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GUIDANCE ON EXTRAPOLATION WHEN USING COMBINED OVER-YEARS UNIFORMITY (COYU)

Document prepared by experts from the United Kingdom

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SUMMARY

1. This document contains an overview of the Combined-Over-Years Uniformity (COYU), guidance on dealing with extrapolation when using COYU and a presentation to be made by experts from the United Kingdom, at the fourth session of the TWM.

INTRODUCTION

2. 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 “Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability”).

3. An improved version of COYU has been under consideration, including the development of supporting software in R and DUSTNT. This development has been reported regularly at UPOV sessions, including the Technical Working Party on Automation and Computer Programs (TWC) and the Technical Working Party for Technical Working Party on Testing Methods and Techniques (TWM). Useful background information can be found in document TWC/38/6 “The Combined-Over-Years Uniformity Criterion (COYU)”.

4. The United Kingdom is in the process of implementing the improved version of COYU. To facilitate this, guidance has been produced to aid crop experts when there is extrapolation. This document presents that guidance, and proposes that the guidance is included in the technical guidance document TGP/8 “Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability” alongside the description of the improved COYU method at the appropriate time.

EXTRAPOLATION

5. In COYU, uniformity is assessed from the variability in a characteristic between plants within a plot. The variability is adjusted for any relationship with the mean score. The improved version of COYU uses splines for adjustment, rather than the moving average method as currently used.

6. Extrapolation is when a candidate variety has a mean score outside the range of scores expressed by the reference varieties in a particular year. In such cases, the adjustment is less reliable. This is true whichever method of adjustment is used, but the issue was not recognised until the introduction of the improved method.

7. An extrapolation index has been developed that reflects the degree of reliability of the adjustment. When this index is sufficiently high, indicating unreliable adjustment, the crop expert must review the results carefully and make a judgement. It is here where guidance is needed. For further information, see document TWM/1/7. The United Kingdom has held workshops for its DUS centers from 2022 to discuss the issue of extrapolation and the drafting of guidance. Several examples from DUS trials were considered, representing a range of situations. It was also noted that the proportion of cases of extrapolation varied markedly between crops, with perennial ryegrass having a higher level.

8. Guidance for use by the UK DUS centers has been developed and is presented in the Appendix in a form that might be suitable for document TGP/8.

[Appendix follows]

APPENDIX

GUIDANCE ON DEALING WITH EXTRAPOLATION WHEN USING COYU

Contents

INTRODUCTION

This document gives some guidance on considerations around the issue of extrapolation for the COYU method for assessing uniformity.

BACKGROUND

COYU is a statistical method used to indicate uniformity based on measured, quantitative characteristics. The issue of extrapolation was highlighted while developing a new version of COYU.

The old and new versions differ in how they relate uniformity to level of expression. The old method used moving averages and the new method uses splines (COYUs). Extrapolation is relevant for both methods.

EXTRAPOLATION

In the context of COYU, extrapolation is where a candidate has a mean score outside the range of scores seen in the reference varieties in a particular year.

Extrapolation is important as in COYU the benchmark used to assess the uniformity of a candidate is adjusted for the relationship between variability in scores and the mean that 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 more speculative. Indeed, the old and new methods of COYU give substantially different “guesses” as to the relationship here.

The old method of COYU did not routinely flag cases of extrapolation. For the new method, cases of extrapolation are flagged and need to be given special attention by DUS experts. In such cases, the verdicts indicated by COYU, old or new method, should not be automatically accepted. Indeed, decisions for the two methods may differ markedly when there is extrapolation.

For practical purposes, an index is used to indicate how serious the degree of extrapolation is. (This index was proposed at the TWC[1].) With this index, a score of 1 or less indicates no strict extrapolations. Numbers above 1 indicate the level of extrapolation. The level increases the further the level of expression of the candidate is from the reference varieties. It will also be higher when there are fewer reference varieties.

