Sequential analysis

Exercises:

1. What is the practical idea at origin of sequential analysis?

2. In which cases sequential analysis is appropriate?

3. What are the supposed advantages of sequential analysis?

4. What does the values from a three steps sequential analysis in the following table are for?

<table>
<thead>
<tr>
<th>nb grains examined</th>
<th>accept</th>
<th>refuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>60</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

5. Do I have alpha and beta risks when I use sequential analysis?
PRINCIPLE OF THE SEQUENTIAL ANALYSIS METHOD

The method originates from a practical observation.
Some objects are so good or so bad that with a quick look we are able to accept or reject them.
For other objects we need more information to know if they are good enough or not.
In other words, we do not need to put the same effort on all the objects we control.
As a result of this we may save time or money if we decide for some objects at an early stage.

The general basis of sequential analysis is to define, before the studies, sampling schemes which permit to take consistent decisions at different stages of examination.

The aim is to compare the results of examinations made on an object to control ←→ decisional limits in order to take a decision.

At each stage of examination the decision is to accept the object if it is good enough with a chosen probability or to reject the object if it is too bad (at a chosen probability) or to continue the study if we need more information before to fall in one of the two above categories.

At each stage a pre-determined number of objects are examined or measured.
The number of objects to examine at each stage is not always the same.

Names given to different sampling schemes:
If the sampling method is defined with two stages it is called a "double" or "two-stages" sampling scheme.
If the sampling method is defined with more than two stages it is called "multiple" sampling scheme.
If at each new stage only one new object is observed the sampling scheme is called "progressive".
NB: In the case of a study in one stage with a pre-determined number of objects to examine, the sampling scheme is called a "fixed size" sampling scheme. This is not a sequential sampling scheme.

To be in the case of a sequential testing the following is required:
- there is more than one stage in the study
- the number of elements to observe is defined in advance for each stage
- the rule of decision at each stage is defined in advance
- the rule of decision at a stage S is based on all the elements observed since the first stage

On the contrary a two stage study in which there are two independent tests with a decision for each stage; plus a decision rule which take into account the elementary decisions is not a sequential test.
ILLUSTRATION OF SEQUENTIAL ANALYSIS WITH AN EXAMPLE

**goal:** We study lots to check if the percentage of off-types is not too high.

**idea:** use an appropriate sequential test and the corresponding decision rule.

**Application of the idea:** We observe plants for different characters and count the number of off-types in our sample. We observe 86 plants in a first stage and take a decision for the samples with low or high number of off-types. For the samples with an intermediate number of off-types, we examine 60 more plants and take our decision on the basis of the number of off-types in the 146 plants observed for the lot (86+60=146).

**Decision rule in this example:**

First stage: 86 plants have been examined, we have a number of off-types as a result of examination.

- if there is 0 or 1 off-type we accept the lot
- if there are 2 or 3 off-types we continue the study with 60 more plants
- if there are 4 off-types or more we refuse the lot (too much off-types)

Second stage: (only if we have 2 or 3 off-types in the first 86 plants examined). 60 more plants are examined. We have a total number of off-types for the 146 plants observed.

- We accept the lot if it has less than 4 off-types (out of 146 plants)
- We reject the lot if there is 4 off-types or more (out of 146 plants)

**Practical examples of application of the decision rule:**

* Practical example for a sample of the lot XXXXXX:
  At first stage we observed 1 off-type out of 86 plants we accept the lot

* Practical example for a sample of the lot YYYYYY:
  At first stage we observed 3 off-types we continue to stage 2
  At the second stage we observed 1 off-type we refuse the lot
  (we have 4 off-types out of 146 plants)

**Should we use a classical one stage study or a two stages study ?(example):**

If the preparation of our experiment is long and if the cost is not much affected by the number of plants to prepare, but our examination is quick and inexpensive; then we might prefer to use a one stage study. This could be the case for classical examinations in the field.

