UNIVERSITY OF HOHENHEIM

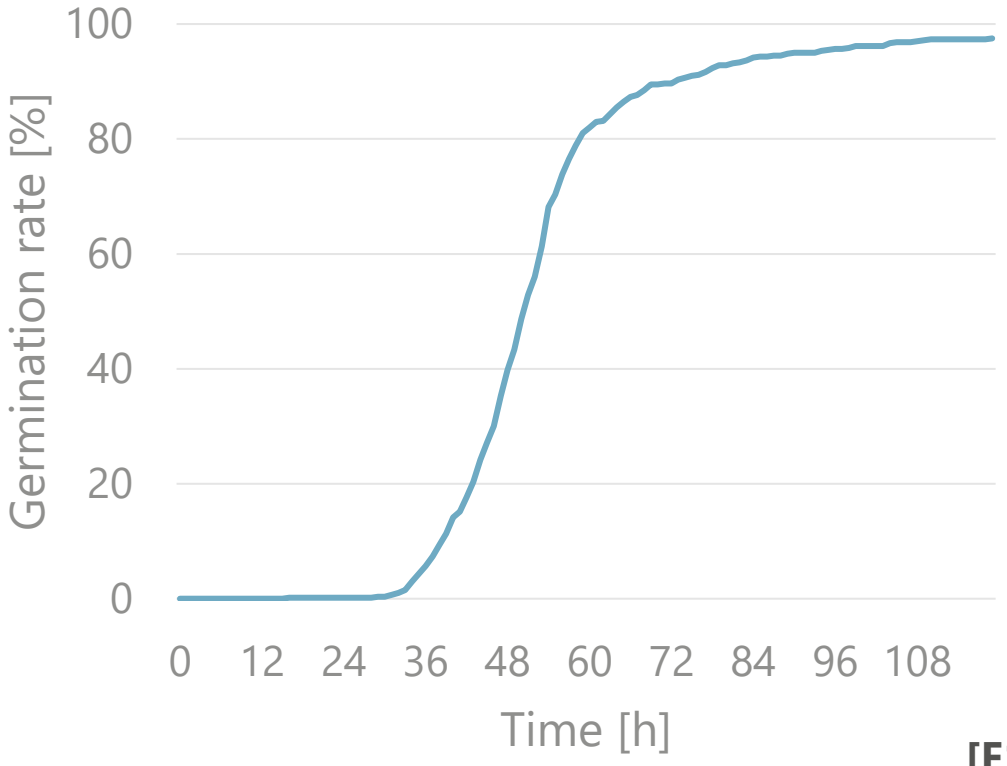
POTENTIAL OF GERMINATION CURVE ANALYSIS: UNTAPPED PARAMETERS FOR ISTA SEED TESTING

Annual ISTA Meeting 2026 | S. Bopper, T. Hograefer & M. Kruse | University of Hohenheim, Germany

GERMINATION CURVE

"The characteristic kinetic cumulative germination pattern of a population of individual seeds following imbibition, usually measured by repeated counting of the proportion or number of seeds showing radicle emergence." [L1]

