Population-Based Threshold Models Describe Effects Of Controlled Deterioration On Seed Respiratory Patterns During Germination

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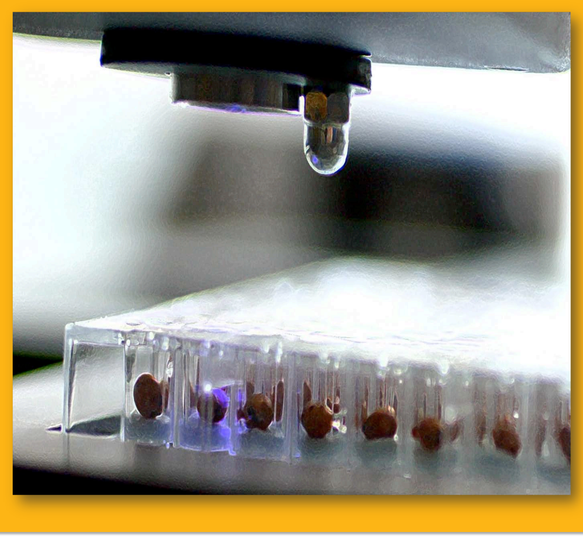

Introduction

Cellular respiration is initiated during the early stages of seed imbibition. Understanding the dynamics of seed respiration during germination provides new opportunities to optimize treatment protocols and to assess seed quality. Previous approaches to measure seed respiration have largely relied on measurements of samples containing many seeds, making it difficult to relate specific respiratory patterns to germination timing. The Q2 instrument (ASTEC Seed Technology) allows the sensitive measurement of respiration (oxygen depletion in sealed vials) by individual seeds, enabling more detailed studies of the relationships between respiration and germination rates.

Oxygen consumption profile during aging

The time required for germination increases prior to the loss of viability as seeds deteriorate during storage (1). We characterized the effects of controlled deterioration ageing on respiratory patterns of lettuce (cv. Salinas) in comparison with their germination kinetics (2). Lettuce seeds exhibited a range of oxygen consumption patterns, with some seeds having a linear rate of respiration, while other seeds present a sigmoid respiration curve. Seeds that had been primed exhibited the sigmoid pattern more frequently compared to control seeds (**Figure 2B**), while as ageing time increased, increasing numbers of seeds shifted from the sigmoid to the linear pattern of respiration (**Figure 2D, E, F**).