If the making of the sample is short and inexpensive, but the process for examination is laborious or expensive, or if the cost is much affected by the number of objects to examine; then we might prefer to use a two stage study, which will reduce the number of objects we examine. This could be the case for electrophoresis for instance.
Sequential analysis is adapted to cases in which we check lots or lots against predefined quality standards.
This is not the main mission of ISTA labs; which is to estimate values (first case of following figure).
Private companies, or special tests asked to ISTA labs can nevertheless correspond to this case.
If the goal is to check a given level of quality (for instance at least 85% of germination,...) sequential analysis might be used (as well as the classical approach of on examination on a given sample size).
Sequential analysis corresponds to the second case of the following figure.

---

LEGEND:
- Confidence intervals
- Seed lot or variety studied
- Seed lot or variety to be compared to the studied
- ISTA
- Estimate
- Standard
- Quality control
- Check against a standard
- Technology or agronomical value
- Control variety
- Compare to a control
- UPOV
- DUS tests
- Other I
- Other J
- Compare to all others

(trueness to cultivar: control and studied object superimposed)
Example of a sequential sampling scheme
(from Bourgoin Annex further in this document)
electrophoresis, count the number of seeds which are not off-types (not as expected for the
given variety.

<table>
<thead>
<tr>
<th>nb grains examined</th>
<th>accept</th>
<th>refuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>60</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

- First step is to examine 20 seeds:
  If there are 0 seeds are off-types, the test suggest to accept the lot
  If there are 1 to 4 off-types, the study continues to the second step
  If there are 5 off-types or more, the test suggest to refuse the lot.
- Second step (only if 0-4 off-types at first step)
  If there are at total (first and second step) less than 2 off-types, the test suggest to accept the lot
  If there are at total (first and second step) 3 to 6 off-types, the study continues to the third step
  If there are 7 off-types or more (first and second step), the test suggest to refuse the lot.
- Third step (only if 3-6 off-types after first and second step)
  If there are at total (Three steps) up to 6 off-types, the test suggest to accept the lot
  If there are at total (Three steps) 7 off-types or more, the test suggest to refuse the lot.

If we use this scheme,
The probability to refuse a good lot is 5% for a lot having in fact 5% of off-types.
The probability to accept a bad lot is 10% for a lot having in fact 18% of off-types.
**Reading of an operating characteristic curve.**

The curve shows the probability to accept a sample for a given true percentage of off-types in a lot. This is illustrated with examples in which we have classical fixed sample sizes. This probability varies from 0.0000 (never accept) to 1.0000 (always accept) on the Y axis. The true percentage of off-types in the lot vary in the examples form 0.0 (0% of off-types) to 30.0 (30% of off-types) on the X axis.

A curve is specific of a given sampling scheme. All the curves have the same shape and the same scale, but the values are different from one example to the other.

**General shape of the curves:**

All sampling schemes start at the point X=0.0 Y=1.0000 (upper left point of the curve).

That means that if the lot has no off-type at all, we will never find off-types and then we will always accept the lot.

On the other end of the curve there is a common point X=100.0 Y=0.0000 (not seen on the graphs).

This point is not on the curves because the scale end at 30.0 (30% of off-types in the variety).

That point means that if there is 100% of off-types we will find only off-types and then always reject the lot.

In between - the less off-types will be present in the lot, the more often we will accept it (upper part of the curve) - if the percentage of off-types increase, we are less likely to accept the lot (lower part of the curve)

The more plants we will observe, the more abrupt will be the decrease of the curve. In the two above examples we examine 20 plants (left curve) or 2100 plants (right curve).

Visually we see that with 20 plants

- we will "always" accept (Y near 1.0000) lots having in fact 0% of off-types
- we will "always" reject (Y near 0.0000) lots having in fact 30% of off-types or more with 2100 plants
- we will "always" accept (Y near 1.0000) lots having in fact 0% to 14% of off-types
- we will "always" reject (Y near 0.0000) lots having in fact more than 16% of off-types

That also means that we are able to work more precisely if we observe 2100 plants than if we observe 20 plants.

The Y axis is the probability to accept a sample.
The X axis is the true percentage of off-types in the lot. We never know this percentage. But we are able with the graph to know how often we will accept a variety if it's true percentage is the value chosen on the X axis.