[1] https://www.upov.int/edocs/mdocs/upov/en/twc_35/twc_35_6.pdf

The following flags are suggested for cases of extrapolation, based on this index:

Index	Flag
Up to 1.2	No extrapolation issue
From 1.2 to 1.5	Decision based on calculated COYU should be reviewed
Above 1.5	Decision based on calculated COYU will be unreliable, and the uniformity recommendation should be determined at the DUS Test Centre meeting

These flags and index are produced by the procedure for COYU with splines within DUSTNT and in the R package. Please note the 'decisions' from COYU are also shown, even if the flag suggests they might be unreliable.

In addition to extrapolation, DUS experts should look for cases where large gaps appear in the mean scores for the reference varieties, particularly when candidates fall within these gaps.

WORKED EXAMPLES OF EXTRAPOLATION

The examples are grouped by the index flags indicated above.

Experts from the United Kingdom worked through each case, and suggested verdicts.

In practice, the following are suggested:

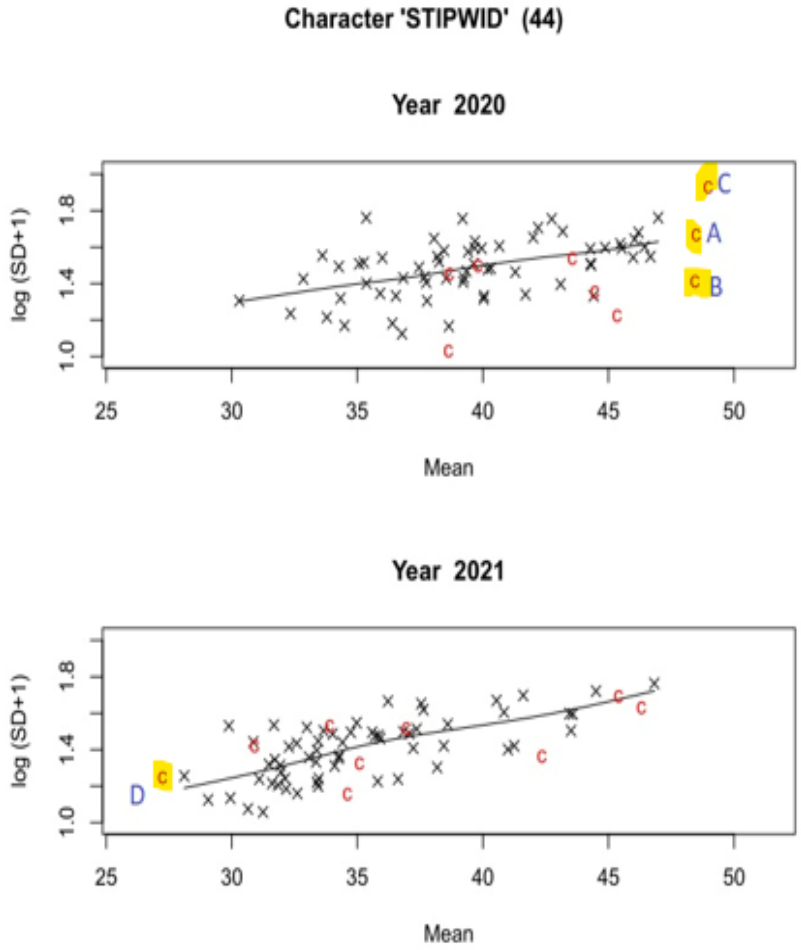
1. Examine the Excel table output by the new COYU with splines software
2. If extrapolation is indicated in the table, look at the graphs for the extrapolated candidates
3. Check in the graphs, the reference data looks sensible. Note if there are large 'gaps' in the reference set, and if candidates fall in these, treat with care.
4. It may be easier for crop experts to look at p-values using significant figures rather than decimal places near the critical thresholds. 2 significant figures is suggested. For example, the number 0.00256901 would be 0.003 to 3 decimal places, and 0.0026 to 2 sig figs.

Low Extrapolation factor < 1.2

With this level of extrapolation, it's expected nearly all cases to go with the COYU calculation. But it is prudent to review the data.

Example: field pea 2020-21 Stipule width (UK characteristic 44, UPOV characteristic 16)

In this example, four of the candidates are extrapolated. In all cases, the extrapolation factor was less than 1.2, and the COYU calculation indicated that the candidate was uniform for this characteristic.



