

**Seed quality enhancement through priming  
treatments in onion (*Allium cepa* L.)**

BY  
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## CERTIFICATE – I

This is to certify that this thesis entitled: **Seed quality enhancement through priming treatments in onion (*Allium cepa* L.)** submitted for the degree of Master of Science in the subject of Seed Science and Technology of the Chaudhary Charan Singh Haryana Agricultural University, Hisar, is a bona-fide research work carried out by **Mr. Gaganpreet Singh**, Admn. No. 2015A79M under my supervision and that no part of the thesis has been submitted by him for any other degree. All the assistance and help received during the course of investigation have been duly acknowledged.

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## **CERTIFICATE – II**

This is to certify that this thesis entitled "**Seed quality enhancement through priming treatments in onion (*Allium cepa* L.)**" submitted by **Mr. Gaganpreet Singh**, Admn. No. 2015A79M. The Student's Advisory Committee has approved the thesis to the Chaudhary Charan Singh Haryana Agricultural University, Hisar in partial fulfillment of the requirements for the degree of Master of Science in the subject of **Seed Science and Technology**, after an oral examination on the same.

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### **LIST OF ABBREVIATION**

GA	:	Gibberellic acid
EC	:	Electrical conductivity
DHA	:	Dehydrogenase activity
CAT	:	Catalase
POD	:	Peroxidase
SOD	:	Superoxidase dismutase
T	:	Treatment
Tz	:	Tetrazolium
PPO	:	Polyphenoloxidase

## CHAPTER-I

### INTRODUCTION

---

Onion (*Allium cepa L.*) is the second most important vegetable crop after tomato in the world. Onion is known as the "Queen of the Kitchen" because of its characteristic flavour. The bulb of onion is a rich source of carbohydrates, proteins, vitamin C and minerals like calcium and phosphorus. The pungency of onion is due to the presence of sulphur bearing compound "Allyl propyl disulphide". Apart from the various uses, onion also possesses several medicinal properties and exported to different countries in substantial quantity, thereby earning valuable foreign exchange for the country. India is the second largest producer of onion after china as it produces 18.9 million tones of onion from about 1.18 million hectares. Major onion producing states of India are Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Bihar, Andhra Pradesh, Rajasthan, Haryana and Tamil Nadu (Anonymous, 2016).

Quality seed will establish a strong and healthy plant in the field which later fight efficiently with various biotic and abiotic stresses. The seed quality is defined by various parameters which have the genetic basis and the variability among genotypes for these parameters is well established (ISTA, 1999). Onion seeds have a shortest life span among the vegetable crops and loose the viability rapidly after harvest. Hence, it possesses a serious problem for the carry-over seed stocks, unless special precautions are taken in its storage. It is recommended that only fresh harvested onion seed should be used for crop production (Rickels *et al.*, 1976). The main reason of low quality of onion seeds include long flowering period resulting in different stages of seed maturity in the umbel, very fast reduction in seed viability if stored in sub-optimal conditions and seed infestation with fungi (Brocklehurst, 1985). The most functional macromolecules in the seed such as proteins, nucleic acids and lipids undergo changes during seed deterioration which ultimately precede to death of seed. Lipid auto-oxidation has been suggested to be one of the causes of seed deterioration (Koostra and Harrington, 1969; Willson and McDonald, 1986) which involves the production of free radicals. Storage fungi, including species of *Aspergillus* and *Penicillium* are mainly responsible for loss in germination and vigour, discoloration and production of mycotoxins, resulting in the deterioration of seed quality (Siddique, 1976). The infestation with seed borne fungi during storage is one of the major factors for quick loss of viability. The reduction in percentage of germination and vigour is attributed to production of fungal metabolites in onion seed storage (Gupta *et al.*, 1989).

Seed invigoration implies an improvement in seed vigour by any post harvest treatment resulting in improved germinability, greater storability and better field performance than the

corresponding untreated (control) seed. It includes three general methods, pre-sowing hydration treatments (priming), coating technologies and seed conditioning (Taylor *et al.*, 1998). Studies have also shown that seed priming or restricted hydration is associated with increase in protein synthesis, rapid resumption of RNA, nucleic acid synthesis and repair (Bray *et al.*, 1989; Dell'Aquila & Bewley 1989). Therefore, it becomes necessary to characterize the changes in seed stored food, which may get affected and would result in either restoration or loss of viability under restricted hydration conditions or priming. Priming can slow down some of the ageing-induced deteriorative events and thus, improve seed performance (Taylor *et al.*, 1998). Pre-sowing seed treatments with water, plant growth regulators, agro-chemicals, fungicides etc also have been reported not only maintain the quality of seeds during storage but also enhance it in several crop species (Basu and Dhar, 1979).

Chitosan is a natural polymer derived from deacetylation of chitin. Chitin is readily available from shellfish waste from food processing. Agricultural applications of chitosan are for stimulation of plant defense. The chitosan molecule triggers a defense response within the plant, leading to the formation of physical and chemical barriers against invading pathogens. *Aloe vera* leaf extract is a very excellent source of plant nutrients, such as calcium, iron, magnesium, potassium, phosphorous and zinc (Dagne *et al.*, 2000); enzymes, such as amylase, catalase, lipase, oxidase and superoxide dismutase (Vazquez *et al.*, 1996); amino acids, such as alanine, glycine, leucine and proline (Reynolds and Dweck 1999); vitamins. such as B-complex, C, -carotene and -tocopherol (Vinson *et al.*, 2005) and other organic compounds, such as triglycerides, triterpenoid, gibberellin, potassium sorbate and salicylic acid (Hamman, 2008). It is available in huge quantity at low cost, so it can be used for seed priming.

Fungicide treatments are discouraged due to toxic residues and development of resistance in pathogens and none of the fungicides have been recommended to treat the grain meant for consumption. Thus there is an urgent need for safer method of pathogen control. Moreover, due to heavy chemical use in intensive cropping systems, concerns to environmental health have been raised world over. Hence bio friendly compounds like chitosan, *aloe vera*, trichoderma and other growth regulators have gained attention in recent times. These have shown positive results in increasing growth and development of many crops along with imparting pest and disease resistance in them. Seed treatments also provide economical and relatively non-polluting delivery systems as compare to other field application system because only a small quantity of material is applied per hectare and in immediate contact with the target site (Taylor and Harman, 1990). Therefore it has been considered one of the least expensive, safe and most effective means of controlling many plant diseases.

Recently, there has been global realization of the important role of PGRs in agriculture for better growth and yield of crops. Developed countries like Japan, China,

Poland, South Korea etc. have been long using PGRs to increase crop yield. Application of commercial antioxidants, vitamins or nutrients for seed quality enhancements is very expensive for resource poor farmers. Onion seeds show poor germination with slow growth of seedling and it has short storage life. Hence, considering the above facts, the present study entitled “Seed quality enhancement through priming treatments in onion (*Allium cepa* L.)” was undertaken to enhance the seed quality by various priming treatments with the following objectives:

1. To standardize the optimum concentration of priming agents
2. To assess the effect of various priming treatments on seed quality
3. To study the effect of priming treatments on seed storability

## CHAPTER-II

### REVIEW OF LITERATURE

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Seed plays a vital role in agriculture and acts as a carrier of the genetic potential of varieties. Seeds are required to be stored since seeds harvested in the preceding season are usually used for sowing in next season after an interval of six months or more. Good quality seed acts as a catalyst for realizing the potential of all other inputs in agriculture. Modern agriculture with its emphasis on modern technology and precision demands that every seed should germinate readily with full potential and produce vigorous seedlings ensuring high yields. However, like any other organism, seeds also have age and deteriorate with the passage of time. Likewise, seed deterioration is a continuous and irreversible process and it varies from species to species and variety to variety within a species (Agarwal, 1976 & 1980). Seed priming (pre-sowing hydration treatments of seeds) enhance seed performance, notably with respect to rate & uniformity of germination thereby enabling better crop establishment (Heydecker *et al.*, 1973; Heydecker, 1978; Bradford, 1986; Taylor *et al.*, 1989; Prera & Cantliffe, 1994) and also increase the protein synthesis, nucleic acid synthesis & repair (Bray *et al.*, 1989; Dell'Aquila & Bewley, 1989; Davison & Bray, 1991; Clark & James, 1991; Dell'Aquila & Spada, 1992). The informations available on effect of priming treatments on seed quality parameters and storability in onion and other crops are discussed as under:

#### **Laboratory parameters:**

##### **Standard germination**

The germination test is universally accepted and widely used as a quality test. Chitosan treatment (2-8mg/ml) of wheat seeds significantly improved seed germination to recommended seed certification standard (>85%) and vigor at concentrations > 4 mg/ml, in two cultivars of spring wheat (Norseman and Max), by controlling seed-borne *Fusarium graminearum* infection (Reddy *et al.*, 1999). Tiwari *et al.* (2002) observed that pre-sowing treatment of onion seeds var. Kalyanpuri Red Round with 100ppm GA<sub>3</sub> increased the germination rate and seedling length. The filtrates of *T. Logibrachiatum* & *T. Viridi* had a statistically significant negative effect on the initial germination and the final count of germinated onion seeds (Celar and Valic, 2005). Seed of *cornus capitata* soaked in GA<sub>3</sub> (different concentration ) showed significant improvement in germination and also reduced the mean germination time significantly in comparison to untreated seeds (Airi *et al.*, 2005). Basavaraj *et al.* (2008) reported that onion seeds coating with polymer @ 12 ml + thiram @ 2 g per kg of seeds recorded higher germination, vigour index, dry weight of seedlings and lower seed infection and electrical conductivity as compared to control.

Chitosan at 0.03%, 0.12%, 0.3% and 0.6% concentration induced seed germination in okra while at 0.03% there was maximum seed germination percentage as compare to other treatments (Jaybhay *et al.*, 2010). Kalsa and Abebie, (2012) reported that seed priming has the potential to improve seed germination and vigour traits in wooly pod vetch. Lal *et al.* (2013) concluded that germination of substandard seed lots of onion can be improved up to 8% by hydro-priming with GA<sub>3</sub> (100ppm). Priming with 2% *aloe vera* leaf extract, 3% *Moringa olifera* leaf extract and 2% sugar beet root extract were the most effective in boosting up germination rate and succeeding seedling growth under chilling condition in Lentil. Better performance of seedling was the consequence of decreased time to 50% germination (T<sub>50</sub>) and mean germination time, elevated germination index and final germination percentage (Shakeel *et al.*, 2014).

### **Seedling length**

The seed treatment with *T. Viridi* has significant effect in increasing the seed germination & emergence, shoot length, root length of seedling in pot culture and in laboratory experiment over control in pigeon pea (Kumar *et al.*, 2000). Mondal *et al.* (2012) observed that chitosan spray @100 and 125 ppm was observed superiority for plant growth, fruit yield over 50 and 75 ppm in okra crops. Mohammad *et al.* (2013) reported highest germination, hypocotyle length, radical length, hypocotyle and radical dry weight were recorded when lentil seed was primed with 3g/l chitosan.

The study conducted to investigate the influence of storage temperature and seed treatments on viability of cotton Cv. LRA5166 under storage, revealed that germination, seedling root and shoot length, dry matter and vigor index decreased with advancement in storage period (Rathinavel K., 2014). Cavusoglu *et al.* (2015) evaluated the role of *aloe vera* L. leaf extract on some physiological and cytogenetical parameters of *Allium cepa* L. seeds exposed to salinity. The radicle length of the seeds germinated in the medium with *aloe vera* L. leaf extract alone increased as compared with control seeds germinated in distilled water, while their radicle number and fresh weight reduced according to the control.

