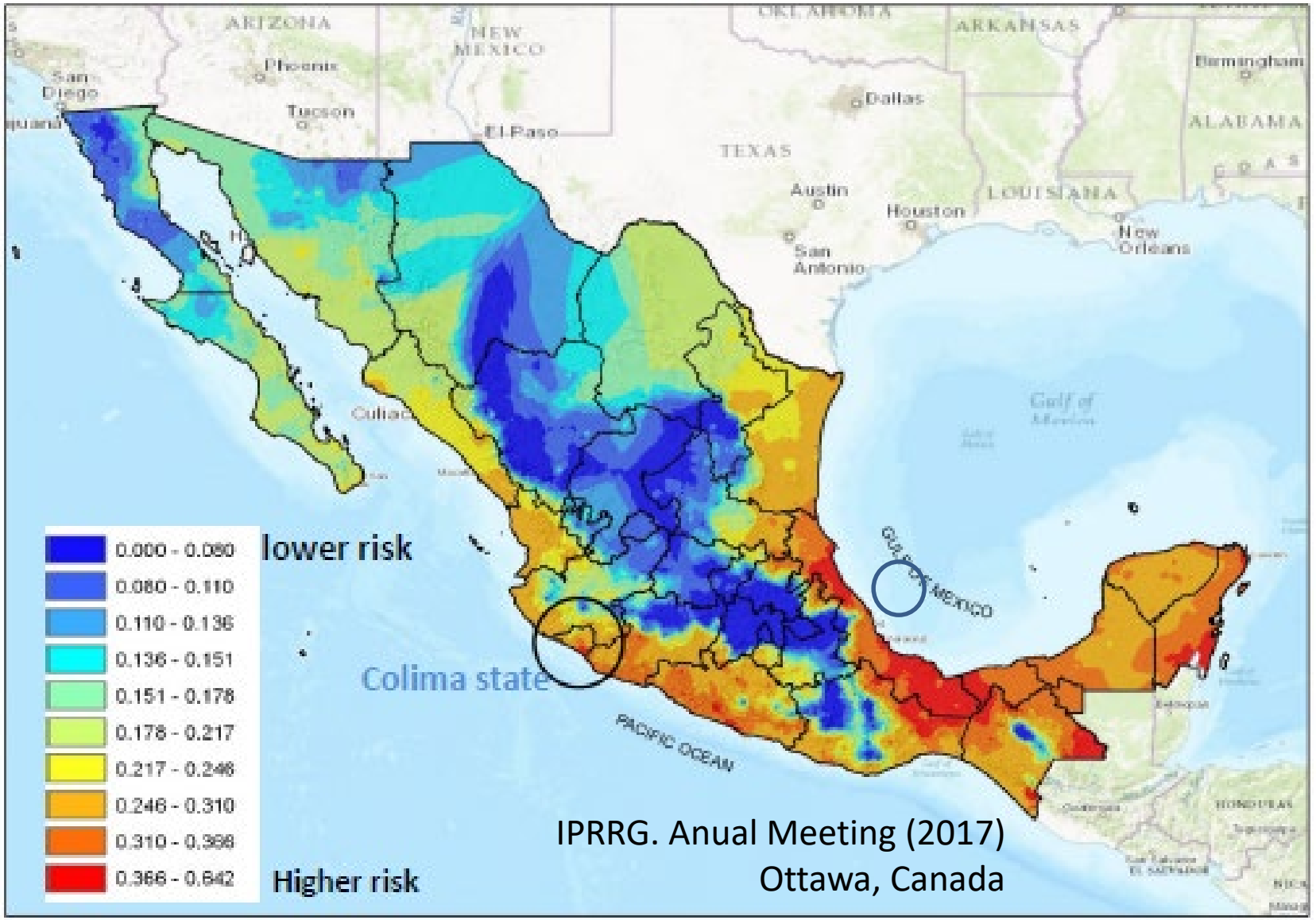
Sequential sampling plan for a regional management control of *Diaphorina citri* in Persian lime: *Citrus latifolia* Tan. in Mexico.

Gabriel Diaz Padilla ,
Arroyo López , Isabel Jose
Panes Guajardo , Alberto Rafael
Ignacio Sánchez Cohen

My first experience in Pest Risk Analysis was the development of this map, where the risk of the potential distribution of Diaphorina citri was evaluated.

I presented this map to citrus producers of Veracruz and one of them took the microphone and said:
…. It is a very nice map but what is it for? , what we really need is ***to know when and what we should apply*** to control the vector populations

Spatial distribuition of potential risk of *D. citri*



IPRRG. Anual Meeting (2017)
Ottawa, Canada

Some classical paper review

Wald, A. 1947. Sequential Analysis. Wiley. New York.

Oakland, G. B. (1950) 'An Application of Sequential Analysis to Whitefish Sampling', *Society International Biometric*, 6(1), pp. 59–67. doi: 10.2307/3001424.

Taylor, L.R. 1961. Aggregation, Variance and the Mean. *Nature* 189: 732-735.

BLISS, C. I., & OWEN, A. R. G. (1958). NEGATIVE BINOMIAL DISTRIBUTIONS WITH A COMMON K. *Biometrika*, *45*(1–2), 37–58. Retrieved from http://dx.doi.org/10.1093/biomet/45.1-2.37

Tsai, J. H., J. J. Wang, and Y.H. Liu. 2000. Sampling of *Diaphorina citri* (Homoptera: Psyllidae) on orange Jessamine in southern Florida. Florida Entomologist. 83: 446-459.

Besides that I have the complete database of the national monitoring campaign 2016 with more or less 7 million of records used in risk map)

Why no study this and implement an strategy of Sequential Sampling in citrus and talk later with that farmer ?

Should I spray pesticide or not?

