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Editorial

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The combined effects of climate change and a growing world population mean that food security is increasingly an issue of concern. The recent 27th United Nations Climate Change Conference, COP27, held in November 2022 saw the launch of the Sharm-El-Sheikh Adaptation Agenda (2022) which recognises that food and agriculture systems will need to become more climate resilient, sustainable, and provide improved yields. Seeds will have a key role to play in achieving these goals, and the papers in this issue provide examples of how seed science can help respond to the changing climate as well as mitigate against the effects of climate change. From providing innovative solutions to improve seed performance, to conducting research on species that have not previously been well studied, research into seed science and technology will help us to achieve the more resilient agricultural systems envisaged in the Adaptation Agenda.

Many innovative solutions to improve seed quality are currently being investigated and several papers highlight the diverse work that is being done in this area. Touchette and Cox (2022), have investigated using pharmaceutical gelatin capsules as a seed enhancement (figure 1). They show that the gelatin itself can act as a biostimulant, promoting root development and plant growth. The capsules have an additional function – they can be used as a system to deliver other treatments such as fertilisers in a controlled and safe manner, reducing possible harmful effects of the treatments were they to be applied directly to the seed. Erasto *et al*. (2022) investigated using natural plant extracts as an alternative to traditional fungicides (figure 2). The authors show that plant extracts of neem, ginger and coffee are more effective as anti-fungal agents if extracted in water than in ethanol. The natural extracts may be safer, less toxic and cheaper than traditional fungicides.

Figure 1. Sowing gelatin capsules containing tomato seeds, from the study by Touchette and Cox (2022). Photo credit: Brant Touchette.

Figure 2. Organic farmers from Mvomero district, Morogoro region-Tanzania ready for seed sowing (field experimentation) in relation to the study by Erasto *et al*. (2022). Photo credit: Rehema Erasto.

Jovičić *et al*. (2022) investigated the effect of hydration treatments on sunflower seed vigour (figure 3) and noted that the effectiveness of the invigoration treatments was dependent on the initial condition of the seed lot, with the treatment being more effective on seed lots with lower vigour. This is consistent with previous work which showed that priming treatments were more effective on aged than non-aged seeds (Powell *et al*., 2000; Butler *et al*., 2009). It is important to be aware of potential variability between seed lots when considering what the response to treatment may be. In addition to the fact that seed lots may respond differently to priming or enhancement treatments, individual seeds within a lot may also respond differently. Seed lots are not uniform, particularly if they have been collected from wild populations, from crops that have indeterminate growth habits and produce mature seed over an extended time period, or where seed lots have been stored and in which individual seeds may have deteriorated at different rates. It is important that research into treatment development is based on seed lots that represent the quality of the seed on which the treatment will eventually be used. Those developing seed treatments for improving quality should take these findings into account when providing advice on how to use treatments.

Figure 3. Germinating sunflower seeds. Photo credit: Dušica Jovičić (Institute of Field and Vegetable Crops).

Han *et al*. (2022) investigated priming with oligosaccharide solutions on foxtail millet (*Setaria itallica*). They studied the effect of priming on seed lots that were subsequently subjected to drought stress by germinating seeds on solutions of polyethylene glycol (PEG) of different concentrations. When under osmotic stress, seeds that had been primed with oligosaccharides showed improved performance. In this case drought conditions were investigated, but there could be similar benefits of priming for improving a seed’s ability to respond to temperature stress, disease pressures, etc. Further study in this area could be beneficial.

A more unusual method of enhancing seed quality is the flash flaming technique described by Ling *et al*. (2022). Briefly exposing seeds to a flame is shown to improve the handling properties of seeds with a range of different morphologies (figure 4). The flame singes seed appendages, reducing the size of the overall seed unit, this makes seeds easier to handle, store and transport, and enables seeds to pass through mechanical seeding devices more easily. An indirect benefit of the flaming was an improvement in germination in several of the species in the study – believed to be a result of the removal of seed covering structures and alleviation of physiological dormancy. The authors note that effects of the flash flaming treatment on seed longevity are not yet known and should be explored in future.

Figure 4. Unflamed (top) and flamed (bottom) diaspores of *Triodia wiseana* from the study by Ling *et al*. (2022). Photo credit: David Symons.

Innovative seed treatments are one way in which seed science can contribute to the climate emergency response. With increasing demands on available agricultural land, it is likely that crops will be grown under poorer conditions, sowing may take place in sub-optimal conditions and seeds may have to be harvested before they have reached maturity and achieved their full potential. Treatments that can improve the quality of seed for sowing or improve performance in specific conditions will be in demand.

The Adaptation Agenda also calls for diversifying production, and the restoration of land. To achieve this, there will be a need to work with less well studied species, undomesticated species, and with seeds in which dormancy levels are high. Seed scientists have long been concerned with methods of classifying dormancy, breaking seed dormancy (Baskin and Baskin, 2004) and understanding how dormancy is affected by environmental conditions (Finch-Savage and Leuber-Metzger, 2006; Penfield and MacGregor, 2017). The study of how dormancy is affected by and interacts with the environment will be vital to understand future effects on seed production. In addition, investigations of the behaviour of less studied species will be required in order that they can be utilised.

Geng and Peng (2022) have investigated dormancy and germination in *Osteomeles schwerinae*, a shrub endemic to the Hengduan region in China. The species is a good candidate for improving soil conditions, restoring vegetation and conserving water, this work investigating how to break dormancy and improve germination is important to ensure that the species can be utilised in future.