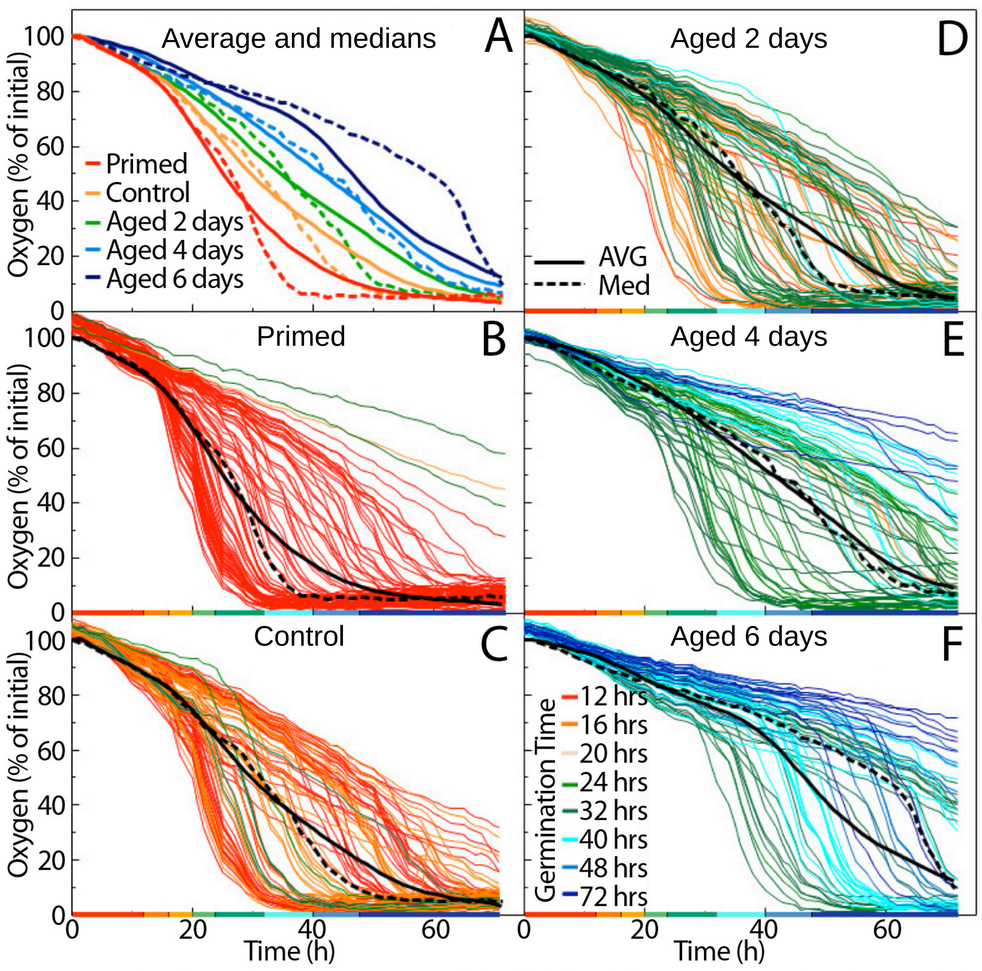

Figure 2. Respiration time courses of individual lettuce seeds that: B) had been primed, C) untreated (control) or subjected to: D) 2 days, E) 4 days or F) 6 days of controlled deterioration at 75% RH and 50°C. Each curve indicates the O_2 consumption time course of an individual seed, and is color coded to reflect the time by which radicle emergence had occurred for that seed. Averages (solid lines) and medians (dashed lines) are shown in black and compiled in panel A.

Better understanding of Q2 data

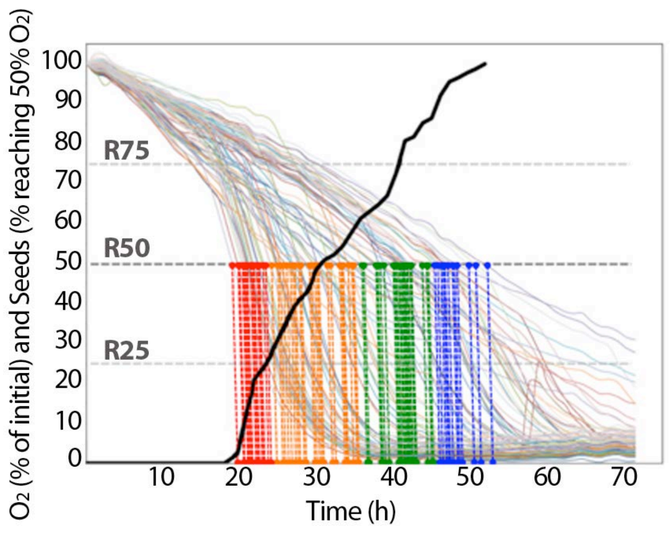

Figure 1. Respiration curves by individual seeds (colored curves) and example of cumulative curve built based on the time required for seeds to reach 50% oxygen levels (R50 values).

We developed new methods to display respiratory data in a manner analogous to germination time courses that illustrate both the timing and variation in respiratory activity among seeds. Cumulative curves were built based on the times when each individual seed consumed 50% of the oxygen inside their vials (**Figure 1**). Any oxygen level can be chosen to relate to germination, for example 75% (R75) or 25% O_2 (R25).

Population-based thresholds from respiration

Population-based threshold models have been created to quantify and predict seed germination times and percentages after ageing periods under controlled deterioration (3). However, those models rely on measurements of germination rates (timing) which are very labor-intensive as they require frequent repeated observations.

