocity of fruit bearing (*Priority 2*)

Precocious trees of a given cultivar are defined as those that start to crop at an early age relative to other cultivars in a comparable situation.

Assessment should be carried out on the same rootstock, place, type of tree and year of planting. If planting was made in autumn, a score of 5 'in season of planting' should be applied for the following year. The age of the tree at planting, rootstock and other relevant factors should be noted for wider comparison.

Table 9. Relative precocity of fruit bearing

State	Precocity of fruit bearing	Observation
1	Extremely low	4 or more seasons after planting
2	Low	3 seasons after planting
3	Intermediate	2 seasons after planting
4	High	1 season after planting
5	Extremely high	In season of planting

2.4 Productivity (*Priority 2*)

Productivity can be assessed as the relative yield per tree. It is recommended that assessment be carried out over a minimum of four to six years before an average score can be allocated as per **Table 10**.

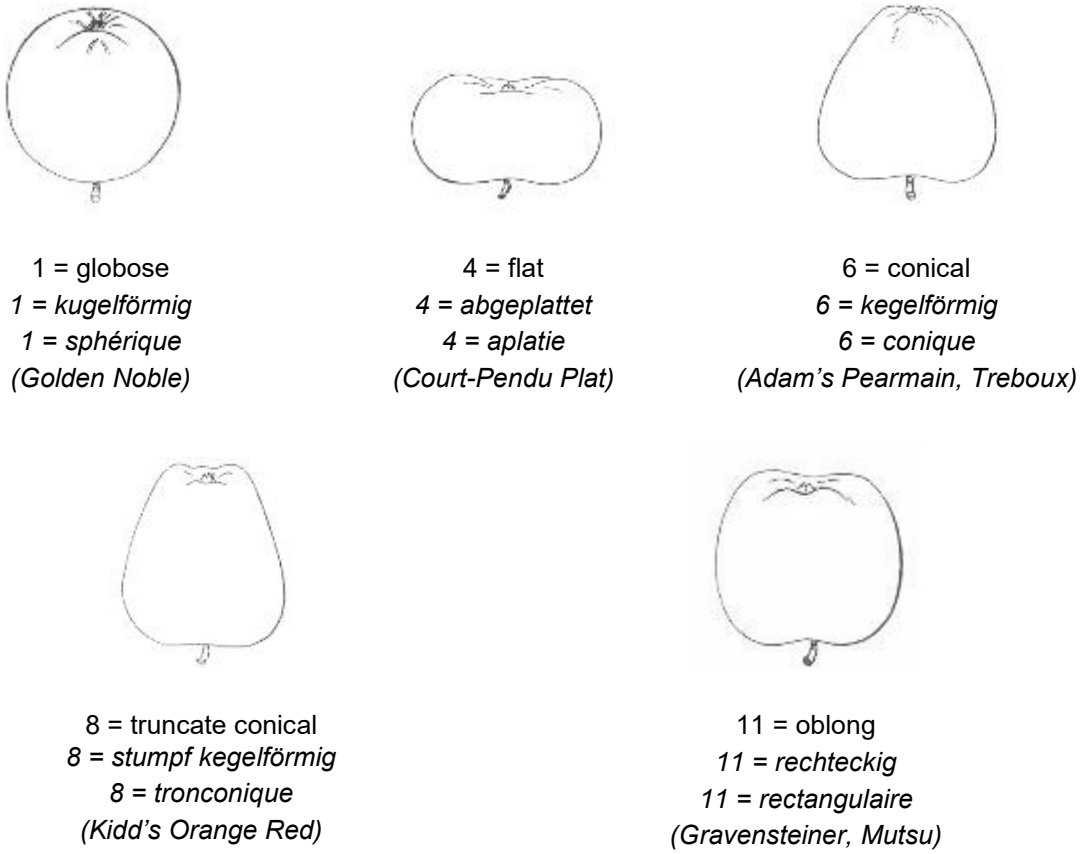
Table 10. Productivity (adapted from Watkins and Smith, 1982)

State	Productivity	Example of reference cultivars
1	Extremely low	
2	X	
3	Low	Discovery
4	X	
5	Medium	Cox's Orange Pippin, Auksis
6	X	
7	High	Golden Delicious
8	X	Greensleeves
9	Extremely high	

'X': Intermediate rating

2.5 Fruit shape (*Priority 1/2*)

We recommend, as a first characterization step, estimating to which of the main groups in **Figure 3** an accession belongs. The ratios between the fruit's height and width, and between the width of the eye basin and stalk cavity can then be estimated, or preferentially measured (further details in **Annexes 1 & 2**) and accessions can be scored using the scale given in **Table 11**.



1 = globose
1 = kugelförmig
1 = sphérique
(Golden Noble)

4 = flat
4 = abgeplattet
4 = aplatie
(Court-Pendu Plat)

6 = conical
6 = kegelförmig
6 = conique
(Adam's Pearmain, Treboux)

8 = truncate conical
8 = stumpf kegelförmig
8 = tronconique
(Kidd's Orange Red)

11 = oblong
11 = rechteckig
11 = rectangulaire
(Gravensteiner, Mutsu)

Images from: Studium der Pomologie (1877), E. Lucas (adapted by Szalatnay)

Figure 3. Global mean fruit shapes with illustration of the main fruit shapes (Szalatnay 2006).

Table 11. Fruit height/width mean ratio (adapted from Dapena et al., 2009) (***Priority 2***)

State	Ratio	Representative average estimated fruit shape	Example of reference cultivars
1	< 0.75	Flat	Court-Pendu Plat (syn. Court-Pendu Rose)
2	0.76–0.85	Slightly flat	Bramley's Seedling, Idared, Grenadier, Auksis
3	0.86–0,99	Intermediate	Cox's Orange Pippin, Golden Noble, Gravensteiner
4	1–1.1	Slightly elongated	Adams's Pearmain, Kidd's Orange Red, Jonagold, Treboux (syn. Paernu Tuvioun)
5	> 1.1	Elongated	Kent, Kandil Sinap, Melon (syn. Prinzenapfel)

Table 12. Fruit eye basin/stalk cavity width mean ratio (See Annexes 1, 2 and 3) (adapted from Dapena et al., 2009) (***Priority 3***)

State	Ratio	Representative average estimated fruit shape	Example of reference cultivars
1	< 0.715	Conical	Adams's Pearmain, Kent, Norfolk Royal
2	0.715–0.815	Truncate conical	Kidd's Orange Red
3	> 0.815	Cylindrical	Gravensteiner, Mutsu

2.6 Regularity of shape in profile (*Priority 2*)

Table 13. Fruit shape variability

State	Fruit shape variability	Example of reference cultivars
1	Regular shape	Blenheim Orange, Ingrid Marie
2	Slightly variable shape	Cox's Orange Pippin, Auksis
3	Highly variable shape	Belle-Fleur de France, Åkerö

2.7 Presence of ribs in top view (*Priority 2*) (Szalatnay, 2006).

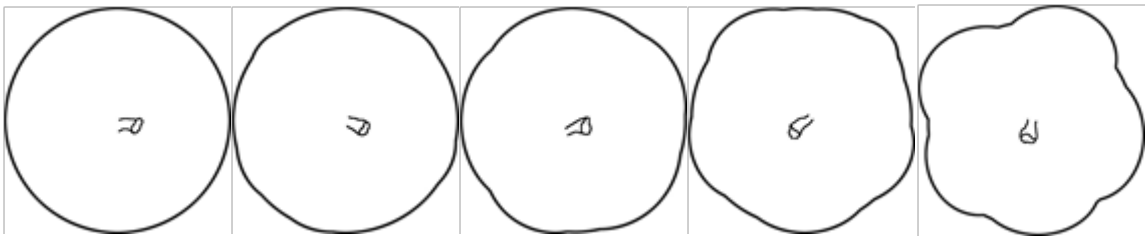


Figure 4. Presence of ribs

2.8 Fruit size (*Priority 1*)

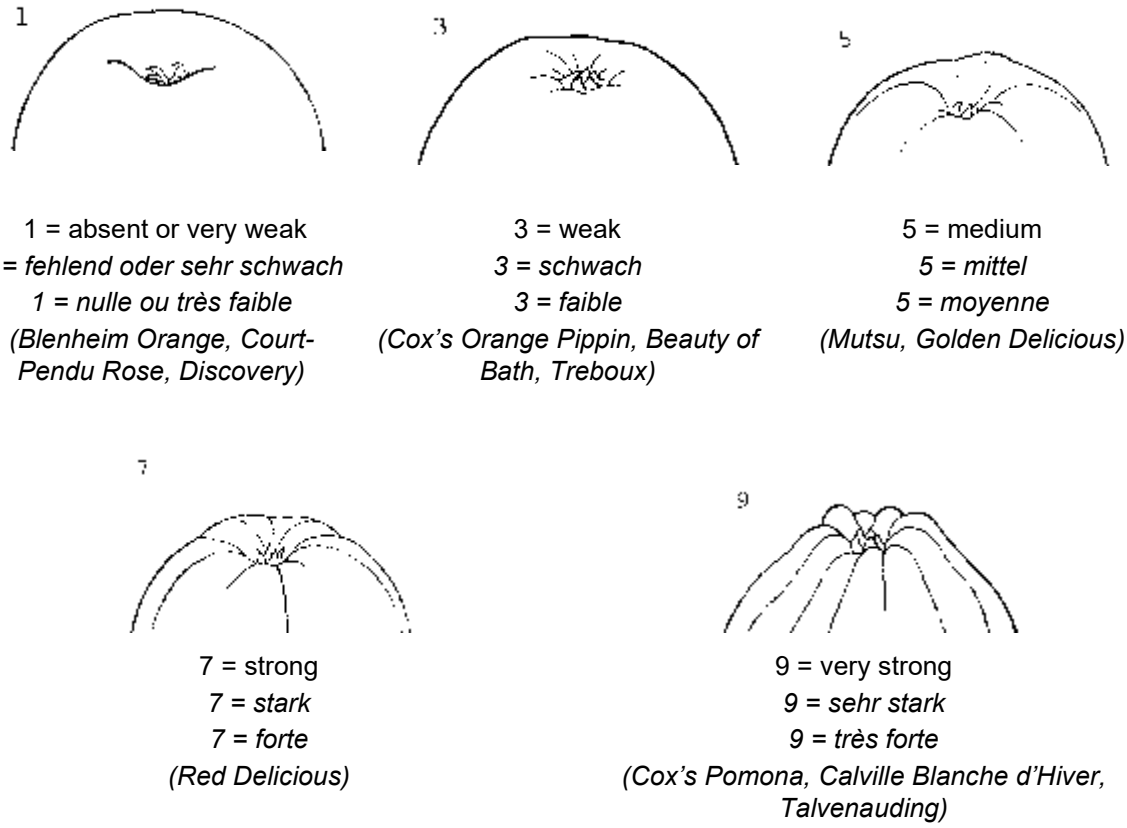
At least 12 representative fruits should ideally be evaluated over a minimum of four to six years. An average score can then be assigned according to **Table 14**. The most straightforward measure of fruit size is based on weight, but since average fruit diameter is more common in commercial classification, indicative values for both are included. It should be noted that these indicative values will differ across locations and growing systems.