### **Dry weight**

The significant effect of pre-soaking seed treatment with GA<sub>3</sub> 200ppm was found superior in respect of seed germination and seedling growth of papaya viz., days required for germination (11.02), germination percentage (83.33%), height of seedling (24.89 cm), fresh weight of seedling (15.00 g) and dry weight of seedling (1.04 g) over rest of the treatments (Wadekar *et al.*, 2016). Tiwari *et al.* (2016) found that the wheat seeds primed @100ppm with GA<sub>3</sub>, IBA, Kinetin and Salicylic acid separately for 12hrs significantly enhanced the seed germination (18-26%), seedling weight (25-72%), vigor index (32-116%), plant height (4-8.4%), no. of tillers(2-14.6%), total dry matter (3-11%), no. of grains (13-18%) and finally test weight (5.3-6.1%) and grain yield (2-14%) over control in variety HUW 234.

### **Vigour indices**

Vigour index-I and vigour index-II were found positively correlated with standard germination, seedling length, seedling dry weight and negatively correlated with electrical conductivity in okra (Yadav and Dhankar, 2001). *T. Harzianum* gave significant reduction of seed borne pathogen (up to 92) over the untreated control and also increased the germination (%), vigour index of the seedling considerably over control (Murthy *et al.*, 2003).

The seed vigour index decreased significantly with increasing ageing duration in urdbean and mungbean (Singh *et al.*, 2003). Dahiya *et al.* (2000) also reported similar findings in sunflower. Hydro- priming resulted in lower time taken to 50% germination, higher germination rate, vigour index and final germination percentage in maize (Dezfuli *et al.*, 2008). Krishnakumary *et al.* (2010) observed higher vigour index in hydro-primed seed over control in chilli. Hanegave *et al.* (2011) reported that germination per cent, root and shoot and seedling vigour index significantly influenced by the priming treatments in maize seed. Gurung *et al.* (2014) recorded maximum vigour index I & II in passion fruit seeds treated with 500ppm GA<sub>3</sub>.

### **Electrical conductivity**

The electrical conductivity test measure the amount of electrolytes which leach out from seed as these deteriorate. The test has been used to measure seed viability and this is being used as one of the best method for evaluating seed deterioration (Presely, 1958). Iibi *et al.* (2006) observed that leakage test therefore appear to be suitable for evaluating seed quality in onion seeds and could be further developed as rapid vigor test. All varieties of okra losses their membrane permeability after 180 days of storage in ambient condition which increased the electrical conductivity values (Narwal, 1995). Banumurthy and Gupta, (1981) revealed that the electrical conductivity showed significant negative correlation with germinability and seedling vigour in soybean, in chickpea (Ram *et al.*, 1989); in cotton and sunflower (Dahiya *et al.*, 1999). The electrical conductivity of the solute was increased with increase in period of accelerated ageing in cotton (Basra *et al.*, 2003). Vidigal *et al.* (2008) found that electrical conductivity test is effective method to evaluate pepper seeds vigour when samples of 50 seeds, soaked for 1 hour in 25 ml of water.

Electrical conductivity test of water soaked seeds of chickpea provides a quick indicative of field emergence (Hosseini *et al.*, 2011). Demir *et al.* (2012) suggested that the standard laboratory germination test can be replaced by electrical conductivity measurements carried out at eight hours soaking, shortening analysis time for the estimation of radish seed germination quality. Sivla *et al.* (2012) observed that electrical conductivity measurements at 4 or 8 hours and use of the Seed Vigor Imaging system on 3 day old seedling can effectively detect difference in vigor between different sunhemp seed lots. Pallavi *et al.* (2003) observed that the seed leachates increased with increased in storage period of sunflower. Vanniarajan

*et al.* (2004) resulted that increase in seed leachates due to ageing showed a significant correlation with germination and vigour in blackgram. The electrical conductivity is suggested as a potential one-day routine test of physiological seed quality for radish and the overall finding are discussed in relation to effects of deterioration brought about by seed ageing (Mavi *et al.*, 2014).

### **Dehydrogenase Activity test**

The activity of Dehydrogenase enzyme is directly correlated with the seed vigour. To estimate the activities of these enzymes, Kittock and Law (1968) gave an indirect method *i.e.* by colorimetric estimation of formazan (product in reaction of tetrazolium solution with dehydrogenase enzyme). Dehydrogenase activity is generally used as reliable index for the evaluation of seed viability by Baki and Anderson (1972). Parrish and Leopold, (1978) revealed that in seed ageing damage to cellular membranes, decrease in mitochondrial dehydrogenases activities, chromosomal aberration and DNA degradation increases. The DHA test is positively correlated with field emergence in pigeon pea (Kharb *et al.*, 1994). Dahiya *et al.* (1999) found that the DHA, Tz, EC test were reliable in prediction of standard germination in cotton. Verma *et al.* (2003) observed that the Dehydrogenase activity was reduced as the ageing progressed and was found lowest after four year of storage in Brassica species. Both electrical conductivity & DHA test were found most reliable tests to predict field emergence in cotton (Tayal *et al.*, 2006).

### **Catalase and peroxidase**

In most of plant species peroxidase activity decreased with loss of viability of the seeds of that species (Barton, 1964). George, (1953) and Sexena, (1979) reported that lower catalase and peroxidase activity in non-viable or slowly germinating seeds as compared to viable or fast germinated seeds of oat, barley, sorghum and soybean. Leprince *et al.* (1990) revealed that during imbibitions and seed germination, higher activity of catalase and several peroxidase have found in seeds of maize, castor endosperm (Klapheck *et al.*,1990); soybean embryonic axis (Puntarulo *et al.*,1991). Venkateshan and Chellappan, (1999) observed that catalase activity has been changed under various abiotic stress like salinity, Chilling (Nayar and Kaushal, 2002) and water stress (Jiang and Zhang, 2000; Dalmia and Sawhney, 2004). Pallavi *et al.* (2003) reported that a sharp decline in peroxidase enzyme noticed during ageing in sunflower seeds. Moosavi *et al.* (2009) reported that seed priming highly increased POD and Polyphenoloxidase (PPO) activities in Amaranth genotypes. Rouhi *et al.* (2012) reported Antioxidant enzyme activity (superoxidase dismutase, catalase and peroxidase) in primed seeds of berseem clover were significantly increased compared to those in control group. Hela *et al.* (2012) suggest that hormonal priming might have increased the salt tolerance of lettuce seed through enhancing the activities of antioxidant enzymes. Umair *et al.* (2012) reported that all the invigoration treatments significantly affected the activities of anti-oxidant *i.e.*

Superoxidase Dismutase (SOD), Peroxidase (POD), Polyphenoloxidase (PPO) and Catalase (CAT) activity.

#### **Lipid peroxidation test (MDA content)**

Total oil content of seeds is slightly affected by storage/seed deterioration (Mathur and Sinha, 1978). The lipid peroxidation increased with ambient storage of naturally aged seeds (Sung, 1996). Aiazzi *et al.* (1996) observed that no correlation between viability and MDA content of naturally deteriorated seeds of *Atriplex cardobensis*. Chan *et al.* (2006) suggested that guaiacol peroxidase activity can be a potential biomarker reflecting Cd sensitivity in rice seedlings. Anjum *et al.* (2011) suggested that the involvement of methyl jasmonate in improving the drought tolerance of soybean by modulating the membrane lipid peroxidation and antioxidant activities.

#### **Field Emergence Index & Seedling Establishment**

The germination test is conducted under controlled optimum conditions and thus the results differ from the field conditions on many instances, so a test consisting of many tests may be needed for testing viability and vigour of seeds. Baskin, (1971) reported that germination after artificial ageing was closely related to field emergence even under adverse conditions. Steiner *et al.* (1989) reported that dehydrogenase enzyme activity (DHA) test was found the best predictor of seedling emergence in wheat. Similar correlations were also reported by Kharb *et al.* (1994) in pigeon pea and Krishnappa *et al.* (1999) in groundnut. Pandey *et al.* (1990) reported positive association between laboratory vigour test and field emergence in cucurbits. Viability and vigour test which predict the maximum plant producing potential of seed lots, found to be related with field emergence under favourable conditions (ISTA, 1999). The seedling establishment decreased with ageing period (Desraj, 2002 in coriander; Kumar, 2004 in onion; Kumar, 2007 in coriander; Singh, 2009 in wheat and Kumar, 2010 in coriander). Tayal *et al.* (2006) revealed that electrical conductivity, dehydrogenase activity and respiration rate tests were found most reliable multiple tests to predict seedling establishment in cotton. The measurement of mean emergence time in oat as a vigour assessment tool of different seed lots of maize (Methew and Hosseini, 2006). Seed germination, seedling emergence and seedling establishment is important factor in crop production and are the main components of seed/seedling vigour in *Arabidopsis* (Devaih *et al.*, 2007). Golezani *et al.* (2008) revealed that hydro-priming is a simple and useful technique for enhancing seedling emergence rate and performance of lentil. These effects can improve seedling establishment and field performance of this important food legume.

#### **Mean emergence time**

The mean emergence time showed a gradual and sequential reduction as per progress of ageing duration in turnip (Khan *et al.*, 2005). Pascual *et al.* (2006) reported that freshly harvested caper seed shows the highest germination rate and shortest mean emergence time as

compared to aged seed lot. Bejandi *et al.* (2009) reported that seed priming had significant effects on mean emergence rate, emergence percentage, relative water content of leaves, relative chlorophyll content, time of maturity, shoot length and grain yield. Mavi *et al.* (2010) conducted research entitled mean germination time estimates the relative emergence of seed lots of three cucurbit crops under stress conditions and reported that, mean emergence time was higher (*i.e.* germination was slower) in physiologically older seed in commercial seed lots of watermelon (10 lots), melon (10 lots) and cucumber (9 lots). Alhamdan *et al.* (2011) reported in four vegetable crops (carrot, cucumber, onion and tomato), that mean germination time was longer when seed stored for 12 months as compared to fresh seed.

## CHAPTER-III

### MATERIALS AND METHODS

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The present study entitled “Seed quality enhancement through priming treatments in onion (*Allium cepa L.*)” was conducted in the department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar during 2016-17. The details of materials and methods used in the present investigation are as follows:

#### 3.1 EXPERIMENTAL MATERIALS

The present study was conducted on freshly harvested seed of onion variety Hisar-2 procured from Department of Vegetable Sciences, CCS, HAU, Hisar. The laboratory study was conducted in Department of Seed Science & Technology and field study was carried out in experimental area of Department of Vegetable Sciences, C.C.S. H.A.U. Hisar.

