

**Technical Working Party on Testing Methods and Techniques****TWM/2/3 Add.****Second Session****Virtual meeting, April 8 to 11, 2024****Original:** English**Date:** April 8, 2024

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**ADDENDUM TO:  
THE COMBINED-OVER-YEARS UNIFORMITY CRITERION (COYU)***Document prepared by experts from the United Kingdom**Disclaimer: this document does not represent UPOV policies or guidance*

The annex to this document contains a copy of a presentation “The Combined-Over-Years Uniformity Criterion (COYU)”, made by an expert from the United Kingdom, at the second session of the Technical Working Party on Testing Methods and Techniques (TWM).

[Annex follows]



# COYU Development Update 2024

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## Overview



- A recap on COYU and the proposed change
- Development process
- Extrapolation
- Software
- Software Evaluation

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## A recap on COYU



- Combined Over-Year Uniformity criterion (COYU)
- A method for determining uniformity of candidate variety
  - Mostly used for agricultural crops, but also some vegetables
  - Characteristic-by-characteristic
  - Quantitative characteristics, measured on single plants
  - Works over two or more cycles
  - More information in TGP/8

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## COYU key concepts



- Compares uniformity with similar varieties
  - TG/1/3 General Introduction  
*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 already known. UPOV has proposed several statistical methods for dealing with uniformity in measured quantitative characteristics. One method, which takes into account variations between years, is the Combined Over Years Uniformity (COYU) method.*
- Measures uniformity through standard deviation (SD) of measurements within plots
  - Log (SD+1)
- Adjusts for any relationship between variability (SD) and level of expression (mean)
  - This is main element that is changed  
Moving-average → Spline

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## Development



- The development process began in 2008
  - Proposal for improved COYU made and supported by TWC
  - Software developed in R and DUST
  - Extrapolation needed to be addressed
  - Further improvements to software
  - Implementation in a member country
  - Introduction of guidance to TGP/8
- } Current stage

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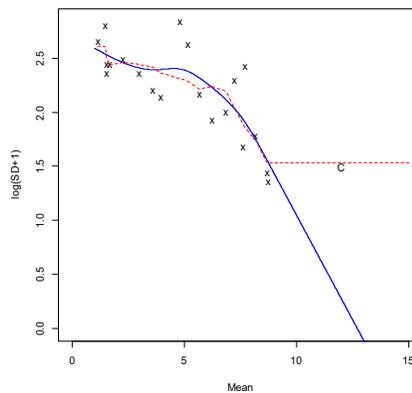
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## Extrapolation



### Key issue

- What if candidate has mean higher or lower than all of the reference varieties?
- Spline and moving average both unreliable
- Plus we need to assess candidate against similar varieties



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## Extrapolation



### UK work

- UK DUS Centres and Statisticians had two workshops
- Agreed measure for flagging cases
  - Extrapolation index – see TWM/1/7

| Index      | Flag  |
|------------|---|
| Up to 1.0  | No extrapolation  |
| 1.0 to 1.2 | No extrapolation issue  |
| 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 |

- Identified examples of extrapolation
  - To develop guidance based on these
  - Revisiting these currently
- Proposed improvements to software, especially plots

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## Software



### DUST9NT

- DUST9NT contains a suite of software modules for analysing DUS trials
- New module for COYU with splines
- Been substantially improved recently, as well as DUST9NT itself
- Distributed by AFBI (<https://eservices.afbini.gov.uk/dustdownload/>)

### R package

- Suitable for those wanting to integrate into their own systems
- The COYU package is freely available, including source code:  
<https://github.com/BiomathematicsAndStatisticsScotland/coyus>

Software improvements focussed on DUST9NT

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Software

### DUST9NT improvements

- COYUS9 module
  - Improved and corrected output, including extrapolation flags
  - CSV output extended – gives easy access to detailed results
  - Graphics improved
    - PDF
    - Candidates labelled
    - Option to print one graph with all candidates or one graph for each of the candidates
    - Spline extrapolated beyond reference varieties as needed
  
- Wider DUST9NT software
  - Maintenance processes modernised with versioned repository and unit tests
  - Installation modernised – now more compatible with current Windows structures
  - Ambition to overhaul interface if funding can be obtained

