SAMPLING COTTON AND OTHER FIELD CROPS FOR INSECTS

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Sampling Cotton and Other Field Crops for Insects

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The increased emphasis on environmental protection and higher prices for insecticide application require more precise decisions about insect control. It is no longer an economical nor an environmentally "sound" practice to treat for insect protection when a few insects are detected.

It is becoming increasingly necessary to establish more precise economic thresholds and to develop techniques for determining when these thresholds are reached.

In Oklahoma, the impact of insect damage on the production of field crops is moderate to severe; the yearly average for all crops is over 43 million dollars per year.

The present work is designed to facilitate sampling by researchers, pest management personnel and others interested in efficient sampling. Most of the techniques used were developed during cotton insect research in southwestern Oklahoma.

How Are Insects Distributed

Most insects in field corps have distributions that fit the negative binomial (Southwood 1966) (Pieters and Sterling 1974) (Harcourt 1960). This means that they are clumped. The clumping may be in the form of large aggregates in one part of the field, or the clumping may simply be small uneven groupings throughout the field, or both.

Clumping increases make sampling difficult because of greater variation between samples. The most extreme clumping produces the most severe variation.

The degree of clumping is generally expressed by the exponent $\underline{k}$ (Rojas 1964). A simple method of calculating the amount of clumping or $\underline{k}$ is

$$\underline{k} = \frac{\bar{x}^2}{s^2 - \bar{x}}$$

where $\bar{x}$ = mean, s^2 = sample variance.

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This method of calculating k is only valid for a mean up to 10. For a more accurate method of developing k see Southwood (1966). Variance or s^2 necessary for this calculation is determined by

$$s^2 = \frac{\Sigma x^2 - \frac{(x)^2}{n}}{n - 1}$$

where x = each sample mean
n = number of samples taken

Most k values for cotton insects in Oklahoma are between 2 and 5 (Hill et al 1975). When the k is small the clumping is severe. Large k values (above 10) means the clumping is minor. When k reaches infinity a Poisson distribution is indicated. The Poisson distribution is a random distribution where the variance s^2 is equal to the mean $\bar{x}$. In the negative binomial distribution the variance is greater than the mean. When the k reaches 0 a logarithm distribution is obtained.

How Many Samples Are Enough

This is a constantly recurring question in insect sampling and has no specific answer. Often the answer is either "take all the samples you have time for" or "take samples until one more sample would not change the mean". Each sampler must decide for himself how accurate he wants to be, how inaccurate he can afford to be and how much time he can devote to sampling.

There are numerous sampling techniques. The Arkansas point sampling is used in cotton. Pieters and Sterling (1974) have proposed a sequential technique as has Allen et al (1972). All these techniques are useful.

The system we are proposing is one devised by Rojas (1964). In this System

$$N = \frac{\frac{1}{k} + \frac{1}{\bar{x}}}{D^2}$$

where N = number of samples needed
D = the desire precision expressed in percent of the standard error of the mean.

This system is sensitive to both the mean and k or clumping. These are the two parameters of the negative binominal distribution. All the tables (1 through 5) in this publication are based on this technique.

The precision of the sampling is dependent on D; that is, the smaller D is the more precise the sampling. Rojas (1964) recommends that for insect control samples D be set at 30 percent (0.30). Southwood (1966) recommends that D be 25 percent (0.25) for insect control sampling and 10 percent (0.10) for ecological investigations. We have chosen 25 percent for insect control work because this level of precision is sensitive to a doubling of the population and anything less would be no more accurate than random "shagging" of a few squares or plants.

A cotton field was sampled for collops beetles using this technique. Five samples of 2.5 feet each are taken at random in the field and is calculated as follows.

