

Technical Working Party for Vegetables

Fifty-Fourth Session

Brasilia, Brazil, May 11 to 15, 2020

TWP/4/11**Original:** English**Date:** April 14, 2020**Technical Working Party for Ornamental Plants and Forest Trees**

Fifty-Second Session

Roelofarendsveen, Netherlands, June 8 to 12, 2020

Technical Working Party for Agricultural Crops

Forty-Ninth Session

Saskatoon, Canada, June 22 to 26, 2020

Technical Working Party for Fruit Crops

Fifty-First Session

Nîmes, France, July 6 to 10, 2020

Technical Working Party on Automation and Computer Programs

Thirty-Eighth Session

Alexandria, United States of America, September 21 to 23, 2020

THE COMBINED OVER YEARS UNIFORMITY CRITERION (COYU)*Document prepared by the Office of the Union**Disclaimer: this document does not represent UPOV policies or guidance***EXECUTIVE SUMMARY**

1. The purpose of this document is to present a draft replacement section on the method of calculation of the Combined Over Years Uniformity Criterion (COYU) for document TGP/8 "Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability".
2. The COYU Criterion is used for the assessment of uniformity with quantitative characteristics, when observations are made on a plant basis over two or more cycles and when there is quantitative variation between plants of a variety.
3. The TWPs are invited to note:
 - (a) the invitation by the TWC for members who use "R" or "DUST" Software to review the new COYU package to identify possible improvement points;
 - (b) the expression of interest by experts from China, Finland, France and the United Kingdom to review the new COYU package;
 - (c) the invitation for editorial suggestions to be communicated to the drafter from the United Kingdom on the proposed draft revision for document TGP/8, Section 9 "The Combined Over Years Uniformity Criterion (COYU)";
 - (d) the invitation for the expert from the United Kingdom to prepare a revised version of the draft guidance, to be presented to the TWC, at its thirty-eighth session.

4. The structure of this document is as follows:

EXECUTIVE SUMMARY	1
BACKGROUND	2
DEVELOPMENTS AT THE TECHNICAL WORKING PARTY ON AUTOMATION AND COMPUTER PROGRAMS	2
CONSIDERATION BY THE TECHNICAL COMMITTEE	3
ANNEX	
Draft replacement section on the method of calculation of the Combined Over Years Uniformity Criterion (COYU) for document TGP/8 "Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability"	

5. The following abbreviations are used in this document:

TC:	Technical Committee
TC-EDC:	Enlarged Editorial Committee
TWA:	Technical Working Party for Agricultural Crops
TWC:	Technical Working Party on Automation and Computer Programs
TWF:	Technical Working Party for Fruit Crops
TWO:	Technical Working Party for Ornamental Plants and Forest Trees
TWPs:	Technical Working Parties
TWV:	Technical Working Party for Vegetables

BACKGROUND

6. The background to this matter is provided in document TWP/1/13 "The Combined-Over-Years Uniformity Criterion (COYU)".

7. The TC, at its fifty-fourth session, noted that the statistical development of the new method of calculation of COYU had been completed, including the establishment of the probability levels required to most closely match decisions using the current method for calculation of COYU.

8. The TC noted the invitation by the TWC for the expert from the United Kingdom to draft a replacement section for document TGP/8 on the method of calculation of COYU.

DEVELOPMENTS AT THE TECHNICAL WORKING PARTY ON AUTOMATION AND COMPUTER PROGRAMS

9. The TWC, at its thirty-eighth session, held in Hangzhou, China, from October 14 to 16, 2019, considered document TWC/37/7 "Combined Over Years Uniformity (COYU) Criterion" (see document TWC/37/12 "Report", paragraphs 8 to 10).

10. 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.

11. Developments on the review of the new COYU package and possible improvement points identified by the experts testing the new COYU package will be reported by the expert from the United Kingdom to the TWC, at its thirty-eighth session, under a separate document on the revision of the COYU procedure.

12. 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 the Annex to 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.