Table 14. Fruit size (adapted by Szalatnay and Lateur).

State	Fruit size	Average diameter (mm)	Average weight (g)	Example of reference cultivars
1	Extremely small	< 45mm	< 40	
2	Very small	46–50	41–60	Golden Harvey, Api Etoilé
3	Small	51–55	61–80	Akane, Miller's Seedling
4	Small to medium	56–60	81–100	
5	Medium	61–70	101–150	Cox's Orange Pippin
6	Medium to large	71–80	151–200	Holsteiner Cox
7	Large	81–90	201–250	Mutsu, Boskoop
8	Very large	91–100	251–320	Bramley's Seedling
9	Extremely large	> 100	> 320	Jumbo, Howgate Wonder

2.9 Fruit crowning at apex (*Priority 2*)

Crowning should be scored relative to the images in **Figure 5** and classifications in **Table 15**. It should be noted that this character is sensitive to fruit size.



1 = absent or very weak
1 = fehlend oder sehr schwach
1 = nulle ou très faible
(Blenheim Orange, Court-Pendu Rose, Discovery)

3 = weak
3 = schwach
3 = faible
(Cox's Orange Pippin, Beauty of Bath, Treboux)

5 = medium
5 = mittel
5 = moyenne
(Mutsu, Golden Delicious)

7 = strong
7 = stark
7 = forte
(Red Delicious)

9 = very strong
9 = sehr stark
9 = très forte
(Cox's Pomona, Calville Blanche d'Hiver, Talvenauding)

Figure 5. Illustration of different types of crowning at apex of fruit (**Table 15**).

Table 15. Fruit crowning at apex

State	Crowning at apex	Example of reference cultivars
1	Absent or very weak	Charles Ross, Blenheim Orange, Court-Pendu Rose, Discovery
2	X	
3	Weak	Cox's Orange Pippin, Beauty of Bath, Treboux (syn. Paernu Tuvioun)
4	X	
5	Medium	Mutsu, Golden Delicious
6	X	
7	Strong	Red Delicious
8	X	
9	Very strong	Cox's Pomona, Calville Blanche d'Hiver, Caville Rouge d'Automne (Röd Höst Kalvil)

'X': Intermediate rating.

2.10 Colour of fruit skin - ground colour at eating maturity (*Priority 1*)

It is recommended when possible to control the judgement of colour against a standard colour chart such as the Royal Horticultural Society Colour Chart and reference to this is either included or needs to be in due course in line with UPOV (2019).

Ground colour should be scored relative to the images in **Figure 6** and classifications in **Table 16**.

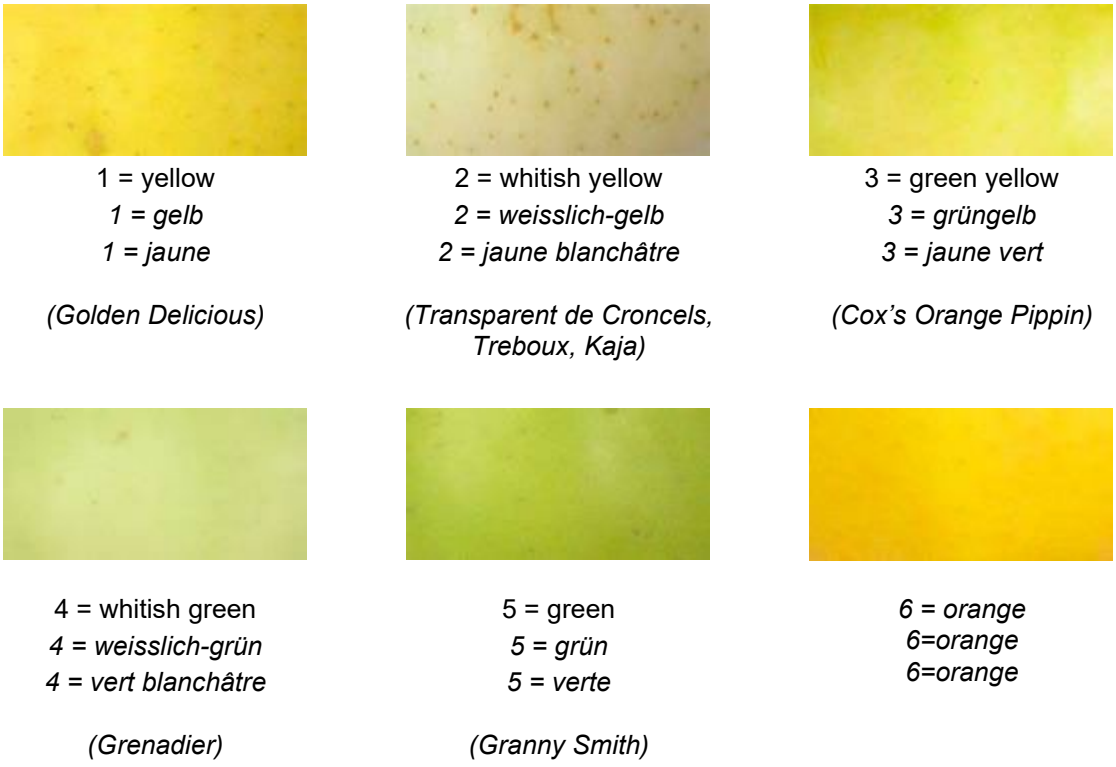


Figure 6. Illustration for fruit skin ground colours (Images: Szalatnay, 2006)

Table 16. Ground colour

State	Ground colour	**Example reference cultivars** (IBPGR, CPVO)
1	Yellow	Golden Delicious
2	Whitish yellow	
3	Green yellow	Cox's Orange Pippin
4	Whitish green	
5	Green	Granny Smith
6	(Yellow) - Orange	

2.11 Amount of over colour on fruit skin at eating maturity (*Priority 1*)

Table 17. Over colour coverage

State	Over colour coverage	Estimated percentage of coverage (%)	Example reference cultivars (UPOV)
1	Absent	0	Granny Smith, Treboux (syn. Paernu Tuvioun), Kaja,
2	Very low	1–10	
3	Low	11–25	Cox's Orange Pippin
4	Low to medium	X	
5	Medium	± 50	(Gala), Aroma, Auksis
6	Medium to high	X	Cortland
7	High	± 75	Spartan
8	High to very high	X	
9	Very high	> 90	

'X': Intermediate rating.

2.12 Over colour of the fully mature fruit skin at eating maturity (*Priority 1*)

Again, it is recommended, when possible, to control the judgement of colour against a standard colour chart such as the Royal Horticultural Society Colour Chart and reference to this is either included or needs to be in due course in line with UPOV (2019).

Over colour should be scored relative to the images in **Figure 7** and classifications in **Table 18**.

1 = orange
1 = orange
1 = orange
(Egremont Russet, Alice)

2 = pink
2 = rosa
2 = rose
(Cripps Pink, Åkerö, Aroma)

3 = red
3 = rot
3 = rouge
(Jonathan, Auksis)

4 = dark red
4 = dunkelrot
4 = rouge foncé
(Starking Delicious, Ingrid Marie)

5 = purple
5 = violett
5 = violette
(Spartan, Lobo)

6 = brownish red
6 = braunrot
6 = brun-rouge
(Lord Burghley, Ilga)

Figure 7. Illustration for fruit skin over colour assessment (adapted from Szalatnay, 2006)

Table 18. Over colour

State	Over colour	**Reference cultivars** (e.g. UPOV)
0	Absent	
1	Orange	Egremont Russet, Alice
2	Pink	Cripps Pink, Åkerö, Aroma
3	Red	Jonathan, Auksis
4	Dark red	Starking Delicious, Ingrid Marie
5	Purple	Spartan, Lobo
6	Brownish Red	Lord Burghley, Ilga

2.13 Pattern of over colour on fruit skin at eating maturity (*Priority 2*)

The predominant pattern of over colour should be scored relative to the images in **Figure 8** and classifications in **Table 19**.