Samples	Squares
1	1
6	36
2	4
7	49
4	16
20 Total	106 = sum of squares

$$\bar{x} = \frac{20}{5} = 4$$

Solve for s^2

$$s^2 = \frac{\Sigma x^2 - \frac{(x)^2}{N}}{N - 1} = \frac{106 - \frac{(20)^2}{5}}{4} = 6.5 \qquad s^2 = 6.5$$

Then solve for k

$$\underline{k} = \frac{\bar{x}^2}{s^2 - \bar{x}} = \frac{4^2}{6.5 - 4} = 6.4$$

Then solve for N with D = .25

$$N = \frac{\frac{1}{k} + \frac{1}{\bar{x}}}{D^2} = \frac{\frac{1}{6.4} + \frac{1}{4}}{0.0625\ (D = .25)} = 6.5$$

or solve for N with D = .10

$$N = \frac{\frac{1}{k} + \frac{1}{\bar{x}}}{D^2} = \frac{\frac{1}{6.4} + \frac{1}{4}}{0.01\ (D = .10)} = 40$$

As can be seen, five samples are not enough to stay within 25 percent of the standard error of the mean. Two more samples are required. Forty samples (or 35 more) are needed to stay within 10 percent of the standard error of the means. (Table 2).

One of the criticisms of this method is that the k value will change. It is true that k values change if the sampling size changes and will often change even when the same sampling size is kept if the sampling is inadequate. However, counts of all insects on every plant of cotton on 11 one-fourth acre plots in southwestern Oklahoma by Hill et al. (1975) have showed that k values are fairly constant for a given sample size. The k values may vary at the beginning of sampling but will gradually become constant as sampling increases.

Table 1 Insect Control Samples[1]

	Mean									
Samples	1	2	3	4	5	6	7	8	9	10
5	–	–	–	100	156	225	306	400	506	625
6	–	–	71	126	197	284	386	504	638	788
7	–	–	87	154	241	347	472	616	780	963
8	–	–	104	184	288	414	564	736	932	1150
9	–	54	122	216	338	486	662	864	1094	1350
10	–	63	141	250	391	563	766	1000	1266	1563
11	–	72	161	286	447	644	876	1144	1448	1788
12	–	81	182	324	506	729	992	1296	1640	2025
13	–	91	205	364	569	819	1115	1456	1843	2275
14	–	102	228	406	634	914	1243	1624	2055	2538
15	–	113	253	450	703	1013	1378	1800	2278	2813
16	–	124	279	496	775	1116	1519	1984	2511	3100
17	34	136	306	544	850	1224	1666	2176	2754	3400
18	37	149	334	594	928	1337	1819	2376	3007	3713
19	40	162	363	646	1009	1454	1978	2584	3270	4038
20	44	175	394	700	1094	1575	2144	2800	3544	4375
21	47	189	425	756	1181	1701	2315	3024	3827	4725
22	50	204	458	814	1272	1832	2493	3256	4121	5089
23	54	219	492	874	1366	1967	2677	3496	4425	5463
24	59	234	527	936	1463	2106	2867	3744	4739	5850
25	63	250	563	1000	1563	2250	3063	4000	5063	6250
26	67	267	600	1066	1666	2399	3265	4264	5397	6663
27	71	284	638	1134	1772	2552	3473	4536	–	–
28	75	301	677	1204	1881	2709	–	–	–	–
29	80	319	718	1276	1994	–	–	–	–	–
30	84	338	759	1350	–	–	–	–	–	–
31	89	357	803	–	–	–	–	–	–	–
32	94	376	–	–	–	–	–	–	–	–

[1]Maximum sums of squares for samples using D at 25%. Take at least 5 samples, calculate the mean and the sum of squares. If the total is no greater than that listed sampling is adequate.

To determine the accuracy of a sample the following procedure applies

$$\text{If } N = \frac{\frac{1}{k} \quad \frac{1}{x}}{D^2} \qquad \text{then } D = \frac{\frac{1}{k} \quad \frac{1}{x}}{N}$$

Many workers are concerned when the coefficient of variability (C.V.) is high.

$$CV = \frac{s}{x} \times 100$$

When sampling low density highly clumped populations of insects, the CV will always be high as shown by the relationship

$$CV = 100 \times \sqrt{\frac{1}{k} + \frac{1}{x}}$$

(McNew 1974).

