Feeding 9.6 Billion People...

- United Nations\(^3\) estimated human population to reach 9.6 billion by the year 2050.
- World food production must increase even more to meet food demand.
- Pollution & environmental damage caused by agriculture is currently a major concern.
- Climate change – drought also becoming a threat for field crop cultivation.
- Sustainable agriculture is essential to protect the environment while increasing food production.
- Natural hydrogels\(^2\) are key materials that can promote plant growth in critical conditions while keeping environmentally-safe.

Project Aim

This project is based on the concept of applying hydrogel technology for agricultural/horticultural use.

The aim is to film coat seeds (Fig. 1) with environmentally friendly hydrogels (Fig. 2) made of natural polymers such as \(\iota\)-carrageenan (Fig. 3) that are biodegradable and non-toxic.

Potential benefits include:
- Faster and higher seed germination rates (Fig. 4)
- Promote water and soil conservation
- Provide protection of seeds against pests
- Low material cost\(^2\) and safe handling

Preparation of Hydrogels and Analytical Tests

1. Hydrogels were formulated by blending natural polymers
   - Agar-/\(\iota\)-carrageenan blend (AC) hydrogel

2. Hydrogels were characterised by swelling studies (Fig. 5) in:
   - 0.1 M NaCl and CaCl\(_2\) solutions
   - pH 4, 7, and 10 buffer solutions
   - The weights of dry and swollen gels were recorded in set time intervals for up to 168 hr

Swelling studies in Saline solutions

![Swelling capacity of AC hydrogels measured in saline solutions](image)

From this study it was found that the natural agar-/\(\iota\)-carrageenan (AC) hydrogel under was more sensitive to CaCl\(_2\) solution than NaCl solution. It was also noticed that in both saline solutions, the AC hydrogels showed higher resistance to disintegration compared to the hydrogels kept in distilled water shown by the large error bar (Fig. 6). In summary, the swelling % of the AC hydrogel and its life-span can change by the difference in the types of salt present in the water.

Swelling studies in pH buffer solutions

![Swelling capacity of AC hydrogels in various pH buffer solutions](image)

From this study it was found that the swelling capacity of natural agar-/\(\iota\)-carrageenan (AC) hydrogel under pH 4 and 7 were similar but tended to reduce in pH 10 buffer solution (Fig. 7). Particularly at times between 0.5 to 72 hrs seemed to swell less in pH 10 than the other two buffer solutions. The swelling % then gradually increased until it reached closer to those of the hydrogels in pH 4 and 7. The AC hydrogel swelling rate changed by the change in the pH of the solution.

Summary and Future Work

The novel agar-/\(\iota\)-carrageenan blended hydrogel coating showed some interesting swelling characteristics under different types of saline solutions and pH levels. The hydrogels acted as smart-gels\(^{16}\) where it changes its swelling behaviour depending on the change in stimulation by the surrounding environment, typically ions, pH levels, or temperatures for example.

Applying the concept of smart-gels which acts as a controlled drug releasing device, incorporation of ‘green pesticides’ and or ‘beneficial microbes’ into the hydrogel is suggested for future work in this study, in order to provide protection of seeds and further growth promoting effect. The controlled release of these active ingredients can greatly promote sustainable pesticide or nutrient management which could contribute to the reduction of pollution into the environment without reducing crop yield.

The preliminary germination study gave an insight to the use of our novel natural hydrogel as seed coatings to speeding up germination for wheat seeds\(^3\). It is anticipated that this natural seed coating can be applied to different variety of seeds and contribute to future food sustainability.

References:
4. Estimated material cost based on quotations from Sigma-Aldrich. 50g of Agar/Carrageenan cost €33.67. 50g of polyvinylalcohol cost €286.0 (Purchased 2015).