

**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**

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**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 The TWC agreed to invite the expert from the United Kingdom to prepare a revised version of the draft guidance, to be presented to the TWC, at its thirty-eighth session.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

[...]

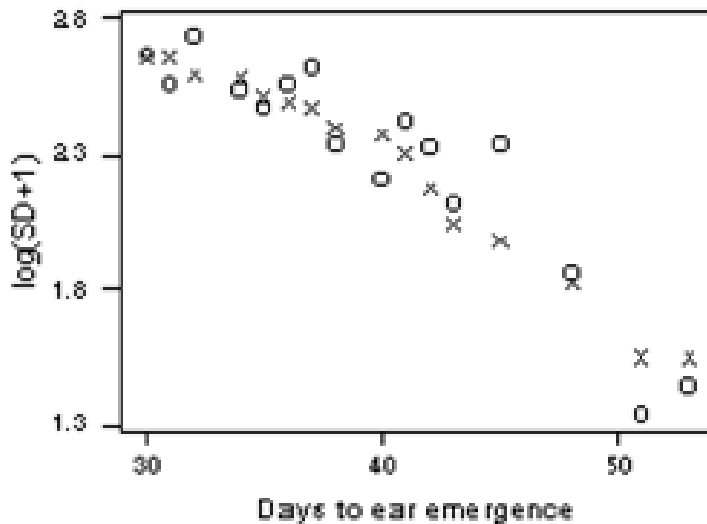
9.6.3 The revised version of COYU uses the method of splines rather the moving average approach used in the previous procedure.

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 1<sup>st</sup> and 2<sup>nd</sup> the trend value is taken to be the mean of the first three values. In the case of the X value ranked 3<sup>rd</sup> the mean of the first five values are taken and for the X value ranked 4<sup>th</sup> 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.

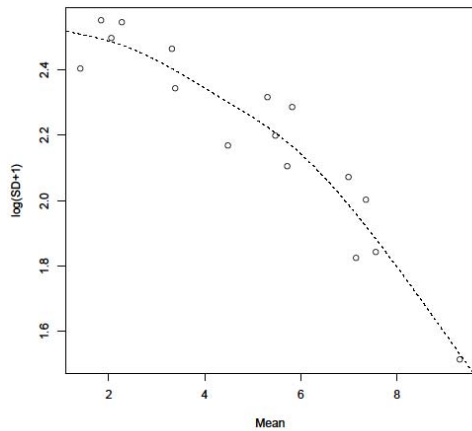
**Figure 1: Association between SD and mean – days to ear emergence in cocksfoot varieties (symbol O is for observed SD, symbol X is for moving average SD)**

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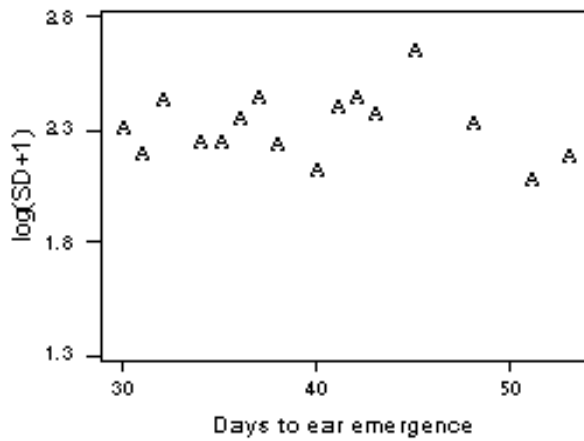
$$T_c = \frac{(X_c - X_i)T_{i+1} + (X_{i+1} - X_c)T_i}{X_{i+1} - X_i}$$

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.

