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Performance of seed germination on cellulose-based hydrogel

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Abstract

Agricultural sector plays a key role in global food security. Urban farming plays a big role in reducing food insecurity in many developing countries. One of the approaches in urban farming is the application of hydrogel. Hydrogel possesses suitable features to promote seed germination, with its amorphous structure and water holding capacity that it may provide water for imbibition. Cellulose-based hydrogel being biodegradable is also advantageous to agriculture. The aim of this research is to assess the performance of cellulose-based hydrogel as the seed germination media for *Ipomoea aquatica*, *Brassica juncea*, *Lactuca sativa* and *Solanum lycopersicum* in comparison with perlite and soil. Each species had 150 seeds sown directly in each media and results were recorded after 15 days. The result of the study demonstrated that hydrogel had the highest germination with *Brassica juncea* plant species with seed germination percentage of 70.67% while perlite was the best germination media for *Ipomoea aquatica*, *Brassica juncea* and *Solanum lycopersicum* with seed germination percentage of 86%, 85%, and 90%, respectively. Hydrogel holds great potential in becoming an alternative seed germination medium.

Keywords: Cellulose, hydrogel, seed germination

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1. Introduction

Food security means having access to required food to meet dietary needs for a healthy lifestyle. To date, food insecurity and under nutrition remain serious issues [1,2]. Research and development in urban farming technology have strengthened the agriculture sector. In traditional farming, the limited space, soil fertility and water usage issues are the bottlenecks. Urban farming in developing countries has benefited food security by providing city markets with fresh produce witnessed by 100-200 million urban farmers [3]. Urban farming can be further improved by employing the latest technologies such as integrating hydrogel as an alternative to the soil for improving water usage and nutrient supplementation [4]. Hydrogel has been applied in the soil as a soil conditioner and controlled-release fertilizer [5]. It has been used in agriculture over the past five decades, and it is found efficient as a water-holding reservoir and nutrient mobilizer when used in the soil [6]. Hydrogel used in combination with other substrates such as vermiculite, pine bark [7] and perlite has also proven to have a positive effect [8]. Cellulose-based hydrogel offers an environmental-friendly solution to improve the water usage problem, which also tackled the zero-waste effort in reducing agricultural waste [9]. Due to the hydrogel capacity of holding water and delivery system, it will have the ability to supply water to the seeds for germination to take place [10]. Having said that, the essential factors for seed germination are water availability, conducive temperature, oxygen supply, and light intensity depending on plant species [11,12]. The first stage of seed germination is the hydration of seed, known as imbibition and the second stage is the initiation of principle metabolic processes [13]. It has been used in agriculture over the past five decades, and it is found efficient as a water-holding reservoir and nutrient mobilizer when used in the soil.

Here, we have applied hydrogel in seed germination. Thus, this study explores the ability of hydrogel as a medium to germinate seeds in comparison to soil and perlite. The main aim of this study is to assess the performance of seed germination in cellulose-based hydrogel compared to the controlled variables. The suitability of the germinating media and the relationship between germination percentage and the characteristic of the germinating media observed through the variable pressure scanning electron microscope (VPSEM) were discussed.

2. Materıals and methods

2.1. Materials

Cellulose in the form of cotton was ordered from China. The cross linker epichlorohydrin (99%) (C_3H_5ClO) was purchased from Sigma Aldrich, urea (CH_4N_2O), and sodium hydroxide (NaOH) purity of ≥96% were obtained from R&M Chemicals. Plant seeds were obtained from Lutie Nursery, Kajang, Malaysia. The growth media used in the study are soil, perlite, and hydrogel.

2.2. Preparatıon of cellulose hydrogel

Hydrogel was prepared from a solvent solution consisting of NaOH/urea/dH_2O solution (100 g) in the proportion of 7:12:81 respectively with continuous stirring. The solution was then kept in the freezer overnight. About 3 g of cotton was dissolved in the aqueous solvent at -13°C. The resulting mixture was crosslinked with a cross linker and stirred continuously to get a homogenous solution and followed by storing in the fridge [14, 15].

2.3. Seed germination percentage

The seeds of *Ipomoea aquatica*, *Brassica juncea*, *Lactuca sativa*, and *Solanum lycopersicum* plant species were sown onto the soil, perlite and hydrogel. The seed germination was carried out in the growth room at 22°C under the 4000 K LED light source and results were obtained after 15 days.

i. Method 1: Soil

150 seeds were directly sown in the soil for each species and were watered every two days.

ii. Method 2: Perlite

150 seeds were directly sown in the perlite for each species and were watered every two days.

iii. Method 3: Hydrogel

150 seeds were directly sown in the hydrogel for each species and were watered every two days.