Candidate A: extrapolation factor 1.09 (candidate larger than reference varieties in 2020). COYUs p-value 0.40. Extrapolation in just one year. *Verdict Uniform* on basis that extrapolation factor is less than 1.2, coupled with p-value well above 0.003.

Candidate B: extrapolation factor 1.09 (candidate larger than reference varieties in 2020). COYUs p-value 0.99. Extrapolation in just one year. *Verdict Uniform* on basis that extrapolation factor is less than 1.2, coupled with p-value well above 0.003.

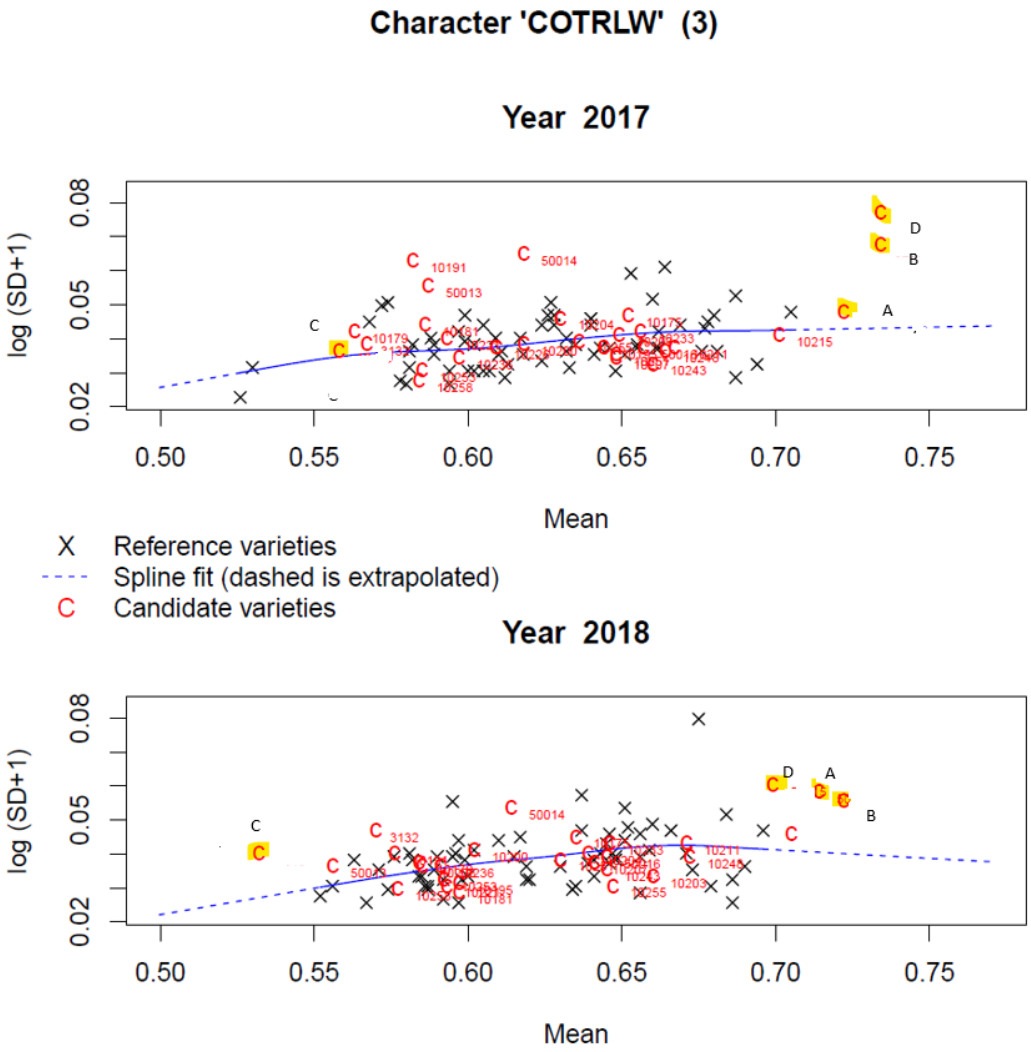
Candidate C: extrapolation factor 1.14 (candidate larger than reference varieties in 2020). COYUs p-value 0.11. *Verdict Uniform* on basis that extrapolation factor is less than 1.2, coupled with p-value well above 0.003.