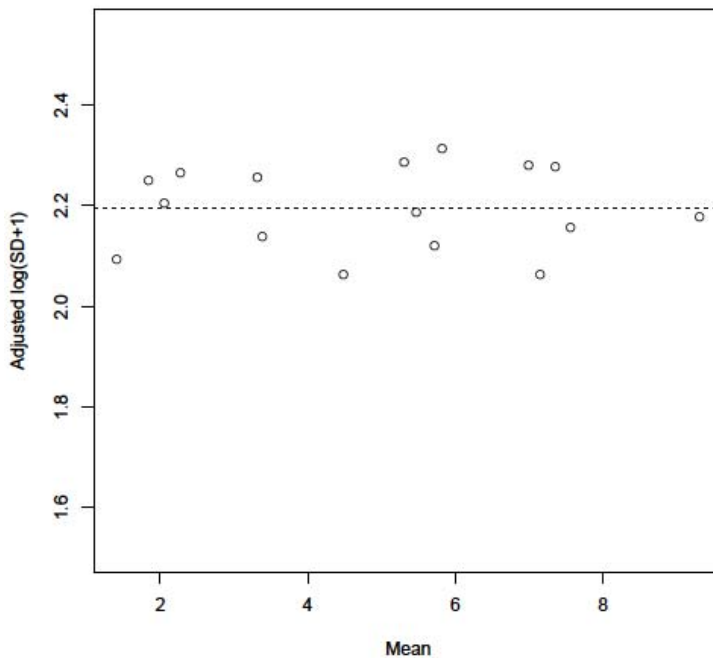
9.6.8 The results for the simple example with 16 varieties are illustrated in Figure 2.

**Figure 2: Adjusting for association between SD and mean — days to ear emergence in cocksfoot varieties** (symbol  $\Delta$  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 formula]

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

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 (X)	Log (SD+1) (Y)	Trend Value T	Adj. Log (SD+1)
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	<b>0.0202</b>
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 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
R2		105	106	98	99	104
R3		97	103	92 1	103	96
R4		102	99	118 2	105	101
R5		102	99	116 3	95	104
R6		103	102	101	99	97
R7		100	95	118 2	102 1	98
R8		97	98	84	95	97
R9		97	105	87	99	101
R10		104	100	96	105 1	96
R11		99	96	112	99	101
R12		100	97	99 1	103	105
R13		95	96	101	100	96
R14		105	103	90	97	101
R15		102	100 1	89	105	105 1
R16		99	98	92 1	98	102
R17		97	101	98	101	101
R18		99	97	96	96	102
R19		103	101	105	102	100
R20		104	99	93	91	100
R21		97	94	103	97	100
R22		101	110*1	112	107 1	103 1
R23		94	101	107	99	104
R24		99	97	95	99	100
R25		104 1	103	93 1	99	101
R26		98	97	111 2	96	102 1
R27		102	99	106 1	99	103
R28		101	106	90	95	101
R29		101	105	83	102	94
R30		99	96	97	99	95
R31		99	102	107	107 1	102
R32		98	93	111 2	102	98
R33		104	102 1	107 1	103	100
R34		95	94	82	95	97
R35		100	102	95	100	99
R36		99	98	111 1	99	100
R37		100	107 1	107	101	100
R38		95	97	102	107 1	97
R39		99	99	90	98	101
R40		104	102	112 1	100	101
C1		100 1	106	113 2	104 1	106 1
C2		103	101	98	97	101
C3		97	93	118 2	98	99
C4		102	101	106	103	99
C5		100	104	99	103	100
C6		101	102	103	100	103
C7		96	98	106	97	102
C8		101	105 1	116 2	103	103
C9		99	99	90 2	91	97

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 AFTER  
+ - SD EXCEEDS OVER-YEARS CRITERION AFTER  
: - 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]