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Software

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ANDIDATE SUMMARY
AFP VARIETY      04  09  05  60  70  08  10  11  14  15  17  24  31  33  34  35  41
109 VARIETY F    -  -  -  -  -  $  $  -  -  -  -  !  -  -  -  !  -
994 VARIETY AD    -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -  -

SYMBOLS
+ SD EXCEEDS OVER-YEARS UNIFORMITY CRITERION AFTER 2 YEARS WITH PROBABILITY 0.0030
: SD NOT YET ACCEPTABLE ON OVER-YEARS CRITERION AFTER 2 YEARS WITH PROBABILITY 0.0030
! There is an extrapolation issue but it is limited. The COYU verdicts should be reviewed alongside the COYU graphs to
$ There is serious extrapolation. The COYU decisions may be unreliable. In these cases, decisions must be made based on
    
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## Software



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\*\*\*\* UNIFORMITY ANALYSIS OF BETWEEN-PLANT STANDARD DEVIATIONS (SD) \*\*\*\*

| APP_VARIETY     | Extrapolation | Char_Mean | Adj_LogSD | Unadj_Log_SD | Mean_1992 | Mean_1993 | Log(SD+1)_1992 | Log(SD+1)_1993 |
|-----------------|---------------|-----------|-----------|--------------|-----------|-----------|----------------|----------------|
| CANDIDATE       |               |           |           |              |           |           |                |                |
| 109 VARIETY F   | 1.81          | 77.25     | 2.57      | 2.51         | 2.42      | 2.6       | 2.58           | 2.57           |
| 994 VARIETY AD  | -             | 82.2      | 2.5       | 2.5          | 2.48      | 2.51      | 2.47           | 2.52           |
| REFERENCE MEANS |               | 85        | 2.53      |              |           |           |                |                |
| REFERENCE       |               |           |           |              |           |           |                |                |
| 101 VARIETY N   |               | 80.7      | 2.56      | 2.57         | 86.7      | 74.8      | 2.64           | 2.5            |
| 1069 VARIETY AE |               | 79.3      | 2.51      | 2.46         | 83.6      | 75        | 2.34           | 2.57           |
| 1080 VARIETY AF |               | 90.5      | 2.58      | 2.6          | 98        | 83        | 2.63           | 2.56           |
| 1088 VARIETY AG |               | 84.7      | 2.51      | 2.53         | 93.9      | 75.5      | 2.53           | 2.54           |
| 203 VARIETY J   |               | 87.3      | 2.45      | 2.45         | 92        | 82.6      | 2.54           | 2.36           |
| 274 VARIETY P   |               | 82.8      | 2.54      | 2.53         | 88        | 77.6      | 2.55           | 2.51           |
| 340 VARIETY H   |               | 82.7      | 2.53      | 2.52         | 89.2      | 79        | 2.6            | 2.44           |
| 4 VARIETY T     |               | 93.6      | 2.51      | 2.57         | 100       | 87.1      | 2.48           | 2.65           |
| 493 VARIETY C   |               | 82.7      | 2.57      | 2.57         | 89        | 76.5      | 2.48           | 2.66           |
| 635 VARIETY K   |               | 82.4      | 2.56      | 2.54         | 86.8      | 78        | 2.61           | 2.47           |
| 64 VARIETY X    |               | 87.3      | 2.6       | 2.61         | 91.4      | 83.2      | 2.59           | 2.64           |
| 65 VARIETY Q    |               | 81.2      | 2.45      | 2.46         | 87.5      | 74.8      | 2.49           | 2.43           |
| 658 VARIETY A   |               | 85.9      | 2.54      | 2.53         | 93        | 78.8      | 2.63           | 2.42           |
| 766 VARIETY O   |               | 82.7      | 2.55      | 2.52         | 86.5      | 78.8      | 2.63           | 2.41           |
| 814 VARIETY H   |               | 89.2      | 2.65      | 2.7          | 93.5      | 85        | 2.66           | 2.73           |
| 83 VARIETY L    |               | 85.8      | 2.5       | 2.48         | 91.2      | 80.4      | 2.36           | 2.59           |
| 925 VARIETY AB  |               | 86.8      | 2.49      | 2.53         | 89        | 84.7      | 2.65           | 2.41           |
| 931 VARIETY AC  |               | 82.6      | 2.48      | 2.43         | 85.9      | 79.3      | 2.55           | 2.32           |

