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Modelling germination curves of magneto-primed sorghum (*Sorghum bicolor*) seeds using Logistic and Gompertz models

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ABSTRACT

The traditional analysis of germination percentages tends to be quite limited, providing minimal information. Thus, a regression model based on the time to germination can be the most effective approach to describing germination behaviour. In this study, the effects of magneto-priming on sorghum [*Sorghum bicolor* (L.) Moench] seed germination were analysed and compared using Logistic and Gompertz models (LM and GM), respectively. Sorghum seeds were primed with a static magnetic field for four distinct durations (0, 1, 3, and 5 h). Germination data, gathered over a 10 days period for all magneto-priming exposures, then LM and GM growth curves were utilised to model seed germination. The experiment relied on two key metrics: the coefficient of determination (R^2) and the mean square error (MSE) to determine the best fitting growth curve. After the appropriate growth curve was selected, both statistical values and graphical plots were used to compare the model outputs and their parameter estimates. The results showed that the GM fit better than the LM model in describing the germination process of sorghum in the magneto priming test, as it yielded the lowest MSE and highest R^2 values. These findings suggest that the GM model can represent the best shape of sorghum germination curves under magneto-primed conditions.

Keywords: Cumulative germination percentage, Curve-fitting, Germination rate, Magnetic field, Primed seed, Seed priming durations

Seed priming methods, such as physical priming, are well-known pre-sowing techniques that are considered to be effective in improving seed germination and plant growth. Several physical agents, such as magnetic fields, microwaves, infrared light, and ultrasonic waves, have been successfully used as priming techniques. Based on magnetic fields, magneto-priming is one of the most extensively researched physical pre-sowing seed treatments. Prior research, including in maize (Himoud *et al.* 2022), soybean (Joshi-Paneri *et al.* 2023), wheat (Rathod and Anand 2015) and in cucumber (Bhardwaj *et al.* 2012), documented improvements in the germination parameters of magnetically treated seed. Traditional methods are most frequently used to characterise the germination kinetics of seeds induced with a magnetic field before sowing. The time course of germination may not be adequately described by conventional techniques for analysing seed germination data, such as germination indices and coefficients of velocity, making the results unclear and insufficient. Germination behaviour over time can be best described using regression models. A suitable fitted curve preserves the essential information regarding germination initiation. The procedure of fitting a curve involves adjusting the free parameters of the function until it approaches the true curve of the assay more closely than any other parameter combination. Although choosing the right curve seems crucial, criteria based on forecasting errors are typically used to choose between the two models. As with other statistical analyses, it is crucial to present the statistical findings of the nonlinear estimation.

Mathematical curves are frequently used to model cumulative germination proportions. The germination process, time, and speed of germination of stimulated seeds can be modeled using a non-linear, suitable description of seed germination (Shafii *et al.*1991). Several models have been proposed to analyse and describe seed germination curves, such as Logistic, Gompertz, Hill, and Richards functions (Hsu *et al.* 1984, Hara 1999, El-Kassaby *et al.* 2008, Sousa *et al.* 2014, Rymuza and Radzka 2021).

The Gompertz and Logistic models (GM and LM) were chosen as the most popular and straightforward models for growth curve analysis. Additionally, these models help to explain the growth mechanisms that go into plant development and seed germination. The comparison between the GM and LM is necessary due to their divergent assumptions regarding growth symmetry. Comparing the

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