SYSTAT Application Notes

Statistical Methods in Agriculture Research using SYSTAT

Introduction

Biology is forecast to be the science of the 21st century. The intrinsic variability of biological systems means that statistical methods will play a leading role in interpreting the massive quantities of data now being generated in the search for the secrets of life.

The history of biometry (biometry: the use of statistical, mathematical and computing methods to answer quantitative biological questions) - the study of measurement in biology goes back over 100years.

Researchers working in the biological sciences may be tackling problems in:

- Genetics - for example, analyzing the heritability of a rare disease through genetic pedigrees, or the patterns of gene expression using microarrays

- Agriculture - for example, testing the performance of new crop varieties, or the efficacy of precision application for reducing pesticide inputs

- Ecology - for example, modeling population change of sea mammals

The purpose of statistical data analysis is to extract as much information as possible from given experimental data, and to help plan new experiments in such a way that the amount of information generated from each experiment is maximized.

Hence, the correct use of statistical methods for agricultural data analysis in particular is crucial, and serves to maximize the benefits obtained from investments in agricultural research.

Applied Research

Statistical Science is concerned with the twin aspect of, theory of design of experiments and sample surveys and drawing valid inferences there-from using various statistical techniques 1 methods.

The art of drawing valid conclusions depends on how the data have been collected and analyzed.

Depending upon the objective of the research study, one has to choose an appropriate statistical procedure to test the hypothesis. The goal of applied research is to provide data to support existing knowledge fill information gaps or develop new methods.

An applied research study is a major commitment. It requires proper study design; management, data collection and analysis to obtain statistically sound results. Some examples of applied research in agriculture include:

- Wind erosion control
- Water erosion control
- Crop residue management
- Reduced fall tillage
- Salinity control
- WeedlDiseaseIInsect control
- PasturelRangeland rejuvenation
- Soil moisture management
- Economics
- Equipment

Applications

Weed Control

One of the main barriers for conventional farmers converting to organic production is weed control. Reddiex et al. (2001) through an experiment evaluated the efficacy of three mechanical weed control methods, tine weeder, spoon weeder and inter-row hoe (only in the beans (Phaseolus vulgaris)), in four organically grown crops. Measurements were made of weed and crop dry matter (DM) production at mid season and final harvest. Crop yield was measured at the time of commercial harvest. For midseason sampling, weed and crop DM were measured from two 0.25 m^2 quadratslplot. At final harvest, four 0.25 m^2 quadratslplot were taken to measure weed andcrop DM and crop yield.

The data were analyzed using Systat with each crop analyzed separately. A repeated measure ANOVA was used to analyze weed and crop DM. If the time x treatment interaction was not significant (P>0.05), then the two sampling dates were averaged, to compare treatments. Crop yield data were analyzed using ANOVA. When significant treatment effects were indicated by ANOVA, pairwise comparisons of treatments were conducted using Fishers LSD test.

They concluded that, in borage (Borago officinalis), weed dry matter (DM) was reduced by 41% in tine-weeded plots but there was no treatment effect on crop DM or yield. There was no treatment effect in the peas (Pisum sativum). In linseed (Linum usitatissimurn), mechanical weeding reduced weed DM by 41% and resulted in a 28% increase in crop yield. In beans, weed DM was reduced by 74% in mechanically weeded plots but the tine weeder reduced crop DM compared with the other mechanical weeding treatments.

Soil Management

Farmers' agricultural practices were studied by Yemefack et al. (2002) especially with respect to changes occurring in soil characteristics and soil productivity of Oxisols during the natural fallow period within the shifting cultivation system in the Tropenbos Cameroon Programme situated in the humid forest zone of Southern Cameroon.

The study design was a Randomized Complete Block Design with three villages as blocks, three farmers per village as replications and five selected plot types per farmer as treatment. Treatments were chosen which comprised three fallow plot types, a groundnut-maize-cassava plot (afub wondo) established following the clearing of fallow age 3 to 9 years, and virgin forest as control. In this cropping system, no chemical fertilizer and no other amendment (except ash from burned biomass materials) were used.

Analysis of variance (ANOVA) was performed for soil property changes under various land use types using Systat, and the least significant difference (LSD) method was used for means separation. Stepwise analyses of multiple linear regressions were used to evaluate relationships between soil properties variation and crop (maize, groundnut, cocoyam and cassava) yields from mixed crop fields following each fallow type.

