

Technical Committee**TC/55/4 Add.****Fifty-Fifth Session
Geneva, October 28 and 29, 2019****Original:** English
Date: October 21, 2019

ADDENDUM TO TGP DOCUMENTS*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 addendum is to report on developments at the thirty-seventh session of the Technical Working Party on Automation and Computer Programs (TWC) concerning: (1) presentation of full scale of notes for quantitative characteristics in Test Guidelines; and (2) a draft replacement section for document TGP/8 "Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability" on the method of calculation of the Combined Over Years Uniformity Criterion (COYU).

Presentation of full scale of notes for quantitative characteristics in Test Guidelines

2. The TWC considered the proposal for the revision of document TGP/7 to present the full scale of notes for quantitative characteristics in Test Guidelines (see document TWC/37/12 "Report", paragraphs 40 and 41).

3. The TWC noted the usefulness of presenting the full scale of notes for electronic application systems and agreed with the TWO, TWV and TWF that all states of expression for quantitative characteristics should be presented in Test Guidelines.

The Combined Over Years Uniformity (COYU) Criterion

4. The TWC considered document TWC/37/7 "Combined Over Years Uniformity (COYU) Criterion" (see document TWC/37/12 "Report", paragraphs 8 to 10).

5. The TWC agreed to invite members who use "R" or "DUST" Software to review the new COYU package to identify possible improvement points. The TWC noted the expression of interest by experts from China, Finland, France and the United Kingdom to review the new COYU package.

6. The TWC considered the proposed draft revision for document TGP/8, Section 9 "The Combined Over Years Uniformity Criterion (COYU)", as presented in the Annex to document TWC/37/7 and reproduced in this document. The TWC agreed that editorial suggestions should be communicated to the drafter. The TWC agreed to invite the expert from the United Kingdom to prepare a revised version of the draft guidance, to be presented to the TWC, at its thirty-eighth session.

7. The following proposal for the revision for document TGP/8, Section 9 "The Combined Over Years Uniformity Criterion (COYU)" (in English only) was considered by the TWC (changes indicated by strikethrough and highlighting for deletions and underlining and highlighting for insertions of text).

9. THE COMBINED-OVER-YEARS UNIFORMITY CRITERION (COYU)

[...]

9.5 Use of COYU

[...]

9.5.3 The probability level "p" used to determine the uniformity criterion depends on the crop. Recommended probability levels are given in sections 9.447 and 9.8.

[...]

9.6 Mathematical details

[...]

9.6.3 The revised version of COYU uses the method of splines rather the moving average approach used in the previous procedure.

9.6.4 For each year separately, the form of the average relationship between SD and characteristic mean is estimated for the comparable varieties. The method of estimation is a 9 point moving average. The log SDs (the Y variate) and the means (the X variate) for each variety are first ranked according to the values of the mean. For each point (X_i, Y_i) take the trend value T_i to be the mean of the values $Y_{i-4}, Y_{i-3}, \dots, Y_{i+4}$ where i represents the rank of the X value and Y_i is the corresponding Y value. For X values ranked 1st and 2nd the trend value is taken to be the mean of the first three values. In the case of the X value ranked 3rd the mean of the first five values are taken and for the X value ranked 4th the mean of the first seven values are used. A similar procedure operates for the four highest ranked X values cubic smoothing spline with four degrees of freedom. The log SDs (the Y variate) are fitted to the means (the X variate) for each variety using the spline.

9.6.5 A simple example in Figure 1 illustrates this procedure for 16 varieties. The points marked "OO" in Figure 1a represent the log SDs and the corresponding means of 16 varieties. The points marked "X" are the 9 point moving averages, which are calculated by taking, for each variety, the average of the log SDs of the variety and the four varieties on either side. At the extremities the moving average is based on the mean of 3, 5, or 7 values. The dashed line represents the fitted smoothing spline.

Figure 1: Association between SD and mean – days to ear emergence in cocksfoot varieties (symbol O is for observed SD, symbol X is for moving average SD)

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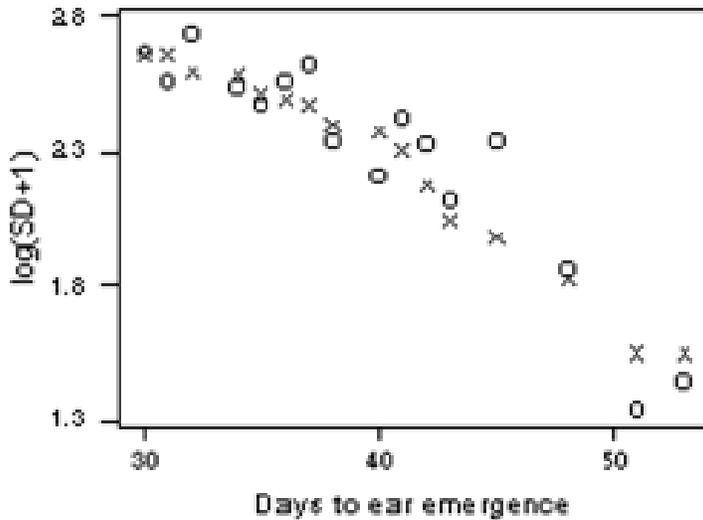
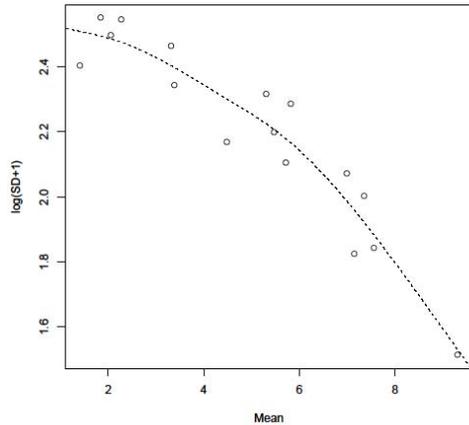


Figure 1: Association between SD and mean (*symbol O is for observed SD, dashed line is fitted spline*)

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Step 4: Adjustment of transformed SD values based on estimated SD-mean relationship

9.6.6 Once the trend values for the comparable varieties have been determined, the trend values for candidates are estimated using linear interpolation between the trend values of the nearest two comparable varieties as defined by their means for the characteristic. Thus if the trend values for the two comparable varieties on either side of the candidate are T_i and T_{i+1} and the observed value for the candidate is X_c , where $X_i \leq X_c \leq X_{i+1}$, then the trend value T_c for the candidate is given by predictions from the spline.

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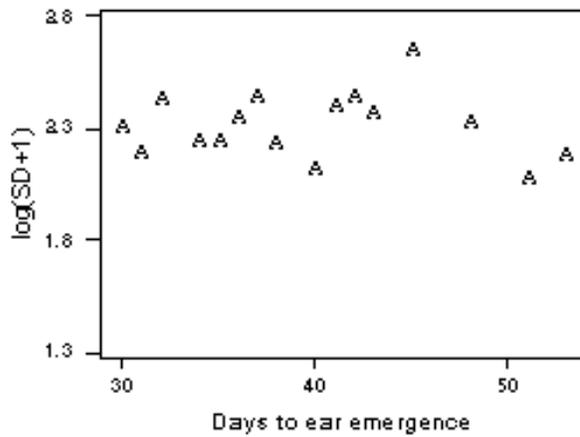
$$T_c = \frac{(X_c - X_i)T_{i+1} + (X_{i+1} - X_c)T_i}{X_{i+1} - X_i}$$

9.6.7 To adjust the SDs for their relationship with the characteristic mean the estimated trend values are subtracted from the transformed SDs and the grand mean is added back.