Sequential Sampling (SS) → *Necessity of tools or methods to support a decision* ← Traditional Sampling(TS)

NO

YES

Why sequential sampling and non-traditional sampling

- The sample size is minimized
- Save time and money
- Computers are often required

- Three possibilities are tested:
- 1. The null hypothesis is not rejected;
- 2. Rejection of the null hypothesis; and
- 3. Uncertainty (the decision is to take another sample)

- The sample size is set in advance
- Depends on the money available
- Maybe more expensive
- The decision is made at the end of the sampling

- Two possibilities are tested:
- 1. The null hypothesis is not rejected;
- 2. Rejection of the null hypothesis

Why Persian Lime ?

(*Citrus latifolia* Tanaka)

In the world context, Mexico is the leading producer

95,609 hectares planted
3,131,000 millions of dollars
(Value of Production)

The annual income of a large number of families depends on the money they receive for harvesting this crop.

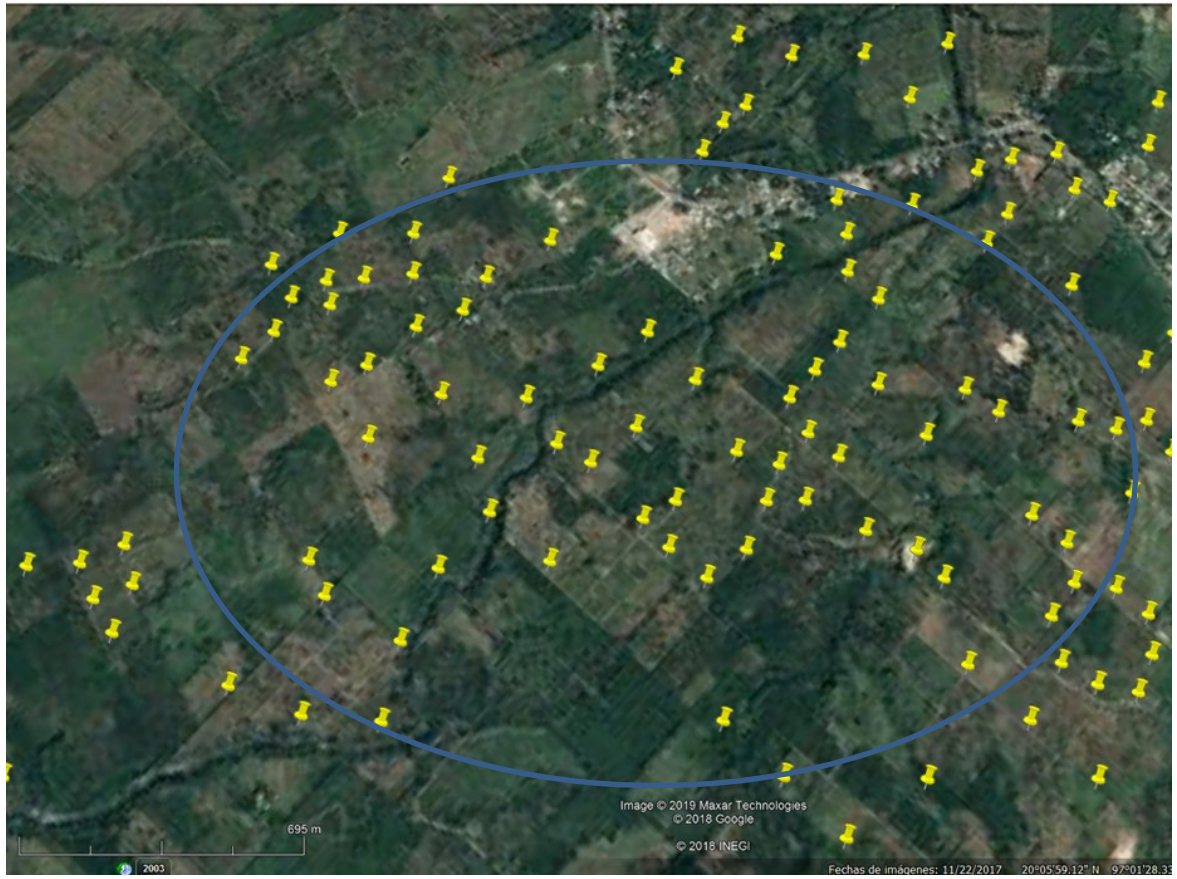
Why *Diaphorina citri* ?

- It is an important pest of citrus in several countries as it is a vector of a serious citrus disease called greening disease or Huanglongbing
- In Mexico, Persian Lime production has decreased by 30%
- Vector control is essential to prevent this disease

Why Area Wide Control (AWC) ?

- It is a strategic component of the Integrated Pest Management.

