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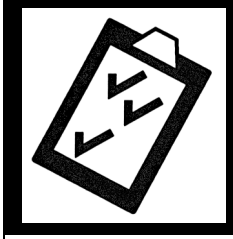

Principles of Scientific Sampling

By Philip Sutton and James VanKirk

Overview

Concept	Activity	Handouts
For sampling to be accurate, we must look at ways of counteracting bias.	#1: The Need to be Unbiased	A. *Sampling Exercise Data Sheet* B. *Explanation of Sampling Principles*
For sampling to be accurate, we must have an adequate sampling size.	#2 The Pitfall of One Sample—and Adequate Sample Size	A. *Sampling Exercise Data Sheet* (from Activity 1.)
	#3 Determining Sample Size	A. *Sampling Exercise Data Sheet* (from Activity 1.) C. *Summary Data Sheet* D. *Sampling Patterns Handout*
Sequential sampling is an efficient way to estimate pest populations… …and producers can base management decisions on it.	#4 How Does Sequential Sampling Work? *and a wrap-up discussion*	E. *Sequential Sampling Data Sheet* You'll also need: ♦ *A filled-out sampling sheet for any pest from your state* ♦ *Your state s scouting calendar* ♦ *A platter, jellybeans, and more... see below*

Resources

IPM Field Corn Pocket Guide: Northeast Region, pp. 26-27; 36-47.

Cornell Field Crop and Soils Handbook, pp.61-63

Penn State Field Crop IPM, pp. 43-45

Related Topics

Module 4: What is a Threshold?
Module 5: Economic Implications of IPM
Module 6: IPM for Alfalfa Weevil
Module 7: IPM for Corn Rootworm
Module 8: IPM for Potato Leafhopper in Alfalfa
Module 9: IPM for Weed Management in Row Crops

Here s what you ll do:

Beforehand:

- gather up jelly beans in exactly two colors (one being black); a plate; a coffee can (or pot) and two colors of cooking beans (should be the same size—you'll need about 1 cup of one color, 3 cups of the other* but don't mix up ahead of time!); a couple other miscellaneous items—a paper clip, a button, that sort of thing.

Today, on site:

- discuss why unbiased sampling is essential;
- demonstrate the pitfalls of one-sample management;
- show the need for adequate sample size;
- learn the process behind sequential sampling.

*For an optional exercise in Activity #4, bring four cups of the second colored bean.

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Principles of Scientific Sampling

ACTIVITY #1: The Need to be Unbiased

Setting	Time Required	Materials	Handouts
Inside, when field work isn t important	*5 minutes*	*A dinner plate and some jelly beans:* *10 black* *10 red* *transparencies*	*A.* Sampling Exercise Data Sheet *B.* Explanation of Sampling Principles

Q:	Pose a series of questions:	A:
Beforehand: arrange the 20 jelly beans on a plate. Hand out the Sampling Exercise Data Sheet*. (You ll also use this sheet for Activities 2 and 3.)*		
Show everyone the plate of jelly beans. What is the ratio of black beans to red? *Offer one to each participant until 10 are taken.*		*If participants would like, they may record results in the* Sampling Exercise Data Sheet*, (part 1).* *Answers to this set of questions will vary according to the group. But it s highly unlikely you ll get as many people choosing black jelly beans as red ones.*
Show the plate again. What's left on the plate? Does this reflect the original ratio?		
What influenced your preference? (color? Flavor?) Did bias enter the sample? How?		
Pretend we didn't know the original ratio. How could these results affect our guess about what the original ratio was?		We might think that this ratio reflects the original ratio.
How does this relate to farming? Can we be biased when we don't want to be?		♦ No one wants a poor crop, so we sample the heavy spots. ♦ We may focus on plants that are damaged.
How does unbiased, representative, efficient sampling help us?		*Distribute copies of* Explanation of Sampling Principles *and discuss.*
What can we do to avoid bias?		♦ Zigzag through the field while we collect samples. ♦ Avoid the borders, where plants grow less well and thickly *(unless the pest—spider mites and certain weeds—need to be sampled at the borders).* ♦ Follow procedures designed to make our sample random. These vary from crop to crop and are part of the "IPM Recommends / Guidelines" for each state.