CONSIDERATION BY THE TECHNICAL COMMITTEE

13. The TC, at its fifty-fifth session, held in Geneva on October 28 and 29, 2019, considered documents TC/55/4 and TC/55/4 Add. (see document TC/55/25 "Report", paragraphs 154 to 156).

14. The TC noted that the TWC, at its thirty-seventh session, had considered a draft replacement section for document TGP/8 on the method of calculation of COYU, as presented in the Annex to this document. The TC noted the invitation by the TWC for 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.

15. The TC noted the invitation by the TWC for members who use "R" or "DUST" Software to review the new COYU package to identify possible improvement points.

16. *The TWPs are invited to note:*

(a) the invitation by the TWC for members who use "R" or "DUST" Software to review the new COYU package to identify possible improvement points;

(b) the expression of interest by experts from China, Finland, France and the United Kingdom to review the new COYU package;

(c) the invitation for editorial suggestions to be communicated to the drafter from the United Kingdom on the proposed draft revision for document TGP/8, Section 9 "The Combined Over Years Uniformity Criterion (COYU)";

(d) the invitation for 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.

17. *The TWC is invited to note that developments on the review of the new COYU package and possible improvement points identified by the experts testing the new COYU package will be reported by the expert from the United Kingdom to the TWC, at its thirty-eighth session, under a separate document on the revision of the COYU procedure.*

[Annex follows]

DRAFT PROPOSAL FOR THE REVISION FOR DOCUMENT TGP/8, SECTION 9:
 “THE COMBINED OVER YEARS UNIFORMITY CRITERION (COYU)”

Note for revisions: changes indicated by
~~strikethrough~~ (highlighted) for deletions and
underlining (highlighted) for additions

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 9.147 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 “⊙” 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)

[to delete this figure]

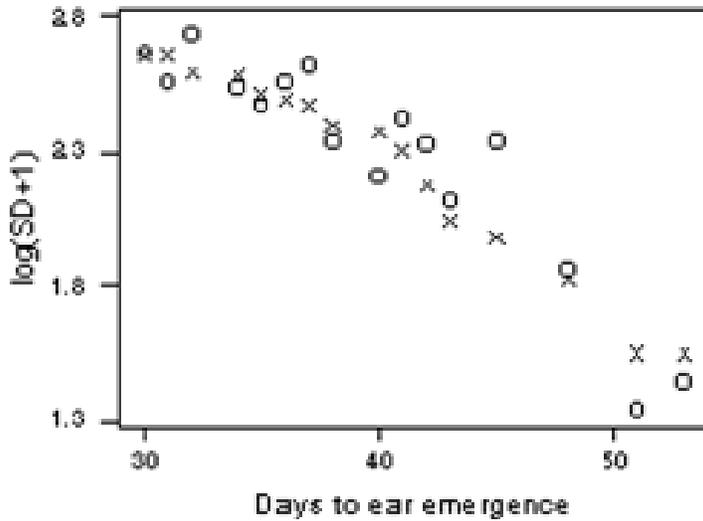
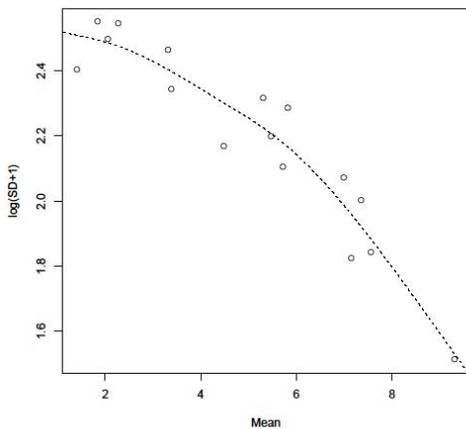


Figure 1: Association between SD and mean (symbol O is for observed SD, dashed line is fitted spline)

[to add this figure]



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.

