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UPOV

INTERNATIONAL UNION FOR THE PROTECTION OF NEW VARIETIES OF PLANTS
Geneva

ENLARGED EDITORIAL COMMITTEE

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TGP DOCUMENTS

Document prepared by the Office of the Union

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EXECUTIVE SUMMARY

1.   The purpose of this document is to provide an overview and to present proposals that would be made to the TC at its fifty-second session concerning revisions of TGP documents.

2.   The structure of this document is as follows:

3.   The following abbreviations are used in this document:

CAJ: Administrative and Legal Committee
TC: Technical Committee
TC-EDC: Enlarged Editorial Committee
TWA: Technical Working Party for Agricultural Crops
TWC: Technical Working Party on Automation and Computer Programs
TWF: Technical Working Party for Fruit Crops
TWO: Technical Working Party for Ornamental Plants and Forest Trees
TWV: Technical Working Party for Vegetables
TWPs: Technical Working Parties

I.   MATTERS FOR ADOPTION BY THE COUNCIL IN 2016

4.   The TC, at its fifty-first session, and the CAJ, at its seventy-first session, approved the program for the development of TGP documents, as set out in the Annex to documents TC/51/39 and CAJ/71/7, respectively (see document TC/51/39 "Report", paragraph 171, and document CAJ/71/12 "Report", paragraph 88, respectively).

5.   The following revisions of TGP documents were agreed to be proposed for adoption by the Council at its fiftieth ordinary session, to be held in Geneva on October 27, 2016:

TGP/7: Development of Test Guidelines

   (i)   Coverage of the Test Guidelines

6.   The TC, at its fifty-first session, agreed to add new standard wording in the TG template, Chapter 4.2 "Uniformity", and amend ASW 8 (c) to provide guidance for Test Guidelines that are developed on the basis of varieties with one type of propagation when varieties may be developed in the future with other types of propagation in a future revision of document TGP/7, as follows:

   "New standard wording: TG template, Chapter 4.2:

      "These Test Guidelines have been developed for the examination of [*type or types of propagation*] varieties. For varieties with other types of propagation the recommendations in the General Introduction and document TGP/13 'Guidance for new types and species', Section 4.5: 'Testing Uniformity' should be followed."

   "ASW 8 (c)

      "(c)   Uniformity assessment by off-types (all characteristics observed on the same sample size)

      "For the assessment of uniformity of [self-pollinated] [vegetatively propagated] [seed-propagated] varieties, a population standard of { x } % and an acceptance probability of at least { y } % should be applied. In the case of a sample size of { a } plants, [{ b } off-types are] / [1 off-type is] allowed."

7.   The following proposals for revision of document TGP/7 will be considered on the basis of the indicated documents:

   (ii)   Use of Proprietary Photographs and Illustrations in Test Guidelines
          See document TC-EDC/Jan16/3

   (iii)   Regional Sets of Example Varieties
          See document TC-EDC/Jan16/4

TGP/8: Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability

   (iv)   New Section: Examining Characteristics Using Image Analysis

8.   Annex I to this document contains a revision already agreed by the TC for document TGP/8 Part II: Selected Techniques Used in DUS Examination, New Section: Examining Characteristics Using Image Analysis.

9.   The following proposal for revision of document TGP/8 will be considered on the basis of the indicated document:

>   *(v)   New Section: Minimizing the Variation due to Different Observers of the Same Trial*
>   See document TC-EDC/Jan16/5

TGP/0: List of TGP Documents and Latest Issue Dates

10.   The Council will be invited to adopt document TGP/0/9, in order to reflect the revisions of TGP documents (see document TC/51/39 "Report", paragraph 113).

II.   FUTURE REVISION OF TGP DOCUMENTS

11.   The following future revisions of TGP documents were agreed to be considered by the TC at its fifty-second session:

TGP/7: Development of Test Guidelines

>   *(i)   Drafter's Kit for Test Guidelines*

TGP/8: Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability

>   *(ii)   The Combined-Over-Years Uniformity Criterion (COYU)*

>   *(iii)   Examining DUS in Bulk Samples*

>   *(iv)   Data Processing for the Assessment of Distinctness and for Producing Variety Descriptions*

TGP/10: Examining uniformity

>   *(v)   New section: Assessing Uniformity by Off-Types on Basis of More than One Growing Cycle or on the Basis of Sub-Samples*

III.   PROGRAM FOR THE DEVELOPMENT OF TGP DOCUMENTS

12.   Annex II to this document presents the program for the development of TGP documents as agreed by the TC, as its fifty-first session, and the CAJ, at its seventy-first session and proposals made by the TWPs, at their sessions in 2015 (see document TC/51/39 "Report", paragraph 171, and document CAJ/71/10 "Report on the Conclusions", paragraph 78).

