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THRESHOLDS FOR EXCLUDING VARIETIES OF COMMON KNOWLEDGE FROM THE SECOND GROWING CYCLE WHEN COYD IS USED

Document prepared by experts from the United Kingdom

SUMMARY

1. When DUS tests are carried out over two independent growing cycles, results may be reviewed after the first cycle of testing in order to identify varieties of common knowledge that are clearly distinct from the candidates (see document TGP/9 "Examining Distinctness").

> *2.4.2.1 "Distinctness Plus" threshold*
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>
> *2.4.2.1.2 It is important that the "Distinctness Plus" threshold is based on experience gained with the varieties of common knowledge and minimizes the risk of excluding varieties of common knowledge which should be compared to one or more candidate varieties in a growing trial.*

2. A method has previously been proposed to calculate thresholds for characteristics where COYD is used (document TWC/33/20 Rev.). In this document the method is evaluated on six data sets from Finland and the United Kingdom.

3. The method appears to work best in crops with larger numbers of varieties of common knowledge.

4. The authors would welcome further data sets to evaluate the utility of the approach. These should have sufficient years (10 years minimum, more is better), sufficient varieties (at least 200) and candidates (at least 100 overall). A data set for red fescue has been received from Slovakia and this will be analysed.

INTRODUCTION

5. When DUS tests are carried out over two independent growing cycles, results may be reviewed after the first cycle of testing in order to identify varieties of common knowledge that are clearly distinct from the candidates (see document TGP/9 "Examining Distinctness").

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6. When COYD is used to assess distinctness for a characteristic, it may be difficult to do this effectively based on experience. In document TWC/33/20 Rev., a mechanism was proposed to calculate thresholds for such characteristics. The method allows for the often sizeable variation in the COYD criterion from cycle to cycle.

7. In document TWC/34/8, the method was illustrated on a field pea DUS data set. This showed how beneficial the method may be in practice. However, the performance was assessed characteristic-by-characteristic. It was suggested that it would be useful to see how well the method works over characteristics.

8. Further data sets have been received from Finland, Slovakia and the United Kingdom. In this document, the method is assessed on these data sets on a characteristic-by-characteristic basis and over characteristics.

OVERVIEW

9. The aim of this approach is to identify after the first test cycle which varieties of common knowledge are so different from the candidate that they do not need to be compared in the second cycle.

10. To achieve this, we estimate the probability that a candidate would be distinct on the 2-cycle COYD criterion from a particular variety of common knowledge, given the results from the first growing cycle. If the probability is suitably large, the candidate is declared distinct from that variety and does not need to be compared in the second cycle.

11. The method is applied characteristic-by-characteristic. In order to judge the variability associated with measurements in a particular characteristic we need to have historical data. The approach might be used in combination with processes such as GAIA to arrive at a “Distinctness Plus” threshold (see TGP/8 “Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability”, Part II: Selected Techniques Used in DUS Examination, 1 “The GAIA Methodology”).

THE METHOD IN BRIEF

12. The method is based on calculating the probability, p_D, that a candidate would be distinct on the 2-cycle COYD criterion based only on the first cycle’s data. If the probability is suitably large, the candidate is declared distinct from that variety and does not need to be compared in the second growing cycle. This process can be inverted to identify thresholds for set probabilities p_D.

13. As well as requiring the first cycle’s trial data, the method requires historical data from past DUS trials. At least 10 cycles of trials are needed – more is better. This is used to estimate the variety-by-cycle variance for each characteristic and, importantly, its variability (or level of heterogeneity). The variety-by-cycle variance is a fundamental component of the COYD criterion (see document TGP/8 “Trial Design and Techniques Used in the Examination of Distinctness, Uniformity and Stability”).

14. At the moment the method requires use of specialist statistical software to estimate the heterogeneity of the variety-by-cycle variance and the parameters of a gamma distribution (https://en.wikipedia.org/wiki/Gamma_distribution). Here the software ‘R’ was used (the function *asreml* from package *ASREML* or function *lme* from package *nmle*). Such calculations may also be done in the software ‘GenStat’ and possibly ‘SAS’. R code is available from the authors.