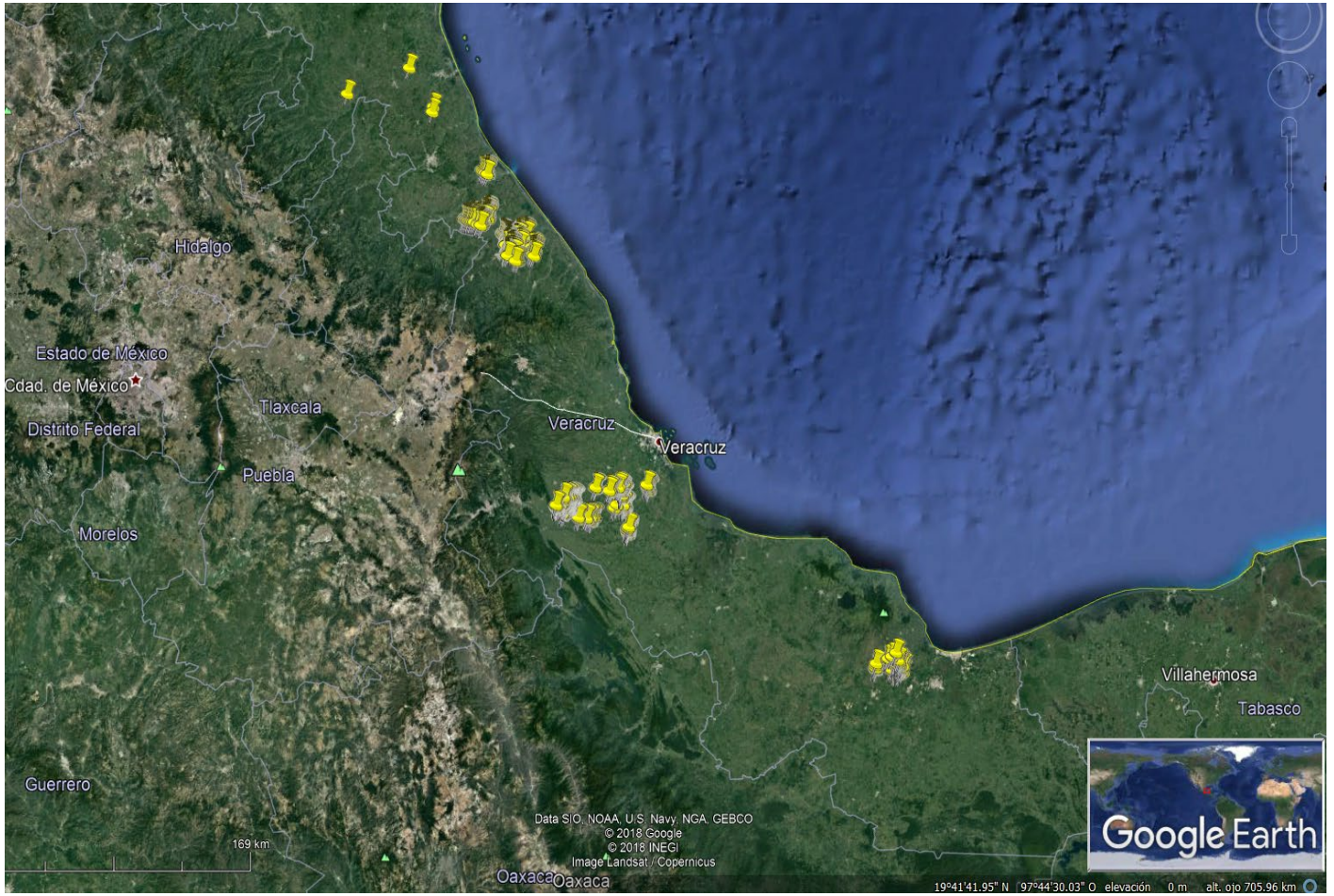
- It has been shown to be:
- an important,
- necessary and
- effective strategy
- for controlling pests and diseases



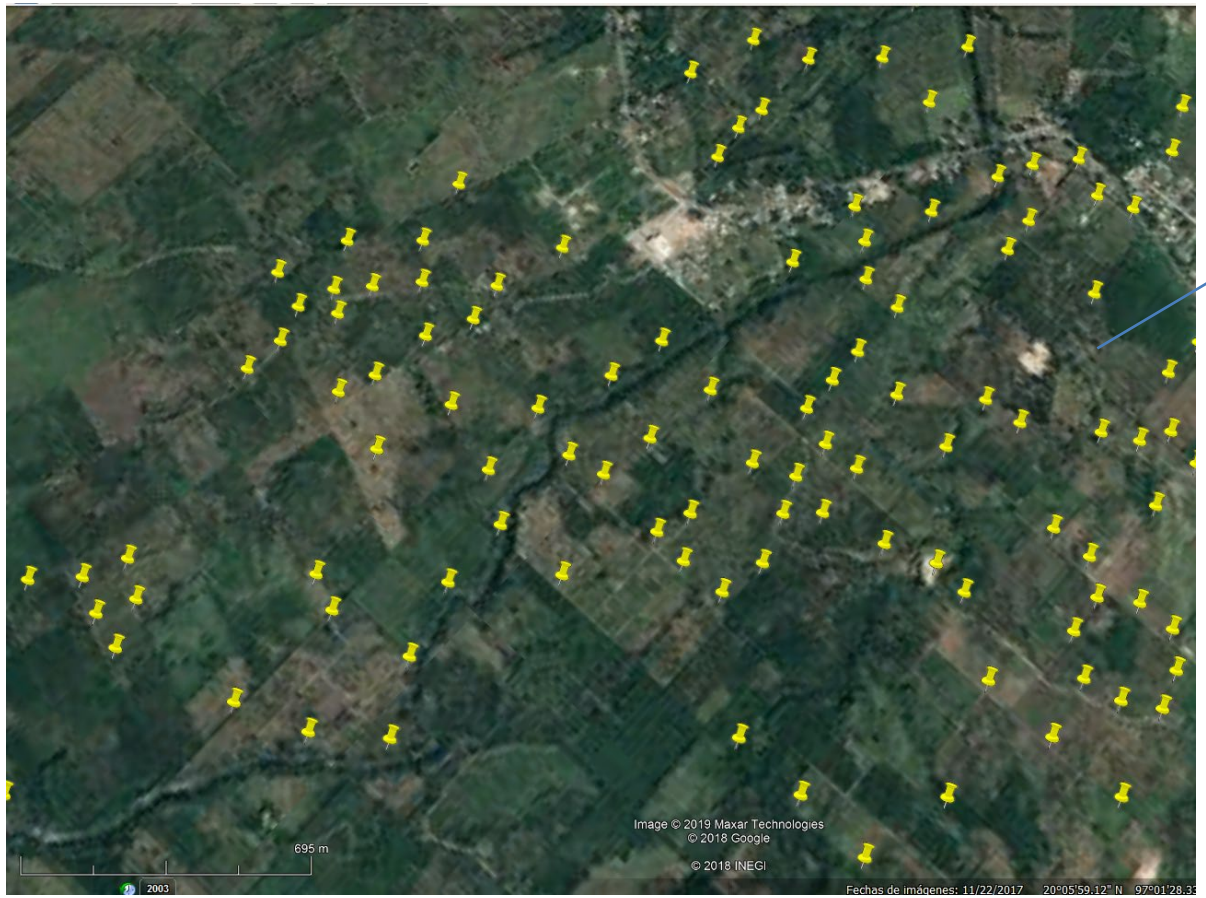
Database:

Are records of the number of *Psyllids capture per Trap per Tree per Week (PCTTW),* at each of the 1150 sticky yellow traps, strategically located in persian lime plantations in Veracruz, State, Mexico.

