

**EFFECT OF PRIMING ON ENHANCING STORABILITY
OF BRINJAL (*Solanum melongena* L.) SEEDS**

Thesis

**Submitted to the Punjab Agricultural University
in partial fulfillment of the requirements
for the degree of**

**MASTER OF SCIENCE
in
BOTANY
(Minor Subject: Biochemistry)**

By

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(L-2018-BS-246-M)**

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2020

CERTIFICATE – I

This is to certify that the thesis entitled “**Effect of priming on enhancing storability of brinjal (*Solanum melongena* L.) seeds**” submitted for the degree of **Master of Science** in the subject of **Botany** (Minor subject: **Biochemistry**) of the Punjab Agricultural University, Ludhiana, is a bonafide research work carried out by **Japneet Kaur (L-2018-BS-246-M)** under my supervision and that no part of this thesis has been submitted for any other degree.


The assistance and help received during the course of investigation have been fully acknowledged.

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CERTIFICATE – II

This is to certify that the thesis entitled “**Effect of priming on enhancing storability of brinjal (*Solanum melongena* L.) seeds**” submitted by **Japneet Kaur (L-2018-BS-246-M)** to the Punjab Agricultural University, Ludhiana, in partial fulfillment of the requirements for the degree of **Master of Science** in the subject of **Botany** (Minor subject: **Biochemistry**) has been approved by the Student’s Advisory Committee along with the External Examiner after an oral examination on the same.

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ABSTRACT

The present study was conducted on brinjal (*Solanum melongena* L.) seeds var. Punjab nagina. The quality of brinjal seeds in-terms of vigour and viability severely declines as a result of natural ageing during storage between harvesting and next sowing season. The objective of this study was to evaluate the effect of various priming treatments on the quality and storability of brinjal seeds. The freshly harvested seed was divided into two lots. One of these seed lots was subjected to accelerated ageing to obtain low vigour seed and the other lot was considered to be high vigour. The high and low vigour seeds were primed with KNO₃ (1%), GA₃ (100ppm), KH₂PO₄ (0.1M), PEG 6000 (30%) and H₂O for 12 hours at 25°C. Thereafter, the seeds were stored in moisture impervious bags for 12 months in a refrigerator (4°C). The objective was to observe whether the priming treatments improve the seed vigour and also retain the advantages obtained from priming during storage. The seeds were drawn at three-monthly intervals, viz. zero, three, six, nine and twelve months of storage. Physiological (germination percentage, speed of germination, mean days to germination, seedling length, root length, shoot length, seedling dry weight and seedling vigour index) and biochemical (Total soluble sugars, total soluble proteins, α-amylase activity and membrane stability index, starch content, total free aminoacids) observations were recorded. With an increase in storage duration, a decline in physiological and biochemical aspects of seed quality was observed in both high and low vigour seeds. All the priming treatments improved the germination related parameters in both high and low vigour seeds over control but the extent of improvement varied. Seed priming with GA₃ (100ppm) followed by priming with KNO₃ (1%) were found to be the best treatments for both high and low vigour seeds even after storage for 12 months.

Keywords: Brinjal, seeds, priming, germination, GA₃, storage

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ਸਾਰ ਅੰਸ਼

ਮੌਜੂਦਾ ਅਧਿਐਨ ਬੈਂਗਣ (*Solanum melongena* L.) ਦੇ ਪੰਜਾਬ ਨਗੀਨਾ ਬੀਜ ਉਪਰ ਕੀਤਾ ਗਿਆ। ਵਾਢੀ ਅਤੇ ਅਗਲੀ ਬੀਜਾਈ ਰੁੱਤ ਵਿੱਚਲੇ ਭੰਡਾਰਨ ਦੌਰਾਨ ਉਮਰ ਵਧਣ ਨਾਲ ਬੀਜ ਦੀ ਠੋਸਤਾ ਅਤੇ ਵਿਵਹਾਰਿਕਤਾ ਦੇ ਲਿਹਾਜ਼ ਨਾਲ ਬੈਂਗਣ ਦੇ ਬੀਜਾਂ ਦੀ ਗੁਣਵਤਾ ਬੁਰੀ ਤਰ੍ਹਾਂ ਪ੍ਰਭਾਵਿਤ ਹੁੰਦੀ ਹੈ। ਇਸ ਅਧਿਐਨ ਦਾ ਉਦੇਸ਼ ਬੈਂਗਣ ਦੇ ਬੀਜਾਂ ਦੀ ਗੁਣਵਤਾ ਅਤੇ ਭੰਡਾਰਨ ਸਮਰੱਥਾ ਉਪਰ ਵੱਖੋ-ਵੱਖਰੇ ਪ੍ਰਾਈਮਿੰਗ ਉਪਚਾਰਾਂ ਦੇ ਪ੍ਰਭਾਵ ਦਾ ਮੁਲਾਂਕਣ ਕਰਨਾ ਸੀ। ਬੈਂਗਣ ਦੇ ਤਾਜ਼ੇ ਬੀਜਾਂ ਨੂੰ ਦੋ ਸ਼੍ਰੇਣੀਆਂ ਵਿੱਚ ਵੰਡਿਆ ਗਿਆ। ਇਹਨਾਂ ਵਿੱਚੋਂ ਘੱਟ ਠੋਸਤਾ ਲਈ ਇੱਕ ਲਾਟ ਦੇ ਬੀਜਾਂ ਨੂੰ ਅਤੇ ਵਧੇਰੇ ਠੋਸਤਾ ਲਈ ਦੂਜੀ ਲਾਟ ਦੇ ਬੀਜਾਂ ਦੀ ਤੇਜ਼ੀ ਏਜਿੰਗ ਕੀਤੀ ਗਈ। ਘੱਟ ਅਤੇ ਵਧੇਰੇ ਠੋਸਤਾ ਵਾਲੇ ਬੀਜਾਂ ਨੂੰ 25°C ਤਾਪਮਾਨ ਉਪਰ 12 ਘੰਟਿਆਂ ਲਈ KNO₃ (1%), GA₃ (100ppm), KH₂PO₄ (0.1M), PEG 6000 (30%) ਅਤੇ H₂O ਨਾਲ ਸੋਧਿਆ ਗਿਆ। ਬੀਜਾਂ ਨਮੀ ਰਹਿਤ ਥੈਲੀਆਂ ਵਿੱਚ ਭਰ ਕੇ 12 ਮਹੀਨਿਆਂ ਲਈ ਰੈਫਰਿਜਰੇਟਰ (4°C) ਵਿੱਚ ਰੱਖਿਆ ਗਿਆ। ਇਸ ਦਾ ਉਦੇਸ਼ ਇਹ ਦੇਖਣਾ ਸੀ ਕਿ ਕੀ ਪ੍ਰਾਈਮਿੰਗ ਉਪਚਾਰਾਂ ਨਾਲ ਬੀਜ ਦੀ ਠੋਸਤਾ ਵਿੱਚ ਸੁਧਾਰ ਹੁੰਦਾ ਹੈ ਅਤੇ ਪ੍ਰਾਈਮਿੰਗ ਤੋਂ ਹੋਣ ਵਾਲੇ ਫਾਇਦੇ ਭੰਡਾਰਨ ਦੌਰਾਨ ਬਰਕਰਾਰ ਰਹਿੰਦੇ ਹਨ ਕਿ ਨਹੀਂ। ਭੰਡਾਰਨ ਦੌਰਾਨ ਹਰ ਤਿੰਨ ਮਹੀਨੇ ਦੇ ਅੰਤਰਾਲ ਤੇ ਭਾਵ ਜ਼ੀਰੋ, ਤਿੰਨ, ਛੇ, ਨੌਂ ਅਤੇ 12 ਮਹੀਨਿਆਂ ਮਗਰੋਂ ਬੀਜਾਂ ਨੂੰ ਕੱਢਿਆ ਗਿਆ। ਫਿਜ਼ੀਓਲਾਜੀਕਲ (ਪੁੰਗਰਨ ਪ੍ਰਤੀਸ਼ਤਤਾ, ਪੁੰਗਰਨ ਦੀ ਗਤੀ, ਪੁੰਗਰਨ ਲਈ ਲੱਗੇ ਔਸਤ ਦਿਨ, ਅੰਕੁਰਾਂ ਦੀ ਲੰਬਾਈ, ਜੜ੍ਹ ਦੀ ਲੰਬਾਈ, ਤਣੇ ਦੀ ਲੰਬਾਈ, ਸੁੱਕੇ ਅੰਕੁਰ ਦਾ ਭਾਰ ਅਤੇ ਅੰਕੁਰ ਦਾ ਠੋਸਤਾ ਸੂਚਕਾਂਕ) ਅਤੇ ਜੀਵ-ਰਸਾਇਣਕ (ਕੁੱਲ ਘੁਲਣਸ਼ੀਲ ਸੂਗਰ, ਕੁੱਲ ਘੁਲਣਸ਼ੀਲ ਪ੍ਰੋਟੀਨ, ਅਲਫਾ-ਐਮਾਈਲੇਜ਼ ਗਤੀਵਿਧੀ ਅਤੇ ਤਿੱਲੀ ਸਥਿਰਤਾ ਸੂਚਕਾਂਕ, ਸਚਾਰਚ ਦੀ ਮਾਤਰਾ, ਕੁੱਲ ਫ੍ਰੀ ਐਮਾਈਨੋ ਐਸਿਡ) ਮਾਪਦੰਡਾਂ ਦੇ ਆਂਕੜੇ ਦਰਜ ਕੀਤੇ ਗਏ। ਭੰਡਾਰਨ ਸਮੇਂ ਵਿੱਚ ਵਾਧਾ ਹੋਣ ਨਾਲ, ਘੱਟ ਅਤੇ ਵਧੇਰੇ ਠੋਸ ਬੀਜਾਂ ਵਿੱਚ ਦੀ ਗੁਣਵਤਾ ਵਿੱਚ ਫਿਜ਼ੀਓਲਾਜੀਕਲ ਅਤੇ ਜੀਵ-ਰਸਾਇਣਕ ਗੁਣਾਂ ਦੇ ਲਿਹਾਜ਼ ਨਾਲ ਕਮੀ ਆਈ। ਸਾਰੇ ਦੇ ਸਾਰੇ ਪ੍ਰਾਈਮਿੰਗ ਉਪਚਾਰਾਂ ਨਾਲ ਅਣ-ਉਪਚਾਰਤ ਬੀਜਾਂ ਦੇ ਮੁਕਾਬਲੇ ਉਪਚਾਰਤ ਬੀਜਾਂ ਦੇ ਪੁੰਗਰਨ ਮਾਪਦੰਡਾਂ ਵਿੱਚ ਸੁਧਾਰ ਕੀਤਾ ਹਾਲਾਂਕਿ ਸੁਧਾਰ ਦੀ ਦਰ ਵੱਖੋ-ਵੱਖਰੀ ਸੀ। ਸਾਰੇ ਦੇ ਸਾਰੇ ਉਪਚਾਰਾਂ ਵਿੱਚੋਂ, GA₃ (100ppm) ਅਤੇ ਇਸ ਮਗਰੋਂ KNO₃ (1%) ਵਾਲਾ ਉਪਚਾਰ ਭੰਡਾਰਨ ਦੇ 12 ਮਹੀਨਿਆਂ ਮਗਰੋਂ ਵੀ ਉੱਚੇ ਅਤੇ ਘੱਟ ਠੋਸ ਬੀਜਾਂ ਲਈ ਸਭ ਤੋਂ ਵਧੀਆ ਉਪਚਾਰ ਸੀ।

ਮੁੱਖ ਸ਼ਬਦ: ਬੈਂਗਣ, ਬੀਜ, ਪ੍ਰਾਈਮਿੰਗ, ਪੁੰਗਰਨ, GA₃, ਭੰਡਾਰਨ

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CHAPTER –I

INTRODUCTION

Brinjal (*Solanum melongena* L.) is a vegetable crop of Solanaceae family grown for its nutritious and edible fruits. India is considered as centre of origin of Brinjal (Bhaskar and Ramesh 2015). Major brinjal yielding countries other than India are China, Egypt, Japan, Italy, Syria, Spain, Iraq, Turkey, Indonesia and the Philippines. In India, brinjal is cultivated in an area of about 0.73 million hectares with average production of about 17.53 metric ton per hectare for both consumption as well as export (FAO 2018). Brinjal is a healthy low-calorie vegetable, rich in proteins, carbohydrates, fibres, minerals and vitamins (Bhavyasree and Vinothini 2019). Improved quantitative production of brinjal is required to meet its increasing demand for its nutritive and therapeutic properties. In general, by improving seed quality with different ameliorating techniques agricultural productivity can be increased by 20 to 25 percent (Raj and Raj 2019).

Good quality seed is the basic input for successful agriculture (Raj and Raj 2019). A vigorous seed lot is the one that has the potential to perform well under wide range of environments (Finch-Savage and Bassel 2016). Normally, viable seeds have the highest seed vigour close to maturity having maximum physiological potential but the vigour successively declines during field weathering, harvesting, seed extraction from fruit, seed drying and storage (Marcos-Filho 2015). Depending upon the consumption, export and various other factors brinjal seeds need to be stored for up to two to three sowing seasons. Seeds are very sensitive to their surrounding environmental conditions, especially when they are stored for long period of time. During prolonged storage, seed quality in terms of vigour and viability severely declines as a result of the degenerative process of natural physiological ageing (Shaban 2013). Successful seed germination is one of the crucial phases in the life cycle of the plant (Shoab *et al* 2012). Poor and delayed germination, decline of seed vigour and slow rate of field establishment of aged seeds ultimately leads to lower yield and economic loss to the farmers. Natural seed deterioration is inevitable but the rate of deterioration can be controlled. Rate of seed ageing process depends on the ability of seed to resist degradation (Mohammadi *et al* 2011). Appropriate storage conditions and seed priming techniques help reduce the rate of seed deterioration and also reverse its detrimental effects (Ghassemi-Golezani *et al* 2012).

Seed longevity is the time span during which seed remains viable (Sano *et al* 2016). Seed longevity and rate of ageing are greatly influenced by storage temperature, relative humidity of air, moisture content of seed and initial seed viability (Rajjou and Debeaujon 2008). Seed priming is a useful way of seed invigouration that delays the process of seed deterioration and improves the physiological status of the seed (Kumar *et al* 2017). It is a simple and cost effective pre-sowing treatment which involves slow and controlled uptake of

water by the seed to start pre-germinative metabolic processes and drying back before radicle protrusion to prevent the loss of desiccation tolerance (Hussain *et al* 2016). During priming, seeds are permitted to enter the metabolism activation stage of germination but are dried back to their original moisture content to prevent its entry into the radicle emergence phase of germination (Ashraf and Foolad 2005). Seed priming aims to control seed hydration by lowering water potential in the seed environment. Seed imbibition, during priming, triggers many metabolic processes such as synthesis and action of hydrolytic enzymes which results in the hydrolysis of storage material into simple form, followed by drying to prevent embryo development and radicle emergence (Zhao *et al* 2018).

Upon subsequent rehydration, germination performance of primed seeds is improved in comparison to un-primed seeds (Yuan *et al* 2010). Seed priming is capable of reversing the causes of seed deterioration like loss of membrane integrity (McDonald 1999). It repairs the age related cellular and sub-cellular metabolic damage of low vigour seeds that may accumulate during seed development (Aswin *et al* 2019). Priming reduces germination time, enhances the uniform field emergence of the seedling, increases germination percentage and improves seed vigour (Nawaz *et al* 2013). The response of seed to priming treatment depends on oxygen supply to the seed (Nascimento 2003), priming agent employed (Farooq *et al* 2005) and osmotic potential of priming solution (Arif *et al* 2008). The efficacy of chemical agents for seed priming is variable, but they can improve crop growth and yield under normal as well as stressed conditions (Naqve *et al* 2018). Various common seed priming techniques include hydro-priming (soaking seeds in pre-determined amounts of distilled water), osmo-priming (soaking seeds in osmotic solutions like PEG), hormonal priming (treating seeds with hormones like GA₃), halo-priming (soaking seeds in solution containing inorganic salts) and solid matrix priming (mixing seeds with organic or inorganic solid materials and water in definite proportions) (Venkatasubramanian and Umarani 2007). Priming improves germination percentage, fresh and dry biomass and seed vigour in tomato (Prabha *et al* 2016). The priming of medium and low vigour eggplant seeds with osmo-priming solution (PEG 6000) with subsequent drying increases their vigour (Gomes *et al* 2012). The treatment of eggplant seeds with GA₃ improved the physiological seed parameters like speed of germination, seedling emergence and seedling length (Neto *et al* 2017).

The primed seeds are dried back to their original moisture content for long term storage under suitable conditions. During the process of seed priming, the seeds that pass the stage of activation of physiological processes, could germinate well under variable environmental conditions as compared to un-primed seeds (Rehman *et al* 2017). Improved viability in primed and stored seeds has been reported by various authors (McDonald 1999, Parera and Cantliffe 2010, Dearman *et al* 2008, Venkatasubramanian and Umarani 2010), Seed

viability was improved in primed rice seeds when stored under appropriate conditions of low temperature and low relative humidity (Wang *et al* 2018).

In the present study, attempts were made to enhance the storability of brinjal (*Solanum melongena* L.) seeds through vigouration techniques. Germination test and seed vigour test offers scope and possibility to determine the vigour of a seed lot so that its emergence and storage performance can be assessed. Accelerated ageing method was used to investigate storability of seeds. High and low vigour seed lots were undertaken for physiological and biochemical investigations after priming and subsequent storage durations. In Brinjal, very little work has been reported so far. Therefore, by studying the storability of primed seeds, it would be possible to know whether the priming treatments improve the seed vigour and also retain the advantages obtained from priming during storage. This information would be beneficial for the farmers.

Considering the above, the present study was conducted with the following objectives:

1. To study the efficacy of seed priming on improving viability of low and high vigour seeds of brinjal.
2. To study the effect of priming on storability of low and high vigour brinjal seeds.

CHAPTER – II

REVIEW OF LITERATURE

Seed is a living entity whose quality is affected by various environmental factors. A good quality seed is a key to successful agriculture (Shoab *et al* 2012). Seeds are rarely sown immediately after harvesting. Appropriate seed storage after harvest is essential in order to sustain their good physical and physiological condition from the time of harvest till planting (Agrawal 1995). Despite low water content in desiccation-tolerant seeds, molecular and metabolic changes can occur during dry storage of seeds and result in reduced seed viability (Rajjou and Debeaujon 2008). During long-term storage seeds undergo deterioration as a result of natural ageing. Seed deterioration process is irreversible, cumulative, unpreventable and degenerative which causes progressive decline in seed quality, viability and vigour when sown after storage (Kapoor *et al* 2011). The rate of ageing process is influenced by environmental and genetic factors such as storage conditions, seed moisture content and seed quality (Walters *et al* 2005). The process of seed deterioration under laboratory conditions essentially mimics natural ageing, however, the rate of deterioration is speeded up making it possible to generate low vigour seeds within short time span to study ageing induced physiological and biochemical changes (Jain *et al* 2006).

2.1 Impact of accelerated ageing on physiological and biochemical parameters

A significant decline in physiological parameters like germination, root length, shoot length, vigour and weight of seedlings was recorded in tomato seeds aged through accelerated ageing as compared to control (Nigam *et al* 2019). Decrease in the antioxidant enzyme activity and soluble protein content suggested increased protein oxidation and loss of functional properties. Likewise Vijayalakshmi *et al* (2014) recorded gradual reduction in speed of germination in tomato seeds with increase in accelerated ageing at 100% relative humidity and 40±1°C for 10 days. A similar declining trend in physiological parameters was observed in okra hybrid seeds after accelerated ageing at 40±1°C and 85±5% relative humidity for 4, 8, 12 and 16 days (Keshavulu *et al* 2012). A significant increase in seed moisture content and considerable decrease in seed germination ability and vigour was recorded in artificially aged five varieties of rice seeds as compared to control by (Kapoor *et al* 2011). A linear decrease in seedling vigour with a concomitant increase in mean emergence time and electrical conductivity in aged cotton seeds suggested that seed damage by accelerated ageing might be due to membrane disintegration and inactivation of enzyme systems (Basra *et al* 2003).

Various biochemical studies were also undertaken by various authors to study metabolic changes in the seed during accelerated ageing. In tomato seeds total soluble protein content markedly declined after artificial ageing at 40° C and 90% relative humidity in tomato

seeds resulting in reduced concentration as compared to non-aged seeds (Koti *et al* 2007). In maize seeds a considerable decrease in the α -amylase activity and protein content in aged maize seeds was recorded (Satish and Sundareswaran 2010). Similar results of decrease in protein content with ageing was recorded by Radha *et al* (2014) in maize seeds and Jain *et al* (2006) in radish seeds. Accelerated ageing of wheat seeds resulted in increase in electrical conductivity, decrease in total soluble sugar content and also, marked decline in protein content with increased ageing duration (Shaaban 2016). Reduction in total soluble sugar content and increase in reducing sugars was reported in aged Safflower seeds (Onder *et al* 2020). Similar observations of decreased total soluble sugars due to ageing process were also reported in mung bean seeds (Murthy *et al* 2003), in canola seeds (Wang *et al* 2018) and in Chinese cabbage seeds (Jiang *et al* 2018). In Capsicum seeds a considerable drop in the activity of α -amylase was observed after ageing. Protein studies further sustained the fact that seed deterioration is due to adverse effect of ageing on seed protein (Bhanuprakash *et al* 2010).

2.2 Seed priming

The accelerated ageing test combined with storage experiment could be a promising technique for estimating the storage potential of seed lots. Seed storage under optimal conditions is essential for the preservation of seeds usually till next sowing season. Various seed vigouration techniques like seed priming can be employed to improve seed quality as well as maintain it during seed storage.

Seed priming is a physiological method of controlled hydration and drying to enhance sufficient pre-germinative metabolic process for rapid germination (Chen *et al* 2010). Priming technique induces imbibitions and a set of biochemical changes such as enzyme activation, metabolism of germination inhibitors, repair of cell damages to promote germination (Farooq *et al* 2010). The basic principle of seed priming is the controlled hydration of seeds by maintaining low water potential of imbibing solution (Nawaz *et al* 2013). Priming promotes seed germination under three phases such as imbibition, activation, and growth. During the imbibition stage, the water uptake promotes protein synthesis and respiratory activities through messenger ribonucleic acid (mRNA). The second stage is related to the initiation of different physiological activities related to germination such as restoration and repair of metabolic activities like protein synthesis, mitochondria synthesis, and alteration in soluble sugars (Varier *et al* 2010). Seed priming typically involves an extension of phase II, which in turn permits the completion of repair processes (Bray 1995). The osmotic potential of dry orthodox seeds is very low (Roberts and Ellis 1989). Reducing the environmental osmotic potential slows down water uptake and extends the duration of phase II, which is the aim of seed priming (Bray 1995). During priming, the seeds that have passed through the

second stage could germinate under variable environmental conditions as compared to unprimed seeds (Corbineau and Come 2006). Priming enhances seed performance by increasing germination rate and uniformity which results in faster and better seedling establishment (Powell *et al* 2000). The most important advantage of priming technique is reducing the time period between sowing and emergence as this plays a key role in crop establishment (Singh *et al* 2015). The positive effects of seed priming are attributed to various biochemical changes such as improvement of the antioxidant defense system, restoration of metabolic activities through the synthesis of proteins and nucleic acids (RNA and DNA) and also repair the damaged membranes. (Di Girolamo and Barbanti 2012).

Metabolic potential of primed and stored okra and beet root seeds enhanced with better membrane integrity, higher protein content, dehydrogenase activity and alpha amylase activity as compared to control seeds (Kuppusamy and Ranganathan 2014). Similarly higher seed protein content, amylase activity, dehydrogenase activity and reduced electrical conductivity was reported in tomato, eggplant and chilli seeds (Venkatasubramanian and Umarani 2010).

2.2.1 Effect of various priming treatments on seed viability and vigour

1. Hydropriming

Hydro-priming is a simple and economical technique in which seeds are imbibed in sufficient amount of water for a specific period and dried to a certain moisture level before sowing (Singh *et al* 2015). Hydropriming improved the germination percentage, germination index, mean germination time, seedling vigour index, seedling growth as compared to unprimed seeds in tomato and brinjal (Patel *et al* 2017). Tomato seeds gave greater germination percentage and reduced mean germination time when compared to control (Anese *et al* 2011). Similarly, hydropriming improved germination parameters like emergence and seedling dry weight in rice seeds (Matsushima and Sakagami 2013). It also increases mean germination of cotton seeds as compared to non-primed seeds (Basra *et al* 2003) and had a promotive effect on germination performance of water melon (Huang *et al* 2002), lentil (Ghassemi-Golezani *et al* 2008) and groundnut (Sepelri and Rouhi 2017) seeds. In all these cases, hydropriming markedly improved final germination percentage, germination rate, seedling length and vigour index while reported a marked reduction in mean germination time and electrolyte leakage as compared to non-primed seeds. In green bell pepper seeds, (Uche *et al* 2016) a significant enhancement in germination parameters with reduced mean germination time and emergence time due to hydropriming was reported. Hydro-priming of aged chickpea seeds repaired seed deterioration and enhanced their performance (Ghassemi-Golezani *et al* 2012). In maize seeds also, hydropriming increased final germination percentage and improved seedling vigour as compared to control (Dezfuli *et al* 2008). Other

beneficial effects of hydropriming were reported in lentil seeds by Saglam *et al* (2010) and in cow pea by Singh *et al* (2011).