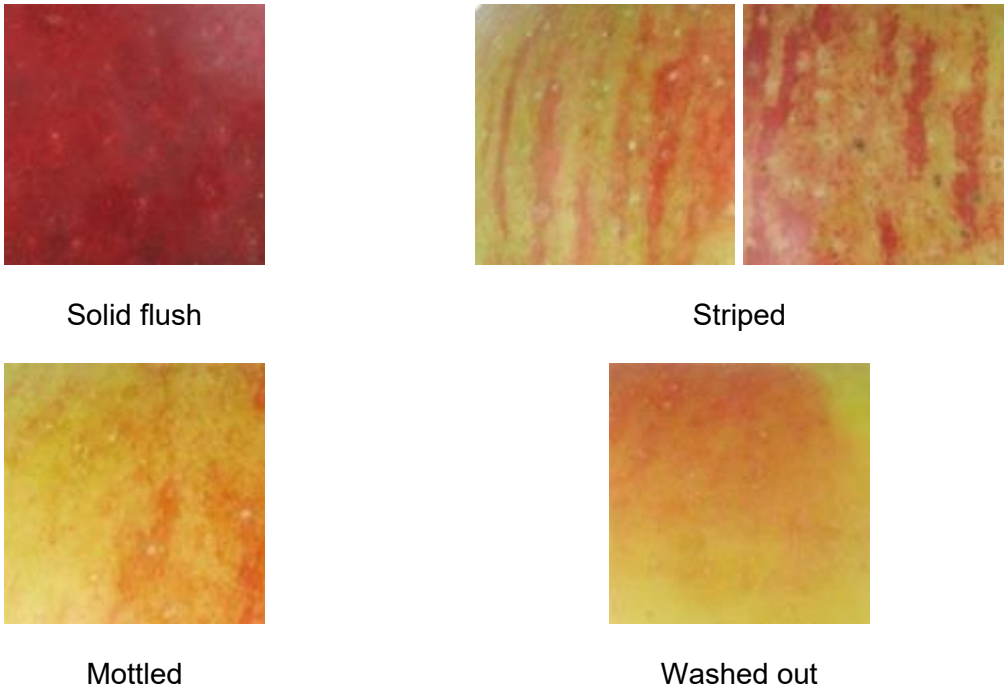


Figure 8. Illustration for fruit skin over-colour pattern assessment (adapted from Szalatnay, 2006)

Table 19. Over-colour pattern

State	Over-colour pattern	**Example of reference cultivars** (UPOV 2005)
1	Only solid flush	Richard Delicious
2	Flush with stripes	Gravensteiner
3	Only stripes	
4	Mottled	
5	Washed out	

2.14 Russet on fruit skin (*Priority 1/3*)

2.14.1 Overall amount of russet on fruit skin (*Priority 1*)

For fruit russet coverage, at least 12 representative fruits should be evaluated. An average score, including russet on cheeks, around eyes and in stalk basin is recorded at harvest, at full fruit ripeness (**Table 20**).

Table 20. Overall russet coverage

State	Russet coverage	Estimated percentage of coverage (%)	Examples of reference cultivars (CPVO-UPOV 2006)
1	Absent	0	Lobo
2	Very low	1–10	Golden Noble, Åkerö
3	Low	11–25	Cox's Orange Pippin
4	Low to medium	X	
5	Medium	± 50	Karmijn de Sonnaville, Coulon Reinette, Boskoop
6	Medium to high	X	
7	High	± 75	Zabergäu Renette
8	High to very high	X	
9	Very high	> 90	Egremont Russet, Canada Gris, Gris Braibant, Brownlee's Russet

'X': Intermediate rating.

2.14.2 Russet area around stalk cavity (adapted from Szalatnay, 2006) (*Priority 3*)

Table 21. Russet around stalk cavity

State	Russet coverage	Estimated percentage of coverage (%)
1	Absent	0
2	Very low	X
3	Low	± 25
4	Low to medium	X
5	Medium	± 50
6	Medium to high	X
7	High	± 75
8	High to very high	X
9	Very high	> 90

'X': Intermediate rating.

2.14.3 Russet area around eye basin (adapted from Szalatnay, 2006) (*Priority 3*)

Table 22. Russet around eye basin

State	Russet coverage	Estimated percentage of coverage (%)
1	Absent	0
2	Very low	X
3	Low	± 25
4	Low to medium	X
5	Medium	± 50
6	Medium to high	X
7	High	± 75
8	High to very high	X
9	Very high	> 90

'X': Intermediate rating.

2.15 Tendency for greasiness on fruit skin during storage (*Priority 3*)

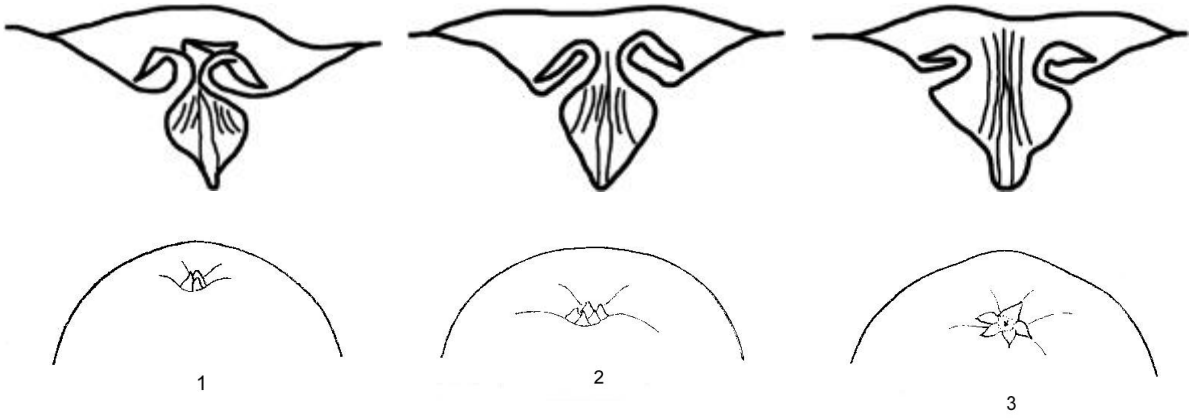
The tendency of the fruit to develop greasiness (wax) on fruit skin should be evaluated on fruits picked when fully ripe, subsequent to open storage at room temperature for at least three to four weeks (**Table 23**).

Table 23. Tendency to fruit skin greasiness (waxy skin)

State	Greasiness intensity	Example of reference cultivars
1	Absent or very low	Canada Gris, Dronning Louise
2	Medium	Boskoop, Auksis
3	Strong	Rubinola, Lord Lambourne, Jacques Lebel, Président Roulin, Lobo, Treboux (syn. Paernu Tuvioun)

2.16 Aperture of eye (*Priority 2*)

For aperture of eye, at least 6–12 representative fruits should be evaluated at full ripeness (**Figure 9**).



1 = closed *1 = geschlossen* *1 = fermé* *(Gris Braibant, Jonathan, Worcester Pearmain, Åkerö)*	2 = partly open *2 = halboffen* *2 = partiellement ouvert* *(Cox's Orange Pippin)*	3 = fully open *3 = offen* *3 = complètement ouvert* *(Court Pendu Rose, Auksis)*

Figure 9. Aperture of eye (reproduced and adapted from Szalatnay, 2006)

2.17 Length of stalk (*Priority 2*)

For length of stalk, at least 6–12 representative fruits will be evaluated at harvest (**Table 24**).

Table 24. Stalk length

State	Stalk length	Average length (mm)	Example of reference cultivars
1	Very short	0–5	Court-Pendu Rose
2	Short	6–15	Cox's Orange Pippin
3	Medium	16–25	Worcester Pearmain, Melba
4	Long	26–30	Golden Delicious
5	Very long	> 30	Rubinette, Pinova, Paide Taliõun

2.18 Flesh colour at eating maturity (*Priority 3*)

Flesh colour should be assessed at full maturity based on a transversal cut through the middle of the fruit (**Table 25** and **Figure 10**).

Table 25. Flesh colour (CPVO, 2006)

State	Flesh colour	Example of reference cultivars
1	White	Akane, Radoux, Lobo, Cortland
2	Cream	Jonagold, Auksis
3	Yellowish	Topaz
4	Greenish	Gloster, Granny Smith
5	Pinkish	Pink Pearl, Pomfit
6	Red	Geneva, Weirouge

Figure 10. Illustration for flesh colour assessment at full maturity. 1 = White, 2 = Cream, 3 = Yellowish, 4 = Greenish, 5 = Pinkish, 6 = Red (reproduced from Dapena and Fernández, 2009).

2.19 Average number of seeds (*Priority 2*)

An average of fully formed seeds from approximately ten fruits should be calculated (**Table 26**). An average lower than three indicates a likelihood that a cultivar is triploid. A complete lack of seeds can be taken as an indicator of parthenocarpy (Lateur, 1996). Note that this characteristic can be highly influenced by environmental conditions and the availability of pollen.

Table 26. Number of seeds (Adapted from Gantar, 2016)

State	Average number of well-formed seeds	Example of reference cultivars
1	0	
2	1–3	Boskoop, Jacques Lebel, Blenheim Orange
3	4–5	
5	6–10	
7	11–15	
9	> 15	

2.20 Photographs of picked fruit samples (adapted from Szalatnay, 2006) (*Priority 1*)

Samples must be representative and very young; old, high- and low-yielding trees should be avoided, along with seasons with uncharacteristic conditions. Labels should include, as a minimum: accession name, accession number, tree position and date. Photographs may be taken under natural light (avoiding early morning or late afternoon) or artificial light (including flash light in studio conditions). A standard size reference (ideally a grid) should be included and a minimum set of views (as shown in **Figure 11**) should be included. All accessions for entry into ECPGR databases should have photographs available.

Further advisory details on photography can be found in **Annex 4**.