Y_i=PCTTW



Visual representation of how does de records was obtained



One trap – one tree -one week

Counting the psyllids captured weekly

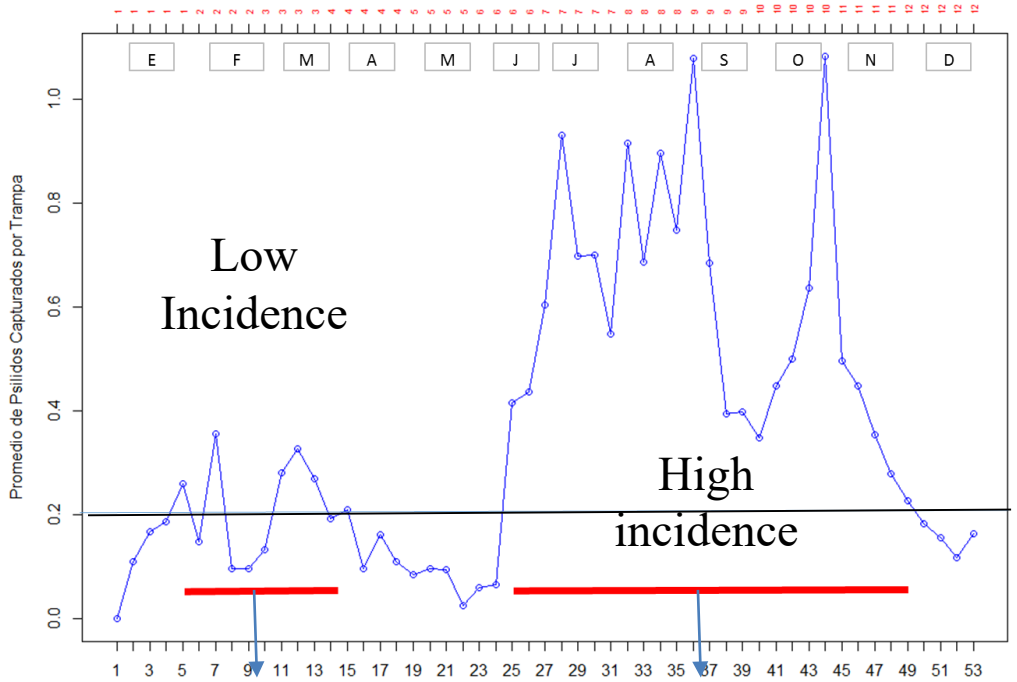
(Yi) → PCTTW

Results

spray

But exactly when ?

not to spray



Presence of psyllids arises from May to October, due to incidence of rain and a strong tree sprouting

Economic treshold =.20

PCTTW

Variable	Global	Week(5-14) Low Incidence	Week (25-49) High Incidence
Mean	.3714	.2162	.5991
Sd	2.36	.99	3.28
Max	326	74	326
N (number of records)	166,220	22,748	56,401

To implement a SS, it is necessary to define:

- the statistical distribution that fits data,
- the type of spatial distribution,
- the possibility of using a common k (kc)
- and setting values decision thresholds.

The statistical distribution that fits data

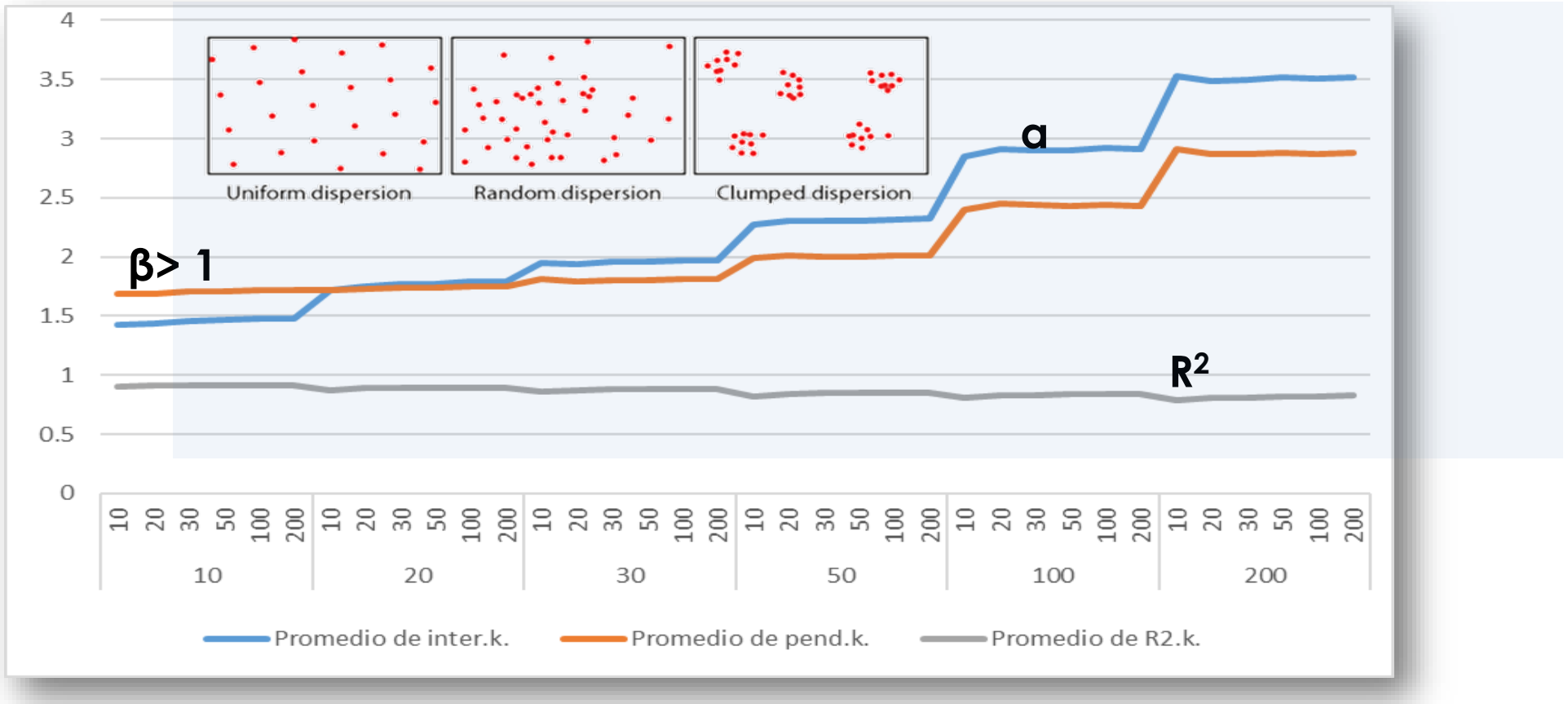
	Poisson	Binomial	Geometric	Negative Binomial(mme)	Negative Binomial(mle)
sum of residuals	0.1243	0.0350	3.2634	9.2275	9.3172
Chi-square Statistic	112.5171	123.0327	44.1295	14.3522	3.2322
p-value	0.0000	0.0000	0.0000	0.2788	0.9937
MSE	939.0411	1032.6554	335.5326	57.5986	1.8276