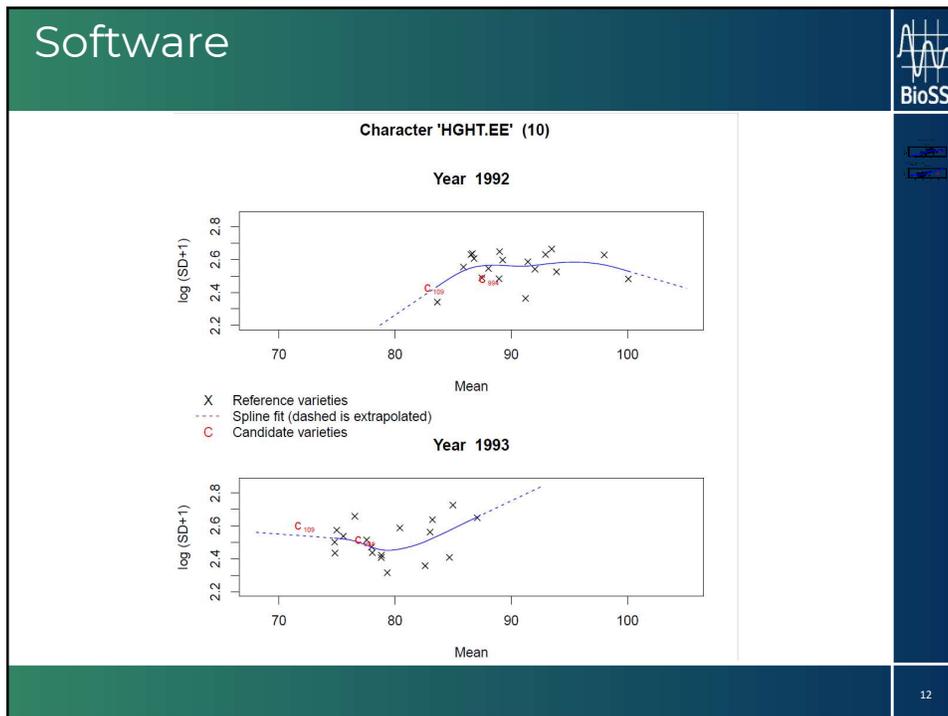
**SYMBOLS**

- + SD EXCEEDS OVER-YEARS UNIFORMITY CRITERION AFTER 2 YEARS WITH PROBABILITY 0.0030
- : SD NOT YET ACCEPTABLE ON OVER-YEARS CRITERION AFTER 2 YEARS WITH PROBABILITY 0.0030
- NO VERDICT.
- T There is an extrapolation issue but it is limited. The COYU verdicts should be reviewed alongside the COYU graphs to verify that the decisions are sensible.
- \$ There is serious extrapolation. The COYU decisions may be unreliable. In these cases, decisions must be made based on the data directly. The graphs in the PDF output may be of use. See TGP8