The electrical conductivity of seed leachate was reduced and total soluble sugar content increased in hydroprimed seeds in comparison to control in chickpea seeds as (Lamichaney *et al* 2018). Amooaghaie *et al* (2010) reported a rise in the concentration of soluble protein and improved membrane integrity after hydropriming followed by drying in tomato seeds. Tomato, chilli and Eggplant seeds resulted in marked increase in protein and amylase activity while significant reduction in electrical conductivity of seed leachate (Venkatasubramanian and Umarani 2010). Similar results were recorded by Kuppusamy and Ranganathan (2014) in okra seeds. In sugar beet seeds, Mukasa *et al* (2003) observed high levels of α -amylase activity and more soluble sugar by dry weight in primed seeds than in control seeds. Sepehri and Rouhi (2017) found significant increase in the soluble sugars and proteins after priming of aged groundnut seeds.

2. Osmopriming with PEG

In osmopriming, the seeds are imbibed in solution of low osmotic potential like sugars (sorbitol, mannitol, etc.) or polyethylene glycol (PEG) instead of pure water, followed by surface drying or redrying to their original weight. Polyethylene glycol (PEG) is the most common substance used to control water potential in primed seed due to its nontoxic nature and large molecular size (6000– 8000 mw) that prevents its penetration into the seed (Thomas *et al* 2000) . Osmopriming of a variety of seeds with PEG has been found to be beneficial in improving seed physiological and biochemical parameters as reported by various authors.

A sharp increase in germination rate was observed in tomato seeds primed with PEG. It also had a considerable effect on root length, shoot length and total fresh weight as compared with unprimed seeds (Zhang *et al* 2012, Mirabi and Hasanabadi 2012) . Fresh seeds of four tomato cultivars were subjected to osmopriming with -1.1 MPa aerated solution of PEG resulted in lower electrical conductivity of seed leachate and improved germination parameters including germination percentage, shoot length, root length, seedling dry weight and seedling vigour (Farooq *et al* 2005). Zang *et al* (2015) reported positive effect of priming treatment with PEG, on germination performance and seedling establishment in Sorghum seeds. Okra seeds primed with 5% PEG solution showed increase in germination percentage and reduced number of days to seed germination as compared to other treatments and control, indicating better establishment of Okra crop after priming with PEG (Kaur *et al* 2015, Ali *et al* 2016). In chickpea also, priming treatment with 20% PEG 6000 for 12 hours had more pronounced effect on germination performance and vigour among other osmopriming treatments (Kumar *et al* 2017). Priming of artificially aged sweet pepper seeds with -1.5 MPa

PEG solution was effective in improving seed quality which may be attributed to accumulation of antioxidants and improvement of cell membrane integrity (Siri *et al* 2013). In soybean seeds also, different concentrations of polyethylene glycol as priming media and different priming durations showed significant increment in the germination percentage, seed vigour as well as sharp reduction in seed quality parameters mainly mean days to germination and electrical conductivity of seed leachate (Sadeghi *et al* 2011). Osmopriming with PEG significantly enhanced the seed emergence and yield of soybean compared to control (Arif *et al* 2008). Chilli seed treatment with PEG at 25°C resulted in maximum germination percentage and vigour index as compared to unprimed seeds (Stephen *et al* 2018).

In chickpea seeds, a significant rise in the total soluble sugars after priming with PEG -1.0MPa as compared to the unprimed control seeds was recorded (Lamichaney *et al* 2018). Kubala *et al* (2015) found positive association of improved germination in PEG osmoprimed *Brassica* seeds with protein synthesis. In Common bean seeds, protein content in seeds reduced with increasing level of ageing but priming had a positive effect on aged seed showing that osmopriming had the ability to ameliorate the ageing effect and restored protein content and germination characteristics (Amanpour and Sedghi 2012). Likewise in tomato, osmopriming with PEG 6000 (-0.5MPa and -1.0MPa) increased soluble protein content of seed as compared to unconditioned seed (Pandita *et al* 2003). Osmopriming induces the synthesis and activation of enzymes catalyzing the breakdown and mobilization of reserve substances Varier *et al* (2010). Khan (1992) indicated that protein and enzyme synthesis were increased by osmo-conditioning suggesting that this treatment makes precursors used for macromolecular synthesis available to the seeds. In Okra seeds, electrical conductivity of the seed leachate of PEG treated seeds was significantly lower than unprimed seeds indicating increased stability of membrane due to osmopriming (Ali *et al* 2016). Suksoon and Jaehyeum (2000) noticed that osmopriming of rice seeds with PEG solution at -0.6 MPa for 4 days at 15°C increased the α -amylase activity and they also reported that amylase activity was positively correlated with the total soluble sugar content in such primed seeds. Jungmoon and Suksoon (2004) reported that osmopriming of sweet corn seeds with -1.2 MPa of PEG 8000 solution at 15°C for 2 days resulted in increased α -amylase activity, total soluble sugars and decreased electrolyte leakage in such seeds.

3. Halopriming with KNO₃ and KH₂PO₄

Halopriming is a priming technique of imbibing seeds in the aerated solutions of inorganic salts (potassium nitrate, sodium chloride, calcium sulfate, and calcium chloride) of variable concentration for varied durations followed by drying. In brinjal seed germination traits improved after priming the seeds with salt solutions of -0.5MPa KNO₃ and -0.5MPa NaCl (Shahlaei *et al* 2009). In Soybean seeds, seed priming with KNO₃ at 6gL⁻¹ concentration

increased the germination percentage and seedling dryweight (Ahmadvand *et al* 2012). Similar results in soybean seeds were also obtained by Mohammadi (2009). Farooq *et al* (2005) had reported earlier and synchronized germination and emergence in primed tomato seeds as compared to the control. Maximum radical and plumule length was noted in seeds primed with KNO_3 . Lettuce seeds primed with KNO_3 had higher germination percentage, root and shoot length and seedling fresh weight than non-primed seeds under saline conditions as reported by Nasri *et al* (2011). The hot pepper seeds, haloprimed with KNO_3 and osmoprimed with PEG had better speed of germination than hydroprimed and control seeds (Pandita *et al* 2007). In cowpea, Singh *et al* (2014) used KNO_3 as priming solution with three levels of time durations (6, 8, and 10 h). The results showed that in comparison to unprimed treatments, halo-priming was proved superior in terms of all germination and growth parameters. Farooq *et al* (2007) found that melon seeds primed with KNO_3 performed better than those primed with CaCl_2 . Priming in KNO_3 solutions at low concentrations improved the germination rate, uniformity and a marked improvement in seedling dry weight.

In tomato seeds, quality of both high and low vigour seeds was enhanced using KH_2PO_4 as a priming agent which led to an increase in germination percentage and seedling vigour (Aswin *et al* 2019). Seed priming with 1% KH_2PO_4 for 6 hours showed an increased physiological performance in both fresh and aged seeds of maize hybrids and this effect was more pronounced in aged seeds (Sathish *et al* 2011). Likewise, low vigour sunflower seeds primed with KH_2PO_4 had better germination related parameters like radical length, plumule length, and root fresh weight as compared to unprimed low vigour (Kausar *et al* 2009). In wheat seeds also priming with KH_2PO_4 improved germination characteristics (Yari *et al* 2010). In cucumber seeds, among various priming chemicals used, KH_2PO_4 and KNO_3 were found to show significant improvement in seed germination and vigour of both high and low vigour seeds over control seeds (Pandey *et al* 2017).

Different biochemical changes associated with halopriming with KNO_3 and KH_2PO_4 have been reported by various authors in a variety of seeds. In tomato, a significantly lower electrolyte leakage in seeds treated with 25mM KNO_3 as compared to control was observed (Nawaz *et al* 2011) indicating membrane stability of seeds after priming. Further, an increase in the α -amylase activity and total soluble sugar content was reported in haloprimed seeds but maximum response was observed in seed primed with KNO_3 . Likewise, halopriming with KNO_3 led to increased α -amylase activity and total soluble sugar content in marigold seeds (Afzal *et al* 2009) and increased total soluble protein content in tomato seeds (Pandita *et al* 2003). Pandey *et al* (2017) evaluated the effect of priming with KH_2PO_4 and K_2HPO_4 on high and low vigour cucumber seeds. The enhancement in seed viability and vigour in primed seeds was due to low membrane injury coupled with high enzyme activities of dehydrogenase

and amylase. The reduced seed leachate values of primed seeds indicated that priming initiates the process of repair by stabilizing membrane integrity. In both low and high vigour seeds, priming led to had higher α -amylase activity as compared to unprimed cucumber seeds. In sunflower seeds primed with KH_2PO_4 lower electrical conductivity and higher α -amylase activity was recorded as compared to unprimed seeds (Manjunatha *et al* 2018).

4. Hormonal priming

Seed imbibition in the presence of plant growth regulators also known as hormonal priming has a direct impact on seed metabolism. Hormonal priming improves germination and emergence of various crops (Carvalho *et al* 2011). Improved seed germination due to GA_3 priming might be due to its effect on stored food within seeds (Abu-Muriefah 2017). The presence of adequate amount of GA_3 in seeds is known to stimulate the synthesis and production of the hydrolases, mainly α - amylase, releasing sugars, resulting in the germination of seeds.

Eggplant seed treatment with GA_3 enhanced speed of germination and seedling emergence (Neto *et al* 2017). GA_3 enhanced seed vigour, germination percentage and shoot length in tomato cultivar (Jyoti *et al* 2016; Hussain *et al* 2012). Priming maize seeds with 100ppm GA_3 increased the germination percentage and improved seed vigour (Kumari *et al* 2017). In aged French bean seeds priming with GA_3 and Ethrel improved the seed quality and showed improved seedling length, seedling dry weight which in turn improved higher seedling vigour index, germination speed and mean germination time (Sarika *et al* 2013). An improvement in seed germination parameters in bell pepper seeds invigorated with GA_3 (200 ppm) as compared to unprimed seeds was observed (Yogananda *et al* 2004). Wheat seeds primed with GA_3 (20 ppm) recorded minimum mean germination and emergence time as compared to control (Khan *et al* 2011). Okra seeds primed with GA_3 +thiram recorded maximum germination percentage, emergence, speed of germination and vigour index followed by priming with GA_3 but seedling length and seedling dry weight were more in GA_3 primed seeds compared to minimum germination attributes in control (Singh *et al* 2004). Pretreatment of maize and pea seeds with GA_3 improved significantly the germination and seedling growth of these crops (Tsegay and Andargie 2018). Priming also alleviated the inhibitory effect of salt stress on germination characters. Onion seeds treated with different concentrations of IAA, Kinetin and GA_3 exhibited an increase in seed germination and seedling growth parameters (Yarnia and Tabrizi 2012).

Higher reducing and total sugars as well as higher α -amylase activity was recorded in spring maize seeds after hormonal priming with GA_3 as compared to control seeds (Afzal 2008). Enhancement of α -amylase activity in primed seeds may be attributed to proper hydration during imbibition that increased starch hydrolysis. This suggests that starch is being

converted into reducing sugars. Seed hormoprimering with GA₃ and GA₃+Ethylene improved biochemical metabolism in rice seeds resulting in increased total soluble sugar content and α -amylase activity in the primed seeds as compared to non primed seeds (Simma *et al* 2017). Priming of chickpea seeds with 100ppm GA₃ invigourated the performance of both high and low vigour seeds and improved the seed metabolism by increasing membrane stability, total protein content and α -amylase activity over control dry seeds (Arun *et al* 2016). Priming of groundnut seeds with 100ppm of GA₃ significantly mitigated the negative effects of both ageing and drought stress. A significant enhancement in the total soluble sugars and total soluble protein in seeds primed with GA₃ under stress conditions as compared to non-primed groundnut seeds was observed (Rouhi and Sepehri 2020).

2.2.2 Effect of priming on storability of seeds

The lengths of time for which the seeds remain viable is highly variable and depend on species, storage durations and conditions (Siddique and Wright 2003). Appropriate storage conditions are necessary for maintaining the seed quality and for preservation and conservation of genetic resources for a considerable storage period (Pradhan and Badola 2012). Seed moisture content and relative humidity are essential factors in determining seed longevity. High moisture content and presence of oxygen cause lipid auto-oxidation of seeds leading to rapid decline in seed quality (Ellis *et al* 2008). Seed ageing during storage is affected by temperature, seed moisture content and type of storage containers used (Walters 2007). High storage temperature accelerates seed deterioration causing seed quality losses and consequently, lower germination percentage of seeds due to enhanced metabolic activities like premature enzymatic oxidation and denaturation of proteins resulting in lowered enzymatic activity of seeds prior to intended germination (Genes and Nyomora 2018). High temperature allows the infestation by fungi, bacteria and pests which causes damage to the seed and adversely affects the seed longevity. For successful storage, seeds need to be dried to moisture contents of less than 10% (Roberts 1973). Seeds stored at low moisture content or at low relative humidity in moisture impervious polythene bags or sealed plastic containers retain viability for longer duration (Agha *et al* 2004).

In contrast to the generally positive effects of priming on seed germination characteristics, there are many contradictions regarding the effects of priming on seed longevity. Some researchers have reported that priming treatments reduce seed lifespan of tomato (Gurusinghe *et al* 2002), lettuce (Schwember and Bradford 2005), rice (Hussain *et al* 2015) seeds. On the other hand in onion (Dearman *et al* 2008), *Ranunculus sceleratus* (Wechsberg 1994) and *Digitalis purpurea* (Butler *et al* 2009) priming improved seed storage capacity.

Storage studies in tomato, eggplant and chilli seeds for six months after hydropriming, halopriming, sand matric priming and osmopriming treatments revealed that irrespective of the crops, the radical protrusion, germination percentage, speed of germination and seedling length were higher in primed as compared to unprimed control seeds indicating that efficacy of the treatments is retained in seed during storage besides maintaining viability of primed seeds (Venkatasubramanian and Umarani 2010). They also suggested that the problem of reduced storability of primed seeds arises only if the duration of seed priming extends to an advanced stage. Probert *et al* (1991) primed *Ranunculus sceleratus* seeds in PEG solutions for 7 days followed by drying and observed four to five fold increase in seed longevity when stored and suggested that besides repairing the accumulated damage, the priming treatment also obviated subsequent damage. Six month storage of okra and beetroot seeds after sand matric priming, hydropriming, osmopriming with PEG and halopriming with NaCl (Kuppusamy and Ranganathan 2014) showed that all the seed priming treatments were found to be superior over control, both initially and after storage. However, optimum duration of priming treatment is important as shorter duration may not be sufficient to achieve maximum beneficial effect of priming treatment and longer duration may permanently damage the seed. Thanos *et al* (1989) reported that osmoconditioning of pepper seeds prior to storage retained a high level of germinability irrespective of storage and germination temperature as compared to untreated seeds. In onion seeds priming before storage delayed the loss of viability (Dearman *et al* 2008). The primed and dried onion seeds maintained improvements in germination even after 18 months storage. Chiu *et al* (2002) observed that primed sweet corn seeds stored at 10 or 28°C recorded higher longevity, and showed better germination and vigor responses than non-primed seeds even after 12 months of storage. Beneficial effects of hydropriming in cauliflower seeds persisted for four months under controlled conditions of storage (Kikuti *et al* 2008). Priming of pepper seeds with 3%KNO₃ and -1.5MPa PEG 6000 solutions improved the germination percentage and mean germination time and seeds maintained quality for four months of storage when compared with the control seeds (Kaewsorn *et al* 2019).

On the other hand, a decline in the primed seed longevity as compared to non primed seeds has also been reported. Tarquis and Bradford (1992) observed that pre-hydration of lettuce seeds in water or priming in -1.5 MPa PEG 8000 for various durations effectively accelerated seed germination rates but at the same time decreased storage life. Primed lettuce seeds were particularly prone to reduced longevity relative to non-primed seeds when stored under high temperature and high moisture conditions (Schwember and Bradford 2005). Storage of hydro-primed and osmo-primed rice seeds at 25°C posed deleterious effects on germination and early seedling growth of rice. In addition to delayed and reduced

germination, storage of primed seeds also resulted in stunted growth of seedling. Compared with primed rice seeds, seed storage at 25°C for 210 days had a little effect on longevity of non-primed seeds (Hussain *et al* (2015). Delayed and lower germination was recorded in primed tomato seeds, when stored at 30°C for 6 months as compared with the control (Agerich *et al* 1989; Liu *et al* 1996). Diminished beneficial effects of hydro-priming in naturally aged Chinese cabbage seeds were observed after storage at 30°C for 9 months, even lower than those of non-primed seeds (Yan 2017). Thus, the beneficial effect of priming in seed storability varies depending upon the species.

CHAPTER-III

MATERIALS AND METHODS

3.1 Plant material

The seeds of Brinjal variety 'Punjab Nagina' under study, were obtained from the office of Director Seeds, Punjab Agricultural University, Ludhiana.

3.2 Location

The experiments were conducted in the laboratories of department of Botany, College of Basic Sciences and Humanities, Punjab Agricultural University, Ludhiana.

3.3 Experimental Procedure

The freshly harvested seeds were subjected to germination test and then divided into two lots. One of these seed lots was considered high vigor (germination percent > 80%) and the other lot was subjected to accelerated ageing to obtain low vigor seeds (germination percent < 65%).

Seed germination: The seeds were surface sterilized with mercuric chloride 0.1% solution for 30 seconds to avoid fungal invasions followed by rinsing with distilled water. Then the seeds were surface dried with filter paper. Germination tests were carried out both in Petri-dishes and by rolled paper towel method. Seed germination was carried out in Petri-dishes lined with moistened brown germination paper. Ten undamaged seeds were placed in each Petri-dish using forceps. The petri-dishes were kept in seed germinator in the dark at $25\pm 2^{\circ}\text{C}$ for 14 days and counts of germinating seeds were recorded each day. A seed was considered to have germinated when its radical was about 1mm long. The seeds were also kept for germination using rolled paper method. The thirty selected seeds were placed between two layers of wet germination paper towels. The paper towels were rolled and placed in upright position in a germinator at $25\pm 2^{\circ}\text{C}$ and 70% RH for 14 days (ISTA 1985). The number of normal seedlings were counted on the 14th day and expressed as germination percentage.

Accelerated ageing: Accelerated ageing was carried out in desiccators. A relative humidity of 90% was achieved by placing super saturated solution of NaCl in the base of the desiccators (Wexler and Hasegawa 1954). A wire mesh was placed above the solution. The seeds were weighed and then spread in a single layer in an open Petri-dish and this Petri-dish was placed above the wire mesh. The lid of the desiccator was sealed with the grease and placed at 45°C for 7 days in an incubator to obtain low vigor seeds. The seed weight was recorded again after the ageing period. The aged seeds were dried in shade for two days to regain the original weight (Delouche and Baskin 1973).

3.4 Seed priming

Low and high vigor Brinjal seeds were primed in solutions of KNO_3 , KH_2PO_4 , PEG 6000, GA_3 and water. Petri-dishes (14.0 cm) were lined with two layers of germination paper

and moistened with priming solution to thoroughly drench the germination paper. The seeds were placed on these for 12 hours for controlled imbibition of priming solution. The following concentration of solutions were used for priming

- i. 1% KNO_3 (10g of KNO_3 in distilled water and volume was made up to 1000ml.
- ii. 0.1 M KH_2PO_4 (13.61g of KH_2PO_4 in distilled water and volume was made up to 1000ml)
- iii. 30% PEG 6000 (300g of PEG 6000 in distilled water and volume made up to 1000ml)
- iv. 100ppm GA_3 (0.1g in small amount of ethanol and volume made to 1000ml with distilled water)
- v. Distilled water

At the end of priming treatment, the seeds were rinsed in water to remove any adhering salts, blotted dry and weighed. These were then spread out in a thin layer for drying under shade for three days to regain their original moisture content.

3.5 Seed Storage

After seed priming followed by drying, both primed high and low vigour seeds were packed in moisture impervious aluminium pouches separately and stored at two temperatures (cold storage at 4°C and room temp 25°C). The seeds were then drawn at tri-monthly intervals and physiological and biochemical observations were recorded.

3.6 Observations:

Observations were recorded at the end of priming treatment and after various storage durations.

1. Physiological observations

i. Germination percentage:

The seeds were surface sterilized and dried before germination the seeds were surface sterilized with 0.1% mercuric chloride solution for 30 seconds to avoid fungal invasions followed by rinsing with distilled water. Thereafter, the seeds were blotted dry. Seed germination was carried out in petri-dishes lined with moistened brown germination paper. Ten undamaged seeds were placed in each Petri-dish using forceps. The Petri-dishes were kept in seed germinator in dark at $25 \pm 2^\circ\text{C}$ for 14 days and counts of germinating seeds were recorded each day. Seeds were considered to have germinated when the radical was about 1mm long. The seeds were also kept for germination using rolled paper method. The selected thirty seeds were placed between two layers of wet germination paper towels. The paper towels were rolled and placed in upright position in a germinator at $25 \pm 2^\circ\text{C}$ and 70% RH for

14 days (ISTA 1985). The number of normal seedlings were counted on the 14th day and expressed as germination percentage.

$$\text{Germination percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds}} \times 100$$

Mean Days to Germination

Number of seeds germinated each day were counted every 24 hours for 14 days. The mean days to germination was calculated as per Ellis and Roberts (1981).

$$\text{Mean days to germination} = \frac{\sum nt}{\sum n}$$

(Where n is the number of seeds, which were germinated on day t and t is number of days counted from the beginning of germination test.)

ii. Speed of germination

The number of seeds germinated was recorded daily up to day of final count. The speed of germination was calculated as per Maguire (1962).

$$\text{Speed of Germination} = \frac{X_1}{Y_1} + \frac{(X_2 - X_1)}{Y_2} + \frac{X_n - (X_n - 1)}{Y_n}$$

Where,

X_n – Number of seeds germinated at nth count.

Y_n – Number of days from sowing to nth count

iii. Seedling length

Ten seedlings were selected at random. Seedling length was measured from tip of shoot till the tip of root with a centimeter scale. Root length (from root tip till root base) and shoot length (from shoot tip to shoot base) were also recorded separately.

iv. Dry weight of seedling (mg)

After the germination test, ten seedlings from each replication were placed in separate bags and dried for 24 hours in a hot air oven maintained at 70°C. The dried seedlings were allowed to cool and weighed using an electronic balance. The average weight of the seedlings was recorded and expressed in milligram.

v. Seeding Vigour Index

- i.** Seedling Vigour index-I (SVI-I) was calculated by formula suggested by Abdul-Baki and Anderson (1973).

$$\text{Seedling vigour index (SVI-I)} = \text{Germination \%} \times \text{Seedling length (cm)}$$

- ii. Seedling Vigour index-II (SVI-II) of seeds were calculated as per Bewly and Black (1994).

Seedling vigour index (SV-II) = Germination% x Seedling dry weight (mg)

2. Biochemical Observations

The contents of total soluble sugars, total starch, total soluble proteins, total free amino acids and activity of α -amylase were estimated from primed seeds immediately after priming (zero month of storage) and at tri-monthly intervals for 12 months.

i. Total soluble sugars

Total soluble sugars were estimated by method as given by Dubois *et al* (1956) and expressed as mg g⁻¹ dry weight.

Principle: Sugars react with concentrated sulphuric acid to form a dehydration product, 5-hydroxymethyl furfural. This dehydration product then reacts with phenol and gives orange yellow colour and acts as chromophore.

Reagents:

Solution A: 80% ethyl alcohol

Solution B: 5% phenol

Solution C: Cold conc. H₂SO₄

Extraction: Seeds weighing approximately 0.1g were homogenized in 5ml of solution A, in a pestle mortar, followed by centrifugation at 5000 rpm for 10 min. The supernatant was taken out of centrifuge tubes and 3ml of Solution A was added to the residue followed by centrifugation to ensure complete extraction. The supernatant from both the extractions were pooled. The final volume was made upto 10 ml by adding distilled water and was used for the estimation of total soluble sugars.

Estimation: 1ml of extract was taken in a test tube and 5ml of Solution B was added to it. The contents were mixed on vortex mixture. 5ml of concentrated H₂SO₄ was poured slowly and directly in the middle of the test tube to ensure proper mixing of solutions. The contents in the test tube were allowed to cool for about half an hour and followed by mixing on vortex mixture. The absorbance was measured at 490nm against blank (5ml 5% phenol + 5ml conc.H₂SO₄). The concentration of total soluble sugars was calculated using pure glucose standards (100µg/ml) run simultaneously.

ii. Total Starch

Total starch was estimated as per Dubois *et al* (1956) and expressed as mg g⁻¹ dry weight.

