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Misunderstood Concepts of Experimental Factor, Experimental Unit and Experimental Error

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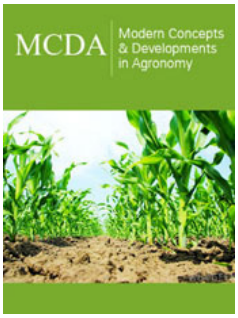

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Abstract

Basic concepts of experimental research, such as experimental factor, experimental unit and experimental error, are vaguely, imprecisely and inconsistently defined in the literature. This deficiency of literature is extended to teaching. This is the main source of the misunderstanding of these concepts by researchers and the consequent failures that imply the derivation of biased inferences from the experiment. This article presents a rational formulation particularly of the concepts of experimental factor, experimental unit and experimental error, coherent with their meanings in the process of the experiment.

Keywords: Experimental research; Planning of experiments; Basic concepts of experiment; Inferences from experiments

Introduction

The misunderstanding of basic concepts of experimental research is prominent in the literature and manifested by researchers. Silva [1] discusses flaws that may arise from the usual concepts for inferences derived from the experiment, suggests the reformulation of some of these concepts and proposes a rational conceptual basis for experimental research. Silva [2] comments that the precarious knowledge of this conceptual basis by researchers originates mainly from the vague, imprecise and incoherent way in which they are presented in reference texts and in teaching. This article particularly discusses the concepts of experimental factor, experimental unit and experimental error, and reviews related concepts suggested by Silva [1,3,4].

The statistical model must properly express the structure of the experiment. This is necessary to ensure that the variance components that affect effects of experimental factors are identical to the variance components used to judge the significance of those effects, except for the variances attributable to those effects themselves. This property is essential for the procedure of testing the significance of an effect of experimental factors that consists of contrasting estimates of variances from two sources:

1. An estimate that includes a component of variance attributable to that source; and
2. An independent estimate with identical composition, except for the presence in the variance estimate 1 of the effect attributable to the referred experimental factor.

In experiments with fixed factors, the variance of source 2 is exclusively attributable to experimental error; in the presence of random experimental factors, this source of variation may also comprise components attributable to these experimental factors. This procedure makes it possible to test the significance of the effects of experimental factors by F statistics that express the mean squares ratio provided by the analysis of variance. In the orthogonal or complete balanced design situation, appropriate F-ratios for these significance tests can

be determined from the expressions of the expected mean squares values that can be obtained by practical methods. However, for this procedure to result in unbiased significance tests, it is necessary that the statistical model correctly expresses the structure of the experiment [1].

Basic Concepts

The experiment is an explanatory research method for verifying a hypothesis of causal relationship between two subsets of characteristics of the units of a target population: a subset of the class of characteristics that express the performance of units - response characteristics, and the characteristics of the class that supposedly affect the response characteristics - explanatory characteristics or experimental factors. The response characteristics are also affected by the characteristics of the class that completes the set of characteristics of the units - extraneous characteristics. Effects of these characteristics on the response characteristics are confounded with the effects of experimental factors.

The experiment is performed on a sample of the target population, called experimental material, which comprises the three classes of characteristics: response characteristics, experimental factors and extraneous.

Experimental factors comprise two classes: treatment factor - factor whose presence in the sample units is controlled by random assignment and control of experimental techniques that avoids biased confounding of its effects with effects of extraneous characteristics, and intrinsic factor - non-controllable factor or partially controllable whose effects on the response variable may be confounded biasedly with the effects of extraneous characteristics. The levels of an experimental factor in the sample are called experimental conditions; the levels of a treatment factor are called treatments. The choice of experimental factors and the corresponding levels and combinations of levels for the sample determines the structure of the experimental factors or structure of the experimental conditions.

The fraction of the experimental material in which information about a response characteristic is recorded independently of the other fractions is the unit of observation of that response characteristic. The largest fraction of the experimental material that is assigned a level of a treatment factor by random process or that manifests a level of an intrinsic factor, independently of the other fractions, is the experimental unit of that experimental factor.

The effect of extraneous characteristics on the observed values of the response variable is the experimental error of that response variable. Consequently, the variation in the values of the response variable that is attributable to extraneous characteristics also constitutes experimental error. Experimental error must be controlled by experimental control, which comprises control of experimental techniques, local control, statistical control and randomization. The experimental control aims to reduce and make unbiased the confounding of the effects of explanatory characteristics with the experimental error, so that the variation manifested by the response characteristics can be attributed to the effects of experimental factors.

Randomization of extraneous characteristics is accomplished by randomly assigning the experimental units and their subsets of extraneous characteristics to the treatment factor levels. This random assignment aims to control, in a statistical sense, for variability attributable to extraneous characteristics that is not controlled by local control and statistical control to allow valid estimates of the uncertainties of inferences. Local control imposes one or more groupings of observation units and consequent restrictions on randomization. Groupings of these units are also constituted by the observation units themselves and by the formations of experimental units. Each of these groupings of observation units constitutes a unit factor. The relationship between unit factors determines the structure of unit factors or structure of units.

The structural relationship between the structure of experimental conditions and the structure of units constitutes the structure of the experiment and the experimental design.

The levels of a unit factor are the experimental units of the levels of the experimental factor with which they have a correspondence relationship in the structure of the experiment. The variation attributable to extraneous characteristics between the experimental units of an experimental factor constitutes the experimental error that affects the effects of this experimental factor. Thus, the structure of the units establishes the structuring and stratification of the experimental error.

References

1. Silva JGC (1999) The consideration of the unit structure in inferences from the experiment. Pesquisa Agropecuária Brasileira 34(6): 911-925.
2. Silva JGC (2001) Experiment planning: Conceptual and methodological basis. In: 46ª Reunião Anual da RBRAS-9º SEAGRO. Piracicaba, Brazil.
3. Silva JGC (2008) A conceptual basis and an approach to the planning of experiments. In: Symposium on the Planning of designed experiments: Recent advances in methods and applications (DEMA2008). Isaac Newton Institute for Mathematical Sciences, University of Cambridge.
4. Silva JGC (2020) Experiment: Conceptual basis. Journal of Experimental Agriculture International 42(6): 7-22.