Candidate D: extrapolation factor 1.04 (candidate smaller than reference varieties in 2021). COYUs p-value 0.34. Extrapolation in just one year. *Verdict Uniform* on basis that extrapolation factor is less than 1.2, coupled with p-value well above 0.003.

Moderate Extrapolation factor >= 1.2 and <1.5

Example: oilseed rape 2017-8 Cotyledon length to width ratio (UK characteristic 3, UPOV characteristic 2 - draft revised guideline)

Here there are four candidates that are extrapolated with differing levels of uniformity in the candidates. Note that the high variation seen in one of the reference varieties in 2018 was validated.



Candidate A: extrapolation factor 1.18 (candidate larger values than reference varieties in 2017 and 2018). Extrapolation in both years. COYUs p-value 0.062. *Verdict Uniform*

Candidate B: extrapolation factor 1.29 (candidate larger values than reference varieties in 2017 and 2018). Extrapolation in both years. COYUs p-value 0.0076. *Verdict marginal* – this case is certainly marginal, and requires discussion by the experts making the decision. It was noted that COYUs will be less strict here than if the candidate was not extrapolated, due the uncertainty in the extrapolation. Inclusion of the extrapolated lines in the graphs added which might help the experts.

Candidate C: extrapolation factor 1.21 (candidate smaller values than reference varieties in 2018). Extrapolation in just one year. COYUs p-value 0.142. *Verdict Uniform*.

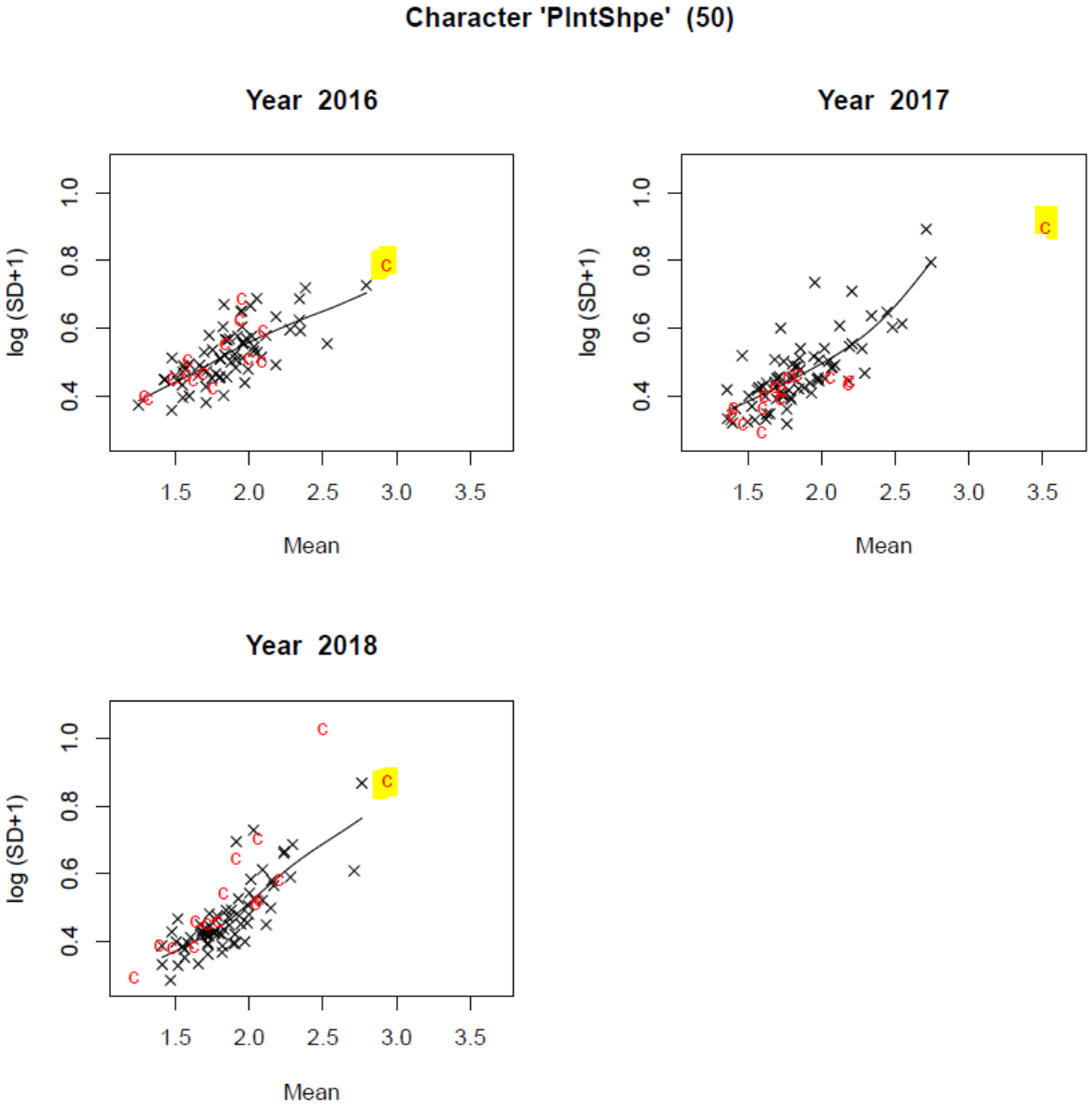
Candidate D: extrapolation factor 1.29 (candidate larger values than reference varieties in 2017 and 2018). Extrapolation in both years. COYUs p-value 0.000. *Verdict not Uniform*.

