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Hydrophilic polymer film coat as a micro-container of individual seed facilitates safe storage of tomato seeds

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ABSTRACT

In high-value, low-volume crops like tomato, the high seed multiplication ratio and low seed rate often leads to large quantity of carry over seeds. Seeds lose viability over time, which manifests in poor crop establishment in the field. Hydrophilic polymer seed coating has been examined for better crop establishment and as a delivery system but has not been investigated as a means to maintain seed quality during storage. Hence, the present study was undertaken to investigate the use of hydrophilic polymer (Disco Clear) film coating as a tool for ensuring safe seed storage. Seed moisture kinetics under saturated atmospheric conditions revealed lower moisture adsorption and desorption pattern in hydrophilic polymer-coated seeds as compared to non-coated seeds. However, when exposed to freely available water, hydrophilic polymer facilitated faster and more controlled imbibition, which manifested in reduced mean germination time. Seeds coated with hydrophilic polymer maintained the quality over a longer storage period than non-coated seeds, irrespective of the packaging material and storage conditions. In polymer-coated seeds that were stored in paper bags under ambient room conditions, non-significant differences were observed for all the observed seed quality parameters for longer period thereby indicating its practical application as an alternative to storage under regulated environment. The presence of the hydrophilic polymer film coat acted as a physical barrier for absorption of moisture in the vapour phase and hence, under ambient conditions, the film coated seeds remained effectively protected from equilibration with fluctuating relative humidity, in a manner comparable with storage in moisture impervious containers. Considering this fact, we propose that the polymer film coat in itself acts as a micro-container for seed and thereby facilitates safe seed storage for an extended length of time.

1. Introduction

Quality seed, being the basic input in agriculture, plays an important role in realizing optimum yield and productivity of any crop. Seeds with high quality and vigour will not only help in achieving optimum plant populations in the field but also result in vigorous seedlings, which can surpass the initial abiotic and biotic stresses to a significant extent. Hence, the quality and physiological status of each seed the farmer buys is crucial for attaining desirable returns, especially for high-value, low-volume crops like tomato.

Seed being a living entity, loses its quality and physiological status over a period of storage. In tomato, storage of carryover seeds is unavoidable due to its high seed multiplication ratio, relatively low seed rate requirement and fluctuating preferences in the seed market. In order to maintain the seed quality during storage, seed entrepreneurs resort to safe seed storage under regulated conditions, which adds to the market price of the seed. This cost is comparatively higher in tropical and sub-tropical regions than in temperate regions. Thus, there is need for a suitable seed technological intervention that could ensure effective maintenance of seed quality under ambient storage, by curtailing the seed deterioration rate and thereby providing a more economical and eco-friendly alternative to seed storage under controlled conditions.

As seed deterioration is inexorable, the performance of stored seeds is always poorer than freshly harvested seeds. In order to enhance the performance of stored seeds, several seed quality enhancement techniques have been developed and commercialized in the seed industry during the past several decades and the most widely adopted among these are seed priming and coating technologies.

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In the past few decades, seed coating technology has evolved through research innovations and has delivered several products that can be used to manipulate the performance potential of the seeds and subsequent crop. Seed coating technology is being widely used for different purposes like synchronization of flowering between parental lines (Johnson et al., 1999), for precision sowing (Lagoa et al., 2012), for seed quality enhancement (Kumar et al., 2007), delivery of nutrients (Farooq et al., 2012), for early sowing in cold and wet soils (Sharratt and Gesch, 2008), delivery of growth hormones (Gevrek et al., 2012), delivery of pesticides (Sherry et al., 2007), delivery of bio control agents (Mastouri et al., 2010), as a bioactive coating (Ziani et al., 2010) and as anti-counterfeiting technology for eliminating fake seeds in the market (Guan et al., 2013). Thus, with the seed coating concept becoming a practical reality for different applications, there is now accumulating interest in multiple aspects of this technology, whereby its application can be extended to different crops that are grown and stored under different agro-climatic conditions.

Among different kinds of polymers, hydrophilic polymer formulations have been proven to enhance crop establishment particularly under sporadic rainfall or drought spell conditions during early growth phase. However, little is known regarding the storage behaviour of hydrophilic polymer-coated seeds. It is well established that since the seed is hygroscopic, the seed moisture content of the stored seeds fluctuates with the fluctuating relative humidity (RH) of the storage atmosphere resulting in faster seed deterioration (Buitink et al., 2000; Murthy et al., 2003). In this context, the response of hydrophilic polymer coat to fluctuating RH and its impact on seed quality needs to be critically assessed prior to its application as a tool for enhancing quality of seeds. In tomato, hydrophilic polymer coating is already reported to act as an effective delivery system for seed protectant chemicals (Jacob et al., 2009). But its wider commercial utilization will be feasible only if the effect of the hydrophilic polymer on seed storability is established. The present study aims to analyze the effect of a hydrophilic film coat on tomato seed quality held under different storage conditions.