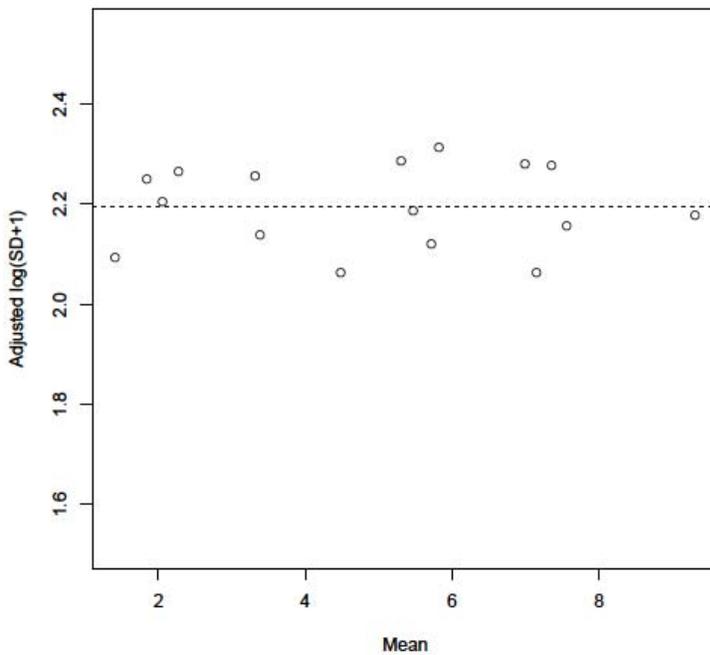
9.6.8 The results for the simple example with 16 varieties are illustrated in Figure 2.

Figure 2: Adjusting for association between SD and mean — days to ear emergence in cocksfoot varieties (symbol Δ is for adjusted SD, dashed line is the grand mean)

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Step 5: Calculation of the uniformity criterion

9.6.8 An estimate of the variability in the uniformity of the comparable varieties is derived by applying a one-way analysis of variance to the adjusted log SDs, i.e. with years as the classifying factor. The variability (V) is estimated from the residual term in this analysis of variance.

9.6.9 The maximum allowable standard deviation (the uniformity criterion), based on k years of trials, is in the form

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$$UC_p = SD_r + t_p \sqrt{V \left(\frac{1}{k} + \frac{1}{Rk} \right)}$$

[to add this fomula]

$$UC = SD_r + t_p \sqrt{V_c}$$

where SD_r is the mean of adjusted log SDs for the comparable varieties, V_c is the variance specific to the candidate variety (related to the uncertainty of the adjusted log SDs after removing year effects, spline prediction), t_p is the one-tailed t-value for probability level p with appropriate degrees of freedom taking into account the spline fit. For further information, see Roberts & Kristensen (2015).

9.6.10 as for V, k The uniformity criterion is specific to the number of years candidate and R is the number of depends on its level of expression relative to the comparable varieties.

9.7 Probability levels

9.7.1 With the previous procedure, a probability level 0.1% was commonly used. For the current procedure, it is recommended that a probability level of 0.3% is used instead.

9.8 Early decisions for a three-year test

9.8.1 Decisions on uniformity may be made after two or three years depending on the crop. If COYU is normally applied over three years, it is possible to make an early acceptance or rejection of a candidate variety using an appropriate selection of probability values.

9.8.2 The probability level for early rejection of a candidate variety after two years should be the same as that for the full three-year test. For example, if the three-year COYU test is applied using a probability level of 0.23%, a candidate variety can be rejected after two years if its uniformity exceeds the COYU criterion with probability level 0.23%.

9.8.3 The probability level for early acceptance of a candidate variety after two years should be larger than that for the full three-year test. As an example, if the three-year COYU test is applied using a probability level of 0.23%, a candidate variety can be accepted after two years if its uniformity does not exceed the COYU criterion with probability level 2%.

9.8.4 Some varieties may fail to be rejected or accepted after two years. In the example set out in section 9.8, a variety might have a uniformity that exceeds the COYU criterion with probability level 2% but not the criterion with probability level 0.23%. In this case, such varieties should be re-assessed after three years.

9.8.5 If a probability level for early rejection of a candidate variety after two years of 1% was used with the previous procedure, it is recommended that a probability level of 2% is used.

9.8 Example of COYU calculations

9.8.1 An example of the application of COYU is given here to illustrate the calculations involved. The example consists of days to ear emergence scores for perennial ryegrass over three years for 11 comparable varieties (R1 to R11) and one candidate (C1). The data is tabulated in Table 1.

Table 1: Example data set – days to ear emergence in perennial ryegrass

| Variety | Character Means | | | Within-Plot SD | | | Log (SD+1) | | |
|---------|-----------------|--------|--------|----------------|--------|--------|------------|--------|--------|
| | Year 1 | Year 2 | Year 3 | Year 1 | Year 2 | Year 3 | Year 1 | Year 2 | Year 3 |
| R1 | 38 | 41 | 35 | 8.5 | 8.8 | 9.4 | 2.25 | 2.28 | 2.34 |
| R2 | 63 | 68 | 61 | 8.1 | 7.6 | 6.7 | 2.21 | 2.15 | 2.04 |
| R3 | 69 | 71 | 64 | 9.9 | 7.6 | 5.9 | 2.39 | 2.15 | 1.93 |
| R4 | 71 | 75 | 67 | 10.2 | 6.6 | 6.5 | 2.42 | 2.03 | 2.01 |
| R5 | 69 | 78 | 69 | 11.2 | 7.5 | 5.9 | 2.50 | 2.14 | 1.93 |
| R6 | 74 | 77 | 71 | 9.8 | 5.4 | 7.4 | 2.38 | 1.86 | 2.13 |
| R7 | 76 | 79 | 70 | 10.7 | 7.6 | 4.8 | 2.46 | 2.15 | 1.76 |
| R8 | 75 | 80 | 73 | 10.9 | 4.1 | 5.7 | 2.48 | 1.63 | 1.90 |
| R9 | 78 | 81 | 75 | 11.6 | 7.4 | 9.1 | 2.53 | 2.13 | 2.31 |
| R10 | 79 | 80 | 75 | 9.4 | 7.6 | 8.5 | 2.34 | 2.15 | 2.25 |
| R11 | 76 | 85 | 79 | 9.2 | 4.8 | 7.4 | 2.32 | 1.76 | 2.13 |
| C1 | 52 | 56 | 48 | 8.2 | 8.4 | 8.1 | 2.22 | 2.24 | 2.21 |

9.8.2 The calculations for adjusting the SDs in year 1 are given in Table 2. The trend value for candidate C1 is obtained by interpolation between values for varieties R1 and R2, since the characteristic mean for C1 (i.e. 52) lies between the means for R1 and R2 (i.e. 38 and 63). That is

$$T_c = \frac{(X_c - X_i)T_{i+1} + (X_{i+1} - X_c)T_i}{X_{i+1} - X_i} = \frac{(52 - 38) \times 2.28 + (63 - 52) \times 2.21}{63 - 38} = 2.28$$