High Extrapolation factor >1.5

It is necessary to review the data and graphs carefully. The DUS expert needs to come to a decision without relying on the COYU calculation.

Example: perennial ryegrass (tetraploid, intermediate) 2016-2018 Plant shape (UK characteristic 50, UPOV characteristic 12)

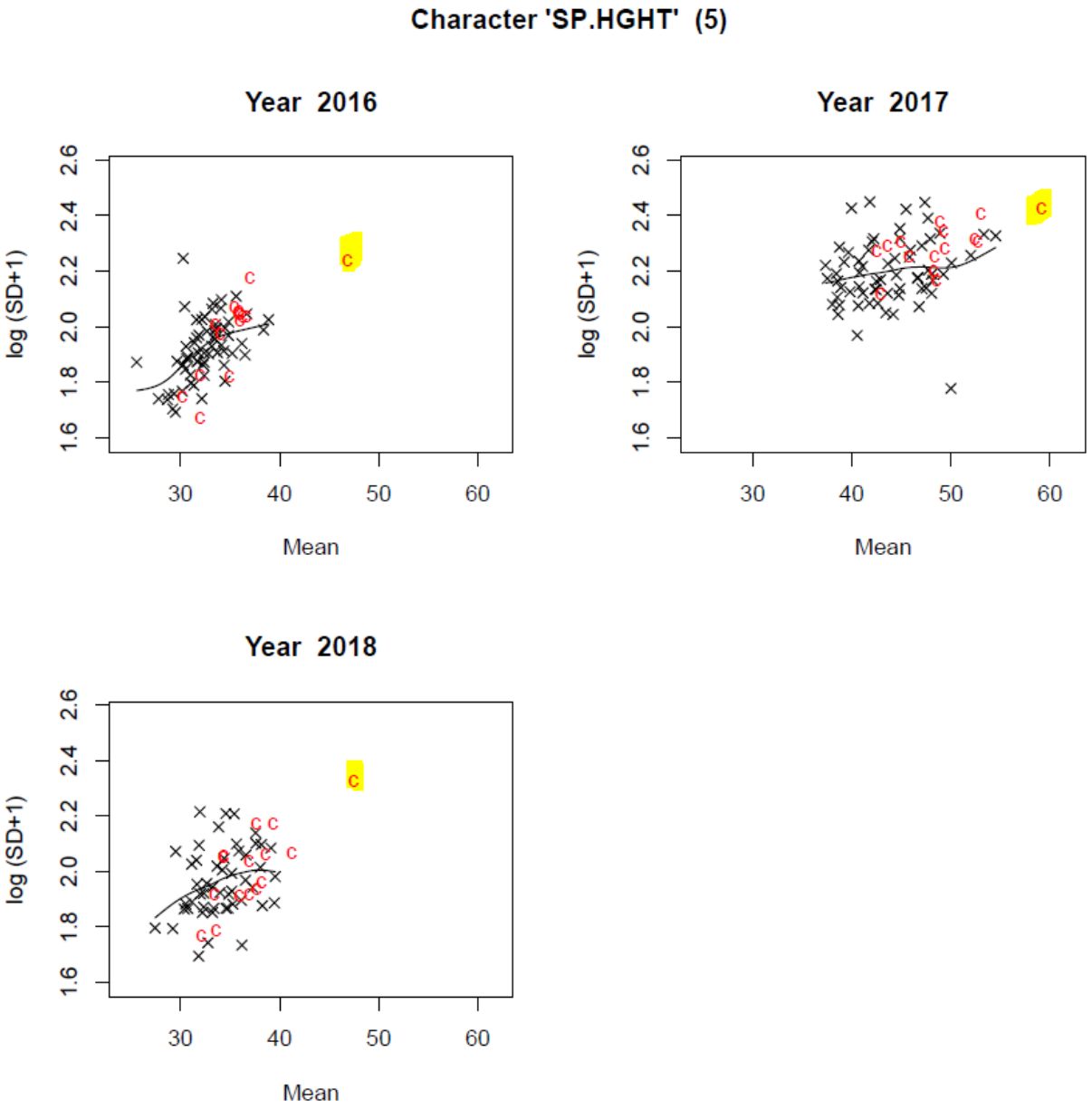
Here there is one candidate with extrapolation in all three years.