[to delete this fomula]

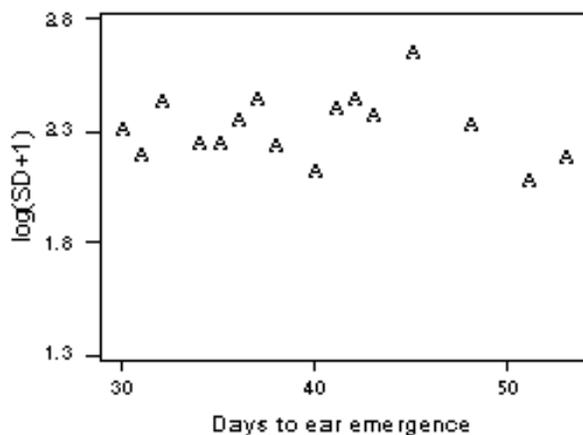
$$T_c = \frac{(X_c - X_i)T_{i+1} + (X_{i+1} - X_c)T_i}{X_{i+1} - X_i}$$

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.

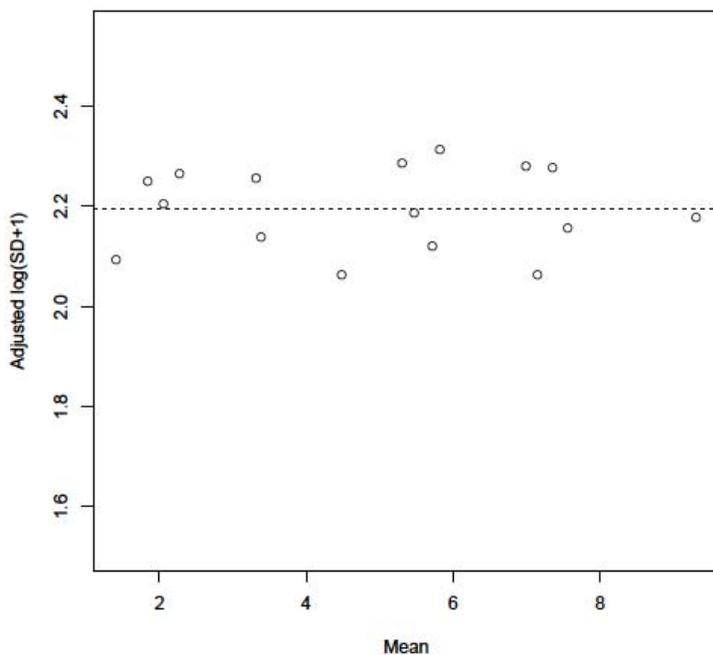
9.6.8 The results for the simple example with 16 varieties are illustrated in Figure 2.

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

[to delete this figure]



[to add this figure]



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

[to delete this formula]

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

[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 a 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	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 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 $\log(\text{SD}+1)$ 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 $\log(\text{SD})$ 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