Table 2: Example data set – calculating adjusted log(SD+1) for year 1

| Variety | Ranked mean | Log (SD+1) | Trend Value | Adj. Log (SD+1) |
|---------|-------------|------------|----------------------------------|-----------------------------|
| | (X) | (Y) | T | |
| R1 | 38 | 2.25 | $(2.25 + 2.21 + 2.39)/3 = 2.28$ | $2.25 - 2.28 + 2.39 = 2.36$ |
| R2 | 63 | 2.21 | $(2.25 + 2.21 + 2.39)/3 = 2.28$ | $2.21 - 2.28 + 2.39 = 2.32$ |
| R3 | 69 | 2.39 | $(2.25 + \dots + 2.42)/5 = 2.35$ | $2.39 - 2.35 + 2.39 = 2.42$ |
| R5 | 69 | 2.50 | $(2.25 + \dots + 2.48)/7 = 2.38$ | $2.50 - 2.38 + 2.39 = 2.52$ |
| R4 | 71 | 2.42 | $(2.25 + \dots + 2.32)/9 = 2.38$ | $2.42 - 2.38 + 2.39 = 2.43$ |
| R6 | 74 | 2.38 | $(2.21 + \dots + 2.53)/9 = 2.41$ | $2.38 - 2.41 + 2.39 = 2.36$ |
| R8 | 75 | 2.48 | $(2.39 + \dots + 2.34)/9 = 2.42$ | $2.48 - 2.42 + 2.39 = 2.44$ |
| R7 | 76 | 2.46 | $(2.42 + \dots + 2.34)/7 = 2.42$ | $2.46 - 2.42 + 2.39 = 2.43$ |
| R11 | 76 | 2.32 | $(2.48 + \dots + 2.34)/5 = 2.43$ | $2.32 - 2.43 + 2.39 = 2.28$ |
| R9 | 78 | 2.53 | $(2.32 + 2.53 + 2.34)/3 = 2.40$ | $2.53 - 2.40 + 2.39 = 2.52$ |
| R10 | 79 | 2.34 | $(2.32 + 2.53 + 2.34)/3 = 2.40$ | $2.34 - 2.40 + 2.39 = 2.33$ |
| Mean | 70 | 2.39 | | |
| C1 | 52 | 2.22 | 2.28 | $2.22 - 2.28 + 2.39 = 2.32$ |

9.8.3 The results of adjusting for all three years are shown in Table 3.

Table 3: Example data set – adjusted log(SD+1) for all three years with over-year means

| Variety | Over-Year Means | | Adj. Log (SD+1) | | |
|---------|-----------------|-----------------|-----------------|--------|--------|
| | Char. mean | Adj. Log (SD+1) | Year 1 | Year 2 | Year 3 |
| R1 | 38 | 2.26 | 2.36 | 2.13 | 2.30 |
| R2 | 64 | 2.10 | 2.32 | 2.00 | 2.00 |
| R3 | 68 | 2.16 | 2.42 | 2.10 | 1.95 |
| R4 | 71 | 2.15 | 2.43 | 1.96 | 2.06 |
| R5 | 72 | 2.20 | 2.52 | 2.14 | 1.96 |
| R6 | 74 | 2.12 | 2.36 | 1.84 | 2.16 |
| R7 | 75 | 2.14 | 2.43 | 2.19 | 1.80 |
| R8 | 76 | 2.02 | 2.44 | 1.70 | 1.91 |
| R9 | 78 | 2.30 | 2.52 | 2.16 | 2.24 |
| R10 | 78 | 2.22 | 2.33 | 2.23 | 2.09 |
| R11 | 80 | 2.01 | 2.28 | 1.78 | 1.96 |
| Mean | 70 | 2.15 | 2.40 | 2.02 | 2.04 |
| C1 | 52 | 2.19 | 2.32 | 2.08 | 2.17 |

9.8.4 The analysis of variance table for the adjusted log SDs is given in Table 4 (based on comparable varieties only). The variability in the uniformity of comparable varieties is estimated from this ($V=0.0202$).

Table 4: Example data set – analysis of variance table for adjusted log (SD+1)

| Source | Degrees of freedom | Sums of squares | Mean squares |
|------------------------------------|--------------------|-----------------|---------------|
| Year | 2 | 1.0196 | 0.5098 |
| Varieties within years (=residual) | 30 | 0.6060 | 0.0202 |
| Total | 32 | 1.6256 | |

9.8.5 The uniformity criterion for a probability level of 0.2% is calculated thus:

$$UC_p = SD_r + t_p \sqrt{V \left(\frac{1}{k} + \frac{1}{Rk} \right)} = 2.15 + 3.118 \times \sqrt{0.0202 \times \left(\frac{1}{3} + \frac{1}{3 \times 11} \right)} = 2.42$$

where t_p is taken from Student's t table with $p=0.002$ (one tailed) and 30 degrees of freedom.

9.8.6 Varieties with mean adjusted log (SD + 1) less than, or equal to, 2.42 can be regarded as uniform for this characteristic. The candidate variety C1 satisfies this criterion.

9.9 Extrapolation

9.9.1 If a candidate has a level of expression in a characteristic outside that seen in other varieties, we call this "extrapolation".

9.9.2 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:

- *"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."*

9.9.3 If the level of expression is very different from other varieties in test, it should be considered whether these varieties are actually comparable.

9.9.4 The COYU procedure has tools to evaluate whether there is extrapolation and the degree of extrapolation. The information produced by COYU can also aid the crop expert in making a decision on uniformity when there is extrapolation.

9.9.5 Firstly, the procedure indicates whether the mean for the candidate is outside the range of means seen in other varieties under test in any of the years.

9.9.6 The degree of extrapolation is based on the inflation of the COYU criterion for the candidate compared to that of the nearest comparable variety (see TWC/35/6 "Method of calculation of COYU, practical exercise, probability levels, extrapolation & software"). In the case of extrapolation, the degree of extrapolation will be more than 1. The greater the number, the greater is the severity of the extrapolation. It is suggested that all cases of extrapolation be reviewed using the output from COYU (see examples below) but that special care be taken when the degree is more than 2.

9.9.7 In cases where the degree of extrapolation is sufficiently high to cause concern, the crop expert may consider output from the COYU procedure to assist the decision-making. These include plots of the log(SD+1) against mean values, along with tables of results. Examples are given below.

9.10 Implementing COYU

9.10.1 The COYU criterion can be applied using COYUS9 module of the DUST software package for the statistical analysis of DUS data. This is available from Dr. Sally Watson, (Email: info@afbini.gov.uk) or from

<http://www.afbini.gov.uk/dustnt.htm>. There is also an R package. This can be found at <https://github.com/BiomathematicsAndStatisticsScotland/coyus/>.

9.11 Example of the use of COYU software

9.11.1 DUST computer program

9.10.1.1 — The main output from the DUST COYU program is illustrated in Table A1. This summarises the results of analyses of within plot SDs for 49 perennial ryegrass varieties assessed over a three year period. Supplementary output is given in Table A2 where details of the analysis of a single characteristic, date of ear emergence, are presented. Note that the analysis of variance table given has an additional source of variation; the variance, V , of the adjusted log SDs is calculated by combining the variation for the variety and residual sources.

9.10.1.2 — In Table A1, the adjusted SD for each variety is expressed as a percent of the mean SD for all comparable varieties. A figure of 100 indicates a variety of average uniformity; a variety with a value less than 100 shows good uniformity; a variety with a value much greater than 100 suggests poor uniformity in that characteristic. Lack of uniformity in one characteristic is often supported by evidence of poor uniformity in related characteristics.

9.10.1.3 — The symbols “*” and “+” to the right of percentages identify varieties whose SDs exceed the COYU criterion after 3 and 2 years respectively. The symbol “.” indicates that after two years uniformity is not yet acceptable and the variety should be considered for testing for a further year. Note that for this example a probability level of 0.2% is used for the three year test. For early decisions at two years, probability levels of 2% and 0.2% are used to accept and reject varieties respectively. All of the candidates had acceptable uniformity for the 8 characters using the COYU criterion.

9.10.1.4 — The numbers to the right of percentages refer to the number of years that a within year uniformity criterion is exceeded. This criterion has now been superseded by COYU.

9.10.1.5 — The program will operate with a complete set of data or will accept some missing values, e.g. when a variety is not present in a year.

9.11.1.1 — Results are produced in detailed for each characteristic and then a summary over characteristics is given.