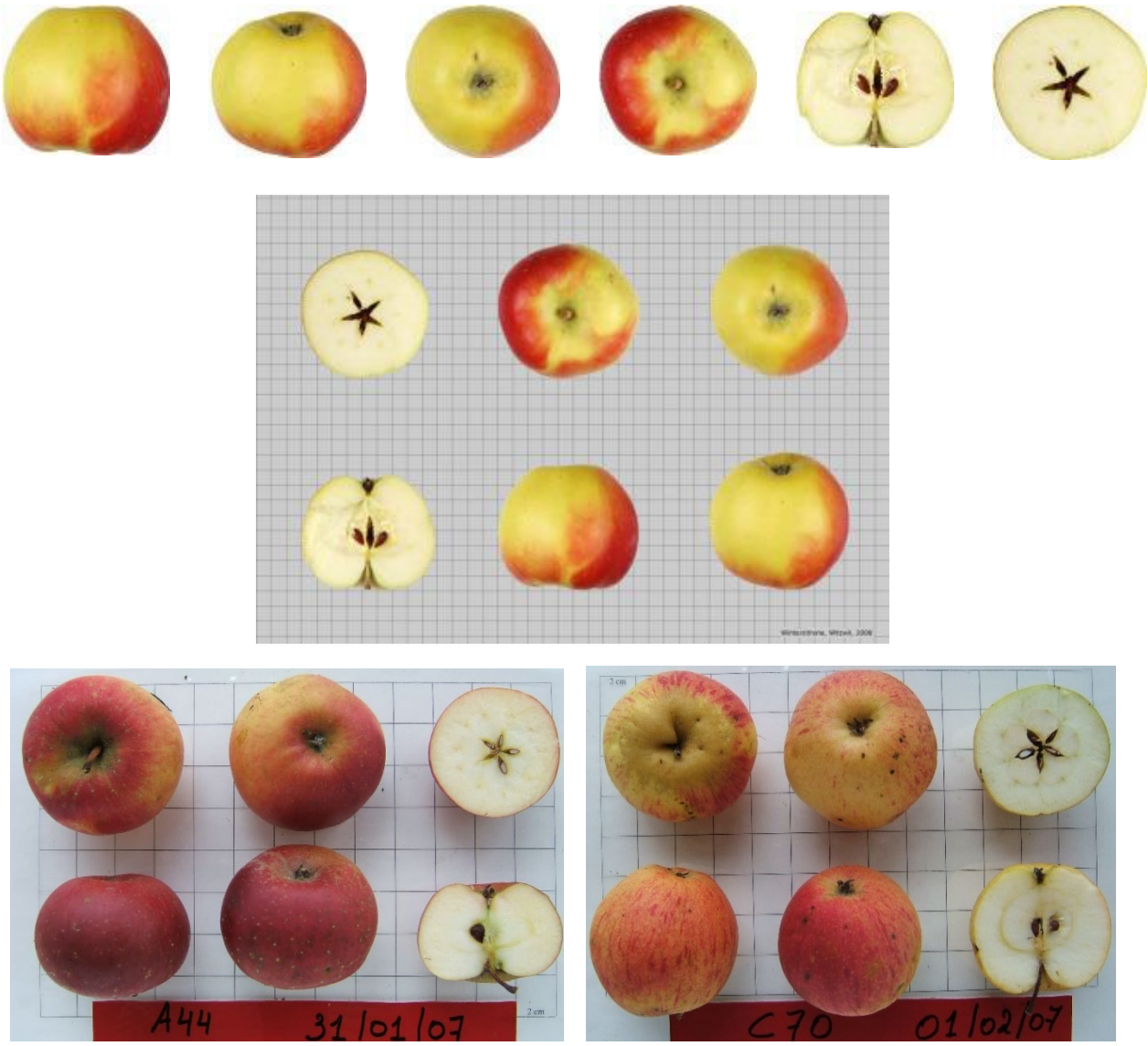


Figure 11. Examples of fruit pictures (Top photos: Courtesy of Szalatnay, 2006. Bottom photos: Courtesy of CRA-W).

2.21 Photographs of fruit hanging on the tree (*Priority 1*)

A representative fruit, or group of fruits well placed on the tree, should be selected. It is often practical to take a picture firstly of the tree label and/or the name on a list in order to trace the name of the accession. It is very important to get a clear view of the fruit eye (**Figure 12**). It is recommended to use a white panel as a natural light reflector as this can improve the precision of the fruit image.

Figure 12. Examples of apple fruit cultivars photographed on the tree (Photos: Courtesy of CRA-W).

3. Tree

3.1 Tree global architecture (*Priority 2*)

Tree architecture should be characterized when trees are at least 7–10 years old and should be scored using the UPOV classifications (**Table 27** and **Figure 13**).

Table 27. Tree architecture

State	Tree form	Example of reference cultivars (UPOV)
0	Columnar type	
1	Very upright or fastigiate	Firiki, Laine
2	X	
3	Upright	Gloster 69, Åkerö
4	X	
5	Spreading	Bramley Seedling's, Idared, Boskoop
6	X	Elstar
7	Drooping	Jonathan, Treboux, Cortland
8	X	
9	Weeping	Elisa Rathke, Kuku, Ritika

'X': Intermediate rating.

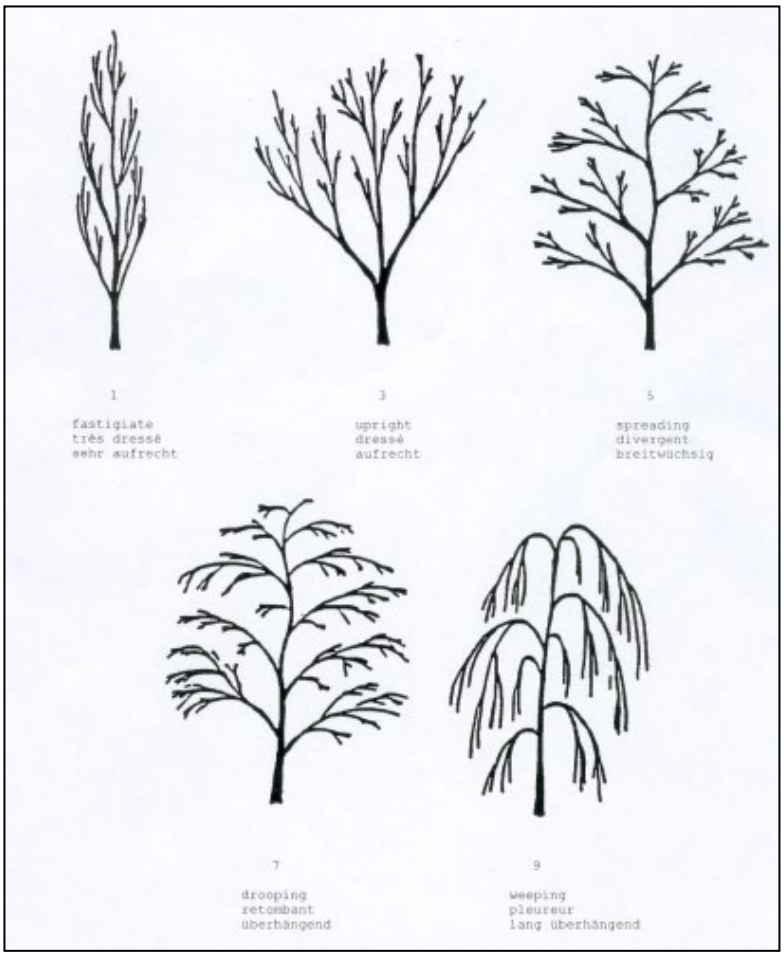


Figure 13. Global tree shape (CPVO, 2006).

3.2 Fruit-bearing habits (*Priority 2)*

Overall fruit-bearing habits can be assessed in a single year (**Table 28**). Ideally, they should be assessed on trees that have not been overly pruned and generally on established trees of 5–10 years old. For further detail of descriptions, see **Figure 14**.

Table 28. Fruit-bearing habits (Watkins and Smith, 1982)

State	Fruit-bearing type	Main fruit position	Indicative tree form	Reference cultivars
1	Columnar	On spurs only	Very few branches	Wijcik, Bolero, Waltz
2	Type I	Numerous short spurs that are long-lived. Fruit zone close to the trunk.	Upright with sparse branching and narrow crotches.	Starkrimson
3	Type II	On spurs mainly, with fruit zone moving slightly away from the trunk.	More frequent branching (than type I) resulting in tree spreading with age.	King of the Pippin (Reine des Reinettes), Cox's Orange Pippin, Blenheim Orange, Schone van Boskoop, White Transparent
4	Type III	On spurs and shoots that are 1–3 years of age. Tendency for the fruit zone to move towards the outside of the tree.	Spreading with frequent branching and wide crotches.	Golden Delicious, Jonagold, Pinova, Auksis
5	Type IV	Mostly at the end of 1-year-old shoots. Strong tendency for fruiting at the extremities of branches.	Upright main scaffold with frequent branching and narrow crotches. Tendency to droop and for the lower part of shoots to be without fruit or leaves.	Granny Smith, Tydeman's Early, Idared, Cortland

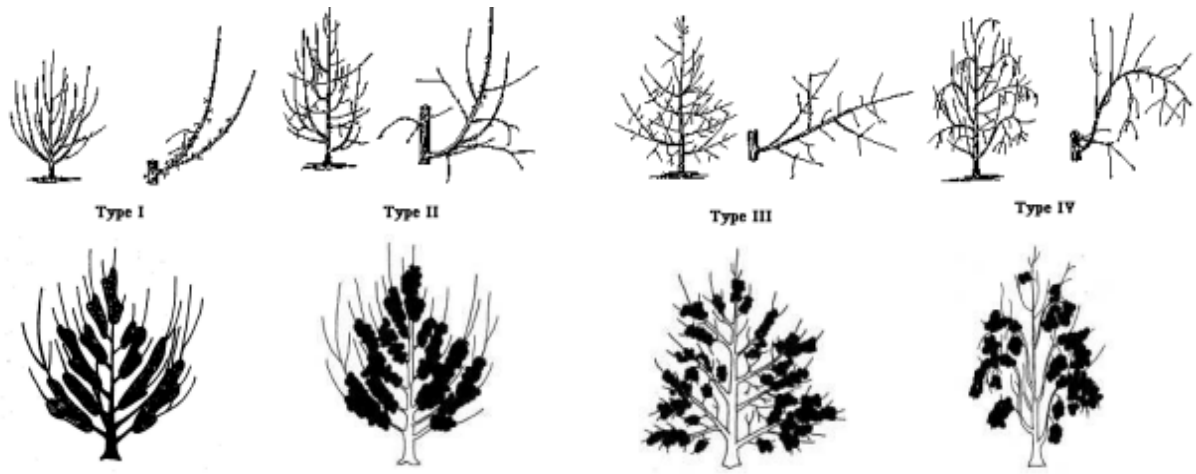


Figure 14. Types of global fruit-bearing habits (reproduced from Lespinasse, 1977).