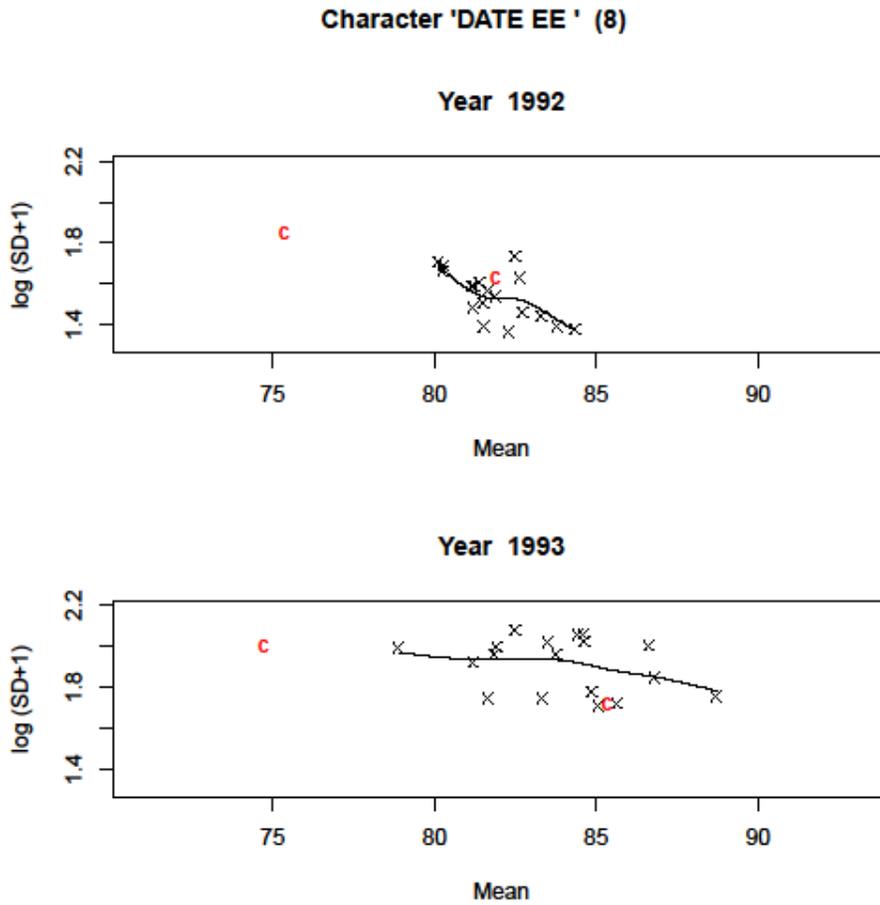
+ SD EXCEEDS OVER-YEARS UNIFORMITY CRITERION AFTER 2 YEARS WITH PROBABILITY 0.0030

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) ****

          OVER-YEARS
          -----
VARIETY   CHAR.  ADJ.  UNADJ
