Mind the gap – Pol II transcription between seed maturation and germination

Seeds are incredible phases in the plant life cycle that hold the potential to sustain life for thousands of years. During that time, if they remain in a dry state, they are almost inactive. While we often focus on their germination and subsequent seedling growth, many crucial seed properties are established when they mature on the mother plant. To achieve exceptional endurance, desiccation tolerance, and gather storage materials, maturing seeds need to fulfil a complex gene expression program. This means that specific genes must be turned on and off in a strictly orchestrated order. When seeds finish their maturation, they start the general shutdown of the maturation program, but they do not do it thoroughly. Some program elements are required to reactivate when dry seeds perform water uptake. While surprising, this is explained by the fact that seeds very rarely encounter perfect conditions for germination after they soak in water. The parts of the seed maturation program are required to postpone germination until the environment is safer for the growth of the fragile seedling. Interestingly, the conditions in which plants grow affect the progression of the seed maturation program, which leaves a trace in dry seeds. One type of this influence is how much the seed maturation program was shut down. For example, if a maturing seed feels low temperature, the seed maturation program will continue for longer. Consequently, dry seeds matured in the cold will have a higher seed maturation program activity, making them germinate later, even if perfect conditions are encountered upon water uptake.

But how is this information recorded in dry seeds, which are almost entirely inactive? In desiccated seeds, the interior of their cells turns into a glass-like material, and large molecules, including DNA, become very condensed and inaccessible for most processes. However, genes for their expression require polymerase II to bind DNA and transcribe it into mRNA. The proposed by me mechanism is relatively simple. Despite most polymerases being removed from DNA at the final stages of seed drying, some polymerase molecules persist on selected genes for the whole dry seed storage period. Later, during water uptake, those polymerases serve as bookmarks to facilitate the transcription of these genes. In this way, seed maturation memory may be mediated by the binding pattern of polymerases to a set of specific genes. However, this is still a hypothesis that I want to confirm in this project by maturing seeds under different conditions and checking polymerase II occupancy. I also want to learn which processes lead to polymerase storage on the selected genes upon seed drying and the creation of a "bookmark", as it will also allow us to understand the transcription process in plants better. Moreover, polymerase binding may have additional functions, such as repairing DNA damage created when DNA is condensed during seed desiccation. These experiments, and many more not mentioned here, will comprehensively explain polymerase II functions in seed maturation and germination. As seeds form the basis of agriculture, my project, in the long run, may have huge application potential as it may help to improve seed production for farming.