3.3 Tree vigour (*Priority 3*)

Vigour can be assessed in a single year and should involve the assessment of height, and spread trees more than 5 years old. Comparisons to reference cultivars should be in the same place and use the same rootstock (**Table 29**).

Table 29. Tree vigour (adapted from Watkins, Smith, 1982)

State	Tree form	Example of reference cultivars
1	Extremely weak	
2	X	Discovery
3	Weak	Beauty of Bath, Grenadier, James Grieve
4	X	
5	Intermediate	Cox's Orange Pippin, Golden Delicious, Auksis
6	X	
7	Vigorous	Boskoop, Blenheim Orange
8	X	Bramley's Seedling, Åkerö
9	Extremely vigorous	

'X': Intermediate rating.

4. Disease and pest susceptibility

For pest and disease susceptibility assessment, it is particularly important to note details of the management scheme for fungicide and insecticide application for at least five years preceding the first evaluation. It is strongly recommended to not spray evaluation orchards for several seasons before the evaluation process (ideally, at least five years).

It is also important to carefully check that the pest/disease is homogeneously distributed inside the plot and useful to plant sufficient susceptible control cultivars throughout the field to help identify the occurrence of localized infections.

The most widely used assessment keys are based on a global approach for the assessment of the intensity of the pest/disease. Intensity forms the sum of two components: incidence and severity. Incidence is the qualitative 'presence' and 'absence' of symptoms (generally defined by the proportion of organs affected by at least one symptom); severity is the quantitative proportion of a surface, length or volume of an organ infected by the disease. In some instances, when more precision is needed on the type of resistance, it can be necessary to evaluate incidence and severity independently.

4.1 Scab (*Venturia inaequalis*) (*Priority 2*)

At least one observation should be made per year at the end of the growing season. If possible, though, it is recommended to assess leaf scab two or three times in the season to be able to evaluate the primary and secondary infections. It is much easier to make the assessment when leaves are dry.

The most common and easiest way for assessing the intensity of symptoms on leaves, fruits and twigs is based on the use of **global assessment** scales that take into account and integrate into one global score the incidence and severity status (**Tables 30** and **31**).

Incidence is defined as the estimated percentage of organs that express at least one clear symptom of the disease and severity refers to the estimated mean area of the majority of organs covered by clear symptoms.

Table 30. Global assessment scale for Scab infection on **leaves** (adapted from Lateur and Populer, 1996)

State	Field observations	Visual rating estimation	
		Incidence (%)	Severity (%)
1	No visible symptom	0	
2	A few small scab spots are detectable on close scrutiny of the tree	≤ 1	
3	Scab immediately apparent, with lesions very thinly scattered over the tree	> 1–5	-
4	X	X	-
5	Infection widespread over the tree, majority of leaves with at least one lesion	≥ 50	≤ 5
6	X	≥ 50	X
7	Heavy infection; multiple lesions or more large surfaces covered by scab on most leaves. Partial leaf fall	≥ 50	± 25
8	X	≥ 50	X
9	Maximum infection; leaves black with scab often fallen	≥ 50	> 75

'X': Intermediate rating.

Table 31. Global assessment scale for Scab infection on **fruits** (adapted from Lateur and Populer, 1996)

State	Field observations	Visual rating estimation	
		Incidence (%)	Severity (%)
1	No visible symptom	0	-
2	A few small scab spots are detectable on close scrutiny of the tree	≤ 1	-
3	Scab immediately apparent, with lesions very thinly scattered over the tree	> 1–5	-
4	X	X	-
5	Infection widespread over the tree, majority of fruits with at least one lesion	≥ 50	≤ 5
6	X	≥ 50	X
7	Heavy infection; multiple lesions or more large surfaces covered by scab on most fruits, some fruits with skin cracks in scabbed lesions	≥ 50	± 25
8	X	≥ 50	X
9	Maximum infection; fruits black with scab	≥ 50	> 75

'X': Intermediate rating.

Alternatively, and at a lower priority level, when a more precise approach is justified, it is recommended to separate the assessment of the two complementary components of disease intensity by making an assessment for incidence and another for severity.

The key for incidence assessment is given in **Table 32** and the key for severity assessment is given in **Table 33**.

Table 32. Incidence assessment key for apple scab, either on leaves or fruits **(*Priority 4*)**

State	Mean proportion of infected organs with at least one visible symptom on leaves or fruits (%)
1	0
2	]0–1]
3	]1–5]
4	X
5	± 25
6	X
7	± 50
8	X
9	> 90

'X': Intermediate rating.

Table 33. Severity assessment key for apple scab, either on leaves or fruits **(Priority 4).**

State	Mean proportion of scab-infected surface of leaves or fruits – on the most infected organs (%)
1	0
2	]0–1]
3	]1–5]
4	X
5	± 25
6	X
7	± 50
8	X
9	> 90

'X': Intermediate rating.

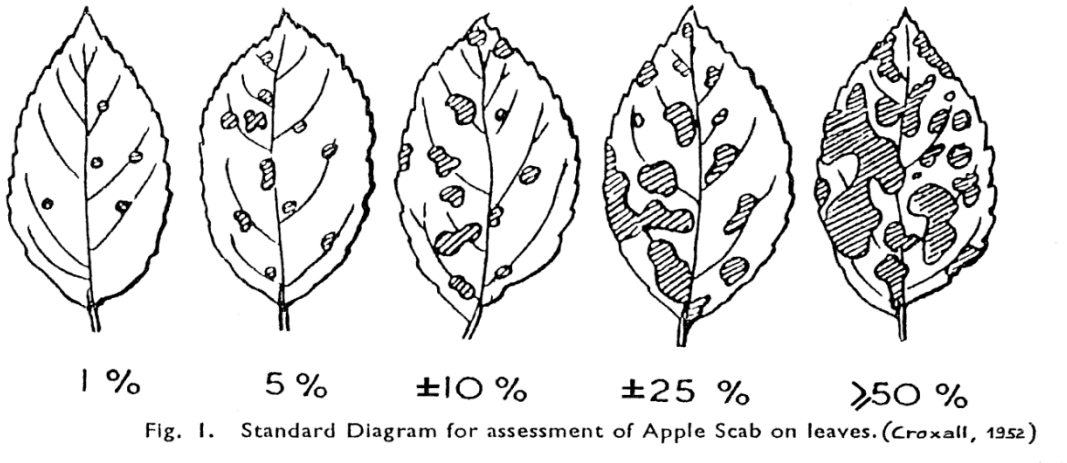


Fig. 1. Standard Diagram for assessment of Apple Scab on leaves. (Croxall, 1952)

Figure 15. Assessment of scab severity on leaves (reproduced from Croxall et al, 1952)

4.2 Powdery mildew (*Podosphaera leucotricha*) (*Priority 2*)

It is possible to carry out a single assessment during late summer to take into account both primary infections, which are the most damaging, and secondary infections (**Table 34**). If possible, two assessments would be recommended: one in spring for the primary symptoms on shoot tips and flower clusters (**Table 35**) and one during summer.

Table 34. Global assessment scale for powdery mildew infection (primary and secondary infections) on apple leaves, shoot tips and flower clusters (adapted from Lateur, 1999).

State	Field observation	Visual rating estimation Incidence of primary infection symptoms (%)
1	No visible macroscopic symptoms	-
2	Very few (0–5%) leaves with secondary infection	0
3	Secondary infections on leaves immediately apparent. Infected leaves thinly scattered over the tree (5–25%). No primary infection	0
4	Same as 3 but with a few primary infections visible	0–5
5	Widespread secondary infection over the tree. Majority of leaves with secondary infections. More twigs or flower clusters with primary infection	5–10
6	X	X
7	Heavy infection, with about half of the shoots showing primary infection	± 50
8	X	X
9	Extremely heavy infection, with nearly all twigs showing primary infection	> 90

'X': Intermediate rating.

Table 35. Primary powdery mildew infection assessment scale at end of shoots and in flower clusters

State	Field observation	Visual rating estimation Incidence of primary infection symptoms (%)
1	No visible symptom	0
2	One or very few organs affected, detectable on close scrutiny of the tree	0–1
3	Infected organs readily apparent but without important consequences for the tree	1–5
4	X	X
5	Primary mildew widespread over the branches, inducing the infection of a substantial part of the crown	± 25
6	X	X
7	Heavy infection; half of the organs are badly affected	± 50
8	X	X
9	Crown completely affected, nearly all top of the organs are infected	> 90

'X': Intermediate rating.

4.3 Neonectria canker (*Neonectria ditissima*) (*Priority 2*)

Accurate evaluation needs to take into account the homogeny distribution of the disease across the orchard; it is normally achieved when more than 50% of the trees are at least moderately infected. **Table 36** shows an assessment scale that is normally used just after leaves are fallen in autumn.

Table 36. Assessment scale for infection of *Neonectria* cankers on branches (adapted from Lateur, 1999)

State	Observation in the orchard	Visual rating estimation Incidence – Proportion of twigs and branches infected (%)
1	No visible symptoms	0
2	One or very few small cankers, detectable only on close scrutiny of the tree	0–1
3	Directly apparent cankers without important consequences for the tree	1–5
4	X	X
5	Cankers widespread over the branches, inducing the death or the ablation of a large part of the crown	± 25
6	X	X
7	Heavy infection; about half of the crown is badly affected with risk of ablation or death	± 50
8	X	X
9	Maximum infection, tree completely affected, nearly dead	> 90

'X': Intermediate rating.