Resampling 1000 times for differents samples sizes (10,20,200,500,1000) and the results were identical, so we concluded that the psyllids population follows a negative binomial distribution with an error of 1 %

The maximun likelihood method present a better fit than the moment method.

Spatial distribution

Resampled= 1,000 times



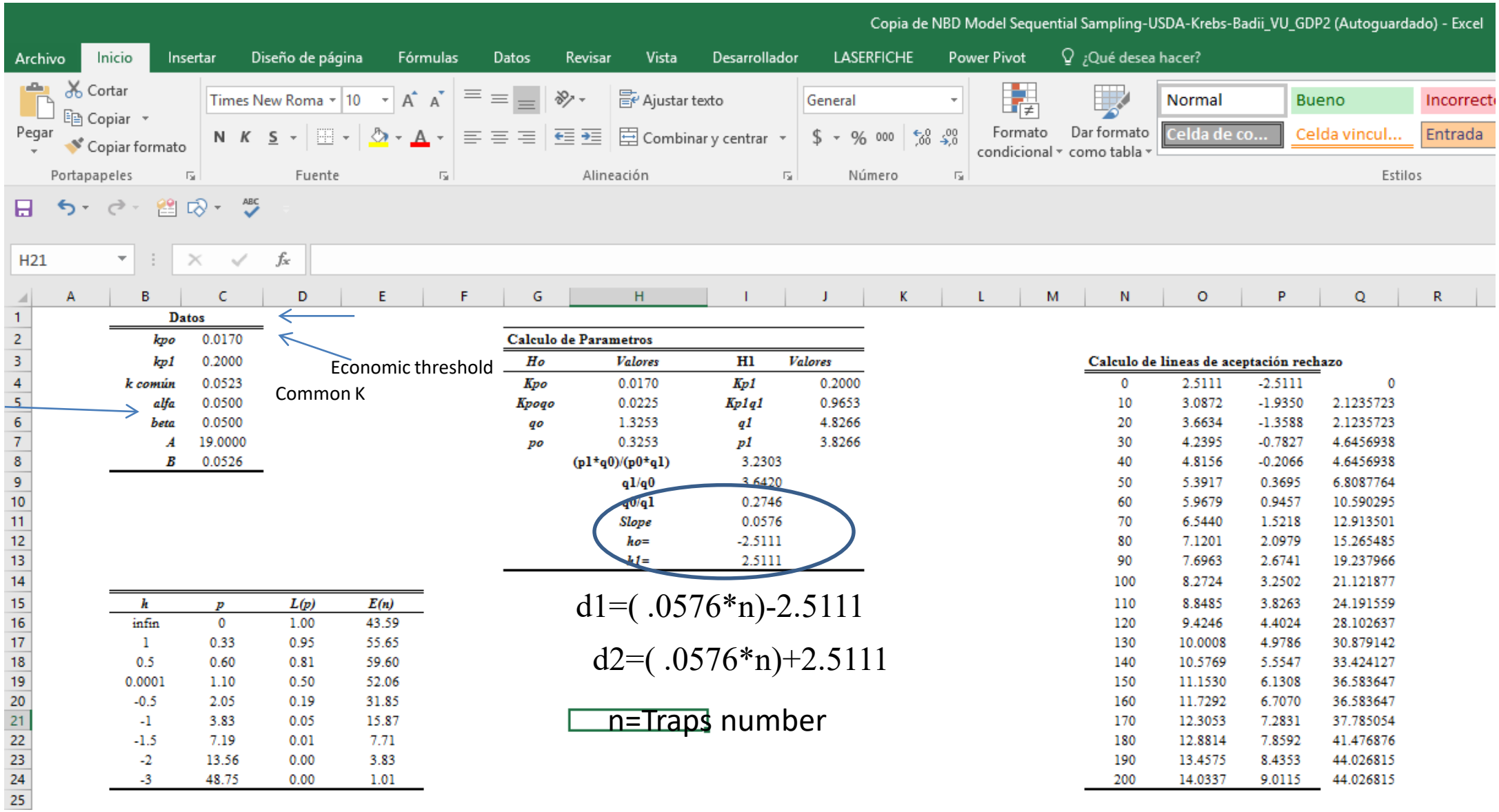
According to Taylor Power Law: If slope β>1 the dispersion pattern is aggregated

Evaluating the possibility of using a common k (kc)

According to Bliss y Owen (1950)

Parameter	Week 5-14	week 25-49
kc	**0.07676573**	**0.05226572**
kc inf	0.06699	0.04947
kc_sup	0.0849	0.05539
F_Slope (1/k)	5.209 **	18.43**
F_Intercept	0.00085 NS	2.5382 NS