Principle: Starch is hydrolysed with the help of perchloric acid (HClO₄) to release free sugars which form a dehydration product with concentrated sulphuric acid. This

dehydration product then reacts with phenol which acts as a chromophore and gives orange yellow colour.

Reagents:

Solution A: 52% perchloric acid

Solution B: 5% PhenoL

Solution C: Cold conc. Sulphuric acid (H₂SO₄)

Extraction: Starch was extracted from the residue of sugars. To this residue, 3ml of 52% perchloric acid (74.28 ml perchloric acid + 25.72 ml distilled water) was added and centrifuged for 15 min at 3000 rpm. The supernatant obtained was transferred to the volumetric flask. The extraction procedure was repeated with the residue to which 2ml of 52% perchloric acid was added and again centrifuged for 15 min at 3000rpm. The supernatant obtained was pooled with that obtained during first extraction. The final volume was made to 10ml with distilled water and used for estimation of starch.

Estimation: 1ml of extract was taken in a test tube and 5ml of Solution B was added to it. The contents were mixed on vortex mixture. 5ml of concentrated H₂SO₄ was poured slowly and directly in the middle of the test tube to ensure proper mixing of solutions. The contents in the test tube were allowed to cool for about half an hour and followed by mixing on vortex mixture. The absorbance was measured at 490nm against blank (5ml 5% phenol + 5ml conc.H₂SO₄). The concentration of total soluble sugars was calculated using pure glucose standards (100µg/ml) run simultaneously.

iii. Total soluble proteins

Total soluble proteins were estimated as per Lowry *et al* (1951) and expressed as mg g⁻¹ dry weight.

Principle: Proteins in sample react with copper tartarate complex present in alkaline solution. The protein –copper complex then reduces to phosphomolybdate of Folin reagent to a blue coloured complex, which has maximum absorbance at 520nm.

Reagents:

A: 2% Na₂CO₃ in 0.1N NaOH

B: 0.5% CuSO₄ in 1% Sodium Potassium tartarate

C: freshly prepared by mixing solution A and solution B in 50:1 ratio

D: 1N Folin Ciocalteau phenol reagent

E: Trichloroacetic acid (TCA) 20%

Extraction: 0.1g seeds were homogenized in 10ml of 0.1N NaOH and centrifuged at 6000 rpm for 15 minutes at 4°C in a cooling centrifuge. From this 2ml supernatant was taken out and 2ml of 20% TCA was added and kept at 4°C for 24 hours. Thos extract was

again centrifuged for 15 minutes at 6000 rpm. 10ml of 0.1N NaOH was dissolved in the obtained residue for the estimation of total protein content in seeds.

Estimation: To 1ml of extract, 5ml of reagent C was added, mixed on a vortex mixture and then kept at room temperature for 10 minutes. 0.5ml of reagent D was added and kept at room temperature for 30 minutes. The intensity of blue color developed, was measured at 520nm against blank. The concentration of protein was calculated from standard curve prepared by using Bovine serum albumin (BSA) as standard (10-100 μ g/ml).

iv. Total free amino acids

Total free amino acids were estimated as per Lee and Takahashi (1956) and expressed as mg g⁻¹ dry weight.

Principle: The amino group in the amino acid reduces ninhydrin, giving rise to ammonia, carbon dioxide and an aldehyde. This reduced ninhydrin further reacts with oxidized ninhydrin, produces purple violet coloured complex having maximum absorbance at 570nm.

Reagents:

A: 80% ethanol

B: 0.5M Citrate buffer (pH 5.5)

C: Standard Glycine (100 μ g/ml)

D: 1% Ninhydrin solution (1g ninhydrin dissolved in 100ml of 0.5M citrate buffer)

E: Ninhydrin reagent (1% ninhydrin solution + pure glycerol + citrate buffer, pH 5.5)

Extraction: Total free amino acids were extracted by following the same procedure as was followed for extraction of total soluble proteins. The supernatant obtained during extraction of proteins, was used as amino acid extract.

Estimation: To 1ml of extract, 5ml of ninhydrin reagent was added and mixed well on a vortex mixture. The test tubes were heated in water bath for about an hour till purple violet color is obtained. The test tubes were then cooled with running water. The absorbance was measured at 570nm using spectrophotometer.

v. Activity of α -amylase

The activity of α -amylase was estimated by method given by Murata *et al* (1968) and the enzyme activity was expressed as μ g maltose produced /ml/min.

Reagents:

A: 0.1M Sodium Phosphate Buffer (0.1M Sodium phosphate dibasic solution was brought to pH 7.2 by adding 0.1M sodium phosphate monobasic solution as much as needed).

B: 1% starch solution (1g starch was dissolved in 100ml of cold distilled water. Then the solution was boiled and used for estimation when cooled).

C: DNS reagent (Dinitrosalicylic acid): 1g of DNS in 20ml of 2N sodium hydroxide and 30g of sodium potassium tartarate made upto 100ml with distilled water

D: 40% Sodium potassium tartarate

E: Stock standard maltose solution (100mg of maltose dissolved in 100ml of distilled water)

F: Standard maltose solution (1.0ml stock solution was made up to 10ml with distilled water)

Extraction: 0.1g of seeds homogenized in 2ml of 0.1M phosphate buffer. The homogenized seeds are left at 4°C for 1 hour. The mixture was then centrifuged at 10,000rpm for 15min at 4°C for 15 min. 1ml of supernatant was diluted to 10ml with 0.1M phosphate buffer.

Estimation: To 1ml of enzyme extract, 2ml of starch was added and incubated for about 15min at room temperature. To this 5ml of DNS reagent was added and boiled for 10minutes. After cooling, 0.5ml of sodium potassium tartarate was added, to the mixture, to stop the reaction. The absorbance was measured at 560nm against blank. The activity of α -amylase was calculated using standard maltose solution (10-100 μ g/ml).

vi. Membrane stability index (MSI)

0.1g brinjal seeds were placed in test tube containing 10ml of distilled water. Incubation was provided for 24hrs at room temperature. The electrical conductivity of the water containing the sample was measured using conductivity meter and termed as (C1). Then the test tubes were kept in boiling water bath for 1 hour and on cooling again electrical conductivity (C2) was measured (Premchandra *et al* 1990). Membrane stability (MSI) was calculated using the following formula:

$$MSI = \frac{C2 - C1}{C2} \times 100$$

Where,

C1 is the electrical conductivity of sample before boiling

C2 is the electrical conductivity of sample after boiling

3.6 Statistical analysis

Statistical analysis of the data collected for all the physiological and biochemical parameters was done in factorial completely randomized design using OP STAT software.

CHAPTER - IV

RESULTS AND DISCUSSION

The present study was undertaken to investigate the effect of different seed priming treatments on the storability of high and low vigour seeds of brinjal (*Solanum melongena* L). The results obtained with regard to various aspects as influenced by different seed priming treatments in laboratory are as follows:

4.1 Physiological parameters

4.1.1 Germination percentage (%)

Germination percentage differed significantly between the high vigour and low vigour seeds. In general, germination (%) decreased with an increase in the storage period. High vigour seeds recorded 80% germination soon after harvesting and 76.11% after 12 months of storage. In low vigour seed a germination of 64.44% was recorded which reduced to 51.11% after 12 months of storage (Table 4.1a).

Both high and low vigour seeds were given priming treatment prior to storage at 4°C. The priming treatments resulted in an increase in germination percentage over control. The extent of increase depended upon the priming treatment given. In high vigour seeds, priming with GA₃ (seed soak in 100ppm GA₃ for 12 hours) led to 98.8% germination in freshly harvested seeds and 86.11% germination at the end of 12 months of storage i.e. an increase of 23.6% and 13.14% over their respective controls. Likewise in low vigour seeds, priming with GA₃ led to 86.63% germination initially and 80.00% at the end of 12 months of storage i.e. 34.43% and 56.53% increase over their respective controls.

Priming with GA₃ 100 ppm for 12 hours improved the percentage germination in low vigour seeds stored for upto 12 months such that it was at par or more than that of untreated high vigour seeds stored for same durations (Table 4.1b). The enhancement of seed germination percentage by GA₃ was probably, because of the activation of some enzymes that digested reserve food material in the endosperm more rapidly to provide sufficient energy for embryo growth as stated by Abu-Muriefah (2017). Similar results of improved seed germination through priming with GA₃ were reported in seeds of eggplant (Neto *et al* 2017) and tomato (Hussain *et al* 2012; Jyoti *et al* 2016). Also, priming maize seeds with 100ppm GA₃ increased the germination percentage and improved seed vigour (Kumari *et al* 2017).

Table 4.1a: Effect of various priming treatments on the germination percentage of high and low vigour seeds of *Solanum melongena* L. stored for various durations.

	Storage duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatments	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High Vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	94.40	81.10	87.75	90.54	80.55	85.55	86.66	77.78	82.22	83.89	77.22	80.55	81.11	76.66	78.89
0.1M KH₂PO₄	86.66	79.99	83.32	84.44	76.66	80.55	82.78	75.55	79.16	80.00	74.45	77.22	77.22	73.33	75.28
30% PEG6000	85.55	75.55	80.55	82.78	75.55	79.16	82.22	73.33	77.77	80.28	71.94	76.11	78.33	70.55	74.44
GA₃100ppm	98.87	86.63	92.75	94.44	83.33	88.88	90.00	81.66	85.83	88.06	80.83	84.44	86.11	80.00	83.05
H₂O	86.66	76.66	81.66	85.00	73.89	79.44	81.67	71.11	76.39	79.72	69.44	74.58	77.78	67.77	72.77
CONTROL	80.00	64.44	72.22	80.00	62.04	72.13	80.00	57.78	68.89	78.06	54.45	66.25	76.11	51.11	63.61
MEAN	88.69	77.39		86.20	75.34		83.89	72.87		81.67	71.39		79.44	69.90	
CD_(p=0.05) (V)	3.26			0.88			0.97			0.73			1.13		
CD_(p=0.05) (T)	5.65			1.52			1.68			1.27			1.96		
CD_(p=0.05)(VXT)	NS			2.15			2.37			1.80			2.78		

Table 4.1b: Effect of various priming treatments on high and low vigour seeds stored for various durations and their interaction on germination percentage in *Solanum melongena* L. seeds.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	94.40	90.54	86.66	83.89	81.11	81.10	80.55	77.78	77.22	76.66	82.99
0.1M KH₂PO₄	86.66	84.44	82.78	80.00	77.22	80.00	76.66	75.55	74.45	73.33	79.11
30% PEG6000	85.55	82.78	82.22	80.28	78.33	75.55	75.55	73.33	71.94	70.55	77.61
GA₃100ppm	98.87	94.44	90.00	88.06	86.11	86.63	83.33	81.66	80.83	80.00	86.99
H₂O	86.66	85.00	81.67	79.72	77.78	76.66	73.89	71.11	69.44	67.77	76.97
Control	80.00	80.00	80.00	78.06	76.11	64.44	62.04	57.78	54.45	51.11	68.40
Mean	88.69	86.20	83.89	81.67	79.44	77.40	75.34	72.87	71.39	69.90	
Overall mean	83.98					73.38					

CD_(p=0.05)

Vigour level : 0.65
 Treatments : 1.13
 Storage durations : 1.03
 Vigour level × Treatments × Storage durations : 3.57

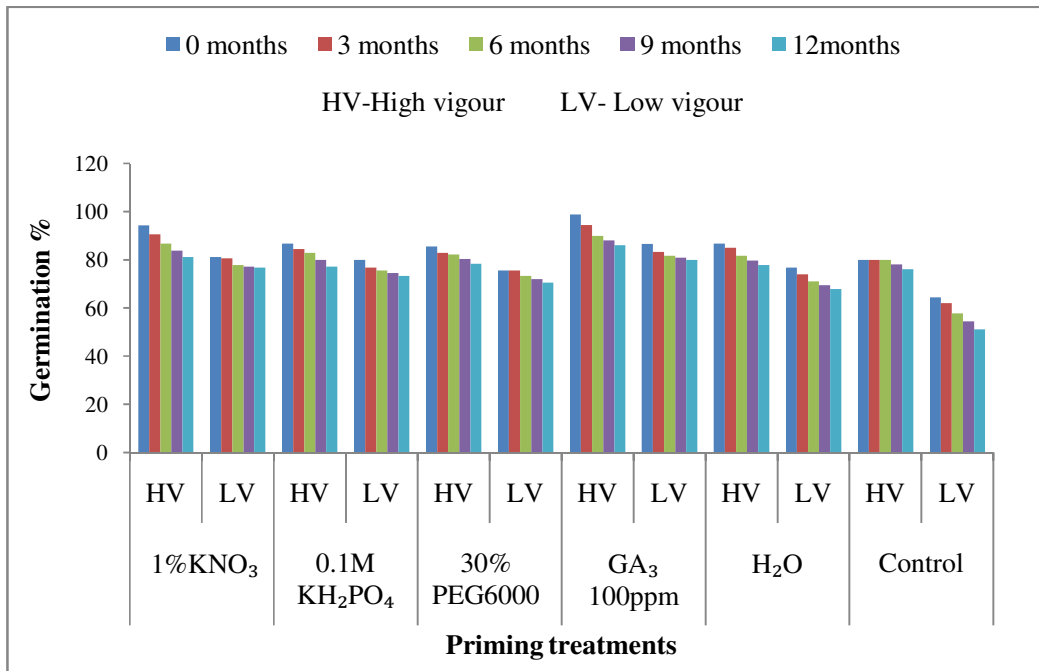


Fig 4.1: Effect of various priming treatments on the germination percentage of high and low vigour seeds of *Solanum melongena* L. stored for various durations.

Priming with KNO₃ also enhanced the germination percentage bringing it at par or more than that of unprimed high vigour seed (Table 4.1b). Priming with KH₂PO₄ in low vigour seeds enhanced the percentage germination in seeds stored for upto 3 months and brought it at par with untreated high vigour seeds stored for the same duration (Table 4.1b). Aswin *et al* (2019) also reported similar results of increased germination percentage of low vigour tomato seeds with KH₂PO₄ and KNO₃ priming treatments. The increased germination percentage was attributed to ion absorption by the seeds. The potassium ions have been reported to increase the ambient oxygen level by making less oxygen available for the citric acid cycle (Bewley and Black 1982). Priming with PEG 6000 (30%) for 12 hours and water although enhanced the percentage germination in low vigour seeds over control but this increase was less than percentage germination observed in high vigour seeds stored for same duration (Table 4.1b).

Thus, priming with GA₃ gave maximum enhancement in germination percentage in both high and low vigour seeds. Higher percentage increase over control was seen in low vigour seeds. Similarly, Pandey *et al* (2017) also reported that in cucumber, the response of low vigour seeds (aged) to priming was much higher as compared to high vigour seeds (unaged). This was possibly because priming is responsible for the repair of age related cellular and sub cellular damage of low vigour seeds that may accumulate during seed development (Bray 1995).

4.1.2 Speed of germination

Speed of germination differed significantly between high and low vigour seeds at the end of storage period. In general, decline in speed of germination was observed with increase in storage period. In high vigour seeds, speed of germination was maximum in freshly harvested (no storage) seeds (1.71) and reduced to (0.89) after 12 months of storage. Low vigour seeds recorded more speed of germination in seeds not subjected to any storage (0.76) and (0.40) after 12 months of storage (Table 4.2a).

With priming treatments, an increase in speed of germination was observed. In both high and low vigour seeds, the highest value of speed of germination was recorded with GA₃ (100ppm treatment for 12 hours) viz., 4.92 and 2.56 respectively. Also, after 12 months of storage, GA₃ primed high and low vigour seeds had highest speed of germination viz., 3.69 and 1.87 respectively as compared to other priming treatments (Table 4.2a) indicating that the positive effect of GA₃ priming is retained even after 12 months of storage period. Kumar and Singh (2013) also observed highest speed of germination in bitter melon seeds, when treated with GA₃ 100ppm.

The possible reason for enhanced speed of germination after GA₃ priming lies in the fact that application of GA₃ accelerates the pre-germinative metabolic processes which gives primed seed a head start over the unprimed seed for radical protrusion (Varier *et al* 2010). The minimum speed of germination was observed in untreated seeds which might be ascribed to slow rate of metabolism in unprimed seeds. The speed of germination was reported to be comparatively lesser in the non-primed seeds. Similar findings of improved speed of germination with priming treatments was reported in seeds of bell pepper (Yogananda *et al* 2004), French bean (Sarika *et al* 2013), Okra (Singh *et al* 2004) and onion seeds (Yarnia and Tabrizi 2012).

The speed of germination at the end of each storage duration was influenced by interaction between vigour levels of seed and the priming treatment. Within each storage duration, the values of speed of germination of GA₃ primed low vigour seeds were significantly more than values of non-primed high vigour seeds (Table 4.2a). While speed of germination of low vigour seeds primed with KNO₃, KH₂PO₄ and PEG was at par with the unprimed high vigour seeds within each storage duration (Table 4.2a).

While there is significant difference in the speed of germination within each storage duration but the interaction between seed vigour, priming treatments and storage duration is non-significant which means the priming treatments have improved the speed of germination even in low vigour seeds and brought it at par with that of high vigour seeds (Table 4.2b).

Table 4.2a: Effect of various priming treatments on the speed of germination of high and low vigour seeds of *Solanum melongena* L. stored for various durations.

	Storage duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO ₃	3.83	1.88	2.85	2.70	1.87	2.29	2.42	1.69	2.05	2.13	1.47	1.80	1.84	1.25	1.55
0.1M KH ₂ PO ₄	2.85	1.64	2.20	2.55	1.28	1.92	2.42	1.15	1.78	2.14	0.98	1.56	1.79	0.82	1.31
30% PEG6000	2.82	1.71	2.27	2.50	1.59	2.04	2.00	1.37	1.68	1.72	1.11	1.42	1.45	0.86	1.15
GA ₃ 100ppm	4.92	2.56	3.74	4.87	2.41	3.64	4.48	2.20	3.34	4.09	2.03	3.06	3.69	1.87	2.78
H ₂ O	1.96	1.01	1.48	1.83	0.90	1.37	1.50	0.78	1.14	1.29	0.67	0.98	1.08	0.55	0.81
CONTROL	1.71	0.76	1.24	1.61	0.70	1.16	1.33	0.62	0.97	1.11	0.51	0.81	0.89	0.40	0.64
MEAN	3.01	1.58		2.68	1.46		2.36	1.30		2.08	1.13		1.79	0.96	
CD _(p=0.05) (V)	0.21			0.14			0.13			0.12			0.10		
CD _(p=0.05) (T)	0.35			0.25			0.22			0.21			0.18		
CD _(p=0.05) (VxT)	0.50			0.35			0.32			0.29			0.25		

Table 4.2b: Effect of various priming treatments on high and low vigour seeds stored for various durations and their interaction on speed of germination in *Solanum melongena* L. seeds.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO ₃	3.83	2.70	2.42	2.13	1.84	1.88	1.87	1.69	1.47	1.25	2.11
0.1M KH ₂ PO ₄	2.85	2.55	2.42	2.14	1.79	1.64	1.28	1.15	0.98	0.82	1.77
30% PEG6000	2.82	2.50	2.00	1.72	1.45	1.71	1.59	1.37	1.11	0.86	1.71
GA ₃ 100ppm	4.92	4.87	4.48	4.09	3.69	2.56	2.41	2.20	2.03	1.87	3.31
H ₂ O	1.96	1.83	1.50	1.29	1.08	1.01	0.90	0.78	0.67	0.55	1.16
Control	1.71	1.61	1.33	1.11	0.89	0.76	0.70	0.62	0.51	0.40	0.96
Mean	3.01	2.68	2.36	2.08	1.79	1.58	1.46	1.30	1.13	0.96	
Overall mean	2.39					1.29					

CD_(p=0.05)

Vigour level : 0.07

Treatments : 0.11

Storage durations : 0.10

Vigour level × Treatments × Storage durations : NS

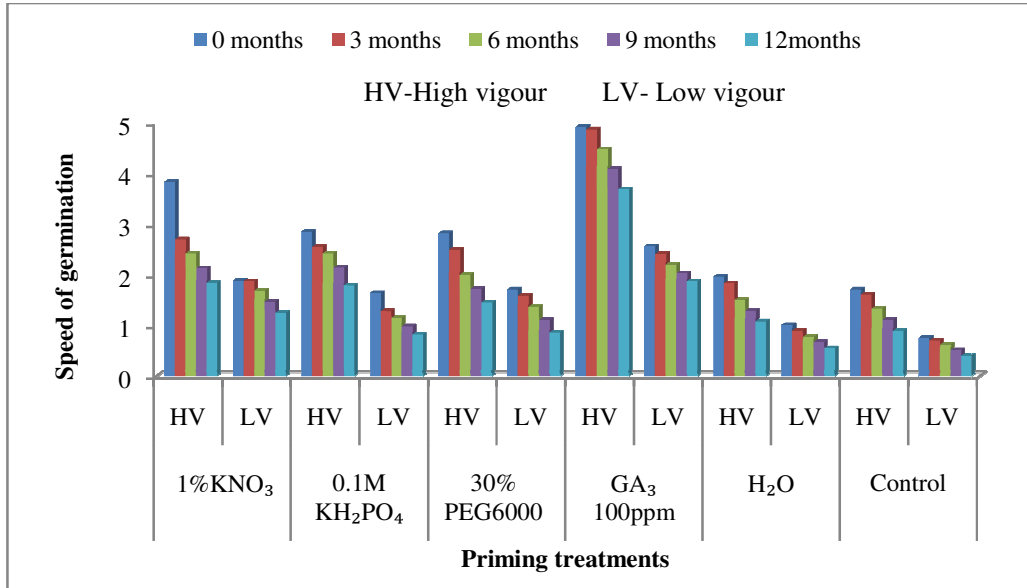


Fig. 4.2: Effect of various priming treatments on the speed of germination of high and low vigour seeds of *Solanum melongena* L. stored for various durations.

4.1.3 Mean days to germination

A significant difference in the mean days to germination was observed in high and low vigour seeds. In general increase in mean days to germination was observed after seeds had been stored for various durations. The high vigour seeds had minimum mean days to germination (4.48) upon harvesting (zero month storage) and maximum after 12 months of storage (5.65). In low vigour seeds minimum (6.53) and maximum (7.45) mean days to germination were observed after storage for zero and 12 months respectively.

A lower value of mean days to germination implies faster rate of germination. With different priming treatments mean days to germination decreased as compared to control in both high and low vigour seeds. Within each storage duration, mean days to germination of the low vigour seeds primed with GA₃ stored for zero, three, six, nine and twelve months respectively were either significantly less or at par with the control of high vigour seeds (Table 4.3a). By priming with both KNO₃ and KH₂PO₄ mean days to germination were at par with those of high vigour seeds (control) within each storage durations.

Similar reduction in mean days to germination was observed in osmoprimed Soybean (Sadeghi *et al* 2011), okra (Kaur *et al* 2015, Ali *et al* 2016) and hydroprimed tomato and brinjal (Patel *et al* 2017) seeds. Similarly priming in GA₃ reduced mean days to germination in wheat (Khan *et al* 2011), maize and pea (Tsegay and Andargie 2018) and French bean (Sarika *et al* 2013) seeds. The reduction in mean days to germination was attributed to GA₃ induced enzymes, which reduce mechanical restrains to the embryo.

Table 4.3a: Effect of various priming treatments on the mean days to germination (MDG) of high and low vigour seeds of *Solanum melongena* L. stored for various durations.