15. Apart from that, the method uses formulae, which whilst being a little complex, should be straightforward to implement in software. It should not be necessary to update the thresholds every year.

16. Further detail on the method is given in document TWC/33/20 Rev. and in a paper (Roberts A.M.I., Nevison I.M., Christie T. (2016) Prediction of variety distinctness decisions under yearly heterogeneity. Journal of Agricultural Science Volume 154 Issue 8 pp 1317-1326).

EXAMPLE DATA SETS

17. We received data sets from Finland and the United Kingdom. These are summarized in Table 1. In addition, we have received red fescue data from Slovakia but this has not yet been analysed.

Table 1: *Summary of data sets received*

Country	Crop	Number of years	Probability level for COYD	Number of characteristics used here	Overall number of varieties	Overall number of candidates
Finland	Meadow fescue[1]	12	0.01	5	64	23
Finland	Red Clover[1]	11	0.01	6	39	10
Finland	Timothy[1]	11	0.01	6	100	9
United Kingdom	Perennial ryegrass[1]	11	0.01	16	232	146
United Kingdom	Pea – semi leafless[2]	19	0.02	10	887	275
United Kingdom	Pea – conventional[2]	20	0.02	12	405	58

18. For herbage crops such as fescue, decisions in the United Kingdom are often taken after three years. At this stage, formulae have not been produced for three-year decisions. So for all crops we have computed thresholds to be used after the first year that are meant to anticipate two-year decisions.

19. Note that the data for perennial ryegrass is quite old (from 1988 to 1998). After this time, cyclic planting was introduced and data using that approach would be of less value for evaluation.

CALCULATION OF THRESHOLDS

20. The calculation of thresholds involves a number of steps:

i. Preparation of the data. The variety means for each year are used (so not plot-level data).
ii. Calculation of variances of each year. This involves fitting a mixed model with fixed variety effects, random year effects and separate residual variances for each year. This can be done in R, GenStat and possibly SAS.
iii. Fitting a gamma distribution to the inverse variances. Again, this can be done in R, GenStat and SAS.
iv. Applying the formula given in document TWC/33/20 Rev..

21. Prior to calculation of the threshold, the data for each characteristic was reviewed. In particular, we examined statistics such as skewness and kurtosis, whether there are anomalous changes of scale and identified extreme outliers. Characteristics exhibiting high degrees of skewness or kurtosis were not considered here (in practice it may be possible to deal with these through transformation). Extreme outliers were removed for the purpose of threshold calculations, which are sensitive to outliers.

22. A number of factors may affect the quality of the calculated thresholds. These include the size of the data set, the number of years (best at least 10 but the more the better), the number of varieties and the number of varieties in common between years. For a given data set, it might be thought best to restrict it to those varieties with more years present to improve connectivity. However this clearly reduces the size of the data set. So there is probably a sensible balance. Here, for all cases apart from the United Kingdom pea data sets, we have not reduced the data in this way. For the semi-leafless pea data set, we chose to reduce to those varieties with 6 or more years. For the conventional pea data set, we investigated the effect of different levels of reduction. Note that although some data sets were reduced for the calculation of thresholds, full data sets were used for assessment.

23. On rare occasions, the threshold calculations gave nonsensical results. This usually occurred where variances fall into distinct sizes and may be in part due to the low number of years. In these cases, the shape parameter of the gamma distribution was estimated at near to 2 or less. A pragmatic solution was to drop one or two of the smallest variances from gamma estimation. This solution should ensure that the threshold is not too low.

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[1] For herbage crops such as fescue, decisions often taken after three years in the United Kingdom.

[2] Pea in the United Kingdom is divided into semi-leafless and conventional types. These are treated separately.

24. As part of the threshold calculations it is necessary to input the degrees of freedom expected for the unknown future COYD analysis of variance (v_{12}). We based this on values experienced in recent years for each example crop. Table 2 shows the degrees of freedom used for each example.