The table contains the numerical values which are on the graph
the first column (% non conf.) is the equivalent of the X axis (true percentage of off-types)
the second column (Efficacité) is the equivalent of the Y axis (probability to accept the sample).

If we take the value 1,000 (1% of off-types is the true percentage of off-types in the variety), then
0.73576 is the probability to accept the sample with this sampling scheme
The corresponding sentence is:
"if the true percentage of off-types is 1% and we examine 100 times (100 samples) the same variety
we will accept it 74 times and reject it 26 times"

74 times is 0.73576 rounded to 74/100
26 times is the probability to reject which is (100-74)=26

In the examples 1% and 5% of off-types are taken as illustrations because they are the limits mentioned in the goal. In fact we can take any value we wish as the true percentage of off-types and find the corresponding probability. For instance for 2% of off-types we would accept the sample 40 times out of 100 (0.40327)
NB: The following text is an extract from a document established in 1995 on the use of sequential analysis in seed testing. This document has not been updated.

2 INTERNATIONAL BACKGROUND

Below is listed general information about organisations and norms in seed testing.

2.1 INTERNATIONAL TRADE:
Two major organisations are involved, ISTA and FIS.
ISTA (International Seed testing Association) delivers International certificates for the trade of seed lots between countries.
FIS (International seed trade organisation) is an organisation of producers and sellers of seeds.

2.2 "QUALITY SEEDS":
Nationally or internationally, quality standards are defined for seeds. These standards might be for
- the establishment of seed certifying systems (see FAO below) or
- the setting of specific standards, as for instance for purity, germination...

FAO has a "quality declared seed " system (see Plant Lots and Seeds (1990) 3 53,55)
In the FAO documents are mentioned hints for a quality system for seeds.
- The quality of seeds is under the responsibility of the owner.
- The national quality standards are defined by the national government authorities.
- Appropriate inspections and tests are the responsibility of the owner.
- Ensuring standards are met in practice is the responsibility of the government, and 10% of the "quality declared seed" offered for sale has to be checked.

In these fields of activity, sequential analysis is a potential method to check quality of lots. Owners for instance may use sequential analysis to check quality at various stages during the course of seed processing, (or during growing in the field).

For official work concerning seeds, such as National Certification, most of the National Offices follow directives (for instance EEC Directives) or recommendations indicating that tests must be conducted in accordance with International procedures for seed testing.

In seed testing, ISTA is the only one leading association establishing, standardising and regularly updating its International rules. The work is done in co-operation with organisations such as AOSA for the United States and Canada, VDLUFA for Germany, NIAB for United Kingdom, GEVES for France...)
ISTA does not support the use of sequential analysis for official seed testing, therefore sequential analysis is not likely to be used.

2.3 NORMS FOR TESTS IN SEED TESTING:
2.3.1 Laboratory work:
Norms linked with testing laboratories (ISO Guide 25, EN 45 001, French JO 90-206,...*) are a general frame in which most testing laboratories tend to work.

*ISO GUIDE 25: General requirements for the competence of calibration and testing laboratories
EN 45 001 European General criteria for the operation of testing laboratories
JO 90-206 (France) bonnes pratiques de laboratoire (good laboratory practice)

In these documents there are no reference to explicitly named statistical methods (but instead reference to "the appropriate statistical methods").

In "ANNEXE NORMS", are some selected sentences which may be of interest to the UPOV TWC.

2.3.2 Statistical methods:
AFNOR (French association for norms) has at least three publications on the topic:

Statistique tome 1 vocabulaire, estimation et tests statistiques
Statistique tome 2 contrôles statistiques de fabrication et de réception fiabilité
Statistique tome 3 traitement des résultats de mesure.
(ISBN 2-12-210-650-6 for the three books together)

In the 2nd tome different sampling schemes are developed, some of them might be used for sequential analysis (progressive sampling). Some tables refer to ISO (for instance ISO 3951).

3 USE OF SEQUENTIAL ANALYSIS WITHIN ISTA.

Before examining the tests conducted within ISTA, to recall the missions of ISTA might be useful. ISTA missions are the following:

The primary purpose of the Association is to develop, adopt and publish standard procedures for sampling and testing seeds, and to promote uniform application of these procedures for evaluation of seeds moving in International Trade.