          MEAN LOG SD LOG SD
-----
REFERENC E
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 $UC_{p_{u2}}$ 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

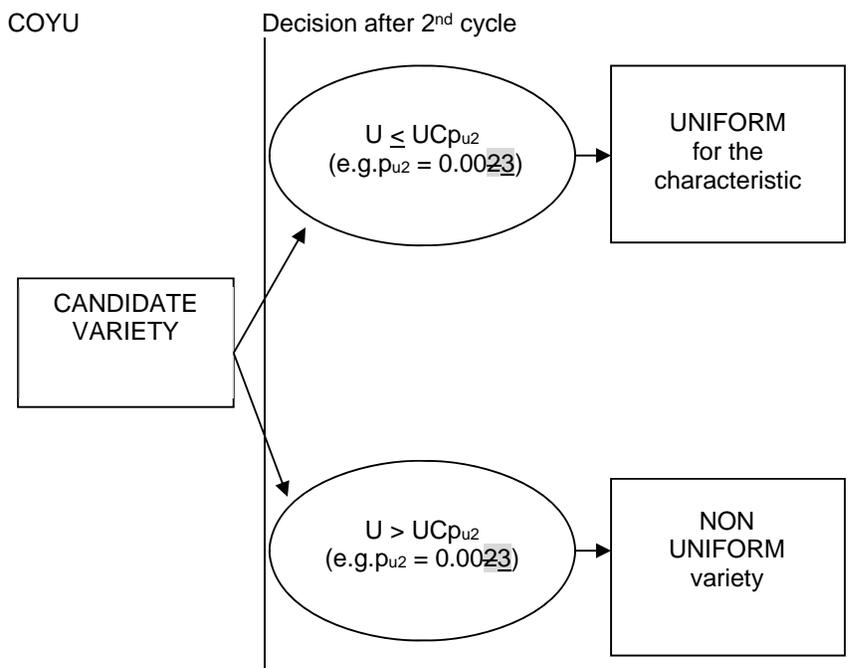
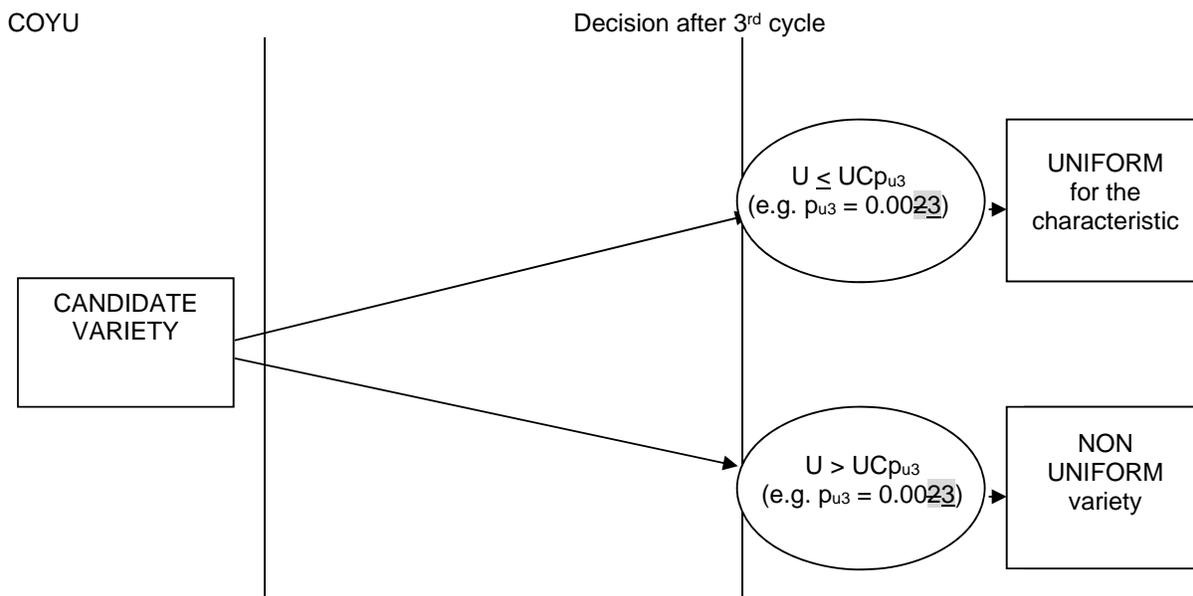