4.4 Fire blight (*Erwinia amylovora*) (*Priority 2*)

Even if the EU recently (2020) classified it as a "regulated non-quarantine pest" organism (Commission Implementing Directive (EU) 2020/177), fire blight (*Erwinia amylovora)* is still a major threat to apple orchards and can have a major impact in the safe management of repository and evaluation orchards. Monitoring of the disease is needed in terms of prophylactic measures, and needs to start during the flowering period. **Table 37** shows a global assessment scale.

Table 37. Global assessment scale for the evaluation of fire blight infection (Lateur, 1999)

State	Observation in the orchard	Visual rating estimation Incidence (%)
1	No visible symptom	0
2	One or very few small infections, detectable only on close scrutiny of the tree	]0–1
3	Directly apparent infections without important consequences for the tree	]1–5
4	X	X
5	Disease widespread over the branches, inducing the death or the ablation of a large part of the crown	± 25
6	X	X
7	Heavy infection; about half of the crown is badly affected with risk of ablation or death	± 50
8	X	X
9	Maximum infection, tree completely affected, nearly dead	> 90

'X': Intermediate rating.

4.5 Blossom wilt – Infection through flowers caused by *Monilinia laxa (Priority 2)*

With climate change, Blossom wilt (formerly defined as '*Sclerotinia laxa'*) could become an emergent disease with severe impact in some regions. Heavy infections have already been observed on many cultivars, especially 'Cox's Orange Pippin', 'Lord Lambourne', 'Alkmene', 'James Grieve' and 'Ingrid Marie', which were highly susceptible.

The first symptoms are detectable approximately a week after full bloom by a wilting of the blossom trusses. The infected spurs are killed and often the fungus extends into the leaves, and the extremities of branches are killed, which may look like fire blight symptoms (Wormald, 1945).

Table 38. Blossom wilt assessment scale

State	Blossom wilt	Visual rating estimation Incidence – Proportion of blossom and ends of one-year twigs infected (%)
1	No symptom visible	0
2	Very low	0–1
3	Low	1–5
4	Low to medium	X
5	Medium	± 25
6	Medium to high	X
7	High	± 50
8	High to very high	X
9	Very high	> 90

'X': Intermediate rating.

4.6 Fruit brown rot (*Monilinia fructigena*) *(Priority 2)*

Table 39 Fruit brown rot at harvest period.

State	Brown rot	Visual rating estimation Incidence – Proportion of rotted fruits on trees (%)
1	No symptom visible	0
2	Very low	0–1
3	Low	1–5
4	Low to medium	X
5	Medium	± 25
6	Medium to high	X
7	High	± 50
8	High to very high	X
9	Very high	> 90

'X': Intermediate rating.

4.7 Anthracnose of leaves and fruits (*Elsinoë piri*) *(Priority 2)*

In recent years, anthracnose symptoms (**Figure 16**) were more often observed in a range of cultivars (Chandelier et al., 2022). Symptoms and damages could be serious. Therefore, evaluating a large diversity of apple genetic resources becomes opportune. A similar global assessment scale approach as for scab is in use. (**Tables 40** and **41**). Observation of leaves and fruits is best performed during late summer up to early autumn.

Table 40. Global assessment scale for anthracnose *(Elsinoë piri)* on **leaves** (adapted from Lateur and Populer, 1996)

State	Field observations	Visual rating estimation	
		Incidence (%)	Severity (%)
1	No visible symptom	0	
2	A few small anthracnose spots are detectable on close scrutiny of the leaves	≤ 1	
3	Anthracnose spots immediately apparent, with lesions very thinly scattered over the tree	>1–5	-
4	X	X	-
5	Infection widespread over the tree, majority of leaves with at least one anthracnose spot	≥ 50	≤ 5
6	X	≥ 50	X
7	Heavy infection; multiple anthracnose spots covering large surfaces on most leaves. Partial leaf fall.	≥ 50	± 25
8	X	≥ 50	X
9	Maximum infection; leaves surfaces covered by more than 75% with anthracnose spots	≥ 50	> 75

'X': Intermediate rating.

Table 41. Global assessment scale for anthracnose (*Elsinoë piri*) **on fruits** (adapted from Lateur and Populer, 1996)

State	Field observations	Visual rating estimation	
		Incidence (%)	Severity (%)
1	No visible symptom	0	-
2	A few small anthracnose spots are detectable on close scrutiny of the fruits	≤ 1	-
3	Anthracnose spots immediately apparent, with lesions very thinly scattered over the fruits on the tree	>1–5	-
4	X	X	-
5	Infection widespread over the tree, majority of fruits with at least one anthracnose spot	≥ 50	≤ 5
6	X	≥ 50	X
7	Heavy infection; multiple anthracnose spots of larger importance covering a quarter up to a third of the surfaces on most fruits, some fruits with skin cracks in anthracnose spots	≥ 50	± 25
8	X	≥ 50	X
9	Maximum infection; more than 75% of fruit surfaces covered with anthracnose spots; many fruits with skin cracks and/or sunken anthracnose spots	≥ 50	> 75

'X': Intermediate rating.

Figure 16. Photos of a diversity of intensity of anthracnose symptoms (*Elsinoë piri*) on fruits and leaves (Photos: Courtesy of CRA-W).

4.8 Rosy aphid (*Dysaphis plantagina*) (*Priority 3*)

Rosy aphids symptoms should be evaluated (**Table 42**) during the late spring period; after this critical period, it becomes difficult to properly assess the degree of infection. Infection can be initially identified by the curling of leaves.

Table 42. Rosy aphid on leaves and fruits (adapted from Lateur, 1999)

State	Observation in the orchard	Visual rating estimation Incidence (%)
1	No visible symptom	0
2	One or very few foci, detectable only on close scrutiny of the tree	]0–1
3	Directly apparent foci without important consequences for the tree	]1–5
4	X	X
5	Number of foci widespread over the branches, inducing the curling of leaves	± 25
6	X	X
7	Heavy infection; about half of the leaves/fruits is badly affected	± 50
8	X	X
9	Maximum infection, tree completely affected, nearly all organs with symptoms	> 90

'X': Intermediate rating.

NB: *Other pests or diseases susceptibility assessments may be developed following the same scoring principle.*

4.9 Global tree foliage health (*Priority 3*)

Assessment should be based on overall appearance, and will represent a combination of disease tolerance, robustness and good nutrient uptake efficiency indicated by healthy green leaves (**Table 43**).

Table 43. Global tree foliage health

State	Appearance
1	**Extremely low** health foliage (> 90% of leaves **suffering** diverse foliar deficiencies)
2	X
3	**Low health** foliage (± 75% of leaves **suffering** diverse foliar deficiencies)
4	X
5	**Medium** health foliage (± 50% of leaves **without** foliar deficiency)
6	X
7	**High health** foliage (± 75% of leaves **without** foliar deficiency)
8	X
9	**Extremely high health** foliage (> 90% of leaves **without any** foliar deficiency)

'X': Intermediate rating.

5. Fruit quality traits

As an initial evaluation procedure, sensory assessment is simple and efficient; it provides relative values that simulate the consumer habit, but it requires some experience. In principle, a first sensory analysis can be performed directly in the orchard in front of the tree (depending on the level of ripeness).

When assessing fruit quality by sensorial approach, it is important to select a representative sample of fruit at eating maturity and neutralize the influence of the sample previously tasted, since this could affect the assessment. The sensorial analysis should be ideally performed by two people and the fruit should be tasted with and without the skin.

Accurately predicting ripening times is difficult and it is recommended to use a simple method for defining the optimal picking date and to note the actual level of maturity at the date of picking by using the scale in **Table 6**.

Many apples need to be picked at their correct maturity stage and have to be stored in a cool room, cellar or fridge for a number of days, weeks or even months before they will reach their optimal ripeness for eating. Some cultivars are not suitable for fresh consumption before having matured. Periodically, fruits should be inspected and the change in ground colour can be used as an indication of the maturity stage. The greenish ground colour starting to turn yellow is a useful indication. This can be cultivar specific, and for some cultivars, the assessment must be carried out earlier; for others, it is necessary to wait until the ground colour becomes fully yellow.

The use of instrumental measurements can be more precise but much more time-consuming although recommendations for these are also provided. General rules and methods recommended for the instrumental fruit trait analysis are defined in the CTIFL reference publication (Vaysse and Landry, 2004).

In general, the sample of fruit should be taken from the upper part of the fruit, on the sunny side.

Ideally, each trait linked with fruit-eating quality needs to be performed at the optimal fruit ripening stage.

Many old apple cultivars were only used for cooking, baking (compotes, cakes, pies,…) or other simple processing methods (drying, juice, cider, syrup, etc.). These specific quality traits are not taken into account in the present document.

5.1 Fruit firmness

5.1.1 Using a penetrometer (*Priority 2*)

Following the protocol described by Watkins and Smith (1982), assessments should be done, as a minimum, at picking time, on a sample of at least six fruits, making two opposite measurements at the widest part of the fruit. Measurements should be taken on both sides of the fruits (for bi-coloured fruit, at the borders between the over-coloured zone and ground colour).

Ideally, a second set of measurements should be taken at eating maturity (if this differs from harvest maturity). In all cases, an 11mm probe should be used and skin should be removed.

The data are expressed as kg/cm^2. Approximate values are included within the scale in **Table 44**.

5.1.2 Sensory analysis (*Priority 1*)

Firmness should be assessed at eating maturity by evaluating the relative force needed for masticating a bit of fruit (**Table 44**).

Table 44. Fruit firmness sensory assessment scale and measured with a penetrometer

State	Fruit firmness	Example reference cultivars	Mean value firmness (kg/cm^2)
1	Extremely soft		< 2
2	Very soft	White Transparent	2–3
3	Soft		3–4
4	X	Elstar, Cox's Orange Pippin	4–5
5	Intermediate	Jonagold, Golden Delicious, Topaz, Auksis	5–6
6	X		6–7
7	Firm	Pinova, Pilot	7–8
8	Very firm	Goldrush	8–9
9	Extremely firm		> 9

'X': Intermediate rating.