How to Use Tables 1 and 2

Tables 1 and 2 are designed for use in insect control work. D is 25 percent. This should be used for research with caution because accuracy is not high.

In these tables the maximum sum of squares has been calculated for each mean and sample number.

Table 2 Insect Control Samples[1]

	MEANS				
Sample No.	**1.10**	**0.25**	**0.35**	**0.50**	**0.75**
22					29
24					33
26					37
28					42
30					47
33				25	56
35				27	62
37				30	68
40				34	77
42				37	
45				42	
50			25	51	
65		20	32		
67		22	42		
70		23	46		
75		26	52		
80		30	58		
85		33	65		
161	18				
165	19				
175	21				
185	23				

[1]Maximum sum of squares for samples using D at 25%. Take at least 22 samples, calculate the mean and the sum of squares. If the sum of squares is no greater than that listed sampling is adequate.

Table 3 Ecological Insect Samples (D = 10%)[1]

	Means									
Sample no.	1	2	3	4	5	6	7	8	9	10
15	–	–	–	–	–	–	838	1094	1385	1710
20	–	–	–	–	–	857	1166	1523	1928	2380
25	–	–	–	–	775	1116	1519	1984	2511	3100
30	–	–	–	619	968	1393	1896	2477	3135	3870
35	–	–	422	750	1173	1688	2298	3002	3799	4690
40	–	–	500	890	1390	2002	2724	3558	4504	5560
45	–	–	583	1037	1620	2333	3175	4147	5249	6480
50	–	–	671	1192	1863	2682	3651	4768	6035	7450
55	–	339	762	1355	2118	3049	4150	5421	6861	8470
60	–	382	859	1526	2355	3434	4675	6106	7727	9540
65	–	426	959	1706	2665	3838	5223	6822	8635	10660
70	–	473	1065	1893	2958	4259	5797	7571	9582	11830
75	–	522	1175	2088	3263	4698	6395	8352	10571	13050
80	–	573	1289	2291	3580	5155	7017	9165	11599	14320
85	–	626	1408	2502	3910	5630	7664	10010	12668	15640
90	–	680	1531	2722	4253	6124	8335	10886	13778	17010
95	–	737	1659	2943	4608	6635	9031	11795	14928	18430
100	–	796	1791	3184	4975	7164	9751	12736	16119	19900
105	214	857	1928	3427	5355	7711	10496	13709	17350	21420
110	230	920	2069	3678	5748	8276	11265	14714	18622	22990
115	240	984	2215	3938	6153	8860	12059	15750	19934	24610
120	263	1051	2365	4205	6570	9461	12877	16819	21287	26280
125	280	1120	2520	4480	7000	10080	13720	17920	21564	28000
130	298	1191	2679	4763	7443	10717	14587	19053	24114	29770
135	316	1264	2843	5022	7898	11372	15479	20218	25588	31590
140	335	1338	3011	5354	8365	12046	16395	21414	27103	33460
145	354	1415	3184	5661	8845	12737	17336	22643	28658	–
150	374	1494	3362	5976	9338	13446	18302	–	–	–
155	394	1575	3543	6299	9843	–	–	–	–	–
160	414	1658	3730	6630	–	–	–	–	–	–
165	436	1742	3920	6970	–	–	–	–	–	–
170	457	1829	4116	–	–	–	–	–	–	–
175	480	1918	4316	–	–	–	–	–	–	–
180	502	2009	4520	–	–	–	–	–	–	–
185	525	2102	–	–	–	–	–	–	–	–
190	549	2234	–	–	–	–	–	–	–	–
195	573	–	–	–	–	–	–	–	–	–
200	598	–	–	–	–	–	–	–	–	–

[1]The sum of squares should not be higher than that indicated for the mean and sample number.

