STATISTICS AND COMPUTER APPLICATIONS IN PEST CONTROL[1]

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1. Introduction

Statisticians who venture into the applied fields of biological and social sciences often end up not only statisticians but also as "computer experts" in addition to being "scientists". Whether we like it or not, we have to live up to this expectation. With today's rapid computerization, we expect our roles to be even more complicated.

The proliferation of microcomputers and statistical packages in the different research and educational institutions will revolutionize pest control in the 80's through rapid data processing as well as information storage and retrieval. These developments will challenge researchers to do more complex experiments and even systems analysis in addition to the usual comparative type of field experiments. Pest data bases will be useful to researchers, extension workers, administrators, and those who need up-to-date information for pest control decision-making.

2. Statistical Application

Crop protection as applied biology has become increasingly quantitative in recent years. With the shift from a single control method like chemical control to Integrated Pest Control (IPC), there is a more pressing need to know more about the agro-ecosystem of which the pest being controlled is but a tiny component of the system.

FAO defines IPC as "a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains its pest populations at levels below those causing economic injury". The possible role of statistics in the development of IPC can be gleaned from the above definition. First, there is the relation between the environment and the pest population dynamics. Statistically, this is a regression type of a problem but more is needed than straightforward regression analysis. Second, there is a need to periodically test if the current population is below economic injury level. Third, is to find the right combination of treatment by experimental methods.

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Torii (1967) defines some statistical methods in rice stemborer research which should also apply to other pests. The statistical studies may be divided into three main classes; first, the so-called statistical methods of occurence prediction,; second, distribution patterns of larvae, egg masses and field infestation; and third, prediction of damange and the assessment of yield losses based on extension sample surveys.

It is interesting to note that many statistical problems of IPC involve estimation and prediction. The applications of experimental designs are already well known. It is worth mentioning that pest control recommendations involving pesticides, resistant varieties, cultural and biological control agents are products of several laboratory and field experiments. This paper will attempt to cover other methods that are potentially useful to IPC.

3. Regression Analysis

One application of regression analysis is the description of a yield loss-pest relationship. In its simplest functional form, the relationship can be adequately described by a simple linear equation:

$$y = a + bx$$

where:

y = yield loss (usually expressed in percent)

x = population density (or alternatively, damage index)

a = y - intercept

b = slope of regression line

Usually, a polynomial regression equation with degree 2 or 3 gives better fit to experimental or sampling data. The direct application of these equations would be in the assessment of monetary loss due to pest. The Philippine Crop Insurance Corporation is most interested in this information for adjusting loss claims by insured farmers.

A by-product of this analysis is the derivation of an economic threshold level (ETL) or action threshold. To be profitable, the benefits to be derived from pest control should be greater than or at least equal to the cost of control (Norton 1976), i.e. application starts to become profitable only when

$$\underset{\text{(benefit)}}{pd\theta} = \underset{\text{(Cost)}}{c}$$

where:

- p = price per unit of yield
- d = damage caused per unit of pest attack (regression coefficient in the simple linear regression)
- Θ = untreated level of pest attack
- k = the effectiveness of the treatment in reducing the level of pest attack
- c = cost of treatment

Then, ETL is given by:

$$\Theta^* = \frac{c}{pdk}$$

Since plants can tolerate damage up to a certain level of attack (graphically, this is the x-intercept where positive loss starts to occur), this constant is added to the ETL equation.

Crop protection researchers have a strong tendency to overuse regression analysis for predictive purposes. For instances, they force regression analysis to predict insect numbers from weather data like rainfall and temperature. Unfortunately, insect populations are dynamic, fluctuating at high and low numbers within the same range of weather conditions. A more realistic approach is the use of a series of regression models such that the output of a previous regression equation becomes the input to the second regression equation. Kiritani (1976) and other workers used this approach in building population simulation models. Thus, for example, given temperature, development rates were estimated from regression equations (Saito and Nakayama, 1981) to predict changes in the population of the asian corn borer (Jackman and Benigno, 1983). Alternatively, one may use Leslie or projection matrices where both survival and reproductive rates are functions of other variables like crop growth stage (Benigno, et. al., 1983).

Probit analysis is another useful method for analyzing sigmoid curve responses. Its usual application is the determination of LD_{50}'s (median lethal dose) of pesticides to provide indices of relative toxicities. Torii (1967) applied probit analysis together with logit analysis for predicting 50 percent emergence of rice stemborers based on light trap catches.

4. Sampling Methods

A sampling method for IPC should provide fast and precise information on pest infestation so farmers may have enough lead time to prepare their control strategies. In this respect, sequential sampling is fast gaining popularity. For one, it does away with the nagging question of sample size. It also saves sampling efforts by 60% (Ferrer, et. al., 1985); and no computations are needed for hypothesis testing since critical values have been pre-computed in the construction of the sequential sampling plans.

The information needed to construct sequential sampling plans include Critical pest levels or ETL and pest distribution within plants or within fields. The risk of committing type I and II errors are usually set at a high 0.20 in order to reduce sample size (Ferrer, et. al., 1985).

The ETL of many major pests are not yet firmly established. For rice insect pests, suggested ETL's (Table 1.) are derived from field experiments. The Department of Entomology of the International Rice Research Institute has successfully fitted the distribution of a number of insect pests to the negative binomial distribution.