	Storage duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean
1% KNO₃	2.64	4.47	3.55	4.10	5.21	4.65	4.48	5.03	4.75	4.87	5.36	5.11	5.26	5.68	5.47
0.1M KH₂PO₄	3.93	4.84	4.39	4.23	5.03	4.63	4.78	5.17	4.97	5.19	5.30	5.25	5.60	5.54	5.57
30% PEG6000	4.02	5.00	4.51	4.23	5.57	4.90	4.83	5.89	5.36	4.98	6.04	5.51	5.13	6.18	5.65
GA₃100ppm	2.38	3.98	3.18	2.77	4.64	3.71	3.55	4.84	4.19	3.79	4.91	4.35	4.03	4.97	4.50
H₂O	4.12	5.16	4.64	4.40	5.52	4.96	4.93	5.88	5.41	5.15	6.04	5.59	5.36	6.18	5.77
Control	4.48	6.53	5.50	4.85	6.96	5.90	5.34	7.25	6.29	5.50	7.35	6.42	5.65	7.45	6.55
Mean	3.59	5.00		4.10	5.49		4.65	5.68		4.91	5.83		5.17	6.00	
CD_(p=0.05) (V)	0.18			0.35			0.12			0.09			0.11		
CD_(p=0.05) (T)	0.31			0.61			0.21			0.16			0.18		
CD_(p=0.05) (VxT)	0.45			NS			0.30			0.23			0.26		

Table 4.3b: Effect of various priming treatments on high and low vigour seeds stored for various durations and their interaction on mean days to germination (MDG) in *Solanum melongena* L. seeds.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO ₃	2.64	4.10	4.48	4.87	5.26	4.47	5.21	5.03	5.36	5.68	4.71
0.1M KH ₂ PO ₄	3.93	4.23	4.78	5.19	5.60	4.84	5.03	5.17	5.30	5.54	4.95
30% PEG6000	4.02	4.23	4.83	4.98	5.13	5.00	5.57	5.89	6.04	6.18	5.18
GA ₃ 100ppm	2.38	2.77	3.55	3.79	4.03	3.98	4.64	4.84	4.91	4.97	3.99
H ₂ O	4.12	4.40	4.93	5.15	5.36	5.16	5.52	5.88	6.04	6.18	5.27
Control	4.48	4.85	5.34	5.50	5.65	6.53	6.96	7.25	7.35	7.45	6.13
Mean	3.59	4.10	4.65	4.91	5.17	5.00	5.49	5.68	5.83	6.00	
Overall mean	4.48					5.60					

CD_(p=0.05)

Vigour level : 0.11
Treatments : 0.19
Storage durations : 0.18
Vigour level × Treatments × Storage durations : NS

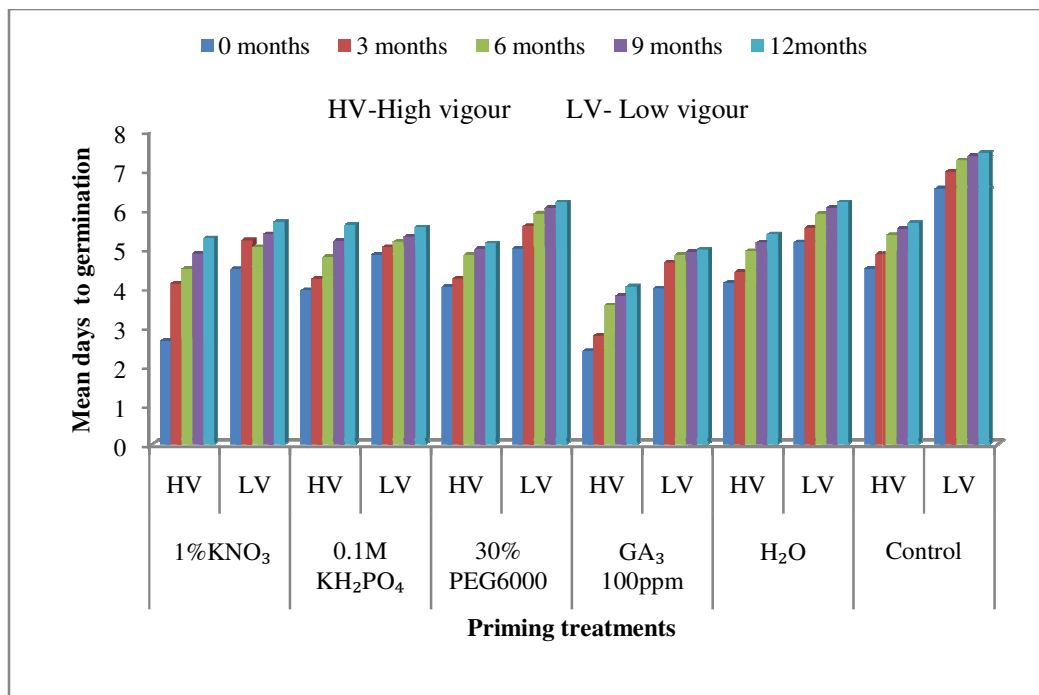


Fig. 4.3: Effect of various priming treatments on the mean days to germination (MDG) of high and low vigour seeds of *Solanum melongena* L. stored for various durations.

Overall the interaction between priming treatments, seed vigour and storage duration was non-significant (Table 4.3b). Priming with GA₃ gave the least value of mean days to germination, hence it is the best priming treatment for reducing the time taken for germination.

4.1.4 Root length

A significant difference in the root length in both high and low vigour seeds was observed in seeds stored for various durations. In general, gradual decline in root length was observed with increase in storage durations. In high vigour seeds, maximum root length was observed in control (no storage) seeds (4.61 cm) and decreased to (3.35 cm) after 12 months of storage. In low vigour seeds, maximum (4.08 cm) and minimum (3.02 cm) root length was observed when subjected to germination at the end of zero and 12 months of storage respectively. At the end of each storage duration, root length was significantly low in low vigour seeds than the high vigour seeds except at the end of 12 months of storage where this difference was non-significant (Table 4.4a).

Table 4.4a: Effect of various priming treatments on the root length (cm) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean
1% KNO₃	7.39	5.24	6.32	6.83	4.75	5.79	6.48	4.27	5.37	6.24	4.12	5.18	5.98	3.96	4.97
0.1M KH₂PO₄	4.72	4.43	4.58	4.75	4.08	4.41	4.30	3.55	3.92	4.15	3.37	3.76	4.00	3.19	3.60
30% PEG6000	6.12	4.37	5.25	5.54	3.69	4.62	5.15	3.65	4.40	4.88	3.51	4.20	4.62	3.32	3.97
GA₃100ppm	8.06	5.51	6.79	7.30	4.48	5.89	7.16	4.43	5.79	6.94	3.99	5.46	6.71	3.55	5.13
H₂O	5.90	4.22	5.06	5.23	3.89	4.56	4.55	3.64	4.09	4.21	3.57	3.94	3.86	3.41	3.67
Control	4.61	4.08	4.34	4.32	3.60	3.96	4.23	3.23	3.73	3.79	3.13	3.46	3.35	3.02	3.19
Mean	6.13	4.64		5.66	4.08		5.31	3.73		5.03	3.63		4.76	3.41	
CD_(p=0.05) (V)	0.19			0.28			0.26			0.15			0.15		
CD_(p=0.05) (T)	0.32			0.49			0.45			0.25			0.26		
CD_(p=0.05)(VxT)	0.45			0.69			0.63			0.36			0.37		

Table 4.4b: Effect of various priming treatments on high and low vigour seeds subjected to germination test at the end of various storage durations and their interaction on root length (cm) in *Solanum melongena* L.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	7.39	6.83	6.48	6.24	5.98	5.24	4.75	4.27	4.12	3.96	5.53
0.1M KH₂PO₄	4.72	4.75	4.30	4.15	4.00	4.43	4.08	3.55	3.37	3.19	4.05
30% PEG6000	6.12	5.54	5.15	4.88	4.62	4.37	3.69	3.65	3.51	3.32	4.49
GA₃100ppm	8.06	7.30	7.16	6.94	6.71	5.51	4.48	4.43	3.99	3.55	5.81
H₂O	5.90	5.23	4.55	4.21	3.86	4.22	3.89	3.64	3.57	3.41	4.28
Control	4.61	4.32	4.23	3.79	3.35	4.08	3.60	3.23	3.13	3.02	3.73
Mean	6.13	5.66	5.31	5.03	4.76	4.64	4.08	3.73	3.63	3.41	
Overall mean	5.38					3.92					

CD_(p=0.05)

Vigour level : 0.10

Treatments : 0.18

Storage durations : 0.16

Vigour level × Treatments × Storage durations : NS

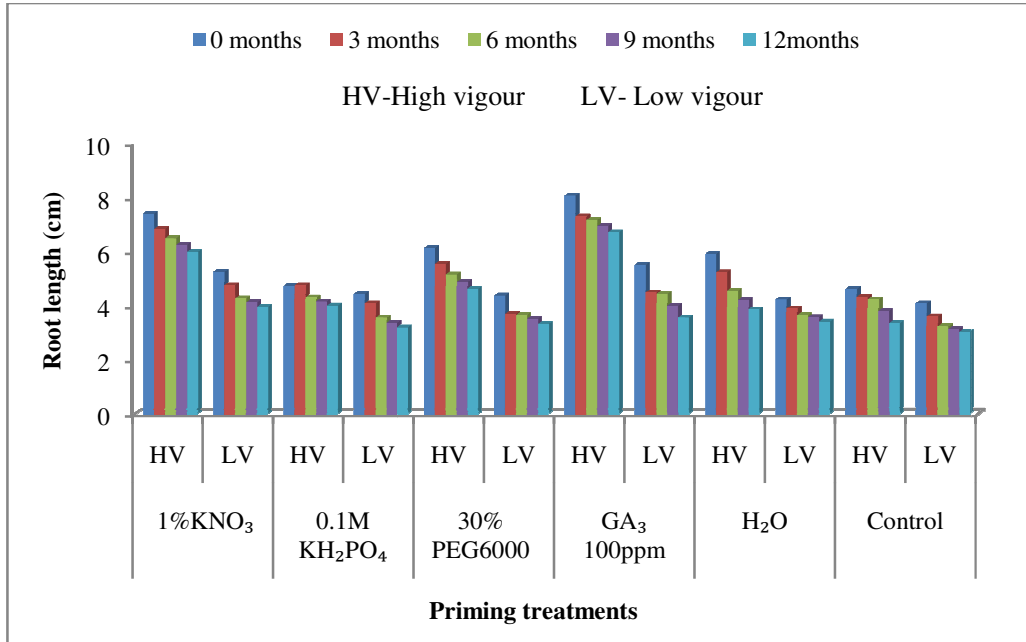


Fig. 4.4: Effect of various priming treatments on the root length (cm) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

The priming treatments resulted in increase in root length over the root length in high vigour control seeds. The highest root length was recorded in high vigour seeds treated with GA₃ 100ppm (8.06) and (6.71 cm) in the end of zero and 12 months of storage respectively followed by treatment with 1% KNO₃ (7.39 cm) and (5.98 cm) in the end of zero and 12 months of storage respectively. In low vigour seeds the root length (5.51cm) was recorded before storage and 3.55cm root length was recorded in seeds stored for 12 months subjected to germination tests (Table 4.4a). The increase in the root length with the priming treatments might be due to repair of cellular membrane which restore physiological and metabolic processes. An induced nuclear replication in root tips was reported in seeds of *Aeluropus macrostachys* (Nejad 2013).

Similar observations of increased root length with various priming treatments were recorded in osmoprimered tomato (Farooq *et al* 2005), haloprimered lettuce (Nasri *et al* 2011), KNO₃ primered cowpea (Singh *et al* 2014), GA₃ primered onions (Yarnia and Tabrizi 2012) and GA₃ primered tomato (Jyoti *et al* 2016) seeds.

The root length of the seedlings obtained from the seeds during different months of storage was influenced by interaction between vigour levels of seed and the priming treatment. Priming of low vigour seeds with GA₃, KH₂PO₄ and KNO₃ the root length was either greater than or at par with the root length of high vigour (control) seeds at the end of zero, three, six, nine and twelve months of storage (Table 4.4a).

Overall an interaction between seed vigour, various priming treatments and root length was non-significant which means the priming treatments have improved the root length even in low vigour seeds and brought it at par with that of high vigour seeds (Table 4.2b). The maximum mean root length (5.81 cm) was recorded with GA₃ priming.

4.1.5 Shoot length

A significant difference in the shoot length of high and low vigour seeds was observed. In general, decrease in shoot length was observed with an increase in storage period of the seed after harvest. In high vigour seeds the shoot length was maximum (5.84cm) in the seed subjected to germination before storage and minimum (4.78 cm) after 12 months of storage. In low vigour seeds maximum shoot length was (5.16 cm) observed in seeds subjected to germination before storage and minimum (3.37cm) at the end of 12 months storage period (Table 4.5a).

Within each storage duration, priming of both high and low vigour seeds had more shoot length over their respective controls. In high vigour seeds, priming with GA₃ led to (9.61cm) shoot length in freshly harvested seeds subjected to germination and (7.37 cm) at the end of 12 months of storage i.e. an increase of 64.54% and 54.18% over their respective controls. While in low vigour seeds, GA₃ priming resulted in 8.33cm shoot length before storage and 6.44 cm at the end of storage period i.e. an increase of 61.46% and 91.10% over their respective controls (Table 4.5a).

The shoot length of the seedlings obtained from the seeds during different months of storage was influenced by interaction between vigour levels of seed and the priming treatments. Priming of low vigour seeds with KNO₃ (1%), PEG 6000 (30%) and GA₃ 100ppm brought the shoot length at par with high vigour (control) seeds within each storage duration i.e. zero, three, six, nine and twelve months respectively (Table 4.5a). The significant increase in the shoot and root length in primed seeds may be due to its involvement in cell elongation, cell division and meristematic growth. Similar observations of increased shoot length with various priming treatments were recorded in osmoprimed tomato (Farooq *et al* 2005), haloprimed lettuce (Nasri *et al* 2011), KNO₃ primed cowpea (Singh *et al* 2014), GA₃ primed onions (Yarnia and Tabrizi 2012) and GA₃ primed tomato (Jyoti *et al* 2016) seeds.

Overall an interaction between seed vigour, various priming treatments and shoot length was significant. All the priming treatments except hydropriming significantly enhanced shoot length over control seeds i.e. high vigour seeds stored for various durations (Table 4.5b). Overall, priming with GA₃ gave highest mean shoot length (8.0cm) which is 87.9% more than mean shoot length (4.79cm) of both high and low vigour seeds stored for various durations.

Table 4.5a: Effect of various priming treatments on the shoot length (cm) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	8.69	6.12	7.40	7.81	6.07	6.94	6.60	5.88	6.24	6.21	5.73	5.97	5.81	5.57	5.69
0.1M KH₂PO₄	9.37	6.29	7.83	9.26	6.16	7.71	8.81	5.26	7.04	8.34	4.62	6.48	7.86	3.97	5.91
30% PEG6000	8.41	6.67	7.54	8.40	6.47	7.43	7.23	6.18	6.70	6.88	5.92	6.40	6.53	5.67	6.10
GA₃100ppm	9.61	8.33	8.97	9.61	8.04	8.83	8.26	7.55	7.91	7.82	7.00	7.41	7.37	6.44	6.91
H₂O	6.76	5.80	6.28	6.69	5.53	6.11	6.44	5.05	5.74	6.30	4.94	5.62	6.14	4.84	5.49
CONTROL	5.84	5.16	5.50	5.53	4.84	5.18	5.32	4.17	4.74	5.08	3.82	4.45	4.78	3.37	4.08
MEAN	8.11	6.40		7.88	6.18		7.11	5.68		6.77	5.34		6.41	4.98	
CD_(p=0.05) (V)	0.20			0.27			0.23			0.15			0.16		
CD_(p=0.05) (T)	0.35			0.47			0.39			0.26			0.27		
CD_(p=0.05)(VxT)	0.49			0.66			0.56			0.37			0.38		

Table 4.5b: Effect of various priming treatments on high and low vigour seeds subjected to germination test at the end of various storage durations and their interaction on shoot length (cm) in *Solanum melongena* L.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	8.69	7.81	6.60	6.21	5.81	6.12	6.07	5.88	5.73	5.57	6.45
0.1M KH₂PO₄	9.37	9.26	8.81	8.34	7.86	6.29	6.16	5.26	4.62	3.97	6.99
30% PEG6000	8.41	8.40	7.23	6.88	6.53	6.67	6.47	6.18	5.92	5.67	6.84
GA₃100ppm	9.61	9.61	8.26	7.82	7.37	8.33	8.04	7.55	7.00	6.44	8.00
H₂O	6.76	6.69	6.44	6.30	6.14	5.80	5.53	5.05	4.94	4.84	5.85
Control	5.84	5.53	5.32	5.08	4.78	5.16	4.84	4.17	3.82	3.37	4.79
Mean	8.11	7.88	7.11	6.77	6.41	6.40	6.18	5.68	5.34	4.98	
Overall mean	7.26					5.72					

CD_(p=0.05)

Vigour level : 0.13

Treatments : 0.23

Storage durations : 0.21

Vigour level × Treatments × Storage durations : 0.71

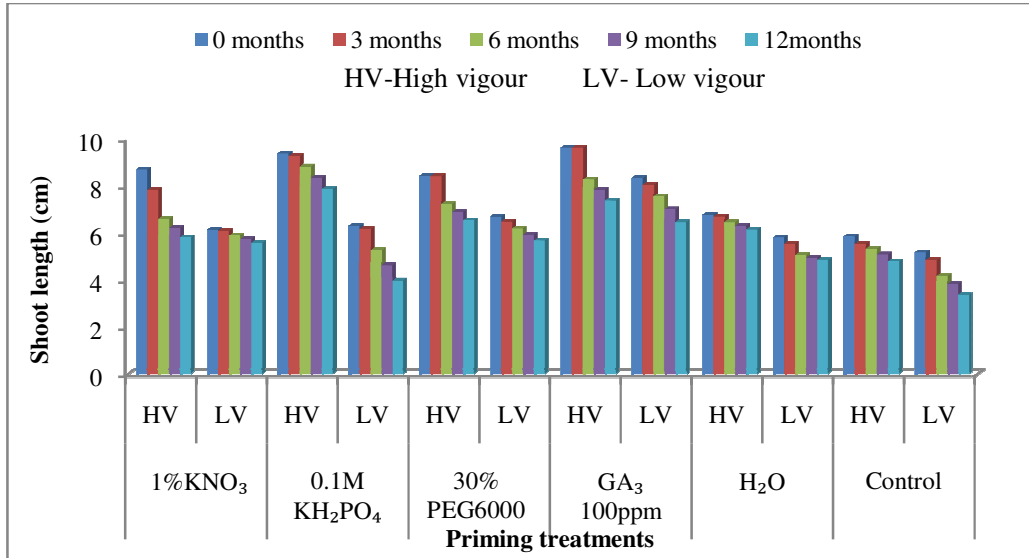


Fig. 4.5: Effect of various priming treatments on the shoot length (cm) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

4.1.6 Seedling length

Storage duration significantly affected seedling length in both high and low vigour seeds. In general, a decrease in seedling length was recorded with increased storage period, prior to germination, in high vigour seeds, the maximum seedling length (10.44 cm) was observed in seed not subjected to storage and minimum (8.13 cm) was observed in seeds stored for 12 months. In low vigour seeds, the maximum seedling length (9.38 cm) was observed in seeds not subjected to storage and minimum (6.39 cm) was observed in seeds stored for 12 months (Table 4.6a).

Within each storage duration, priming treatments increased the seedling length over control un-stored seeds. In high vigour seeds, priming with GA₃ led to 17.67cm seedling length in freshly harvested seeds subjected to germination tests and seedling length of 14.09cm at the end of 12 months of storage i.e. an increase of 69.25% and 73.31% over their respective controls. Likewise in low vigour seeds, priming with GA₃ led to 13.84cm seedling length initially and 9.99cm at the end of 12 months of storage i.e. 47.55% and 56.34% increase over their respective controls (Table 4.6a). The probable reason for improved seedling length after seed treatment is the increase in the metabolic activity that leads to better mobilization efficiency of stored food during the early stages of germination (Bailly *et al* 2002). Also exogenous application of GA₃ increases internodal length of shoot as a result of cell elongation, cell division and increased meristematic growth. Likewise an increase in seedling length in okra seeds was reported by GA₃ priming (Singh *et al* 2014), in hot pepper

Table 4.6a: Effect of various priming treatments on the seedling length (cm) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	16.08	11.36	13.72	14.64	10.82	12.73	13.08	10.14	11.61	12.44	9.84	11.14	11.79	9.53	10.66
0.1M KH₂PO₄	14.10	10.72	12.41	14.01	10.23	12.12	13.11	8.80	10.96	12.49	7.99	10.24	11.86	7.16	9.51
30% PEG6000	14.53	11.04	12.79	13.94	10.12	12.03	12.38	9.86	11.12	11.77	9.43	10.60	11.15	8.99	10.07
GA₃100ppm	17.67	13.84	15.75	16.91	12.52	14.72	15.42	11.98	13.70	14.76	10.99	12.87	14.09	9.99	12.04
H₂O	12.66	9.88	11.27	11.92	9.12	10.52	10.99	8.88	9.94	10.50	8.61	9.55	10.00	8.33	9.17
Control	10.44	9.38	9.91	9.85	8.52	9.18	9.55	7.40	8.47	8.87	6.94	7.91	8.13	6.39	7.26
Mean	14.25	11.04		13.54	10.22		12.42	9.51		11.80	8.97		11.17	8.40	
CD_(p=0.05) (V)	0.27			0.41			0.39			0.26			0.24		
CD_(p=0.05) (T)	0.47			0.71			0.67			0.44			0.42		
CD_(p=0.05)(VxT)	0.67			1.01			0.95			0.62			0.59		

Table 4.6b: Effect of various priming treatments on high and low vigour seeds subjected to germination test at the end of various storage durations and their interaction on Seedling length (cm) in *Solanum melongena* L.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	16.08	14.64	13.08	12.44	11.79	11.36	10.82	10.14	9.84	9.53	11.97
0.1M KH₂PO₄	14.10	14.01	13.11	12.49	11.86	10.72	10.23	8.80	7.99	7.16	11.05
30% PEG6000	14.53	13.94	12.38	11.77	11.15	11.04	10.12	9.86	9.43	8.99	11.32
GA₃100ppm	17.67	16.91	15.42	14.76	14.09	13.84	12.52	11.98	10.99	9.99	13.82
H₂O	12.66	11.92	10.99	10.50	10.00	9.88	9.12	8.88	8.61	8.33	10.13
Control	10.44	9.85	9.55	8.87	8.13	9.38	8.52	7.40	6.94	6.39	8.53
Mean	14.25	13.54	12.42	11.80	11.17	11.04	10.26	9.51	8.97	8.40	
Overall mean	12.64					9.64					

CD_(p=0.05)

Vigour level : 0.20

Treatments : 0.34

Storage durations : 0.31

Vigour level × Treatments × Storage durations : NS

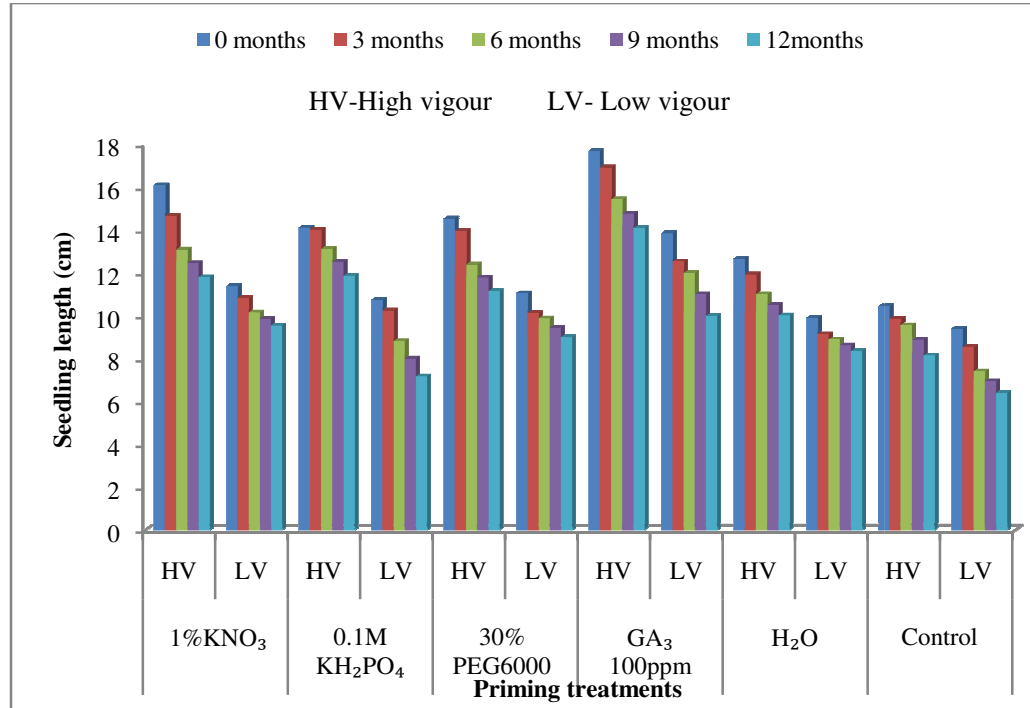


Fig. 4.6: Effect of various priming treatments on the seedling length (cm) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

by KNO₃ priming (Pandita *et al* 2007), by hydropriming (Anese *et al* 2011) and PEG priming (Mirabi and Hasanabadi 2012) in tomato.

The seedling length was influenced by interaction between vigour levels of seed and the priming treatment during different months of storage. Within each storage duration, priming of low vigour seeds with GA₃ 100ppm resulted in significantly more seedling length as compared to respective high vigour control while priming of low vigour seeds with 1% KNO₃ resulted in either significantly more seedling length or it was at par with the seedling length in the respective high vigour seeds (control). While priming with KH₂PO₄ resulted in seedling length which was at par with seedling length in the respective control in seeds stored for upto six months (Table 4.6a).

Overall interaction between seed vigour, storage duration and priming treatments was non-significant for seedling length. This implies that overall priming treatments improved the seedling length and brought it at par with the control (high vigour seeds, no storage) (Table 4.6b). With GA₃ priming maximum mean seedling length of 13.82 was observed while in unprimed seed it was 8.53cm.

