Practical exercise: comparison of results when conducting inspection using percentage-based versus Risk-Based Sampling

Inspections traditionally conducted at ports of entry are based on sampling a percentage of the consignment (usually 2%). Traditional inspections usually stop when the inspector finds a pest, independent of whether the entire sample was inspected or not.

For Risk-Based Sampling (RBS) it is necessary to calculate the sample size based on the consignment size taking into consideration a maximum acceptable infestation level or percent infestation to be detected in a consignment (for example, 10 %). In this type of sampling, the level of confidence and the probability that a consignment with a degree of infestation higher than the detection level will be detected are also defined. A 95% confidence level indicates that sampling will detect a non-compliant consignment an average of 95 out of 100 times.

The objective of this exercise is to demonstrate how percentage-based sampling and Risk-Based Sampling (RBS) differ with respect to efficacy and consistency of results. Below we list the required materials and instructions on how to conduct the exercise.

1.1.1. Materials and their organization

a) Five fabric or plastic bags with string or zip-lock closure that will represent consignments or lots of different sizes. Label the bags as shown below.

b) Beans. Dark and light-colored beans of similar size and shape are needed. Light-colored beans will represent non-infested samples in the consignment or lot. Dark-colored beans will represent infested samples in the consignment or lot.

Each bag should contain the following number of beans according to the consignment size, **representing a 10% infestation in each bag**:

Bag labeled	light-colored beans	dark-colored beans	Total # of beans in each bag
Consignment size = 100	90	10	100
Consignment size = 500	450	50	500
Consignment size = 1,000	900	100	1,000
Consignment size = 2,000	1,800	200	2,000
Consignment size = 5,000	4,500	500	5,000
Total beans needed	**7,740**	**860**	**8,600**

1.1.2. Conducting the exercise

a) Percentage-based sampling (2%)

i. Sample size calculation: Calculate a sample size of 2% for each consignment:

Consignment or lot size	2% sample = # of beans to sample from each bag
100	2
500	10
1,000	20
2,000	40
5,000	100

ii. Sampling procedure

- Work with one consignment size at a time.
- To take a sample, remove a single bean out of the bag.
- Do not return the beans to the bag until you finish your sample.

- If you find a dark-colored bean (= an infestation) before completing your 2% sample (see table above), record the number of beans you removed before finding the infestation in the results table below. Return all the beans to the bag and shake the bag before resampling.
- If you complete your 2% sample without finding an infestation, record your result as "no detection." Return all the beans to the bag and shake the bag before resampling.
- Repeat the process 3 different times for each consignment size.

iii. Calculating the results

- For each consignment size, calculate the mean number of beans you sampled before detecting the infestation. See example below for a consignment size of 5,000:

  Assay 1 = 23 samples (beans) taken before finding a dark bean
  Assay 2 = 28 samples (beans) taken "…"
  Assay 3 = 27 samples (beans) taken "…"

  Calculate the mean: 23+28+27 = 78/3 = 26

- Now, calculate the mean percentage sampled:

$$\frac{26}{5{,}000} = 0.0052$$

$$(0.0052 * 100) = \mathbf{0.52}\%$$

- In this example, 0.52% was the true percentage sampled to find the infestation in the consignment.

- If the result of one or more of your assays was "no detection" for a determined consignment size, then record "no detection" for that sample size.

iv. Recording and presenting the data

Use the table below to record your sampling data, including the mean and the true percentage sampled. See example below for a consignment size of 5,000.

Consignment size	2% sample rate	Number of samples taken before finding the infestation			Results	
		Assay 1	Assay 2	Assay 3	Mean	True percentage sampled
100	2					
500	10					
1,000	20					
2,000	40					
5,000	100	23	28	27	26	0.52%

b) Risk-Based Sampling - RBS

Calculate the sample size: use the hypergeometric tables (see Chapter 10, Appendix 2) or the sample size calculator found here https://nappo.org/english/learning-tools/Resources-and-Learning-Tools-for-Risk-Based-Sampling/Sample-Size-Calculator to calculate the sample size. Use a 10% detection level and a 95% confidence level. These parameters result in the following sample sizes per consignment:

Consignment or lot size	Sample size
100	25
500	28
1,000	29
2,000	29
5,000	29

i. Sampling procedure

- As before, for each consignment and without looking inside the bag, remove one bean at a time until you find an infestation or until completing the sample size indicated in the table.
- When you find a dark bean, count the number of beans sampled before finding the infestation and record the data in the table and continue sampling until you reach the calculated sample size.
- Return all beans to their bag and mix them up before repeating the assay.
- Repeat the sampling process for each consignment three times.

ii. Calculating the results

- As above, calculate the mean samples taken from each consignment.
- Then, divide the mean by the total number of beans in the consignment.

- Multiply that number by 100 to determine the percentage of beans sampled before finding the infestation.
- If the result is "no detection" in any of the assays for a specific consignment size, then record "no detection" for that consignment size.

iii. Recording and presenting the data

As above, record your results in the table below.

Consignment	Sample size	Number of samples before finding the infestation			Results	
		Assay 1	Assay 2	Assay 3	Average	Percentage
100	25					
500	28	23	28	27	26	5.2%
1,000	29					
2,000	29					
5,000	29					

c) Consolidation and comparison of results

Place tables side by side to allow easy comparison of the data. Review and compare the results obtained, and record the most relevant observations with regard to each of the sampling methods:

Percentage-based sampling:

- ____
____
- ____
____
- ____
____

Risk-Based Sampling:

- ____
____
- ____
____
- ____
____

d) Document the exercise by taking some photographs

To share the results with other groups we suggest that you consider taking photographs of the following parts of the exercise:

- ✓ Preparation of consignments
- ✓ Conduct of both exercises
- ✓ Fully completed table of percentage-based sampling (2%) results
- ✓ Fully completed table of RBS results.

1.1.3. Points to consider

When we compare the results from the 2% sampling with those from Risk-Based Sampling we see that with RBS we detect the infestation in most of consignments, which is not the case with percentage-based sampling. The latter is less effective at detecting infestation, especially for smaller consignments.

Percentage-based sampling results in less likelihood of detecting low infestation rates in small consignments, and for large consignments percentage-based sampling results in oversampling (= more time and resources). Furthermore, detection levels per consignment are not consistent for different lot sizes. Inconsistent detection levels mean that percentage-based sampling is not a technically justified measure as a risk management tool.

With Risk-Based Sampling we can detect infestations at a defined detection level regardless of the consignment size, which is technically justified. Risk-Based Sampling uses smaller sample sizes for larger lots allowing resources to be used in a more efficient manner.

In RBS, even after finding an infested sample, the process continues until the entire sample is examined. This provides information on how many different pests may be present and their level of infestation.