Table 1. Recommended Economic Threshold for Some Major Insect Pests of Rice in the Philippines

Insect Pests	Susceptible Stage of Rice Plant	Suggested Economic Threshold
1. Whorl Maggot	Seedling stage with maximum damage at 30 DAT	No practical threshold developed yet because of rapid damage rate
2. Green Leafhopper	Seedling stage within first half of the crop growth stage period	5/hill at tillering stage, 10/hill at flowering stage. Lower number when viruliferous hoppers are observed.
3. White-Backed Planthopper	Tillering Stage	1/tiller subjectto further confirmation
4. Brown Plant-hopper	Throughout growing period but most significantly during booting and dough stage of grain	1/tiller for areas where population growth pattern still unknown.
5. Stemborer (Tryporyza & Chilo)	Seedling stage Whiteheads during flowering stage	10% deadhearts up to the maximum tillering stage No threshold for whiteheads. 5-10 damaged leaves/hill at flowering stage IRRI recommendation, but not yet determined.
6. Rice Bug	Flowering to soft dough stage	2/sq. m.

Computer programs have been written for the T.I. 59 (Shepard and Gouthusen, 1984) and the HP 9816S personal computer at NCPC to facilitate sampling plan construction for varying ETL levels and distribution patterns. The program generates both the table and the graph. For field use, the table is more practical because it allows adjustment of the pest counts to the number of predator and parasites present. In the IRRI SEQPRED model (Ferrer, et. al., 1985), each predator encountered in the field is given a pest equivalent (say, 5 predators = 5 hoppers) and subtracted from the running total of pest count.

5. Computer Applications

A number of research institutions now have micro or table top computers. NCPC has HP 9845B and HP 9816S and a 4-color programmable plotter. Our statistical package developed by the Statistical Laboratory of the Colorado State University include Basic Statistics, Analysis of Variance Regression Analysis, Statistical Graphics, Principal Components and Factor Analysis, Monte Carlo Simulations and Forecasting. A strong point of these packages is the graphics feature which is capable of producing 2- or 3-dimensional plots, and charts which researchers appreciate more than tabular presentations. A rather weak point in our system is the data handling (entry, editing, transformation, storage). This takes so much of our time that we need to process voluminous data using SAS. The most frequently used softwares are the Basic Statistics, ANOVA and Regression Analysis. At present, crop protection researchers rarely do multivariate statistical analysis.

Besides statistical softwares, we have VISICALC for spread sheet calculations. We find this useful as an instruction and training tool for computing partial budgets and ETL for varying pest control inputs and product prices. We also have the IMAGE 45 data base management system with a DBMS statistical Linkage. These are newly acquired so we have yet to explore their applications. We plan to include this in the agriculture extension program through a communication link between UPLB and the governor's office of Laguna. A sample search would be: PEST = ASIAN CORN BORER and complete results would be:

CROP	:	CORN
PEST	:	ASIAN CORN BORER
PESTICIDE	:	FURADAN; .15% LANNATE
IPM	:	I. MODE-RES VAR: IPB VARI, PIONEER 6181, SMC 101/121 CARGILL 100; APPLY FURADAN 3G (0.33g) OR 0.15% LANNATE (1 tsp/li. WATER) PER ACTIVELY INFESTED PLANTS WITH PIN HOLE/EARLY SHOTHOLE DAMAGE AT 30 & 40-45 DAE.

CROP	:	CORN
PEST	:	ASIAN CORN BORER
PESTICIDE	:	FURADAN, LANNATE
IPM	:	(SEE I) II. DETASSELLING: BEFORE POLLEN SHED DETASSEL 4 OUT OF EVERY 6 ROWS. REMOVE TASSELS FROM FIELD. DONT FEED FURADAN TREATED TASSELS TO ANIMALS UP TO 14 DAYS FROM APPLICATION; 3 DAYS FOR LANNATE.

Such inquiries and answers may be by telephone, two-way radio or personal contact with the office. We have just started this pest recommendations data base. We also plan to store historical surveillance data to use with the DBMS - statistical linkage program.

We have also translated the DYNAMO subroutines from FORTRAN version, FORDYN (Llewellyn, 1965), to HP enhanced BASIC for our pest modelling work (Palis, et. al, 1984). We find modelling a good exercise for learning the dynamic of pest populations besides predicting the time of population peaks for timing control and playing pest management games.

6. Problems and Needs

Pest control researchers and practitioners now have greater access to computers and data systems. With this comes a greater chance that statistical softwares will be misused. Thus, even with all the packages available, expert advise from statisticians is still needed. Besides, these packages do not always provide the type of analysis and the exact formatted results needed by individual researchers. For instance, our ANOVA package analyzes randomized complete block design with sub-sampling but does not have provisions for the usual RCBD data without sub-sampling. In such cases, the statistician/programmer should be able to modify the package to suit the needs of the agency.

The problem with a single-user microcomputer in most research institutes is that once a user sits beside the computer everybody else except the boss has to line up for his turn. It is still advisable for such institutes to have access to a mainframe computer which is either multi-user or one which has several work stations for data entry. Likewise, in our experience, the software available on the big computer particularly SAS is superior to most software for micro computers.

Ironically, there are a number of softwares waiting to be "touched" by the pest control researchers, such as linear programming and statistical smoothing and forecasting programs. Perhaps our researchers on one hand and the statisticians on the other hand are not aware of the applications of such tools in pest management. It is high time we explore some innovative approaches to our research work.