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REVISION OF DOCUMENT TGP/8:
PART I: DUS TRIAL DESIGN AND DATA ANALYSIS
New Section 2 – Data to be Recorded

Document prepared by an expert from Germany

BACKGROUND

1. The Technical Committee (TC), at its forty-eighth session, held in Geneva from March 26 to 28, 2012, agreed that New Section 2- “Data to be recorded”, with certain improvements to the structure and the removal of duplications, could be considered by the Technical Working Parties (TWPs) in 2012 and by the TC at its forty-ninth session, for adoption as a revision of document TGP/8/1. It agreed that the next draft should be prepared by Mr. Uwe Meyer (Germany), in conjunction with the Office of the Union (see document TC/48/22 “Report on conclusions” paragraph 50).

2. The Annex to this document contains the proposed text for New Section 2 – Data to be recorded, prepared by Mr. Uwe Meyer (Germany).

[Annex follows]

PROPOSED TEXT FOR:TGP/8/1: PART I: NEW SECTION 2: DATA TO BE RECORDED

2.1 Introduction

Document TGP/9 Examining Distinctness, sections 4.4 and 4.5 provide the following guidance on the type of observation for distinctness in respect to the type of characteristic and the method of propagation of the variety:

"4.4 Recommendations in the UPOV Test Guidelines

"The indications used in UPOV Test Guidelines for the method of observation and the type of record for the examination of distinctness, are as follows:

"Method of observation

"M: to be measured (an objective observation against a calibrated, linear scale e.g. using a ruler, weighing scales, colorimeter, dates, counts, etc.);
"V: to be observed visually (includes observations where the expert uses reference points (e.g. diagrams, example varieties, side-by-side comparison) or non-linear charts (e.g. color charts). "Visual" observation refers to the sensory observations of the expert and, therefore, also includes smell, taste and touch.

"Type of record(s)

"G: single record for a variety, or a group of plants or parts of plants; "S: records for a number of single, individual plants or parts of plants

"For the purposes of distinctness, observations may be recorded as a single record for a group of plants or parts of plants (G), or may be recorded as records for a number of single, individual plants or parts of plants (S). In most cases, "G" provides a single record per variety and it is not possible or necessary to apply statistical methods in a plant-by-plant analysis for the assessment of distinctness.

"4.5 Summary

"The following table summarizes the common method of observation and type of record for the assessment of distinctness, although there may be exceptions:

	Type of expression of characteristic		
Method of propagation of the variety	QL	PQ	QN
Vegetatively propagated	VG	VG	VG/MG/MS
Self-pollinated	VG	VG	VG/MG/MS
Cross-pollinated	VG/(VS*)	VG/(VS*)	VS/VG/MS/MG
Hybrids	VG/(VS*)	VG/(VS*)	**

* Records of individual plants only necessary if segregation is to be recorded.
** To be considered according to the type of hybrid."

2.2 Types of expression of characteristics

2.2.1 Characteristics can be classified according to their types of expression. The following types of expression of characteristics are defined in the General Introduction to the Examination of Distinctness, Uniformity and Stability and the Development of Harmonized Descriptions of New Varieties of

Plants, (document TG/1/3, the "General Introduction", Chapter 4.4):

2.2.2 Qualitative characteristics" (QL) are those that are expressed in discontinuous states (e.g. sex of plant: dioecious female (1), dioecious male (2), monoecious unisexual (3), monoecious hermaphrodite (4)). These states are self-explanatory and independently meaningful. All states are necessary to describe the full range of the characteristic, and every form of expression can be described by a single state. The order of states is not important. As a rule, the characteristics are not influenced by environment.

2.2.3 "Quantitative characteristics" (QN) are those where the expression covers the full range of variation from one extreme to the other. The expression can be recorded on a one-dimensional, continuous or discrete, linear scale. The range of expressions is divided into a number of states for the purpose of description (e.g. length of stem: very short (1), short (3), medium (5), long (7), very long (9)). The division seeks to provide, as far as practical, an even distribution across the scale. The Test Guidelines do not specify the difference needed for distinctness. The states of expression should, however, be meaningful for DUS assessment.