>   *13.   The TC-EDC is invited to note the information in this document to be presented to the TC and propose any improvements to the document in that regard.*

[Annexes follow]

EXAMINING CHARACTERISTICS USING IMAGE ANALYSIS

INTRODUCTION

1.   Section III of document TGP/12/1 Draft 7 "Special Characteristics" reads:

"Characteristics which may be examined by image analysis should also be able to be examined by visual observation and/or manual measurement, as appropriate. Explanations for observing such characteristics, including where appropriate explanations in Test Guidelines, should ensure that the characteristic is explained in terms which would enable the characteristic to be understood and examined by all DUS experts."

2.   Combined characteristics

       2.1   The General Introduction (document TG/1/3, Chapter 4, Section 4) states that:

              '4.6.3   Combined Characteristics

              '4.6.3.1 A combined characteristic is a simple combination of a small number of characteristics. Provided the combination is biologically meaningful, characteristics that are assessed separately may subsequently be combined, for example the ratio of length to width, to produce such a combined characteristic. Combined characteristics must be examined for distinctness, uniformity and stability to the same extent as other characteristics. In some cases, these combined characteristics are examined by means of techniques, such as Image Analysis. In these cases, the methods for appropriate examination of DUS are specified in document TGP/12, 'Special Characteristics'.'

       "2.2   Thus, the General Introduction clarifies that the use of image analysis is one possible method for examining characteristics which fulfill the basic requirements for use in DUS testing (see document TG/1/3, Chapter 4.2), which includes the need for the uniformity and stability of such characteristics to be examined. With regard to combined characteristics, the General Introduction also explains that such characteristics should be biologically meaningful."

3.   Image analysis is the extraction of information (e.g. plant measurements) from (digital) images by means of a computer. Image analysis is used in plant variety testing to help in the assessment of plant characteristics. It can be regarded as an intelligent measurement device (advanced ruler). This document aims to give guidance when using image analysis in plant variety testing.

4.   Image analysis can be used in a fully automated or semi-automated way. When fully automated, the expert just records images of plant parts with a camera or scanner and the computer automatically calculates relevant characteristics without human interference. In a semi-automated way, the computer shows the images on a screen and a user can interact with the software to measure specific plant parts, e.g. by clicking with a mouse.

IMAGE RECORDING: CALIBRATION AND STANDARDIZATION

5.   An important aspect to consider when recording and analyzing digital images is standardization and calibration in cases where image analysis is automated. Standardization is done by using as much as possible the same setup (illumination, camera, camera-settings, lens, perspective, and object-camera distance) for every recording. It is important to check that the recordings are done according to a prescribed protocol, as the software may depend on it. For example, pods may have to be orientated horizontally in the

images, with the beaks pointing to the left. Calibration of the system is needed to make the recording as much as possible independent of any varying conditions by correcting for the variations, e.g. in size or color.

6.   Size calibration is necessary. Since the measure unit in pictures is the pixel, a relation needs to be established between the pixels on the image and millimeters. A standard way to perform this calibration is to include a ruler in every recorded image, at the same distance from the camera as the plant part being recorded. In that case the user can relate the size of the ruler to the number of pixels, and make the calibration manually. A preferred way is to use an object of standard dimensions, e.g. a coin, which can automatically be analyzed with the software and then used for an implicit size calibration. A coin also allows checking if pixels are square (i.e. if the aspect ratio of every pixel is 1:1). In all cases, the object should be sufficiently close to the calibration object and sufficiently far from the camera, to minimize the effect of varying magnification with distance. Alternatively a telecentric lens could be used to minimize this effect.

7.   Illumination calibration is also necessary: an object has to be segmented from the background in the image. An often used and very simple way to do this, is to use thresholding: a pixel with a (grey) value above a certain threshold is considered an object pixel and below the threshold a background pixel (or vice versa). If the illumination is not constant, it may occur that the segmentation is not optimal for every image and that part of the pixels are assigned to the wrong class (object/background), even if the threshold value is determined automatically. This may result in erroneous measurements. It is therefore advisable to check the segmentation results by having a quick look at the segmented binary images.