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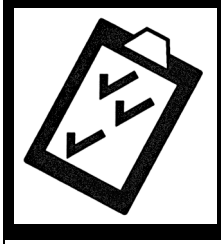

Principles of Scientific Sampling:

ACTIVITY #2: The Pitfall of One Sample and Adequate Sample Size

Setting	Time Required	Materials	Handouts
Inside, when field work isn t important *Group size: At least 10*	*5 minutes*	*1 c. red beans** *3 c. white beans** *Large coffee can or cook pot*	*A.* Sampling Exercise Data Sheet

Q:	Pose a series of questions:	A:
Beforehand: Fill can or kettle with mixture of 1 c. red beans, 3 c. white beans. Stir them thoroughly so that all are randomly distributed. *Tell group that the red beans represent pest-damaged plants and the white beans represent healthy plants.* *Have someone pick a bean from the can without looking.*		
What color bean is it?		*Everyone records the sample on the* Sampling Exercise Data Sheet, part (2).
Based on the sample, what sort of damage do you have in the field?		*Determine field health or damage **according to** the sample.*
Are we ready yet to make a decision on whether or not to spray? Why?		No! We have no idea how the rest of the field is doing.
Have you ever known anyone to base a management decision on a "sample of one?" What would be some examples?		A farmer who has one bad experience with a pesticide failure may decide never to use that product again, even when statistics show that it's the best one to use. Farming decisions that are based on a past drought year or a bumper-crop year also show the pitfall of one sample.
Mini-lecture: Just as it doesn t necessarily make sense to decide to spray because you ve noticed a few pests, it also doesn t make sense to abandon time- (and research-) tested management strategies because of a single experience.		

*Throughout the exercise we refer to "red" beans and "white" beans… but if you can't locate red beans, substitute black or pinto beans.

A:	***Continue with the questions***	***B:***
Ask for a volunteer to separate the beans and count all the pests, then report to you when finished say, tomorrow or next week. Indicate that you need accuracy to + or — 5%. ***This should elicit some protest!***		
Is counting every single pest the most accurate way to determine crop damage and pest populations?	Well… sure, IF you could do it.	
Is counting every single pest any more practical than the using just one sample?	Certainly not. Who has the time, or can afford to pay someone else to do it?	
So… what great truth can we derive from all this?	We need to balance sample size and frequency between too few samples (inadequate information) and too many samples (too costly to gather).	

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Principles of Scientific Sampling:

ACTIVITY #3: Determining Sample Size

Setting	Time Required	Materials	Handouts
Inside, when field work isn t important *Group size: At least 10*	*20 minutes*	*The pot full of beans from the previous activity* *Calculators A button, paper clip, or other small object*	*A.* Sampling Exercise Data Sheet *C.* Summary Data Sheet *D.* Sampling Patterns Handout

Q:	Pose a series of questions:	A:

Show the pot of beans and tell everyone that you happen to know that the percentage of so-called damaged plants to undamaged plants in the can: 25% are damaged, 75% are undamaged.

Divide the group into three teams.

Hand out the Sampling Exercise Data Sheets.

Have each group fill out its own data sheet.

- *As before, the red beans represent damaged plants and the white beans represent undamaged plants*
- *Walk around the room, asking someone from each group to remove 10 beans without looking in the can.*
- *Each group records the number of damaged plants represented by each of these samples.*
- *Repeat until each group has filled in a data sheet. But interrupt the process once and*

Ask one group to lose its sample. This represents your sample flying off before you have a chance to secure it.

What should happen next?	Why, take another sample!

Drop the button or paperclip into another person s sample. This represents the unexpected while sampling in this case, a plant damaged by a different, unanticipated pest.

Should we worry? Is there a pattern? Are there very many?	Discuss what to do if there is legitimate reason for concern. ♦ Send pest to diagnostic lab for ID. ♦ Call your extension agent for information and scouting forms.

And back to the data sheets

Now that everyone has recorded all the samples

- *add up the running totals (3rd row);*
- *calculate the percentage of damaged plants after each sample (5th row);*
- *calculate the degree of accuracy of our ratios (6th row).*