The secondary purposes of the Association are to actively promote research in all areas of seed science and technology (sampling, testing, storing, processing, and distributing seeds).

In particular ISTA delivers, via accredited stations, "ISTA certificates" showing results obtained in accordance with ISTA rules (regularly published).

(ISTA PO BOX 412 CH-8046 ZURICH SWITZERLAND fax 1 377 72 01)

The general philosophy of ISTA work is to estimate seed quality characteristics by testing representative samples taken from an identified and sealed lot of seeds, and to furnish the corresponding results on official certificates.

The methods to use to obtain these estimates are described in published rules and annexes (see International Rules for Seed Testing 1993 ISBN 3-906 549-27-5).

The sample size is prescribed for each test, the following table gives some examples of the sample sizes of the most common tests performed.
The sample size is usually either a mass (a weight) or a number of seeds, corresponding to an assumed number of seeds.

<table>
<thead>
<tr>
<th>type of test</th>
<th>type of sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>sampling (submitted sample)</td>
<td>a specified mass</td>
</tr>
<tr>
<td>purity</td>
<td>a specified mass corresponding to a minimum of 2500 seeds, or a minimum of 2500 seeds, less or equal to 1kg.</td>
</tr>
<tr>
<td>seeds by number</td>
<td>a specified mass corresponding to a minimum of 25000 seeds, or a minimum of 25000 seeds</td>
</tr>
<tr>
<td>mass of 1000 seeds</td>
<td>1000 seeds, or 8 replicates of 100 seeds</td>
</tr>
<tr>
<td>germination</td>
<td>400 seeds</td>
</tr>
<tr>
<td>germination by weighed replicates</td>
<td>a specified mass corresponding to presumably 400 seeds</td>
</tr>
<tr>
<td>excised embryo viability</td>
<td>400 seeds</td>
</tr>
<tr>
<td>biochemical viability</td>
<td>400 seeds</td>
</tr>
<tr>
<td>moisture content</td>
<td>4 g or 10 g depending upon size of sample container</td>
</tr>
<tr>
<td>seed health</td>
<td>400 1000 2000 or 4000 seeds fixed, depending on the disease to be tested <em>Ustilago nuda</em> in <em>Hordeum</em> 2X100 g corresponding to 2000-4000 seeds</td>
</tr>
<tr>
<td>verification of species or cultivar</td>
<td>100 or more plants indoor, 400 or more seeds or seedlings, no clear indication in field plots, (observation), more than 2000 possible 100 seeds (electrophoresis) 50 seeds or less (electrophoresis &quot;simple check on the identity&quot;)</td>
</tr>
</tbody>
</table>

NB: other figures are prescribed for coated seeds.

For all tests except 'verification of species or cultivar' the sample size is fixed. The sample size depends on the test to be conducted and on the species of the seed (or the disease to look at in seed health).

For *Ustilago nuda* the prepared sample size is not strictly defined but a fixed number of 1000 embryos must be examined, therefore it is a fixed sample size.

In order to check trueness to variety of *Triticum, Hordeum, Pisum, Lolium* using PAGE in electrophoresis a number of 100 seeds is "recommended". Depending on the precision needed, more than that might be used (X batches of 50), or less than 50 seeds for "a simple check of a major single constituent". (see annexe 8.6.A.2).

Sequential analysis is explicitly mentioned in this paragraph for cases in which there is a comparison to a standard. But no indication is given, neither on the level of the standard, nor the scheme to accept/continue/reject.

For trueness to variety by examination in field plots, the number of plants to examine is not clearly indicated. Field observation refers to OECD schemes, it is not an actual true obligation in seed testing. The important role played by the specialist for this test is explicitly mentioned in the Annexe of the Rules.

For trueness to variety the sample is tested along with an authentic reference sample. The result is an estimate (percentage of seeds not being of the true variety).
So, in ISTA the estimates are obtained with a fixed sample size. There is never use of sequential analysis. For trueness to species or variety the sample size is more flexible, and sequential analysis is explicitly mentioned with electrophoresis for check toward a standard. The result of the testing of a standard is not an ISTA result.