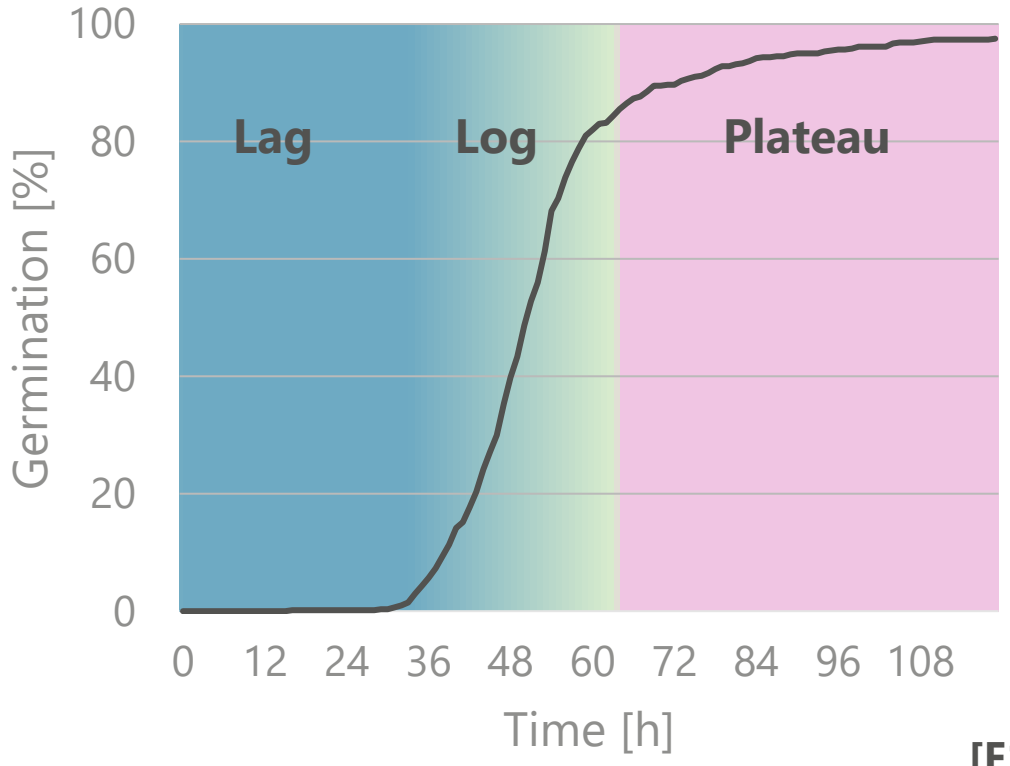
- commonly modelled as sigmoid (s-shaped) function
- inherit a broad range of key seed-performance indicators
- considering uniformity in seed testing: standardisation assessment needed



[F1]

KEY SECTIONS OF GERMINATION CURVES

- lag-phase
  - flat or nearly horizontal section at the beginning
  - little to no visible germination
- log-phase
  - steep (near) linear middle section
  - rapid increase in cumulative germination
- plateau-phase
  - curve flattens and approaches horizontal asymptote
  - germination rate decreases progressively



[F1]