Highlighted candidate: extrapolation factor 1.79 (candidate larger values than reference varieties in all three years). Extrapolation in all three years. COYUs p-value 0.884. *Verdict: Uniform* on the basis that the candidate is nearer the extended line in 2016 and 2018, and below it in 2017.

Example: perennial ryegrass (tetraploid, intermediate) 2016-2018 Spring Height (UK characteristic 5, UPOV characteristic 8)

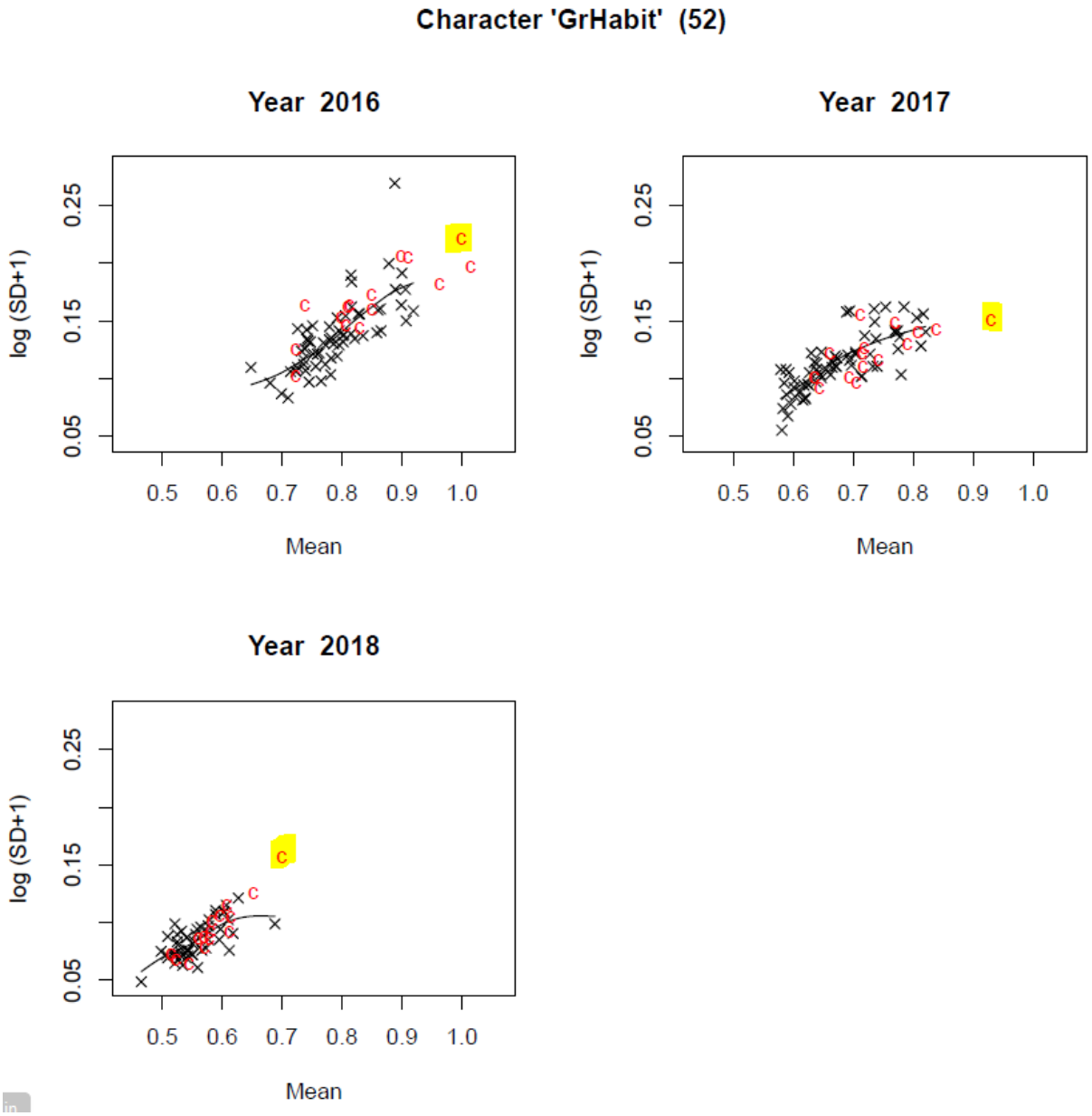
Here there is one candidate showing substantial extrapolation in all three years.