Q:	Continued	A:
How do we calculate the percentage (ratio) and its accuracy? ♦ *Divide the running total of damaged plants by the running total of plants sampled.* ♦ *Calculate the degree of accuracy of our ratios.* Here's an example: ♦ *A sample indicates that 40% of plants are damaged (4th row).* ♦ *But we know that damaged plants comprise 25% of the sample.* ♦ *Subtract 25 from 40. (40 minus 25=15) The degree of accuracy is plus or minus 15%. We express it as +/- 15%.* *We want an accuracy level of +/- 5%. Calculate the degree of accuracy for each set.* *As groups calculate their degree of accuracy, record their figures in your* Summary Data Sheet *on the overhead projector, or tape their sheets on the wall and have everyone gather around to compare.*		
Did anyone get our desired degree of accuracy the very first time? If so, and this were really a pest, would you be comfortable taking just that first sample?		*It s possible that at least one group did. Mini-lecture: Samples fall on the true mean only by chance. We can never know for sure when this will occur. Scientists rely on statistics and experimental controls for acceptable accuracy levels.* No.
As you continued to sample, were you more and more likely to hover around the +/- 5% accuracy ratio?		Yes.
What else do you gain from taking an increasing number of samples?		Confidence and accuracy. You know what you have to deal with, so you can be confident that you're making the right call.
What do you lose from taking an increasing number of samples?		Time. Fill out a hundred of these charts and see how you feel afterward.
This is all fine and good for beans, but what if this were the real thing? Would we always have such a random distribution of pests?		No. Some pests are clumped, some are uniform, some are random, some are at field margins; pests may move through the field in different patterns. *Have people give examples from their experiences with weeds, insects, and diseases even animals, such as deer.*
Does this variability make us confident in the accuracy of sampling procedures?		*Discuss.* *Remind participants that researchers base their conclusions on a thorough understanding of each pest s life cycle and compile their data on samples from hundreds of fields.*
Hand out the Sampling Patterns Handout *discuss.*		

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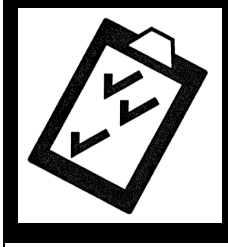


Principles of Scientific Sampling

ACTIVITY #4: How Does Sequential Sampling Work?

and a wrap-up discussion

Setting	Time Required	Materials	Handouts
Inside, when field work isn t important *Group size: At least 10*	*20 minutes*	*The can of beans from the previous activity* *For an optional activity, have another cup of white beans ready to stir in.*	*E.* Sequential Sampling Data Sheet A filled-out sampling sheet for any pest from your state Your state s scouting calendar

Q:	Pose a series of questions:	A:

Pass out the Sequential Sampling Data Sheet.

This time, the red beans represent damaged plants and the white beans represent undamaged plants.

Let s say we re in Farmer A s field. Once again, ask each person (or group) to

- *remove 10 beans without looking in the can;*
- *record the number of damaged plants represented by each of these samples on the* Sequential Sampling Data Sheet*;*
- *keep running totals, and calculate the percentage of damaged plants in Farmer A s field after each sample.*

Discuss the Data Sheet:

What do results in the "Don't Treat") column mean? (Some charts show this as NT, or No Treatment.)	When all running totals are consistently in the "Don't Treat" column, you can quickly decide that the pests will not pose a problem for your crops… …with this caveat: you may need to sample to be certain that pests will not get out of hand.
What about results that fall between the two?	When running totals consistently fall between the "Don't Treat" column and the "Treat" column, you need to take a number of samples before you can tell that the pests will not pose a problem for your crops. …with this caveat: you WILL need to sample again to be certain that pests will not get out of hand.
What do results in the "T" ("Treat") column mean?	When running totals fall *EVEN ONCE* in the "Treat" column, stop sampling. You've determined that your crops are under threat and it's time to do something. That "something" may involve sprays, early harvest, or parasite release, depending on the situation.

Q:	Continue the questions and discussion	A:
According to your results, do you need to consider a treatment plan? Why or why not?		
OPTIONAL: Stir one more cup of white beans into the mix. You are in a different field. Do the 10-bean thing again, with running totals the works *And discuss, again is it time to consider a treatment plan?*		
Do sequential sampling schemes vary according to the pest you're sampling for?	Yes. Naturally, pests vary in destructiveness depending on species. Sampling schemes that work for one pest won't work for another.	
Now for some final discussion points *Hand out a filled-in sample of a scouting form from your state. Ask people what they would do with it. Then discuss*		
What important information is (probably) missing from this form, and why?	It doesn't tell when you should start sampling… how often to sample… when to quit sampling. When and how often may vary from year to year, depending on conditions. Call your extension agent for information.	
What do we need to know in order to develop a sampling protocol for a pest?	♦ What time of year it's active; ♦ How mobile it is; ♦ How quickly it develops to a damaging stage; ♦ How many generations it goes through in a year; *In other words, we need to know the life cycle and biology of the pest in order to know when to scout and when to quit. Other knowledge also plays a part, such as* ♦ Crop stage… weather…etc.	
How are pest populations affected by crop stage or weather?	*Discuss as examples, people may suggest potato leafhopper, alfalfa weevil, corn rootworm, etc.*	
What sorts of pests have we left out of this discussion? What would we need to know about them?	Weeds and diseases. Pretty much the same things we need to know about insects.	
Can we scout for weeds and diseases?	Definitely. Some states don't have sampling sheets for them yet. BUT every time you're out scouting, you should be observing the crop.	
When should you be on the lookout for weeds and diseases?	It depends, of course, on the life cycle and crop interaction. For weeds, monitor them early… look for escapes in mid-summer… look again late in the season to consider management options for next year. Diseases may coincide with crown development, or with developing canopies… each one has a peak time. (Ask people for examples.)	
Remember that button we dropped into someone's sample? How else can scouting help you?	You'll be on the alert for other, perhaps unforeseen problems, such as nutrient deficiencies. You'll see how the crop is doing, how close it is to harvest, etc.	
Hand out your state s Scouting Calendar *and discuss, then have everyone fill out an evaluation form and remind them about the next class.*		