9.11.1.2 — Table A1 shows an example of the detailed results for a characteristic (ear emergence). This was for a two-year test. In this case, neither candidate exceeds the COYU criterion (with probability level at 0.003). However, candidate C1 show signs of a high degree of extrapolation. Figure A1 shows the log(SD) values plotted against the means for this characteristic. This shows the candidate being much earlier than the comparable varieties. Such plots may be used by the crop expert to help evaluate the uniformity of a candidate which has a level of expression different from that of the comparable varieties.

TABLE A1: Example of summary-detailed output for a character from the COYUS program

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**** OVER-YEARS UNIFORMITY ANALYSIS SUMMARY ****

WITHIN-PLOT STANDARD DEVIATIONS AS % MEAN OF
REFERENCE VARIETY SDS

| | CHARACTERISTIC NUMBER | | | | | |
|-----|-----------------------|-------|-------|-------|-------|-----|
| | 5 | 60 | 8 | 10 | 11 | |
| R1 | 100 | 100 | 95 1 | 100 | 97 | 97 |
| R2 | 105 | 106 | 98 | 99 | 104 | 101 |
| R3 | 97 | 103 | 92 1 | 103 | 96 | 98 |
| R4 | 102 | 99 | 118 2 | 105 | 101 | 101 |
| R5 | 102 | 99 | 116 3 | 95 | 104 | 110 |
| R6 | 103 | 102 | 101 | 99 | 97 | 104 |
| R7 | 100 | 95 | 118 2 | 102 1 | 98 | 99 |
| R8 | 97 | 98 | 84 | 95 | 97 | 93 |
| R9 | 97 | 105 | 87 | 99 | 101 | 99 |
| R10 | 104 | 100 | 96 | 105 1 | 96 | 102 |
| R11 | 99 | 96 | 112 | 99 | 101 | 98 |
| R12 | 100 | 97 | 99 1 | 103 | 105 | 106 |
| R13 | 95 | 96 | 101 | 100 | 96 | 101 |
| R14 | 105 | 103 | 90 | 97 | 101 | 97 |
| R15 | 102 | 100 1 | 89 | 105 | 105 1 | 101 |
| R16 | 99 | 98 | 92 1 | 98 | 102 | 98 |
| R17 | 97 | 101 | 98 | 101 | 101 | 95 |
| R18 | 99 | 97 | 96 | 96 | 102 | 99 |
| R19 | 103 | 101 | 105 | 102 | 100 | 98 |
| R20 | 104 | 99 | 93 | 91 | 100 | 102 |
| R21 | 97 | 94 | 103 | 97 | 100 | 102 |
| R22 | 101 | 110*1 | 112 | 107 1 | 103 1 | 101 |
| R23 | 94 | 101 | 107 | 99 | 104 | 97 |
| R24 | 99 | 97 | 95 | 99 | 100 | 103 |
| R25 | 104 1 | 103 | 93 1 | 99 | 101 | 96 |
| R26 | 98 | 97 | 111 2 | 96 | 102 1 | 106 |
| R27 | 102 | 99 | 106 1 | 99 | 103 | 107 |
| R28 | 101 | 106 | 90 | 95 | 101 | 101 |
| R29 | 101 | 105 | 83 | 102 | 94 | 93 |
| R30 | 99 | 96 | 97 | 99 | 95 | 100 |
| R31 | 99 | 102 | 107 | 107 1 | 102 | 99 |
| R32 | 98 | 93 | 111 2 | 102 | 98 | 103 |
| R33 | 104 | 102 1 | 107 1 | 103 | 100 | 97 |
| R34 | 95 | 94 | 82 | 95 | 97 | 96 |
| R35 | 100 | 102 | 95 | 100 | 99 | 94 |
| R36 | 99 | 98 | 111 1 | 99 | 100 | 103 |
| R37 | 100 | 107 1 | 107 | 101 | 100 | 107 |
| R38 | 95 | 97 | 102 | 107 1 | 97 | 101 |
| R39 | 99 | 99 | 90 | 98 | 101 | 100 |
| R40 | 104 | 102 | 112 1 | 100 | 101 | 97 |
| C1 | 100 1 | 106 | 113 2 | 104 1 | 106 1 | 106 |
| C2 | 103 | 101 | 98 | 97 | 101 | 109 |
| C3 | 97 | 93 | 118 2 | 98 | 99 | 109 |
| C4 | 102 | 101 | 106 | 103 | 99 | 101 |
| C5 | 100 | 104 | 99 | 103 | 100 | 107 |
| C6 | 101 | 102 | 103 | 100 | 103 | 107 |
| C7 | 96 | 98 | 106 | 97 | 102 | 103 |
| C8 | 101 | 105 1 | 116 2 | 103 | 103 | 93 |
| C9 | 99 | 99 | 90 2 | 91 | 97 | 98 |

CHARACTERISTIC

| | | | |
|----|---------------|----|---------------|
| 5 | SPRING | 60 | NATURAL SPRIN |
| 8 | DATE OF EAR | 10 | HEIGHT AT EAR |
| 11 | WIDTH AT EAR | 14 | LENGTH OF FLA |
| 15 | WIDTH OF FLAG | 24 | EAR LENGTH |

SYMBOLS

- * - SD EXCEEDS OVER-YEARS CRITERION AFTEF
- + - SD EXCEEDS OVER-YEARS CRITERION AFTEF
- : - SD NOT YET ACCEPTABLE AFTER 2 YEARS
- 1, 2, 3 - THE NUMBER OF OCCASIONS THE WITHIN-YE

8 - DATE EE

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

[to add this table]

| AFP | VARIETY | Extrapolation | Char_Mean | Adj_LogSD | Unadj_Log_SD | Mean_y1 | Mean_y2 | Log(SD+1)_y1 | Log(SD+1)_y2 |
|-----------|---------|---------------|-----------|-----------|--------------|---------|---------|--------------|--------------|
| CANDIDATE | | | | | | | | | |
| 101 | C1 | 6.0 | 75.0! | 1.45 | 1.92 | 75.3 | 74.7 | 1.85 | 2.00 |
| 102 | C2 | - | 83.6 | 1.69 | 1.67 | 81.9 | 85.3 | 1.63 | 1.71 |
| REFERENCE | MEANS | | | 82.9 | 1.73 | | | | |
| REFERENCE | | | | | | | | | |
| 1 | R1 | | 81.9 | 1.76 | 1.77 | 84.4 | 88.7 | 1.38 | 1.76 |
| 2 | R2 | | 82.9 | 1.83 | 1.83 | 82.7 | 84.9 | 1.46 | 1.78 |
| 3 | R3 | | 84.5 | 1.63 | 1.58 | 81.7 | 83.8 | 1.57 | 1.96 |
| 4 | R4 | | 83.7 | 1.55 | 1.54 | 81.5 | 83.5 | 1.51 | 2.02 |
| 5 | R5 | | 79.5 | 1.74 | 1.85 | 80.3 | 81.9 | 1.69 | 1.96 |
| 6 | R6 | | 82.5 | 1.75 | 1.77 | 82.3 | 85.1 | 1.37 | 1.71 |
| 7 | R7 | | 81.1 | 1.75 | 1.83 | 81.2 | 81.2 | 1.59 | 1.92 |
| 8 | R8 | | 82.5 | 1.78 | 1.84 | 81.2 | 81.7 | 1.48 | 1.74 |
| 9 | R9 | | 81.2 | 1.74 | 1.76 | 81.4 | 84.5 | 1.61 | 2.06 |
| 10 | R10 | | 82.7 | 1.76 | 1.76 | 80.1 | 78.9 | 1.71 | 1.99 |
| 11 | R11 | | 86.5 | 1.72 | 1.57 | 81.9 | 81.9 | 1.54 | 2.00 |
| 12 | R12 | | 83.8 | 1.64 | 1.62 | 80.3 | 84.6 | 1.66 | 2.02 |
| 13 | R13 | | 82.4 | 1.56 | 1.57 | 83.3 | 85.7 | 1.44 | 1.72 |
| 14 | R14 | | 84.7 | 1.78 | 1.74 | 81.5 | 83.4 | 1.39 | 1.74 |
| 15 | R15 | | 81.8 | 1.81 | 1.84 | 82.6 | 86.8 | 1.63 | 1.85 |
| 16 | R16 | | 83.6 | 1.90 | 1.90 | 81.2 | 82.5 | 1.59 | 2.08 |
| 17 | R17 | | 85.2 | 1.79 | 1.70 | 82.5 | 84.6 | 1.73 | 2.06 |
| 18 | R18 | | 81.4 | 1.59 | 1.61 | 83.8 | 86.6 | 1.39 | 2.00 |

