

**Technical Committee****TC/58/6****Fifty-Eighth Session  
Geneva, October 24 and 25, 2022****Original:** English  
**Date:** October 5, 2022**THE COMBINED-OVER-YEARS UNIFORMITY CRITERION (COYU)***Document prepared by the Office of the Union**Disclaimer: this document does not represent UPOV policies or guidance***EXECUTIVE SUMMARY**

1. The purpose of this document is to consider a proposal for a draft revision of document TGP/8 “Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability”, Section 9 “The Combined-Over-Years Uniformity Criterion (COYU)”.

2. The TC is invited to:

(a) note that a new version of DUSTNT incorporating COYU with splines (DUST9NT) was planned to be launched by September 2023, once the improvements identified from the testing campaign have been incorporated, including extrapolation;

(b) note that further revisions to document TGP/8 would be required to incorporate guidance on extrapolation and minimum data requirements;

(c) note the recommendation that there should be particular consideration of uniformity by the crop experts when extrapolation occurred;

(d) note that the TWM agreed that further discussion would be required on approaches when extrapolation was indicated and invited the United Kingdom and other members to report at the second session of the TWM; and

(e) request the TWM to prepare a report of the results of the test campaign of the software for COYU Splines for consideration by the TC, in conjunction with the revision of document TGP/8.

3. The structure of this document is as follows:

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4. The following abbreviations are used in this document:

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
TWM:	Technical Working Party on Testing Methods and Techniques
TWO:	Technical Working Party for Ornamental Plants and Forest Trees

TWPs: Technical Working Parties  
TWW: Technical Working Party for Vegetables

## BACKGROUND

5. The Combined-Over-Years Uniformity (COYU) criterion is a method used to assess uniformity on the basis of measured quantitative characteristics (see document TGP/8/3 “Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability”).
6. The TC, at its fifty-fourth session<sup>1</sup>, noted that the statistical development of the new method of calculation of COYU had been completed, including the establishment of the probability levels required to most closely match decisions using the current method for calculation of COYU. The TC noted the invitation by the TWC for the expert from the United Kingdom to draft a replacement section for document TGP/8 on the method of calculation of COYU (see document TC/54/25 “Report”, paragraphs 221 to 224).
7. Further background to this matter is provided in document TC/57/7 “The Combined Over Years Uniformity Criterion (COYU)”.
8. The TC, at its fifty-seventh session<sup>2</sup>, noted that software for COYU Splines was under evaluation and was planned to be implemented in the United Kingdom from 2022.
9. The TC noted that evaluation versions of software for COYU Splines were made available in August 2021.
10. The TC noted the invitation for members of the Union to participate in the test campaign of the COYU Splines software and report outcomes to the expert from the United Kingdom by December 31, 2021.
11. The TC agreed to request the TWC to prepare a report of the results of the test campaign of the software for COYU Splines for consideration by the TC, at its fifty-eighth session, in conjunction with the revision of document TGP/8 (see document TC/57/25 “Report”, paragraph 33).

## DEVELOPMENTS AT THE TECHNICAL WORKING PARTIES

12. At their sessions in 2022, the TWV<sup>3</sup>, TWA<sup>4</sup>, TWO<sup>5</sup>, TWF<sup>6</sup> and TWM<sup>7</sup> considered document TWP/6/11 “The Combined-Over-Years Uniformity Criterion (COYU)” (see documents TWV/56/22 “Report”, paragraphs 12 to 15; TWA/51/11 “Report”, paragraphs 30 to 35; TWO/54/6 “Report”, paragraphs 29 to 33; TWF/53/14 “Report”, paragraphs 14 to 18; and TWM/1/26 “Report”, paragraphs 37 to 42).
13. The TWV, TWA, TWO, TWF and TWM noted that software for COYU Splines would be under evaluation and planned to be implemented in the United Kingdom from 2022. The TWV, TWA, TWO, TWF and TWM noted that evaluation versions of software for COYU Splines had been made available in August 2021.
14. The TWV, TWA, TWO, TWF and TWM noted the invitation for members of the Union to participate in the test campaign of the COYU Splines software and report outcomes to the expert from the United Kingdom. The TWM noted that feedback had been received from Czech Republic, Finland, Slovakia and United Kingdom.
15. The TWV, TWA, TWO, TWF and TWM noted the request for the TWM to prepare a report of the results of the test campaign of the software for COYU Splines for consideration by the TC, at its fifty-eight session, in conjunction with the revision of document TGP/8.