4 ELECTROPHORESIS WITHIN ISTA

A "Electrophoresis handbook : variety identification" is available from ISTA
In this document 11 pages written by STEINER AM and MEYER U refer to the statistical evaluation of electrophoresis results.

For full details see "ANNEXE STEINER".

The text indicates that sequential analysis is not permitted to be used for issuing ISTA certificates.
The text indicates that sequential analysis may be used when the check against a specified standard is the goal of the study.
In that respect, the possible use for national certification purposes is debated and figures are given.

5 USE OF SEQUENTIAL ANALYSIS IN OFFICIAL SEED TESTING STATIONS:

According to various contacts, the use of sequential analysis is very limited.
Many contacts told that sequential analysis was not officially in use in their laboratory.

5.1 Seed Certification in former East-Germany:
Sequential analysis was used as a routine method for certification in East Germany before reunification. Unfortunately I was not able to obtain information on the number of tests made and sampling schemes before the dead line of this paper.

5.2 Test of trueness to variety with electrophoresis in France:
Sequential analysis has been used for Wheat hybrids and for maize.
Between 1985 and 1988 Wheat 75 lots were tested according to the sample scheme shown in "ANNEXE BOURGOIN".
The reason to decide to apply sequential analysis was to save costs. No such tests were performed after 1988 (no wheat hybrids to test anymore). In that case the choice of the sampling scheme was made from computations knowing the standard to check (90%) and a choice of alpha and beta after considering different sampling schemes (alpha =5%, beta=10%)
The use of sequential analysis was performed only occasionally in maize, because the routine technique is based on a fixed sample size.

5.3 Other uses in France:
Occasionally sequential analysis was used for field observations in Allium, and in germination tests in oil rape. In the first case the aim was to save cost, in the second case to take a decision as soon as possible.
A presently used example of the use of sequential analysis is given in "ANNEXE BLOUET" (Linum).
It is a copy of a sheet used by the persons who examine the plants and the people who take decisions.
The "prébase and base" case corresponds to NQA=0.3% NQT=0.8% alpha=5% beta=10%
The "R1 case" corresponds to NQA=2% (acceptable quality level AQL) NQT=6% (lot tolerance per cent defective LTPD), alpha=5% beta=5%.
The reason for the choice of this test was to use a statistical method taking into account both alpha and beta risks.

5.4 Tetrazolium test in Great-Britain:
To answer a demand from customers who wish to have a very quick advice on germination of lots; a RSV Test (Rapid Seed Viability Test) is regularly performed in England using sequential analysis.
The procedure is fully described in "ANNEXE COSTER".
The test is used as an advisory test for farmers or seed processors and for statutory purposes.
The number of tests performed with sequential sampling is the following:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ADVISORY purpose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cereal</td>
<td>1754</td>
<td>823</td>
<td>115</td>
<td>274</td>
<td>324</td>
</tr>
<tr>
<td>oilseed rape</td>
<td>232</td>
<td>274</td>
<td>311</td>
<td>467</td>
<td>271</td>
</tr>
<tr>
<td>field beans</td>
<td>15</td>
<td>38</td>
<td>2</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1986</td>
<td>1112</td>
<td>464</td>
<td>743</td>
<td>709</td>
</tr>
<tr>
<td>STATUTORY purpose *</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cereals</td>
<td>265</td>
<td>184</td>
<td>72</td>
<td>101</td>
<td>70</td>
</tr>
</tbody>
</table>

* risk removal tool as defined under article 2.2.b of the cereal seed directive, to be followed in all cases by a full germination test.

6 DISCUSSION
Sequential analysis is very rarely used for official testing in seed testing.
Sequential analysis is used by private companies at various stages of seed production. However, the importance of the use of sequential analysis in private companies could not be well established by the contacts made for preparing this paper. One reason for this is that persons were contacted and not organisations, the latter only might have general statistics. Another reason is that it is difficult to obtain precise information from private companies. The usual answer is, yes we did some sequential analysis, yes we still do some, yes we think of making more in the future (if costs are to be cut, or when there is a lack of time if usual tests are used).
The aim of sequential analysis introduction is commonly seen as

reducing costs
and/or reducing time before decision making

The difficulties mentioned are the following:

The principles of the method and the use is sometimes difficult to understand by the persons who do the work
The number of objects to study before the end is not known in advance, that can cause difficulties in work organisation.
There might be tendencies not to follow exactly the rules defined in advance.
The number of objects examined must be "small" (not much than 10%, never more than 15%) compared to the total number of objects, sometimes there is few material at time of the study.