2.2.4 In the case of "pseudo-qualitative characteristics" (PQ) the range of expression is at least partly continuous, but varies in more than one dimension (e.g. shape: ovate (1), elliptic (2), circular (3), obovate (4)) and cannot be adequately described by just defining two ends of a linear range. In a similar way to qualitative (discontinuous) characteristics – hence the term "pseudo-qualitative" – each individual state of expression needs to be identified to adequately describe the range of the characteristic.

2.3 Types of scales of data

2.3.1 The possibility to use specific procedures for the assessment of distinctness, uniformity and stability depends on the scale level of the data which are recorded for a characteristic. The scale level of data depends on the type of expression of the characteristic and on the way of recording this expression. The type of scale may be nominal, ordinal, interval or ratio.

2.3.2 Data from qualitative characteristics

2.3.2.1 Data results from qualitative characteristics are nominal scaled data without any logical order of the discrete categories. They result from visually assessed (notes) qualitative characteristics.

Examples:

Type of scale	Example	Example number
nominal	Sex of plant	1
nominal with two states	Leaf blade: variegation	2

For description of the states of expressions, see Table 6.

2.3.2.2 A nominal scale consists of numbers which correspond to the states of expression of the characteristic, which are referred to in the Test Guidelines as notes. Although numbers are used for designation there is no logical order for the expressions and so it is possible to arrange them in any order.

2.3.2.3 Characteristics with only two categories (dichotomous characteristic) are a special form of a nominal scaled characteristic.

2.2.2.4 The nominal scale is the lowest classification of the scales (Table 1). Few statistical procedures are applicable for evaluations (section 2.3.8 *[cross ref.]*).

2.3.3 Data from quantitative characteristics

2.3.3.1 Data results from quantitative characteristics are metric (ratio or interval) or ordinal scaled data.

2.3.3.2 Metric scaled data are all data which are recorded by measuring or counting. Weighing is a special form of measuring. Metric scaled data can have a continuous or a discrete distribution.

Continuous metric data result from measurements. They can take every value out of the defined range. Discrete metric data result from counting.

Examples

Type of scale	Example	Example number
Continuous metric	Plant length in cm	3
Discrete metric	Number of stamens	4

For description of the states of expression, see Table 6.

2.3.3.3 The continuous metric scaled data for the characteristic “Plant length” are measured on a continuous scale with defined units of assessment. A change of unit of measurement e.g. from cm into mm is only a question of precision and not a change of type of scale.

2.3.3.4 The discrete metric scaled data of the characteristic “Number of stamens” are assessed by counting (1, 2, 3, 4, and so on). The distances between the neighboring units of assessment are constant and for this example equal to 1. There are no real values between two neighboring units but it is possible to compute an average which falls between those units.

2.3.3.5 Metric scales can be subdivided into ratio scales and interval scales.

2.3.3.6 Ratio scale

2.3.3.6.1 A ratio scale is a metric scale with a defined absolute zero point. There is always a constant non-zero distance between two adjacent expressions. Ratio scaled data may be continuous or discrete.

The absolute zero point:

2.3.3.6.2 The definition of an absolute zero point makes it possible to define meaningful ratios. This is a requirement for the construction of indexes, which are the combination of at least two characteristics (e.g. the ratio of length to width). In the General Introduction, this is referred to as a combined characteristic (see document TG/1/3, section 4.6.3).

2.3.3.6.3 It is also possible to calculate ratios between expressions of different varieties. For example, in the characteristic ‘Plant length’ assessed in cm, there is a lower limit for the expression which is ‘0 cm’ (zero). It is possible to calculate the ratio of length of plant of variety ‘A’ to length of plant of variety ‘B’ by division:

Length of plant of variety ‘A’ = 80 cm
Length of plant of variety ‘B’ = 40 cm
Ratio = Length of plant of variety ‘A’ / Length of plant of variety ‘B’
= 80 cm / 40 cm
= 2.

2.3.3.6.4 So it is possible in this example to state that plant ‘A’ is double the length of plant ‘B’. The existence of an absolute zero point ensures an unambiguous ratio.

2.3.3.6.5 The ratio scale is the highest classification of the scales (Table 1). That means that ratio scaled data include the highest information about the characteristic and it is possible to use many statistical procedures (section 2.3.8 *[cross ref.]*).