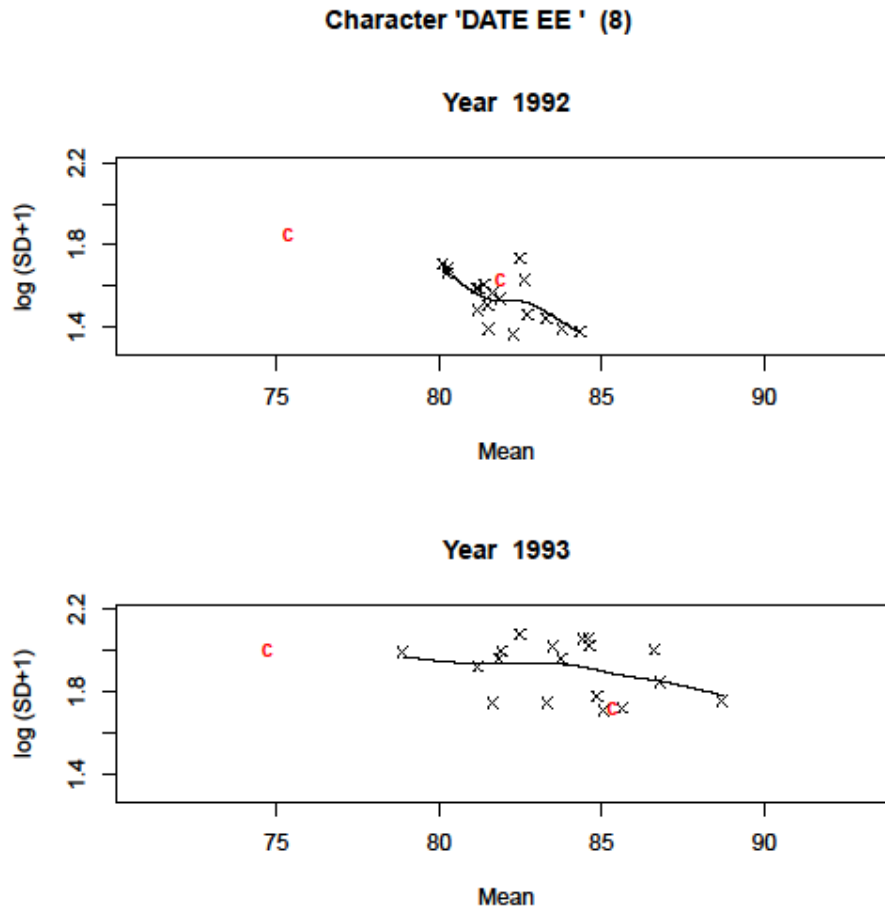
AFP	VARIETY	Extrapolation	Char_Mean	Adj_LogSD	Unadj_Log_SD	Mean_y1	Mean_y2	Log(SD+1)_y1	Log(SD+1)_y2
CANDIDATE									
101	C1	6.0	75.0!	1.45	1.92	75.3	74.7	1.85	2.00
102	C2	-	83.6	1.69	1.67	81.9	85.3	1.63	1.71
REFERENCE									
REFERENCE	MEANS			82.9	1.73				
REFERENCE									
1	R1		81.9	1.76	1.77	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.	ADJ.	UNADJ	-----			---			---		
	MEAN	LOG SD	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	2.26
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  $p_{u3}$ ).

