Germination and Priming

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The following paper will present some of the basic physiological mechanisms underlying the germination of orthodox seeds. The same mechanisms will be invoked in an attempt to explain "seed priming".

The most important physical/chemical factors influencing the germination process are the availability of water and oxygen and the influence of temperature. The following discussion will make reference to Fig. 1.

When dry seeds come in contact with a sufficiently humid substrate the seed will imbibe water very quickly if the seed coat permits it — this is called Phase 1. Phase 1 is a passive process and will happen also in dead seeds. The seed swells and the water content will level at a plateau. During the next phase, Phase 2 or lag period, the water content will only increase marginally. The duration of Phase 2 varies widely and is dependent on plant species. To a lesser degree it varies by seed lot within a species, however, it is differences in the length of this period between seeds within a lot that determines the uniformity of emergence of a particular lot. After this genetically and environmentally determined Phase 2 the water uptake enters the third and final phase, Phase 3. A sudden increase in water content is seen, which is timed exactly with the perforation of the seed coat by the radical. The consumption of oxygen takes more or less the same course as the water uptake. In Phase 3, after the protrusion of the radical, the consumption of food reserves raises dramatically as a consequence of the strong increase in general metabolism. In seed physiological

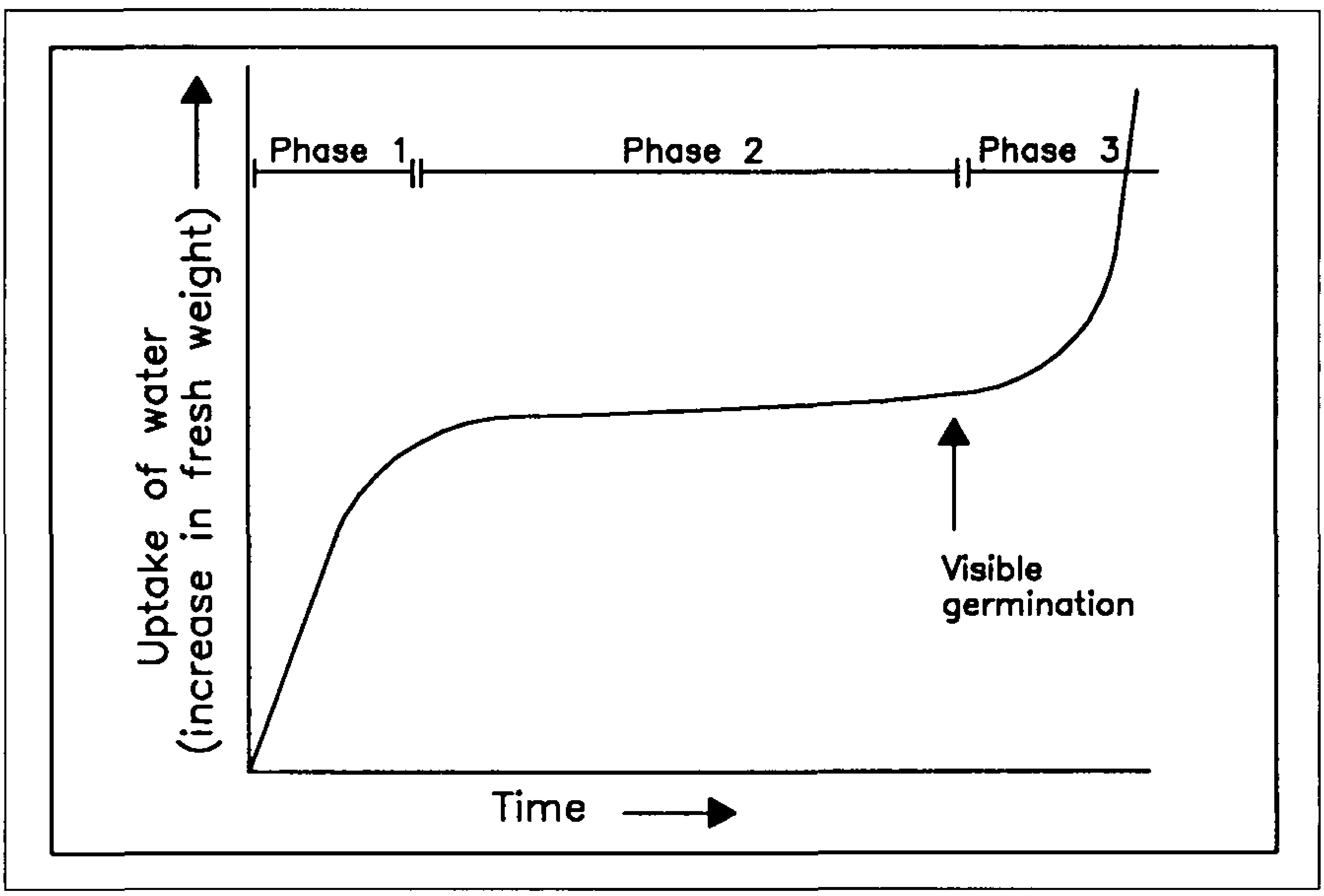

Figure 1. The germination process.

terms, Phase 2 is considered the germination per se, whereas Phase 3 is regarded as a post germination growth phase. This is not in accordance with commonly accepted nomenclature.