4.1.7 Seedling dry weight

A significant difference in the seedling dry weight (mg) of high and low vigour seeds was observed among seeds stored for different storage periods. In general, with an increase in storage period a decrease in the seedling dry weight was observed. In the high vigour seeds, maximum seedling dry weight (7.57mg) was observed in seeds subjected to germination soon after harvesting and minimum (6.10mg) was observed in seeds germinated after the 12 months of storage. In low vigour seeds, maximum seedling dry weight (5.90mg) was recorded before storage and minimum seedling dry weight (4.08 mg) was recorded after 12 months of storage (Table 4.7a).

Seedling dry weight increased with various priming treatments. In high vigour seeds, priming with GA₃ led to 14.85mg seedling dry weight in freshly harvested seeds subjected to germination tests and 11.09mg in 12 months of storage. Likewise in low vigour seeds, priming with GA₃ led to 11.90mg seedling dry weight initially and 9.15mg at the end of 12 months of storage (Table 4.7a). Similar results were observed by GA₃ priming in wheat (Khan *et al* 2011), maize, pea seeds (Tsegay and Andargie 2018) and French bean (Sarika *et al* 2013) seeds. In Soybean seeds, seed priming with KNO₃ at 6gL⁻¹ concentration increased the germination percentage and seedling dry weight (Ahmadvand *et al* 2012). Similar increase in seedling dry weight was recorded in soybean seeds (Mohammadi 2009).

Seedling dry weight was influenced by interaction between vigour level and priming treatment during different months of storage. Within each storage duration, priming of low vigour seeds with GA₃ 100ppm, 0.1M KH₂PO₄, 1% KNO₃ and PEG6000 (30%) resulted in significantly more seedling dry weight as compared to seedling dry weight of respective high vigour control (Table 4.7a).

Overall interaction between seed vigour, storage duration and priming treatments was non-significant for seedling dry weight. This implies that overall priming treatments improved the seedling dry weight and brought it at par with the control (high vigour seeds, no storage) (Table 4.7b). Maximum mean seedling dry weight of 11.80mg was obtained with GA₃ priming as against 5.81mg for control (not subjected to storage) seeds.

4.1.8 Seedling Vigour index I (SVI-I)

A significant difference in the seedling vigour index I of the seed was observed depending on the vigour of the seed. In general, SVI-I decreased with the increase in storage period. In high vigour seeds the maximum SVI-I (836) was recorded soon after harvesting while the minimum (621) was recorded in seeds subjected to 12 months of storage. In low

Table 4.7a: Effect of various priming treatments on the Seedling dry weight (mg) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	12.03	9.07	10.55	11.54	8.47	10.01	10.35	8.17	9.26	9.65	7.72	8.69	8.95	7.28	8.11
0.1M KH₂PO₄	11.46	9.57	10.51	11.23	8.57	9.90	10.10	7.97	9.03	9.48	7.59	8.53	8.85	7.20	8.03
30% PEG6000	11.07	8.80	9.93	10.97	8.67	9.82	10.73	8.35	9.54	10.22	7.53	8.88	9.70	6.72	8.21
GA₃100ppm	14.85	11.90	13.38	14.03	11.33	12.68	13.50	10.32	11.91	12.96	9.74	11.35	11.09	9.15	10.12
H₂O	10.00	8.23	9.12	8.90	7.30	8.10	8.80	7.12	7.96	8.44	6.66	7.55	8.08	6.19	7.14
Control	7.57	5.90	6.73	6.83	5.33	6.08	6.62	4.78	5.79	6.45	4.43	5.44	6.10	4.08	5.09
Mean	11.16	8.91		10.59	8.28		10.02	7.78		9.53	7.28		8.80	6.77	
CD_(p=0.05) (V)	0.36			0.33			0.22			0.14			0.14		
CD_(p=0.05) (T)	0.63			0.58			0.39			0.25			0.25		
CD_(p=0.05)(VXT)	NS			0.81			0.55			0.35			0.35		

Table 4.7b: Effect of various priming treatments on high and low vigour seeds subjected to germination test at the end of various storage durations and their interaction on Seedling dry weight (mg) in *Solanum melongena* L.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	12.03	11.54	10.35	9.65	8.95	9.07	8.47	8.17	7.72	7.28	9.32
0.1M KH₂PO₄	11.46	11.23	10.10	9.48	8.85	9.57	8.57	7.97	7.59	7.20	9.20
30% PEG6000	11.07	10.97	10.73	10.22	9.70	8.80	8.67	8.35	7.53	6.72	9.28
GA₃100ppm	14.85	14.03	13.50	12.96	11.09	11.90	11.33	10.32	9.74	9.15	11.89
H₂O	10.00	8.90	8.80	8.44	8.08	8.23	7.30	7.12	6.66	6.19	7.97
Control	7.57	6.83	6.62	6.45	6.10	5.90	5.33	4.78	4.43	4.08	5.81
Mean	11.16	10.59	10.02	9.53	8.80	8.91	8.28	7.78	7.28	6.77	
Overall mean	10.02					7.80					

CD_(p=0.05)

Vigour level : 0.16

Treatments : 0.27

Storage durations : 0.25

Vigour level × Treatments × Storage durations : NS

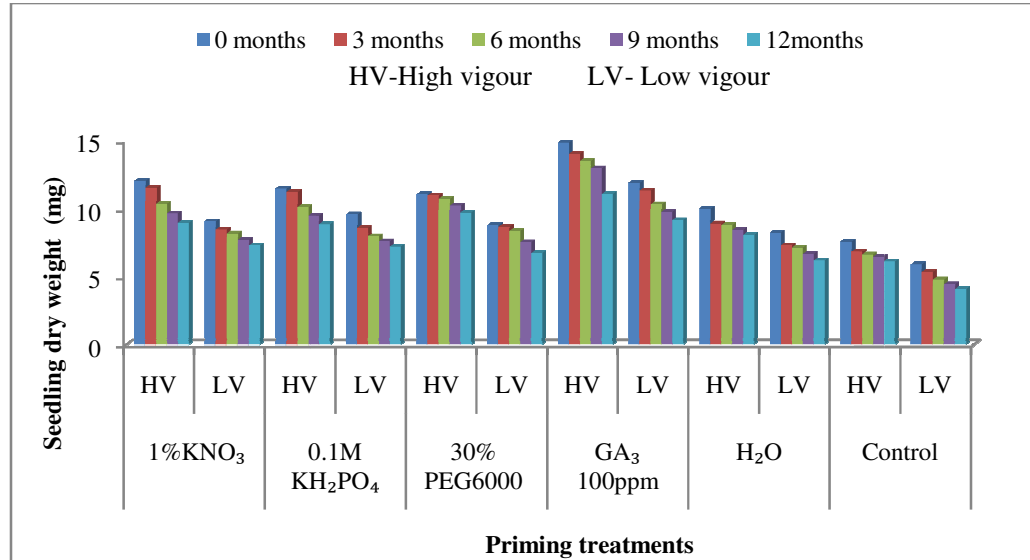


Fig. 4.7: Effect of various priming treatments on the Seedling dry weight (mg) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

vigour seeds not subjected to any storage, maximum SVI-I was (604) recorded which reduced to (327) in seeds stored for 12 months after harvesting (Table 4.8a).

Different priming treatments significantly increased the SVI-I as compared to the control within each storage duration. In high vigour seeds, priming with GA₃ (seed soak in 100ppm GA₃ for 12 hours) led to a SVI-I of 1747 in freshly harvested seeds and an SVI-I of 1215 at the end of 12 months of storage. Likewise in low vigour seeds, priming with GA₃ led to an SVI-I value of 1197 initially and an SVI-I value of 803 at the end of 12 months of storage (Table 4.8a). Similar results of improved seedling vigour index I due to GA₃ priming treatments was reported by many authors e.g. wheat seeds (Khan *et al* 2011), maize (Kumari *et al* 2017), pea seeds (Tsegay and Andargie 2018) and French bean seeds (Sarika *et al* 2013).

Within each storage duration, priming of low vigour seeds with GA₃ 100ppm resulted in significantly more seedling vigour index-I (SVI-I) as compared to respective control high vigour seeds (Table 4.8a). All the other priming treatments also improved the seedling vigour index but the GA₃ treatment was the best.

Overall interaction between vigour level, priming treatment and storage duration for SVI-I was non-significant. So, this means that with the priming treatments the SVI-I was statistically at par with SVI-I in control seeds (high vigour seeds stored for zero months) (Table 4.8b). The overall mean value of SVI-I with GA₃ was 1218 which was significantly more than that of control (595).

Table 4.8a: Effect of various priming treatments on the Seedling Vigour Index-I (SVI-I) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	1518	920	1219	1327	872	1100	1135	791	963	1045	760	903	959	730	844
0.1M KH₂PO₄	1222	857	1039	1183	786	984	1085	666	876	1000	595	797	917	526	721
30% PEG6000	1241	832	1036	1155	766	960	1019	727	873	946	681	813	875	637	756
GA₃100ppm	1747	1197	1472	1601	1046	1324	1390	983	1186	1302	892	1097	1215	803	1009
H₂O	1097	758	927	1013	674	844	898	632	765	837	598	718	779	565	672
Control	836	604	720	788	530	659	764	428	576	693	380	536	621	327	474
Mean	1277	861		1178	779		1049	704		970	651		894	598	
CD_(p=0.05) (V)	35			38			34			22			21		
CD_(p=0.05) (T)	61			67			59			38			37		
CD_(p=0.05)(VXT)	86			94			NS			54			53		

Table 4.8b: Effect of various priming treatments on high and low vigour seeds subjected to germination test at the end of various storage durations and their interaction on Seedling Vigour Index-I (SVI-I) in *Solanum melongena* L.

Vigour level Storage duration Treatments	High vigour					Low vigour					Mean
	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	
1% KNO ₃	1518	1327	1135	1045	959	920	872	791	760	730	1006
0.1M KH ₂ PO ₄	1222	1183	1085	1000	917	857	786	666	595	526	884
30% PEG6000	1241	1155	1019	946	875	832	766	727	682	637	888
GA ₃ 100ppm	1747	1601	1390	1302	1215	1197	1046	983	892	803	1218
H ₂ O	1097	1013	898	837	779	758	674	632	599	565	788
Control	836	788	764	693	621	604	530	428	380	327	595
Mean	1277	1178	1049	970	894	861	779	704	651	598	
Overall mean	1073					720					

CD_(p=0.05)

Vigour level : 20
Treatments : 35
Storage durations : 32
Vigour level × Treatments × Storage durations : NS

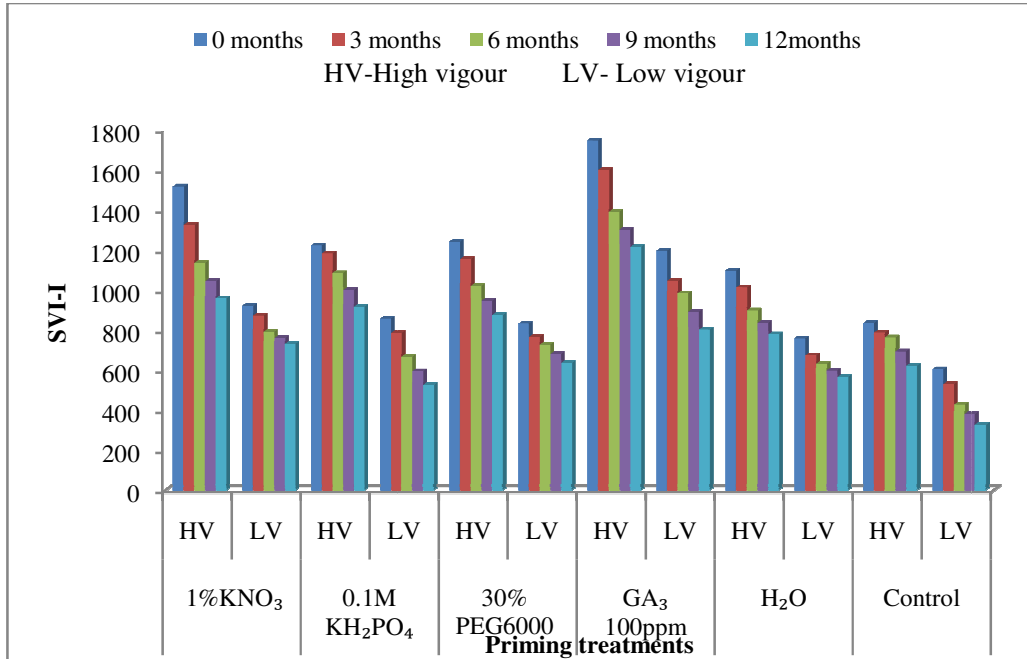


Fig. 4.8: Effect of various priming treatments on the Seedling Vigour Index-I (SVI-I) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

4.1.9 Seedling Vigour Index (SVI-II)

In general in both high and low vigour seeds with an increase in storage durations a decrease in seedling vigour index II was observed. In the high vigour seeds maximum SVI-II (604) was observed before storage and minimum (465) was recorded after 12 months of storage. In low vigour control seeds, maximum SVI-II (381) was observed before storage and minimum (208) was observed after 12 months of storage (Table 4.9a).

Primed seeds had significantly higher value of SVI-II as compared to control within each storage period. The highest SVI-II was observed in high vigour seeds treated with GA₃ 100ppm (1468) before storage and which decreased to 956 at the end of 12 months of storage duration. Similarly for low vigour seeds the highest SVI-II (1031) was recorded in seeds before storage and a value of 732 was obtained after 12 months of storage (Table 4.9a). Similar increase in SVI-II was observed in seeds of many crops primed with GA₃ e.g. wheat (Khan *et al* 2011), maize and pea (Tsegay and Andargie 2018) and French bean seeds (Sarika *et al* 2013) seeds.

Seedling Vigour Index-II was influenced by interaction between vigour level and priming treatment during different months of storage. In all the storage durations, priming of low vigour seeds with GA₃ enhanced SVI-II equal to or more than control (high vigour seeds stored for zero months) (Table 4.9a).

Table 4.9a: Effect of various priming treatments on the Seedling Vigour Index-II (SVI-II) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	1136	734	935	1047	683	865	899	636	768	813	597	705	727	558	643
0.1M KH₂PO₄	993	765	879	952	659	805	837	603	720	762	566	664	687	528	607
30% PEG6000	949	665	807	910	656	782	886	613	749	824	544	684	762	475	619
GA₃100ppm	1468	1031	1250	1325	946	1135	1215	843	1029	1143	788	965	956	732	844
H₂O	866	631	748	757	541	649	719	506	613	674	463	569	629	420	525
Control	604	381	493	547	332	439	530	277	403	505	243	374	465	208	337
Mean	1003	701		923	636		850	580		787	533		704	487	
CD_(p=0.05) (V)	42			31			19			13			14		
CD_(p=0.05) (T)	72			53			33			22			23		
CD_(p=0.05)(VXT)	102			75			47			31			33		

Table 4.9b: Effect of various priming treatments on high and low vigour seeds subjected to germination test at the end of various storage durations and their interaction on Seedling Vigour Index-II (SVI-II) in *Solanum melongena* L.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	1136	1047	899	813	727	734	683	636	597	558	783
0.1M KH₂PO₄	993	952	837	762	687	765	659	603	566	528	735
30% PEG6000	949	910	886	824	762	665	656	613	544	475	728
GA₃100ppm	1468	1325	1215	1143	956	1031	946	843	788	732	1045
H₂O	866	757	719	674	629	631	541	506	463	420	621
Control	604	547	530	505	465	381	332	277	243	208	409
Mean	1003	923	850	787	704	701	636	580	533	487	
Overall mean	853					587					

CD_(p=0.05)

Vigour level : 16
Treatments : 28
Storage durations : 25
Vigour level × Treatments × Storage durations : NS

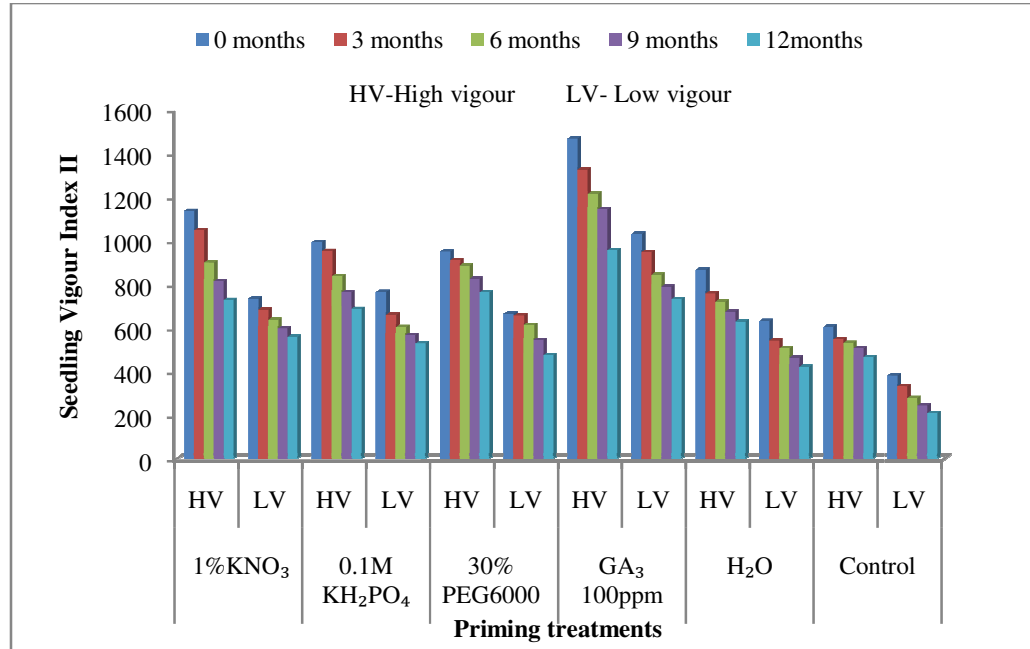


Fig. 4.9: Effect of various priming treatments on the Seedling Vigour Index-II (SVI-II) of high and low vigour brinjal seeds stored for various durations and subjected to germination test in rolled paper towels under laboratory conditions at 25°C.

Overall interaction between vigour level, priming treatment and storage duration for SVI-II was non-significant. So, this means that with the priming treatments the SVI-II was statistically at par with SVI-II in control seeds (high vigour seeds stored for zero months) (Table 4.9b). The overall mean highest value of SVI-II (1045) was obtained with GA₃ priming while that of control is (409).

4.2 Biochemical Parameters

4.2.1 Total soluble sugars

In the present study, at the end of each storage duration the amount of total soluble sugars was high in high vigour seeds than in low vigour seeds. This can be explained in terms of activity of α -amylase. The activity of α -amylase was low in low vigour seeds (Table 4.12a) hence the seeds had higher starch content (Table 4.11a) and low total soluble sugar content (Table 4.10a).

In general, with an increase in storage duration the total soluble sugars content in the seeds decreased. In high vigour seeds maximum total soluble sugar content (9.11mg/g) was recorded immediately after harvest while minimum total soluble sugars content (5.28 mg/g) was recorded after 12 months of storage. Similarly, in low vigour seeds maximum amount of total soluble sugars (3.16mg/gDW) was recorded initially and minimum (1.82 mg/gDW) after 12 months of storage (Table 4.10a).

Table 4.10a: Effect of various priming treatments on the Total soluble sugar content (mg/g DW) in high and low vigour seeds of *Solanum melongena* L. stored for various durations.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	13.36	9.63	11.25	12.33	8.77	10.55	10.53	8.61	9.57	10.28	8.33	9.31	10.03	7.55	8.79
0.1M KH₂PO₄	10.00	9.13	9.81	9.39	8.40	8.89	8.94	7.04	7.99	8.28	7.00	7.64	7.62	6.95	7.28
30% PEG6000	10.34	8.88	9.61	9.65	7.62	8.64	8.79	6.44	7.62	8.24	6.34	7.29	7.69	6.24	6.97
GA₃100ppm	10.30	7.58	8.94	9.82	7.06	8.44	9.27	6.91	8.09	9.02	6.85	7.93	8.77	6.78	7.77
H₂O	9.18	5.73	7.45	8.80	5.66	7.23	7.46	5.06	6.26	6.68	4.46	5.57	5.90	3.86	4.88
Control	9.11	3.16	6.14	8.54	2.57	5.56	7.68	2.25	4.96	6.48	2.03	4.26	5.28	1.82	3.55
Mean	10.38	7.35		9.75	6.68		8.78	6.05		8.16	5.83		7.55	5.53	
CD_(p=0.05) (V)	1.21			0.38			0.34			0.23			0.27		
CD_(p=0.05) (T)	2.10			0.66			0.59			0.39			0.47		
CD_(p=0.05)(VXT)	NS			0.93			0.83			0.56			0.66		

Table 4.10b: Effect of various priming treatments on high and low vigour seeds stored for various durations and their interaction on total soluble sugar content (mg/g DW) in *Solanum melongena* L. seeds.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	13.36	12.33	10.53	10.28	10.03	9.63	8.77	8.61	8.33	7.55	9.94
0.1M KH₂PO₄	10.00	9.39	8.94	8.28	7.62	9.13	8.40	7.04	7.00	6.95	8.32
30% PEG6000	10.34	9.65	8.79	8.24	7.69	8.88	7.62	6.44	6.34	6.24	8.02
GA₃100ppm	10.30	9.82	9.27	9.02	8.77	7.58	7.06	6.91	6.85	6.78	8.24
H₂O	9.18	8.80	7.46	6.68	5.90	5.73	5.66	5.06	4.46	3.86	6.28
Control	9.11	8.54	7.68	6.48	5.28	3.16	2.57	2.25	2.03	1.82	4.89
Mean	10.38	9.75	8.78	8.16	7.55	7.35	6.68	6.05	5.83	5.71	
Overall mean	8.93					6.31					

CD_(p=0.05)

Vigour level : 0.20

Treatments : 0.34

Storage durations : 0.31

Vigour level × Treatments × Storage durations : NS

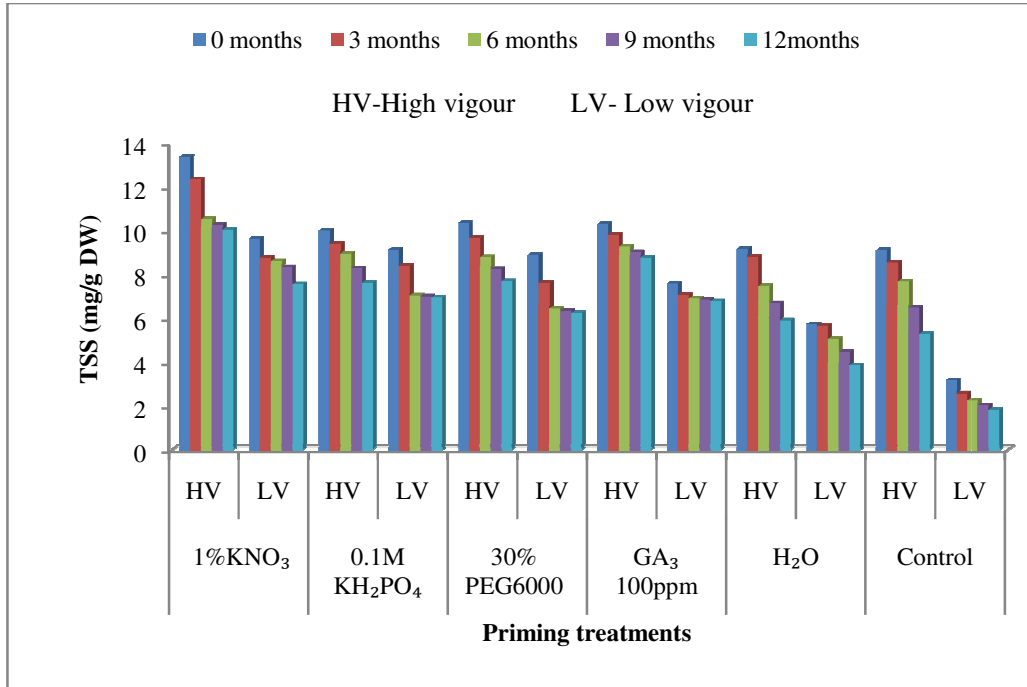


Fig. 4.10: Effect of various priming treatments on the Total soluble sugar content (mg/g DW) in high and low vigour seeds of *Solanum melongena* L. stored for various durations.

Priming treatments resulted in an increase in total soluble sugar content in both high and low vigour seeds over respective control seeds though extent of increase varied. This is also attributed to increased activity of α -amylase (Table 4.12a). Maximum amount of soluble sugars (13.36mg/g DW) before storage was recorded in high vigour seeds treated with 1% KNO₃ which reduced to 10.03mg/gDW after 12 months of storage. Likewise in low vigour seeds maximum amount of total soluble sugars (9.63 mg/gDW) were recorded with 1% KNO₃ priming treatment before storage and (7.55mg/gDW) at the end of 12 months of storage period (Table 4.10a). Similar results of increased amount of total soluble sugars with increased α -amylase activity after KNO₃ priming were reported in tomato (Nawaz *et al* 2011) and marigold (Afzal *et al* 2009) seeds.