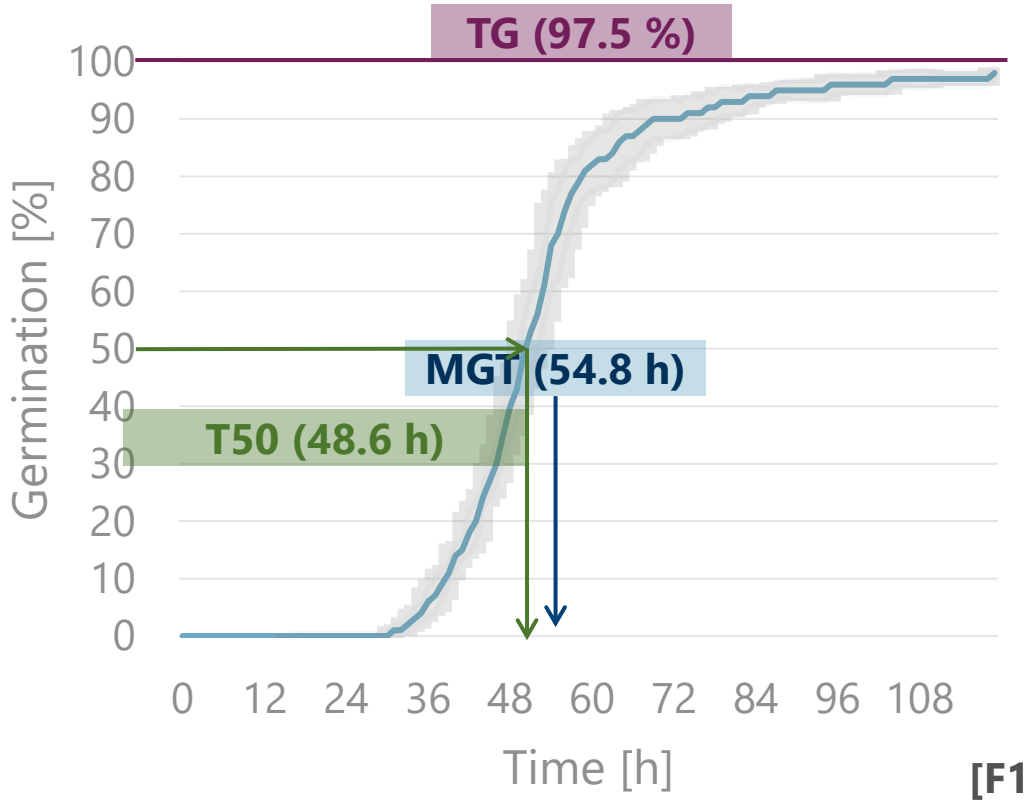
MODELLING GERMINATION CURVES

- germination is evaluated as non-independent count-data following poisson or negative binomial distributions
- common approaches to model germination data over time: [L2]

Weibull-function	Gompertz-function
$y = M(1 - \exp(-(k(t - z)^c))$	$y = M * \exp(-\exp(-k(t + b)))$
where • y = response • M = max. germination rate • z = location parameter (lag/shift) • k = rate parameter • c = shape parameter • t = time parameter	where • y = response • M = max. germination rate • k = rate parameter • b = location parameter • t = time

GERMINATION CURVES PROVIDE KEY SEED-QUALITY FIGURES

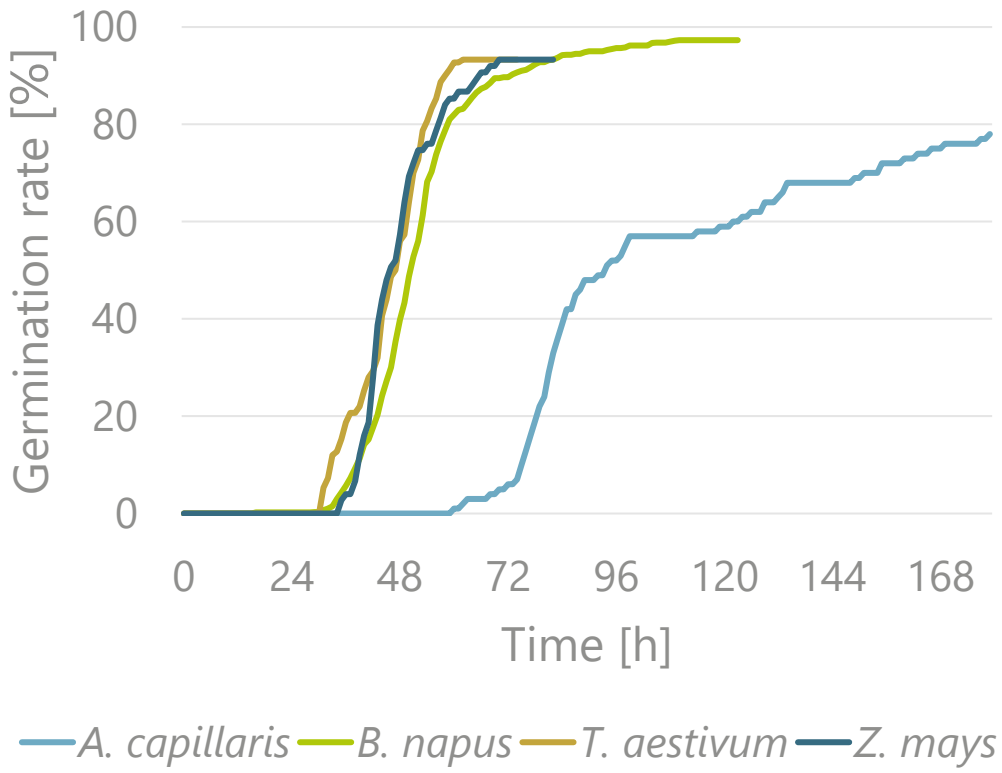
- mean germination time (MGT)
- time taken to reach 50 % germination (T50)
- standard deviation of germination (SD)
- total germination (TG)
- coefficient of velocity of germination (CVG)
- continuous germination index (CGI)



[F1]