**Experiment 1: To standardize the optimum concentration of priming agents and their effect on seed quality**

**Treatments:** The freshly harvested seed of cultivar Hisar-2 was invigorated for 8 hours at room temperature with following priming treatments prior to laboratory and field study:

T<sub>0</sub>: Control

T<sub>1</sub>: Hydration and dehydration

T<sub>2</sub>: Hydration with 25 ppm chitosan

T<sub>3</sub>: Hydration with 50 ppm chitosan

T<sub>4</sub>: Hydration with 75 ppm chitosan

T<sub>5</sub>: Hydration with 100 ppm chitosan

T<sub>6</sub>: T<sub>1</sub> + trichoderma @ 5 gm/kg

T<sub>7</sub>: T<sub>1</sub> + trichoderma @ 10gm/kg

T<sub>8</sub>: Hydration with 100 ppm GA<sub>3</sub>

T<sub>9</sub>: Hydration with 200 ppm GA<sub>3</sub>

T<sub>10</sub>: Hydration with 300 ppm GA<sub>3</sub>

T<sub>11</sub>: Hydration with 1% *aloe vera*

T<sub>12</sub>: Hydration with 2% *aloe vera*

T<sub>13</sub>: Hydration with 3% *aloe vera*

T<sub>14</sub>: Seed coating with *aloe vera* gel

The primed seed was dried back at room temperature to bring their original moisture content before assessing the various quality parameters. After drying to a safer moisture level *i.e.* 6%, the seeds were stored in the plastic bags (700gauge) under ambient conditions and the following observations were recorded:

### **3.1.1 Laboratory parameters:**

#### **Standard germination test (%):**

Three replications with 100 seeds of each treatment were placed on sufficiently moistened rolled papers (BP) in the seed germinator at 20°C. The germination was recorded on 12<sup>th</sup> day and only normal seedlings were considered for germination percentage according to the rules of International Seed Testing Association (ISTA, 2011).

#### **Seedling length (cm):**

Ten normal seedlings from three replications of each treatment were randomly selected at the time of final count of standard germination and average seedling length was calculated and expressed in centimeters.

#### **Seedling dry weight (mg):**

Seedling dry weight was assessed after the final count in the standard germination test (12 days). The 10 seedlings which were used for seedling length in each treatment replicated thrice were used. Seedlings were dried in a hot air oven for 24 hr at 80±1°C. The dried seedlings of each replication were weighed and average seedling dry weight was calculated.

#### **Vigour indices:**

Seedling vigour indices were calculated according to the method suggested by Baki and Anderson (1973):

Vigour index-I = Standard germination (%) x Average seedling length (cm)

Vigour index-II = Standard germination (%) x Average seedling dry weight (mg)

#### **Electrical conductivity (µS/cm/seed):**

To measure the electrical conductivity, 25 normal and uninjured seeds were soaked in 75 ml deionized water in 100 ml beakers in three replications. Seeds were immersed completely in water and beakers were covered with foil. Thereafter, these samples were kept at 25±1°C for 24 h. The electrical conductivity of the seed leachates was measured using a direct reading conductivity meter and expressed in µS/cm/seed (as per AOSA, 1983).

#### **Dehydrogenase activity test (ODg<sup>-1</sup>ml<sup>-1</sup>):**

In DHA test, reduction of 2, 3, 5-Triphenyl tetrazolium chloride to red formazan by dehydrogenase enzyme in seed embryo is the basic principle for topographical tetrazolium test for seed viability. It is a quantitative method which may be used to determine varying dehydrogenase activity between seeds of similar viability and therefore, it is measure of seed vigour. Sample of 2 gram seed of each seed treatment replicated thrice were grinded to pass through a 20 mesh screen. 200 mg flour was soaked in 5 ml of 1% tetrazolium solution at 38°C for 3-4 h. Then it was centrifuged at 10000 rpm for 3 minutes and the supernatant was poured off. The formazan was extracted with 10 ml acetone for 16 h followed by centrifugation and absorbance of the solution was determined by spectrophotometer at 480

nm. These observations were expressed as change in O D  $\text{g}^{-1}\text{ml}^{-1}$  and this procedure as per procedure suggested by Kittock and Law, (1968).

**Catalase Activity test ( $\mu\text{moles}/\text{min}/\text{g}$ ):**

For the extraction of catalase enzyme, seeds of each variety were imbibed in beaker at  $30^{\circ}\text{C}$  in the germinator for 24 h. Two hundred milligram of imbibed seed sample was ground in a chilled paste mortar by adding 10 ml phosphate buffer (pH 7.8) and a pinch of corning sand. The 10 ml homogenate was centrifuged at 12,000 rpm for 20 minutes at  $4^{\circ}\text{C}$ . The supernatant obtained was then re-centrifuged at 15000 rpm for 10 minutes. The clear supernatant, thus obtained, was used for estimating the activity of catalase. The catalase activity was assayed by the method described by Aebi (1983) based on the reduction of potassium dichromate to chromic acetate by hydrogen peroxide.

**Reagents:** 0.3 M hydrogen peroxide ( $\text{H}_2\text{O}_2$ ), 0.1 M phosphate buffer (pH 7.0), Dichromate-acetic acid reagent (5% potassium dichromate + glacial acetic acid in the ratio of 1:3).

0.5 ml of  $\text{H}_2\text{O}_2$  and 1.0 ml of phosphate buffer (pH 7.0) was added in 0.5 ml of enzyme extract in a side mouthed test tube. This was mixed rapidly and then incubated at  $37^{\circ}\text{C}$  for 5 minutes. The test tubes were then taken out and 4 ml of dichromate acetic acid reagent was added. These were then heated for 10 minutes in a boiling water bath. The colour which changed to green due to the formation of chromic acetate after cooling was measured by Systronic Spectrophotometer 169 at 570 nm. The activity of catalase has been expressed as the amount of enzyme required to bring about a change in absorbance by 0.01 per minute.

**Peroxidase Activity test ( $\mu\text{moles}/\text{min}/\text{g}$ ):**

The enzyme extract was prepared as described earlier for catalase. Peroxidase activity was determined by the method of Shannon *et al.* (1966), following the oxidation of O-dianisidine in the presence of hydrogen peroxide ( $\text{H}_2\text{O}_2$ ).

**Reagents:** 0.1 M sodium acetate buffer (pH 4.5); 0.2 M hydrogen peroxide ( $\text{H}_2\text{O}_2$ ); 10 mg O-dianisidine dissolved per 2 ml of methanol.

2.0 ml of acetate buffer (pH 4.5) and 0.1 ml of O-dianisidine solution was added to 0.05 ml of enzyme extract. Then 0.1 ml of 0.2 M hydrogen peroxide also added to start the reaction. The reading was taken at 470 nm wavelength after every 15 second for 1 minute and enzyme unit was expressed as the amount of enzyme required to bring about a change in absorbance of 0.01 per minute.

**Lipid peroxidation (Malondialdehyde content):**

The level of lipid peroxidation was measured in terms of malondialdehyde (MDA) present in the seeds. MDA is a product of lipid peroxidation and was measured by thiobarbituric acid (TBA) reaction by the method of Heath and Packer (1968) with minor modification.

**Reagents:** 0.5 % TBA in 20% Trichloroacetic acid (TCA); 0.1 % TCA.

**Extraction:** Decoated dry seeds (200 mg) were homogenized with 5 ml of 0.1 % TCA. The homogenate was centrifuged at 8000 rpm for 15 minutes.

**Estimation:** Supernatant was precipitated with 4 ml of 20% TCA containing 0.5% TBA. The mixture was heated in a water bath shaker at 95°C for 30 minutes and quickly cooled in ice bath. After centrifugation at 8000 rpm for 10 minutes, the absorbance of the supernatant was recorded at 532 nm and the value for non-specific absorption at 600 nm was subtracted. The concentration of MDA was calculated using its estimation coefficient of 155 mM<sup>-1</sup> cm<sup>-1</sup>.

### 3.1.2 Field parameters:

#### Field Emergence index:

The number of seedlings emerged were counted on each day upto seedling establishment and the speed of emergence was calculated by the method as described by Maguire (1962).

$$FEI = \frac{\text{No. of seedlings emerged}}{\text{Day of first count}} + \frac{\text{No. of seedlings emerged}}{\text{Day of last count (12}^{\text{th}}\text{)}}$$

#### Mean emergence/germination Time (MET/MGT, days):

$$MET/MGT = \{(Dn) / \{n \text{ (Ellis and Roberts, 1980)}\}$$

Where,

n = number of seeds which germinate / emerged on day D

D = the number of days counted from the planting

#### Total Seedling Emergence (%):

The total seedling emergence potential was determined by counting the total number of seedlings when the emergence was completed or when there was no further addition in the final emerged seedlings. (Kharb, 1992).

#### Seedling Height (cm):

Average height of 10 randomly selected seedlings of one month from each treatment was calculated and expressed in centimeters.

#### Experiment 2: To study the effect of priming treatments on seed storability

The primed seed was stored in plastic bags (700gauge) at ambient conditions and observations on following seed quality parameters were recorded at 3 months interval till the germination falls below Indian Minimum Seed Certification Standards (Anonymous, 2013).

1. Standard germination test (%) as per ISTA, 2011
2. Seedling length (cm)
3. Seedling dry weight (mg)
4. Vigour indices as per Abdul – Baki and Anderson, 1973
  - a. Vigour Index-I= Standard germination (%) X Seedling length (cm)
  - b. Vigour Index-II= Standard germination (%) X Seedling dry weight (mg)

5. Electrical conductivity ( $\mu\text{S}/\text{cm}/\text{seed}$ ) as per AOSA, 1983

The observations on following enzyme activity were recorded after the germination fall below IMSCS:

1. Dehydrogenase Activity test ( $\text{ODg}^{-1}\text{ml}^{-1}$ )
2. Lipid peroxidation test (MDA content) ( $\mu\text{mol g}^{-1}\text{DW}$ )
3. Catalase and peroxidase ( $\text{mg protein}^{-1}\text{min}^{-1}$ )

**STATISTICAL ANALYSIS**

The factorial experiment in completely randomized design (CRD) as well as in randomized complete block design (RBD) was conducted in three replicates for laboratory and field parameters, respectively and data was subjected to the statistical analysis as described by Panse and Sukhatme (1985).

The main objective of storage is to preserve the high germination and vigour from harvest till next planting season. Seed possesses highest vigour and viability at the time of physiological maturity on the plant. Thereafter, the quality declines with progress in seed ageing. Deterioration of seed is a continuous process and can't be stopped but it can be slow down by using proper storage conditions and priming treatments.

The results of the study entitled, "Seed quality enhancement through priming treatments in onion (*Allium cepa L*)". carried out in the laboratories of department of Seed Science and Technology and experimental area of department of Vegetable Sciences during the period 2016-17 are presented in this chapter with the help of tables under following sub heads:

### **Effect of priming treatments on seed quality parameters:**

#### **Standard Germination (%):**

All the treatments showed significant improvement in standard germination over control ranged between 80.33 to 89.00 (Table-1). Maximum germination was observed in the seeds hydrated with 100ppm GA<sub>3</sub> & seeds coated with *aloe vera* gel (89.00) followed by seeds hydrated with 100ppm chitosan (87.33) while minimum was observed in control (80.33). Effect on germination was also noticed among the various concentrations of the priming agents. As the concentration of chitosan increased from 25ppm to 100ppm, enhancement in germination was also increased and maximum germination was found in seeds hydrated with 100ppm chitosan (87.33). Similarly, more germination was observed in hydrated-dehydrated seed treated with trichoderma @ 10g/kg seed (87.00) than hydrated-dehydrated seed treated with trichoderma @ 5g/kg seed (85.66). In GA<sub>3</sub>, maximum germination was observed in seeds hydrated with 100ppm GA<sub>3</sub> (89.00) over the other concentrations. In *aloe vera*, maximum germination was recorded in *aloe vera* coated seeds (89.00) over the other concentrations.