SYMBOLS

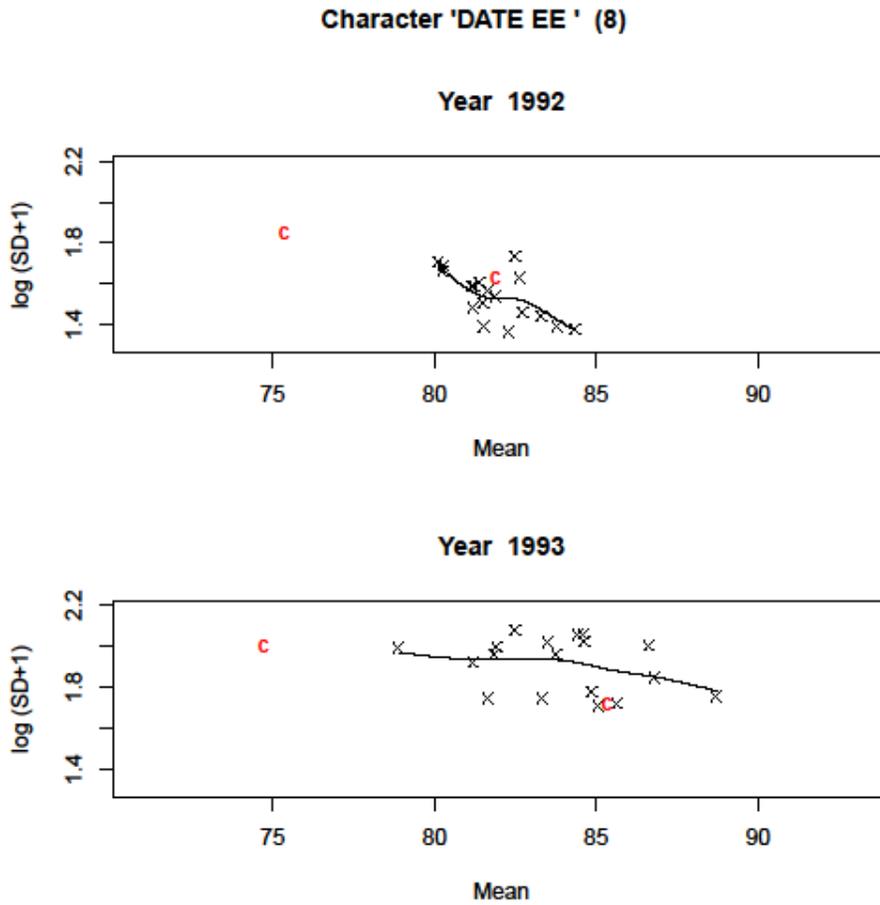
+ SD EXCEEDS OVER-YEARS UNIFORMITY CRITERION AFTER 2 YEARS WITH PROBABILITY 0.0030

NO VERDICT.

! EXTRAPOLATION DETECTED.

FIGURE A1: Example plot of log SD vs mean from the COYUS program

[to add these figures]



9.11.1.3 The program also gives a summary over characteristics. See Table A2 for an example. It can be seen that neither candidate fails the COYU uniformity criterion in any characteristics. However, C2 exhibits signs of extrapolation in several characteristics. So the expert would be advised to look at this candidate with care.

**TABLE A2: Example of supplementary DUST output for date of ear emergency (char.8) summary output
from the COYUS program
[to delete this table]**