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<sup>1</sup> held in Geneva on October 29 and 30, 2018

<sup>2</sup> at its fifty-seventh session, held via electronic means, on October 25 and 26, 2021

<sup>3</sup> at its fifty-sixth session, held via electronic means, from April 18 to 22, 2022

<sup>4</sup> at its fifty-first session, hosted by the United Kingdom and held via electronic means, from May 23 to 27, 2022

<sup>5</sup> at its fifty-fourth session, , hosted by Germany held via electronic means, from June 13 to 17, 2022

<sup>6</sup> at its fifty-third session, held via electronic means, from July 11 to 15, 2022

<sup>7</sup> at its first session, held via electronic means, from September 19 to 23, 2022

Development of software for the improved COYU method (splines)

16. The TWA received a presentation on “COYU Splines: Path to implementation in the United Kingdom” by an expert from the United Kingdom. A copy of the presentation is provided in document TWA/51/8. The TWA noted the work reported and agreed to invite the expert from the United Kingdom to report developments at its fifty-second session.

17. The TWM considered document TWM/1/8, as provided in Annex I to this document, and received a presentation from Mr. Adrian Roberts and Ms. Haidee Philpott (United Kingdom) on “Developments on the improved COYU method (splines)”, a copy of which is reproduced in document TWM/1/8 Add..

18. The TWM noted that a new version of DUSTNT incorporating COYU with splines (DUST9NT) would be launched by September 2023, once the improvements identified from the testing campaign had been incorporated, including extrapolation.

19. The expert from the United Kingdom noted that further revisions to document TGP/8 would be required to incorporate guidance on extrapolation and minimum data requirements.

Extrapolation in relation to COYU

20. The TWM considered document TWM/1/7, as provided in Annex II to this document, and received a presentation from Mr. Adrian Roberts (United Kingdom) on “Combined-over-year uniformity (COYU) criterion: Extrapolation”, a copy of which is reproduced in document TWM/1/7 Add..

21. The TWM noted the recommendation that there should be particular consideration of uniformity by the crop experts when extrapolation occurred. Whichever COYU approach is used (moving average; splines), the verdict on uniformity should be subject to confirmation by the crop experts (when extrapolation occurred).

22. The TWM agreed that further discussion would be required on approaches when extrapolation was indicated and agreed to invite the United Kingdom and other members to report at the second session of the TWM.

## NEXT STEPS

23. The TC is invited to renew its request for the TWM to prepare a report of the results of the test campaign of the COYU Splines software for consideration by the TC, in conjunction with the revision of document TGP/8.

24. *The TC is invited to:*

*(a) note that a new version of DUSTNT incorporating COYU with splines (DUST9NT) was planned to be launched by September 2023, once the improvements identified from the testing campaign have been incorporated, including extrapolation;*

*(b) note that further revisions to document TGP/8 would be required to incorporate guidance on extrapolation and minimum data requirements;*

*(c) note the recommendation that there should be particular consideration of uniformity by the crop experts when extrapolation occurred;*

*(d) note that the TWM agreed that further discussion would be required on approaches when extrapolation was indicated and agreed to invite the United Kingdom and other members to report at the second session of the TWM; and*

*(e) request the TWM to prepare a report of the results of the test campaign of the software for COYU Splines for consideration by the TC, in conjunction with the revision of document TGP/8.*

[Annexes follow]



International Union for the Protection of New Varieties of Plants

**E****Technical Working Party on Testing Methods and Techniques****TWM/1/8****First Session****Virtual meeting, September 19 to 23, 2022****Original:** English**Date:** August 29, 2022**DEVELOPMENTS ON THE IMPROVED COYU METHOD (SPLINES)***Document prepared by experts from the United Kingdom**Disclaimer: this document does not represent UPOV policies or guidance***EXECUTIVE SUMMARY**

1. The purpose of this document to give an update on developments on the improved version of the Combined Over Years Uniformity (COYU) criterion using splines. It reports on a test campaign for the software implementing the new method, and the subsequent software development.
2. The document should be read along with document TWP/6/11 “The Combined Over Years Uniformity Criterion (COYU)”.
  - (a) The TWM is invited to note the developments.