Table 2: *Degrees of freedom used for threshold calculations*

Country	Crop	v_{12}
Finland	Meadow fescue	38
Finland	Red Clover	27
Finland	Timothy	60
United Kingdom	Perennial ryegrass	100
United Kingdom	Pea – semi leafless	50
United Kingdom	Pea – conventional	14

ASSESSMENT OF PERFORMANCE

25. To establish the effect of using the calculated thresholds, the full example data sets were used to compare first-year decisions with the relevant two-year COYD decisions.

26. First-year decisions were compared with COYD decisions in consecutive pairs of years (e.g. 1995-96, 1996-97, 1997-98 …) for each characteristic. To evaluate the different thresholds, error rates were calculated:

- *False positive rate:* this is the proportion of times for each characteristic that the first-year threshold indicated a variety would be distinct from another variety when the subsequent second-year decision was non-distinct. This indicates the downside of taking early decisions: sometimes a pair of varieties might be declared distinct in the first year when they might later be found non-distinct. The rate of false positives is lower for higher thresholds.
- *False negative rate*: this is the proportion of times that the first-year decision was non-distinct when the second-year decision was distinct. This gives an indication of how useful the threshold might be in practice, with lower rates indicating that more pairs of varieties would be found distinct after the first year.

27. Results should be interpreted with care since typically reference varieties that were clearly distinct from the candidate after the first year may have been removed from further comparisons. The effect of this selection would be to give a pessimistic view of the performance of the calculated thresholds (false negative rates).

28. For each example data set, decisions were compiled over characteristics to give a more complete impression of performance. For the United Kingdom semi-leafless pea, we also took into account grouping (so only comparisons within groups are considered). However, at this stage we were not able to take account of information provided by other characteristics not included (so e.g. qualitative characteristics).

RESULTS - THRESHOLDS

29. Tables 3 to 8 show the mean 2 year COYD criteria calculated for each pair of years plus the calculated one-year thresholds with p_D being set at 0.99, 0.98 and 0.95.

Table 3. *First cycle thresholds for Finland meadow fescue, allowing for heterogeneity over cycles. For comparison, the mean COYD criterion is shown.*

UPOV no	Characteristic	Mean COYD criterion	Threshold with p_D=0.99	Threshold with p_D=0.98	Threshold with p_D=0.95
8	Plant: time of inflorescence emergence (after vernalization)	1.92	6.62	4.72	3.30
11	Stem: length of longest stem including inflorescence	72.22	246.12	180.98	129.35
12	Flag leaf: width	0.88	1.81	1.60	1.36
13	Inflorescence: length	16.29	86.64	53.18	33.79
14	Flag leaf: length on representative stem	20.11	47.82	40.85	33.29

Table 4. *First cycle thresholds for Finland red clover, allowing for heterogeneity over cycles. For comparison, the mean COYD criterion is shown.*

UPOV no	Characteristic	Mean COYD criterion	Threshold with p_D=0.99	Threshold with p_D=0.98	Threshold with p_D=0.95
11	Time of flowering	6.25	26.03	11.90	6.62
12	Stem: length	99.34	640.70	332.16	194.15
13	Stem: thickness	58.90	172.30	138.23	106.15
14	Stem: number of internodes	1.05	7.52	3.55	2.00
17	Leaf: length of medial leaflet	6.47	33.55	20.22	12.72
18	Leaf: width of medial leaflet	4.67	44.23	15.16	7.72

Table 5 *First cycle thresholds for Finland timothy, allowing for heterogeneity over cycles. For comparison, the mean COYD criterion is shown.*

UPOV no	Characteristic	Mean COYD criterion	Threshold with p_D=0.99	Threshold with p_D=0.98	Threshold with p_D=0.95
4	Flag leaf:width	0.89	1.86	1.66	1.42
6	Plant: time of inflorescence emergence (in second year)	2.08	17.31	7.58	4.15
7	Flag leaf:length	16.82	36.40	32.39	27.58
9	Stem: length of longest stem	91.64	234.57	198.32	160.01
10	Stem: length of longest internode	39.21	84.28	74.85	63.59
11	Inflorescence: length	15.26	36.05	31.43	26.17

Table 6. *First cycle thresholds for United Kingdom perennial ryegrass, allowing for heterogeneity over cycles. For comparison, the mean COYD criterion is shown.*