Highlighted candidate: extrapolation factor 2.82 (candidate larger than reference varieties in all three years). Extrapolation in all three years. COYUs p-value 0.116. *Verdict: tricky decision*. There is substantial extrapolation in all three years. In all years the candidate is near the extended trend line if it were to continue its trend, but due to the extensive extrapolation, we don't know if trend would continue. An alternative rationale for this example is to say that the candidate is so different from the reference varieties in this characteristic that it cannot be compared with existing varieties. Therefore, it should be considered uniform. For the future, the IDSG will consider a rule for defining how different would a candidate need to be before it is treated in this way. They will also consider proposals for dealing with such candidates.

Example: perennial ryegrass (tetraploid, late) 2016-2018 Growth habit (UK characteristic 52 – is not a UPOV characteristic)

In this example, one of the candidates shows extrapolation in all three years.



Highlighted candidate: extrapolation factor 1.77 (candidate larger values than reference varieties in all three years). Some, but not extensive extrapolation in all 3 years. COYUs p-value 0.234. *Verdict: candidate is arguably uniform*, on the basis that in 2016 and 2017 the candidate is near the extended trend line if it were to continue its trend, which looks likely. In 2018 it is above the extended trend line, but not excessively so.

The annex to this document contains a presentation “Guidance on Extrapolation when using Combined Over-Years Uniformity (COYU)”, to be made by experts from the United Kingdom, at the fourth session of the TWM.

[Annex follows]

Guidance on **Extrapolation** when using Combined Over-Years Uniformity(COYU)

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Purpose of this Guidance

- Support DUS experts when extrapolation occurs in COYU
- Explain why extrapolation increases uncertainty
- Promote consistent, transparent expert decisions

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What is COYU?

- Combined-Over-Years Uniformity (COYU)
- Assesses uniformity using measured **quantitative characteristics**
- See **UPOV document TGP/8**
- UK are currently evaluating the new improved version of COYU using splines. Old method used moving averages.
- **Splines** are a flexible statistical method for modelling how one variable changes with another when the relationship is not strictly linear.

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Why Extrapolation Matters

- Extrapolation occurs when a candidate variety's mean score lies **outside the range** of Control varieties in trial in a given year.
- In extrapolation cases, the **adjustment becomes less reliable**, regardless of the adjustment method used.
- This reliability issue was **only recognised with the introduction** of the improved COYU with splines method.
- **An extrapolation index** has been developed to indicate the reliability of the adjustment.
- When the index shows unreliable adjustment, **crop experts must review results and apply expert judgement**, highlighting the need for guidance.