#### **Seedling Length (cm):**

The seedling length was also enhanced significantly by all the treatments ranged between 16.26 to 20.33 (Table-1). Maximum seedling length was observed in 100ppm GA<sub>3</sub> (20.33) followed by seeds coated with *aloe vera* gel (19.90) while minimum was observed in control (16.26). Effect on seedling length was also noticed among the various concentrations of the priming agents. As the concentration of chitosan increased from 25ppm to 100ppm, enhancement in seedling length was also increased and maximum seedling length was found in seeds hydrated with 100ppm chitosan (18.93). Similarly, seedling length was observed

more in hydrated-dehydrated seed treated with trichoderma @ 10g/kg seed (19.10) than hydrated-dehydrated seed treated with trichoderma @ 5g/kg seed (18.16). In GA<sub>3</sub>, maximum seedling length was observed in seeds hydrated with 100ppm GA<sub>3</sub> (20.33) over the other concentrations. In *aloe vera*, maximum seedling length was recorded in *aloe vera* coated seeds (19.90) over the other concentrations.

#### **Seedling dry weight (mg):**

Seedling dry weight was also enhanced significantly by all the treatments ranged between 23.00 to 30.67 (Table-1). Maximum seedling dry weight was observed in 100ppm GA<sub>3</sub> (30.67) followed by seeds coated with *aloe vera* gel (29.87) while minimum was observed in control (23.00). Effect on seedling dry weight was also noticed among the various concentrations of the priming agents. As the concentration of chitosan increased from 25ppm to 100ppm, enhancement in seedling dry weight was also increased and maximum seedling dry weight was found in seeds hydrated with 100ppm chitosan (26.83). Similarly, seedling dry weight was observed more in the hydrated-dehydrated seed treated with trichoderma @ 10g/kg seed (27.67) than the hydrated-dehydrated seed treated with trichoderma @ 5g/kg seed (26.00). In GA<sub>3</sub>, maximum seedling dry weight was observed in seeds hydrated with 100ppm GA<sub>3</sub> (30.67) over the other concentrations. In *aloe vera*, maximum seedling dry weight was recorded in *aloe vera* coated seeds (29.87) over the other concentration.

#### **Vigour Index – I:**

Significantly higher vigour index-I was observed in all the treatments ranged between 1306.16 to 1809.37 (Table-1). Maximum vigour index-I was observed in 100ppm GA<sub>3</sub> (1809.37) followed by seeds coated with *aloe vera* gel (1771.10) while minimum was observed in control (1306.16). Effect on vigour index-I was also noticed among the various concentrations of the priming agents. As the concentration of chitosan increased from 25ppm to 100ppm, enhancement in vigour index-I was also increased and maximum vigour index-I was found in seeds hydrated with 100ppm chitosan (1653.15). Similarly, vigour index-I was observed more in the hydrated-dehydrated seed treated with trichoderma @ 10g/kg seed (1661.70) than the hydrated-dehydrated seed treated with trichoderma @ 5g/kg seed (1555.76). In GA<sub>3</sub>, maximum vigour index-I was observed in seeds hydrated with 100ppm GA<sub>3</sub> (1809.37) over the other concentrations. In *aloe vera*, maximum vigour index-I was recorded in *aloe vera* coated seeds (1771.10) over the other concentrations.

#### **Vigour Index- II:**

Significantly higher vigour index-II was observed in all the treatments ranged 1847.59 to 2729.63 (Table-1). Maximum vigour index-II was observed in 100ppm GA<sub>3</sub> (2729.63) followed by seeds coated with *aloe vera* gel (2658.43) while minimum was observed in control (1847.59). Effect on vigour index-II was also noticed among the various concentrations of the priming agents. As the concentration of chitosan increased from 25ppm

to 100ppm, enhancement in vigour index-II was also increased and maximum vigour index-II was found in seeds hydrated with 100ppm chitosan (2343.06). Similarly, vigour index-II was observed more in the hydrated-dehydrated seed treated with trichoderma @ 10g/kg seed (2407.29) than the hydrated-dehydrated seed treated with trichoderma @ 5g/kg seed (2227.42). In GA<sub>3</sub>, maximum vigour index-II was observed in seeds hydrated with 100ppm GA<sub>3</sub> (2729.63) over the other concentrations. In *aloe vera*, maximum vigour index-II was recorded in *aloe vera* coated seeds (2658.43) over the other concentrations.

#### **Electrical Conductivity ( $\mu\text{S}/\text{cm}/\text{seed}$ )**

No significant difference was observed in initial electrical conductivity among the treatments (Table-1). Significant difference among the various concentrations was also not observed in any of the priming agents.

#### **Field emergence index:**

Field emergence index was enhanced significantly in all the treatments ranging between 4.25 to 6.14 (Table-2). Maximum field emergence was observed in the seeds coated with *aloe vera* gel (6.14) followed by the seeds hydrated with 3% *aloe vera* (6.04) while minimum was observed in control (4.25). Effect on field emergence index was also noticed among the various concentrations of the priming agents. Maximum enhancement in field emergence index was found in seeds hydrated with 75ppm chitosan (4.88) over other concentrations. Similarly, field emergence index was observed more in hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (5.24) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (5.11). In GA<sub>3</sub>, maximum field emergence index was observed in seeds hydrated with 100ppm GA<sub>3</sub> (5.99) over the other concentrations. In *aloe vera*, maximum field emergence index was recorded in *aloe vera* coated seeds (6.14) over the other concentrations.

#### **Mean emergence time:**

Significantly lower mean emergence time was observed in all the treatments over control ranged between 9.84 to 13.17 (Table-2). Minimum mean emergence time was observed in the seeds coated with *aloe vera* gel (9.84) followed by the seeds hydrated with 3% *aloe vera* (10.03) while maximum was observed in control (13.17). Effect on mean emergence time was also noticed among the various concentrations of the priming agents. Minimum mean emergence time was observed in seeds hydrated with 100ppm chitosan (11.17) over other concentrations. Similarly, mean emergence time was observed minimum in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (10.87) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (11.10). In GA<sub>3</sub>, minimum mean emergence time was observed in seeds hydrated with 100ppm GA<sub>3</sub> (10.61) over the other concentrations. In *aloe vera*, minimum mean emergence time was recorded in *aloe vera* coated seeds (9.84) over the other concentrations.

**Table 1: Effect of priming treatments on various seed quality parameters of onion seeds**

<b>Treatments</b>	<b>Standard Germination (%)</b>	<b>Seedling length (cm)</b>	<b>Seedling Dry Weight (mg)</b>	<b>Vigour Index-I</b>	<b>Vigour Index-II</b>	<b>Electrical Conductivity (<math>\mu</math>S/cm/seed)</b>
Control	80.33(63.66)	16.26	23.00	1306.16	1847.59	0.320
Hydration and dehydration	86.33(68.35)	17.96	25.33	1550.48	2186.73	0.310
Hydration with 25 ppm chitosan	84.66(66.94)	17.46	24.67	1478.16	2088.56	0.310
Hydration with 50 ppm chitosan	87.00(68.85)	18.26	26.33	1588.62	2290.71	0.310
Hydration with 75 ppm chitosan	87.00(68.85)	18.23	26.00	1586.01	2262.00	0.310
Hydration with 100 ppm chitosan	87.33(69.20)	18.93	26.83	1653.15	2343.06	0.320
T <sub>1</sub> + trichoderma @ 5 gm/kg	85.66(67.74)	18.16	26.00	1555.76	2227.42	0.320
T <sub>1</sub> + trichoderma @ 10gm/kg	87.00(68.86)	19.10	27.67	1661.70	2407.29	0.310
Hydration with 100 ppm GA <sub>3</sub>	89.00(70.68)	20.33	30.67	1809.37	2729.63	0.320
Hydration with 200 ppm GA <sub>3</sub>	85.00(67.19)	18.13	26.01	1541.05	2210.85	0.310
Hydration with 300 ppm GA <sub>3</sub>	86.00(68.03)	18.90	26.70	1625.40	2296.20	0.320
Hydration with 1% <i>aloe vera</i>	84.33(66.66)	17.26	24.00	1455.53	2023.92	0.320
Hydration with 2% <i>aloe vera</i>	87.00(69.15)	18.36	26.43	1600.44	2303.90	0.310
Hydration with 3% <i>aloe vera</i>	86.33(68.29)	18.03	26.00	1556.53	2244.58	0.320
Seed coating with <i>aloe vera</i> gel.	89.00(70.61)	19.90	29.87	1771.10	2658.43	0.320
<b>C.D. at 5%</b>	1.72	0.94	2.63	72.40	236.36	N.S.

\* Figures in parenthesis are angular transformed values

**Seedling height at one month (cm):**

Significantly higher seedling height was observed in all the treatments ranged between 10.33 to 13.06 (Table-2). Maximum seedling height was observed in the seeds coated with *aloe vera* gel (13.06) followed by seeds hydrated with 100ppm GA<sub>3</sub> (12.53) while minimum was observed in control (10.33). Effect on seedling height was also noticed among the various concentrations of the priming agents. Maximum enhancement in seedling height was found in seeds hydrated with 75ppm chitosan (11.40) over other concentrations. Similarly, seedling height was observed more in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (12.43) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (12.36). In GA<sub>3</sub>, maximum seedling height was observed in seeds hydrated with 100ppm GA<sub>3</sub> (12.53) over the other concentrations. Among *aloe vera* concentrations, maximum seedling height was recorded in *aloe vera* coated seeds (13.06).

**Seedling Establishment (%):**

All the treatments significantly enhanced seedling establishment ranged between 64.33 to 74.00 (Table-2). Maximum seedling establishment was observed in seeds coated with *aloe vera* gel (74.00) followed by seeds hydrated with GA<sub>3</sub> 100ppm (72.66) while minimum was observed in control (64.33). Effect on seedling establishment was also noticed among the various concentrations of the priming agents. Maximum enhancement in seedling establishment was found in seeds hydrated with 75ppm chitosan (68.00) over other concentrations. Similarly, seedling establishment was observed more in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (71.36) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (69.66). In GA<sub>3</sub>, maximum seedling establishment was observed in seeds hydrated with 100ppm GA<sub>3</sub> (72.66) over the other concentrations. Among *aloe vera* concentrations, maximum seedling establishment was recorded in *aloe vera* coated seeds (74.00).

**Pest and Disease incidences:**

No insect pest was observed in any treatment during the study.

**Dehydrogenase activity (ODg<sup>-1</sup>ml<sup>-1</sup>):**

Significant enhancement in dehydrogenase activity was observed in all the treatments ranged between 0.733 to 0.833 (Table-3). Maximum dehydrogenase activity was observed in 100ppm GA<sub>3</sub> (0.833) followed by the seeds hydrated with 100ppm chitosan and seeds coated with *aloe vera* gel (0.810) while minimum was observed in control and seeds hydrated with 300ppm GA<sub>3</sub> & in control (0.733). Effect on dehydrogenase activity was also noticed among the various concentrations of the priming agents. Maximum enhancement in dehydrogenase activity was found in seeds hydrated with 100ppm chitosan (0.810) over other concentrations.