UPOV no	Characteristic	Mean COYD criterion	Threshold with p_D=0.99	Threshold with p_D=0.98	Threshold with p_D=0.95
2	Plant: Vegetative Growth habit (without vernalization)	4.33	8.28	7.60	6.70
8	Plant: Height (after vernalization)	5.01	9.05	8.31	7.34
11	Plant: time of inflorescence emergence	4.72	34.38	16.42	9.28
12	Plant: natural height at inflorescence emergence	6.54	13.15	11.88	10.30
13	Plant: width at inflorescence emergence	7.37	23.83	18.57	13.90
14	Flag leaf: length	2.68	6.10	5.29	4.38
15	Flag leaf: width	0.58	1.54	1.31	1.07
16	Flag leaf: length/width ratio	0.34	0.83	0.71	0.58
17	Plant: Length of longest stem, inflorescence included (when fully expanded)	7.03	23.93	18.06	13.18
19	Inflorescence: length	2.17	7.19	5.52	4.08
20	Inflorescence: number of spikelets	1.82	4.41	3.81	3.15
21	Inflorescence: density	0.09	0.24	0.20	0.17
22	Inflorescence: length of outer glume on basal spikelet	1.28	3.79	3.07	2.38
23	Inflorescence: length of basal spikelet excluding awn	1.62	4.11	3.50	2.84
c39[3]	Flag Leaf Size	1.11	2.31	2.07	1.77
c60[3]	Plant: Natural Height (after vernalization)	5.05	15.12	8.00	4.72

Table 7. *First cycle thresholds for United Kingdom semi-leafless pea, allowing for heterogeneity over cycles. For comparison, the mean COYD criterion is shown.*

UPOV no	Characteristic	Mean COYD criterion	Threshold with p_D=0.99	Threshold with p_D=0.98	Threshold with p_D=0.95
5	Stem: number of nodes up to and including first fertile node	0.86	4.13	2.73	1.81
15	Stipule: length (mm)	10.58	23.38	20.91	17.90
16	Stipule: width (mm)	6.72	14.18	12.84	11.15
22	Petiole: length from axil to first leaflet or tendril (mm)	12.26	28.38	25.16	21.31
28	Flower: width of standard (mm)	2.30	5.99	5.13	4.18
34	Peduncle: length from stem to first pod (mm)	19.49	45.63	40.00	33.46
37	Pod: length (mm)	5.91	12.56	11.33	9.79
38	Pod: width (mm)	0.96	2.00	1.82	1.59
46	Pod: number of ovules	0.45	1.03	0.91	0.77

[3] Characteristic not in the UPOV Test Guidelines

Table 8. *First cycle thresholds for United Kingdom* *<u>conventional pea</u>, allowing for heterogeneity over cycles. For comparison, the mean COYD criterion is shown. These calculations are based on varieties with at least four years of data.*

UPOV no	Characteristic	Mean COYD criterion	Threshold with p_D=0.99	Threshold with p_D=0.98	Threshold with p_D=0.95
9	Leaf: maximum number of leaflets	0.64	4.20	2.05	1.17
10	Leaflet: length	9.46	59.35	33.58	20.45
11	Leaflet: width	6.81	79.19	25.86	13.05
14	Leaflet: dentation	1.36	5.87	3.93	2.63
15	Stipule: length (mm)	11.75	78.05	41.60	24.64
16	Stipule: width (mm)	7.89	87.94	28.07	14.09
28	Flower: width of standard (mm)	3.33	28.65	10.58	5.51
34	Peduncle: length from stem to first pod (mm)	27.90	238.73	94.58	50.24
37	Pod: length (mm)	5.85	14.53	12.43	10.13
38	Pod: width (mm)	1.06	8.41	3.68	2.02
46	Pod: number of ovules	0.50	2.42	1.50	0.96
57	Seed: weight	3.23	23.36	10.79	6.03

30. In the case of the conventional pea data set, we examined the effect of restricting the data set to those varieties with a set number of years present. The number of years varied from 2 to 6. This restriction has obviously reduces the size of the data set; with 2 years there were 778 observation, 3 years 650, 4 years 518, 5 years 418 and 6 years 318. Note: restricting to two years produces the same variance estimates as no restriction.