A. *Sampling Exercise Data Sheet*

Worksheet for Activities 1-3

(1) The Need to Be Unbiased

Number of red jelly beans chosen: _____

Number of black jelly beans chosen: _____

Ratio of sample: _____

Original ratio: _____

(2) The Pitfall of One Sample

Bean Color: _____ (Ratio of red beans to white beans in container is 1 cup to 3 cups, or 25:75)

(3) Adequate Sample Size

Sample set	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***
Number of damaged plants (red beans)										
Running total of damaged plants (red beans)										
Running total of sampled plants (all beans)	*10*	*20*	*30*	*40*	*50*	*60*	*70*	*80*	*90*	*100*
% of damaged plants = Running total damaged / Running total all beans										
Degree of accuracy of ratio (=/-)										

How to calculate degree of accuracy (example):

- *Assume that a sample from the 4th row indicates that 40% of plants are damaged.*
- *But we know that damaged plants comprise 25% of the sample.*
- *Subtract 25 from 40. Your result? 15. Thus*
- *The degree of accuracy is plus or minus 15%. We express it as +/- 15%.*

We want an accuracy level of +/- 5%. Calculate the degree of accuracy for each set.

B. *Explanation of sampling principles*

Handout for Activity 1

Knowing how many pests are in your fields helps you determine their damage potential. But who has the time or money to count them all—if even you could? A smaller portion of the population—an estimate, or *sample*—will efficiently indicate population size.

If you farm five fields of one crop, you'll need to scout each one because each field is different. Can you afford to spend at a large amount of time in each field? Probably not! To save time, you need to know the smallest sample size and number that will adequately describe the pest population. And while you're out sampling pests, you can keep tabs on beneficial insects too.

A certain minimum number of samples will provide accuracy while limiting your time in the field. But is it 10 samples, 20, 30, or more? Research scientists have experimentally determined the best answer for each type of pest.

Sequential sampling

This labor-saving sampling method* puts pests into two basic categories depending on their population density. On the average, the sequential method requires fewer samples than conventional sampling schemes.

If populations are high, a few samples will tell you that it's time to act. If populations are low, you can quickly decide that you have little cause for concern.

On the other hand, at intermediate levels you may need to take a number of samples to make a confident decision. With certain pests, you may need to come several weeks in a row after a "don't treat" diagnosis and sample again.

**Sequential sampling methods have not been developed for every pest, or your state mayprefer a different method. For any given pest, use the sampling method that your state s Cooperative Extension Service stands behind.*

C. *Summary Data Sheet*

Worksheet for Activity 3
You may use this for an overhead

As groups calculate their degree of accuracy, record their figures here.

Group 1

Degree of accuracy of ratio (=/-)	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**

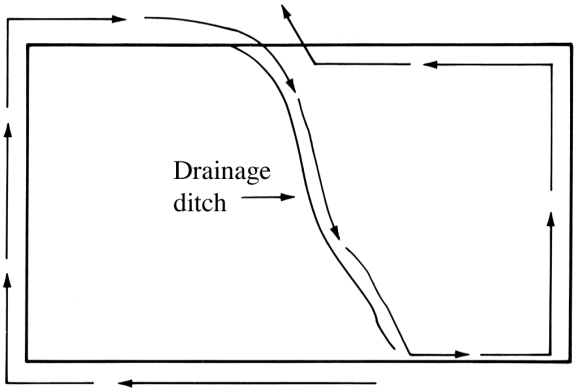
Group 2

Degree of accuracy of ratio (=/-)	10	20	30	40	50	60	70	80	90	100

Group 3

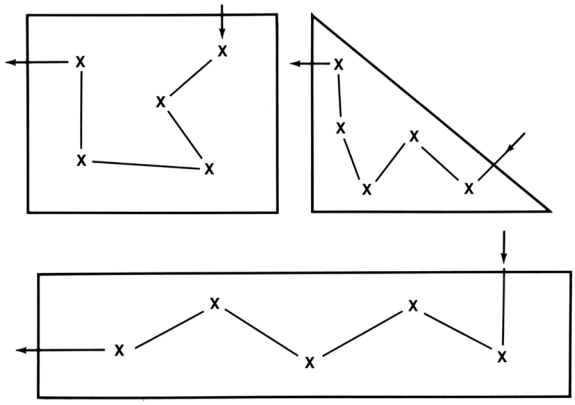
Degree of accuracy of ratio (=/-)	10	20	30	40	50	60	70	80	90	100

Figure 1.