**Table 2: Effect of priming treatments on field parameters of onion seeds**

<b>Treatments</b>	<b>Field Emergence Index</b>	<b>Mean Emergence Time</b>	<b>Seedling Height (cm) at one month</b>	<b>Seedling Establishment (%)</b>	<b>Pest and Disease incidences</b>
Control	4.25	13.17	10.33	64.33(53.30)	-
Hydration and dehydration	4.87	11.34	11.40	67.66(55.33)	-
Hydration with 25 ppm chitosan	4.62	11.62	10.66	66.33(54.52)	-
Hydration with 50 ppm chitosan	4.26	11.51	11.36	67.00(54.92)	-
Hydration with 75 ppm chitosan	4.88	11.45	11.40	68.00(55.54)	-
Hydration with 100 ppm chitosan	4.28	11.17	10.60	66.33(54.51)	-
T <sub>1</sub> + trichoderma @ 5 gm/kg	5.11	11.10	12.36	69.66(56.56)	-
T <sub>1</sub> + trichoderma @ 10gm/kg	5.24	10.87	12.43	71.36(57.82)	-
Hydration with 100 ppm GA <sub>3</sub>	5.99	10.61	12.53	72.66(58.47)	-
Hydration with 200 ppm GA <sub>3</sub>	4.39	11.50	11.70	68.33(55.73)	-
Hydration with 300 ppm GA <sub>3</sub>	4.69	11.55	12.13	68.66(55.94)	-
Hydration with 1% <i>aloe vera</i>	5.10	11.34	11.83	68.00(55.53)	-
Hydration with 2% <i>aloe vera</i>	5.07	11.27	11.40	66.00(54.32)	-
Hydration with 3% <i>aloe vera</i>	6.04	10.03	12.46	71.40(57.60)	-
Seed coating with <i>aloe vera</i> gel.	6.14	9.84	13.06	74.00(59.32)	-
<b>C.D. at 5%</b>	4.25	0.84	0.59	2.51	-

\* Figures in parenthesis are angular transformed value.

Similarly, dehydrogenase activity was observed more in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (0.790) than hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (0.767). In GA<sub>3</sub>, maximum dehydrogenase activity was observed in seeds hydrated with 100ppm GA<sub>3</sub> (0.833) over the other concentrations. In *aloe vera*, maximum dehydrogenase activity was recorded in *aloe vera* coated seeds (0.810) over the other concentrations.

**Catalase activity (μmoles/min/g):**

The catalase activity was enhanced significantly in all the treatments ranged between 0.220 to 0.303 (Table-3). Maximum catalase activity was observed in 100ppm GA<sub>3</sub> (0.303) followed by seeds coated with *aloe vera* gel (0.293) while minimum was observed in control (0.220). Effect on catalase activity was also noticed among the various concentrations of the priming agents. Maximum enhancement in catalase activity was found in seeds hydrated with 75ppm chitosan (0.260) over other concentrations. Similarly, catalase activity was observed more in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (0.262) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (0.250). In GA<sub>3</sub>, maximum catalase activity was observed in seeds hydrated with 100ppm GA<sub>3</sub> (0.303) over the other concentrations. In *aloe vera*, maximum catalase activity was recorded in *aloe vera* coated seeds (0.293) over the other concentrations.

**Peroxidase activity (μmoles/min/g):**

All the treatments significantly enhanced peroxidase activity ranged between 0.627 to 0.923 (Table-3). Maximum peroxidase activity was observed in 100ppm GA<sub>3</sub> (0.923) followed by the seeds coated with *aloe vera* gel (0.870) while minimum was observed in control (0.627). Effect on peroxidase activity was also noticed among the various concentrations of the priming agents. Maximum enhancement in peroxidase activity was found in seeds hydrated with 75ppm chitosan (0.807) over other concentrations. Similarly, peroxidase activity was observed more in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (0.863) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (0.800). In GA<sub>3</sub>, maximum peroxidase activity was observed in seeds hydrated with 100ppm GA<sub>3</sub> (0.923) over the other concentrations. In *aloe vera*, maximum peroxidase activity was recorded in *aloe vera* coated seeds (0.870) over the other concentrations.

**Lipid peroxidation (μmol g<sup>-1</sup>DW):**

Significantly lower lipid peroxidation was recorded in all the treatments ranged between 0.110 to 0.227 (Table-10). The minimum lipid peroxidation was observed in 100ppm GA<sub>3</sub> (0.110) followed by the seeds coated with *aloe vera* gel (0.120) while maximum was observed in control (0.227).

**Table 3: Effect of priming treatments on enzyme activity of onion seeds**

<b>Treatments</b>	<b>Dehydrogenase activity (ODg<sup>-1</sup>ml<sup>-1</sup>)</b>	<b>Catalase activity (μmoles/min/g)</b>	<b>Peroxidase activity (μmoles/min/g)</b>	<b>Lipid peroxidation (μmol g<sup>-1</sup>DW)</b>
Control	0.733	0.220	0.627	0.227
Hydration and dehydration	0.790	0.250	0.753	0.175
Hydration with 25 ppm chitosan	0.760	0.243	0.723	0.163
Hydration with 50 ppm chitosan	0.780	0.257	0.763	0.157
Hydration with 75 ppm chitosan	0.803	0.260	0.807	0.170
Hydration with 100 ppm chitosan	0.810	0.255	0.753	0.143
T <sub>1</sub> + trichoderma @ 5 gm/kg	0.767	0.250	0.800	0.157
T <sub>1</sub> + trichoderma @ 10gm/kg	0.790	0.262	0.863	0.140
Hydration with 100 ppm GA <sub>3</sub>	0.833	0.303	0.923	0.110
Hydration with 200 ppm GA <sub>3</sub>	0.787	0.245	0.783	0.157
Hydration with 300 ppm GA <sub>3</sub>	0.733	0.246	0.777	0.174
Hydration with 1% <i>aloe vera</i>	0.740	0.24	0.773	0.178
Hydration with 2% <i>aloe vera</i>	0.757	0.265	0.707	0.165
Hydration with 3% <i>aloe vera</i>	0.800	0.257	0.857	0.140
Seed coating with <i>aloe vera</i> gel.	0.810	0.293	0.870	0.120
<b>C.D. at 5%</b>	0.041	0.041	0.040	0.040

Effect on lipid peroxidation was also noticed among the various concentrations of the priming agents. Minimum lipid peroxidation was found in seeds hydrated with 100ppm chitosan (0.143) over other concentrations. Similarly, lipid peroxidation was observed minimum in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (0.0.140) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (0.157). In GA<sub>3</sub>, minimum lipid peroxidation was observed in seeds hydrated with 100ppm GA<sub>3</sub> (0.110) over the other concentrations. In *aloe vera*, minimum lipid peroxidation was recorded in *aloe vera* coated seeds (0.120) over the other concentrations.

#### **Effect of priming treatments on seed storability:**

##### **Standard Germination (%):**

The data revealed decrease in standard germination with increase in storage period. Standard germination was recorded between 78.66 to 85.67 at the end of 3 months of storage (Table-4). The maximum germination was observed in 100ppm GA<sub>3</sub> (85.67) followed by the seeds coated with *aloe vera* gel (84.33) while it was found minimum in control (78.66)

Standard germination was observed between 83.33 to 74.00 at the end of 6 months of storage. The highest value was recorded in 100ppm GA<sub>3</sub> (83.33) followed by the seeds coated with *aloe vera* gel (82.33) while minimum germination was recorded in control (74.00).

All the treatments maintained standard germination above the IMSCS (70%) at the end of 9 months of storage except the seeds hydrated with 100ppm chitosan. The maximum germination was recorded in 100ppm GA<sub>3</sub> (81.67) followed by the seeds coated with *aloe vera* gel (80.00) while minimum was observed in seeds hydrated with 100ppm chitosan (68.00). Effect of concentration of priming agents on germination was also observed during storability. After 9 months of storage, maximum germination was observed in the seeds treated with 50ppm chitosan (76.00) over other concentrations. Similarly, more germination was observed in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (79.00) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (77.00) at the end of 9 months. In GA<sub>3</sub>, maximum germination was observed in seeds hydrated with 100ppm GA<sub>3</sub> (81.67) and in *aloe vera*, maximum germination was recorded in *aloe vera* coated seeds (80.00) over the other concentrations at the end of 9 months.

##### **Seedling Length (cm):**

The data divulged decrease in seedling length with increase in storage period. Seedling length was recorded between 15.16 to 18.20 at the end of 3 months of storage (Table-5). The maximum seedling length was observed in 100ppm GA<sub>3</sub> (18.20) followed by the seeds coated with *aloe vera* gel (17.90) while it was found minimum in control (15.16).

Same trend was observed after 6 months of storage also and seedling length was recorded between 14.23 to 17.40. The maximum seedling length was recorded in 100ppm

**Table 4: Effect of priming treatments on standard germination (%) of onion seed during storage**

Treatments	Storage period (months)			
	0	3	6	9
Control	80.33(63.66)	78.66(62.48)	74.00(59.33)	69.00(56.15)
Hydration and dehydration	86.33(68.35)	82.00(64.90)	77.33(61.55)	73.33(58.90)
Hydration with 25 ppm chitosan	84.66(66.94)	82.33(65.14)	78.33(62.26)	75.33(60.20)
Hydration with 50 ppm chitosan	87.00(68.85)	84.00(66.42)	78.66(62.48)	76.00(60.64)
Hydration with 75 ppm chitosan	87.00(68.85)	82.50(65.38)	80.33(63.68)	73.33(58.93)
Hydration with 100 ppm chitosan	87.33(69.20)	83.33(65.88)	76.33(60.90)	68.00(55.54)
T <sub>1</sub> + trichoderma @ 5 gm/kg	85.66(67.74)	80.33(63.69)	79.33(62.94)	77.00(61.33)
T <sub>1</sub> + trichoderma @ 10gm/kg	87.00(68.86)	83.33(65.89)	81.66(64.62)	79.00(62.72)
Hydration with 100 ppm GA <sub>3</sub>	89.00(70.68)	85.67(67.73)	83.33(65.91)	81.67(64.63)
Hydration with 200 ppm GA <sub>3</sub>	85.00(67.19)	81.33(64.38)	79.33(62.96)	76.33(60.88)
Hydration with 300 ppm GA <sub>3</sub>	86.00(68.03)	82.67(65.41)	79.33(62.94)	75.00(60.00)
Hydration with 1% <i>aloe vera</i>	84.33(66.66)	83.33(65.90)	81.00(64.14)	74.33(59.54)
Hydration with 2% <i>aloe vera</i>	87.00(69.15)	84.00(66.66)	80.66(63.90)	76.67(61.19)
Hydration with 3% <i>aloe vera</i>	86.33(68.29)	83.00(65.67)	80.00(63.41)	77.33(61.56)
Seed coating with <i>aloe vera</i> gel.	89.00(70.61)	84.33(66.68)	82.33(65.13)	80.00(63.42)
<b>C.D. at 5%</b>	1.72	1.64	1.51	1.67

\* Figures in parenthesis are angular transformed values

GA<sub>3</sub> (17.40) followed by seeds coated with *aloe vera* gel (17.10) while minimum was found in control (14.23).

Seedling length was observed maximum in all the treatments over control (12.16) at the end of 9 months. The maximum seedling length was recorded in treatment 100ppm GA<sub>3</sub> (16.60) followed by seeds coated with *aloe vera* gel (16.30). Effect of concentration of priming agents on seedling length was also observed during storability. After 9 months of storage, maximum seedling length was observed in the seeds treated with 50ppm chitosan (13.96) over other concentrations. Similarly, more seedling length was observed in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (15.93) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (15.26) at the end of 9 months. In GA<sub>3</sub>, maximum seedling length was observed in seeds hydrated with 100ppm GA<sub>3</sub> (16.60) and in *aloe vera*, maximum seedling length was recorded in *aloe vera* coated seeds (16.30) over the other concentrations at the end of 9 months.

**Seedling dry weight (mg):**

The data revealed decrease in seedling dry weight with increase in storage period. Seedling dry weight was recorded between 18.000 to 29.67 at the end of 3 months of storage (Table-6). The maximum seedling dry weight was observed in the seeds hydrated with 100ppm GA<sub>3</sub> (29.67) followed by seeds coated with *aloe vera* gel (28.000) while it was found minimum in control (18.00).