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

| VARIETY | OVER-YEARS | | | INDIVIDUAL YEARS | | | | | | | | |
|----------------------|---------------|----------------|-----------------|------------------|-------|-------|-------|-------|-------|------|------|------|
| | CHAR. MEAN | ADJ. LOG SD | UNADJ LOG SD | 88 | 89 | 90 | 88 | 89 | 90 | 88 | 89 | 90 |
| REFERENCE | | | | | | | | | | | | |
| R3 | 38.47 | 1.823 | 2.179 | 39.07 | 41.21 | 35.12 | 2.02 | 2.18 | 2.34X | 1.73 | 1.78 | 1.96 |
| R5 | 50.14 | 2.315 | 2.671 | 48.19 | 53.69 | 48.54 | 2.52X | 2.74X | 2.76X | 2.23 | 2.33 | 2.39 |
| R16 | 59.03 | 1.833 | 2.179 | 57.25 | 63.33 | 56.50 | 2.28X | 2.24 | 2.01 | 1.96 | 1.73 | 1.81 |
| R26 | 63.44 | 2.206 | 2.460 | 61.00 | 66.53 | 62.81 | 2.50X | 2.75X | 2.13 | 2.18 | 2.33 | 2.11 |
| R9 | 63.99 | 1.739 | 1.994 | 62.92 | 68.32 | 60.72 | 2.21 | 2.03 | 1.74 | 1.96 | 1.64 | 1.62 |
| R12 | 66.12 | 1.964 | 2.086 | 67.89 | 65.35 | 65.12 | 2.07 | 2.58X | 1.60 | 1.97 | 2.14 | 1.78 |
| R33 | 67.58 | 2.124 | 2.254 | 66.66 | 71.54 | 64.53 | 2.55X | 2.26 | 1.95 | 2.32 | 1.92 | 2.12 |
| R1 | 67.87 | 1.880 | 1.989 | 69.07 | 70.64 | 63.90 | 1.60 | 2.45X | 1.93 | 1.60 | 2.08 | 1.96 |
| R20 | 68.74 | 1.853 | 1.893 | 67.17 | 74.31 | 64.74 | 2.05 | 1.95 | 1.68 | 1.92 | 1.75 | 1.89 |
| R25 | 68.82 | 1.853 | 1.905 | 68.28 | 72.38 | 65.81 | 1.83 | 2.39X | 1.49 | 1.75 | 2.09 | 1.72 |
| R18 | 69.80 | 1.899 | 1.853 | 68.61 | 75.22 | 65.58 | 1.88 | 1.84 | 1.84 | 1.82 | 1.80 | 2.08 |
| R30 | 70.53 | 1.919 | 1.864 | 70.36 | 75.08 | 66.15 | 2.04 | 1.84 | 1.71 | 2.00 | 1.78 | 1.98 |
| R13 | 70.63 | 2.005 | 2.000 | 70.23 | 75.00 | 66.66 | 1.97 | 2.03 | 2.01 | 1.91 | 1.86 | 2.24 |
| R32 | 71.49 | 2.197 | 2.238 | 70.03 | 74.98 | 69.44 | 2.32X | 2.45X | 1.94 | 2.31 | 2.27 | 2.01 |
| R34 | 72.09 | 1.630 | 1.545 | 71.32 | 77.35 | 67.59 | 1.57 | 1.49 | 1.58 | 1.54 | 1.58 | 1.78 |
| R40 | 72.24 | 2.222 | 2.178 | 72.71 | 75.07 | 68.95 | 2.25X | 2.26 | 2.03 | 2.29 | 2.16 | 2.22 |
| R23 | 72.40 | 2.122 | 2.058 | 69.72 | 78.39 | 69.10 | 2.11 | 2.14 | 1.93 | 2.16 | 2.14 | 2.06 |
| R29 | 72.66 | 1.657 | 1.580 | 73.13 | 75.80 | 69.04 | 1.46 | 1.63 | 1.65 | 1.47 | 1.69 | 1.81 |
| R7 | 73.19 | 2.341 | 2.342 | 72.23 | 75.80 | 71.52 | 2.62X | 2.30X | 2.10 | 2.61 | 2.30 | 2.11 |
| R24 | 73.19 | 1.888 | 1.796 | 74.00 | 76.37 | 69.20 | 1.62 | 1.84 | 1.93 | 1.71 | 1.91 | 2.04 |
| R19 | 73.65 | 2.083 | 2.049 | 73.32 | 76.06 | 71.57 | 1.96 | 2.05 | 2.14 | 1.96 | 2.13 | 2.16 |
| R2 | 73.85 | 1.946 | 1.897 | 72.98 | 78.16 | 70.42 | 1.76 | 1.96 | 1.97 | 1.79 | 2.02 | 2.03 |
| R31 | 74.23 | 2.119 | 2.012 | 73.73 | 78.23 | 70.71 | 2.05 | 1.86 | 2.13 | 2.25 | 1.94 | 2.17 |
| R37 | 74.38 | 2.132 | 2.020 | 74.87 | 76.95 | 71.32 | 1.97 | 2.04 | 2.04 | 2.23 | 2.11 | 2.06 |
| R11 | 74.60 | 2.224 | 2.150 | 73.87 | 78.07 | 71.87 | 2.21 | 2.08 | 2.16 | 2.36 | 2.10 | 2.21 |
| R38 | 74.76 | 2.029 | 1.916 | 76.11 | 78.24 | 69.93 | 1.84 | 2.15 | 1.75 | 1.98 | 2.24 | 1.87 |
| R8 | 74.83 | 1.677 | 1.593 | 74.27 | 78.77 | 71.45 | 1.62 | 1.55 | 1.61 | 1.75 | 1.64 | 1.64 |
| R15 | 75.54 | 1.760 | 1.682 | 75.72 | 78.68 | 72.22 | 1.53 | 1.79 | 1.73 | 1.64 | 1.84 | 1.80 |
| R10 | 75.64 | 1.915 | 1.847 | 73.47 | 79.24 | 74.23 | 1.87 | 1.66 | 2.00 | 1.99 | 1.78 | 1.98 |
| R22 | 75.68 | 2.228 | 2.133 | 74.57 | 79.17 | 73.32 | 2.18 | 2.21 | 2.01 | 2.40 | 2.26 | 2.03 |
| R14 | 75.84 | 1.797 | 1.688 | 74.53 | 79.56 | 73.43 | 1.54 | 1.63 | 1.90 | 1.70 | 1.76 | 1.93 |
| R17 | 76.13 | 1.942 | 1.832 | 75.34 | 79.09 | 73.96 | 1.65 | 2.04 | 1.81 | 1.90 | 2.10 | 1.83 |
| R39 | 76.83 | 1.781 | 1.676 | 75.49 | 80.50 | 74.50 | 1.56 | 1.51 | 1.96 | 1.72 | 1.70 | 1.92 |
| R35 | 77.22 | 1.886 | 1.773 | 76.67 | 80.85 | 74.15 | 1.73 | 1.67 | 1.92 | 1.88 | 1.85 | 1.93 |
| R4 | 77.78 | 2.349 | 2.268 | 76.80 | 81.22 | 75.33 | 2.36X | 2.13 | 2.31X | 2.52 | 2.33 | 2.20 |
| R36 | 77.98 | 2.209 | 2.173 | 78.97 | 79.85 | 75.11 | 2.13 | 2.15 | 2.25X | 2.24 | 2.21 | 2.18 |
| R6 | 78.73 | 2.009 | 1.935 | 77.53 | 82.88 | 75.78 | 2.00 | 1.75 | 2.06 | 2.03 | 2.09 | 1.91 |
| R27 | 78.78 | 2.116 | 2.098 | 77.61 | 80.03 | 78.69 | 1.80 | 2.25 | 2.24X | 1.87 | 2.39 | 2.09 |
| R28 | 79.41 | 1.785 | 1.722 | 78.28 | 81.99 | 77.97 | 1.68 | 1.43 | 2.05 | 1.79 | 1.67 | 1.89 |
| R21 | 80.52 | 2.045 | 1.950 | 77.43 | 85.02 | 79.11 | 1.98 | 1.75 | 2.13 | 2.07 | 2.09 | 1.98 |
| CANDIDATE | | | | | | | | | | | | |
| C1 | 64.03 | 2.252 | 2.438 | 63.85 | 63.33 | 64.92 | 2.49X | 2.81X | 2.02 | 2.25 | 2.29 | 2.21 |
| C2 | 86.11 | 1.940 | 1.837 | 84.83 | 88.63 | 84.85 | 1.79 | 1.71 | 2.01 | 1.90 | 2.05 | 1.87 |
| C3 | 82.04 | 2.349 | 2.248 | 82.26 | 87.45 | 76.40 | 2.37X | 2.03 | 2.35X | 2.48 | 2.37 | 2.20 |
| C4 | 78.63 | 2.104 | 2.033 | 78.01 | 82.17 | 75.72 | 2.05 | 2.01 | 2.04 | 2.15 | 2.27 | 1.90 |
| C5 | 72.99 | 1.973 | 1.869 | 71.98 | 79.40 | 67.59 | 1.95 | 1.78 | 1.88 | 1.93 | 1.90 | 2.08 |
| C6 | 83.29 | 2.050 | 1.947 | 84.10 | 85.57 | 80.21 | 2.05 | 1.69 | 2.10 | 2.16 | 2.03 | 1.96 |
| C7 | 83.90 | 2.100 | 1.997 | 84.12 | 87.99 | 79.60 | 1.93 | 1.95 | 2.11 | 2.04 | 2.29 | 1.97 |
| C8 | 83.50 | 2.304 | 2.201 | 82.43 | 85.98 | 82.08 | 2.27X | 2.00 | 2.34X | 2.38 | 2.33 | 2.20 |
| C9 | 51.89 | 1.788 | 2.157 | 52.35 | 55.77 | 47.56 | 1.83 | 2.34X | 2.31X | 1.52 | 1.91 | 1.93 |
| MEAN OF REFERENCE | 71.47 | 1.988 | | 70.78 | 74.97 | 68.65 | 1.97 | 2.03 | 1.96 | 1.99 | 1.99 | 1.99 |

| UNIFORMITY CRITERION | PROB. LEVEL |
|----------------------|-------------|
| 3-YEAR REJECTION | 2.383 0.002 |
| 2-YEAR REJECTION | 2.471 0.002 |
| 2-YEAR ACCEPTANCE | 2.329 0.020 |

**** ANALYSIS OF VARIANCE OF ADJUSTED LOG(SD+1) ****

| | DF | MS | F RATIO |
|-----------|-----|---------|---------|
| YEARS | 2 | 0.06239 | |
| VARIETIES | 39 | 0.11440 | 5.1 |
| RESIDUAL | 78 | 0.02226 | |
| TOTAL | 119 | 0.05313 | |

SYMBOLS

- * - SD EXCEEDS OVER-YEARS UNIFORMITY CRITERION AFTER 3 YEARS.
- + - SD EXCEEDS OVER-YEARS UNIFORMITY CRITERION AFTER 2 YEARS.
- : - SD NOT YET ACCEPTABLE ON OVER-YEARS CRITERION AFTER 2 YEARS.
- X - SD EXCEEDS 1.265 TIMES MEAN OF REFERENCE VARIETIES

CANDIDATE SUMMARY

[to add this table]

| AFP | VARIETY | 4 | 9 | 5 | 60 | 70 | 8 | 10 | 11 | 14 | 15 | 17 | 24 | 31 | 33 | 34 | 35 | 41 |
|-----|---------|---|---|---|----|----|---|----|----|----|----|----|----|----|----|----|----|----|
| 101 | C1 | - | - | - | - | - | ! | ! | - | - | ! | - | ! | - | - | - | ! | ! |
| 102 | C2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |

SYMBOLS

+ SD EXCEEDS OVER-YEARS UNIFORMITY CRITERION AFTER 2 YEARS WITH PROBABILITY 0.0030
! EXTRAPOLATION DETECTED.