RESIDUAL DEGREES OF FREEDOM: 28

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Software

COYU\_UK93206\_2024-04-03\_data.csv - Excel

| character | n_AFP | is_candidate | variety | extrapolation_factor | extrapolation_mean | actual_logSD | adjusted_logSD | COYU_pval  | prediction_err | candidate_hold | candidate_min | candidate_max | Extrapolation_1992 | Extrapolation_1993 | Mean_1992 | Mean_1993  | Log[SD+1]_1992 | Log[SD+1]_1993 | AdjLog[SD+1]_1992 | AdjLog[SD+1]_1993 |    |    |
|-----------|-------|--------------|---------|----------------------|--------------------|--------------|----------------|------------|----------------|----------------|---------------|---------------|--------------------|--------------------|-----------|------------|----------------|----------------|-------------------|-------------------|----|----|
| 1         | 4     | 109          | 1       | VARIETY F            | 0                  | NA           | 48.0835        | 2.3751849  | 2.3750485      | 0.55478703     | 0.06233591    | 2.57216724    | FALSE              | 51.5               | 44.667    | 2.31085084 | 2.43938613     | 2.35490283     | 2.39518486        | NA                | NA |    |
| 2         | 4     | 994          | 1       | VARIETY AD           | 0                  | NA           | 49.125         | 2.3630544  | 2.38351282     | 0.50213554     | 0.06225936    | 2.5689683     | FALSE              | 52.5               | 45.75     | 2.2969933  | 2.42904152     | 2.36844662     | 2.39857902        | NA                | NA |    |
| 3         | 4     | 101          | 0       | VARIETY H            | NA                 | NA           | 49.861         | 2.3692216  | 2.3410726      | NA             | NA            | NA            | NA                 | NA                 | 51.972    | 47.75      | 2.2289355      | 2.36830397     | 2.2824797         | 2.39389615        | NA | NA |
| 4         | 4     | 1069         | 0       | VARIETY AE           | NA                 | NA           | 42.5625        | 2.41249116 | 1.36499192     | NA             | NA            | NA            | NA                 | NA                 | 46.625    | 30.5       | 2.49196501     | 2.3330173      | 2.3848413         | 2.3455997         | NA | NA |
| 5         | 4     | 1080         | 0       | VARIETY AF           | NA                 | NA           | 48.25          | 2.39788798 | 2.40524899     | NA             | NA            | NA            | NA                 | NA                 | 52        | 44.5       | 2.40170618     | 2.3940978      | 2.461972          | 2.34868988        | NA | NA |
| 6         | 4     | 1088         | 0       | VARIETY AG           | NA                 | NA           | 48.264         | 2.36450126 | 2.39590593     | NA             | NA            | NA            | NA                 | NA                 | 51        | 45.528     | 2.2969933      | 2.41203319     | 2.32117473        | 2.39792643        | NA | NA |
| 7         | 4     | 203          | 0       | VARIETY J            | NA                 | NA           | 50.6665        | 2.38835544 | 2.4290909      | NA             | NA            | NA            | NA                 | NA                 | 53.75     | 47.583     | 2.32649691     | 2.45057397     | 2.40094612        | 2.4259567         | NA | NA |
| 8         | 4     | 274          | 0       | VARIETY P            | NA                 | NA           | 50.625         | 2.29340919 | 1.33761529     | NA             | NA            | NA            | NA                 | NA                 | 53.25     | 48         | 2.2851337      | 2.36108469     | 2.36108147        | 2.31214911        | NA | NA |
| 9         | 4     | 490          | 0       | VARIETY U            | NA                 | NA           | 44.014         | 2.5111827  | 2.45111992     | NA             | NA            | NA            | NA                 | NA                 | 46.778    | 41.25      | 2.61124557     | 2.4109997      | 2.51893908        | 2.38364075        | NA | NA |
| 10        | 4     | 4            | 0       | VARIETY T            | NA                 | NA           | 44.9375        | 2.42393575 | 1.37819901     | NA             | NA            | NA            | NA                 | NA                 | 48.625    | 41.25      | 2.41031068     | 2.50481043     | 2.27928596        | 2.47913221        | NA | NA |
| 11        | 4     | 340          | 0       | VARIETY C            | NA                 | NA           | 45.75          | 2.36666618 | 2.2986075      | NA             | NA            | NA            | NA                 | NA                 | 46.75     | 44.75      | 2.27047504     | 2.46325732     | 2.17749           | 2.41972501        | NA | NA |
