HLB sample size calculator for detecting Huanglongbing in trees, psyllids and vegetative material

A statistical methodology to estimate a simple size for detecting agricultural pests

Martha Elva Ramírez Guzmán Ph.D. *,

- Statistics Program. Campus Montecillo. Colegio de Postgraduados. Montecillo, Estado de México. (martharg@colpos.mx.). México.

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1. INTRODUCTION

What is the sample size to detect a pest?. This is a reiterated question that decision maker makes when a pest starts to be a hazard in commercial crops. A proposal to answer this question is presented in this work. It is accompanied with an easy program which is named HLB calculator. It was developed taking into account the following considerations.

2. GENERAL CONSIDERATIONS

A proposal to estimate a sample size for detecting HLB is developed using acceptance sample plans with an acceptance number C=0, for detecting the bacteria in trees and/or plants (T), psyllids (P) and vegetative material (V) in citrical comercial areas. The sample size depends on:

- Observed HLB bacteria incidence ratio: in T (p_T), P (p_P) and V (p_V).
- Confidence level estipulated by SENASICA (National health service for food safety and quality): 1-β_T, 1-β_P, and 1-β_V, for detecting HLB bacteria in T, P and V, respectively.
- Statistical distribution as sugested by Bergamin Filho et al (2008), Madden L.V. and Huges G (1999) and Kohji y Tomio (1995).
- Observed visual dectection proportion: ϕ_1, δ_1 and λ_1. for for T, P and V, respectively.
- Risk for closeness to states and towns with HLB (ϕ_2).

3. SAMPLE SIZE

- Sample size for T from beta-binomial distribution:

$$n_T = \left(N_i - \frac{N_i p_T \phi_1 \phi_2 - 1}{2} \right) \left(1 - \beta_T^{\,1/(N_i p_T \phi_1 \phi_2)} \right)$$

- Sample size for P from binomial distribution:

$$n_P = \frac{-\log(\beta_P)}{p_P \delta_1 \phi_2}$$

- Sample size for V from binomial distribution:

$$n_V = \frac{-\log(\beta_V)}{p_V \lambda_1 \phi_2}$$

N_i = Number of trees in the ith state or town of interest.

4. RISK STRATIFICATION

A HLB risk index was designed using the Failure Mode and Effects Analysis (FMEA) methodology. This technique was developed by the NASA and was knowed as MIL-P-1629 procedure in 1949. A severity number from 1 to 10 was fixed to measure risk, 1 was asociated to minimum and 10 to maximun severity. Hence a HLB risk index (ϕ_2) was defined inversely to the severity number as is showed in the Risk Table).

Risk Table

Severity	Severity rank	ϕ_2	Stratum	Description
High	10	1/10 = 0.10	0	State or town with HLB or close to locations with HLB.
Medium-high	9	1/9 = 0.11	1	State or town contiguous to 0 stratum.
Low	6 – 8	1/7 = 0.14	2	State or town contiguous to 1 stratum.
Very low	2 – 5	1/3.5 = 0.28	3	State or town contiguous to 2 stratum.
Unlikely	1	1/1 = 1	4	No citrus commercial state or town.

5. COMMAND TABLE

(DATA ON GREEN CELL CAN BE CHANGED)

	Trees or plans					Psyllids				Vegetative material			
		1-β_T=	99	%		1-β_P=	92	%		1-β_V=	92	%	
Stratum	p_T	ϕ_1	ϕ_2	n_T	n ha	p_P	δ_1	ϕ_2	n_P	p_V	λ_1	ϕ_2	n_V
0	0.0003257	0.3	0.10	467,957	3,059	0.012750	0.95	0.10	2,084	0.3	0.30	0.10	279
1	0.0003257	0.3	0.11	425,691	2,782	0.018000	0.95	0.11	1,341	0.3	0.30	0.11	254
2	0.0003257	0.3	0.14	334,936	2,189	0.018000	0.95	0.14	1,054	0.3	0.30	0.14	199
3	0.0003257	0.3	0.28	167,894	1,097	0.100000	0.95	0.28	94	0.3	0.30	0.28	99
4	0.0003257	0.3	1.00	47,095	308	1.000000	0.95	1.00	1	0.3	0.30	1.00	27

6. HLB CALCULATOR

HLB sample size calculator

HLB risk strata	
High	0
Medium high	1
Low	2
Very low	3
Unlikely	4

Instructions:
**** Only enter data in the eight green cells.***
***** Note: If you do not know the 5 and 6 concepts please type *.***

Input data

Concepts	Data	
1 Name of the state or town (or at national level):	Veracruz	
2 Citrical ha of the state or town (or at national level):	215,613	ha
3 Trees or plants by ha:	153	
4 Stratum as attached table:	0	
5 Number of positive trees:	*	** Note
6 Number of trees sampled:	*	** Note
7 estimated incidence proportion:	0.0003257	
8 Cost per tree:	$1.00	
9 Lab cost analysis:	$800.00	

Output results

Sample size for:	Veracruz
ha to sample:	3,059 ha
Trees or plants to sample:	467,957 trees/plants
Psyllids compositive samples:	2,084 samples
Vegetative material samples:	279 samples

Investment

Cost (pesos) of trees or plants to sample:	$467,956.91
Cost (pesos) of psyllids to sample:	$1,667,169.41
Cost (pesos) of vegetative material:	$223,497.40
Total cost (pesos):	$2,358,623.73

7. GENERAL RECOMMENDATIONS

		
a) Use White clothes	b) Disinfect working tools	c) Disinfect personal equipment
d) Standardize criteria for recording data	e) Check limonarias in recovery booths	f) Continuously update: • % HLB detection • % of positive psyllid samples • % of plant material positive

8. CONCLUSIONS

A practical and easy program for estimating sample size for detecting HLB can be useful for decision making. It implies savings in time and economical resources.

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