31. Thresholds for these different levels of restriction are shown in table 9. It can be seen that the thresholds are more stable when p_D is smaller. There is no clear pattern with the number of years restricted. We have used thresholds based on a restriction of 4 years for the evaluation of performance.

Table 9. *Effect of different restrictions on the first cycle thresholds for United Kingdom conventional pea.*

(a) With p_D=0.99

UPOV no	2 years	3 years	4 years	5 years	6 years
9	2.14	2.17	4.20	2.34	4.20
10	53.74	59.26	59.35	81.05	33.13
11	53.22	73.03	79.19	78.66	68.82
14	4.87	5.39	5.87	9.89	7.14
15	58.73	65.52	78.05	76.93	133.88
16	88.58	71.57	87.94	57.95	82.89
28	16.26	23.55	28.65	17.46	21.76
34	106.58	211.22	238.73	177.15	235.33
37	14.57	14.30	14.53	15.97	17.00
38	11.24	10.01	8.41	5.41	9.84
46	3.74	2.98	2.42	4.17	4.60
57	20.91	19.40	23.36	14.56	20.74

(b) With p_D=0.98

UPOV no	2 years	3 years	4 years	5 years	6 years
9	1.56	1.57	2.05	1.63	2.05
10	31.52	32.78	33.58	35.57	24.48
11	24.99	26.58	25.86	25.52	25.80
14	3.58	3.77	3.93	4.58	3.03
15	36.32	38.02	41.60	40.80	45.58
16	28.19	24.65	28.07	28.32	26.50
28	9.23	10.21	10.58	9.47	6.96
34	74.09	93.89	94.58	86.62	94.24
37	12.43	12.26	12.43	13.11	13.58
38	3.81	3.81	3.68	3.13	3.14
46	1.77	1.62	1.50	1.67	1.66
57	10.64	10.44	10.79	9.21	10.67

(c) With p_D=0.95

UPOV no	2 years	3 years	4 years	5 years	6 years
9	1.10	1.11	1.17	1.12	1.17
10	19.55	19.75	20.45	19.53	17.55
11	14.05	13.79	13.05	12.86	13.49
14	2.56	2.60	2.63	2.56	1.64
15	23.19	23.46	24.64	24.11	23.24
16	14.15	12.61	14.09	16.17	13.31
28	5.63	5.58	5.51	5.66	3.49
34	50.84	51.76	50.24	49.47	50.22
37	10.12	10.02	10.13	10.28	10.38
38	1.94	2.00	2.02	1.93	1.58
46	1.00	0.97	0.96	0.89	0.86
57	6.18	6.21	6.03	5.95	6.23

RESULTS - PERFORMACE

32. Table 10 shows the proportions of false positive and false negative decisions over the characteristics for each example data set. Semi-leafless pea results are shown when groups were ignored and when decisions were made within groups. The quality of these evaluations does depend of the number of candidates – error rates are best estimated for perennial ryegrass and pea.

Table 10. *Proportions of false positive and false negative decisions made using the thresholds in tables 3 to 8*

Data set	False positives (%)			False negatives (%)		
	p_D=0.99	p_D=0.98	p_D=0.95	p_D=0.99	p_D=0.98	p_D=0.95
Meadow fescue	0.0	0.7	2.7	95.2	87.3	66.4
Red Clover	0.0	0.0	4.8	100.0	73.5	37.1
Timothy	0.1	0.1	1.0	96.2	90.1	72.0
Perennial ryegrass	0.2	1.0	7.7	69.2	48.3	22.6
Pea – semi-leafless without groups	0.5	0.5	8.1	45.6	29.7	15.0
Pea – semi-leafless with groups	0.8	0.8	9.4	65.7	45.9	24.2
Pea – conventional	0.0	0.0	2.4	85.2	71.4	26.3

33. The false positive rate indicates the number of times that early distinct decisions are made that do not agree with the eventual COYD result (non-distinct). So ideally this should be very low. The results above indicate that use of thresholds with p_D at 0.95 should not be recommended, but that p_D might be set at 0.98 or 0.99. The false negative rate represents the utility of the method. Lower rates indicate that it was possible to identify more pairs of varieties in the first year as distinct using this approach. So for example, a rate of 30% means that the thresholds can identify in advance 70% of the pairs of varieties that are subsequently found to be distinct.