CANDIDATE UNIFORMITY CRITERIA

[to add this table]

| | | 4 | 9 | 5 | 60 | 70 | 8 | 10 | 11 | 14 | 15 | 17 | 24 | 31 | 33 | 34 | 35 | 41 |
|---------------|----|------|------|------|------|------|------|------|------|------|------|-----|------|------|------|------|------|-------|
| 2 YEAR REJECT | | | | | | | | | | | | | | | | | | |
| 101 | C1 | 2.57 | 2.55 | 2.51 | 2.49 | 2.49 | 3.05 | 2.89 | 2.7 | 1.95 | 1.2 | 2.8 | 1.94 | 1.77 | 1.75 | 1.24 | 1.74 | 0.196 |
| 102 | C2 | 2.57 | 2.55 | 2.51 | 2.49 | 2.49 | 1.99 | 2.75 | 2.69 | 1.94 | 1.19 | 2.8 | 1.88 | 1.77 | 1.74 | 1.23 | 1.68 | 0.187 |
| 2 YEAR ACCEPT | | | | | | | | | | | | | | | | | | |
| 101 | C1 | 2.57 | 2.55 | 2.51 | 2.49 | 2.49 | 3.05 | 2.89 | 2.7 | 1.95 | 1.2 | 2.8 | 1.94 | 1.77 | 1.75 | 1.24 | 1.74 | 0.196 |
| 102 | C2 | 2.57 | 2.55 | 2.51 | 2.49 | 2.49 | 1.99 | 2.75 | 2.69 | 1.94 | 1.19 | 2.8 | 1.88 | 1.77 | 1.74 | 1.23 | 1.68 | 0.187 |

9.11.1.4 The COYUS program also outputs a comma-separated value formatted file of results to allow easy transfer to Excel.

9.12 Schemes used for the application of COYU

The following four cases are those which, in general, represent the different situations which may arise where COYU is used in DUS testing:

Scheme A: Test is conducted over 2 independent growing cycles and decisions made after 2 growing cycles (a growing cycle could be a year and is further on denoted by cycle)

Scheme B: Test is conducted over 3 independent growing cycles and decisions made after 3 cycles

Scheme C: Test is conducted over 3 independent growing cycles and decisions made after 3 cycles, but a variety may be accepted after 2 cycles

Scheme D: Test is conducted over 3 independent growing cycles and decisions made after 3 cycles, but a variety may be accepted or rejected after 2 cycles

The stages at which the decisions are made in Cases A to D are illustrated in figures 1 to 4 respectively. These also illustrate the various standard probability levels (p_{u2} , p_{nu2} and p_{u3}) which are needed to calculate the COYU criteria depending on the case. These are defined as follows:

| Probability Level | Used to decide whether a variety is :- |
|-------------------|--|
| p_{u2} | uniform in a characteristic after 2 cycles |
| p_{nu2} | non-uniform after 2 cycles |
| p_{u3} | uniform in a characteristic after 3 cycles |

In Figures 1 to 4 the COYU criterion calculated using say the probability level p_{u2} is denoted by UCp_{u2} etc. The term "U" represents the mean adjusted $\log(SD+1)$ of a variety for a characteristic.

Table 1 summarizes the various standard probability levels needed to calculate the COYD and COYU criteria in each of Cases A to D. For example, in Case B only one probability level is needed (p_{u3}), whereas Case C requires two (p_{u2} and p_{u3}).

| CASE | COYU | | |
|------|----------|-----------|----------|
| | p_{u2} | p_{nu2} | p_{u3} |
| A | | | |
| B | | | |
| C | | | |
| D | | | |

Figure 1. COYU decisions and standard probability levels (p_i) in Case A

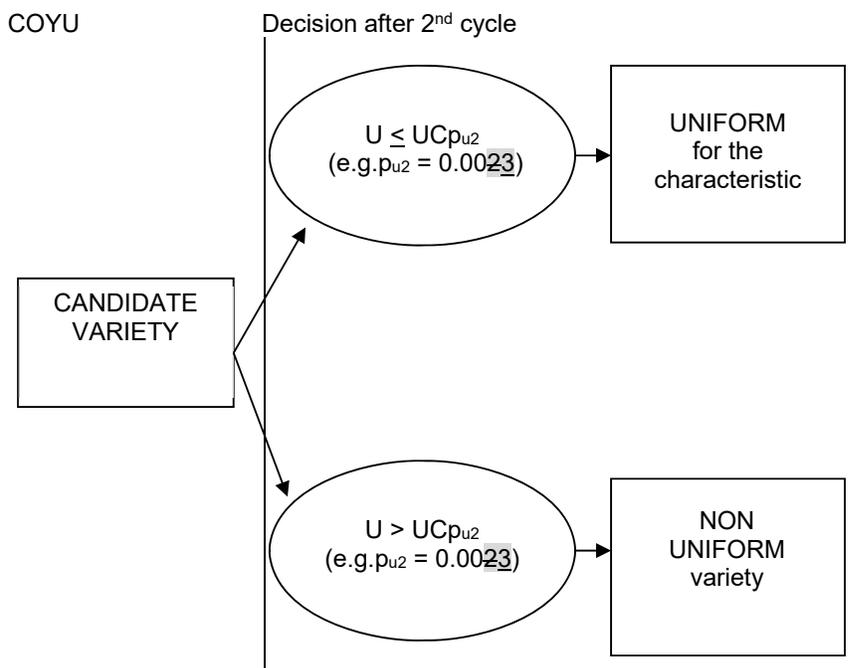
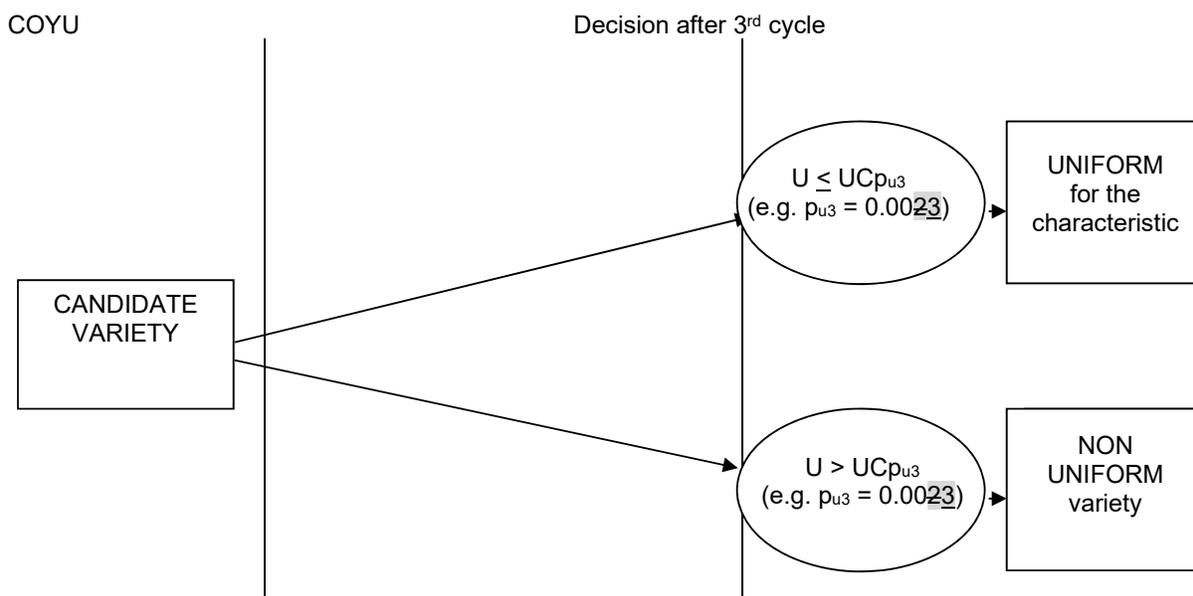