F_cal= To justify the use of a common k the value of F of slope 1/k must be significant and that the intercept should be no significative)



Datos	
kpo	0.0170
kp1	0.2000
k común	0.0523
alfa	0.0500
beta	0.0500
A	19.0000
B	0.0526

Economic threshold

Common K

Fit the Error probability Type (I,II)

Calculo de Parametros			
Ho	*Valores*	H1	*Valores*
Kpo	0.0170	*Kp1*	0.2000
Kpoqo	0.0225	*Kp1q1*	0.9653
qo	1.3253	*q1*	4.8266
po	0.3253	*p1*	3.8266
	(p1*q0)/(p0*q1)	3.2303	
	q1/q0	3.6420	
	q0/q1	0.2746	
	Slope	0.0576	
	ho=	-2.5111	
	h1=	2.5111	

h	*p*	*L(p)*	*E(n)*
infin	0	1.00	43.59
1	0.33	0.95	55.65
0.5	0.60	0.81	59.60
0.0001	1.10	0.50	52.06
-0.5	2.05	0.19	31.85
-1	3.83	0.05	15.87
-1.5	7.19	0.01	7.71
-2	13.56	0.00	3.83
-3	48.75	0.00	1.01

$$d1=(.0576*n)-2.5111$$

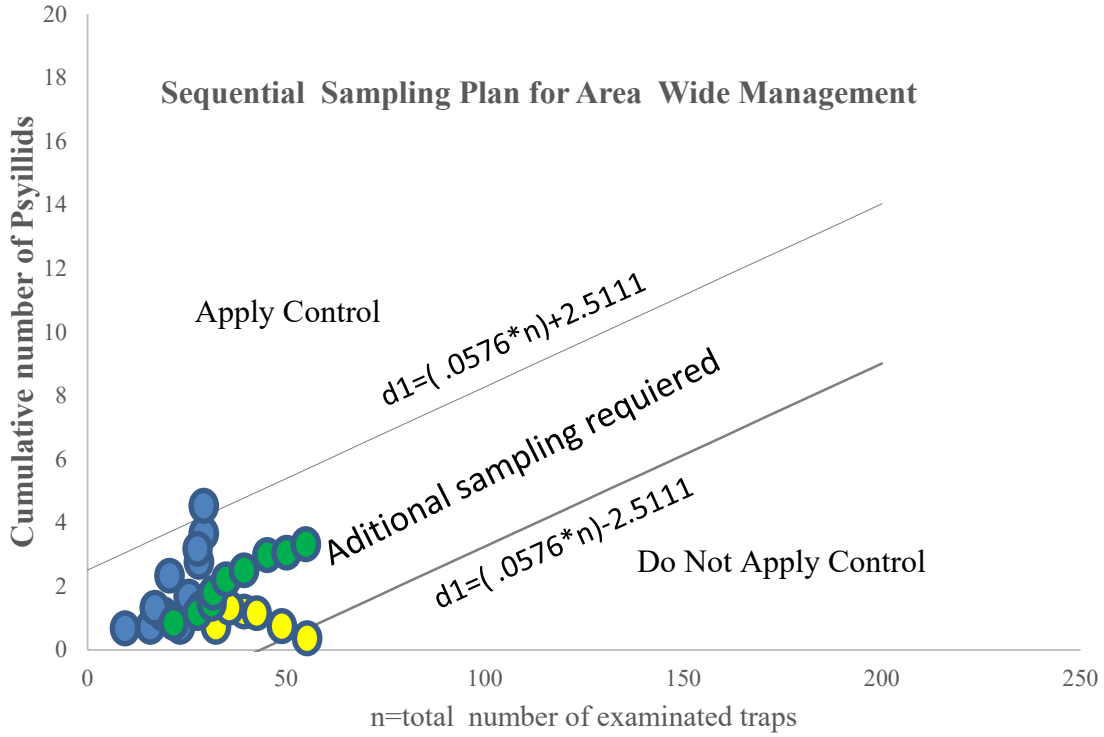
$$d2=(.0576*n)+2.5111$$

n=Traps number

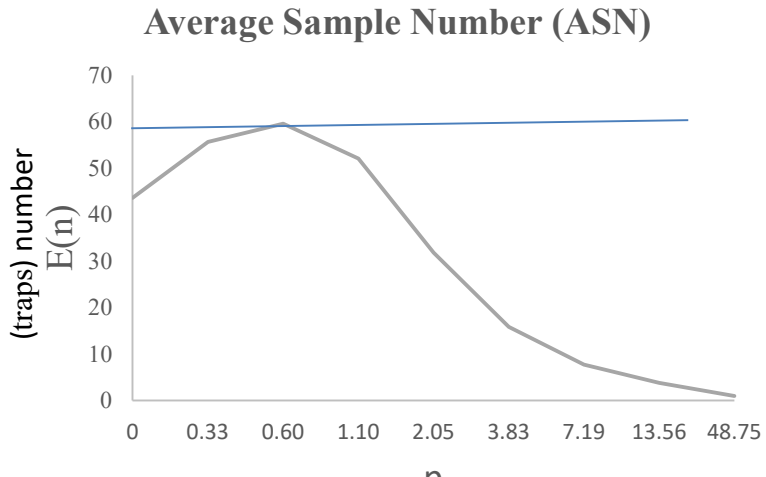
Calculo de lineas de aceptación rechazo			
0	2.5111	-2.5111	0
10	3.0872	-1.9350	2.1235723
20	3.6634	-1.3588	2.1235723
30	4.2395	-0.7827	4.6456938
40	4.8156	-0.2066	4.6456938
50	5.3917	0.3695	6.8087764
60	5.9679	0.9457	10.590295
70	6.5440	1.5218	12.913501
80	7.1201	2.0979	15.265485
90	7.6963	2.6741	19.237966
100	8.2724	3.2502	21.121877
110	8.8485	3.8263	24.191559
120	9.4246	4.4024	28.102637
130	10.0008	4.9786	30.879142
140	10.5769	5.5547	33.424127
150	11.1530	6.1308	36.583647
160	11.7292	6.7070	36.583647
170	12.3053	7.2831	37.785054
180	12.8814	7.8592	41.476876
190	13.4575	8.4353	44.026815
200	14.0337	9.0115	44.026815