Total soluble sugar content in seeds was influenced by interaction between vigour level and priming treatment during different months of storage. The interactive effect of vigour level and priming treatments was non-significant at the end of zero months of storage while the interaction was significant for the succeeding months of storage. Within each storage duration, the amount of total soluble sugars in low vigour seeds treated with 1%KNO₃ was either statistically at par or significantly more than the amount of total soluble sugars in respective high vigour control seeds (Table 4.10a).

Overall there was no significant difference in the amount of total soluble sugars in an interaction between seed vigour, priming treatment and storage duration. This implies that overall priming treatments increased the amount of total soluble sugars in the seeds and brought it at par with amount of soluble sugars in control (high vigour seeds, no storage) (Table 4.10b). The maximum mean total sugar content (9.94mg/g DW) was recorded in KNO₃ treated seeds while least (4.89mg/g DW) was recorded in unprimed seeds.

4.2.2 Starch content

At the end of each storage duration, the low vigour seeds had higher starch content than the high vigour seeds. In high vigour seeds, a starch content of (7.90 mg/g DW) was recorded while in the low vigour a starch content of 17.64mg/g was recorded. On the other hand, in high vigour seeds stored for 12 months a starch content of 6.56mg/g DW was recorded while in low vigour seeds a starch content of 14.61mg/g DW was recorded (Table 4.11a).

The priming treatments lowered the starch content in both high and low vigour seeds. Within each storage duration, the lowest starch content was recorded with GA₃ priming i.e. 4.35mg/g DW and 8.27mg/g DW in high and low vigour seeds respectively. Similarly in both the seed lots stored for 12 months lowest starch content with GA₃ priming was recorded i.e. 4.01mg/gDW and 7.76mg/g DW respectively (Table 4.11a). This can be explained in terms of increased activity of α -amylase with priming treatments (Table 4.12a) that catalyses the hydrolysis of α -1,4 glycosidic linkages in starch, converting starch into low molecular weight sugars.

Within each storage duration, the synergistic effect of seed vigour level and priming treatments on starch content was significant. Priming of low vigour seeds with GA₃ lowered the amount of starch content that was statistically at par with the starch content in high vigour seeds stored for zero, three, six, nine and twelve months respectively (Table 4.11a).

Overall there was no significant difference in the amount of starch content in an interaction between seed vigour, priming treatment and storage duration. This implies that overall priming treatments increased the amount of total soluble sugars in the seeds and brought it at par with amount of starch content in control (high vigour seeds, no storage) (Table 4.11b).

4.1.3 Activity of α -amylase

Within each storage duration the activity of α -amylase was higher in high vigour seeds and less in low vigour seeds (Table 4.12a). This explains the high amount of starch in low vigour seeds at the end of each storage duration (Table 4.11a). In general, with increase in storage duration the activity of α -amylase in the seeds decreased. In high vigour seeds, 15.63 μ g maltose produced/ml/min α - amylase activity was recorded while in the seed lot

Table 4.11a: Effect of various priming treatments on the Starch content (mg/g DW) in high and low vigour seeds of *Solanum melongena* L. stored for various durations.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	5.96	8.07	7.02	5.79	7.90	6.85	5.69	7.87	6.78	5.45	7.67	6.56	5.20	7.47	6.34
0.1M KH₂PO₄	7.68	10.94	9.31	7.14	10.65	8.89	7.24	10.11	8.68	7.07	10.18	8.62	6.89	9.74	8.32
30% PEG6000	5.87	10.90	8.38	5.45	10.64	8.04	5.36	10.21	7.78	5.11	9.81	7.46	4.85	9.72	7.28
GA₃100ppm	4.35	8.27	6.31	4.34	8.15	6.25	4.32	8.07	6.19	4.21	7.91	6.06	4.01	7.76	5.88
H₂O	6.95	12.55	9.75	6.90	11.69	9.30	6.86	10.79	8.83	6.67	10.58	8.62	6.83	10.36	8.60
Control	7.90	17.64	12.77	7.51	17.36	12.44	7.44	16.96	12.20	7.00	15.82	11.41	6.56	14.67	10.61
Mean	6.45	11.39		6.19	11.06		6.15	10.67		5.92	10.33		5.72	9.95	
CD_(p=0.05) (V)	0.62			0.38			0.23			0.29			0.55		
CD_(p=0.05) (T)	1.07			0.66			0.40			0.50			0.95		
CD_(p=0.05)(VXT)	1.51			0.94			0.56			0.70			1.34		

Table 4.11b: Effect of various priming treatments on high and low vigour seeds stored for various durations and their interaction on Starch content (mg/g DW) in *Solanum melongena* L. seeds.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	5.96	5.79	5.69	5.45	5.20	8.07	7.90	7.87	7.67	7.47	6.71
0.1M KH₂PO₄	7.68	7.14	7.24	7.07	6.89	10.94	10.65	10.10	10.18	9.74	8.76
30% PEG6000	5.87	5.45	5.36	5.11	4.85	10.90	10.64	10.21	9.81	9.72	7.79
GA₃100ppm	4.35	4.34	4.32	4.21	4.01	8.27	8.15	8.07	7.91	7.76	6.14
H₂O	6.95	6.90	6.86	6.67	6.83	12.55	11.69	10.79	10.58	10.36	9.02
Control	7.90	7.51	7.44	7.00	6.56	17.64	17.36	16.96	15.82	14.68	11.89
Mean	6.45	6.19	6.15	5.92	5.72	11.39	11.06	10.67	10.32	9.96	
Overall mean	6.09					10.68					

CD_(p=0.05)

Vigour level : 0.15

Treatments : 0.26

Storage durations : 0.23

Vigour level × Treatments × Storage durations : NS

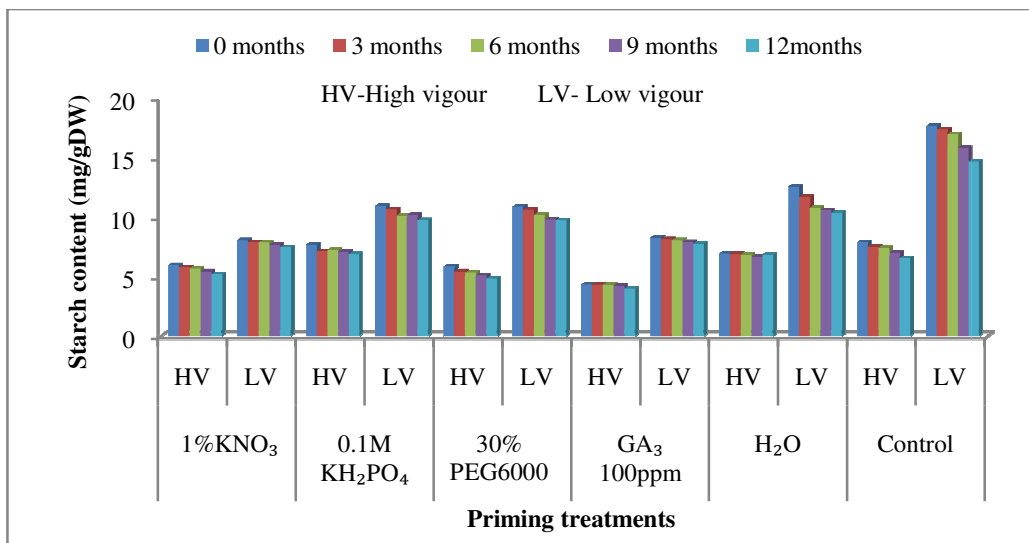


Fig. 4.11: Effect of various priming treatments on the Starch content (mg/g DW) in high and low vigour seeds of *Solanum melongena* L. stored for various durations.

subjected to accelerated ageing (low vigour seeds) an α -amylase activity of 7.61 μ g maltose produced/ml/min was recorded. On the other hand, in high vigour seeds stored for 12 months an α -amylase activity of 9.82 μ g maltose produced/ml/min was recorded while in low vigour seeds an α -activity of 4.64 μ g maltose produced/ml/min was recorded (Table 4.12a). In *Capsicum* seeds also a considerable drop in the activity of α -amylase has been reported after ageing (Bhanuprakash *et al* 2010).

Priming treatments enhanced the activity of α -amylase in both high and low vigour seeds. Hence, there is concomitant decrease in starch content due to priming (Table 4.11a). In high vigour seeds, immediately after harvesting the highest activity of α -amylase was recorded in seeds treated with 1% KNO₃ (21.51 μ g maltose produced/ml/min) over other treatments while in low vigour seeds the highest α -amylase activity was recorded in seeds soaked in GA₃ 100ppm (18.14 μ g maltose produced/ml/min) over other treatments. Similar trend was observed in the succeeding months of storage. In high vigour seeds stored for 12 months, priming with 1%KNO₃ resulted in (14.74 μ g maltose produced/ml/min) activity of α -amylase while in low vigour seeds stored for 12 months priming with GA₃ 100ppm resulted in (13.87 μ g maltose produced/ml/min) activity of α -amylase (Table 4.12a). In both primed high and low vigour seeds the activity of α -amylase was higher than in unprimed high and low vigour seeds. *De novo* synthesis of α -amylase was reported during priming in rice seeds (Lee and Kim 2000). During seed priming activation of various metabolic processes such as synthesis of a number of enzymes and nucleic acids, ATP synthesis and cytoplasmic metabolic repair begins as reported by Hosseini and Koocheki (2011) in sugarbeet seeds.

Table 4.12a: Effect of various priming treatments on the activity of α -amylase (μg maltose produced/ml/min) in high and low vigour seeds of *Solanum melongena* L. stored for various durations.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	21.51	16.08	18.80	20.58	13.75	17.17	18.57	10.16	14.36	16.57	9.46	13.01	14.74	8.76	11.75
0.1M KH₂PO₄	16.64	11.42	14.03	16.35	11.31	13.83	15.61	10.87	13.24	13.68	8.72	11.20	11.75	6.56	9.15
30% PEG6000	17.87	11.47	14.67	14.73	10.54	12.63	14.04	10.62	12.33	13.33	9.55	11.44	12.63	8.47	10.55
GA₃100ppm	20.72	18.14	19.46	19.00	16.80	17.90	16.16	14.98	15.57	15.01	12.94	13.98	13.87	10.91	12.39
H₂O	17.27	9.56	13.41	16.72	9.26	12.99	14.85	8.33	11.59	13.72	7.25	10.48	10.24	6.16	8.20
CONTROL	15.63	7.61	11.62	14.58	6.18	10.38	13.86	5.07	9.47	11.84	4.57	8.21	9.82	4.64	7.23
MEAN	18.27	12.38		16.99	11.31		15.52	10.00		14.03	8.75		12.40	7.58	
CD_(p=0.05) (V)	0.28			0.52			0.35			0.39			0.59		
CD_(p=0.05) (T)	0.49			0.90			0.60			0.68			1.02		
CD_(p=0.05)(VxT)	0.69			1.28			0.85			0.96			NS		

Table 4.12b: Effect of various priming treatments on high and low vigour seeds stored for various durations and their interaction on activity of α -amylase (μg maltose produced/ml/min) in *Solanum melongena* L. seeds.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	21.51	20.58	18.57	16.57	14.74	16.08	13.75	10.16	9.46	8.76	15.02
0.1M KH₂PO₄	16.64	16.35	15.61	13.68	11.75	11.42	11.31	10.87	8.72	6.56	12.29
30% PEG6000	17.87	14.73	14.04	13.33	12.63	11.47	10.54	10.62	9.55	8.47	12.32
GA₃100ppm	20.72	19.00	16.16	15.01	13.87	18.14	16.80	14.98	12.94	10.91	15.85
H₂O	17.27	16.72	14.85	13.72	10.24	9.56	9.26	8.33	7.25	6.16	11.33
Control	15.63	14.58	13.86	11.84	9.82	7.61	6.18	5.07	4.57	4.64	9.38
Mean	18.27	16.99	15.52	14.03	12.40	12.38	11.31	10.00	8.75	7.58	
Overall mean	15.40					10.00					

CD_(p=0.05)

Vigour level : 0.31
Treatments : 0.54
Storage durations : 0.50
Vigour level \times Treatments \times Storage durations : NS

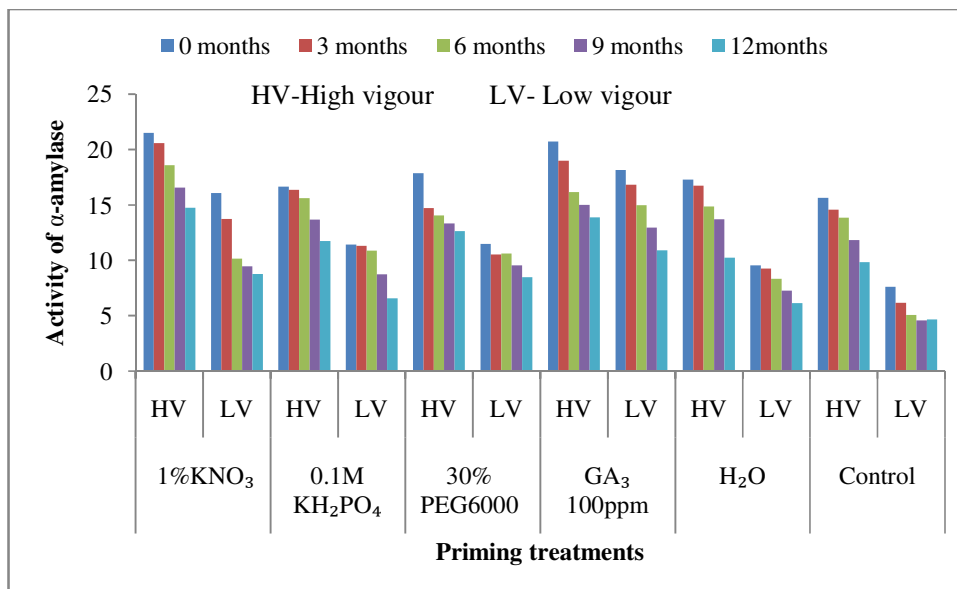


Fig. 4.12: Effect of various priming treatments on the activity of α -amylase (μg maltose produced/ml/min) in high and low vigour seeds of *Solanum melongena* L. stored for various durations.

Similarly, higher reducing and total sugars as well as higher α -amylase activity was recorded in spring maize seeds after hormonal priming with GA_3 as compared to control seeds (Afzal 2008). Enhancement of α -amylase activity in primed seeds may be attributed to proper hydration during imbibition that increased starch hydrolysis. Likewise, haloprimering with KNO_3 led to increased α -amylase activity and total soluble sugar content in marigold seeds (Afzal *et al* 2009).

The activity of α -amylase was influenced by an interaction between seed vigour level and priming treatment during different storage durations. The synergistic effect of seed vigour level and priming treatments on activity of α -amylase was significant for upto 9 months of storage but for seeds stored for 12 months the effect was non-significant. The α -amylase activity of low vigour seeds primed with GA_3 100ppm was either significantly higher or statistically at par with the α -amylase activity of high vigour seeds (control) within each storage duration (Table 4.12a).

Overall the effect of interaction of seed vigour level, treatments and storage duration on activity of α -amylase was non-significant. So this means that with priming treatments the activity of α -amylase was statistically at par with the activity of α -amylase in control seeds (High vigour seeds stored for zero months) (Table 4.12b). Overall highest α -amylase activity was reported with GA_3 priming, followed closely by KNO_3 priming.

4.1.4 Total Soluble Proteins

Within each storage duration, the amount of protein content was higher in high vigour seeds than in low vigour seeds (Table 4.13a). In general with storage the amount of protein content in both high and low vigour seeds decreased. In high vigour seeds, 5.41mg/g DW of total soluble protein content was recorded while in the seed lot subjected to accelerated ageing (low vigour seeds) a protein content of 2.65 mg/g DW was recorded. On the other hand, in high vigour seeds stored for 12 months the amount of protein content recorded was 3.07 mg/g DW while in low vigour seeds the protein content recorded was 2.10mg/g DW (Table 4.13a). Similar results of decreased protein content with accelerated ageing were observed by various authors, e.g. maize (Satish and Sundareswaran 2010, Radha *et al* 2014) and radish (Jain *et al* 2006) seeds. The protein content decreased during ageing process due to de-naturation and irreversible damage to protein structure as a result of free radical invasion.

The priming treatments increased the amount of protein content in both high and low vigour seeds. Before storage, in high vigour seeds the highest amount of protein content was recorded in seeds treated with GA₃ 100ppm (9.46mg/g DW) while in low vigour seeds the highest amount of protein content was recorded in seeds treated with 1% KNO₃ (6.61 mg/g DW). In both high and low vigour seeds stored for 12 months, the highest amount of protein content was recorded in seeds treated with GA₃ 100ppm i.e. 6.89mg/g DW and 4.57mg/gDW respectively over other priming treatments (Table 4.13a). Similar results of increased total soluble protein content with KNO₃ priming in tomato seeds (Pandita *et al* 2003). Priming of chickpea seeds with 100ppm GA₃ invigorated the performance of both high and low vigour seeds and improved the seed metabolism by increasing membrane stability, total protein content and α -amylase activity over control dry seeds (Arun *et al* 2016). A significant enhancement in the total soluble sugars and total soluble protein in seeds primed with GA₃ under stress conditions as compared to non-primed groundnut seeds was observed (Rouhi and Sepehri 2020). It was reported that seed priming enhances protein synthesis by improving functioning of the protein synthesis machinery (Varier *et al* 2010).

The total soluble protein content was influenced by the interaction between seed vigour level and priming treatment during different storage durations. The amount of total soluble protein content in low vigour seeds primed with GA₃ 100ppm was either significantly higher or statistically at par with the protein content in high vigour seeds (control) within each storage duration (Table 4.13a).

Table 4.13a: Effect of various priming treatments on the Protein content (mg/g DW) in high and low vigour seeds of *Solanum melongena* L. stored for various durations.

Vigour level Treatment	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	7.44	6.61	7.03	6.88	5.78	6.33	5.16	4.87	5.02	4.54	3.93	4.24	3.92	3.00	3.46
0.1M KH₂PO₄	7.96	4.16	6.06	7.62	4.02	5.82	7.17	4.02	5.60	5.75	3.52	4.63	4.32	3.01	3.67
30% PEG6000	8.64	5.70	7.17	7.86	4.66	6.26	6.54	4.11	5.32	5.73	3.47	4.60	4.92	2.84	3.88
GA₃100ppm	9.46	5.61	7.53	8.49	5.33	6.91	8.15	5.01	6.58	7.52	4.79	6.16	6.89	4.57	5.73
H₂O	6.25	3.52	4.88	5.81	2.60	4.21	4.56	2.53	3.55	4.10	2.77	3.43	3.64	2.43	3.04
Control	5.41	2.65	4.03	4.18	2.35	3.26	3.70	2.32	3.01	3.38	2.21	2.80	3.07	2.10	2.59
Mean	7.53	4.71		6.81	4.12		5.88	3.81		5.17	3.45		4.46	2.99	
CD_(p=0.05) (V)	0.37			0.41			0.31			0.17			0.05		
CD_(p=0.05) (T)	0.64			0.71			0.53			0.29			0.09		
CD_(p=0.05)(VXT)	0.90			1.00			0.75			0.40			0.13		

Table 4.13b: Effect of various priming treatments on high and low vigour seeds stored for various durations and their interaction on protein content (mg/g DW) in *Solanum melongena* L. seeds.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	7.44	6.88	5.16	4.54	3.92	6.61	5.78	4.87	3.93	3.00	5.21
0.1M KH₂PO₄	7.96	7.62	7.17	5.75	4.32	4.16	4.02	4.02	3.52	3.01	5.15
30% PEG6000	8.64	7.86	6.54	5.73	4.92	5.70	4.66	4.11	3.47	2.84	5.45
GA₃100ppm	9.46	8.49	8.15	7.52	6.89	5.61	5.33	5.01	4.79	4.57	6.58
H₂O	6.25	5.81	4.56	4.10	3.64	3.52	2.60	2.53	2.77	2.43	3.82
Control	5.41	4.18	3.70	3.38	3.07	2.65	2.35	2.32	2.21	2.10	3.14
Mean	7.53	6.81	5.88	5.17	4.46	4.71	4.12	3.81	3.45	2.99	
Overall mean	5.97					3.82					

CD_(p=0.05)

Vigour level : 0.14

Treatments : 0.24

Storage durations : 0.22

Vigour level × Treatments × Storage durations : NS

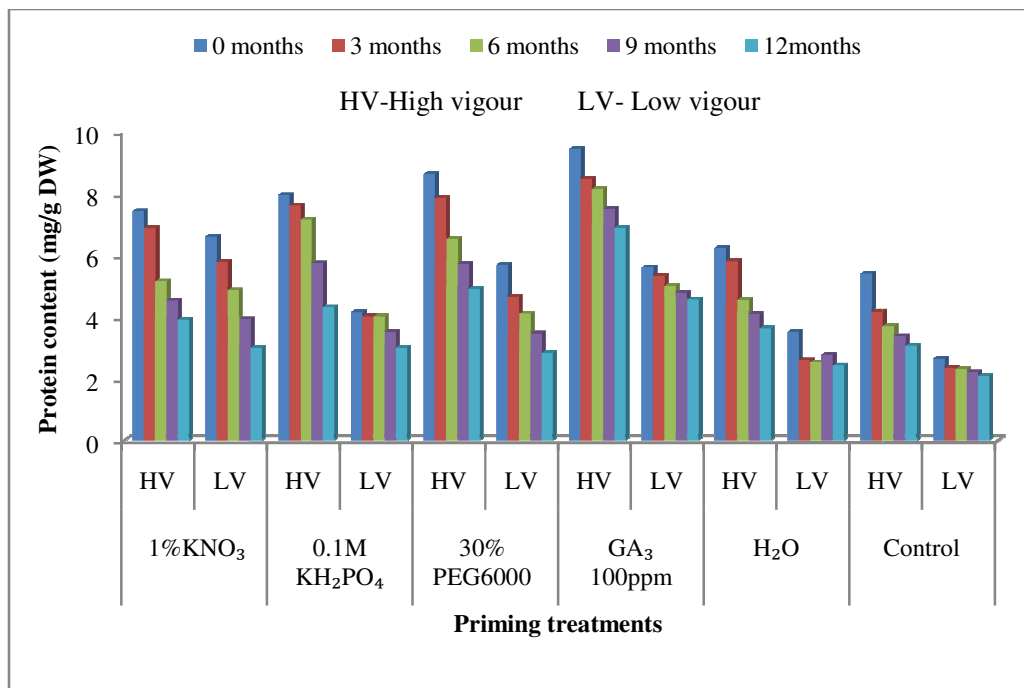


Fig 4.13: Effect of various priming treatments on the Protein content (mg/g DW) in high and low vigour seeds of *Solanum melongena* L. stored for various durations.

Overall the effect of interaction of seed vigour level, treatments and storage duration on protein content was non-significant. So this means that with priming treatments the protein content was statistically at par with the protein content in control seeds (high vigour seeds stored for zero months) (Table 4.13b).

4.1.5 Free aminoacid content

Within each storage duration free aminoacid content was lower in high vigour seeds than in low vigour seeds (Table 4.14a). In general with increase in storage duration the amount of total free aminoacids in both high and low vigour seeds increased. In high vigour seeds, 3.11mg/gDW amount of free aminoacids was recorded while in the seed lot subjected to accelerated ageing (low vigour seeds) an aminoacid content of 4.74 mg/g DW was recorded. On the other hand, in high vigour seeds stored for 12 months the amount of free aminoacid content recorded 5.22 mg/gDW while in low vigour seeds the free aminoacid content recorded was 5.62mg/g DW (Table 4.14a). Accelerated ageing (low vigour seeds) resulted in increase in total free aminoacid content in seeds (Table 4.14a) while simultaneous decrease in protein content in seeds (Table 4.13a) indicating that the hydrolysis of protein increased under ageing conditions resulting in increased free aminoacid content in low vigour seeds.