<table>
<thead>
<tr>
<th>9 PROGRAMS THAT ALLOW EXPLORATION OF SEQUENTIAL ANALYSIS</th>
</tr>
</thead>
</table>

**QALSTAT**
Qalstat is a set of three programs designed for quality control. (DAUDIN DUBY TRECOURT INA PG mathématiques et informatique 16 rue C BERNARD 75005 PARIS FRANCE).
The first program, qalstat1, allows the understanding of the use of simple, double, multiple or progressive sample schemes. It gives graphical curves and tables of probability values.

**PEST**
Planning and Evaluation of Sequential Trials. Whitehead J Brunier H Department of applied statistics; University of Reading, whiteknights, READING Great-Britain.
"SEEDS" is also available for viability tests (Whitehead and Ellis).
NB: The sentences are typed in the order in which they appear in the documents. The documents hereafter are linked to quality insurance. The sentences linked to automation are not retyped, being too numerous.

**ISO/IEC GUIDE 25**

3.5 test: A technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure.

10.2 The laboratory shall use appropriate methods and procedures for all calibrations and tests and related activities within its responsibility (including sampling, handling, transport and storage, preparation of items, estimation of uncertainty of measurement and analysis or calibration and/or test data). They shall be consistent with the accuracy required, and with any standard specifications relevant to the calibrations or tests concerned.

10.3 Where methods are not specified; the laboratory shall, wherever possible, select methods that have been published in international or national standards, those published by reputable technical organisations or in relevant scientific texts or journals.

10.4 Where it is necessary to employ methods that have not been established as standard, these shall be subject to agreement with the client, be fully documented and validated, and be available to the client and other recipients of the relevant reports.

10.5 Where sampling is carried out as a part of the test method, the laboratory shall use documented procedures and appropriate statistical techniques to select samples.

10.6 Calculations and data transfers shall be subject to appropriate checks.

10.7 Where computers or automated equipment are used for the capture, processing, manipulation, recording, reporting, storage or retrieval of calibration or test data, the laboratory shall ensure that,

a) the requirements of this guide are complied with;
b) computer software is documented and adequate for use;
c) procedures are established and implemented for protecting the integrity of data; such procedures shall include, but not limited to, integrity of data entry or capture, data storage, data transmission and data processing;
d) computer and automated equipment is maintained to ensure proper functioning and provided with the environmental and operating conditions necessary to maintain the integrity of calibration and test data;
e) it establishes and implements procedures for the maintenance of the security of data including the prevention of unauthorised access to, and the unauthorised amendment of, computer records.

13.2 (certificates and reports)

...  
l) a statement of the estimated uncertainty of the calibration or test result (where relevant)

**EN 45 001**

2.1 test: technical operation that consists of the determination of one or more characteristics of a given product, process or service according to a specified procedure

5.4.1 test methods and procedures:

... 

The testing laboratory shall use methods and procedures required by the technical specification against which the test items are to be tested. The technical specification shall be available to personnel performing the test. The testing laboratory shall reject requests to perform tests according to test methods that may endanger an objective result or have a low validity.

Where it is necessary to employ test methods and procedures which are non standard, they shall be fully documented. All calculation and data transfers shall be subject to appropriate checks. Where results are derived by electronic data processing techniques, the reliability and stability of the system shall be such that the accuracy of the results is not affected.

5.4.3 (test reports)

...  
k) a statement on measurement uncertainty (where relevant)

...  

