Sample sizes

At the Forty-second session of the Specialized Section on Standardization of Seed Potatoes (Geneva, 13-15 October 2014) it was agreed that it would be helpful to have guidance (e.g. an indicative table) in the Standard on the sample size that would ensure desired confidence levels for faults having different tolerance levels. The Specialized Section established a Working Group composed of the delegations of Finland, New Zealand (rapporteur), Sweden and the United States to propose, at the next meeting of the Extended Bureau, amendments to the Standard related to sample sizes for both field inspection and post-harvest testing.

Introduction

The Standard (Annex II) establishes the tolerances for faults that are not to be exceeded. However the Standard does not specify the number of plants that are required to be inspected or the level of confidence required when establishing a sample size. It is therefore probable that DAs have established sampling and inspection procedures that result in varying levels of confidence in the result of the inspection. This is explained further in the attached "Statistical Notes".

There also appears to be a contradiction in the Standard. Annex II A of the Standard specifies the "minimum conditions to be satisfied by the crop" *as the proportion of growing plants* that shall not exceed a specified tolerance. For example the proportion of growing plants showing symptoms of virus diseases shall not exceed 0.1 per cent in the crop for production of Pre-basic class seed.

However Annex II B contradicts section A, in that section B states that "The number of plants affected by the diseases listed in annex II, section A, points 2 and 3 and those not true to variety or of another variety (annex II, section A, point 4) should be recorded separately in the field inspection report and each expressed *as a percentage of the total number of plants inspected in the crop*."

Part B suggests that if 3000 plants are inspected and there are 3 faults a tolerance of 0.1% has not been exceeded. However Part A states that the tolerance is *the tolerance for the crop*. This is different from the number of faults allowable in the sample. For example if 3000 plants are inspected in the crop and the tolerance is 0.1% the maximum number of allowable faults is zero in order to be 95% confident that the overall level of faults in the crop does not exceed 0.1% – not 3 in 3000 (or 0.1% of the inspection sample). The attached "Statistical Notes" paper explains this reasoning.

This is an important point for clarification.

Statistical considerations

Where tolerances are very small, e.g., 0.01%, a much larger number of plants need to be inspected (30,000 to be 95% confident). This number changes slightly depending on the number of plants in the crop, but over a certain number of plants makes no difference at all and can be ignored for the purposes of this paper.

Differing tolerances will apply to each crop. In a Certified Class II crop the tolerance for blackleg is 2%, virus 6%, and off types 0.5%. To be 95% confident that the tolerance for off types is not exceeded 600 plants need to be inspected but for virus only 50 plants need to be inspected with no virus detected. As a minimum of 600 plants will be inspected to allow the off type tolerance to be verified the number of virus and blackleg faults in the 600 inspection sample is adjusted to provide an acceptance number. The paper establishes the minimum number of plants that can be inspected with no faults found in order to verify that the tolerance is not exceeded. A larger number of plants can be inspected and an acceptance number <0 can be applied.

The paper presents minimum sample sizes for 90%, 95%, and 99% confidence that the tolerances specified in the Standard will not be exceeded. Depending on the selected confidence level it can be expected that true level of faults in the crop may exceed the specified tolerance once every 10, 20, or 100 crop inspections respectively.

The Standard specifies a zero tolerance for several diseases. This is problematic in that to verify that there is no disease in a crop every plant would have to be inspected. Even if a tolerance of 1/100,000 plants (rather than zero) was established this would require inspection of 300,000 plants in order to be 95% confident. For other faults the number of plants inspected will vary depending on the class of seed crop being inspected but is considerable lower – this could range from 50 to 30,000 plants. So the level of confidence of detecting "zero tolerance" diseases even at a rate of 1/100,000 is very low (<5% if 50 plants are inspected).

Practical considerations

Classes to which very low tolerances are applied (e.g., 0.01% for off-types in pre-basic) are usually planted in small areas so the very large number of plants required to be inspected to achieve 95% or 99% confidence would normally exceed the number of plants in the crop, so all of the plants would be inspected. In practice the number of plants to be inspected in a crop to achieve 95% confidence that a 0.01% tolerance is not exceeded will not be 30,000 plants it will be the actual number of plants and will be far lower than this number. For higher tolerances the number of plants will be an achievable number – perhaps even considered unrealistically low.

Recommendations

1. In order to encourage standardization in field and post-harvest evaluations it is recommended that the Specialized Section agrees on an appropriate level of confidence that should be achieved in field inspections. Ideally this will reflect current practices of DAs.

2. It is recommended that Annex II B is modified to confirm that the tolerances specified in the Standard are the maximum allowable proportions of faults in the crop. Section 2 of Annex II B could be re-written by modifying the second paragraph as follows:

   The DA shall specify the inspection procedures. In general, the procedures should allow the inspector to inspect at random a representative sample of plants from a crop. The number of plants inspected should be sufficient to ensure that, with XX% confidence, the tolerances given in Annex II A are not exceeded. Table YY provides guidance on the number of plants to sample and maximum allowable number of each fault in each sample size.

   The number of plants affected by the diseases listed in annex II, section A, points 2 and 3 and those not true to variety or of another variety (annex II, section A, point 4) should be recorded separately in the field inspection report and ~~each expressed as a percentage of the total number of plants inspected in the crop~~ compared to the acceptance number for each fault in Table YY for the sample size.

   XX% will be the confidence level agreed in recommendation 1.

   Table YY will be developed if this approach is accepted by the working group.

3. The Specialized section should also revise its position on zero tolerance diseases. It may be more appropriate to express these as zero faults observed in the inspection sample and any other part of the crop viewed by the inspector (this is in line with the Field Inspection Guide). However in doing so it must be recognised that the level of confidence in detecting these diseases will be very low. It may be necessary to determine a minimum number of plants to be inspected in any class that provides an acceptable level of confidence that "zero tolerance" diseases will not be detected and provide a table of acceptance numbers for faults with higher tolerances in the same class. Annex II B could be modified by adding a paragraph, following those modified above, to read:

   No symptoms of the diseases specified in Annex II A 5 shall be detected in the inspection sample of any other part of the crop viewed by the inspector during the course of field inspections.

4. Annex IV specifies that the sample size for post-harvest visual evaluations is 100 tubers. To achieve 95% confidence that the tolerances referred to in the Annex would require a much larger sample size (e.g., 0.01 per cent for Pre-basic class). Table 1 of Annex IX reflects this by indicating that for a tolerance of 0.5% with no faults detected the true number of faults lies between 0 and 2.95 (the confidence interval). Put another way, the confidence level in this example is

39%. It is recommended that this section is revised to reflect the detection limits imposed by a sample size of 100 tubers.