2.3.3.6.6 The examples 3 and 4 (Table 6) are examples for characteristics with ratio scaled data.

2.3.3.7 Interval scale

2.3.3.7.1 An Interval scale is a metric scale without a defined absolute zero point. There is always a constant non-zero distance between two adjacent units. Interval scaled data may be distributed continuously or discretely.

2.3.3.7.2 An example for a discrete interval scaled characteristic is 'Time of beginning of flowering' measured as date which is given as example 5 in Table 6. This characteristic is defined as the number of days from April 1. The definition is useful but arbitrary and April 1 is not a natural limit. It would also be possible to define the characteristic as the number of days from January 1.

2.3.3.7.3 It is not possible to calculate a meaningful ratio between two varieties which is illustrated by the following example:

Variety 'A' begins to flower on May 30 and variety 'B' on April 30

Case I) Number of days from April 1 of variety 'A' = 60
Number of days from April 1 of variety 'B' = 30

$$\text{Ratio}_{\text{I}} = \frac{Number\ of\ days\ from\ April\ 1\ of\ variety\ 'A'}{Number\ of\ days\ from\ April\ 1\ of\ variety\ 'B'} = \frac{60\ days}{30\ days} = 2$$

Case II) Number of days from January 1 of variety 'A' = 150
Number of days from January 1 of variety 'B' = 120

$$\text{Ratio}_{\text{II}} = \frac{Number\ of\ days\ from\ January\ 1\ of\ variety\ 'A'}{Number\ of\ days\ from\ January\ 1\ of\ variety\ 'B'} = \frac{150\ days}{120\ days} = 1.25$$

$\text{Ratio}_{\text{I}} = 2 > 1.25 = \text{Ratio}_{\text{II}}$

2.3.3.7.4 It is incorrect to state that the time of flowering of variety 'A' is twice that of variety 'B'. The ratio depends on the choice of the zero point of the scale. This kind of scale is defined as an "Interval scale": a metric scale without a defined absolute zero point.

2.3.3.7.5 The interval scale is lower classified than the ratio scale (Table 1). At the interval scale, no useful indexes can be formed such as ratios. The interval scale is theoretically the minimum scale to calculate arithmetic mean values.

2.3.3.8 Ordinal scale

2.3.3.8.1 Discrete categories of ordinally scaled data can be arranged in an ascending or descending order. They result from visually assessed (notes) quantitative characteristics.

<u>Example</u>:

Type of scale	Example	Example number
ordinal	Intensity of anthocyanin	6

For description of the states of expressions, see Table 6

2.3.3.8.2 An ordinal scale consists of numbers which correspond to the states of expression of the characteristic (notes). The expressions vary from one extreme to the other and thus they have a clear logical order. It is not important which numbers are used to denote the categories. In some cases ordinal data may reach the level of discrete interval scaled data or of discrete ratio scaled data (section 2.3.8 *[cross ref.]*).

2.3.3.8.3 The distances between the discrete categories of an ordinal scale are not exactly known and not necessarily equal. Therefore, an ordinal scale does not fulfil the condition to calculate arithmetic mean values, which is the equality of intervals throughout the scale.

2.3.3.8.4 The ordinal scale is lower classified than the interval scale (Table 1). Less statistical procedures can be used for ordinal scale than for each of the higher classified scale data (section 2.3.8 *[cross ref.]*).

2.3.4 Data from <u>pseudo-qualitative characteristics</u>

2.3.4.1 Data results from pseudo-qualitative characteristics are nominal scaled data without any logical order of <u>all</u> discrete categories. They result from visually assessed (notes) qualitative characteristics.

<u>Examples</u>:

Type of scale	Example	Example number
nominal	Shape	7
nominal	Flower color	8

For description of the states of expressions, see Table 6.

2.3.4.2 A nominal scale consists of numbers which correspond to the states of expression of the characteristic, which are referred to in the Test Guidelines as notes. Although numbers are used for designation there is no inevitable order for <u>all</u> of the expressions. It is possible to arrange only some of them in an order.