34. Overall it seems that the rates seen for the larger data sets may be useful in practice. However the method was not so successful for the smaller data sets from Finland. The performance was better in the semi-leafless group of pea than for the conventional group. This is due to the smaller expected size of conventional pea trials, reflected in the low degrees of freedom and resulting in larger thresholds.

35. Rates of false positives and negatives for each characteristic are tabulated in the Annex. This shows that the performance of the first-year thresholds varies between characteristics. For meadow fescue, red clover and timothy, it seems that a single characteristic may be sufficient. For the other data sets, several characteristics provide early discrimination.

CONCLUSIONS AND FUTURE WORK

36. This evaluation shows that the thresholds can be used to identify in advance those pairs of varieties that would be found distinct using COYD. The method is most applicable to crops with large numbers of varieties of common knowledge and where current trial sizes are large.

37. The utility of using such methods will depend on the crop and the DUS assessment framework being applied. In the United Kingdom for pea, the combination with grouping means that trial size reductions are possible. The method may also be useful when similar varieties are placed together in second trials to aid comparison.

38. The approach could be combined with similar approaches for scored characteristics (e.g. via GAIA).

39. The results indicate that thresholds setting p_D at 0.95 would likely produce too many false positives. Values for p_D of 0.99 or 0.98 give more acceptable rates. We noted that thresholds based on p_D at 0.99 are sensitive to the changes in the way that the data set is used.

40. Here the focus has been on using first-year thresholds for two-year COYD decisions. However for some of the samples here, three-year decisions are more common in the United Kingdom. If there is a need, formulae can be developed for three-year decisions.

41. R code has been developed for calculation of thresholds and evaluation of performance. This can be made available on request.

42. The authors would welcome further data sets to evaluate the utility of the approach. These should have sufficient years (10 years minimum, more is better), sufficient varieties (at least 200) and candidates (at least 100 overall). The red fescue data from Slovakia will be analysed.

ACKNOWLEDGEMENTS

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Adrian Roberts (Biomathematics and Statistics Scotland (BioSS)), Ian Nevison (BioSS) & Tom Christie (SASA)

[Annex follows]

ANNEX

PERFORMANCE BY CHARACTERISTIC

Table A. *Meadow fescue*

Characteristic No.	False positives (%)			False negatives (%)		
	p_D=0.99	p_D=0.98	p_D=0.95	p_D=0.99	p_D=0.98	p_D=0.95
8	0.0	0.3	1.6	94.5	85.8	71.7
11	0.0	0.0	0.0	98.6	94.3	75.0
12	0.0	0.4	0.8	98.1	96.2	90.4
13	0.0	0.0	0.5	98.7	97.4	75.2
14	0.0	0.0	0.3	100.0	100.0	89.6

Table B. *Red clover*

Characteristic No.	False positives (%)			False negatives (%)		
	p_D=0.99	p_D=0.98	p_D=0.95	p_D=0.99	p_D=0.98	p_D=0.95
11	0.0	0.0	6.7	100.0	70.1	24.7
12	0.0	0.0	0.0	100.0	94.7	63.2
13	0.0	0.0	0.5	100.0	100.0	100.0
14	0.0	0.0	2.3	100.0	82.4	45.9
17	0.0	0.0	0.0	100.0	100.0	88.9
18	0.0	0.0	0.5	100.0	100.0	61.1

Table C. *Timothy*

Characteristic No.	False positives (%)			False negatives (%)		
	p_D=0.99	p_D=0.98	p_D=0.95	p_D=0.99	p_D=0.98	p_D=0.95
4	0.0	0.1	0.6	97.4	92.8	83.6
6	0.0	0.0	0.0	100.0	99.5	88.1
7	0.0	0.1	0.1	98.2	95.2	85.5
9	0.0	0.1	0.3	99.0	92.7	78.2
10	0.1	0.1	0.3	97.7	95.9	87.8
11	0.0	0.2	0.7	94.8	89.1	71.0