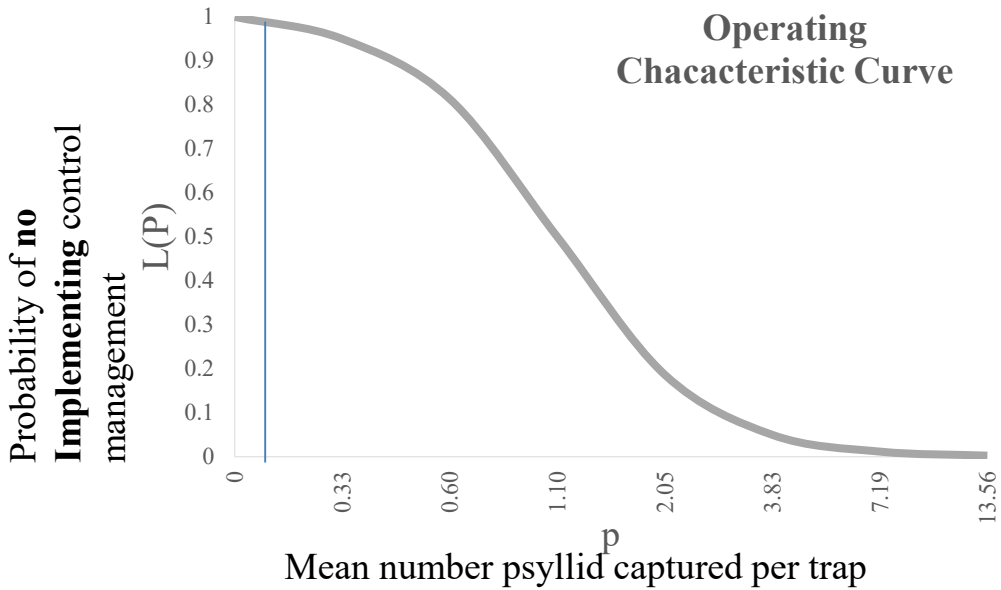
Sequential Sampling Plan for Area Wide Management

(Week 25 to 43)