**BACKGROUND**

3. The Combined Over Years Uniformity (COYU) criterion is a method used to assess uniformity on the basis of measured quantitative characteristics (see document TGP/8/3 “Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability”). Previously, the development of an improved method has been reported. For further background on the improved method using splines, see document TWC/38/6 “The Combined Over Years Uniformity Criterion (COYU)”.
4. Previously, it was noted that software had been developed to support the implementation of COYU with splines. This software is available in two forms: as a package for R, and as a module in DUSTNT.
5. DUSTNT is a software package for the analysis of data from DUS trials, and is freely available (see document UPOV/INF/16/9 “Exchangeable Software”). This software is not only used routinely by a number of members, but has been used for benchmarking software for COYD and COYU. As part of the process of incorporating the new module, the installation process has been updated to fit the current Windows model.
6. The version in the form of an R package is suitable for those members already using R software for DUS analysis. R is freely available as is the COYU package. The COYU package is available either as source code or as a more easily installed R library binary.

**EVALUATION OF THE NEW SOFTWARE**

7. In early August 2021, a circular was sent out by the UPOV Office to seek participation in the testing of the new software. This campaign was due to be completed by the end of December 2021. Both forms of software were made available for evaluation.

8. Many members took part in the exercise, as evidenced by downloads of the evaluation version of DUSTNT. The following gave feedback following their evaluations: Czech Republic, Finland, Slovakia, United Kingdom. The development team is very grateful for these valuable responses.

9. Whilst overall feedback was positive, a number of software improvements were identified for the DUST version.

#### FURTHER DEVELOPMENT OF SOFTWARE INCORPORATING THE NEW COYU METHOD

10. The following improvements to the DUSTNT software were identified from the testing campaign:

- Improvements to the reports, including formatting and extra information;
- Criteria for flagging data sets that are too small;
- Extra tables in csv format;
- Improved graphics;
- Modification of flagging of cases with extrapolation;
- Managing diacritics in file and directory names.

11. At the time of writing, many of these identified improvements have been coded. An update will be given at the TWM.

12. Once the improvements have been incorporated and tested, a new version of DUSTNT incorporating COYU with splines will be launched.

#### INTRODUCTION OF COYU WITH SPLINES IN THE UNITED KINGDOM

13. The United Kingdom has started a process of introducing COYU with splines into DUS testing.

14. This year, comparisons have been made between the old COYU method (moving average) and COYU with splines using historical data. Crops covered included perennial ryegrass, pea, onion, swede, and oilseed rape. Few differences in decisions were found, and in only a small number of marginal cases which was to be expected. The work highlighted the importance of the extrapolation issue (see below).

15. Following this study, the United Kingdom is considering the way forward.

#### EXTRAPOLATION

16. Extrapolation is a key issue for COYU and is discussed in document TWM/1/7. This is an issue particular to both versions of COYU, but was not identified with COYU (moving average).

#### GUIDANCE ON COYU WITH SPLINES

17. Guidance for the new method of COYU with splines has been drafted (see document TWP/5/11 The Combined Over Years Uniformity Criterion (COYU)).

18. The testing exercise indicated two areas for improvement to the draft guidance:

- To the criteria for indicating whether a data set is sufficiently large to allow use of COYU;
- To guidance on extrapolation.