Table 1	COYU		
	CASE	$p_{u2}$	$p_{u3}$
	A		
	B		
	C		
	D		

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

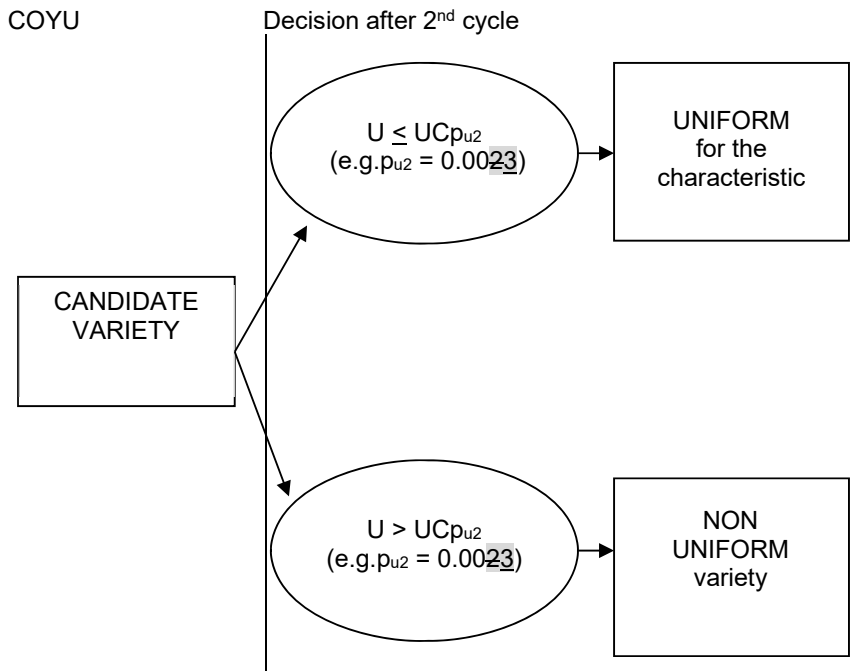
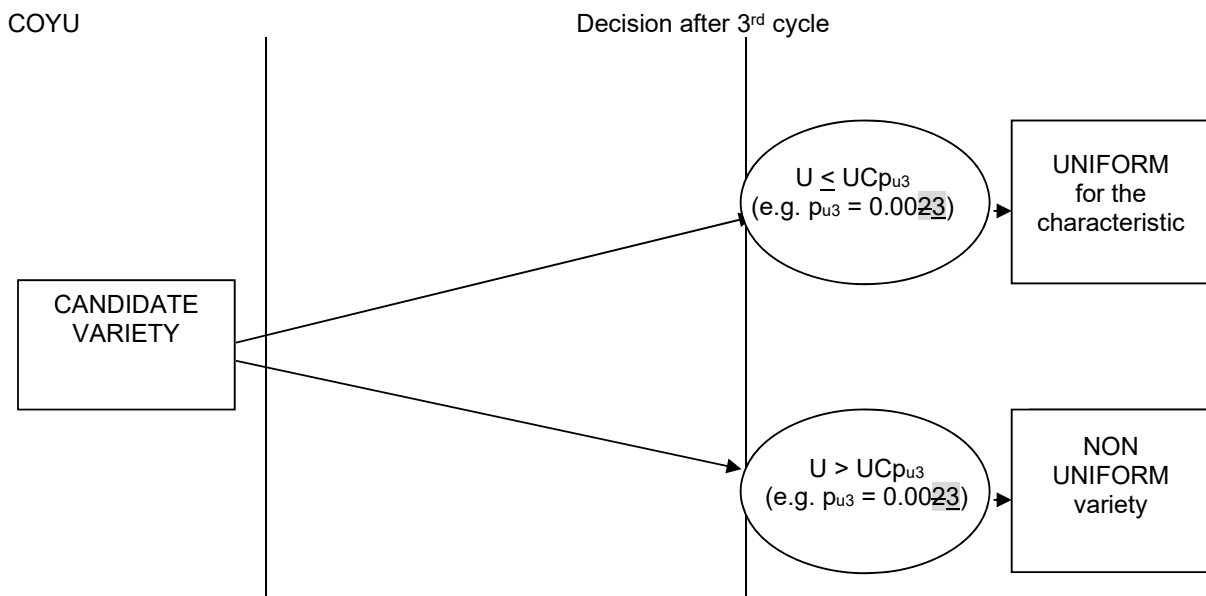


Figure 2. COYD and COYU decisions and standard probability levels ( $p_i$ ) in Case B



