Swelling granular media made of plant seeds: pressurisation and inverse silo effect

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Abstract

Plants do not possess a heart to drive the circulations of their internal fluids, but rely on two mechanisms: osmotic pressure and evaporation. The osmotic effects lead to high turgor pressures, that are responsible for maintaining the shape of non-lignified plants.

Here we are interested in a specific aspect of fluid circulation in plants: the rehydration of dessicated seeds. In contact with water, seeds attract water through osmotic effects leading in a strong volume increase and possibly strong pressures. Plants seeds act as elements of peculiar type of granular media, not really studied in literature: swelling granular media. The main objective of this talk is to present the physics of imbibition of these plant granular media.

First we will show the temporal dynamics of imbibition of single seeds in water, using chickpeas because of their near spherical shapes. The volume increased by a factor three, and we model the dynamics of imbibition using two kinetic models: diffusion trough the volume and membrane limited regime.

Second we measured the forces exerted by seeds when they are hydrated and confined in spaces, such as in between two planes, in a tube or within a chamber with a piston. In an a chamber full of seeds, we could measure contact pressures as high as 8 bars in a chamber. In a vertical tube we observe an inverse Janssen effect, were the pressure increases very rapidly when entering deeper in the stack, exactly the opposite as the traditional Janssen effect.

Third we will generalize these findings with different types of plant seeds or artificial hydrogel materials. Finally, we aim at using this granular media as an autonomous media to exert pressures by sole imbibition reproducing the phenomenon of turgor pressure.

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