19. The authors intend to propose improvements to the draft guidance following the session of the TWM.

*The TWM is invited to note these developments.*

[Annex II follows]



International Union for the Protection of New Varieties of Plants

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Technical Working Party on Testing Methods and Techniques

TWM/1/7

First Session

Original: English

Virtual meeting, September 19 to 23, 2022

Date: August 29, 2022

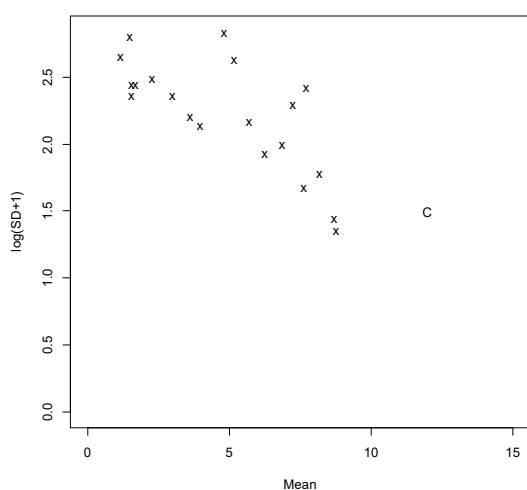
## COMBINED-OVER-YEAR UNIFORMITY (COYU) CRITERION: EXTRAPOLATION

*Document prepared by experts from the United Kingdom*

*Disclaimer: this document does not represent UPOV policies or guidance*

### INTRODUCTION

1. This document describes the issue of extrapolation in relation to COYU. It makes proposals about how this issue can be managed. These proposals are open for discussion by experts.
2. In UPOV document TWC/31/15 corr., the issue of extrapolation was raised in connection with COYU. This issue is relevant to both old and improved methods of COYU, but was only identified during the development of the improved method.
3. In the context of COYU, extrapolation is where a candidate variety has a mean score outside the range of scores expressed by the reference varieties in a particular year. Figure 1 shows an example.



**Figure 1:** Example of extrapolation. For a single year/cycle, a measure of variability (log of the standard deviation of within-plot scores) is plotted against the mean score (read document TGP/8 for more details on COYU). The reference varieties are represented by 'x' and the candidate by 'c'. The candidate has a larger mean than any of the reference varieties. Whilst a trend can be seen in the reference varieties, can we extend this out to the candidate?

4. Extrapolation is a problem both in principle and technically. The General Introduction to the Examination of Distinctness, Uniformity and Stability and the Development of Harmonized Descriptions of New Varieties of Plants (TG/1/3) says in relation to uniformity:

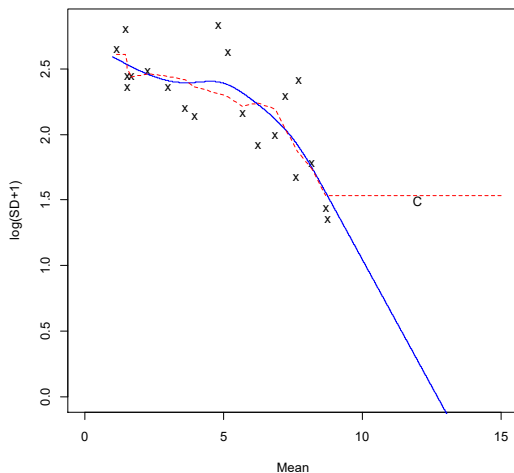
*“6.4.2.2.1 For measured characteristics, the acceptable level of variation for the variety should not significantly exceed the level of variation found in comparable varieties<sup>8</sup> already known.”*

If the level of expression of the candidate variety is very different from the set of “comparable” varieties, it might be questioned whether these varieties are actually comparable.

5. Extrapolation is particularly important as in COYU we adjust for the relationship between variability between plants and the mean. Such as relationship occurs in many characteristics. Within the range of the reference varieties, the relationship can be based on the evidence provided by these varieties. Outside the range, the relationship is speculative. Indeed, the old and new methods of COYU give substantially different “guesses” as to the relationship (see below).
6. Previously, cases of extrapolation were not routinely flagged. For the new method, we have suggested that cases of extrapolation should be flagged and given special attention by DUS experts. In such cases, the verdicts indicated by COYU, old or new, should not be automatically accepted. Indeed, decisions for the two methods may be quite different from each other when there is extrapolation.