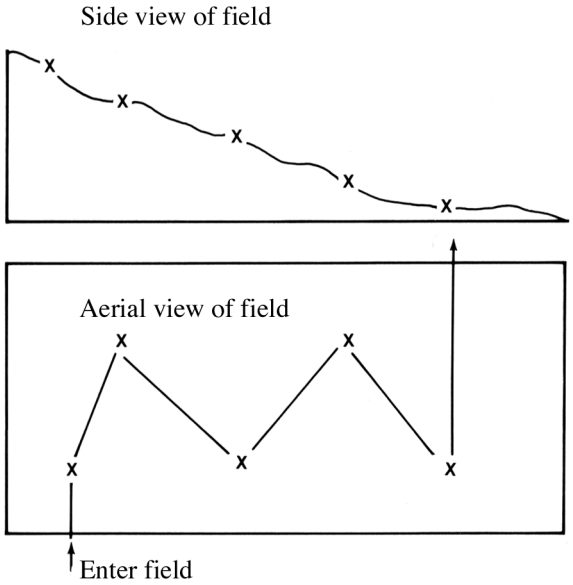
Sampling pattern for pests expected to be concentrated along field margins or ditches.

Figure 2.



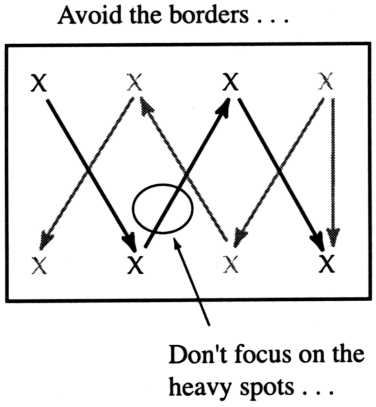
Sampling pattern for pests expected to have uniform distribution in the field.
X = sample area.

Figure 3.



Sampling pattern for pests expected to be concentrated in areas of the field with unique characteristics.

Figure 4.



Illustrations 1 - 3 courtesy of *Cornell Field Crops and Soils Handbook*

E. *Sequential Sampling Data Sheet*

Worksheet for Activity 4
You may cut this worksheet in half

Sample number	***# per sample***	***Running total (RT)***	***Don t treat*** *(resample in 7 days)*		***Treat***
1				Is your running total in between? Keep sampling	
2					
3			6		8
4			9		11
5			12		14
6			15		17
7			18		20
8			21		23
9			24		25
10			27		28
11			29		30
12			31		33
13			34		35
14			36		38
15			39		40

Sequential Sampling Data Sheet

Sample number	***# per sample***	***Running total (RT)***	***Don t treat*** *(resample in 7 days)*		***Treat***
1				Is your running total in between? Keep sampling	
2					
3					11
4					12
5					13
6					14
7					15
8					16
9					17
10			1		18
11			2		19
12			4		20
13			5		21
14			7		22
15			8		23

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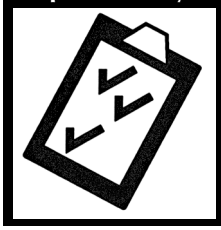

Module Feedback

Principles of Scientific Sampling

Modify this according to your needs.

Tell us a little about yourself:

I m a	*My commodity area is:*
♦ Farmer _____	♦ Dairy and field crops _____
♦ Crop advisor _____	♦ Vegetables _____
♦ Industry rep _____	♦ Fruits and berries _____
♦ Extension educator _____	♦ Greenhouse and nursery stock _____
♦ Other _____	♦ Other _____

Let us know what you think:

What part of the workshop was most interesting for you?
What part of the workshop was most valuable to you?
What two new ideas would you like to try on your farm or in your business?
Do you feel you understand IPM—and how to use it—better now?
What other information should be included in this module?
What other topics would you like us to cover in future modules?

Teachers, please fill out an evaluation as well. Photocopy and send all informative evaluations to:

NE-IPM Modules, NYS IPM Program, Box 28 Kennedy Hall, Cornell University, Ithaca NY 14853