Seedling dry weight was recorded between 15.67 to 27.67 at the end of 6 months of storage. Maximum seedling dry weight was recorded in the seeds hydrated with 100ppm GA<sub>3</sub> (27.67) followed by seeds coated with *aloe vera* gel (26.33) while minimum was found in seeds hydrated with 100ppm chitosan (15.67).

All the treatments maintained seedling dry weight significantly over control (13.67) at the end of 9 months of storage except the seeds hydrated with 100ppm chitosan (12.00). The maximum seedling dry weight was recorded in the seeds hydrated with 100ppm GA<sub>3</sub> (24.00) followed by by seeds coated with *aloe vera* gel (23.67) while minimum was observed in seeds hydrated with 100ppm chitosan (12.00). Effect of concentration of priming agents on seedling dry weight was also observed during storability. After 9 months of storage, maximum seedling dry weight was observed in the seeds treated with 50ppm chitosan (16.33) over other concentrations. Similarly, more seedling dry weight was observed in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (20.67) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (17.33) at the end of 9 months. In GA<sub>3</sub>, maximum seedling dry weight was observed in seeds hydrated with 100ppm GA<sub>3</sub> (24.00) and in *aloe vera*, maximum seedling dry weight was recorded in *aloe vera* coated seeds (23.67) over the other concentrations at the end of 9 months.

**Table 5: Effect of priming treatments on Seedling length (cm) of onion seeds during storage.**

<b>Treatments</b>	<b>Field Emergence Index</b>	<b>Mean Emergence Time</b>	<b>Seedling Height (cm) at one month</b>	<b>Seedling Establishment (%)</b>	<b>Pest and Disease incidences</b>
Control	4.25	13.17	10.33	64.33(53.30)	-
Hydration and dehydration	4.87	11.34	11.40	67.66(55.33)	-
Hydration with 25 ppm chitosan	4.62	11.62	10.66	66.33(54.52)	-
Hydration with 50 ppm chitosan	4.26	11.51	11.36	67.00(54.92)	-
Hydration with 75 ppm chitosan	4.88	11.45	11.40	68.00(55.54)	-
Hydration with 100 ppm chitosan	4.28	11.17	10.60	66.33(54.51)	-
T <sub>1+</sub> trichoderma @ 5 gm/kg	5.11	11.10	12.36	69.66(56.56)	-
T <sub>1+</sub> trichoderma @ 10gm/kg	5.24	10.87	12.43	71.36(57.82)	-
Hydration with 100 ppm GA <sub>3</sub>	5.99	10.61	12.53	72.66(58.47)	-
Hydration with 200 ppm GA <sub>3</sub>	4.39	11.50	11.70	68.33(55.73)	-
Hydration with 300 ppm GA <sub>3</sub>	4.69	11.55	12.13	68.66(55.94)	-
Hydration with 1% <i>aloe vera</i>	5.10	11.34	11.83	68.00(55.53)	-
Hydration with 2% <i>aloe vera</i>	5.07	11.27	11.40	66.00(54.32)	-
Hydration with 3% <i>aloe vera</i>	6.04	10.03	12.46	71.40(57.60)	-
Seed coating with <i>aloe vera</i> gel.	6.14	9.84	13.06	74.00(59.32)	-
<b>C.D. at 5%</b>	4.25	0.84	0.59	2.51	-

**Table 6: Effect of priming treatments on seedling dry weight (mg) of onion seeds during storage**

Treatments	Storage period (Months)			
	0	3	6	9
Control	23.00	18.00	16.00	13.67
Hydration and dehydration	25.33	21.67	19.67	15.00
Hydration with 25 ppm chitosan	24.67	19.00	17.67	15.33
Hydration with 50 ppm chitosan	26.33	21.33	17.67	16.33
Hydration with 75 ppm chitosan	26.00	21.67	19.33	13.67
Hydration with 100 ppm chitosan	26.83	21.67	15.67	12.00
T <sub>1</sub> + trichoderma @ 5 gm/kg	26.00	23.33	19.00	17.33
T <sub>1</sub> + trichoderma @ 10gm/kg	27.67	25.00	23.67	20.67
Hydration with 100 ppm GA <sub>3</sub>	30.67	29.67	27.67	24.00
Hydration with 200 ppm GA <sub>3</sub>	26.01	22.67	19.67	16.33
Hydration with 300 ppm GA <sub>3</sub>	26.70	21.67	18.67	15.67
Hydration with 1% <i>aloe vera</i>	24.00	21.33	18.33	15.00
Hydration with 2% <i>aloe vera</i>	26.43	22.33	21.00	19.33
Hydration with 3% <i>aloe vera</i>	26.00	24.00	22.33	20.00
Seed coating with <i>aloe vera</i> gel.	29.87	28.00	26.33	23.67
<b>C.D. at 5%</b>	2.63	3.01	3.06	3.27

### Vigour Index – I:

The data revealed decrease in vigour index-I with increase in storage period. Vigour index-I was recorded between 1192.48 to 1559.19 at the end of 3 months of storage (Table-7). The maximum vigour index-I was observed in seeds hydrated with 100ppm GA<sub>3</sub> (1559.19) followed by the seeds coated with *aloe vera* gel (1509.50) while it was found minimum in control (1192.48).

**Table 7: Effect of priming treatments on Vigour Index-I of onion seed during storage.**

Treatments	Storage period (Months)			
	0	3	6	9
Control	1306.16	1192.48	1053.02	839.04
Hydration and dehydration	1550.48	1407.12	1200.93	970.15
Hydration with 25 ppm chitosan	1478.16	1369.14	1159.28	1013.94
Hydration with 50 ppm chitosan	1588.62	1371.72	1195.63	1060.96
Hydration with 75 ppm chitosan	1586.01	1328.25	1231.45	921.02
Hydration with 100 ppm chitosan	1653.15	1321.61	1088.46	833.68
T <sub>1</sub> +trichoderma @ 5 gm/kg	1555.76	1341.51	1253.41	1175.02
T <sub>1</sub> +trichoderma @ 10gm/kg	1661.70	1433.27	1390.67	1258.47
Hydration with 100 ppm GA <sub>3</sub>	1809.37	1559.19	1449.94	1355.72
Hydration with 200 ppm GA <sub>3</sub>	1541.05	1257.36	1208.19	1134.26
Hydration with 300 ppm GA <sub>3</sub>	1625.40	1364.05	1239.92	1032.00
Hydration with 1% <i>aloe vera</i>	1455.53	1419.11	1257.93	1010.88
Hydration with 2% <i>aloe vera</i>	1600.44	1354.92	1263.13	1104.04
Hydration with 3% <i>aloe vera</i>	1556.53	1369.50	1272.00	1187.78
Seed coating with <i>aloe vera</i> gel.	1771.10	1509.50	1407.84	1304.00
<b>C.D. at 5%</b>	72.40	65.04	50.82	58.49

Vigour Index-I was recorded between 1053.03 to 1449.94 at the end of 6 months of storage. The highest vigour index-I was recorded in seeds hydrated with 100ppm GA<sub>3</sub> (1449.94) followed by seeds coated with *aloe vera* gel (1407.84) while minimum was recorded in control (1053.03).

Vigour index-I was observed more in all the treatments over control (839.04) at the end of 9 months of storage except seeds hydrated with 100ppm chitosan (833.68). Maximum vigour index-I was recorded in seeds hydrated with 100ppm GA<sub>3</sub> (1355.72) followed by seeds coated with *aloe vera* gel (1304.00) while minimum was observed in seeds hydrated with 100ppm chitosan (833.68). Effect of concentration of priming agents on vigour index-I was also observed during storability. After 9 months of storage, maximum vigour index-I was observed in the seeds treated with 50ppm chitosan (1060.96) over other concentrations. Similarly, more vigour index-I was observed in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (1258.47) than the hydrated-dehydrated seeds treated with

trichoderma @ 5g/kg seed (1175.02) at the end of 9 months. In GA<sub>3</sub>, maximum vigour index-I was observed in seeds hydrated with 100ppm GA<sub>3</sub> (1355.72) and in *aloe vera*, maximum vigour index-I was recorded in *aloe vera* coated seeds (1304.00) over the other concentrations at the end of 9 months.

### Vigour Index- II:

The data divulged revealed decrease in vigour index-II with increase in storage period. Vigour index-II was recorded between 1415.88 to 2541.82 at the end of 3 months of storage (Table-8). The maximum Vigour index-II was observed in seeds hydrated with 100ppm GA<sub>3</sub> (2541.82) followed by the seeds coated with *aloe vera* gel (2361.24) while it was found minimum in control (1415.88)

**Table 8: Effect of priming treatments on Vigour Index-II of onion seed during storage**

Treatments	Storage period (Months)			
	0	3	6	9
Control	1847.59	1415.88	1184.00	943.23
Hydration and dehydration	2186.73	1776.94	1521.08	1099.95
Hydration with 25 ppm chitosan	2088.56	1564.27	1384.09	1154.80
Hydration with 50 ppm chitosan	2290.71	1791.72	1389.92	1241.08
Hydration with 75 ppm chitosan	2262.00	1787.77	1552.77	1002.42
Hydration with 100 ppm chitosan	2343.06	1805.76	1196.09	816.00
T <sub>1</sub> + trichoderma @ 5 gm/kg	2227.42	1874.09	1507.27	1334.41
T <sub>1</sub> + trichoderma @ 10gm/kg	2407.29	2083.25	1932.89	1632.93
Hydration with 100 ppm GA <sub>3</sub>	2729.63	2541.82	2305.74	1960.08
Hydration with 200 ppm GA <sub>3</sub>	2210.85	1843.75	1560.42	1246.46
Hydration with 300 ppm GA <sub>3</sub>	2296.20	1791.45	1481.09	1175.25
Hydration with 1% <i>aloe vera</i>	2023.92	1777.42	1484.73	1114.95
Hydration with 2% <i>aloe vera</i>	2303.90	1875.72	1693.86	1482.03
Hydration with 3% <i>aloe vera</i>	2244.58	1992.00	1786.40	1546.60
Seed coating with <i>aloe vera</i> gel.	2658.43	2361.24	2167.74	1893.60
<b>C.D. at 5%</b>	236.36	266.81	261.71	300.19

Vigour index-II was recorded between 1184.00 to 2305.74 at the end of 6 months of storage. Maximum vigour index-II was recorded in seeds hydrated with 100ppm GA<sub>3</sub> (2305.74) followed by the seeds coated with *aloe vera* gel (2167.74) while minimum was recorded in control (1184.00).

Vigour index-II was observed maximum in all the treatments over control (943.23) at the end of 9 months of storage except the seeds hydrated with 100ppm chitosan (816.00). Maximum vigour index-II was recorded in seeds hydrated with 100ppm GA<sub>3</sub> (1960.08) followed by the seeds coated with *aloe vera* gel (1893.60) while minimum was observed in the seeds hydrated with 100ppm chitosan (816.00). Effect of concentration of priming agents on vigour index-II

was also observed during storability. After 9 months of storage, maximum vigour index-II was observed in the seeds treated with 50ppm chitosan (1241.08) over other concentrations. Similarly, more vigour index-II was observed in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (1632.93) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (1334.41) at the end of 9 months. In GA<sub>3</sub>, maximum vigour index-II was observed in seeds hydrated with 100ppm GA<sub>3</sub> (1960.08) and in *aloe vera*, maximum vigour index-II was recorded in *aloe vera* coated seeds (1893.60) over the other concentrations at the end of 9 months.