Table 4.14a: Effect of various priming treatments on the Free aminoacid content (mg/g DW) in high and low vigour seeds of *Solanum melongena* L. stored for various durations.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	1.85	3.01	2.43	1.74	3.43	2.58	1.82	3.99	2.90	2.11	4.53	3.32	2.40	5.07	3.74
0.1M KH₂PO₄	2.42	2.81	2.62	2.52	3.03	2.78	2.71	3.69	3.20	3.10	3.92	3.51	3.49	4.14	3.81
30% PEG6000	2.38	3.32	2.85	3.07	3.57	3.32	3.35	4.08	3.71	3.71	4.38	4.04	4.06	4.68	4.37
GA₃100ppm	1.59	2.55	2.07	1.72	3.02	2.37	2.05	2.37	2.21	2.31	2.81	2.56	2.56	3.25	2.91
H₂O	2.03	3.74	2.88	2.18	4.21	3.20	2.40	4.41	3.41	3.01	4.73	3.87	3.61	5.04	4.33
Control	3.11	4.74	3.93	3.54	4.90	4.22	4.06	5.38	4.72	4.64	5.50	5.07	5.22	5.62	5.42
Mean	2.23	3.36		2.46	3.69		2.73	3.99		3.14	4.31		3.56	4.63	
CD_(p=0.05) (V)	0.23			0.10			0.12			0.07			0.07		
CD_(p=0.05) (T)	0.40			0.17			0.20			0.12			0.12		
CD_(p=0.05)(VXT)	0.57			0.24			0.28			0.17			0.16		

Table 4.14b: Effect of various priming treatments on high and low vigour seeds stored for various durations and their interaction on free aminoacid content (mg/g DW) in *Solanum melongena* L. seeds.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	1.85	1.74	1.82	2.11	2.40	3.01	3.43	3.99	4.53	5.07	2.99
0.1M KH₂PO₄	2.42	2.52	2.71	3.10	3.49	2.81	3.03	3.69	3.92	4.14	3.18
30% PEG6000	2.38	3.07	3.35	3.71	4.06	3.32	3.57	4.08	4.38	4.68	3.66
GA₃100ppm	1.59	1.72	2.05	2.31	2.56	2.55	3.02	2.37	2.81	3.25	2.42
H₂O	2.03	2.18	2.40	3.01	3.61	3.74	4.21	4.41	4.73	5.04	3.54
Control	3.11	3.54	4.06	4.64	5.22	4.74	4.90	5.38	5.50	5.62	4.67
Mean	2.23	2.46	2.73	3.14	3.56	3.36	3.69	3.99	4.31	4.63	
Overall mean	2.82					4.00					

CD_(p=0.05)

Vigour level : 0.08

Treatments : 0.13

Storage durations : 0.12

Vigour level × Treatments × Storage durations : 0.42

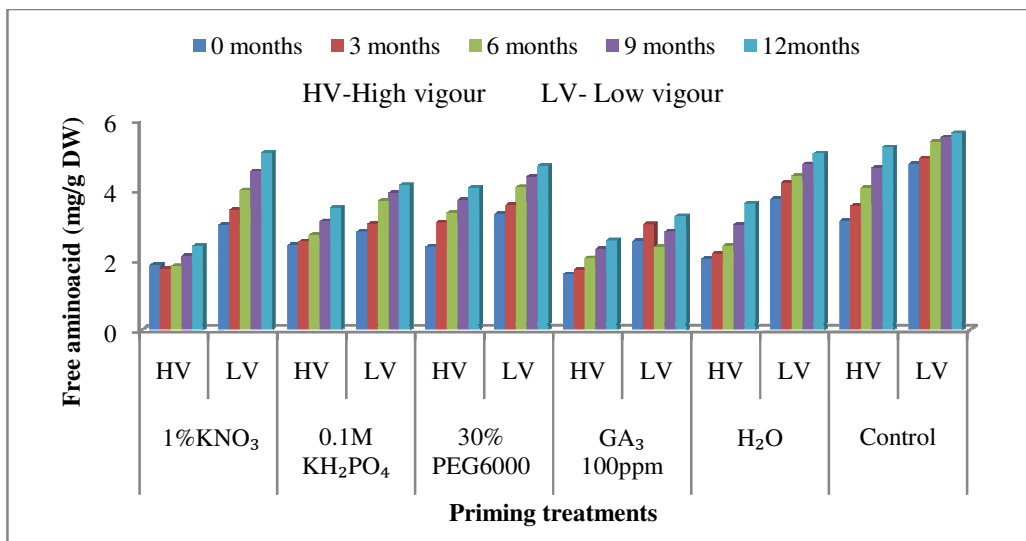


Fig. 4.14 Effect of various priming treatments on the free amino acid content (mg/g DW) in high and low vigour seeds of *Solanum melongena* L. stored for various durations.

The priming treatments decreased the amount of free aminoacids in both high and low vigour seeds. In high vigour seeds prior to storage, priming with GA₃ 100ppm resulted in least amount of free amino-acids (1.59 mg/g DW) as compared to other treatments and in low vigour seeds 2.55mg/g DW amount of free amino-acid content was recorded with GA₃ priming which was lowest as compared to other treatments. In both GA₃ primed high and low vigour seeds subjected to 12 months of storage, the free aminoacid content increased to 2.56mg/gDW and 3.25mg/g DW respectively (Table 4.14a). Similar results of decreased free aminoacid content with seed priming have been reported in okra (Pandita *et al* 2010) and sorghum (Zhang *et al* 2015) seeds. Seed priming resulted in decrease in free aminoacid content (Table 4.14a) and simultaneous increase in protein content (Table 4.13a) indicating that seed priming improved the protein synthesis machinery at the sub-cellular basis resulting in synthesis of more proteins using free aminoacids. Thus seed priming decreased the hydrolysis of proteins resulting in decreased free aminoacid content in seeds.

The free aminoacid content was influenced by the interaction between seed vigour level and priming treatment during different storage durations. The amount of free aminoacid content in low vigour seeds primed with GA₃ 100ppm was either significantly lower or statistically at par with the protein content in high vigour seeds (control) within each storage duration indicating that free aminoacids reduced in low vigour seeds with priming and reached to the same amount or lower than in high vigour seeds (Table 4.14a).

Table 4.15a: Effect of various priming treatments on the Membrane Stability Index (MSI) of high and low vigour seeds of *Solanum melongena* L. stored for various durations.

	Storage Duration														
	0 months			3 months			6 months			9 months			12 months		
Vigour level Treatment	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low vigour	Mean	High vigour	Low Vigour	Mean	High vigour	Low Vigour	Mean
1% KNO₃	49.89	43.19	46.54	42.65	41.48	42.06	40.31	34.50	37.40	36.58	32.24	34.41	32.85	29.96	31.41
0.1M KH₂PO₄	48.66	30.69	39.18	42.90	29.69	36.80	38.20	23.95	31.08	34.08	22.64	28.36	29.95	21.33	25.64
30% PEG6000	54.87	36.67	45.77	51.51	32.08	41.79	46.35	29.40	37.87	41.05	25.90	33.47	35.74	22.40	29.07
GA₃100ppm	63.05	41.26	52.15	59.71	37.23	48.47	55.81	34.93	45.37	49.80	28.91	39.36	43.79	22.89	33.34
H₂O	60.92	37.32	49.12	56.45	32.46	44.45	51.40	28.18	39.79	45.19	24.63	34.91	38.98	21.07	30.02
Control	40.33	28.67	34.50	36.42	26.91	31.67	32.99	22.76	27.88	30.27	20.15	25.21	27.54	17.54	22.54
Mean	52.95	36.13		48.27	33.47		44.18	28.95		39.49	25.74		34.81	22.53	
CD_(p=0.05) (V)	3.80			0.40			0.27			0.17			0.24		
CD_(p=0.05) (T)	6.58			0.70			0.47			0.29			0.42		
CD_(p=0.05)(VXT)	NS			0.99			0.66			0.41			0.59		

Table 4.15b: Effect of various priming treatments on high and low vigour seeds stored for various durations and their interaction on Membrane Stability Index (MSI) of *Solanum melongena* L. seeds.

Vigour level	High vigour					Low vigour					
Storage duration	0 months	3 months	6 months	9 months	12 months	0 months	3 months	6 months	9 months	12 months	Mean
Treatments											
1% KNO₃	49.89	42.65	40.31	36.58	32.85	43.19	41.48	34.50	32.24	29.96	38.36
0.1M KH₂PO₄	48.66	42.90	38.20	34.08	29.95	30.69	29.69	23.95	22.64	21.33	32.31
30% PEG6000	54.87	51.51	46.35	41.05	35.74	36.67	32.08	29.40	25.90	22.40	37.60
GA₃100ppm	63.05	59.71	55.81	49.80	43.79	41.26	37.23	34.93	28.91	22.89	43.74
H₂O	60.92	56.45	51.40	45.19	38.98	37.32	32.46	28.18	24.63	21.07	39.66
Control	40.33	36.42	32.99	30.27	27.54	28.67	26.91	22.76	20.15	17.54	28.36
Mean	52.95	48.27	44.18	39.49	34.81	36.13	33.47	28.95	25.74	22.53	
Overall mean	43.94					29.40					

CD_(p=0.05)

Vigour level : 0.57

Treatments : 0.99

Storage durations : 0.90

Vigour level × Treatments × Storage durations : NS

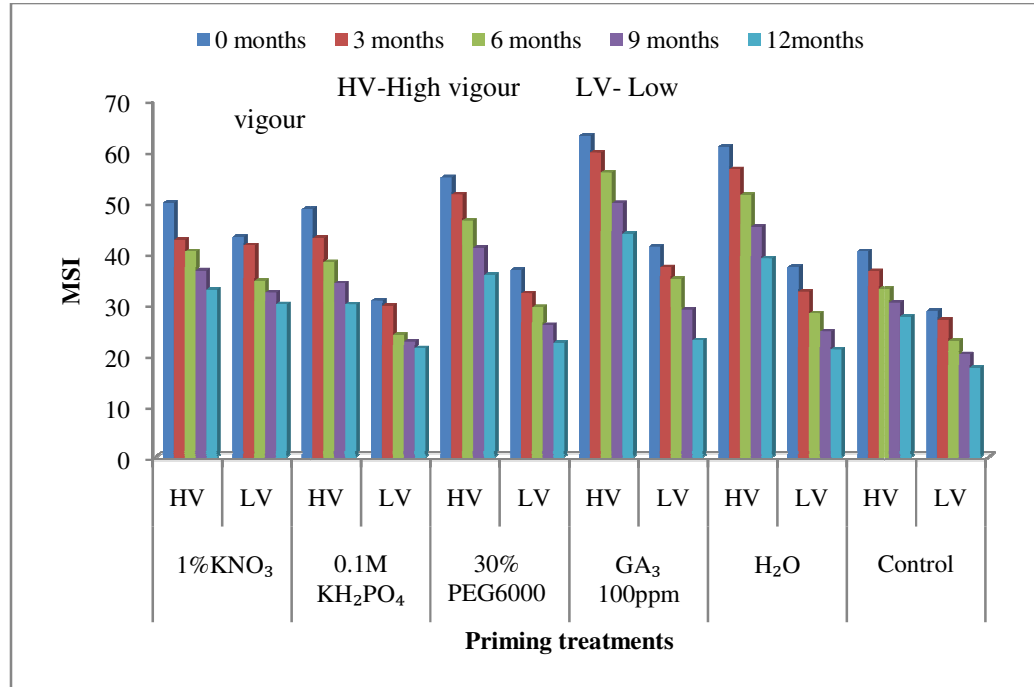


Fig. 4.15: Effect of various priming treatments on the Membrane Stability Index (MSI) of high and low vigour seeds of *Solanum melongena* L. stored for various durations.

Overall the interactive effect of vigour level, priming treatments and storage duration on free amino-acid content in seeds was significant (Table 4.14b). The least amount of total free amino-acids was found with GA₃ priming and maximum in unprimed seeds (Table 4.14b).

4.1.6 Membrane stability index (MSI)

The membrane stability index indicates the status of seed membranes. Within each storage duration membrane stability index was higher in high vigour seeds than in low vigour seeds (Table 4.15a). In general with increase in storage duration the value of membrane stability index reduced. In high vigour seeds, prior to storage the value of MSI recorded was 40.33 while in the seed lot subjected to accelerated ageing (low vigour seeds) the value MSI recorded was 28.67 indicating that accelerated ageing of seeds resulted in membrane damage causing leakage of solutes. On the other hand, in high vigour seeds stored for 12 months the value of MSI reduced to 27.54 while in low vigour seeds MSI reduced to 17.54 (Table 4.15a).

The priming treatments increased the value of MSI in both high and low vigour seeds indicating that priming treatments helped in the repair of damaged membrane thus improving membrane integrity. In high vigour seeds prior to storage, priming with GA₃ 100ppm resulted in highest value of MSI, i.e., 63.05 and in low vigour seeds MSI of 41.26 was recorded with

GA₃ priming. The results indicate that protective action of priming treatments extends viability and restores the vigour of seeds. In both GA₃ primed high and low vigour seeds subjected to 12 months of storage, the value of MSI decreased to 43.79 and 22.89 respectively (Table 4.15a). Similar results of improved membrane integrity with priming treatments was reported in cotton (Dias *et al* 2004) and chickpea (Beedi *et al* 2018) seeds.

The synergistic effect of vigour level and priming treatments on MSI was non-significant for seeds not subjected to storage while it was significant for succeeding storage durations. In low vigour seeds priming with KNO₃ and GA₃ enhanced the membrane stability index in seeds stored for 3 and 6 months respectively and enhanced it to their respective controls. In seeds stored for nine and twelve months, priming with KNO₃ significantly improved MSI in low vigour more than their respective control high vigour seeds (Table 4.15a).

Overall the interaction of vigour level, priming treatment and storage duration on MSI was non-significant indicating that with priming treatments the MSI was statistically at par with the MSI in control seeds (high vigour seeds stored for zero months) (Table 4.15b). Overall maximum MSI was obtained with GA₃ priming and least in unprimed seeds.

CHAPTER V

SUMMARY

Brinjal is a seed propagated vegetable crop of Solanaceae family grown for its nutritious and edible fruits. The demand for brinjal seeds varies depending on various factors, the excess seeds need to be stored for longer durations. Prolonged storage of seeds results in decline in seed quality in terms of vigour and viability due to natural process of ageing. Seed deterioration during storage results in less viable poor quality seeds which when sown results in poor quality seedlings resulting in low yields and economic loss to the farmers. Good quality seed is essential for successful agriculture. The rate of seed deterioration during storage can be controlled through seed invigouration techniques like seed priming. Seed priming is claimed to play a vital role in modern agriculture for precision planting and to supplement nutrition through seed for uniform and vigorous seedling growth and safe guarding the storage life of seeds. The present study entitled “Effect of priming on enhancing storability of brinjal (*Solanum melongena* L.) seeds” was conducted in the laboratories of department of Botany, Punjab Agricultural University, Ludhiana with the objectives to study the efficacy of seed priming on improving viability of low and high vigour seeds of brinjal and the effect of priming on storability of low and high vigour brinjal seeds.

The freshly harvested seed was divided into two lots. One of these seed lots was considered high vigour and the other lot was subjected to accelerated ageing at 45°C temperature and 90% relative humidity for 7days to obtain low vigour seed. The high and low vigour seeds were primed with KNO₃ (1%), GA₃ (100ppm), KH₂PO₄ (0.1M), PEG 6000 (30%) and H₂O for 12 hours. Primed high and low vigor seed lots were packed in moisture impervious aluminium bags and stored for a year. The seeds were drawn at tri-monthly intervals and observations were recorded on seed germination, its speed and mean days to germination; seedling vigour index, seedling dry weight and seedling growth in terms of seedling length and its parts viz., shoot and root. The amount of total soluble sugars, starch, total soluble proteins, total free aminoacids, activity of α -amylase and membrane stability index was estimated at tri-monthly intervals.

- In the seeds not subjected to any storage, the seed quality parameters (germination percentage, speed of germination, seedling length, root length, shoot length, seedling dry weight and seedling vigour index) were significantly less while mean days to germination were significantly more in low vigour seeds when compared with high vigour seeds. Likewise the biochemical parameters (Total soluble sugars, total soluble proteins, α -amylase activity and membrane stability index) were significantly less while starch content and total free aminoacid were significantly more in low vigour seeds.

- As the duration of storage increased, there was a decline in physiological and biochemical aspects of seed quality except increase in mean days to germination, starch and free amino acid in both high and low vigour seeds.
- The seed priming treatments improved the seed quality in terms of higher germination percentage, speed of germination, root length, shoot length, seedling length, less MDG, higher seedling dry weight, seedling vigour index-I and seedling vigour index-II in both high and low vigour seeds but the extent of improvement varied among different priming treatments.
- Priming treatments increased the total soluble sugars, total soluble proteins, α -amylase activity and membrane stability index in both high and low vigour seeds but decreased starch content and total free amino acid content.
- Among the priming treatments, GA₃ priming resulted maximum improvement in both physiological and biochemical parameters followed by KNO₃ priming. Priming of high vigour seeds with GA₃ (not subjected to any storage) resulted in 23.6% increase in germination percentage over control. In low vigour seeds (not subjected to any storage) priming with GA₃ resulted in 34.43% increase in germination percentage as compared to control.

From the present investigation it was concluded that between high and low vigour seeds, high vigour seeds maintained higher seed quality parameters for longer durations. Seed priming with GA₃ (100ppm) followed by priming with KNO₃ (1%) were found to be the best treatments for both high and low vigour seeds. Upon storage, high vigour seeds consistently showed better seed quality attributes due to priming compared to low vigour seeds. Even after storage, seeds primed with GA₃ showed better performance in all seed quality parameters followed by KNO₃ priming. Decline in germination percentage in both primed and unprimed seeds was observed after storage but primed seeds maintained the priming effect. Priming with GA₃, brought the performance of low vigour seeds at par with that of high vigour control (no storage) seeds. Although priming treatments resulted in improvement in seed germination of both high and low vigour seeds but the improvement in low vigour seeds in terms of percentage increase over control was higher than high vigour seeds.

REFERENCES

- Abdul-Baki A A and Anderson J D (1973) Vigour determination in Soybean by multiple criteria. *Crop Sci* **13**:630-33.
- Abu-Muriefah S S (2017) Phytohormonal priming improves germination and antioxidant enzymes of soybean (*Glycine max*) seeds under lead (Pb) stress. *Biosci Res* **14**: 42-56.
- Afzal I, Ashraf S, Qasim M, Basra S M A and Shahid M (2009) Does haloprimering improve germination and seedling vigour in marigold (*Tagetes* spp.). *Seed Sci Technol* **37**: 436-45.
- Afzal I, Basra S M A, Shahid M, Farooq M and Saleem M (2008) Priming enhances germination of spring maize (*Zea mays* L.) under cool conditions. *Seed Sci Technol*. **36**: 497-503.
- Agerich C, Bradford K and Tarquis A (1989) The effects of priming and ageing on resistance to deterioration of tomato seeds. *J Exp Bot* **40**: 593-98.
- Agha S K, Malik Z H, Hatam M and Jamro G H (2004) Emergence of healthy seedlings of Soyabean as influenced by seed storage containers. *Pak J Biol Sci* **7**: 42-44.
- Agrawal R L (ed) (1995) *Seed Technology*. pp 410-12. Oxford and IBH Publishing, New Delhi.
- Ahmadvand G, Soleimani F, Bijan S B, and Pouya M (2012) Effects of seed priming on germination and emergence traits of two soybean cultivars under salinity stress. *J Basic Appl Sci Res* **3**: 234-41.
- Ali S, Alam M, Adnan M, Ullah H, Faisal M, Malik A, Shah A, Ibrahim M and Basir A (2016) Effect Of seed priming on germination performance and yield of Okra (L.) *Abelmoschus esculentus*. *Pak J Agric Res* **29**: 253-61.
- Amanpour B B and Sedghi M (2012) Effect of aging and priming on physiological and biochemical traits of common bean (*Phaseolus vulgaris* L.). *Not Sci Biol* **4**: 95-100.
- Amooaghaie R, Nikzad K and Shareghi B (2010) The effect of priming on emergence and biochemical changes of tomato seeds under suboptimal temperatures. *Seed Sci Technol* **38**: 508-12.
- Anese S, Da Silva E A A, Davide A C, Rocha F J M, Soares G C M, Matos A C B and Toorop P E (2011) Seed priming improves endosperm weakening, germination, and subsequent seedling development of *Solanum lycocarpum* St. Hil. *Seed Sci Technol* **39**: 125-39.
- Arif M, Jan M, Marwat K and Khan M (2008) Seed priming improves emergence and yield of soybean. *Can J Bot* **40**: 1169-77.
- Arun M, Bhanuprakash K, Hebbar S and Senthivel T (2016) Effects of seed priming on biochemical parameters and seed germination in cowpea [*Vigna unguiculata* (L.) Walp]. *Legum Res- An In J* **40**: 1-9.
- Ashraf M and Foolad M R (2005) Pre-sowing seed treatment: A shot-gun approach to improve germination growth and crop yield under saline and non-saline conditions. *Adv Agron* **88**: 223-71.

- Aswin C, Vakeswaran V and Geetha R (2019) Effect of seed priming on seed quality enhancement in high and low vigour seed lots of tomato (*Lycopersicum esculentum*). *Int J Chem Stud* **7**: 1645-48.
- Bailly C, Bogatek-Leszczynska R, Come D and Corbineau F (2002) Changes in activities of antioxidant enzymes and lipoxygenase during growth of sunflower seedlings from seeds of different vigor. *Seed Sci Res* **12**: 47-55.
- Basra S M A, Farooq A M, Ahmad N and Tabassum R (2005) Physiological and biochemical aspects of pre-sowing seed treatment in rice (*Oryza sativa* L.). *Seed Sci Technol* **33**: 623-28.
- Basra S M A, Ahmad N, Khan M M, Iqbal N and Cheema M A (2003) Assessment of cottonseed deterioration during accelerated ageing. *Seed Sci Technol* **31**: 531-40.
- Beedi S, Macha S I, Gowda B, Savitha A S and Kurnallikar V (2018) Effect of seed priming on germination percentage, shoot length, root length, seedling vigor index, moisture content and electrical conductivity in storage of kabuli chickpea cv., MNK-1 (*Cicer arietinum* L.). *J Pharmacogn Phytochem* **7**: 2005-10.
- Bewley J D and Black M (1982) Physiology and biochemistry of seeds in relation to germination vol 2 Springer-Verlag, Berlin.
- Bewley J D and Black M (1994) Seeds; Physiology of development and germination. New York: Plenum Press.
- Bhanuprakash K, Yogeesh H S and Arun M N (2010) Physiological and biochemical changes in relation to seed quality in ageing bell pepper (*Capsicum annum*) seeds. *Indian J Agric Sci* **80**: 777-80.
- Bhaskar B and Ramesh K P (2015) Genetically modified crops face an uncertain future in India: Bt Brinjal appraisal: A perspective. *Ann Plant Sci* **4**: 960-75.
- Bhavyasree R K and Vinothini N (2019) Enhancement of seed quality through orgoprimering in Brinjal (*Solanum melongena* L.). *Int J Chem Stud* **7**: 242-44.
- Bray C M (1995) Biochemical processes during the osmoprimering of seeds. In: Kigel J and Galili G (eds) Seed development and germination. Pp 767-89. Marcel Dekker Inc. New York NY, USA.
- Butler L H, Hay F R, Ellis R H, Smith R D and Murray T B (2009) Priming and re-drying improve the survival of mature seeds of *Digitalis purpurea* during storage. *Ann Bot* **103**: 1261-270.
- Carvalho R F, Piotto F A, Schmidt D, Peters L P, Monteiro C C and Azevedo R A (2011) Seed priming with hormones does not alleviate induced oxidative stress in maize seedlings subjected to salt stress. *Sci Agric* **68**: 598-602.
- Chen K, Arora R and Arora U (2010) Osmoprimering of spinach (*Spinacia oleracea*) seeds and germination performance under temperature and water stress. *Seed Sci Techol* **38**: 36-48.
- Chiu K, Chen C and Sung J (2002) Effect of priming temperature on storability of primed sweet corn seed. *Crop Sci* **42**: 1996-2003.
- Corbineau F and Come D (2006) Priming: a technique for improving seed quality. Seed testing international. ISTA News Bulletin No **132**:38-40.