Quantitative results shall be given together with calculated of estimated uncertainty.
ANNEXE BOURGOIN

WHEAT HYBRIDS ELECTROPHORESIS FRANCE

PROGRESSIVE CONTROL NF_X06024

ALPHA 0.05  Pa 0.05  BETA 0.10  Pr 0.20
V 2.89  U 2.25
X 1.39  Y 0.17
HA 1.44  HR 1.86  S 0.11  HA/S 13

<table>
<thead>
<tr>
<th>TAUX ECHANTILLON</th>
<th>PROBABILITE ACCEPICATION</th>
<th>EFFECTIF MOYEN CONTROLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>P1 0.05</td>
<td>0.95</td>
<td>41</td>
</tr>
<tr>
<td>S 0.11</td>
<td>0.56</td>
<td>22</td>
</tr>
<tr>
<td>P2 0.2</td>
<td>0.1</td>
<td>25</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

20 SEEDS OBSERVED AT A TIME

<table>
<thead>
<tr>
<th>nb grains</th>
<th>accept</th>
<th>refuse</th>
<th>NB OF SAMPLES EXAMINED (STOP AT 20 40 OR 60)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 TO 10</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>12 TO 18</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>20 TO 22</strong></td>
<td><strong>0</strong></td>
<td><strong>5</strong></td>
<td><strong>19</strong></td>
</tr>
<tr>
<td>24 TO 26</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>28 TO 30</td>
<td>1</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>32 TO 34</td>
<td>2</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>36 TO 40</td>
<td>2</td>
<td>7</td>
<td><strong>20</strong></td>
</tr>
<tr>
<td>42 TO 48</td>
<td>3</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>50 TO 54</td>
<td>4</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>56 TO 60</td>
<td>6</td>
<td>7</td>
<td><strong>26</strong></td>
</tr>
</tbody>
</table>
ANNEXE MILES

A well known handbook for tolerances in seed testing, written by S R MILES was published in 1963 in the proceedings of the International Seed Testing Association (ISTA).

In that document sequential tests are proposed for some seed testing purposes. A look at this document (proc. Int. Seed Test. Ass. Vol. 28 (1963) No 3 p 525-686) is summarised below.

The author remind that "nothing herein should be considered as official for any association or other agency unless or until it is included in their rules". The aim of the handbook is to give references when people (any seed trade fellows) wants to compare an estimate of an attribute to either another estimate or a specification.

In the glossary and in the text, the difference between an estimate and a specification is defined. An estimate is "any determination of the value of a seed attribute from examination of a sample". A specification is "the allowed minimum quality specified or stated for a seed attribute in a law, a regulation, a standard or a contract".

Miles gives four typical cases for which people want to compare an estimate:

Case 1: Two estimates have been made. The first is by or for a vendor and the second is by a buyer or an official. the 2 estimates are compared to decide from the second estimate whether the seed is as good as the first estimate indicates. A 1-way test is made.

Case 2: Two estimates have been made in the same or different laboratories and by the same or different analysts. Now there is no distinction between the two estimates. The question to be answered is: Are the 2 estimates compatible?. A two way test is made.

Case 3: A specification of minimum quality is provided by law, regulation, standard or contract. A single estimate is used in a 1-way test to decide whether the seed is as good as specified.

Case 4: There is 1 specification and 1 estimate. A 2-way test is made to decide whether the seed is either better or poorer than the specification.(for instance to establish the grade of a lot).

Special case: When a second estimate is made because the seeds man thinks his seed is better than the first estimate made, the final estimate should not be the best of the 2.

Through the all document, references are given for proposals and tables to help the reader to choose an appropriate method to it's corresponding case.

In most cases sequential tests are proposed for cases 3 or 4 "estimate compared to specification" (see for instance p 546-547 and tables p 571-580 for purity, p 597-599 + 600-608 and tables p 629-639 for foreign seeds, p 643 and table p 651 for germination, etc.). But the definition and examples (p 542-543) for sequential tests are somehow confusing in my personal understanding.

It is clear that sequential testing might be used for cases where an estimate has to be compared to a specification. But it seems to me that sequential testing stands in the text also for cases in which people want another (new) estimate because "there is a doubt" on the first estimate (with no regard to whether the doubt is founded or not, or the cause of the doubt).

This wording seems too general to me for the possible application of sequential testing. It may cause the made of further examinations until the reach of a pre-determined "wish" of the analyst or the vendor.