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

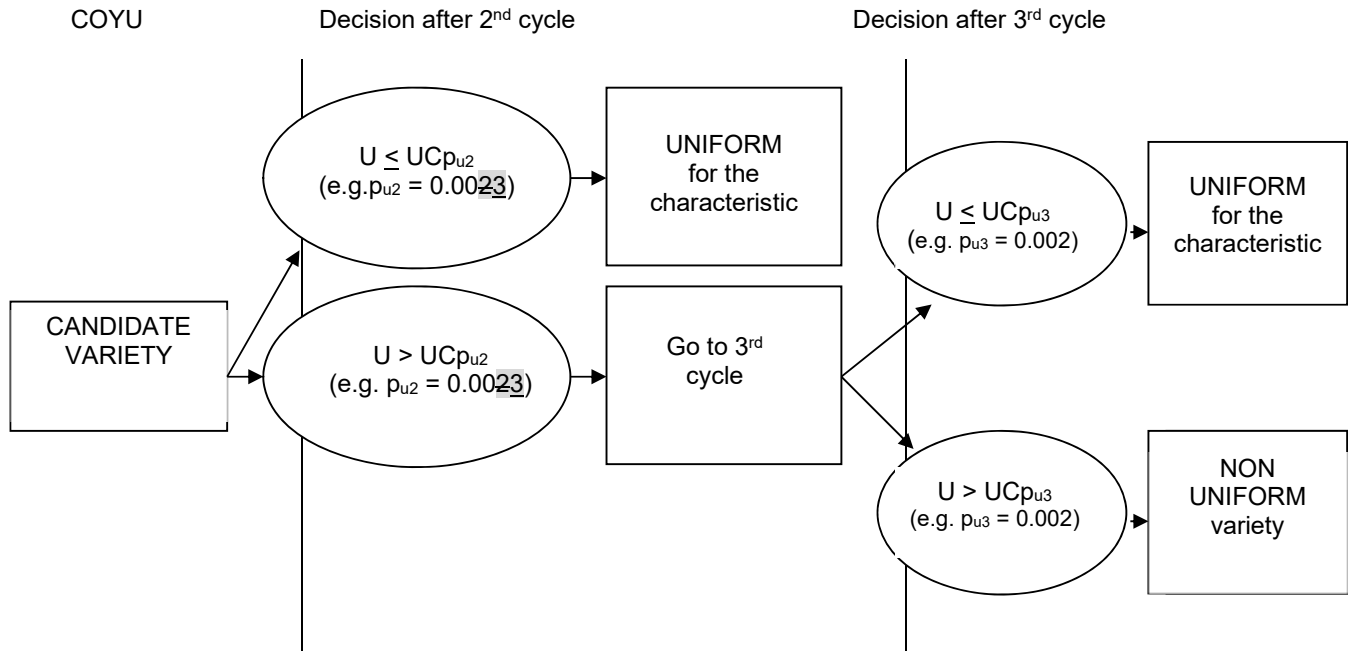
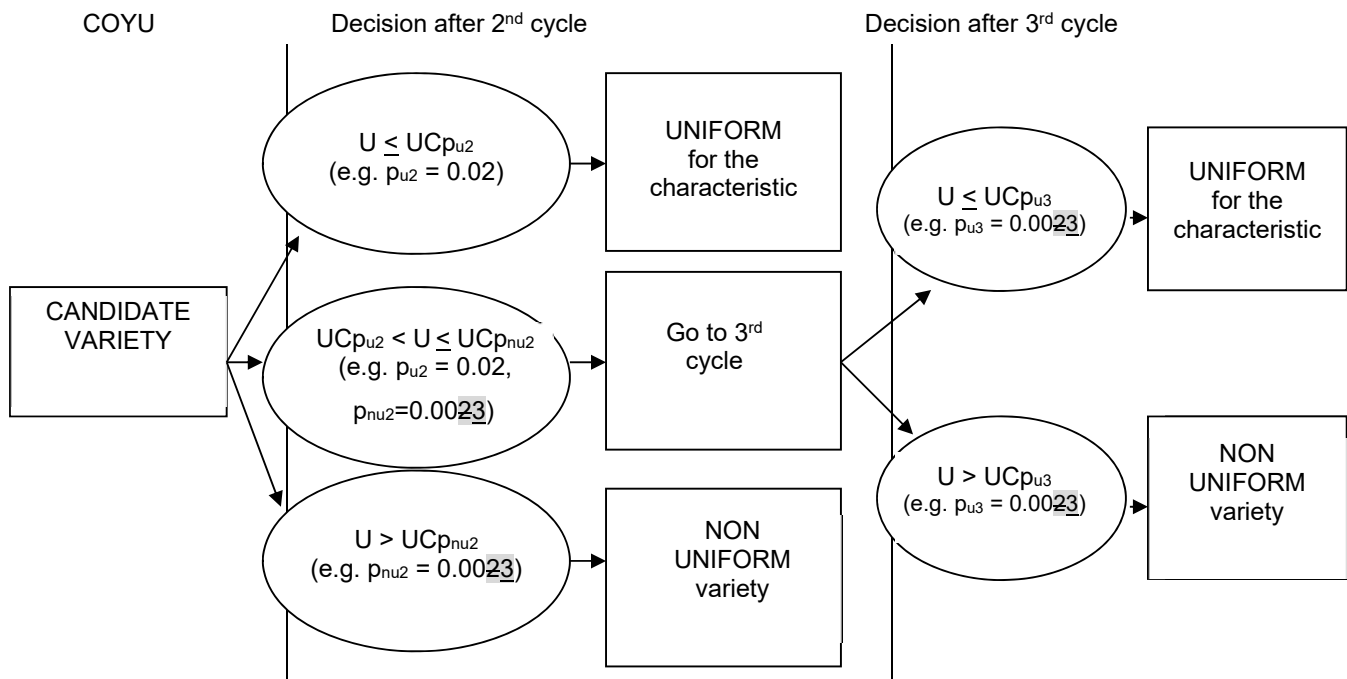


Figure 4. COYD and COYU decisions and standard probability levels ( $p_i$ ) in Case D



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.