- Dearman J, Brocklehurst P A and Drew R L K (2008) Effects of osmotic priming and ageing on onion seed germination. *Ann Appl Biol* **108**: 639-48.
- Delouche J C and Baskin C C (1973) Accelerated ageing techniques for predicting the relative storability of seed lots. *Seed Sci Technol* **1**:427-52.
- Dezfuli P M, Sharif-Zadeh F and Janmohammadi M (2008) Influence of priming techniques on seed germination behavior of maize inbred lines (*Zea mays* L.). *J Agric Biol Sci* **3**: 22-25.
- Di Girolamo G and Barbanti L (2012) Treatment conditions and biochemical processes influencing seed priming effectiveness. *Ital J Agron* **7**: 25.
- Dias D C F S, Freitas R A, Dias L A S and Olivera M G A (2004) Storage potential of vigour seeds predicted by vigour tests and biochemical assays. 27th ISTA Congress Budapest Hungary. 70 (Abstr).
- Dubois M, Gilles K A, Hamilton J K, Rebers P A and Smith F (1956) Colorimetric methods for determination of sugars and related substances. *Anal Chem* **28**:350-56.
- Ellis R A and Roberts E H (1981) The quantification of ageing and survival in orthodox seeds. *Seed Sci Technol* **9**:373-409.
- Ellis R H, Hong T D and Roberts E H (2008) Seed moisture content, storage, viability and vigour. *Seed Sci Res* **1**: 275-79.
- FAO (2018) Food and Agriculture Organization of the United Nations. FAOSTAT Database FAO, Rome, www.faostat3.fao.org
- Farooq M, Basra S M A, Saleem B A, Nafees M and Christi S A (2005) Enhancement of tomato seed germination and seedling vigour by osmopriming. *Pak J Agri Sci* **42**: 3-4.
- Farooq M, Basra S M A, Wahid A and Ahmad N (2010) Changes in nutrient-homeostasis and reserves metabolism during rice seed priming: consequences for seedling emergence and growth. *Agric Sci China* **9**: 191-98.
- Farooq M, Basra S, Rehman H, Ahmad N and Saleem B (2007) Osmopriming improves the germination and early seedling growth of melons (*Cucumis melo* L.). *Pak J Agric Sci* **44**: 529-36.
- Finch-Savage W E and Bassel G W (2016) Seed vigour and crop establishment: extending performance beyond adaptation. *J Exp Bot* **67**: 567-91.
- Genes F and Nyomora A M S (2018) Effect of storage time and temperature on germination ability of *Escoecaria bussei*. *Tanz J Sci* **44**: 123-133.
- Ghassemi-Golezani K, Aliloo A A, Valizadeh M and Moghaddam M (2008) Effects of hydro and osmo-priming on seed germination and field emergence of lentil (*Lens culinaris*). *Not Bot Hort Agrobot Cluj* **36**: 29-33.
- Ghassemi-Golezani K, Hosseinzadeh-Mahootchy A, Zehtab-Salmasi S and Tourchi M (2012) Improving field performance of aged chick pea seeds by hydropriming under water stress. *Int J Plant Animal Environ Sci* **2**: 168-76.
- Gomes D P, Silva A F, Dias D C F S, Alvarenga E M and Panozzo L E (2012) Priming and drying on physiological quality of eggplant seeds. *Hortic Bras* **30**: 484-88.

- Gurusinghe S, Powell A L T and Bradford K J (2002) Enhanced expression of BiP is associated with treatments that extend storage longevity of primed tomato seeds. *J Am Soc Hortic Sci* **127**: 528-34.
- Hosseini A and Koocheki A (2011) The effect of different priming treatments on germination percent and mean germination time of four varieties of sugar beet. *J Agro Res* **5**: 69-76.
- Huang R, Sukprakarn S, Thongket T and Juntakool S (2002) Effect of hydropriming and redrying on the germination of triploid watermelon seeds. *Kasetsart J (Nat Sci)* **36**: 219-24.
- Hussain B, Afzal I, Basra S M A and Habib U S (2012) Tomato seed invigouration enhances germination capacity and stand establishment. *J Agric Soc Sci* **8**: 69-72.
- Hussain S, Khan F, Hussain H and Nie L (2016) Physiological and biochemical mechanisms of seed priming-induced chilling tolerance in rice cultivars. *Front Plant Sci* **7**: 1-14.
- Hussain S, Zheng M, Khan F, Khaliq A, Fahad S, Peng S and Nie L (2015). Benefits of rice seed priming are offset permanently by prolonged storage and the storage conditions. *Sci Rep* **5**:8101.
- ISTA (1985) International rules for seed testing. *Seed Sci Technol* **13**:299-355.
- Jain N, Kapoor R and Saxena S (2006) Effect of accelerated ageing on seeds of Radish (*Raphanus sativus* L.). *Asian J Plant Sci* **5**: 461-64.
- Jiang F L, Bo L P, Xu J J and Wu Z (2018) Changes in respiration and structure of non-heading Chinese cabbage seeds during gradual artificial aging. *Sci Hortic* **238**: 14-22.
- Jungmoon S and Suksoon L (2004) Effect of seed priming on quality improvement of maize seeds in different genotypes. *Korean J Crop Sci* **49**: 381-88.
- Jyoti B, Gaurav S S and Pant U (2016) Use of growth regulators as priming agent for improvement of seed vigour in tomato (*Lycopersicum esculentum*). *J Appl Natur Sci* **8**: 84-87.
- Kaewsorn P, Chotanakoon K, Chulaka P, Chanprasert W and Chunthawodtiporn J (2019) Effects of hydropriming and osmopriming in germinability and storability of 'Bang Chang' pepper (*Capsicum annuum* L.) seeds. *Acta Hortic* **1245**: 45-52.
- Kapoor N, Arya A, Siddiqui M A, Kumar H and Amir A (2011) Physiological and biochemical changes during seed deterioration in aged seeds of rice (*Oryza sativa* L.). *Am J Plant Physiol* **6**: 28-35.
- Kaur H, Chawla N and Pathak M (2015) Effect of different seed priming treatments and priming durations on biochemical parameters and agronomic characters of okra. *Int J Plant Physiol Biochem* **7**: 1-11.
- Kausar M, Mahmood T, Basra S and Arshad M (2009) Vigouration of low vigour sunflower hybrids by seed priming. *Int J Agric Biol* **11**: 521-28.
- Keshavulu K, Reddy N M, Rajeswari B, Kumar M A and Ankaiah R (2012) Effect of seed vigour on field performance and seed yield in Okra (*Abelmoschus esculentus* L.). *Int J Bio-resource Stress Manag* **3**: 26-30.

- Khan A A (1992) Preplant physiological seed conditioning. *Hortic Rev* **13**: 131-81.
- Khan M B, Gurchani M A, Hussain M, Freed S and Mahmood K (2011) Wheat seed enhancement by vitamin and hormonal priming. *Pak J Bot* **43**: 1495-99.
- Kikuti A L P and Filho J M (2008) Drying and storage cauliflower (*Brassica oleracea*) hydroprimed seeds. *Seed Sci Technol* **36**: 396-406.
- Koti V, Prasanna K P R, Siddegowda R P, Gowda R and Pallavi H M (2007) Influence of accelerated ageing on total soluble seed protein profiles of tomato. *Seed Res* **35**: 194-97.
- Kubala S, Garnczarska M, Wojtyla L and Sobkowiak R R (2015) Deciphering priming-induced improvement of rapeseed (*Brassica napus* L) germination through an integrated transcriptomic and proteomic approach. *Plant Sci* **231**: 94-113.
- Kumar A, Puniya R C, Bhuker A, Sharma R and Devi R (2017) Seed quality as influenced by seed vigouration treatments in pigeon pea (*Cajanus cajan* L.). *Legume Res: An Int J* **40**: 924-28.
- Kumar P M, Chaurasia A K and Bara B M (2017) Effect of osmopriming on seed germination behaviour and vigour of chickpea (*Cicer arietinum* L). *Int J Sci Nature* **8**: 330-35.
- Kumar R and Singh R (2013) Effect of priming on emergence and vigour of bitter melon (*Momordica charantia* L.). *J Res* **50**: 114-18.
- Kumari N, Rai P K, Bara B M and Singh I (2017) Effect of halo priming and hormonal priming on seed germination and seedling vigour in maize (*Zea mays* L.) seeds. *J Pharmacog Phytochem* **6**:27-30.
- Kuppusamy N and Ranganathan U (2014) Storage potential of primed seeds of okra (*Abelmoschus esculentus*) and beet root (*Beta vulgaris*). *Aust J Crop Sci* **8**: 1290-97.
- Lamichaney A, Kumar V and Katiyar P K (2018) Effect of seed priming induced metabolic changes on germination and field emergence. *J Environ Biol* **39**: 522-28.
- Lee S S and Kim J H (2000) Total sugars, α -amylase activity and germination after priming of normal and aged rice seeds. *Korean J Crop Sci* **43**: 157-60.
- Lee Y P and Takahashi T (1956) An improved colorimetric determination of amino acids with the use of ninhydrin. *Anal Biochem* **14**:71-77.
- Liu Y, Bino R J, Vanderburg W J, Groot S P C and Hilhorst H W M (1996) Effects of osmotic priming on dormancy and storability of tomato (*Lycopersicon esculentum* Mill) seeds. *Seed Sci Res* **6**: 49-55.
- Lowry O H, Rosenbrough N J, Farr A L and Randall R J (1951) Protein measurement with the Folin Phenol Reagent. *J Biol Chem* **193**:265-75.
- Maguire J D (1962) Speed of germination and in selection and evaluation for seedling emergence and vigour. *Crop Sci* **2**:176-77.
- Manjunatha B, Channakeshava B C, Shadakshari Y G, Bhanuprakash K, Sreeramulu K R and Balakrishna P (2018) Effect of priming on physiological seed quality in fresh and aged seeds of sunflower (*Helianthus annuus* L.) Hybrid KBSH-53. *Int J Curr*

- Microbiol App Sci* **7**: 2087-95.
- Marcos-Filho J (2015) Seed vigour testing : An overview of the past. Present and future perspective. *Sci Agric* **72**: 363-74.
- Matsushima K I and Sakagami J I (2013) Effects of seed hydropriming on germination and seedling vigour during emergence of rice under different soil moisture conditions. *Am J Plant Sci* **4**: 1584-93.
- McDonald M B (1999) Seed deterioration: Physiology, repair and assessment. *Seed Sci Technol* **27**: 177-237.
- Mirabi E and Hasanabadi M (2012) Effect of seed priming on some characteristics of seedling and seed vigour of tomato. *J Adv Lab Res Biol* **3**: 237-40.
- Mohammadi G R (2009) The effect of seed priming on plant traits of late-spring seeded soybean (*Glycine max* L.). *Am Eur J Agric Environ Sci* **5**: 322-26.
- Mohammadi H, Soltani A, Sadeghipour H R and Zeinali E (2011) Effect of seed ageing on subsequent seed utilization and seedling growth in soybean. *Int J Plant Production* **5**: 65-70.
- Mukasa Y, Takahashi H, Taguchi K, Ogata N, Okazaki K and Tanaka M (2003) Accumulation of soluble sugar in true seeds by priming of sugar beet seeds and the effects of priming on growth and yield of drilled plants. *Plant Prod Sci* **6**: 74-82.
- Murata T, Akazawa T and Furuchi S (1968) Enzymic mechanism of starch breakdown in germinating rice seeds I an analytical study. *Plant Physiol* **43**:1899-2005.
- Murthy U M N, Kumar P P and Sun W Q (2003) Mechanisms of seed ageing under different storage conditions for *Vigna radiata* (L.) Wilczek: lipid peroxidation, sugar hydrolysis, Maillard reactions and their relationship to glass state transition. *J Exp Bot* **54**: 1057-67.
- Naqve M, Shahbaz M, Wahid A and Waraich EA (2018) Seed priming with alpha tocopherol improves morpho-physiological attributes of okra under saline conditions. *Int J Agric Biol* **20**: 2647-54.
- Nascimento W M (2003) Muskmelon seed germination development in response to seed priming. *Sci Agric* **60**: 71-75.
- Nasri N, Kaddour R, Mahmoudi H, Baatour O, Bouraoui N and Lachaal N (2011) The effect of osmopriming on germination, seedling growth and phosphatase activities of lettuce under saline condition . *Afr J Biotech* **10**: 14366-372.
- Nawaz A, Amjad M, Pervez M and Afzal I (2011) Effect of halopriming on germination and seedling vigour of tomato. *Afr J Agric Res* **6**: 3551-559.
- Nawaz J, Hussain M, Jabbar A, Nadeem G A, Sajid M, Subtain M U and Shabbir I (2013) Seed priming A technique. *Int J Agri Crop Sci* **6**: 1373-81.
- Nejad H A (2013) The effects of seed priming techniques in improving germination and early seedling growth of *Aleuropus macrostachys*. *Int J Adv Biol Biom Res* **1**: 86-95.
- Neto F J D, Dalanhol S J, Machry M, Junior A P, Rodrigues J D and Ono E O (2017) Effects of plant growth regulators on eggplant seed germination and seedling growth. *Aust J Crop Sci* **11**:1277-82.

- Nigam M, Mishra A P, Salehi B, Kumar M, Sahrifi-Rad M, Coviello E, Iriti M and Sharifi-Rad J (2019) Accelerated ageing induces physiological and biochemical changes in tomato seeds involving MAPK pathways. *Sci Hortic* **248**: 20-28.
- Onder S, Tonguc M, Guvercin D and Karakurt Y (2020) Biochemical changes stimulated by accelerated ageing in safflower seeds (*Carthamus tinctoris* L). *J Seed Sci* **42**: 1-12.
- Pandey P, Bhanuprakash K and Umesh (2017) Effect of seed priming on seed germination and vigour in fresh and aged seeds of cucumber. *Int J Envir Agri Technol* **2**: 2261-64.
- Pandita V K, Anand A and Nagarajan S (2007) Enhancement of seed germination in hot pepper following pre-sowing treatments. *Seed Sci Technol* **35**: 282-90.
- Pandita V K, Nagarajan S, Sinha J P and Modi B S (2003) Physiological and biochemical changes induced by priming in tomato seeds and its relation to germination and field emergence characteristics. *Indian J Plant Physiol* **1**: 249-54.
- Parera C and Cantliffe D J (2010) Presowing seed priming. *Hort Rev* **16**: 109-41.
- Patel R V, Panday K Y, Jasrai R T and Brahmabhatt N (2017) Effect of hydropriming and biopriming on seed germination of Brinjal and Tomato seed. *Res J Agri For Sci* **5**: 1-14.
- Powell A A, Yule L J, Jing H C, Groots S P C and Raoul J (2000) The influence of aerated hydration seed treatment on seed longevity as assessed by the viability equation. *J Exp Bot* **51**: 2031-43.
- Prabha D, Negi S, Kumari P, Negi Y K and Chauhan J S (2016) Effect of seed priming with some plant leaf extract on seedling growth characteristics and root knot disease in tomato. *Int J Agric Syst* **4**: 46-51.
- Pradhan B K and Badola H K (2012) Effect of storage conditions and storage periods on seed germination in eleven populations of *Swertia chirayita*: A critically endangered medicinal herb in Himalaya. *Sci World J* **2012**: 1-9.
- Premchandra G S, Saneoka H and Ogata S (1990) Cell membrane stability, an indicator of drought tolerance as affected by applied nitrogen in soybean. *J Agric Sci* **115**:63-66.
- Probert R J, Bogh S V, Smith A J and Wechs B G E (1991) The effect of priming on seed longevity in *Ranunculus sceleratus* L. *Seed Sci Res* **1**: 243-249.
- Radha B N, Channakeshava B C, Nagaraj H, Pandurange G K T, Bhanuprakash K, Ramachandrappa B K and Munirajappa R (2014) Effect of seed ageing on protein quality and quantity in maize. *Int J Bioassays* **3**: 1708-13.
- Raj A B and Raj S K (2019) Seed priming: An approach towards agricultural sustainability. *J Appl Nat Sci* **11**: 227-34.
- Rajjou L and Debeaujon I (2008) Seed longevity : Survival and maintenance of high germination ability of dry seeds. *C R Biol* **331**: 796-805.
- Rehman H, Basra S M A, Rady M M and Wang Q (2017) Moringa leaf extract improves wheat growth and productivity by affecting senescence and source sink relationship. *Int J Agric Biol* **19**: 479-84.
- Roberts E H (1973) Predicting the storage life of seeds. *Seed Sci Technol* **1**: 499-514.
- Roberts E H and Ellis R H (1989) Water and seeds survival. *Ann Bot* **63**: 39-52.

- Rouhi H and Sepehri A (2020) Hormonal priming to overcome drought stress and aging damage in groundnut seed (*Arachis hypogaea* L.) *Iran J Plant Physiol* **10**: 3167-174.
- Sadeghi H, Khazaei F, Yari L and Sheidaei S (2011) Effect of seed osmopriming on seed germination behavior and vigour of soybean (*Glycine max* L.). *J Agric Biol Sci* **6**: 39-43.
- Saglam S, Day S, Kaya G and Gurbuz A (2010) Hydropriming increases germination of lentil (*Lens culinaris* Medik.) under water stress. *Not Sci Biol* **2**:103-06.
- Sano N, Rajjou L, North H M, Debeaujon I, Poll A M and Seo M (2016) Staying alive: Molecular aspects of seed longevity. *Plant Cell Physiol* **57**: 660-74.
- Sarika G, Basavaraju G V, Bhanuprakash K, Chaanakeshva B C, Paramesh R and Radha B N (2013) Investigations on seed viability and vigour of aged seeds by priming in french bean (*Phaseolus vulgaris* L.) *Veg Sci* **40**: 169-73.
- Sathish S, Sundareswaran S and Ganesan N (2011) Influence of seed priming on physiological performance of fresh and aged seeds of maize hybrid [COH(M) 5] and its parental lines. *J Agric Biol Sci* **6**: 12 - 17.
- Satish S and Sundareswaran S (2010) Biochemical evaluation of seed priming in fresh and aged seeds of maize hybrid [COH(M)5] and its parental lines. *Current Biotica* **4**: 162-170.
- Schwember A and Bradford K (2005) Drying rates mowing priming affect temperature sensitivity of germination and longevity of lettuce seeds. *Hort Sci* **40**: 778-81.
- Sepehri A and Rouhi H R (2017) Effect of hydropriming on morphological and physiological performance of aged groundnut (*Arachis hypogaea* L.) seeds. *Iran J Field Crop Sci* **1**: 43-53.
- Shaaban M (2016) The effect of ageing on antioxidant and biochemical changes in wheat (*Triticum aestivum* L) seeds. *Iran J Plant Physiol* **6**: 1805-14.
- Shaban M (2013) Study on some aspects of seed viability and vigour. *Int J Adv Biol Biomed Res* **1**: 1692-97.
- Shahlaei A, Ansari N A and Aliniaifard S (2009) Osmopriming eggplant (*Solanum melongena* L.) seeds by using salt solutions. *Middle E Russ J Plant Sci Biotechnol* **3**: 41-43.
- Shoab M, Tanveer A, Khaliq A and Haider A H (2012) Effect of seed size and ecological factors on germination of *Emex spinosa*. *World Appl Sci J* **17**: 964-69.
- Siddique A B and Wright D (2003) Effects of different drying time and temperature on moisture percentage and seed quality (viability and vigour) of pea seeds (*Pisum sativum* L.). *Asian J Plant Sci* **2**: 978-82.
- Simma B, Polthanee A, Goggi A, Siri B, Promkhambut A and Caragea P (2017) Wood vinegar seed priming improves yield and suppresses weeds in dryland direct-seeding rice under rainfed production. *Agron Sustain Dev* **37**: 1-9.
- Singh A, Abubakar A H, Ahmed H G, Aliyu U, Sokoto M B, Alhassan J, Musa M and Singh R B (2011) Seed hydropriming effects on germination, emergence and growth of cowpea (*Vigna unguiculata* L. Walp.). *Trends Adv Sci Eng* **1**: 37-42.

- Singh A, Dahiru R, Musa M and Haliru B (2014) Effect of osmopriming duration on germination, emergence, and early growth of cowpea (*Vigna unguiculata* (L.) walp.) in the Sudan Savanna of Nigeria. *Int J Agron* **2014**: 1-4.
- Singh H, Jassal R K, Kang J S, Sandhu S S, Kang H and Grewal K (2015) Seed priming techniques in field crops-a review. *Agric Rev* **36**: 251-64.
- Singh J S, Kanwar and Geeta B (2004) Seed vigour as influenced by different seed priming treatments in okra (*Abelmoschus esculentus* L. Moench). *Seed Res* **32**: 122-25.
- Siri B, Vichitphan K, Kaewnaree P, Vichitphan S and Klanrit P (2013) Improvement of quality, membrane integrity and antioxidant systems in sweet pepper seeds affected by osmopriming. *Aust J Crop Sci* **7**: 2068-73.
- Stephen K, Khan D, Mazahir H S, Lone S, Bhat S, Narayan S, Mir S, Hussain K, Gul M, Khurshid A and Siddiqi I (2018) Optimizing priming concentration and duration of various priming agents for improved seed germination in chilli (*Capsicum annum* L.). *J Pharmacog Phytochem* **7**: 2689-93.
- Suksoon L and Jaehyeum K (2000) Total sugars, alpha-amylase activity, and germination after priming of normal and aged seeds. *Korean J Crop Sci* **42**: 108-11.
- Tarquis A M and Bradford K J (1992) Prehydration and priming treatments that advance germination also increase the rate of deterioration of lettuce seeds. *J Exp Bot* **43**: 307-17.
- Thanos C A, Georghiou K and Passam H C (1989) Osmoconditioning and ageing of Pepper seeds during storage. *Ann Bot* **63**: 65-69.
- Thomas U C, Varughese K, Thomas A and Sadanandan S (2000) Seed priming for increased vigour, viability and productivity of upland rice. *Leisa India* **4**: 14.
- Tsegay B A and Andargie M (2018) Seed Priming with Gibberellic Acid (GA₃) Alleviates Salinity Induced Inhibition of Germination and Seedling Growth of *Zea mays* L., *Pisum sativum* Var. abyssinicum A. Braun and *Lathyrus sativus* L. *J Crop Sci Biotechnol* **21**:261-67.
- Uche O J, Adinde J O, Omeje T E, Agu C J and Anieke U J (2016) Influence of hydropriming on germination and seedling emergence of green bell pepper (*Capsicum annum* Cv. Goliath). *Int J Sci Nature* **7**: 70-75.
- Varier A, Vari A K and Dadlani M (2010) The subcellular basis of seed priming. *Curr Sci* **99**: 450-456.
- Venkatasubramanian A and Umarani R (2007) Evaluation of seed priming methods to improve seed performance of tomato (*Lycopersicon esculentum*), eggplant (*Solanum melongena*), chilli (*Capsicum annum*). *Seed Sci Technol* **35**: 487-93.
- Venkatasubramanian A and Umarani R (2010) Storability of primed seeds of tomato (*Lycopersicon esculentum*), eggplant (*Solanum melongena*), chilli (*Capsicum annum*). *Madras Agric J* **97**: 117-24.
- Vijayalakshmi V, Poonguzhali S, Ramamoorthy K and Natarajan N (2014) Physiological and biochemical changes in accelerated aged tomato (*Solanum lycopersicum*) seeds. *J Appl Hortic* **16**: 241-44.

- Walters C (2007) Materials used for seed storage containers: Response to Gomez-Campo [Seed Science Research 16, 291-294 (2006)]. *Seed Sci Res* **17**: 233-242.
- Walters C, Wheeler L M and Grotenhuis J M (2005) Longevity of seeds stored in genebank: species characteristics. *Seed Sci Res* **15**: 1-20.
- Wang T, Hou L, Jian H, Di F, Li J and Liu L (2018) Combined Qtl Mapping, physiological and transcriptomic analyses to identify candidate genes involved in *Brassica napus* seed aging. *Mol Genet Genomics* **293**:1421-35.
- Wang W, He A, Peg S, Huang J, Cui K and Nie L (2018) The effect of storage condition and duration on the deterioration of primed rice seeds. *Front Plant Sci* **9**: 1-17.
- Wechsberg G E, Probert R J and Bray C M (1994) The relationship between 'dehydrin-like' proteins and seed longevity in *Ranunculus sceleratus* L. *J Exp Bot* **45**: 1027-30.
- Wexler A and Hasegawa S (1954) Relative humidity-temperature relationships of some saturated salt solutions in the temperature range of 0°C to 50°C. *J Res Natl Bur Stand* **53**(1):19-26.
- Yan M (2017) Prolonged storage reduced the positive effect of hydropriming in Chinese cabbage seeds stored at different temperatures. *S Afr J Bot* **111**: 313-15.
- Yari L, Aghaalikani M and Khazaei F (2010). Effect of seed priming duration and temperature on seed germination behavior of bread wheat (*Triticum aestivum* L.). *J Agr Biol Sci* **5**: 1–6.
- Yarnia M and Tabrizi E F M (2012). Effect of Seed Priming with Different Concentration of GA₃, IAA and Kinetin on Azarshahr Onion Germination and Seedling Growth. *J Basic Appl Sci Res* **2**: 2657-661.
- Yogananda D K, Vyakaranahal B S and Shekhargouda M (2004) Effect of seed vigouration with growth regulators and micronutrients on germination and seedling vigour of bell pepper cv. California wonder. *Karnataka J Agric Sci* **17**: 811-13.
- Yuan Y S U N, Yong J S U N, Ming T W A N G, Xu Y L I, Xiang G U O, Rong H U and Jun M A (2010) Effects of seed priming on germination and seedling growth under water stress in rice. *Acta Agron Sin* **36**: 1931-40.
- Zang F, Yu J, Johnston C R, Wang Y, Zhu K, Lu F, Zang Z and Zou J (2015) Seed priming with Polyethylene Glycol induces physiological changes in Sorghum (*Sorghum bicolor*) seedlings under suboptimal soil moisture environments. *Plos one* **10**: 1-15.
- Zhang M, Yin C, Wang L, Haung J, Yuan L, Cheng J and Zhang H (2012) Osmopriming improves tomato seed vigour under ageing and salinity stress. *Afr J Biotechnol* **11**: 6305-11.
- Zhao M, Zhang H, Yan H, Qiu L and Baskin C C (2018) Mobilization and role of starch, protein and fat reserves during seed germination of six wild grassland species. *Front Plant Sci* **9**: 1-21.

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