2.3.4.3 The nominal scale is the lowest classification of the scales (Table 1). Few statistical procedures are applicable for evaluations (section 2.3.8 *[cross ref.]*).

2.3.5 The different types of scales are summarized in the following table:

<u>Table 1: Types of expressions and type of scales</u>

Type of expression	Type of scale	Description	Distribution	Data recording	Scale Level
QN	ratio	constant distances with absolute zero point	Continuous	Absolute Measurements	High
			Discrete	Counting	
	interval	constant distances without absolute zero point	Continuous	Relative measurements	↑
			Discrete	Date	
	ordinal	Ordered expressions with varying distances	Discrete	Visually assessed notes	↑
PQ or QL	nominal	No order, no distances	Discrete	Visually assessed notes	Low

2.3.6 Scale levels for variety description

The description of varieties is based on the states of expression (notes) which are given in the Test Guidelines for the specific crop. In the case of visual assessment, the notes from the Test Guidelines are usually used for recording the characteristic as well as for the assessment of DUS. The notes are distributed on a nominal or ordinal scale (see Part I: section 4.5.4.2 *[cross ref.]*). For measured or counted characteristics, DUS assessment is based on the recorded values and the recorded values are transformed into states of expression only for the purpose of variety description.

2.3.7 Relation between types of expression of characteristics and scale levels of data

2.3.7.1 Records taken for the assessment of qualitative characteristics are distributed on a nominal scale, for example "Sex of plant", "Leaf blade: variegation" (Table 6, examples 1 and 2).

2.3.7.2 For quantitative characteristics the scale level of data depends on the method of assessment. They can be recorded on a metric (when measured or counted) or ordinal (when visually observed) scale. For example, "Length of plant" can be recorded by measurements resulting in ratio scaled continuous metric data. However, visual assessment on a 1 to 9 scale may also be appropriate. In this case, the recorded data are ordinal scaled because the size of intervals between the midpoints of categories is not exactly the same.

Remark: In some cases visually assessed data on metric characteristics may be handled as measurements. The possibility to apply statistical methods for metric data depends on the precision of the assessment and the robustness of the statistical procedures. In the case of very precise visually assessed quantitative characteristics the usually ordinal data may reach the level of discrete interval scaled data or of discrete ratio scaled data.

2.3.7.3 A pseudo-qualitative type of characteristic is one in which the expression varies in more than one dimension. The different dimensions are combined in one scale. At least one dimension is quantitatively expressed. The other dimensions may be qualitatively expressed or quantitatively expressed. The scale as a whole has to be considered as a nominal scale (e.g. "Shape", "Flower color"; Table 6, examples 7 and 8).

2.3.7.4 In the case of using the off-type procedure for the assessment of uniformity the recorded data are nominally scaled. The records fall into two qualitative classes: plants belonging to the variety (true-types) and plants not belonging to the variety (off-types). The type of scale is the same for qualitative, quantitative and pseudo-qualitative characteristics.

2.3.7.5 The relation between the type of characteristics and the type of scale of data recorded for the assessment of distinctness and uniformity is described in Table 2. A qualitative characteristic is recorded on a nominal scale for distinctness (state of expression) and for uniformity (true-types vs. off-types). Pseudo-qualitative characteristics are recorded on a nominal scale for distinctness (state of expression) and on a nominal scale for uniformity (true-types vs. off-types). Quantitative characteristics are recorded on an ordinal, interval or ratio scale for the assessment of distinctness depending on the characteristic and the method of assessment. If the records are taken from single plants the same data may be used for the assessment of distinctness and uniformity. If distinctness is assessed on the basis of a single record of a group of plants, uniformity has to be judged with the off-type procedure (nominal scale).