| 12        | 4     | 635          | 0       | VARIETY K            | NA                 | NA           | 51             | 2.42501404 | 2.4390547      | NA             | NA            | NA            | NA                 | NA                 | 55.25     | 46.75      | 2.40351581     | 2.44651226     | 2.44441967        | 2.43368973        | NA | NA |
| 13        | 4     | 64           | 0       | VARIETY X            | NA                 | NA           | 43.73          | 2.4789313  | 1.43570779     | NA             | NA            | NA            | NA                 | NA                 | 49.5      | 62         | 2.30000142     | 2.39790237     | 2.31999914        | 2.3571639         | NA | NA |
| 14        | 4     | 65           | 0       | VARIETY Q            | NA                 | NA           | 54.5555        | 2.33519901 | 2.35395514     | NA             | NA            | NA            | NA                 | NA                 | 55.361    | 53.75      | 2.31747371     | 2.35292432     | 2.35391907        | 2.35251921        | NA | NA |
| 15        | 4     | 658          | 0       | VARIETY A            | NA                 | NA           | 50.6495        | 2.33579416 | 2.38043913     | NA             | NA            | NA            | NA                 | NA                 | 53.25     | 48.048     | 2.2851337      | 2.36837462     | 2.36308147        | 2.39779727        | NA | NA |
| 16        | 4     | 766          | 0       | VARIETY O            | NA                 | NA           | 52.75          | 2.32398544 | 2.4140053      | NA             | NA            | NA            | NA                 | NA                 | 54        | 51.5       | 2.2823372      | 2.35893916     | 2.36295413        | 2.45786652        | NA | NA |
| 17        | 4     | 814          | 0       | VARIETY H            | NA                 | NA           | 46.4445        | 2.4772542  | 2.41777473     | NA             | NA            | NA            | NA                 | NA                 | 47.167    | 45.722     | 2.49287482     | 2.46163802     | 2.40484988        | 2.43069958        | NA | NA |
| 18        | 4     | 83           | 0       | VARIETY L            | NA                 | NA           | 46.875         | 2.51774259 | 2.46521833     | NA             | NA            | NA            | NA                 | NA                 | 48.5      | 45.25      | 2.49601143     | 2.53947375     | 2.42910498        | 2.50133207        | NA | NA |
| 19        | 4     | 925          | 0       | VARIETY AB           | NA                 | NA           | 47.75          | 2.40318157 | 2.36635596     | NA             | NA            | NA            | NA                 | NA                 | 49.25     | 46.25      | 2.41821159     | 2.39444154     | 2.36974921        | 2.36283282        | NA | NA |
| 20        | 4     | 931          | 0       | VARIETY AC           | NA                 | NA           | 49.736         | 2.2451875  | 2.27311086     | NA             | NA            | NA            | NA                 | NA                 | 53.25     | 46.222     | 2.23205533     | 2.26831968     | 2.3100031         | 2.23621825        | NA | NA |
| 21        | 9     | 109          | 1       | VARIETY F            | 0                  | NA           | 54.861         | 2.40596728 | 2.35850607     | 0.55402896     | 0.06213219    | 2.55181779    | FALSE              | 59                 | 50.722    | 2.49979526 | 2.31213911     | 2.4904109      | 2.2971045         | NA                | NA |    |
| 22        | 9     | 994          | 1       | VARIETY AD           | 0                  | NA           | 54.8           | 2.36429068 | 2.19623892     | 0.59481060     | 0.06217451    | 2.51949462    | FALSE              | 58.5               | 50.5      | 2.20818169 | 2.29268846     | 2.20002164     | 2.15221631        | NA                | NA |    |
| 23        | 9     | 101          | 0       | VARIETY H            | NA                 | NA           | 58.6945        | 2.31107209 | 2.36875205     | NA             | NA            | NA            | NA                 | NA                 | 60.889    | 56.5       | 2.41805434     | 2.25400885     | 2.42113192        | 2.31619019        | NA | NA |
| 24        | 9     | 1069         | 0       | VARIETY AE           | NA                 | NA           | 48.75          | 2.41979115 | 2.35526448     | NA             | NA            | NA            | NA                 | NA                 | 53.25     | 44.25      | 2.40351581     | 2.41600648     | 2.36402282        | 2.34650615        | NA | NA |
| 25        | 9     | 1080         | 0       | VARIETY AF           | NA                 | NA           | 52.25          | 2.31431518 | 2.28679991     | NA             | NA            | NA            | NA                 | NA                 | 60.5      | 52         | 2.28263840     | 2.34091919     | 2.28189614        | 2.29170187        | NA | NA |