Figure 2. COYU and COYU decisions and standard probability levels (p_i) in Case B



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

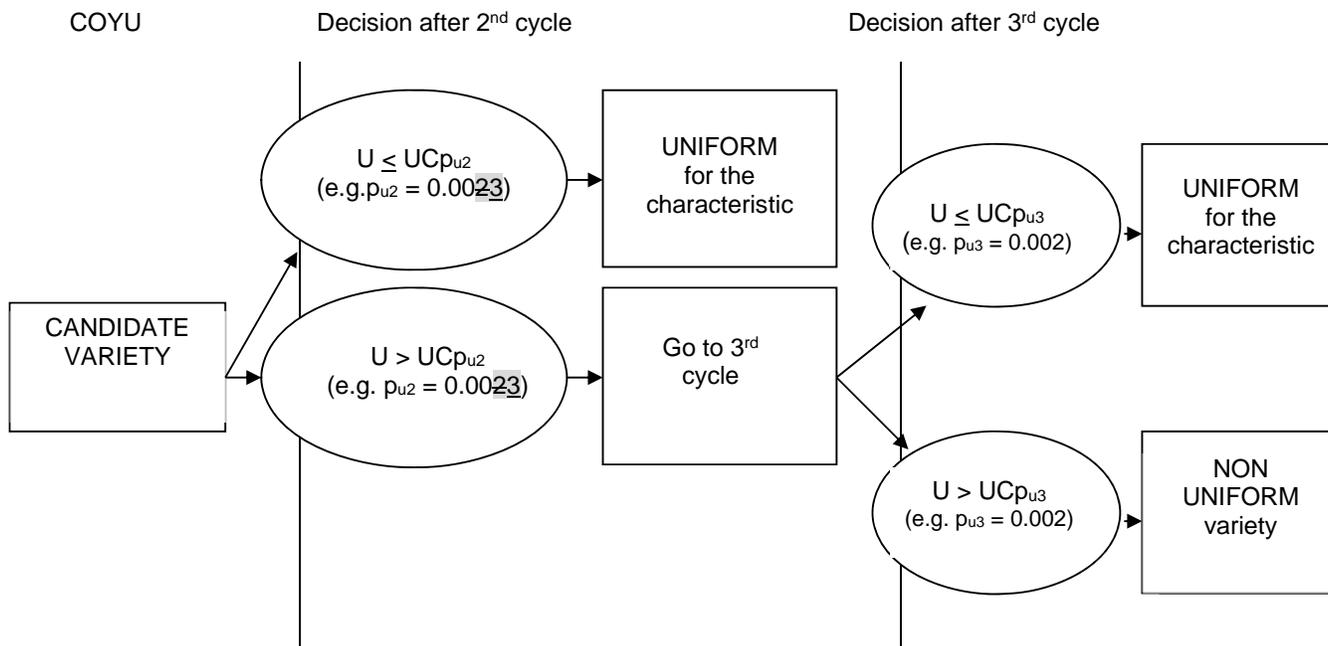
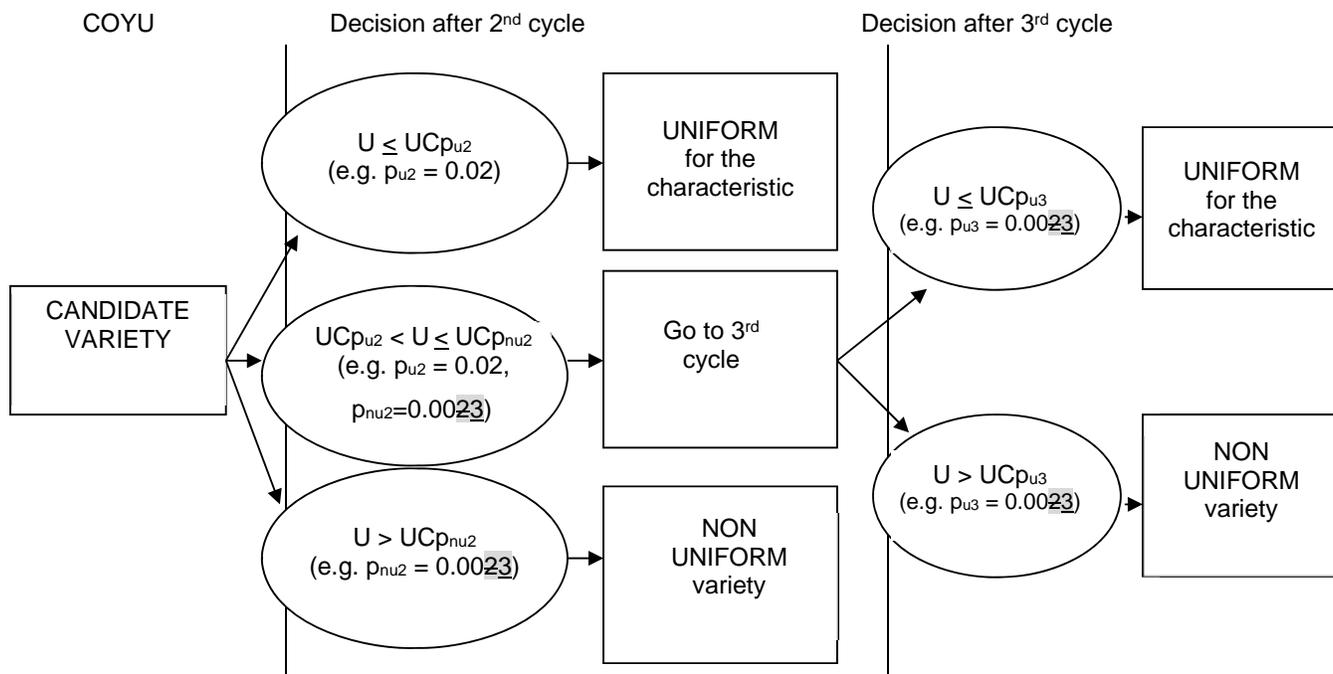


Figure 4. COYU and COYU decisions and standard probability levels (p_i) in Case D



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.

[End of Annex and of document]