In Phase 2 all the cellular processes which are a prerequisite for successful plantlet establishment are initiated and completed. As the water content raises in the seed, the cellular membrane structures are reestablished and repair mechanisms can take place on damage incurred earlier as a consequence of poor seed management or just deterioration as the seeds age. Respiration is initiated, new proteins (enzymes) are formed and the osmotic pressure rises during Phase 2 as a consequence of the formation of simple sugars from more complex structures. To a larger extent, the degradation of the endosperm or other reserve materials takes place only in Phase 3. In the last part of Phase 2 a noticeable amount of DNA is formed, this is a prerequisite for cell division. No such division takes place before Phase 3, all growth, including the growth of the radical at "germination" is accounted for by cell enlargement only. It is the building up of the osmotic pressure within the radical cells which is the direct reason for the raise in turgor pressure which eventually culminates in the protrusion of the radical. In some species a concomitant relaxation *of intercellular binding forces in the structures covering the radical (endosperm)* is also seen.

It is a well known fact that there are large differences in the time from sowing to emergence between plant species. Likewise, differences can exist between single seeds in a lot. It is also known that temperature is influencing the germination/emergence rate as is the water relations of the substrate. As mentioned they are all factors influencing Phase 2 of the germination process. The relations with respect to temperature and water relations has been quantified in the following equations:

1) $\Theta g = (T - Tb)\, tg$

where: Θg is the temperature sum / day degrees necessary for g%, germination
T is the actual temperature
Tb is the minimum temperature for germination
tg is number of days to g% germination

and

2) $\Theta h = (\Psi - \Psi bg)\, tg$

where: Θh is the so-called hydro time constant
Ψ is the water potential of the substrate
Ψbg is the minimum water potential that allows for g% to germinate
tg is the number of days to g% germination

This brings us now to a discussion of seed priming. The purpose of priming is to enhance the emergence of the seeds in a more uniform way under more diverse environmental conditions such as high or low temperatures and/or suboptimal substrate water conditions. The priming process influences all the mentioned cellular processes in the seed during Phase 2. In a physiological way you can say that the seed has germinated. Phase 2 takes place under controlled conditions in a time sufficient to allow the germination processes to come more or less to an end. At the same time the seed water content is kept low enough to hinder radical protrusion. This allows for an extended priming period, which should result in a more uniform emergence. It has been shown that priming does not lower the basic temperature for a certain species for germination. The effect is rather seen in a decrease in the need for day degrees or heat sum after priming as the seeds in effect have "used" a certain amount of the needed "temperature time" during the priming process. The same effect is seen with respect to "hydro time". The seeds have "used" some of the necessary hydro time sum during priming. It is less often seen that primed seed has obtained a lower minimum water potential for germination, in fact, primed seed cannot in general be said to be able to germinate under drier conditions than unprimed seed.

THE MECHANICS OF PRIMING

To have the maximum benefit of the treatment it is necessary to find the combination of water content, treatment time, and treatment temperature that best achieves your goal. There are at least three possible methods to achieve the desired seed water content:

Osmotic Priming. The seeds are held in an osmotic solution under constant agitation during which a predetermined amount of water is taken up by the seeds. The correct osmotic potential is determined experimentally; temperature and time are important variables. After treatment the seeds are washed and dried back to their normal storage water content. This method is the oldest but is not convenient for large quantities of seed because of oxygenation problems and the large amounts of osmoticum which must be discarded.

Matrix Priming. The seed is mixed with a suitable carrier of fine consistency and water in such a way that the seed imbibes a predetermined amount of water. The technique is quite simple and is in fact analogous to what happens when seeds are sown in a medium too dry for germination — the water uptake is limited. The method is rather new and patented in a number of countries by Kamterter Products in Nebraska, U.S.A.

Drum Priming. This is the newest and best method for the treatment of seed in large quantities. This method is also patented in some European countries and U.S.A.

Due to the above mentioned patent we at Dæhnfeldt have developed our own method which is based on the same principles which hold for all the above methods: To add to the seed a predetermined amount of water (this allows cellular germination processes to take place without radical protrusion), hold the seed at this water content for a specific time period at a specific temperature, and then dry the seed back to normal water storage content.