#### HOW NEW AND OLD COYU METHODS PERFORM WITH EXTRAPOLATION

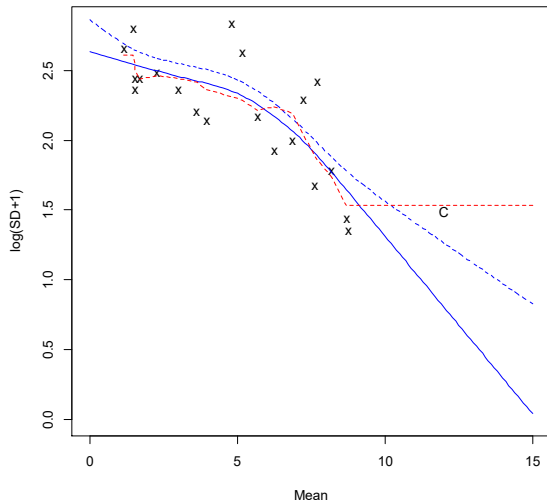
7. The old and new COYU methods differ in the statistical model used to relate variability to the mean scores. The old method uses moving averages, and the new method uses splines.
8. This has the following repercussions when there is a case of extrapolation:
  - Outside the range of the reference varieties, the line is horizontal for moving averages (following the trend of the outer varieties), and linear but not necessarily horizontal for splines. This is illustrated in Figure 2.
  - Relative to the fitted line, the uncertainty used to produce the COYU threshold is undetermined, and presumed constant for COYU with moving averages outside the range of the reference varieties, but increases using the new COYU the further away from the reference varieties. This is illustrated in Figure 3.



**Figure 2:** Example from Figure 1 showing how the moving average and spline trend extend when extrapolating outside the range of the reference varieties. The reference varieties are represented by 'x' and the candidate by 'c'. The red dashed line is for the moving average method, and the blue line is for the spline.

<sup>8</sup> Comparable varieties are known varieties believed to be of a similar type or nature to the new variety in question. This terminology is used in TG/1/3 and TGP/8/3 in preference to the term reference varieties in this context



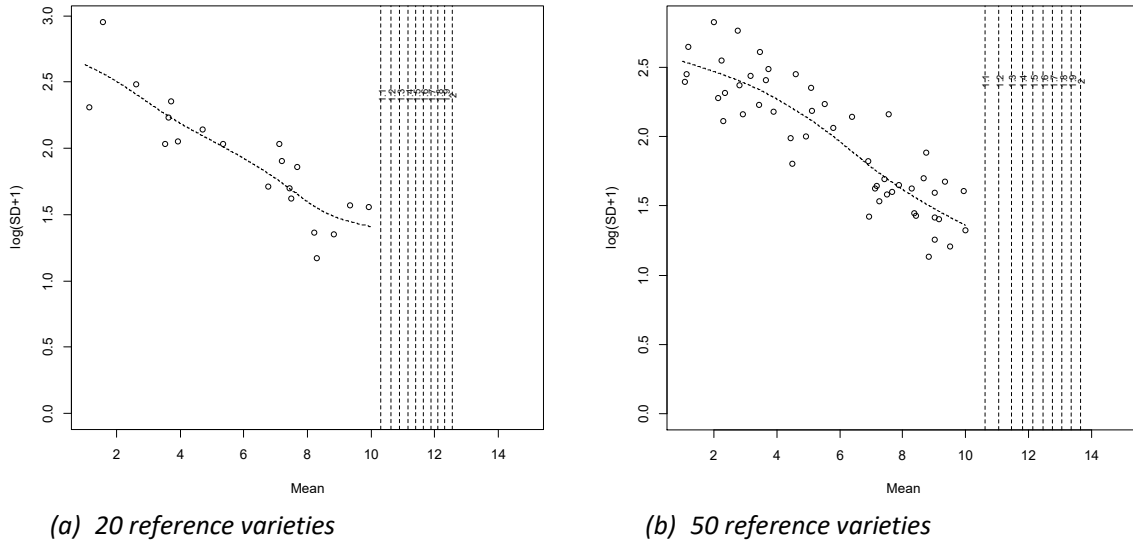


**Figure 3:** Example continued from Figure 2. Here, a blue dashed line represents one standard error for prediction above the spline trend line. Note, this standard error is not used directly, but enters into the COYUs calculations through an amalgamation with the other years/cycles. It does show though the steep increase in the uncertainty due to extrapolation