Moghimifam and Haghighi (2022) investigated dormancy breaking in seed of three Iranian forest species (figure 5), showing that soaking in concentrated acid combined with long stratification periods (up to 90 days) were required for optimum germination. This highlights the difficulties of working with and propagating such species with a combination of physical and physiological dormancy.

Figure 5. Trees and fruits of *Cornus mas*, one of the species studied by Moghimifam and Haghighi (2022). Photo credit: Roya Moghimifam.

The study by Liu *et al*. (2022) shows how nitrogen deposition affects germination and dormancy of species in the cold desert (figure 6). They studied nine species, four of which were significantly affected by nitrogen, with the response being species specific – in some species nitrogen inhibited germination, but in others, nitrogen had a positive effect on germination, particularly at lower concentrations. It has been suggested that short-lived species, such as those in this study, could be especially vulnerable to climate change (Compagnoni *et al*. 2021). It is therefore particularly important that such plants are studied so that we can predict how they might respond to environmental changes. Changes in nitrogen deposition are usually a result of human activity, particularly fertiliser application. The data collected in this study will help predict how populations may respond in future, as well as inform future plant restoration strategies.

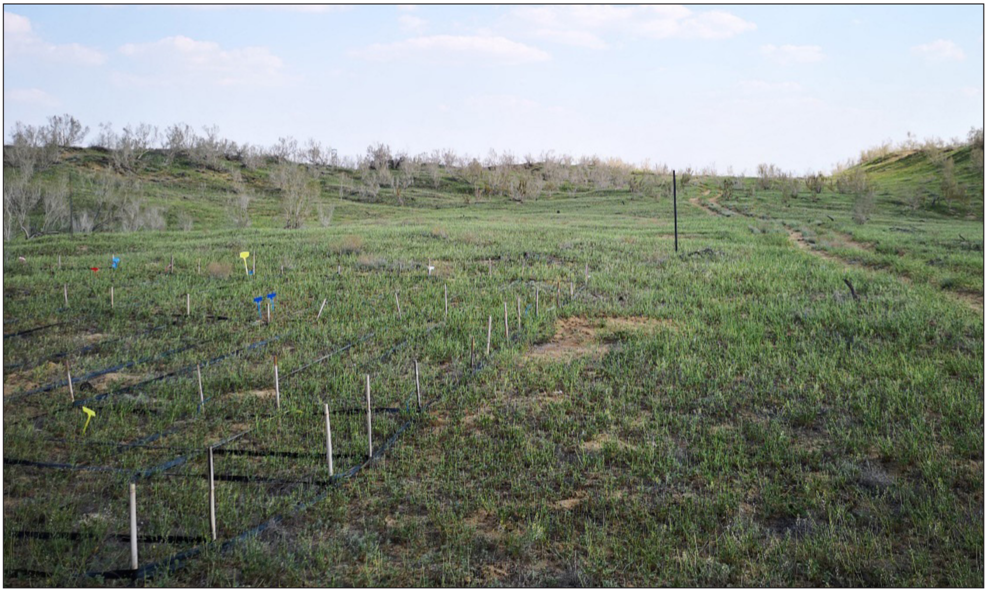
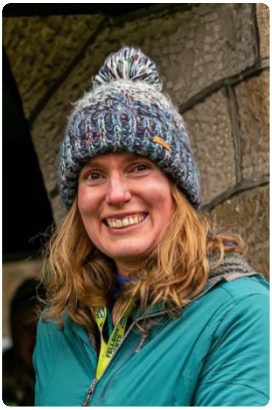


Figure 6. Ephemeral plants studied by Liu *et al.* (2022). Photo credit: Huiliang Liu.

Seiler (2022) presents work from a 38 year experiment where germination of wild sunflower seed has been monitored over time. Seeds lose viability in a predictable manner depending on their storage conditions (Ellis and Roberts, 1980; Ellis, 2022) and here actual viability is compared with the change in germination predicted by the viability equations. For *Helianthus petiolaris* the predicted values compare almost perfectly with the true viability after 28 years. In *H. annuus* the actual germination values are slightly better than predicted values. In addition to showing that even under sub-optimal storage conditions sunflower seeds can maintain viability over considerable periods of time the data highlight the importance of monitoring of seed collections to ensure that changes in viability are detected at an early stage.

Munyaneza *et al*. (2022) show the importance of selecting the most appropriate test for seed quality. They have studied two species of forage grass, on which various tests for seed vigour have been conducted and the correlation of these test results with field emergence observed. The results demonstrate the importance of determining the correct vigour testing conditions for different species. The optimum time for recording radicle emergence, or for subjecting seeds to ageing conditions differed depending on species. In addition, although several of the tests correlated with field emergence some of the tests had better correlations than others. Knowing which vigour test is most appropriate to use is important if seeds will be sown into sub-optimum conditions, which, with climate change may become a more common occurrence.

In summary, the testing of seed quality has always had an important role to play in agriculture and in ensuring food security. Good quality seeds are needed to guarantee that crops establish well in the field and produce a high yielding crop. In future there may increasingly be an emphasis on how we can improve seed lots, and several articles in this issue have described novel post-harvest treatments that can be used to improve seed quality. The idea of priming seeds to improve uniformity of performance is well established, but seed invigoration methods are continually being improved and novel priming media being investigated. If we start to diversify our agricultural crops then research may well shift away from traditional crops and varieties and towards less well understood underutilised species which are perhaps better adapted to future conditions, in such instances the understanding of how we can break dormancy and ensure good germination in these species is vital to their utilisation. We know that climate change will have a significant effect on agriculture over the coming years. The papers in this issue of Seed Science and Technology give some good examples of how seed science and technology can help to ensure that agricultural systems will be able to adapt.



Laura Bowden

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