2. Materials and methods

2.1. Plant material

Freshly harvested seeds of tomato, *Lycopersicon esculentum* (L.) Mill. cv. Pusa Rohini, were subjected to film coating, in batches of 100 g. The coating was carried out using the commercial vinyl monomer based hydrophilic polymer, Disco Clear (Incotec International B.V. Ltd, The Netherlands) @ 250 ml L^{-1} distilled water as per manufacturer's instruction. As is the farmers' practice, seeds were mechanically mixed with 50 ml of the diluted polymer in a drum-shaped container, by stirring with a glass rod in clock-wise and anti-clock wise directions for five min. each. For the control treatment, seeds were mixed with 50 ml of distilled water (hereafter referred to as non-coated seeds). Coated and non-coated seeds were first shade dried and then kept in a desiccator containing dry silica gel until seed moisture content of 6% was attained. The dried seeds were used for subsequent studies as detailed below.

2.2. Mean germination time (MGT)

Coated and non-coated seeds in three replicates of hundred seeds each were subjected to germination test between moist paper towels, at 25 °C for fourteen days (ISTA, 1999). The germinating seeds, with a minimum radicle protrusion of 2 mm size were counted daily until the fourteenth day. Mean germination time was estimated as per the equation, $MGT = \Sigma fx/\Sigma x$ where x is the number of seeds newly germinated on f^{th} day and f is the number of days from the start of the germination test (Nicholas and Heydecker, 1968).

2.3. Effect of polymer coat on seed moisture kinetics

2.3.1. Direct imbibition in water

Imbibition was measured under standard germination conditions. As the test weight (100 seeds weight) difference between the coated and non-coated seeds was not significant (data not presented), 1 g (comprising total of 344 ± 5 seeds) each of coated and non-coated seeds, in three replicates, was placed inside Petri dishes containing germination paper that was pre-soaked with 5 ml distilled water. The petri dishes were then maintained at 25 °C and the increase in fresh weight was determined after 2, 4, 6, 8, 10 and 24 h of imbibition.

2.3.2. Hydration-dehydration-rehydration cycle

To assess the effect of hydrophilic polymer coat on moisture adsorption and desorption process of the seed, hydration-dehydration-rehydration experiments were conducted under saturated RH conditions. A closed desiccator containing distilled water was placed in a 25 °C incubator one day before the start of the experiment to create a chamber with saturated RH conditions. Three replicates of 1 g each of coated and non-coated seeds were separately packed in plastic wire mesh bags and placed over a tray in the saturated RH chamber. Seeds were kept in the incubator for 48 h for hydration and gain in weight was recorded at 2, 4, 6, 24, 26, 28, 30 and 48 h. After 48 h of hydration, the seeds were dehydrated by placing seeds in an open Petri plate which was placed in an incubator set at 35 °C. The loss of weight was recorded at 2, 4, 6, 24, 26, 28, 30 and 48 h. The dehydrated seeds were then subjected to a rehydration cycle in the desiccator as mentioned above and periodical gain in weight was recorded at regular intervals as in the case of dehydration cycle. After completion of rehydration cycle, final dry weight of the seeds was estimated by oven drying the seeds at 130 °C for 1 h (ISTA, 1999) and this was used to calculate the moisture content of seeds at each time period during the dehydration-rehydration cycles. The hysteresis loops were established as per the procedure described by Moharir and Prakash (1995), after normalizing the seed moisture values to equalize curve heights. Average seed moisture content of three replicates obtained during different time period of dehydration cycle was normalized by dividing each seed moisture value by the initial average seed moisture value obtained at the beginning of the dehydration cycle. Similarly, the average seed moisture values of three replicates obtained during different time points in the rehydration cycle were normalized by dividing each seed moisture value by the final average seed moisture value obtained during rehydration cycle.

2.4. Effect of polymer film coat on seed quality attributes before and during storage period

To assess the effect of polymer film coat on seed quality attributes during storage, the coated and non-coated seeds, dried as described in 2.1., were packed in paper bags and aluminium pouches, the latter being heat-sealed after pressing out the air manually. Packed seeds were subsequently stored for a period of one year under ambient room and low temperature-low humidity (15 ± 1 °C; 30 ± 5% RH – hereafter referred to as LTLH) storage conditions. Monthly high and low averages of temperature and RH of ambient room that prevailed during the study are given as Supplementary 1 in the online version at DOI: 10.1016/j.scienta.2016.04.010. The effect of the polymer film coat on seed quality was assessed by evaluating seed moisture, seed germination and seed