8.   In many situations only a silhouette/contour of the plant material is necessary, e.g. for size and shape. In these cases it is often advisable to use a background illumination, e.g. a light box. This will increase the contrast between the background and the object, and make the segmentation result much less dependent on the threshold value.

9.   It should be ensured that the lighting is homogenously distributed over the image. Darker parts in the image may result in a wrong segmentation and hence lead to incorrect and incomparable measures, especially when multiple objects are recorded in the same image.

10.   For colors and (variegation or blush) patterns on the plant part, it is essential that the illumination is done correctly and checked regularly, preferably for every image. In that case illumination calibration can be done by recording (part of) a standard color chart in the image. Special algorithms are available to correct for color changes due to differing illumination conditions, but in many situations this correction causes some loss of precision.

COLOR CALIBRATION CHART

11.   The light source is of large influence on the observed color in the image. Especially for color, the type of light source is important. In many cases, lamp color and intensity change during warming up of the lamps which should consequently sufficiently be warmed up before starting the recordings. If fluorescent tubes are used, it should regularly be verified that they have more or less the same intensity/color, as they may change rather rapidly with age. Calibration charts can be used to this purpose.

12.   Especially when recording shiny objects like apples or certain flowers, specular reflection needs to be taken into account. Objects with specular spots cannot be measured reliably. In such cases, attention should be paid to uniform and indirect illumination, using special light tents.

13.   Both (color) cameras and scanners can be used for image recording. The choice is dependent on the application and the preference of the user. Other more advanced systems, such as 3D cameras or hyperspectral cameras are not yet used in standard plant variety testing.

ANALYSIS OF STANDARD UPOV CHARACTERISTICS

14.   In general image analysis is used to automate the measurement of characteristics described in the guidelines of UPOV. In that case the aim is to replace a hand measurement by a computer measurement. This requires an additional calibration in addition to the image recording calibration. The measurements can then be checked with manual measurements for consistency, e.g. by a scatterplot of hand versus computer measurement with a regression line and the line y=x.

15.   In some cases, image analysis requires a more precise and mathematical definition of the characteristic than is required for human experts. E.g. the length of the pod can be redefined as the length of the medial axis of the pod, excluding the stem. In such cases, there is a special need to check for differences in behavior for different genotypes (bias). The measurement for some genotypes may be exactly the same, whereas for others a systematic difference may be present. A nice example is for determining the bulb height in onions (van der Heijden, Vossepoel and Polder, 1996), where the top of the bulb was defined as the bending point of the shoulder. As long as such a change or refinement of the definition of a characteristic is known and accounted for, this is not a problem. In general, it is advisable to consult the crop experts for redefining a characteristic and check if a minor modification of the guideline might be necessary.

16.   In some cases the object consists of different parts which have to be measured separately, e.g. the pod, beak and stem of a pod of French bean. This requires a special algorithm to separate the different parts (distinguish stem and beak from the pod) and this has to be tested extensively on a large number of genotypes in the reference collection, to be sure that the implementation is robust over the entire range of expressions.

17.   Shape characteristics can also be measured with image analysis, but in general it will be restricted to characteristics already in the guideline, e.g. by defining the shape as the ratio between length and width.

18.   Although color is a standard UPOV characteristic, and could be measured by image analysis, it is not used often. In most cases, crop experts still rely on visual observation with RHS colour charts.

ANALYSIS OF NON STANDARD CHARACTERISTICS

19.   In addition to standard characteristics, image analysis offers the possibility to assess more complex characteristics which could be more difficult to observe visually or to measure. E.g. the total shape distribution of an onion can be described by storing the onion width along the different positions of the length axis, the ground coverage of foliage could be observed more precisely than with a visual observation, disease resistance could be assessed in measuring the area of infection on a leaf or the curvature of the perimeter of leaves could help assessing the fineness of foliage.

CONCLUSIONS

20.   Image analysis is used for measurements and to automate, at least partially, the assessment of characteristics. It requires a good and precise definition of the characteristic, computerization using existing

or ~~home-made~~ in-house software, a good preparation of samples, checking with existing procedures, careful calibration and standardization. It often necessitates therefore an investment which can only be profitable versus hand assessment of characteristics if it concerns a significant number of measurements or measurements which are difficult and time consuming to assess by the examiner. In case of organs of a small size, seed size for example, image analysis will be more precise and more reliable.