**Electrical Conductivity ( $\mu\text{S}/\text{cm}/\text{seed}$ ):**

The data divulged no significant different among the treatments initially but increase in electrical conductivity was observed with increase in storage period (Table-9). Electrical conductivity was recorded between 0.353 to 0.550 at the end of 3 months of storage. The minimum electrical conductivity was observed in the seeds hydrated with 100ppm GA<sub>3</sub> (0.353) followed by the seeds coated with *aloe vera* gel (0.387) while it was found maximum in control (0.550)

**Table 9: Effect of priming treatments on Electrical conductivity ( $\mu\text{S}/\text{cm}/\text{seed}$ ) of onion seed during storage**

Treatment	Storage period (Months)			
	0	3	6	9
Control	0.320	0.550	0.743	0.920
Hydration and dehydration	0.310	0.507	0.570	0.860
Hydration with 25 ppm chitosan	0.310	0.510	0.657	0.810
Hydration with 50 ppm chitosan	0.310	0.483	0.647	0.770
Hydration with 75 ppm chitosan	0.310	0.473	0.597	0.833
Hydration with 100 ppm chitosan	0.320	0.467	0.567	0.877
T <sub>1</sub> + trichoderma @ 5 gm/kg	0.320	0.433	0.507	0.733
T <sub>1</sub> + trichoderma @ 10gm/kg	0.310	0.410	0.520	0.667
Hydration with 100 ppm GA <sub>3</sub>	0.320	0.353	0.407	0.453
Hydration with 200 ppm GA <sub>3</sub>	0.310	0.483	0.657	0.760
Hydration with 300 ppm GA <sub>3</sub>	0.320	0.473	0.600	0.780
Hydration with 1% <i>aloe vera</i>	0.320	0.450	0.543	0.803
Hydration with 2% <i>aloe vera</i>	0.310	0.433	0.547	0.737
Hydration with 3% <i>aloe vera</i>	0.320	0.427	0.573	0.720
Seed coating with <i>aloe vera</i> gel.	0.320	0.387	0.450	0.547
<b>C.D. at 5%</b>	N.S.	0.074	0.095	0.139

Electrical conductivity was recorded between 0.407 to 0743 at the end of 6 months of storage. The lowest value was recorded in the seeds hydrated with 100ppm GA<sub>3</sub> (0.407)

followed by the seeds coated with *aloe vera* gel (0.450) while maximum electrical conductivity was recorded in control (0.743).

Significantly lower electrical conductivity was recorded in all the treatments over control at the end of 9 months of storage. The minimum electrical conductivity was recorded in the seeds hydrated with 100ppm GA<sub>3</sub> (0.453) followed by the seeds coated with *aloe vera* gel (0.547) while maximum was observed in control (0.920). Effect of concentration of priming agents on electrical conductivity was also observed during storability. After 9 months of storage, minimum electrical conductivity was observed in the seeds treated with 50ppm chitosan (0.770) over other concentrations. Similarly, minimum electrical conductivity was observed in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (0.667) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (0.733) at the end of 9 months. In GA<sub>3</sub>, minimum electrical conductivity was observed in seeds hydrated with 100ppm GA<sub>3</sub> (0.453) and in *aloe vera*, minimum electrical conductivity was recorded in *aloe vera* coated seeds (0.547) over the other concentrations at the end of 9 months.

#### **Dehydrogenase activity (ODg<sup>-1</sup>ml<sup>-1</sup>):**

The data revealed decrease in dehydrogenase activity with increase in storage period (Table-10). All the treatments maintained dehydrogenase activity above the control (0.537) at the end of 9 months of storage. The maximum dehydrogenase activity was recorded in the seeds hydrated with 100ppm GA<sub>3</sub> (0.790) followed by seeds coated with *aloe vera* gel (0.770) while minimum was observed in control (0.537). Effect of concentration of priming agents on dehydrogenase activity was also observed during storability. After 9 months of storage, maximum dehydrogenase activity was observed in the seeds treated with 50ppm chitosan (0.683) over other concentrations. Similarly, more dehydrogenase activity was observed in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (0.737) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (0.697) at the end of 9 months. In GA<sub>3</sub>, maximum dehydrogenase activity was observed in seeds hydrated with 100ppm GA<sub>3</sub> (0.790) and in *aloe vera*, maximum dehydrogenase activity was recorded in *aloe vera* coated seeds (0.770) over the other concentrations at the end of 9 months.

#### **Catalase activity (μmoles/min/g)**

The data was reported that decrease in catalase activity with increase in storage period (Table-10). All the treatments maintained catalase activity above the control (0.120) at the end of 9 months of storage. The maximum catalase activity was recorded in the seeds hydrated with 100ppm GA<sub>3</sub> (0.250) followed by seeds coated with *aloe vera* gel (0.230) while minimum activity was recorded in control (0.120). Effect of concentration of priming agents on catalase activity was also observed during storability. After 9 months of storage, maximum catalase activity was observed in the seeds treated with 25ppm chitosan (0.200) over other concentrations. Similarly, more catalase activity was observed in the hydrated-dehydrated

seeds treated with trichoderma @ 10g/kg seed (0.210) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (0.197) at the end of 9 months. In GA<sub>3</sub>, maximum catalase activity was observed in seeds hydrated with 100ppm GA<sub>3</sub> (0.250) and in *aloe vera*, maximum catalase activity was recorded in *aloe vera* coated seeds (0.230) over the other concentrations at the end of 9 months.

**Peroxidase activity ( $\mu\text{moles}/\text{min}/\text{g}$ ):**

The data divulged decrease in peroxidase activity with increase in storage period (Table-10). All the treatments maintained peroxidase activity above the control (0.273) at the end of 9 months of storage. The maximum peroxidase activity was recorded in the seeds hydrated with 100ppm GA<sub>3</sub> (0.683) followed by seeds coated with *aloe vera* gel (0.647). Effect of concentration of priming on peroxidase activity was also observed during storability. After 9 months of storage, maximum peroxidase activity was observed in the seeds treated with 25ppm chitosan (0.493) over other concentrations. Similarly, more peroxidase activity was observed in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (0.587) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (0.563) at the end of 9 months. In GA<sub>3</sub>, maximum peroxidase activity was observed in seeds hydrated with 100ppm GA<sub>3</sub> (0.683) and in *aloe vera*, maximum peroxidase activity was recorded in *aloe vera* coated seeds (0.647) over the other concentrations at the end of 9 months.

**Lipid peroxidation ( $\mu\text{mol g}^{-1}\text{DW}$ )**

The data revealed increase in lipid peroxidation with increase in storage period (Table-10). All the treatments maintained lipid peroxidation below the control (0.673) at the end of 9 months of storage. The minimum lipid peroxidation was recorded in the seeds hydrated with 100ppm GA<sub>3</sub> (0.330) followed by seeds coated with *aloe vera* gel (0.380). Effect of concentration of priming agents on lipid peroxidation was also observed during storability. After 9 months of storage, minimum lipid peroxidation was observed in the seeds treated with 50ppm chitosan (0.510) over other concentrations. Similarly, minimum lipid peroxidation was observed in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed (0.423) than the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seed (0.467) at the end of 9 months. In GA<sub>3</sub>, minimum lipid peroxidation was observed in seeds hydrated with 100ppm GA<sub>3</sub> (0.330) and in *aloe vera*, minimum lipid peroxidation was recorded in *aloe vera* coated seeds (0.380) over the other concentrations at the end of 9 months.

**Table 10: Effect of priming treatments on enzyme activity of onion seed during storage**

Treatments	DHA(ODg <sup>-1</sup> ml <sup>-1</sup> )		CAT(μmoles/min/g)		POD(μmoles/min/g)		LPT(μmol g <sup>-1</sup> DW)	
	Initial	After 9 months	Initial	After 9 months	Initial	After 9 months	Initial	After 9 months
Control	0.733	0.537	0.220	0.120	0.627	0.273	0.227	0.673
Hydration and dehydration	0.790	0.633	0.260	0.177	0.753	0.460	0.175	0.607
Hydration with 25 ppm chitosan	0.760	0.680	0.253	0.200	0.723	0.493	0.163	0.593
Hydration with 50 ppm chitosan	0.780	0.683	0.257	0.167	0.763	0.480	0.147	0.510
Hydration with 75 ppm chitosan	0.803	0.653	0.263	0.173	0.807	0.463	0.170	0.533
Hydration with 100 ppm chitosan	0.810	0.553	0.243	0.140	0.753	0.420	0.143	0.547
T <sub>1</sub> + trichoderma @ 5 gm/kg	0.767	0.697	0.270	0.197	0.800	0.563	0.157	0.467
T <sub>1</sub> + trichoderma @ 10gm/kg	0.797	0.737	0.270	0.210	0.863	0.587	0.140	0.423
Hydration with 100 ppm GA <sub>3</sub>	0.833	0.790	0.303	0.250	0.923	0.683	0.110	0.330
Hydration with 200 ppm GA <sub>3</sub>	0.787	0.683	0.267	0.187	0.783	0.503	0.157	0.520
Hydration with 300 ppm GA <sub>3</sub>	0.733	0.633	0.267	0.137	0.777	0.487	0.174	0.523
Hydration with 1% <i>aloe vera</i>	0.740	0.683	0.240	0.177	0.773	0.470	0.178	0.560
Hydration with 2% <i>aloe vera</i>	0.757	0.680	0.273	0.170	0.707	0.533	0.165	0.540
Hydration with 3% <i>aloe vera</i>	0.800	0.710	0.270	0.213	0.857	0.573	0.140	0.430
Seed coating with <i>aloe vera</i> gel.	0.810	0.770	0.293	0.230	0.870	0.647	0.120	0.380
<b>C.D. at 5%</b>	0.041	0.036	0.029	0.035	0.063	0.043	0.040	0.067

Onion seeds have a shortest life span among the vegetable crops and lose the viability rapidly after harvest. Hence, it possesses a serious problem for the carry-over seed stocks, unless special precautions are taken in its storage. It is recommended that only fresh harvested onion seed should be used for crop production (Rickels *et al.*, 1976). Fungicide treatments are discouraged due to toxic residues and development of resistance in pathogens. Thus there is an urgent need for safer method of pathogen control. Moreover, due to heavy chemical use in intensive cropping systems, concerns to environmental health have been raised world over. Hence bio friendly compounds like chitosan, *aloe vera*, trichoderma and other growth regulators have gained attention in recent times. Recently, there has been global realization of the important role of PGRs in agriculture for better growth and yield of crops. Developed countries like Japan, China, Poland, South Korea etc. have long been using PGRs to increase crop yield. Application of commercial antioxidants, vitamins or nutrients for seed quality enhancements is very expensive for resource poor farmers. Onion seeds show poor germination with slow growth of seedling and it has short storage life. Hence, considering the above facts, the present study entitled “Seed quality enhancement through priming treatments in onion (*Allium cepa* L.)” was undertaken to enhance the seed quality by various priming treatments to assess the effect of various priming treatments on seed quality and to study the effect of priming treatments on seed storability.