GERMINATION CURVES CAN DESCRIBE KEY PROCESSES OF GERMINATION

- homogeneity of germination
- germination velocity
- lag-time
- log-phase (can be near-linear)
- plateau-phase



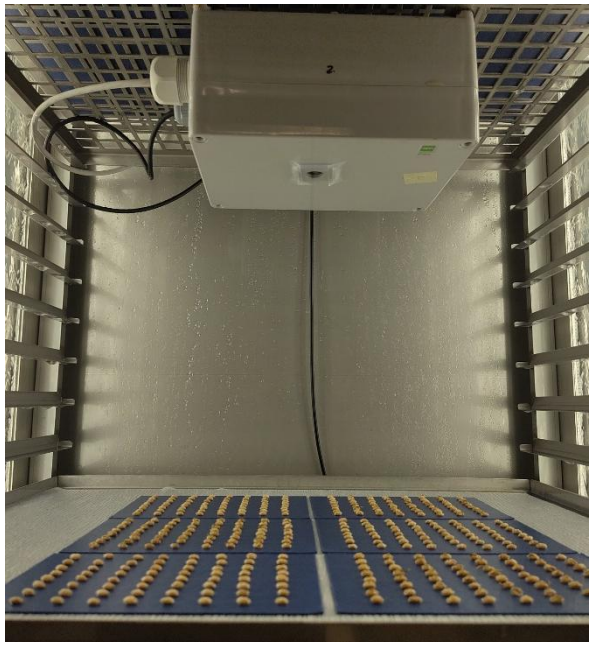
[F5]

FIELDS OF APPLICATION AND USE CASES

- **research**
  - gene regulation during germination processes [L3]
  - resistance and resilience [L4]
- **commercial use**
  - plant breeding (trait discovery)
  - high-throughput seed quality assessment
- **seed laboratories**
  - offering a new ISTA method to customers

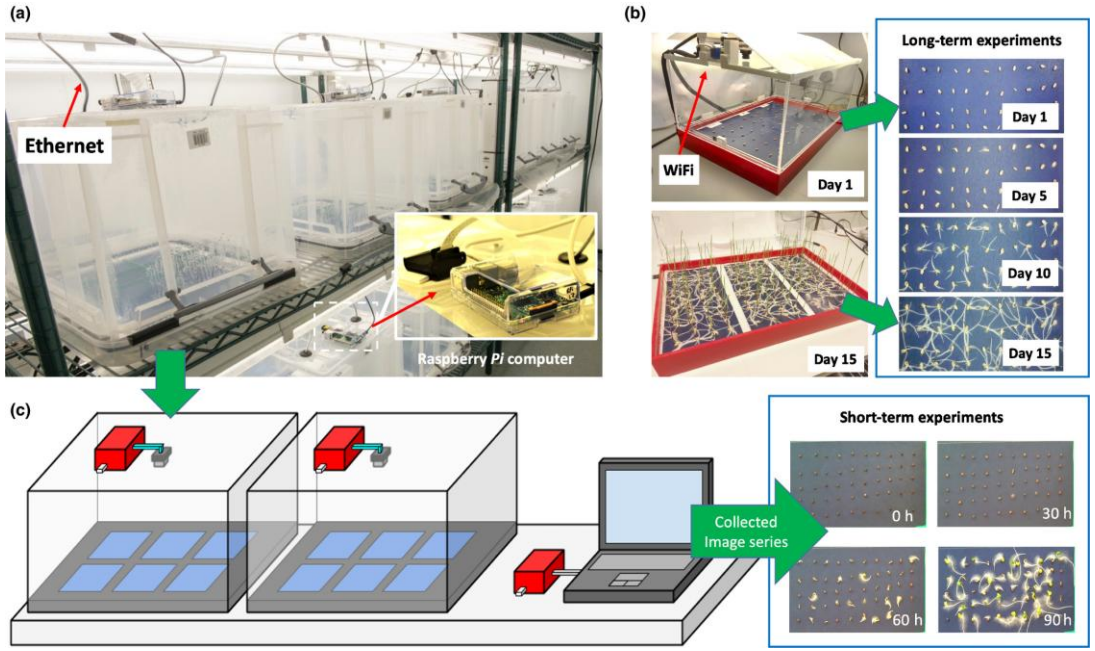
THERE ARE VARIOUS WAYS TO GENERATE GERMINATION CURVES

manual



[F2]

semi-automated



[F3, L5]

fully-automated

[F4]