Table 2: Relation between type of characteristic and type of scale of assessed data

Procedure	Type of scale	Distribution	Type of characteristic		
			Qualitative	Pseudo-qualitative	Quantitative
Distinctness	ratio	Continuous	No	No	**Yes**
		Discrete	No	No	**Yes**
	interval	Continuous	No	No	**Yes**
		Discrete	No	No	**Yes**
	ordinal	Discrete	No	No	**Yes**
	nominal	Discrete	**Yes**	**Yes**	No
Uniformity	ratio	Continuous	No	No	**Yes**
		Discrete	No	No	**Yes**
	interval	Continuous	No	No	**Yes**
		Discrete	No	No	**Yes**
	ordinal	Discrete	No	No	**Yes**
	nominal	Discrete	**Yes**	**Yes**	**Yes**

2.3.8 Relation between method of observation of characteristics, scale levels of data and recommended statistical procedures

2.3.8.1 Established statistical procedures can be used for the assessment of distinctness and uniformity considering the scale level and some further conditions such as the degree of freedom or unimodality (Tables 3 and 4).

2.3.8.2 The relation between the expression of characteristics and the scale levels of data for the assessment of distinctness and uniformity is summarized in Table 6.

Table 3: Statistical procedures for the assessment of distinctness

Type of Scale	Distribu-tion	Observation method	Procedure	Further Condition	Reference document
Ratio	continuous	MS MG (VS) 1)	COYD	df≥ 20 3)	TGP/8 and 9
	discrete		long term COYD	df<20	TGP/8
interval	continuous		2x1% method	df≥20	TGP/8
	discrete				
ordinal	discrete	VS	Pearson's Chi-Square test	$E_{ij} \geq 5$ 4)	TGP/8
		VS	Fisher's Exact test	$E_{ij} < 10$	TGP/8
		VS	GLM models Threshold models	$E_{ij} \geq 5$	TWC/28/29 TWC/14/12
		VG	See also explanation for QN characteristics in TGP/9 sections 5.2.2 and 5.2.3 See explanation for QN characteristics in TGP/9 section 5.2.4		TGP/9
nominal	discrete	(VS) 2)	Pearson's Chi-Square test	$E_{ij} \geq 5$	TGP/8
		VS	Fisher's Exact test	$E_{ij} < 10$	TGP/8
		VS	GLM models	$E_{ij} \geq 5$	TWC/28/29
		VG	See explanation for QL and PQ characteristics in TGP/9 sections 5.2.2 and 5.2.3		TGP/9

1) see remark in section 2.3.3.8.2 *[cross ref.]*
2) normally VG but VS would be possible
3) df – degree of freedom
4) E_{ij} – expected value of a class

Table 4: Statistical procedures for the assessment of uniformity

Type of scale	Distribution	Observation method	Procedure	Further Conditions	Reference document
ratio	continuous				
	discrete	MS	COYU	df≥20	TGP/8 and 10
interval	continuous	MS	Relative variance method	$s^2_c \leq 1.6 s^2$	TGP/8
	discrete	VS			
ordinal	discrete	VS	Threshold model		TWC/14/12
nominal	discrete	VS	off-type procedure for dichotomous (binary) data	Fixed population standard	TGP/8 and 10

2.4 Different levels to look at a characteristic

2.4.1 Characteristics can be considered in different levels of process (Table 5). The characteristics as expressed in the trial (type of expression) are considered as process level 1. The data taken from the trial for the assessment of distinctness, uniformity and stability are defined as process level 2. These data are transformed into states of expression for the purpose of variety description. The variety description is process level 3.

Table 5: Definition of different process levels to consider characteristics

Process level	Description of the process level
1	characteristics as expressed in trial
2	data for evaluation of characteristics
3	variety description

From the statistical point of view, the information level decreases from process level 1 to 3. Statistical analysis is only applied in level 2.

2.4.2 Sometimes for DUS experts it seems that there is no need to distinguish between different process levels. The process level 1, 2 and 3 could be identical. However, in general, this is not the case.

2.4.3 Understanding the need for process levels

2.4.3.1 The DUS expert may know from UPOV Test Guidelines or his own experience that, for example, ‘Length of plant’ is a good characteristic for the examination of DUS. There are varieties which have longer plants than other varieties. Another characteristic could be ‘Variegation of leaf blade’. For some varieties, variegation is present and for others not. The DUS expert has now two characteristics and he knows that ‘Plant length’ is a quantitative characteristic and ‘Variegation of leaf blade’ is a qualitative characteristic (definitions: see Part I: section 2.2.3 to 2.2.2 *[cross ref.]* below). This stage of work can be described as **process level 1.**