The results showed that (i) ashes from burned vegetation biomass at the beginning of the cropping period act like lime fertilizer and significantly increase soil properties such as pH, exchangeable bases (especially calcium), and decrease exchangeable acidity; (ii) there is a slow but almost irreversible decrease in topsoil day content during the cropping period; and (iii) at the age 7 to 9 year bush fallow, there is a morphological recovery of the topsoil thin (3-5 cm) A1 organic horizon, which was destroyed by tillage during the cropping period.

Agricultural Machinery

Selecting farm machinery sufficiently large to complete the desired task in a timely manner that is cost effective has long been a challenge for farmers. Taylor et al. (2001) studied the use precision agriculture technologies to determine the relationship between the time of day that corn was planted and subsequent yield while accounting for other yield determining factors.

Three cooperating farmers planted no-till corn into soybean and wheat stubble on 36 fields representing nearly 2900 total acres in northeast Kansas with 6-, 12-, and 16-row planters. Each planter tractor was equipped with differential GPS and a logging device. Differential correction was obtained through the Coast Guard beacon station at Kansas City. Data for the 6- and 16-row planter were recorded on I-s intervals, while data for the 12-row planter were recorded on 3-s intervals.

The planters were not equipped with switches to pause data logging when the planters were raised; therefore, data were logged continuously during planter operation. Multivariate linear regression was used to evaluate the relationship between yield and planting date, planting time, and binary variables of interest using Systat.

Planting date and time of day effects was hypothesized to be nonlinear so both linear and squared terms for these variables were included in the model. Binary variables included hybrids of interest, rainfall and soil ratings, and cooperator. Each binary variable was created by adding a column to the data set of 429 points and assigning a value of '1' where the observation matched the condition of interest and a value of '0' where it did not.

They concluded that rainfall estimates, hybrids, and cooperator were the most significant explainers of yield variability. Yield difference among hybrids was better explained with regression analysis than simple farm averages because it accounted for differences in other yield determining factors. Soil ratings, planting time of day, and planting date influenced yields to a lesser extent.

Fertilizer Management

The introduction of high yielding hybrid canola cultivars has necessitated re-visiting management practices to obtain optimum canola yields. Hybrid canola results in higher yields compared to conventional or open pollinated canola cultivars.

The objectives of a study by Karamanos et al. (2002) were to assess:

- Nitrogen, sulphur and phosphorus requirements of hybrid compared to conventional canola cultivars;

- Interaction of nitrogen and sulphur (NS) in both conventional and hybrid canola;

- Interaction of nitrogen and phosphorus (NP) in both conventional and hybrid canola.

The results from all tests were subject to ANOVA and regression analysis using Systat. They concluded that, Hybrid canola cultivars yield, on average, as much as 25 % higher than conventional canola cultivars. Decisions concerning the nitrogen, phosphorus and sulphur requirements of both hybrid and conventional canola cultivars should be based on soil test levels for the corresponding nutrients.

Pest Control

A fungicide trial was established in a commercial style greenhouse at The University of Arizona Campus Agricultural Center in November 2000 to evaluate efficacy of several fungicides for control of powdery mildew on bell pepper (Olshen et al. (2001)).

Treatments included five registered fungicides: Microthiol Special (micronized sulfur), Trilogy (neem extract), Flint (trifloxystrobin), Serenade (Bacillus subtilis QST713) and AQ10 (Ampelomyces quisqualis) applied as single treatments every 10- 14 days to each of four replicates. That is, five fungicide treatments and a control treated with water only were used in a randomized block design with four replications. Blocks consisted of 6 bags with three plants each. Means of each replication within each treatment were subjected to ANOVA and Tukey test in Systat.

In samples to determine the percentage of leaf area affected by powdery mildew lesions and the number of leaves infected within different treatments, Microthiol Special and Serenade were significantly different from non-treated controls, while Flint and AQ10 had fewer lesions and number of leaves infected but were not significantly different from the control. Although Trilogy was not different from the control, this treatment had more lesions and number of leaves infected than all treatments.

Agricultural Economics

Most farmers in the Kumasi district of Ghana are crop farmers. In recent years, however, many of them have started rearing animals on a commercial basis, even though most of the animal enterprises in the district remain sideline activities. Cattle rearing is now becoming popular with many traders and office workers as well.

An experiment was carried (Asare et al. (2002)) for 120 days during the dry season of 1998199, to assess the sustainability of dry season feed supplementation in an emerging peri-urban dairy production system.

Fifty-three Sanga cows were divided into four treatment groups T1, T2, T3 and T4, and were fed 0,1,1.5 and 2 kg respectively, of a homemade concentrate supplement containing 18% crude protein. The treatment groups contained 12,14,12 and 15 cows, respectively.