9. Figure 2 shows how the two COYU methods may lead to different conclusions. The candidate is under the moving average trend line for the moving average but considerably above it for the spline. It is arguable that the COYU with splines treats cases with extrapolation more sensibly. The line fitted seems a better guess for what might happen, and the increasing uncertainty better reflects the reality.

#### DEFINING EXTRAPOLATION

10. How should we define extrapolation in practice? A strict definition where the candidate score is outside the range of the reference varieties, even by a minuscule amount, could lead to a very high number of cases for the expert to consider. In an earlier study reported at the TWC ([https://www.upov.int/edocs/mdocs/upov/en/twc\\_35/twc\\_35\\_6.pdf](https://www.upov.int/edocs/mdocs/upov/en/twc_35/twc_35_6.pdf), see annex, page 9), levels of strict extrapolation varied by crop, for example being relatively high for the perennial ryegrass (13%) and low for oilseed rape (1-2%).
11. In document TWC/35/6, two methods were proposed for indicating the degree of extrapolation (paragraph 19). Following this document, the second of the two methods (19b) was adopted in draft guidance and in the software code developed.
12. The extrapolation index measures the inflation of the COYU criterion for the candidate variety in question, compared to the closest reference variety.
13. In more detail, for each year/cycle, the extrapolation index is the ratio of the square roots of the spline prediction errors and the closest variety. It has a value of 1 for when there is strictly no extrapolation, and greater than 1 when the candidate is outside the range of the reference varieties. The value increases the greater the degree of extrapolation. In the developed software, the maximum index over the years/cycles is given as the overall extrapolation index for the candidate.
14. Figure 4 shows how the extrapolation index increases outside of the reference varieties. The index increases more slowly when there are more reference varieties. This reflects the greater certainty in the estimated trend.



**Figure 4:** Two examples showing how the extrapolation index increases with distance from outer reference varieties. Vertical dashed lines indicate the extrapolation index, with values from 1.1 to 2.0. In (a), there are 20 reference varieties, and in (b) there are 50

15. We propose that a threshold is set for the extrapolation index, such that the COYU is not used if the threshold is exceeded. The choice of threshold is subjective, and needs to balance the practicalities of having too many cases with extrapolation and the need to make well-founded decisions. It would be beneficial to agree a fixed threshold for use with COYU, and this requires discussion.
16. As part of a recent United Kingdom study comparing the old and new methods of COYU, there was an analysis of how different extrapolation index thresholds would affect the number of cases identified. The study covered three years of results, in four subgroups of perennial ryegrass.
17. In the ryegrass study, there were 4640 cases in total (number of candidate variety by characteristic combinations) and 105 candidate varieties. Table 1 shows how the number of cases depends on the threshold adopted. Note that even 1% of cases would mean a considerable number of cases that need to be examine more carefully (46 in this example).

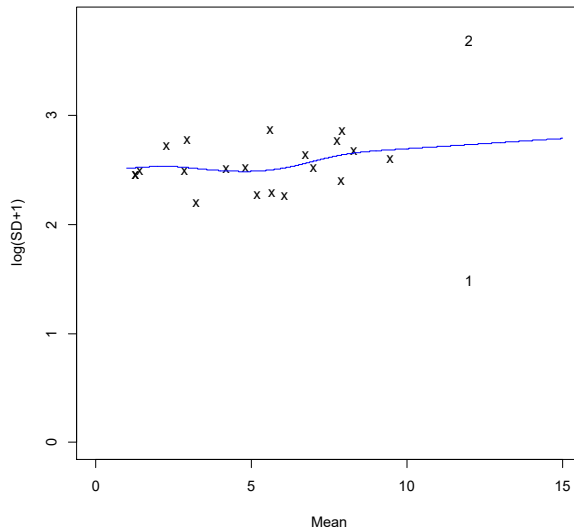
**Table 1:** Number of cases and candidates affected by extrapolation under varying thresholds