2.4.3.2 The DUS expert then has to plan the trial and to decide on the type of observation for the characteristics. For characteristic ‘Variegation of leaf blade’, the decision is clear. There are two possible expressions: ‘present’ or ‘absent’. The decision for characteristic ‘Plant length’ is not specific and depends on expected differences between the varieties and on the variation within the varieties. In many cases, the DUS expert will decide to measure a number of plants (in cm) and to use special statistical procedures to examine distinctness and uniformity. But it could also be possible to assess the characteristic 'Plant length' visually by using expressions like 'short', 'medium' and 'long', if differences between varieties are large enough (for distinctness) and the variation within varieties is very small or absent in this characteristic. The continuous variation of a characteristic is assigned to appropriate states of expression which are recorded by notes (see document TGP/9, section 4*)[cross ref.]*. The crucial element in this stage of work is the recording of data for further evaluations. It is described as **process level 2**.

2.4.3.3 At the end of the DUS test, the DUS expert has to establish a description of the varieties using notes from 1 to 9 or parts of them. This phase can be described as **process level 3**. For 'Variegation of leaf blade' the DUS expert can take the same states of expression (notes) he recorded in process level 2 and the three process levels appear to be the same. In
cases where the DUS expert decided to assess 'Plant length' visually, he can take the same states of expression (notes) he recorded in process level 2 and there is no obvious difference between process level 2 and 3. If the characteristic 'Plant length' is measured in cm, it is necessary to assign intervals of measurements to states of expressions like 'short', 'medium' and 'long' to establish a variety description. In this case, for statistical procedures, it is important to be clearly aware of the relevant level and to understand the differences between characteristics as expressed in the trial, data for evaluation of characteristics and the variety description. This is absolutely necessary for choosing the most appropriate statistical procedures in cooperation with statisticians or by the DUS expert.

Table 6: Relation between expression of characteristics and scale levels of data for the assessment of distinctness and uniformity

Example	Name of characteristic	Distinctness				Uniformity			
		Unit of assess-ment	Description (states of expression)	Type of scale	Distri-bution	Unit of assess-ment	Description (states of expression)	Type of scale	Distri-bution
1	Sex of plant	1 2 3 4	dioecious female dioecious male monoecious unisexual monoecious hermaphrodite	nominal	discrete	True-type Off-type	Number of plants belonging to the variety Number of off-types	nominal	discrete
2	Leaf blade: variegation	1 9	absent present	nominal	discrete	True-type Off-type	Number of plants belonging to the variety Number of off-types	nominal	discrete
3	Length of plant	cm	assessment in cm without digits after decimal point	ratio	conti-nuous	cm	assessment in cm without digits after decimal point	ratio	conti-nuous
						True-type Off-type	Number of plants belonging to the variety Number of off-types	nominal	discrete
4	Number of stamens	counts	1, 2, 3, ... , 40,41, ...	ratio	discrete	counts	1, 2, 3, ... , 40,41, ...	ratio	discrete
5	Time of beginning of flowering	Date	e.g. May 21, 51st day from April 1	interval	discrete	Date	e.g. May 21, 51st day from April 1	interval	discrete
						True-type Off-type	Number of plants belonging to the variety Number of off-types	nominal	discrete

Example	Name of characteristic	Distinctness				Uniformity			
		Unit of assess-ment	Description (states of expression)	Type of scale	Distri-bution	Unit of assess-ment	Description (states of expression)	Type of scale	Distri-bution
6	Intensity of anthocyanin	1 2 3 4 5 6 7 8 9	very low very low to low low low to medium medium medium to high high high to very high very high	ordinal	discrete (with an under-lying quanti-tative vari-able)	True-type Off-type	Number of plants belonging to the variety Number of off-types	nominal	discrete
7	Shape	1 2 3 4 5 6 7	deltate ovate elliptic obovate obdeltate circular oblate	nominal	discrete	True-type Off-type	Number of plants belonging to the variety Number of off-types	nominal	discrete
8	Flower color	1 2 3 4 5 6 7 8 9 10	dark red medium red light red white light blue medium blue dark blue red violet violet blue violet	nominal	discrete	True-type Off-type	Number of plants belonging to the variety Number of off-types	nominal	discrete

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