| 26        | 9     | 1088         | 0       | VARIETY AG           | NA                 | NA           | 54.0979        | 2.43292347 | 2.37974279     | NA             | NA            | NA            | NA                 | NA                 | 55.690    | 51.895     | 2.3785271      | 2.44777984     | 2.19145186        | 2.38130118        | NA | NA |
| 27        | 9     | 203          | 0       | VARIETY J            | NA                 | NA           | 58.2085        | 2.36573185 | 2.40144743     | NA             | NA            | NA            | NA                 | NA                 | 60.75     | 55.667     | 2.36047657     | 2.37099113     | 2.36217208        | 2.4447757         | NA | NA |
| 28        | 9     | 274          | 0       | VARIETY P            | NA                 | NA           | 58             | 2.25728462 | 2.30946184     | NA             | NA            | NA            | NA                 | NA                 | 59.5      | 56.5       | 2.15839816     | 2.25617107     | 2.15095327        | 2.26827442        | NA | NA |
| 29        | 9     | 340          | 0       | VARIETY U            | NA                 | NA           | 50.9385        | 2.51044506 | 2.42090646     | NA             | NA            | NA            | NA                 | NA                 | 53.617    | 48.5       | 2.4120971      | 2.6081901      | 2.3742021         | 2.48181371        | NA | NA |
| 30        | 9     | 4            | 0       | VARIETY T            | NA                 | NA           | 53.3905        | 2.31808847 | 2.47997256     | NA             | NA            | NA            | NA                 | NA                 | 58.625    | 48.556     | 2.42391738     | 2.6252556      | 2.4145793         | 2.52768718        | NA | NA |
| 31        | 9     | 491          | 0       | VARIETY C            | NA                 | NA           | 50             | 2.40139159 | 2.31543392     | NA             | NA            | NA            | NA                 | NA                 | 52.25     | 47.75      | 2.32649691     | 2.47628627     | 2.28110214        | 2.34976957        | NA | NA |
| 32        | 9     | 635          | 0       | VARIETY K            | NA                 | NA           | 55.875         | 2.37547019 | 2.36349491     | NA             | NA            | NA            | NA                 | NA                 | 58.5      | 53.25      | 2.38280472     | 2.57257486     | 2.37029456        | 2.35174478        | NA | NA |
| 33        | 9     | 64           | 0       | VARIETY X            | NA                 | NA           | 49.8195        | 2.50395449 | 2.42595117     | NA             | NA            | NA            | NA                 | NA                 | 53.25     | 46.389     | 2.58484898     | 2.424422       | 2.54299398        | 2.30890836        | NA | NA |
| 34        | 9     | 65           | 0       | VARIETY Q            | NA                 | NA           | 61.222         | 2.20912977 | 2.38437183     | NA             | NA            | NA            | NA                 | NA                 | 61.444    | 61         | 2.40937459     | 2.00888495     | 2.4208746         | 2.3481562         | NA | NA |
| 35        | 9     | 658          | 0       | VARIETY A            | NA                 | NA           | 60.6145        | 2.2699139  | 2.3691941      | NA             | NA            | NA            | NA                 | NA                 | 64.5      | 58.723     | 2.21818469     | 2.30188491     | 2.32179015        | 2.42481558        | NA | NA |
| 36        | 9     | 766          | 0       | VARIETY O            | NA                 | NA           | 62.361         | 2.20589941 | 1.38692505     | NA             | NA            | NA            | NA                 | NA                 | 65.778    | 58.944     | 2.24251657     | 2.16928225     | 2.37361374        | 2.40023636        | NA | NA |
| 37        | 9     | 814          | 0       | VARIETY H            | NA                 | NA           | 55.014         | 2.44590483 | 2.41927344     | NA             | NA            | NA            | NA                 | NA                 | 57.722    | 52.306     | 2.44443182     | 2.44473784     | 2.43731657        | 2.40123031        | NA | NA |

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Software evaluation

UK currently undergoing detailed evaluation of DUST9NT

- Installation
- Usual modules – same results as before?
- COYUs module – does it run on your data?

After incorporating any improvements ...

Launch of evaluation version of new DUST9NT for UPOV members

- Hopefully late May?
- Would like involvement by current users of DUST9NT
- Evaluation open for ~ one year
- Current version also available

Launch of new version of DUST9NT approx. May 2025

- Old version will still be available for a period

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[End of Annex and of document]