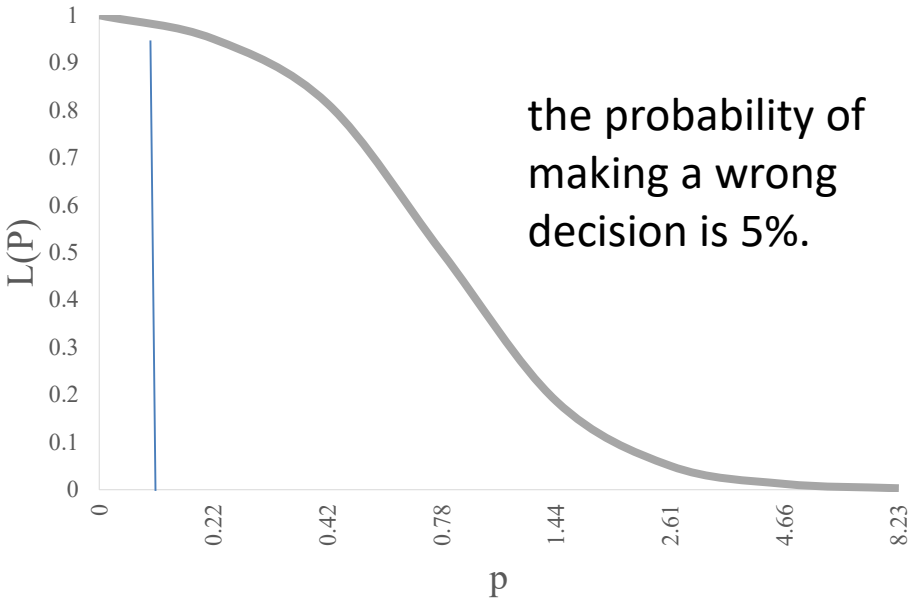


A critical threshold corresponds to find 3 Psyllids in 10 traps





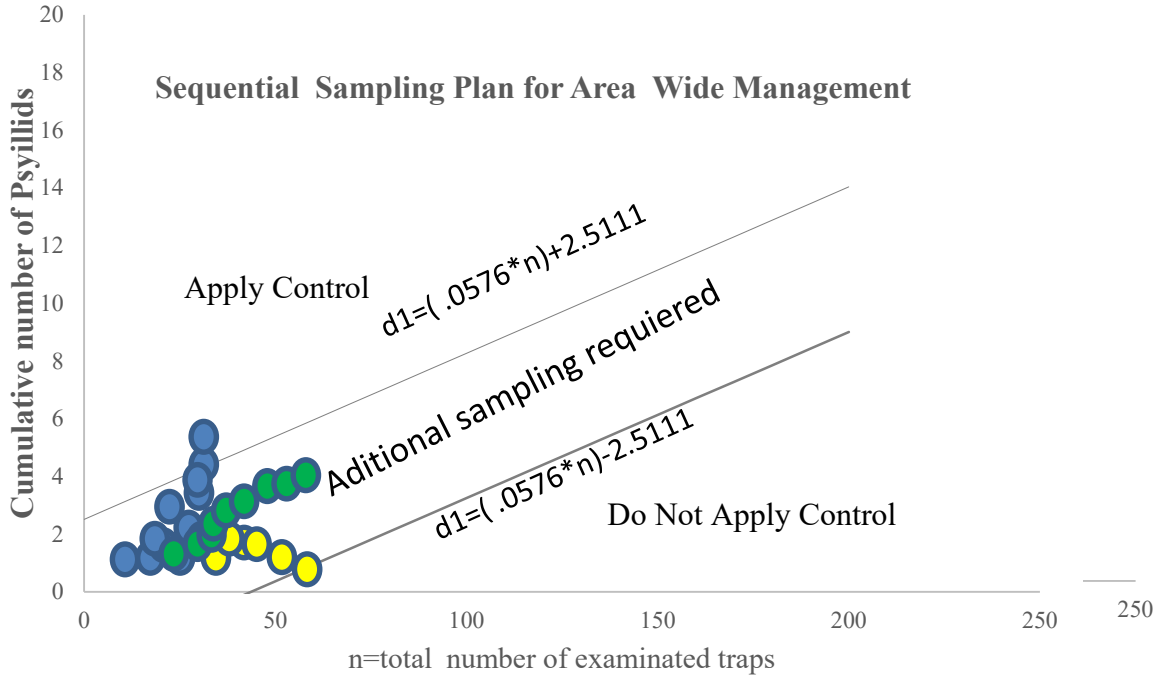
Curva Operativa Caracteristica



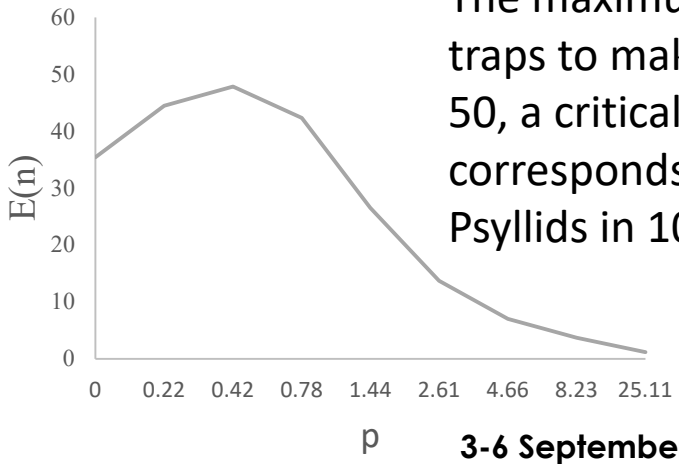
the probability of making a wrong decision is 5%.

Sequential Sampling Plan for Area Wide Management

(Week 5 to 15)

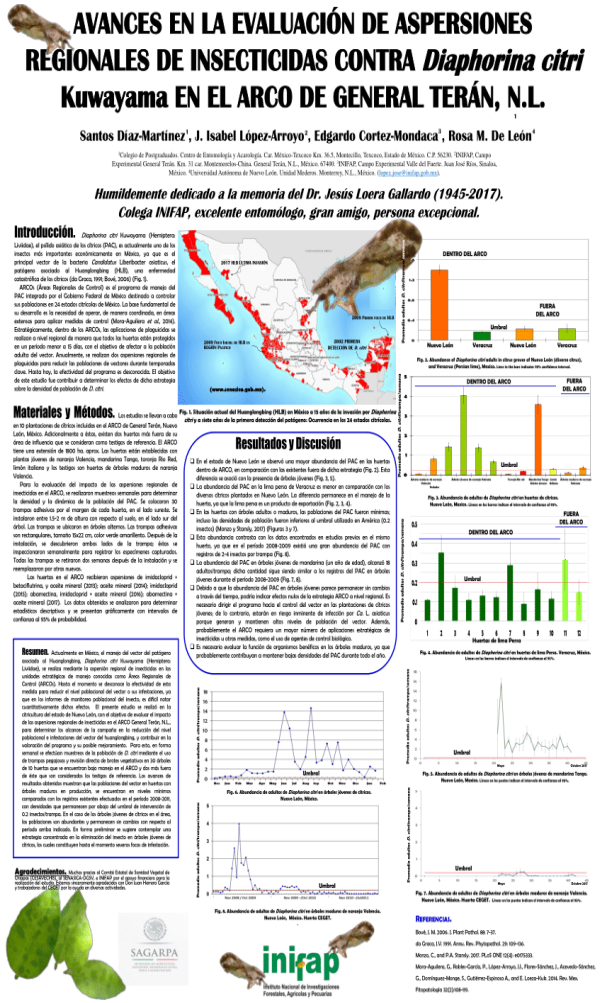


Curva número de muestreo promedio



The maximum number of traps to make a decision is 50, a critical threshold corresponds to find 3 Psyllids in 10 traps

Some advances in results in the Regional Control Areas (ARCO)



AVANCES EN LA EVALUACIÓN DE ASPERSIONES REGIONALES DE INSECTICIDAS CONTRA *Diaphorina citri* Kuwayama EN EL ARCO DE GENERAL TERÁN, N.L.

Santos Díaz-Martínez[1], J. Isabel López-Arroyo[2], Edgardo Cortez-Mondaca[3], Rosa M. De León[1]

Humildemente dedicado a la memoria del Dr. Jesús Loera Gallardo (1945-2017). Colega INIFAP, excelente entomólogo, gran amigo, persona excepcional.

Introducción.

Materiales y Métodos.

Resultados y Discusión

Resumen.

Agradecimientos.

Referencias.

- It has a great effect in reducing the incidence (90%) and rate of progress (75%) of the HLB;
- The incidence starts later and is slower,
- Reduces the population of local psyllids (from 76 to 97%), even in abandoned orchards
- It allows the use of a less intensive program of local vector control.

Mora (2018),Robles(2016), López(2018)

Thank you Engineer, I am convinced about Sequential Sampling, but I have two question for you :

how are we going to get organized for regional control because we are too many?

1) How you're going to convince SENASICA to include their model in the official protocol ?

The big challenge:
How to implement the strategy with small citrus producers (60%)

ARCOS= 500 -1000 ha

The average size of a citrus orchard is 1.5-2 ha

(SENASICA)The National Service for Agri-Food Health, Safety and Quality

Thank you for your attention !!!!!

Dr Gabriel Díaz Padilla
INIFAP
Agrometeorology and Modeling
diaz.gabriel@inifap.gob.mx

Thank you everbody for your attention !!!!!

Dr Gabriel Díaz Padilla
INIFAP
Agrometeorology and Modeling

diaz.gabriel@inifap.gob.mx

I hope you see you at the group dinner !!!