21.   Image analysis offers the possibility to store information: images can be recorded and analyzed at a later stage in order to avoid peaks of work and they can be retrieved at a later stage to compare varieties for example in case of doubt.

22.   Today it is mainly used for size and shape features but with the development of techniques, it will be possible to use it for a wider range of standard UPOV characteristics in future.

REFERENCES

van der Heijden, G., A. M. Vossepoel & G. Polder (1996) Measuring onion cultivars with image analysis using inflection points. *Euphytica,* 87**,** 19-31.

[Annex II follows]

TC-EDC/Jan16/2
ANNEX II
PROGRAM FOR TGP DOCUMENTS

Title of document	Current approved documents	2016					2017						2018					
		TC-EDC	TC/52	TWPs	CAJ/72	C/50	TC-EDC	TC/53	CAJ/73	TWPs	CAJ/74	C/51	TC-EDC	TC/54	CAJ/75	TWPs	CAJ/76	C/52
TGP/0 List of TGP Documents and Latest Issue Dates	TGP/0/8 ADOPTED					TGP/0/9 Adopt												TGP/0/10 Adopt
TGP/1 General Introduction with Explanations	-	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
TGP/2 List of Test Guidelines Adopted by UPOV	TGP/2/2 ADOPTED																	
TGP/3 Varieties of Common Knowledge	C(Extr.)/19/2 Rev.																	
TGP/4 Constitution and Maintenance of Variety Collections	TGP/4/1 ADOPTED																	
TGP/5 Experience and Cooperation in DUS Testing	ADOPTED																	
TGP/6 Arrangements for DUS Testing	ADOPTED																	
TGP/7 Development of Test Guidelines	TGP/7/4 ADOPTED																	
Drafter's Kit for Test Guidelines (Drafter: Office of the Union)			TC/52/5	x			x	x		x			x	x	x			TGP/7/6 Adopt
Coverage of the Test Guidelines (Drafter: Office of the Union)	Approved by TC	TC-EDC/Jan16/2	TC/52/15		x	TGP/7/5 Adopt												
Use of Proprietary Text, Photographs and Illustrations in Test Guidelines (Drafter: Office of the Union)		TC-EDC/Jan16/3	TC/52/14		x	TGP/7/5 Adopt												
Regional Sets of Example Varieties (Drafter: Office of the Union)		TC-EDC/Jan16/4	TC/52/15		x	TGP/7/5 Adopt												
TGP/8 Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability	TGP/8/2 ADOPTED																	
Examining characteristics using image analysis (document TC-EDC/Jan16/2 Annex I)	Approved by TC	TC-EDC/Jan16/2	TC/52/5		x	TGP/8/3 Adopt												
Minimizing variation due to different observers (Drafter: Nik Hulse (Australia))		TC-EDC/Jan16/5	TC/52/16		x	TGP/8/3 Adopt												
Method of Calculation of COYU (Drafter: Adrian Roberts (United Kingdom))			TC/52/17	x				x		x			x	x	x			TGP/8/4 Adopt
Examining DUS in Bulk Samples (Drafter: Office of the Union)			TC/52/18	x				x		x			x	x	x			TGP/8/4 Adopt
Data Processing for the Assessment of Distinctness and for Producing Variety Descriptions (Drafter: Office of the Union)			TC/52/19	x				x		x			x	x	x			TGP/8/4 Adopt
TGP/9 Examining Distinctness	TGP/9/2 ADOPTED																	
TGP/10 Examining Uniformity	TGP/10/1 ADOPTED																	
Assessing Uniformity by Off-types on the Basis of More than One Growing Cycle or on the Basis of Sub-Samples (Drafter: Office of the Union)			TC/52/20	x				x		x			x	x	x			TGP/10/2 Adopt
TGP/11 Examining Stability	TGP/11/2 ADOPTED																	
TGP/12 Guidance on Certain Physiological Characteristics	TGP/12/2 ADOPTED																	
TGP/13 Guidance for New Types and Species	TGP/13/1 ADOPTED																	
TGP/14 Glossary of Terms Used in UPOV Documents	TGP/14/3 ADOPTED																	
TGP/15 Guidance on the Use of Biochemical and Molecular Markers in the Examination of Distinctness, Uniformity and Stability (DUS)	TGP/15/1 ADOPTED																	

[End of Annex]