Figure 2. COYD and COYU decisions and standard probability levels (p_i) in Case B



NOTE:-

“U” is the mean adjusted $\log(SD+1)$ of the candidate variety for the characteristic.
 UCp is the COYU criterion calculated at probability level p .

Figure 3. COYU decisions and standard probability levels (p_i) in Case C

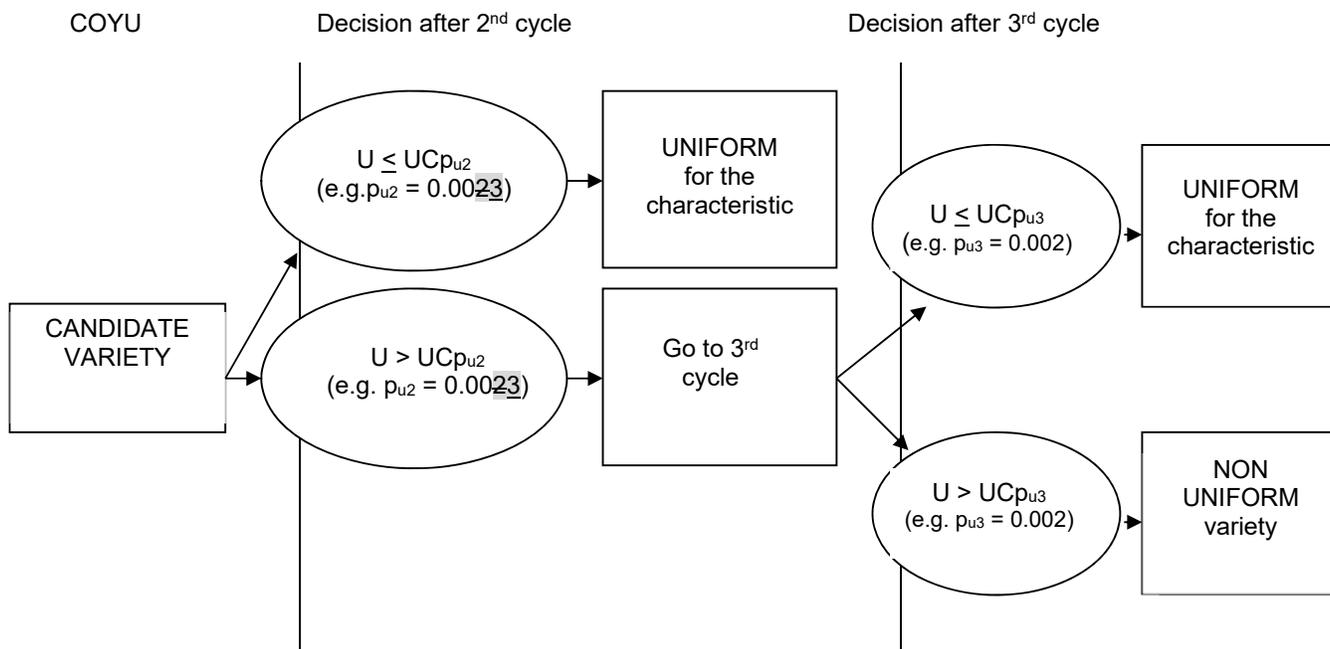
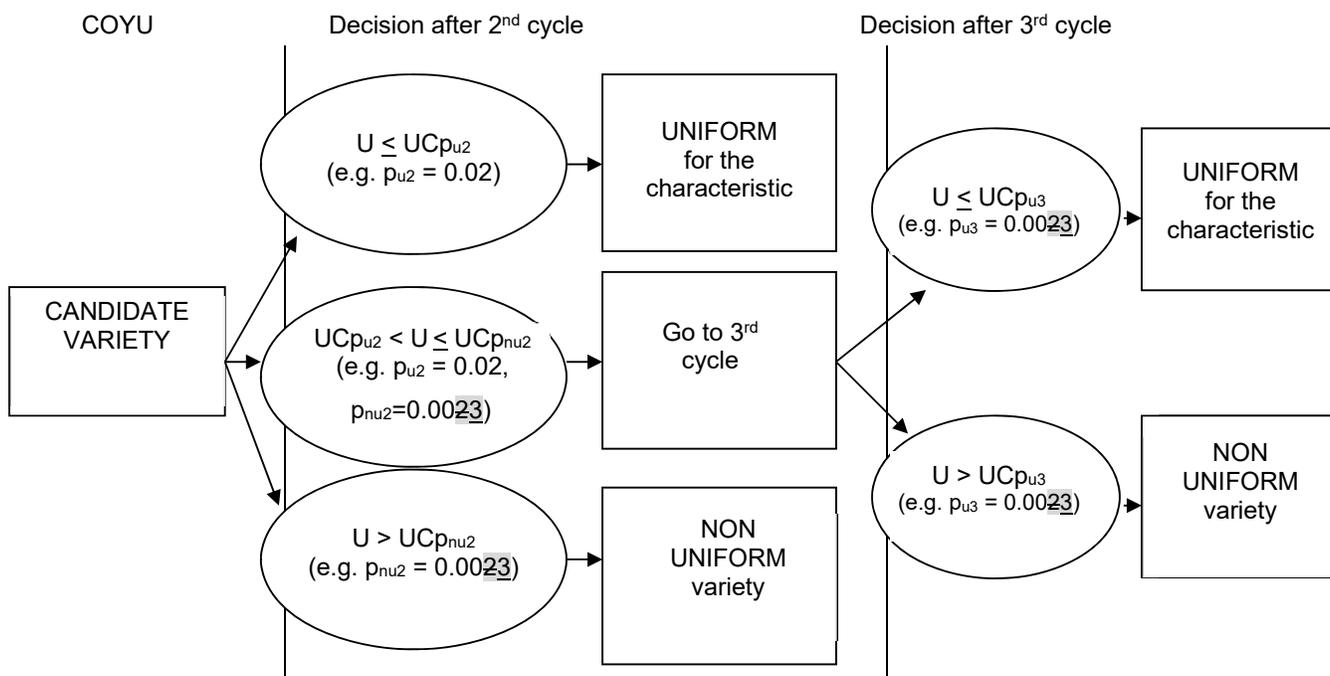


Figure 4. COYD and COYU decisions and standard probability levels (p_i) in Case D



NOTE:-

“U” is the mean adjusted $\log(SD+1)$ of the candidate variety for the characteristic
 UCp is the COYU criterion calculated at probability level p

9.13 References

Roberts A.M.I., Kristensen K (2015) An improved Combined-Over-Year Uniformity Criterion for assessing uniformity based on quantitative characteristics. *Biuletyn Oceny Odmian* 34, 49-57.