High-throughput phenotyping of seed germination, twenty years of experience at GEVES

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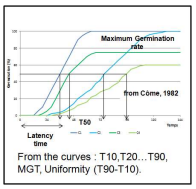
Introduction

The faster a seed germinates, the better its physiological condition.
Germination study (radicle emergence) is important to evaluate precisely seed quality. Germination of seed sample among imbibition time is represented by a sygmoid curve. From curves, several traits can be extracted like Mean Germination Time, percentiles (T10 to T90) and uniformity .
GEVES has collaborated with INRAE, Angers University and ESEO to develop a computer-vision based prototype to phenotype seed germination.



From the curves : T10,T20…T90, MGT, Uniformity (T90-T10).


Sugarbeet germination Aker project

From proof of concept to high throughput experiment

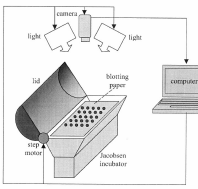
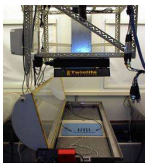
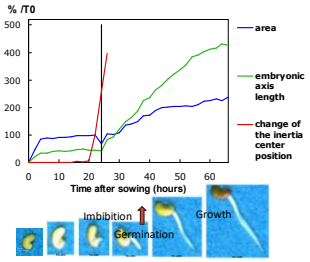


Fig. 1. Schematic representation of the image acquisition system.


First prototype one camera 768x576 pixels (25 seeds)



Demilly et *al*. 9th ISSS conference on Seed Biology, Olsztyn Poland, July 6-11, 2008

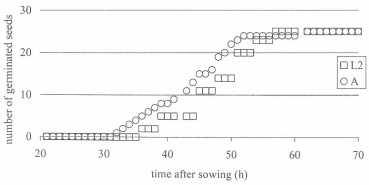
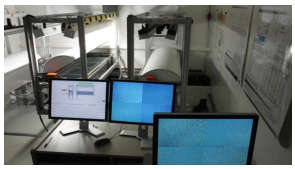
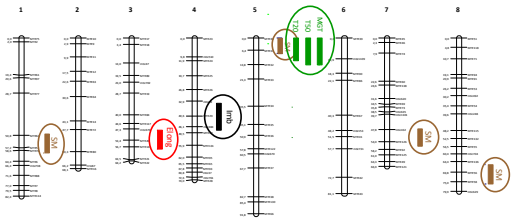


Fig. 10. Germination kinetics at 20 °C of 25 sunflower seeds (series 9), derived (A) from the automatic algorithmic procedure and (L2) from examination of images on a monitor screen by human expert number 2.

Ducournau et *al. Seed Sci. & Technol*., 2004 ; Comput. Electron. Agric., 2005


First version 4 cameras 1280x1024 pixels 100 seeds/camera

First high troughput experiment: QTLs mapping of Medicago truncatula



QTLs identified for seed mass and traits associated with germination and growth at 20°C in the RIL4 population

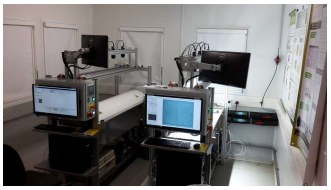
Experiment : 178 lines and parents from the crossing of 2 Medicago truncatula genotypes ; 100 seeds / line

SM seed mass **Imb** imbibition **T25/T50** time for 25%/50% germination **MGT** mean time germ. **Elong** elongation

Dias et *al. Theoretical and Applied Genetics*, 2011

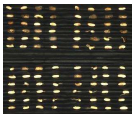
Improvement and wider use

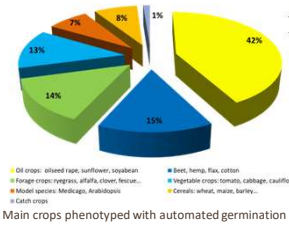
- 5 Jacobsen incubators in two climates chambers
- Optimal and suboptimal, 2 experiments in parallel in the two climate chambers
- High accuracy temperature regulation from 5 to 34°C +/-0.5°C
- Sowing design zone 5x5 with sowing equipments
- Continous watering of blotters
- Tests in rectangle petri boxes with PEG to apply water potential stresses



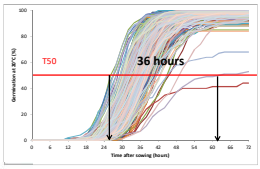
- 4 RGB cameras per incubator
- Image shot automation
- New cameras 2349x1953 pixels, up to 600 seeds/camera
- Workflow : sowing, image acquisition, image sequence analysis, data- management
- Total : 1.4 million of seeds on 318 000 RGB images on 42 species since 2005


Sowing plate for analysis on top of paper


Analysis on pleated paper for large legume seeds



Main crops phenotyped with automated germination tools

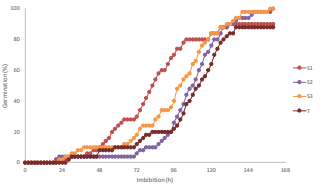


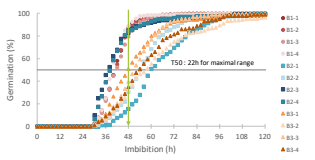
Oilseed rape, 246 cultivars produced twice in the same conditions. 50% of germination from 26 to 62h after sowing.
Hatzig *et al., Front. Plant Sci.*, 2018

PLANT-KBBE CONVIGOUR

Applications

Seed vigour evaluation,
Seed physiology knowledge,
International seed testing development: radicle emergence test,
Genetic resources screening in stress abiotic conditions,
Seed treatment evaluation for priming or biostimulants.


Germination time courses of wheat for 1 varieties with 3 treatment of biostimulant at 10°C. *Dupont et al*, Biostimulant World Congress. 2023.



Germination time courses of cabbage (Brassica oleracea) for 3 varieties 4 lots/variety at 20°C. High variability and best correlation with field emergence 7 days after sowing for 48h of imbibition (R^2=0.7543) ; Wagner *et al.*, Seed Sci. & Technol. 2024

Conclusion

Thanks to the automatic acquisition of images of seed germination and the analysis of these images, it is possible to obtain precise germination time courses with many useful data, even at night and on weekends. It is thus possible to extract from these germination time courses, traits relating to seed quality and vigour.

Poster ref. P4.2-012

European Plant Phenomics Symposium (EPPS) – 2025 Bonn Germany