The respiratory response to ageing is consistent and highly correlated with germination. Hence, both the germination and the respiration data could be modeled using the ageing population-based threshold model (**Figure 3**). For lettuce, values based on seeds reaching higher levels of oxygen (i.e. R75), were more significant when using the model, with r = 0.975**.

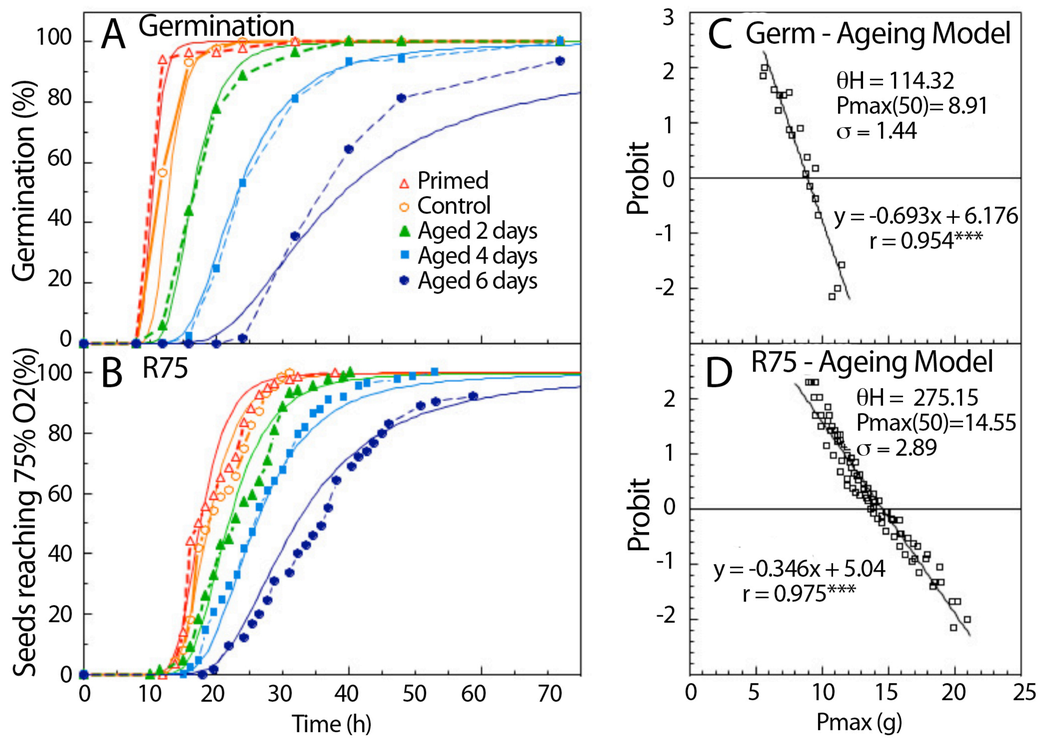

Figure 3. A) Germination time courses and B) time courses of cumulative percentages of lettuce seeds reaching 75% of initial oxygen levels. Treatments are described in the legend in A. The ageing model is represented for all treatments as solid lines with colors indicating treatments and the ageing model fit (by regression analysis) is represented on panels C) and D).

Conclusions

- Respiratory rates determined from **Q2 tests could substitute for germination rates** determined by repeated observations
- Valuable parameters can be extracted from a population-based threshold model to provide indicators of expected shelf-life.

References

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2. Bradford K.J., Bello P., Fu J-C., and Barros, M. 2013. Single-seed Respiration: A New Method to Assess Seed Quality. Seed Science and Technology, 41 (3), in press.

3. Bradford K.J., Tarquis A.M., Duran J.M.1993. A Population-based Threshold Model Describing the Relationship between Germination Rates and Seed Deterioration. Journal of Experimental Botany 44: 1225-1234.