The statistical analysis of the data was carried out using Systat. The data were subjected to analysis of covariance. The terms for the covariance analysis were treatment, herd, treatment x herd interaction and the covariant was initial (first week) partial milk yield. The monthly means for daily partial milk yield were also calculated. Using the technique of regression analysis, the rate of change in monthly milk yield was determined for each cow and then for the treatments and herds. The Pearson chi-square test was used to determine the significance of proportion of cows cycling versus those not cycling as well as pregnant versus empty cows between the treatments.

Their results suggested that Cows fed with 1.5 kg concentrate generated the highest net income from milk sales. They produced 53% more milk and 16% more milk revenue than the control cows. Their-daily partial milk yield was not significantly different ($P > 0.05$) from that of cows fed 2 kg concentrate supplement, but was significantly higher ($P < 0.05$) than that from other groups. It was found that feeding 2 kg concentrate supplement a day to Sanga cows in the Kumasi district may not be economical even though milk yield may be increased. It is suggested that given the large variability observed in individual low performance, selection of more productive cows or culling of less productive ones could be used in conjunction with feed supplementation to improve the productivity of Sanga cows in less endowed environments.

They concluded that with proper feeding of lactating cows and education of farmers, peri-urban dairying could be a significant component of the agricultural economy of the Kumasi area.

Summary

Applied research experiments involve any aspect of agriculture, such as crop production, livestock production, soil and water conservation, machinery and economics.

Developing an adequate design to such an experiment is perhaps the trickiest and most difficult task that a researcher faces. Many design types have been developed for agricultural field experiments. Any of several designs may be possible for a particular project, but each design has its own advantages and disadvantages. The overriding principle for experimental design is: keep the design as simple as possible while satisfying the required level of scientific soundness. You do not need a complex design with many experimental treatments, multi-factor interactions and difficult statistical analysis when a basic, simply designed experiment will produce the required information.

Systat offers three methods for generating experimental designs: Classic DOE, the DOE Wizard and the DESIGN command.

Classic DOE provides a standard dialog interface for generating the most popular complete (full) and incomplete (fractional) factorial designs. Complete factorial designs can have two or three levels of each factor, with two-level designs limited to two to seven factors, and three-level designs limited to two to five factors.

Incomplete designs include: Latin square designs with 3 to 12 levels per factor; selected two-level designs with 3 to 11 factors and from4 to 128 runs; 13 of the most popular Taguchi designs; all of the Plackett and Burman two-level designs with 4 to 100 runs; the 6 three-, five-, and seven-level designs described by Plackett and Burman; and the set of 10 three-level designs described by Box and Behnken in both their blocked and unblocked versions. In addition, the Lattice, Centroid, Axial and Screening mixture designs can be generated.

The DOE Wizard provides an alternative interface consisting of a series of questions defining the structure of the design. The wizard offers more designs than the classic DOE, including response surface and optimal designs. Optimization methods include the Federov, k-exchance and coordinate exchange algorithms with three optimally criteria available. The coordinate exchange algorithms accommodate both continuous and categorical variables. The search algorithms for fractional factorial designs allow any number of levels for any factor and search for orthogonal, incomplete blocks if requested.

The DESIGN command generates all designs found in Classic DOE using Systat's command language.

Also we saw above a partial view of different analytical techniques of Systat being used across various applications. However, Systat provides a complete powerful statistical and graphical analysis system in a graphical environment using descriptive menus and simple dialog boxes.

Systat's command language provides functionality not available in the dialog box interface in addition to complete coverage of menu-based functionality. Matrix procedure allows you to use matrix algebra to specify statistical analyses and perform data management tasks.

Create compelling reports by combining formatted statistical output with publication-quality graphs in Systat's rich text output window.

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Corporate Headquarters
North, Central & South America
Systat Software, Inc.
2107 North First Street, Suite 360
San Jose, CA 95131-2026 USA
Phone : 800-797-7401
Fax : 800-797-7406
Email : info-usa@systat.com

UK and Ireland
Systat Software Inc
4th Floor, Block B, Vista Centre,
50, Salisbury Road,
Hounslow, - TW4 6JQ, London, UK.
Phone : +44-(0)208-538 0128
Fax : + 44-(0)208-538 0273
Email : info@systat.co.uk

Germany and Austria
Systat Software GmbH
Schimmelbuschstrasse 25
D-40699 Erkrath
Germany
Phone: +49.2104.9540
Fax: +49.2104.95410
E-mail: kontakt@systat.de

Asia-Pacific, AUS & NZ
Phone : +91 - 80 - 4128 1111
Fax : +91 - 80 - 4128 0203
Email : info-intl@systat.com