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Extrapolation Index

- Index measures the distance between the **candidate mean score and the nearest Control variety's mean.**
- Numerical indicator used to show **how reliable** the adjustment for mean is when assessing uniformity.
- Quantifies how much the COYU adjustment is **based on extrapolation** rather than observed data.
- Index ≤ 1.2 means the adjustments is well-supported by data.
- Higher values reflect increasing uncertainty and means the adjustment relies heavily on extrapolation.

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Decision Flags

Index	Flag
Up to 1.2	No extrapolation issue
From 1.2 to 1.5	Review COYU-based decision
Above 1.5	COYU unreliable; expert judgement required

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Expert Review Process

1. Review Excel output from COYUs
2. Inspect spline graphs for extrapolated candidates
3. Check for gaps in means of Control varieties in trial
4. Use sensible significant figures for p-values

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Low extrapolation index: <1.2

- Candidate mean lies within or very close to the range of Control varieties in trial
- Adjustment is considered reliable
- COYU result can normally be used without concern

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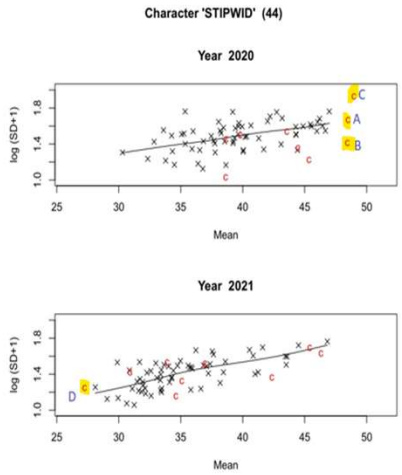
Low extrapolation example



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Moderate extrapolation index: >= 1.2 - <1.5

- Candidate slightly outside the range of Control varieties in trial
- Adjustment may still be usable, but care is needed
- Expert should check neighbouring years, characteristics, or trial context

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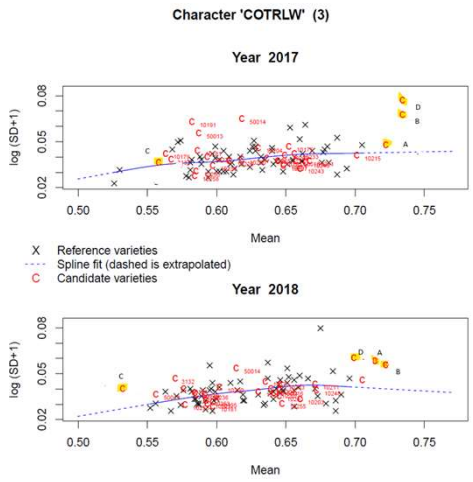
Moderate extrapolation example



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Candidate D: extrapolation factor 1.29 (candidate larger values than Control varieties in 2017 and 2018). Extrapolation in both years. COYUs p-value 0.000. ***Verdict not Uniform***.

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High extrapolation index: >1.5

- Candidate clearly outside the range of Control varieties in trial
- Adjustment is unreliable
- Automatic COYU outcome should not be relied upon alone
- Expert judgement is required

This is the point at which guidance becomes **essential**.

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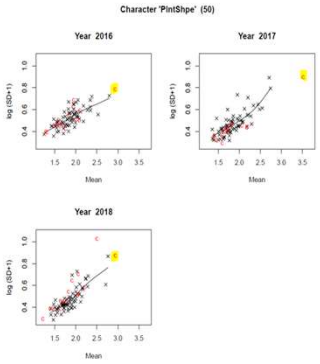
High extrapolation example



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Lessons from Worked Examples

- Low extrapolation generally supports COYU result
- Moderate extrapolation may produce marginal cases
- High extrapolation demands case-by-case expert agreement

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Key Take-Home Messages

- Extrapolation increases uncertainty in uniformity decisions
- COYU is a decision-support tool, not an automatic verdict
- Expert judgement remains essential

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Thank you!

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[End of Annex and of document]