BENEFITS / POTENTIAL FOR SEED TESTING

- commercial and open-source solutions available
  - adaptation to fit within existing budgets feasible
- reduced manual labour, precise data
  - automation of RGB-picture evaluation and key figure calculation
- scaling
  - high-throughput solutions possible

➢ BUT: seed testing depends on standardised procedures

CHALLENGES AND LIMITATIONS OF GERMINATION CURVES

- new equipment, new trainings, new procedures, …
- works with TP and PP (not feasible for BP, S, …)
- germination process can be highly species-specific
  - new species-specific day/night temperature assessment necessary?
- robust and precise standardisation of procedures needed

SUMMARY

- for certain species, seed quality can be assessed effectively using germination curves
- procedures are highly adaptable to working environments and requirements
- automated data evaluation reduces the necessity of manual labour
- in-depth analysis pending / in progress

LET'S DISCUSS, WHAT IF … WE HAVE A NEW, KINETIC DIMENSION OF SEED QUALITY

What we have:

- *Germinability* — **how many?**
- *Vigour* — **how robust?**

What curves can tell us:

- *Curve kinetics* — **how does it get there?**

REFERENCES

Figures

[F1] **Mean germination curve of *Brassica napus*.**
6 panels with 100 seeds each. Generated using an open-source based in-house developed platform.

[F2] **Open-source based in-house platform to generate germination curves.**
RGB pictures are taken in defined intervals during the germination process.

[F3] **Open-source platform „SeedGerm“.**
Developed and published by Colmer et al. (2020) [L5].

[F4] **Commercial seed phenotyping platform (SeedAIxpert HT by Lemnatec).**
Source: https://www.lemnatec.com/seed-and-seedling-testing-systems/seedaixpert-ht/

[F5] **Mean germination curves of selected species.**
At least 4 replicates with at least 50 seeds. Generated using an open-source based in-house developed platform.

Literature

[L1] Black M, Bewley JD, Halmer P. The encyclopedia of seeds science, technology and uses. Trowbridge: Cromwell Press; 2006. https://www.cabidigitallibrary.org/doi/book/10.1079/9780851997230.0000

[L2] Brown, R. F., & Mayer, D. G. (1988). Representing Cumulative Germination.: 2. The Use of the Weibull Function and Other Empirically Derived Curves. Annals of Botany, 61(2), 127–138. https://doi.org/10.1093/oxfordjournals.aob.a087535

[L3] Joosen, R. V. L., Arends, D., Willems, L. A. J., Ligterink, W., Jansen, R. C., & Hilhorst, H. W. M. (2012). Visualizing the Genetic Landscape of Arabidopsis Seed Performance1[W][OA]. Plant Physiology, 158(2), 570–589. https://doi.org/10.1104/pp.111.186676

[L4] Wijewardana, C., Reddy, K. R., Krutz, L. J., Gao, W., & Bellaloui, N. (2019). Drought stress has transgenerational effects on soybean seed germination and seedling vigor. PLOS ONE, 14(9), e0214977. https://doi.org/10.1371/journal.pone.0214977

[L5] Colmer, J., O'Neill, C. M., Wells, R., Bostrom, A., Reynolds, D., Websdale, D., Shiralagi, G., Lu, W., Lou, Q., Le Cornu, T., Ball, J., Renema, J., Flores Andaluz, G., Benjamins, R., Penfield, S., & Zhou, J. (2020). SeedGerm: A cost-effective phenotyping platform for automated seed imaging and machine-learning based phenotypic analysis of crop seed germination. New Phytologist, 228(2), 778–793. https://doi.org/10.1111/nph.16736

UNIVERSITY OF
HOHENHEIM

THANK YOU FOR YOUR ATTENTION!

S. Bopper, T. Hograefer, M. Kruse | University of Hohenheim, Germany