5.2 Skin thickness (*Priority 3*)

Skin thickness should be scored by sensory assessment based on the resistance to masticating the skin. (**Table 45**).

Table 45. Sensory evaluation of relative fruit skin thickness

State	Skin thickness	Example reference cultivars (UPOV, Szalatnay)
1	Extremely thin	
2	Very thin	White Transparent
3	Thin	
4	X	
5	Medium	
6	X	
7	Thick	Cortland, Delicious
8	Very thick	Jonathan
9	Extremely thick	

'X': Intermediate rating.

5.3 Flesh sweetness *(Priority 1/2)*

5.3.1 Sensory analysis (*Priority 2*)

Table 46. Flesh sweetness sensory assessment scale at optimal eating maturity

State	Sweetness	Refractometer (°Brix)
1	Extremely low	< 10
2	Very low	10–12.5
3	Low	12.5–13,5
4	X	
5	Intermediate	13.5–15
6	X	
7	High	15–17
8	Very high	17–20
9	Extremely high	> 20

'X': Intermediate rating.

5.3.2 Refractometer method (*Priority 2*)

In a laboratory: this should be carried out at optimal eating time on a sample of at least six representative fruits. Juice should be extracted using standard protocols with either a press or extractor, and measurements should be taken at room temperature. Standard protocols extract juice from two slices/fruit – with a press or an extractor – and then make the measurement on the obtained juice with a refractometer at room temperature.

In the field: the simplest method is to place on the refractometer a mix of at least six droplets of juice extracted by pressure between the thumb and index finger from pieces of different representative fruits. Alternatively, a glass stick can be inserted into the fruit at two opposite sites situated at the widest part of the fruit in order to extract droplets.

Scores should be expressed as °Brix and can be compared to **Table 46**.

5.4 Flesh acidity

5.4.1 Sensory analysis (*Priority 2*)

Table 47. Flesh acidity sensory assessment scale

State	Flesh intensity of acidity
1	Extremely low acidity
2	Very low acidity
3	Low acidity
4	X
5	Intermediate acidity
6	X
7	High acidity
8	Very high acidity
9	Extremely high acidity

'X': Intermediate rating.

5.4.2 Measurement with a pH meter (*Priority 3*)

Measurements should be taken on juice from a sample of at least six representative fruits using juice extraction techniques as for flesh sugar measurement.

5.4.3 Measurement by titration (*Priority 3*)

Standard methods (Vaysse, Landry, 2004) should be used, with titration using NaOH. Data should be expressed in g Malic acid/l, g Sulphuric acid/l or meq/l (milliequivalents/litre).

Table 48. Acidity by pH measurement or titration

State	Flesh Acidity	pH	g/l of Malic acid	g/l of sulphuric acid	meq/l
1	Extremely low				
2	Very low				
3	Low	> 3,8	≤ 4,0	≤ 2,94	≤ 60
4	X				
5	Intermediate	3,5–3,4	4,0–6,0	2,94–4,41	60–90
6	X				
7	High	3,3–3,1	6,0–8,0	4,41–5,88	90–120
8	Very high	< 3,0	> 8,0	> 5,88	> 120
9	Extremely high				

'X': Intermediate rating.

5.5 Ratio between acidity and sweetness (*Priority 1*)

When tasting a sample of fruit at eating maturity, a general impression of the balance between acidity and sweetness should be scored (**Table 49**).

Table 49. Ratio acidity/sweetness of flesh sensory assessment scale

State	Acidity/sweetness	Example of reference cultivars
1	Extremely more acid than sweet	
2	Much more acid than sweet	Bramley's Seedling, Antonovka
3	More acid than sweet	Boskoop
4	X	Elstar
5	Good balance acid/sugar	Cox's Orange Pippin, Auksis
6	X	Jonagold
7	More sweet than acid	Golden Delicious, Pinova
8	Much more sweet than acid	Fuji, Starkrimson, Gala
9	Extremely more sweet than acid	

'X': Intermediate rating.

5.6 Flesh juiciness (*Priority 1*)

Sensory assessment should be made of the quantity of juice extracted from a sample of fruit when it is masticated (**Table 50**).

Table 50. Sensory assessment scale for flesh juiciness in apple

State	Flesh juiciness	Example of reference cultivars
1	Extremely low	
2	Very low	Cripps Pink
3	Low	Pinova, Revaler Birnapfel
4	X	
5	Intermediate	
6	X	
7	High	Gravensteiner Scifresh, Delcorf (Delbarestivale)
8	Very high	
9	Extremely high	

'X': Intermediate rating.

5.7 Flesh crunchiness (*Priority 2*)

Crunchiness should be assessed as the sustained granular resistance of flesh during mastication. It can be distinguished from crispness, in that crispness is generally associated with brittleness and the shattering of food and is short-lived. Crunchiness can also be identified by the noise made during mastication (**Table 51**).

Table 51. Sensory assessment scale for flesh crunchiness

State	Flesh crunchiness	Example of reference cultivars
1	Extremely low	
2	Very low	
3	Low	
4	X	
5	Intermediate	Pinova, Mutsu, Auksis
6	High	
7	Very high	Gravensteiner, Scifresh, Delcorf (Delbardestivale)
8	X	
9	Extremely high	Honey Crisp

'X': Intermediate rating.

5.8 Flesh bitterness (*Priority 3*)

Should be assessed sensorially based on **Table 52**.

Table 52. Sensory assessment scale for flesh bitterness

State	Bitterness	Example of reference cultivars
1	Extremely low	Gala, Auksis
2	Very low	
3	Low	
4	X	Jonagold, Orlik
5	Medium	Starkrimson
6	X	
7	High	
8	Very high	
9	Extremely high	

'X': Intermediate rating.

5.9 Tendency for flesh to become mealy (*Priority 3*)

Mealiness should be assessed as the flesh becoming dryer, softer and often of coarse texture. It should be assessed (**Table 53**) at the end of the eating maturity period, and ideally after a period of storage (it is important to note which).

Table 53. Sensory assessment scale for flesh mealiness

State	Tendency to become mealy	Example of reference cultivars
1	Extremely low	Scifresh, Sinap Orlovski
2	Very low	Pinova
3	Low	Reinette de France, Auksis
4	X	
5	Intermediate	Jonagold
6	X	
7	High	Jacques Lebel, Revaler Birnapfel
8	Very high	White Transparent
9	Extremely high	

'X': Intermediate rating.

5.10 Fruit flesh texture (*Priority 3*)

The fineness or coarseness of flesh texture should be assessed sensorially and scored according to **Table 54**.

Table 54. Sensory assessment scale for fruit flesh texture

State	Flesh texture	Example reference cultivars
1	Extremely fine	
2	Very Fine	
3	Rather fine	
4	X	
5	Intermediate	
6	X	
7	Coarse	
8	Very coarse	
9	Extremely coarse	

'X': Intermediate rating.

5.11 Intensity of fruit aroma (*Priority 1*)

Should be assessed as the aromatic taste of fruit at optimal eating maturity (**Table 55**). Obviously, there are different types of aroma and the assessment should be a quantitative assessment of intensity rather than characterize types of aroma.

Table 55. Sensory assessment scale for intensity of fruit aroma

State	Intensity of aroma	Example of reference cultivars
1	Extremely low	
2	Very low	
3	Low	
4	X	Golden Delicious
5	Medium	Auksis
6	X	Cox's Orange Pippin
7	High	
8	Very high	Aroma, Ellison's Orange
9	Extremely high	

'X': Intermediate rating.

5.12 Overall fruit quality (*Priority 1*)

It is an obvious hedonic and relative global evaluation of the fruit quality based on multi criteria analysis. An assessment should be made of the overall quality of the fruit at eating maturity, taking into account all the individual quality traits. It is important to maintain an objective and comparative approach and to avoid being influenced by personal tastes (**Table 56**).

Table 56. Sensory assessment scale for overall fruit quality

State	Overall fruit quality	Example reference cultivars
1	Extremely poor	
2	Very poor	
3	Poor	
4	Poor to good	
5	Good	Red Delicious
6	Good to very good	Golden Delicious
7	Very good	McIntosh
8	X	Cox's Orange Pippin
9	Extremely good	

'X': Intermediate rating.

5.13 Fruit storage capacity

5.13.1 Storage life in natural cellar conditions (*Priority 2*)

Assessment should be made on a sample of 20–40 fruits by monitoring the increase in the percentage of decayed fruits and classifying them according to **Table 57**. The limit of storability should be considered to be met when more than 50% of the fruits are no more eatable.

It is important to record the date of harvesting, temperature and humidity, and it is important to note fungicide treatments applied prior to harvest. It is also valuable to note the internal fruit quality in order to define the best period for consumption during storage.

Table 57. Storage life in cellar conditions

State	Storage life	**Example of reference cultivars** (UPOV, Szalatnay)	**Indicative keeping period** in Northwestern Europe (Lateur)
1	Extremely short	Close, Vista Bella	Earlier than mid-August
2	Very short	White Transparent	Mid to end-August
3	Short	Discovery, Tydeman's Early Worcester	September
4	X	Alkmene	October
5	Medium	Gala, Elstar, Cox's Orange Pippin	November
6	X		December
7	Long	Golden Delicious, Jonagold	January
8	Very long	Fuji, Glockenapfel	February–March
9	Extremely long	Granny Smith, Président Van Dievoet ('Cabarette'), Marie Joseph d'Othée, Gueule de Mouton	April and later

'X': Intermediate rating.

