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Application of Microcalorimetry to Plant Technology: Germination and Initial Growth

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Instrument:

2277 Thermal Activity Monitor

Field of Application:

Biology

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Introduction

In practice, the aging of plant seeds is an economic problem. Evaluation of the effect of storage conditions on the germinal force of seed grains is subjective and laborious. The use of calorimetry in the field of plant physiology, particularly when related to seed germination, was described in a review by Calvet and Prat (Ref 1). Their conclusion was that the thermal behaviour of plants was considered to be one of the most accurate reflections of their functional activities.

A classical example of the thermogenesis of plants is the heat produced by germinating seeds, for example barley when used in the brewing process. Two distinct phases of thermal activity can be distinguished. A physicochemical phase which is caused by uptake of water by the seeds, followed by a biological phase which is primarily due to the activation of cell metabolism and mitosis.

Some preliminary results of the study of germination of young and artificially aged rape seeds are reported and are discussed below.

Experimental

A 2277 Thermal Activity Monitor at 25°C was used to accurately measure the rate of heat production of a number of seeds. Filter paper was placed at the bottom of disposable glass ampoules and moistened with 250µl of water. The seeds (40 - 125mg) were placed in the ampoules and then capped. A glass ampoule without seeds was used as a reference. The ampoules were subsequently pre-equilibrated for 20 - 30 min in the TAM prior to lowering into the measuring position.

Results and Discussion

Figure 1 shows the rate of heat production of young and artificially aged seeds over 48h when undergoing germination. In each case, the initial part of the heat

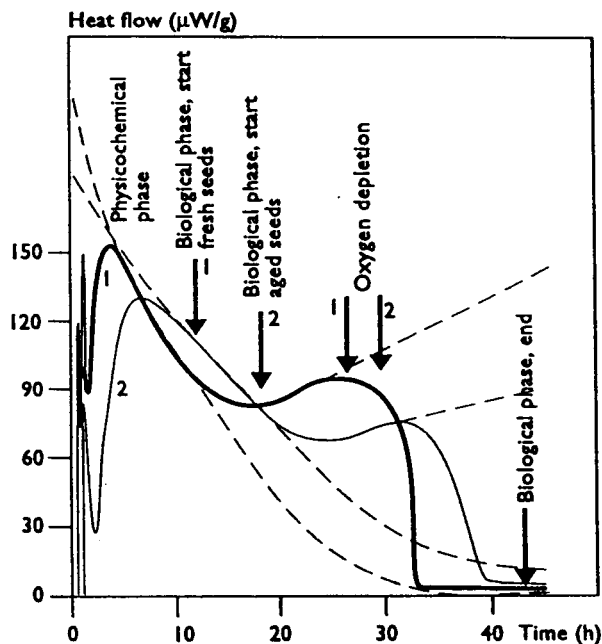


Fig 1. Heat flow curves of young (fresh) and aged seeds measured in sealed glass ampoules.

flow curve mainly represents the physicochemical phase (water uptake). In this phase the seeds are still in the dormant state. The heat output decreases with time and would tend towards zero if no biological process took place in the seeds. An in depth analysis of this part of the curve would provide information about the rate of water uptake which is related to the physicochemical state of seeds.

The second part of the heat flow curve represents the biological activity phase where there is an increase in the biological processes taking place. The fresh seeds are observed to have a more active metabolism than aged seeds.

A sharp reduction in heat output is observed at 25 and 30 hours for the young and aged seeds respectively. This means that both the physicochemical and biological phases have ceased. Oxygen depletion causes the cessation of the biological activity, since removing the ampoules and introducing fresh air results in the continuation of biological activity. The use of a gas flow vessel (Ref 2) would overcome this problem, and hence allow the monitoring of the entire biological phase.

In a separate experiment, to avoid oxygen depletion, the seeds were incubated at 25°C on moistened filter paper for 96 hours outside the calorimeter. Five seeds were taken at various times and transferred to disposable glass ampoules, which were sealed and lowered into the calorimetric units. The average rate

of heat production was recorded over a 30 min period. The biological activity is seen to continue to increase after 96 hours for both sets of seeds (fig 2), but the rate is higher for the young seeds compared to the aged ones.

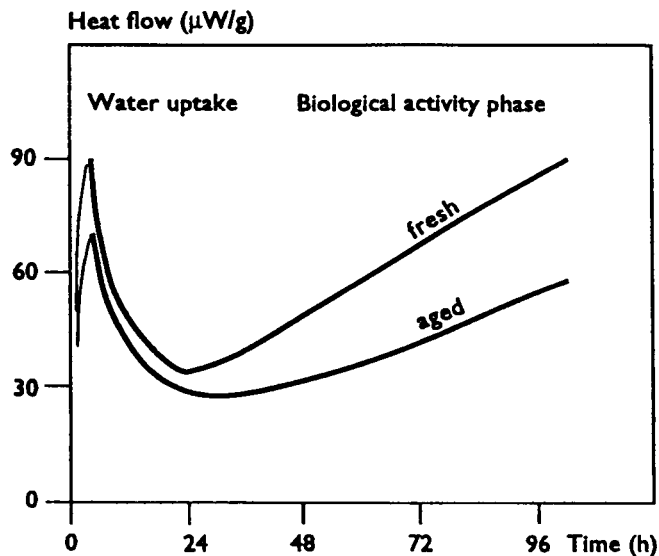


Fig 2. Heat flow curves of young (fresh) and aged seeds taken as point measurements of germination over 96h.

Conclusion

Microcalorimetry is a simple and useful tool to study the physiological processes of plants. The germination of rape seeds was followed and quantified. Correlation between heat output and the state of aging was clearly shown in both the water uptake and biological phases. Reproducibility of measurements was found to be within acceptable limits.

Reference

- (1) Calvet, E. and Prat, H. - Plant thermogenesis. Recent Progress in Microcalorimetry, (ed) Skinner, H. A, Pergamon Press, Oxford. 1963 (p116-128).
- (2) Bakri, A. 1991 - Personal Communication.