2.4. Characterization of germinating media

The morphology aspects of the germinating media were observed under variable pressure scanning electron microscope (VPSEM).

3. Results and discussıon

3.1. Seed germination percentage

The results revealed that perlite is the best media for seed germination for all plant species tested except for *Lactuca sativa* as represented in Fig 1. *Brassica juncea* showed the highest germinated rate in the hydrogel. The rate of seed germination for *Ipomoea aquatica*, *Brassica juncea*, and *Solanum lycopersicum* were 86%, 85% and 90%, respectively in perlite, while the germination rate of *Brassica juncea* in the hydrogel was 70.67%. Hydrogel is comparable to soil because there is no significant difference in terms of performance to soil, which indicates hydrogel also can be used as a medium for seed germination. For *Brassica juncea* and *Lactuca sativa* there is no significance difference among the medium types tested. Thus, hydrogel can be potentially used as a seed germination medium.

3.2. Microscopic view of perlite and hydrogel

The lightweight and amorphous structured perlite is a volcanic glass as captured through VPSEM in Fig.2 (a) [16 ,17]. Such material characterizations have been adapted well by the three plant species encouraging germination of the seeds. On the other hand, hydrogel used in this study is a cellulose-based polymer sourced from cotton linter as cellulose is one of the most abundant polysaccharides [18,19]. Thousands of β(1-4) linked D-glucose units in the cellulose chain carry plenty of hydroxyl groups [20]. The hydrophilic functional groups aid in water absorption and retain water [21, 22, 23]. During the formation of hydrogel, the crystalline structure of cellulose is demolished and changed to amorphous regions. The crosslinking of the dissolved cellulose solution process contributed to a decreased crystallinity index [14]. The transformation from crystalline structure to amorphous structure has led to a higher porosity of the hydrogel [10]. On this account, hydrogel produced in this study is porous, as displayed in Fig 2(b). Porous structure helps in aeration for oxygen availability to the seeds. These properties may have contributed to the higher seed germination rate of *Brassica juncea* plant species in hydrogel.

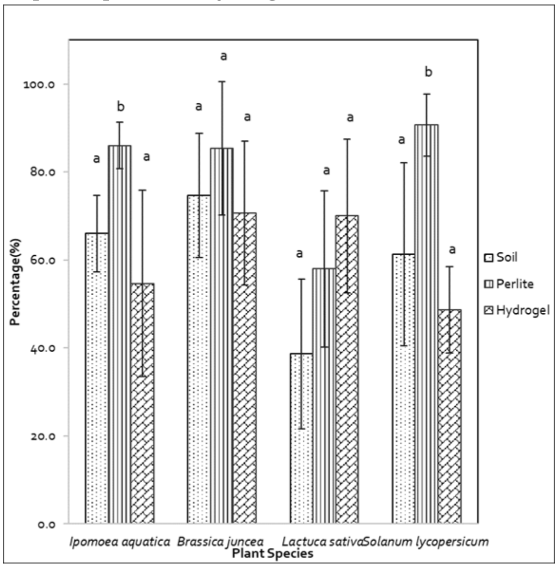

Fig. 1: Seed germination percentage in soil, perlite and hydrogel. Error bars represent standard deviation of the mean. Letters indicate significant differences between hydrogel and controlled variables with $P < 0.05$, n= 150

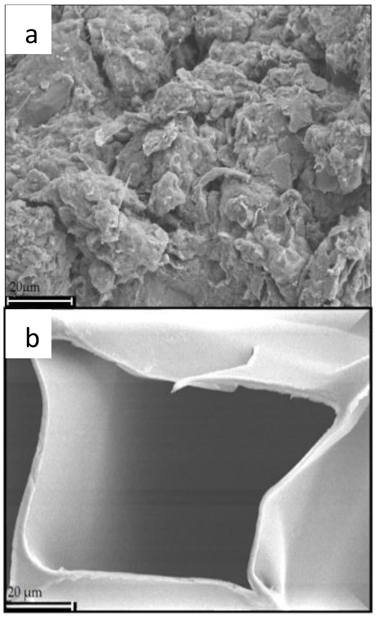

Fig. 2: VPSEM images of freeze-dried (a) perlıte-magnification of 1000 X and (b) hydrogel-magnification of 1000X

4. Conclusions

Hydrogel has comparable performances compared to soil and perlite as a seed germination medium in some plant species. Hydrogel has shown a significant seed germination rate indicating the highest germination is with *Brassica juncea* plant species. Hydrogel has huge prospects in emerging as a suitable germinating medium, and there are more room for improvements in terms of hydrogel preparation and customization of plant species in the future. Hydrogel potentially can be used as a seed germination medium.

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