Take at least 5 samples; calculate the mean or average, square each number (multiply each number times itself), and add up the squares (the sum of squares). If the sum of squares for the mean and sample number is greater than that listed, additional samples must be taken. Take samples until the sum of squares is equal to or less than that listed for the mean and sample number. This is considered minimum sampling for insect control surveys. Sampling at less than this precision is not recommended. Table 1 is for means 1-10. Table 2 is for means less than 1.

How to Use Table 3

Table 3 is for researchers and others who need fairly precise sampling. It is the maximum sum of squares for a D of 10 percent. Take a minimum of 15 samples. Calculate the mean and the sum of squares. If the sum of squares for your sample number and mean is at or below the sum of squares indicated then sampling is adequate. If the sum of squares is greater than that indicated for the sample number and mean then additional samples must be taken. Take samples until the SS is at or below that indicated for the sample number and mean.

How to Use Tables 4 and 5

Tables 4 and 5 are to be used if the k values are known. The k values are often constant for an insect and sampling size in a given area.

If the k value is known, calculate the mean; the point where the k and the mean intercept is the number of samples needed. For example, in Table 4 at a mean of 4 and a k of 1 you need 125 samples.

Table 4 is for research sampling and Table 5 is for insect control surveys.

If a 2.6 feet row of sample is used a k of 5 can be used with reason-

Table 4 Samples when k is known and D is 10%

			k		
Mean	**1**	**2**	**3**	**4**	**5**
0.5	300	250	233	225	220
1	200	150	133	125	120
2	150	100	83	75	70
3	133	83	67	58	53
4	125	75	58	50	45
5	120	70	53	45	40
6	117	67	50	42	37
7	114	64	48	39	34
8	113	63	46	38	33
9	111	61	44	36	31
10	110	60	43	35	30

able accuracy for hooded beetles, fleahoppers and collops in southwestern Oklahoma. A k of 3 should be used for lady beetles.

Table 5 Samples when k is known and D is 25%

			k		
Mean	**1**	**2**	**3**	**4**	**5**
0.5	48	40	37	36	35
1	32	24	21	20	19
2	24	16	13	12	11
3	21	13	11	9	9
4	20	12	9	8	7
5	19	11	9	7	6
6	19	11	8	7	6
7	18	10	8	6	5
8	18	10	7	6	5
9	18	10	7	6	5
10	18	10	7	6	5

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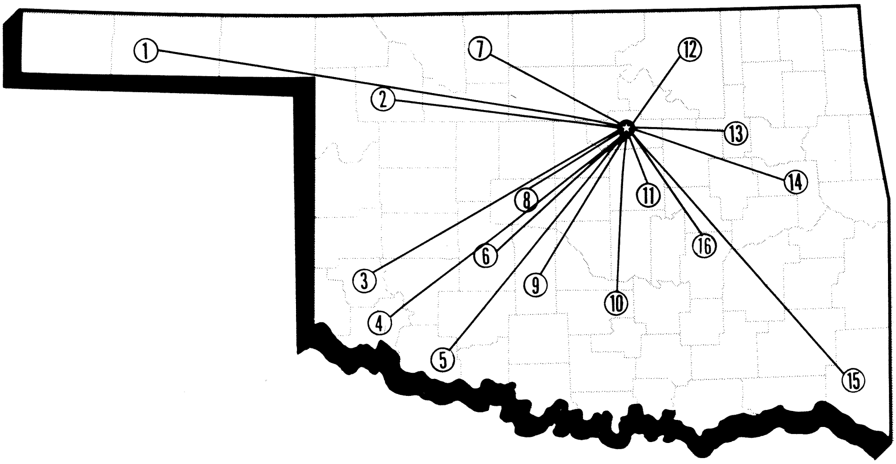

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