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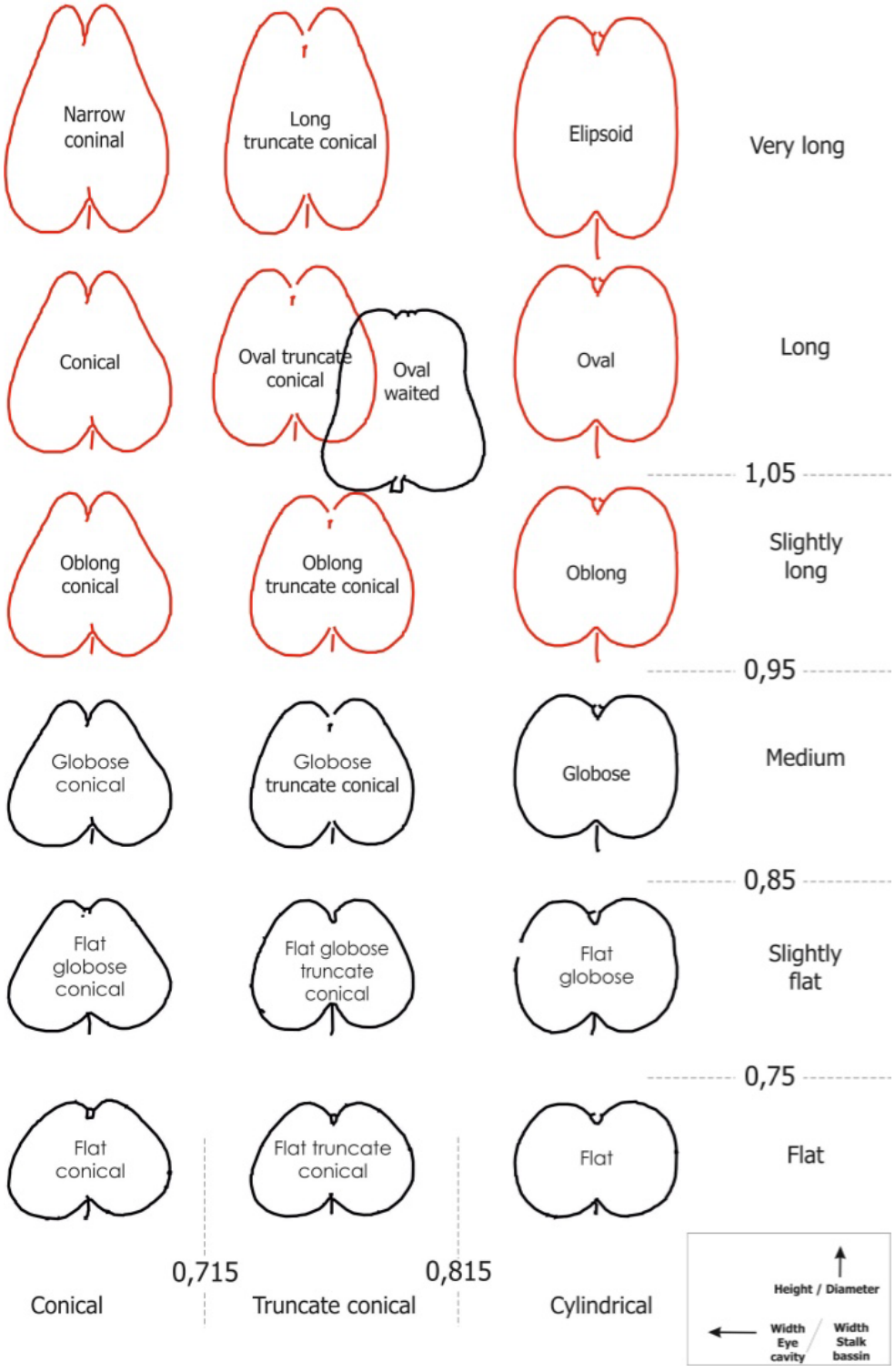
Annex 1. Illustration of fruit general shapes (a)

Illustration of fruit general shapes in function of the relation height/diameter and of the ratio of width of the eye basin/width of the stalk cavity (adapted from Dapena et al., 2009).

Annex 2. Illustration of fruit general shapes (b)

Illustration of fruit general shapes in function of the relation height/diameter and of the ratio of width of the eye basin/width of the stalk cavity (Dapena et al., 2009).



Annex 3. Measuring width and depth of eye basin and stalk fruit cavity

Illustration (**Figure 17**) of how to measure the width and depth of the eye basin and stalk cavity of the fruit (Dapena and Fernández, 2009).

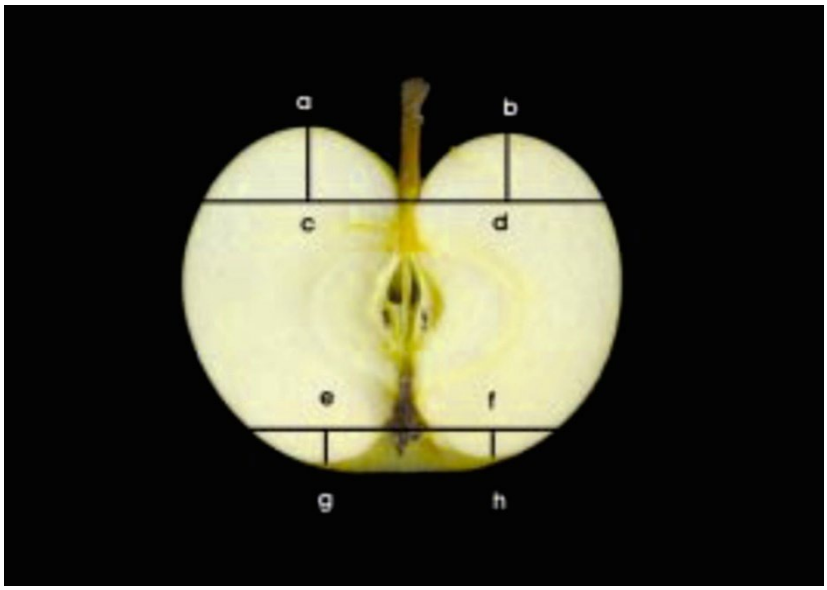


Figure 17. Measurement of width and depth of basin and stalk fruit cavities (Dapena et al., 2009)

Annex 4. Further guidance on photography

Correct camera settings are essential. **Figure 18** shows how to do it correctly.

Camera settings	✓	✗
Focus		
Exposure		
White balance		

Figure 18. Correct camera settings (Szalatnay, 2006)

Suggested camera settings

-F25

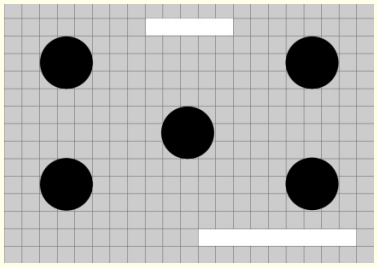
-1/640

-ISO100

Photographs can be taken in two different ways (**Figures 19** and **20**):

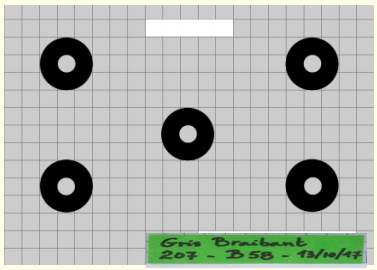
- The first option is appropriate if photographs are needed for a database only
- The second option is appropriate if pictures need to be used for high-quality printing and/or as a reference for identification/verification.

Option 1. Taking all views at once (Szalatnay, 2006)



Print templates available at http://www.clg-champollion-voisins.ac-versailles.fr/IMG/pdf/papiers_millimetres-2.pdf

Attach template on a cardboard box and put holes in cardboard box and template at places where fruits need to be placed



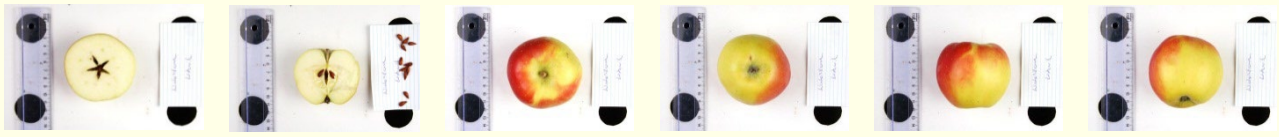
Print templates available at: http://www.clg-champollion-voisins.ac-versailles.fr/IMG/pdf/papiers_millimetres-2.pdf

Use rings (plastic, metal, model clay, …) to place fruits in the right spots

Put label with: Accession name, accession number, Tree ID, date.

Option 2. Taking all views separately, create a picture with photo-editing software

Take a photograph of every view/angle separately



Resize every picture and cut out the fruit with photo-editing software (Adobe Photoshop or other)

Combine photographs into a picture

Main advantage: → much higher quality

Figure 19. Illustration of the different steps to taking fruit pictures

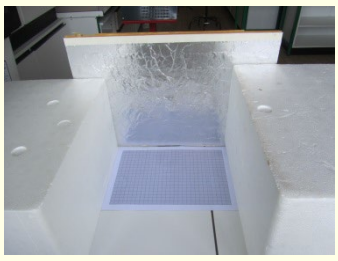
As an alternative, another less sophisticated option for taking fruit picture is building a simple natural 'light chamber', as illustrated in **Figure 20**.

Choose a room with large windows oriented north or north-west, place a table near the window and build a 'light chamber' with sides being either white or covered with aluminium film. Leave an opening in front of the window as illustrated below.

In north-western European countries, the best quality pictures are obtained between around 10:00 am and 15:00 pm.

1. View of the handmade light chamber

Build your light chamber in front of a north/north-east window.

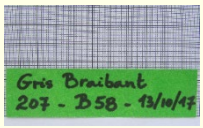


Print grey template available at http://www.clg-champollion-voisins.ac-versailles.fr/IMG/pdf/papiers_millimetres-2.pdf and place it in front of the backplate.

2. Fruit arrangement, label and taking pictures

Use rings (plastic, metal, model clay, etc.) to place fruits at the right spots (here plums as examples).

Put a label with: accession name, accession number, Tree ID, date.



Take the picture in a perpendicular position with adapted camera tuning and having prior to that regulated the 'white balance'.

Figure 20. Illustration of an alternative way to take fruit pictures. Pictures courtesy of M. Lateur.