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Oral Section

Poisson distribution and process as a well-fitting pattern for counting variables in biologic models

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ABSTRACT

One of the major criticisms directed to basic research on high dilution effects is the lack of a steady statistical approach; therefore, it seems crucial to fix some milestones in statistical analysis of this kind of experimentation. Since plant research in homeopathy has been recently developed and one of the mostly used models is based on in vitro seed germination, here we propose a statistical approach focused on the Poisson distribution, that satisfactorily fits the number of non-germinated seeds.

Poisson distribution is a discrete-valued model often used in statistics when representing the number X of specific events (telephone calls, industrial machine failures, genetic mutations etc.) that occur in a fixed period of time, supposing that instant probability of occurrence of such events is constant. If we denote with λ the average number of events that occur within the fixed period, the probability of observing exactly k events is:

$$P(k) = e^{-\lambda} \lambda^k / k! , \quad k = 0, 1, 2, \ldots$$

This distribution is commonly used when dealing with rare effects, in the sense that it has to be almost impossible to have two events at the same time. Poisson distribution is the basic model of the so called Poisson process, which is a counting process $N(t)$, where t is a time parameter, having these properties:

- The process starts with zero: $N(0) = 0$;
- The increments are independent;
- The number of events that occur in a period of time $d(t)$ follows a Poisson distribution with parameter proportional to $d(t)$;
- The waiting time, i.e. the time between an event and another one, follows and exponential distribution.

In a series of experiments performed by our research group ([1], [2], [3], [4]) we tried to apply this distribution to the number X of non-germinated seeds out of a fixed number N* of seeds in a Petri dish (usually N* = 33 or N* = 36). The goodness-of-fit was checked by different tests (Kolmogorov distance and chi-squared), as well as with the Poissonness plot proposed by Hoaglin [5].

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The goodness-of-fit of Poisson distribution allows to use specific tests, like the global Poisson test (based on a chi-squared statistics) and the comparison of two Poisson parameters, based on the statistic $z = X_1 - X_2 / (X_1+X_2)^{1/2}$ which is, for large samples (at least 20 observations) approximately standard normally distributed. A very clear review of these tests based on Poisson distribution is given in [6]. This good fit of Poisson distribution suggests that the whole process of germination of wheat seeds may be considered as a non-homogeneous Poisson process, where the germination rate is not constant but changes over time.

Keywords: Poisson process, counting variable, goodness-of-fit, wheat germination

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