Table D*. Perennial Ryegrass*

Characteristic No.	False positives (%)			False negatives (%)		
	p_D=0.99	p_D=0.98	p_D=0.95	p_D=0.99	p_D=0.98	p_D=0.95
2	0.2	0.6	1.3	85.1	79.5	68.7
8	0.1	0.2	0.9	68.6	61.4	49.8
11	0.0	0.0	0.0	98.1	63.6	29.9
12	0.2	0.6	1.5	69.7	61.2	49.1
13	0.0	0.3	1.0	99.6	96.9	85.3
14	0.0	0.2	0.8	97.5	92.8	83.6
15	0.0	0.0	0.4	94.8	89.1	74.5
16	0.0	0.0	0.4	98.5	95.7	87.1
17	0.0	0.2	1.8	99.0	93.4	80.3
19	0.0	0.0	0.8	99.3	94.4	76.5
20	0.0	0.1	0.9	83.0	72.7	56.3
21	0.0	0.0	0.2	90.7	82.5	68.6
22	0.0	0.1	0.7	97.4	92.9	81.8
23	0.0	0.0	0.4	92.7	83.8	67.3
c39	0.0	0.2	1.0	90.3	83.8	70.5
c60	0.0	3.1	14.7	95.0	62.3	23.5

Table E. *Semi-leafless pea – without groups*

Characteristic No.	False positives (%)			False negatives (%)		
	p_D=0.99	p_D=0.98	p_D=0.95	p_D=0.99	p_D=0.98	p_D=0.95
5	0.0	0.0	0.4	85.8	64.0	40.0
15	0.3	0.7	1.8	86.0	78.4	65.2
16	0.5	0.8	2.1	74.2	66.3	54.1
22	0.1	0.4	1.4	89.0	81.8	69.1
28	0.0	0.3	1.0	89.0	81.3	66.0
34	0.0	0.1	0.8	85.1	76.8	61.6
37	0.0	0.2	0.7	79.5	73.3	61.7
38	0.2	0.6	1.6	76.5	67.7	56.0
46	0.1	0.4	1.4	63.8	55.3	41.7
57	0.0	0.1	0.6	61.1	50.1	37.3

Table F. *Semi-leafless pea – with groups*

Characteristic No.	False positives (%)			False negatives (%)		
	p_D=0.99	p_D=0.98	p_D=0.95	p_D=0.99	p_D=0.98	p_D=0.95
5	0.0	0.0	0.1	91.9	69.2	43.3
15	0.1	0.4	1.4	90.6	84.9	74.2
16	0.3	0.5	1.5	84.0	76.6	65.1
22	0.1	0.5	1.5	90.2	83.8	70.9
28	0.0	0.1	0.4	95.8	90.2	76.3
34	0.0	0.1	0.7	87.0	78.9	64.2
37	0.0	0.0	0.3	86.8	81.8	71.3
38	0.1	0.1	0.6	83.9	75.5	63.2
46	0.1	0.3	1.3	75.4	66.8	51.4
57	0.0	0.0	0.3	90.7	83.7	69.8

Table G. *Conventional pea*

Characteristic No.	False positives (%)			False negatives (%)		
	p_D=0.99	p_D=0.98	p_D=0.95	p_D=0.99	p_D=0.98	p_D=0.95
9	0.0	0.0	1.3	100.0	100.0	58.4
10	0.0	0.0	0.0	100.0	100.0	96.2
11	0.0	0.0	0.1	100.0	100.0	72.8
14	0.0	0.0	0.3	100.0	98.0	88.5
15	0.0	0.0	0.1	100.0	100.0	96.4
16	0.0	0.0	0.6	100.0	100.0	84.4
28	0.0	0.0	1.6	100.0	99.3	76.3
34	0.0	0.0	0.0	100.0	100.0	82.6
37	0.0	0.0	0.6	71.4	63.3	46.5
38	0.0	0.0	0.7	100.0	94.7	57.5
46	0.0	0.0	3.2	98.2	79.6	49.5
57	0.0	0.0	0.2	100.0	91.6	53.0

[End of Annex and of document]