#### **Seed quality parameters study in laboratory:**

All the treatments enhanced standard germination significantly. Maximum initial germination was observed in the seeds hydration with 100ppm GA<sub>3</sub>. After 9 months of storage maximum germination was recorded in same, seeds hydrated with 100ppm GA<sub>3</sub> followed by the seeds coated with *aloe vera* gel. Decrease in standard germination was observed with increase in storage period. All the priming treatments maintained standard germination above the IMSCS (70%) at the end of 9 months of storage except the seeds hydrated with 100ppm chitosan but enhancement in germination was observed in the seeds treated with lower concentration of chitosan *i.e.* 50ppm. This type of response by GA<sub>3</sub> has also been reported by various worker Tiwari *et al.* (2002) in onion; Lal *et al.* (2013) in onion; Airi *et al.* (2005) in *cornus capitata*, Kuchlan *et al.* (2002) in sunflower; Behtari and Tilaki, (2012) in *F. arundinacea*. It is reported that gibberellins promote germination and play an important role in mobilization of endosperm reserves during germination of seeds (Weiss and Ori, 2007). During seed germination, in carbohydrate rich crops, gibberellins are released from the embryo into the aleurone layer where they induce protein synthesis and the expression of a

number of genes encoding hydrolytic enzymes, including  $\alpha$ -amylase (Jacobsen *et al.*, 1995). The  $\alpha$ -amylase is key enzyme for the germination and subsequent seedling growth of seeds (Mitsui, 1987; Mitsunaga *et al.*, 2007). The treatment of cereal seeds with gibberellins induces rapid hydrolysis of starch in endosperm and proteins in aleurone layer and appearance of free phosphate in the seed whereas adverse effect in germination after 9 months of storage in hydration with 100ppm chitosan may be due to higher concentration of priming treatment.

All the treatments registered enhancement in seedling length over the control. Maximum initial seedling length was observed in the seeds hydrated with 100ppm GA<sub>3</sub>. After 9 months of storage also, maximum seedling length was recorded in the seeds hydrated with 100ppm GA<sub>3</sub> followed by the seeds coated with *aloe vera* gel. Decrease in seedling length was observed with increase in storage period. Similar finding were reported by Wadekar *et al.* (2016) in papaya seeds. It was observed that increase in seedling length can be attributed to the fact that GA<sub>3</sub> increase activities during seed germination and resulted in increased seedling length (Lal, *et al.*, 2013).

Significantly increase by all the treatments was registered in seedling dry weight over the control. Maximum initial seedling dry weight was observed in the seeds hydrated with 100ppm GA<sub>3</sub>. Maximum seedling dry weight was recorded in the seeds hydrated with 100ppm GA<sub>3</sub> followed by the seeds coated with *aloe vera* gel except seed hydration with 100ppm chitosan after 9 months of storage also. The results were supported by Yoganada *et al.* (2004) in bell pepper. It was reported that gibberellins (GA) trigger the hydrolysis of reserve food material in seeds and directly affect the growth potential of the embryo thereby enhancing the germination in GA<sub>3</sub> primed seeds (Lal *et al.*, 2013) whereas negative effect in seedling dry weight after 9 months of storage in hydration with 100ppm chitosan may be due to higher of priming treatment.

All the treatments significantly enhanced vigour index-I & vigour index- II over the control. Maximum initial vigour index-I & vigour index- II was observed in the seeds hydrated with 100ppm GA<sub>3</sub>. After 6 & 9 months of storage, maximum vigour index-I & vigour index- II was also recorded in the seeds hydrated with 100ppm GA<sub>3</sub> followed by the seeds coated with *aloe vera* gel except the seed hydrated with 100ppm chitosan. Decrease in seedling length was observed with increase in storage period. The similar finding was observed by Tiwari *et al.*, 2016 in wheat; Gurung *et al.*, (2014) in passion fruit. It was reported that the seedling vigour is an important criterion for the germination study and it was expressed in term of seedling length and seedling dry weight. The vigour attributes were influenced significantly due to seed priming and the values were higher in all the treatments as compared to the control. The adverse effect of hydration with 100ppm on vigour indices may be due to adverse effect on seedling weight.

After 9 months of storage electrical conductivity was also recorded in the seeds treated with 100ppm GA<sub>3</sub> followed by the seeds coated with *aloe vera* gel. The present results are in accordance with Khan *et al.* (2005) in turnip and Ching and Schoolcrat, (1968) in red clover. Most of the treatments maintained the intactness of membranous system of the seed although for variable periods during storage. A highly significant correlation between electrolyte leakage and seed deterioration under naturally aged conditions in various crops suggested that one of major cause of seed deterioration is due to the membrane damage which increases the membrane permeability by the lipid per-oxidation. The results clearly indicated that the damage to membrane system seems to be a major cause of seed viability and germination loss during storage in onion.

### **Enzyme activities test**

All the priming treatments were reported higher activity of these enzymes viz., Dehydrogenase, peroxidase and catalase activity as compare to control but maximum enhanced was observed by hydration treatments with 100ppm GA<sub>3</sub> followed by seed coating with *aloe vera* gel.

Higher activities of catalase and several peroxidases during imbibitions and seed germination have been found in the seeds of maize (Leprince *et al.*, 1990) castor endosperm (Klapheck *et al.*, 1990), soybean embryonic axis (Puntarulo *et al.*, 1991) and wheat endosperm and embryo (Cakmak *et al.*, 1993). The present result are in accordance with the finding of Ghosh *et al.* (1978) in rice; Sung and Chiu (1995) in soybean; Moosavi *et al.*(2009) in amaranth.

All the treatments registered significantly lower lipid peroxidation value over the control. Minimum initial lipid peroxidation value was observed in the seeds hydrated with 100ppm GA<sub>3</sub>. After 9 months of storage minimum lipid peroxidation value was also recorded in the seeds hydrated with 100ppm GA<sub>3</sub> followed by the seeds coated with *aloe vera* gel.

The data divulged increase in lipid peroxidation with increase in storage period. In the presnt study, level of melonaldehyde increase with the advancement of the ageing period. Similarly, increased MDA content was reported during natural and artificial ageing in pea (Harman and Mattick, 1976), peanut (Jeng and Sung, 1994), soybean (Senartna *et al.*, 1988; Sung and Chiu, 1995) and sunflower (Baily *et al.*, 1996).

### **Field parameters study**

All the treatments reported significantly higher field emergence index over the control. Maximum field emergence index was observed in the seeds coated with *aloe vera* gel followed by the seeds hydration with 3% *aloe vera*. The result was supported by Cavusoglu *et al.* (2016) in onion seeds. All the treatments reported lower mean germination time over the control. Minimum mean germination time was observed in the seeds coated with *aloe vera* gel followed by the seeds hydration with 3% *aloe vera*. All the priming treatments

significantly enhanced seedling establishment over the control. Seedling establishment was recorded in the seed coated with *aloe vera* gel followed by seed hydration with 100ppm GA<sub>3</sub>. Similarly, increase in seed germination was also reported by Maurya *et al.* (1987) and Tiwari *et al.* (2002) with GA<sub>3</sub>. It was reported that GA<sub>3</sub> enhances amylase synthesis with helps in conversion of reserve food material into amino acids and their translocation via phloem into the young roots and shoot causing emergence of the seedling.

The concentration of the priming agents also affected the seed quality parameters during storability. Initially, 100ppm chitosan showed the maximum improvement in the seed quality parameters but at the end of 9 months 50ppm concentration of chitosan maintained the maximum germination over the other concentrations. Similarly, maximum germination was observed in the hydrated-dehydrated seeds treated with trichoderma @ 10g/kg seed over the hydrated-dehydrated seeds treated with trichoderma @ 5g/kg seeds at the end of 9 months storage. Similar trend was observed in other seed quality parameters also. Among GA<sub>3</sub> concentrations, seeds hydrated with 100ppm GA<sub>3</sub> maintained the seed quality parameters at the end of 9 months of storage while among *aloe vera* concentrations, seeds coated with *aloe vera* gel maintained the better seed quality after the 9 months of storage. So the priming treatment should be given with optimum concentration in onion seed to maintain the seed quality during storage.

Onion seeds are categorized under micro-biotic seeds among the vegetable crops and loose the viability rapidly after harvest. Quality seed plays an important role in the crop establishment and overall performance of the crop. The seed of a particular harvest is not used immediately for sowing the following crop, so the fresh seed has to be stored for 6-9 months after harvest. The present study entitled, “Seed quality enhancement through priming treatments in onion (*Allium cepa L*)” was conducted during rabi 2016-17 at research area of vegetable science and laboratories of Seed Science & Technology of CCS, HAU, Hisar with the objectives to standardize the optimum concentration of priming agents, to assess the effect of various priming treatments on seed quality and to study the effect of priming treatments on seed storability. The freshly harvested seed of onion variety Hisar-2 was subjected to different seed priming treatments and observations on various seed quality parameters and field parameters were recorded. The summary of results is given below:

- 6.1 Significant enhancement in seed quality parameters was observed in all the treatments over control.
- 6.2 Maximum enhancement in laboratory parameters was observed in the seeds hydrated with 100ppm GA<sub>3</sub> followed by seeds coated with *aloe vera* gel.
- 6.3 In field conditions, seed coated with *aloe vera* gel showed best result registering highest seedling establishment followed by seed hydration with 100ppm GA<sub>3</sub>
- 6.4 Germination percentage, vigour indices and other quality parameters decreased with storage period.
- 6.5 Higher concentration of chitosan (>75ppm) first showed maximum improvement among the treatments in seed quality parameters but with the passage of time it adversely affect the seed quality.
- 6.6 The concentration of the priming agents also affected the seed quality parameters during storability. So the priming treatment should be given with optimum concentration in onion seed to maintain the seed quality during storage.
- 6.7 The priming treatments enhanced the enzymatic activity of Dehydrogenase, peroxidase and catalase and maximum enhanced was observed by hydration treatments with GA<sub>3</sub> followed by seed coating with *aloe vera* gel. Similarly lower value of lipid peroxidation was recorded in the same treatments.
- 6.8 The germination can be maintained above IMSCS in onion seed by treating the onion seeds with GA<sub>3</sub> 100ppm & *aloe vera* when stored in plastic containers (700gauge) under ambient conditions.

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## ABSTRACT

**Title of thesis** : Seed quality enhancement through priming treatments in onion (*Allium cepa* L).  
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**Year of Award of Degree** : 2017  
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**Total number of pages in the thesis** : 38 + viii  
**Number of words in the abstract** : 234  
**Key words:** Onion, seed priming, storage, Chitosan, *aloe vera*

Onion seeds are micro-biotic in nature and lose the viability rapidly after harvest. If special precautions are not taken during storage, a serious problem in germination exists for the carry-over seed stocks. Fungicide treatments are discouraged due to toxic residues and development of resistance in pathogens. Hence, there is an urgent need for safer method of pathogen control through bio friendly compounds like chitosan, *aloe vera*, trichoderma and other growth regulators. So, the present study was planned to assess the seed quality by various priming treatments in onion. Significant enhancement in seed quality parameters was observed in all the treatments and maximum enhancement in germination was recorded in the seed hydrated with 100ppm GA<sub>3</sub> followed by seed coated with *aloe vera* gel. In field condition *aloe vera* gel coated seed performed better and recorded maximum seedling establishment. All the treatment maintained the germination percentage above IMSCS after nine months except the seed treated with 100ppm chitosan. Lower concentration of chitosan *i.e.* 50ppm enhanced the seed quality parameters but as the concentration increases, it inversely affects the seed quality parameters. Same trend was also observed for other seed quality parameters viz. seedling length, seedling dry weight, vigour indices and electrical conductivity. The concentration of the primers also affected the seed quality parameters during storability. Hence, priming treatment should be given with optimum concentration in onion seed to maintain the seed quality during storage. It was concluded from the study that germination can be maintained above IMSCS in onion seed by treating seeds with GA<sub>3</sub> 100ppm & *aloe vera* when stored in plastic containers (700gauge) under ambient conditions.

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