Extrapolation index threshold	Cases with extrapolation	Candidates with extrapolation in any characteristic
1 (= strict extrapolation)	8.4%	67%
1.1	3.8%	38%
1.2	2.3%	30%
1.3	1.5%	27%
1.4	1.0%	17%
1.5	0.9%	14%

18. Based on Figure 4, the reduction in the number of cases seen in the example, and the implications on decisions, we suggest a threshold of 1.2 as starting point for discussions in the TWM.

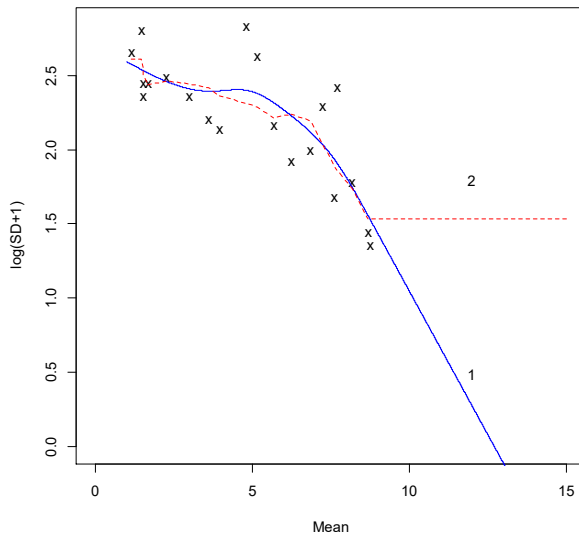
## WHAT TO DO IN CASE OF EXTRAPOLATION?

19. With no extrapolation, the COYU criterion with splines gives a clear basis for uniformity. With extrapolation, the crop experts must apply judgement. The output from the software, including graphs, can help here. Here, we discuss the factors that may influence the decision, with examples.
20. The following should be considered:
  - The degree of extrapolation;
  - Is it likely that the trend seen in the reference varieties would extend to the candidate?
  - What is the situation in other cycles, is there also extrapolation?
21. The degree of extrapolation is key. If not great, perhaps it is possible to make judgements based on trends seen in the reference varieties. If very large, then the candidate could be seen as having no comparable varieties. In this case, perhaps the benefit of doubt should be given to the candidate.
22. The trend seen in the reference varieties may be expected for some characteristics. In these cases, there may be more confidence in extrapolation.
23. It is important to examine the other cycles/years. The COYU decision is made over cycles/years, and it can be tricky to combine results subjectively if there is inconsistency.
24. We now give some examples for consideration. In Figure 5, we have a case where there is little trend in the reference varieties. Candidate 1 is clearly low in variability compared to the reference varieties, and so might indicate satisfactory uniformity if the other cycles/years are similar. On the other hand, candidate 2 shows high levels of variability compared to the reference varieties, and there may be strong concerns about lack of uniformity.



**Figure 5:** Example with little trend evident. The reference varieties are represented by 'x' and the candidates by '1' and '2'. The blue line is for the spline.

25. In the next example, we return to the same data as in Figure 1. Figure 6 shows the same reference variety data, but with two new candidates. Here candidate 1 is broadly in line with the trend, and arguably there would be no concerns about uniformity here. However, candidate 2 is significantly above the trend line.



**Figure 6:** Example with a strong trend. The reference varieties are represented by 'x' and the candidates by '1' and '2'. The blue line is for the spline.

#### DISCUSSIONS NEEDED

26. Extrapolation is a newly identified issue for COYU, and there is little practical experience of managing it. Although the issue was highlighted in the development of COYU with splines, it is just as relevant to the old method. Therefore, some discussion is required on how to define it in practical terms, and on what to do when extrapolation is indicated.
27. Experts from the United Kingdom have made proposals here to start discussions within the forum of the TWM.
28. Once guidance is developed, it can be incorporated into document TGP/8, and reflected in the software.

[End of Annex II and of document]