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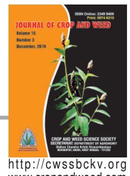

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Ameliorative effect of priming on germination potential of aged seeds of flowering winter annuals

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ABSTRACT

Decreasing germination potential of aged seeds in annuals poses a major threat to their business. To harness this loss, effect of priming on germination of seven winter annuals was studied in freshly harvested seeds (June), seeds after 3 (September) and 6 (December) months of storage. The seeds were primed for 24 hours and evaluated for germination potential. Germination of primed seeds was greater in all winter annuals as compared to their respective controls, and it decreased linearly with increase in storage duration. Priming Gaillardia seeds with boric acid@10 ppm was most effective in improving germination even after 6 months. The fresh Gazania seeds respond well to boric acid@50 ppm (96.67%), boric acid @75 ppm (90.33%) after 3 months and boric acid @25 ppm (91.67%) after 6 months. Thus, seed priming improved the germination potential of stored seeds of winter annuals although different annuals responded differently to chemicals used for priming.

Keywords: Germination, seed priming, seed storage, winter annuals

Flowers have long been associated with mankind, dating back to the dawn of civilization. They are used for a variety of purposes in our daily lives, including worship, religious and social activities, weddings and interior decoration (Kumari *et al.,* 2017). India has a wide range of agro-climatic and ecological conditions that are ideal for growing a wide range of commercially important flowers generally found all over the world. During the winter months, it also has the ideal climate for floriculture in certain areas (Sudhagar, 2013). Flowering annuals are in high demand for landscape beautification all over the world because they are easy to grow from seeds. Britishers brought the majority of winter annuals to India. As these annuals can withstand relatively low temperatures, hence cultivated comfortably throughout the winter and bloom at their best during this time (Kumari *et al.,* 2017).

Uniformity, rapid germination and seedling emergence capacity of direct-seeded crops have a major impact on final yield, quality and ultimately profits in cropping (Tzortzakis, 2009). High physiological potential seeds with rapid and uniform field emergence are required for effective crop establishment, especially under harsh weather conditions. Normal seedlings can emerge and develop quickly and consistently in a broad range of field conditions provided the seed is of high quality (ASPB, 2003). However, unless special precautions are followed, seed quality deteriorates during field weathering, harvesting, and/or storage (Farhoudi, 2012). Seed deterioration can result in yearly losses of up to 25% of the produced crop. It is a major concern, especially in developing nations, because seeds are kept in areas where air humidity, temperature, and O_2/CO_2 concentration are not properly controlled. Therefore, seed degradation and invigoration studies, determining the physiological capability of seed in terms of germinability and seedling establishment, are important. Poor seed germination is the major limiting factor for large scale production and cultivation.

Seed priming is one of the strategies being used to accelerate seed germination in many crops (Karimi and Varyani, 2016). In priming, seeds are exposed to eliciting factor that regulate hydration level within the seed for initiation of germination but not radical emergence (Paparella *et al.,* 2015). In priming technique, prevention of the emergence of radical is an important step that suspends the seed in the lag phase (Afzal *et al.,* 2002). Seed priming shortens the period between sowing and seedling emergence and helps to synchronize the emergence of seedlings (Parera and Cantliffe, 1994). Priming treatments known to enhance seed germination include hydro-priming, halopriming, osmopriming and hormonal priming (Nawaz *et al.,* 2013). Hydro-priming means soaking the seeds in water before sowing or planting which may or may not be followed by air-drying (Nawaz *et al*., 2013). This pre-sowing seed treatment allows the seed to absorb water and enter first phase of germination where pre-germination metabolic activities initiated, while the second and third phases of germination are prevented (Pill and Necker, 2001). Halo priming is the process of soaking seeds in an inorganic salt solution, such as sodium chloride (NaCl), potassium

Short Communication

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nitrate (KNO_3), calcium chloride ($CaCl_2$), calcium sulphate ($CaSO_4$) *etc*. Priming seeds with inorganic salts may boost the activity of most of the enzymes involved in seed germination, allowing organic substances to be mobilized to different areas of the embryo (Nawaz *et al*., 2013). Hormonal priming entails soaking or treating seeds in appropriate plant growth regulator (PGR) concentrations. Auxins, gibberellins, cytokinins, abscisic acids, polyamines, brassinilide, salicylic acid, triacontanol and ascorbic acid are some of the most commonly used growth regulators for seed priming. Seeds that have been treated with growth hormones have also been shown to promote germination in stressful conditions (Zaidi *et al*., 2013).

Keeping in view the above scenario, this study was conducted to investigate the effect of priming with different chemicals on stored seeds for enhancing germination and uniform emergence of some winter annuals.

This experiment was conducted during 2020 to investigate the effect of seed priming with different chemicals on germination of *Coreopsis lanceolata, Gaillardia aristata, Gazania splendens, Matthiola incana, Nemesia strumosa, Verbena hybrida* and *Viola tricolor* in the laboratory of Department of Floriculture and Landscaping, PAU, Ludhiana. Seeds of all winter annuals were kept in desiccator after harvesting and tested for germination percentage at three durations *i.e*., freshly harvested seeds (June), three (September) and six (December) months after harvesting. There were thirty six treatments *viz*. priming with Thiourea (500, 600, 700, 800 and 900 ppm), Potassium nitrate (10, 25, 50, 75 and 100 ppm), Boric acid (10, 25, 50, 75 and 100 ppm), BA (5, 10, 25, 50, and 75 ppm), Kinetin (5, 10, 25, 50, and 75 ppm), GA (10, 25, 50, 75 and 100 ppm), Ethrel (10, 25, 50, 75 and 100 ppm) and water *i.e*. control. The seeds were surface- sterilized with $HgCl_2$ (0.1%) for few seconds followed by thorough rinsing with distilled water twice or thrice. The seeds were blotted to dry and then dipped in different priming solutions for 24 hours. After completion of 24 hours of priming, seeds were dried at room temperature. Ten seeds from each treatment were placed in the Petri plates lined with two layers of filter paper and 5 ml distilled water was added. Petri plates were observed daily for evaluation of germination percentage.

The germination potential of winter annuals is presented below:

Coreopsis lanceolata L.

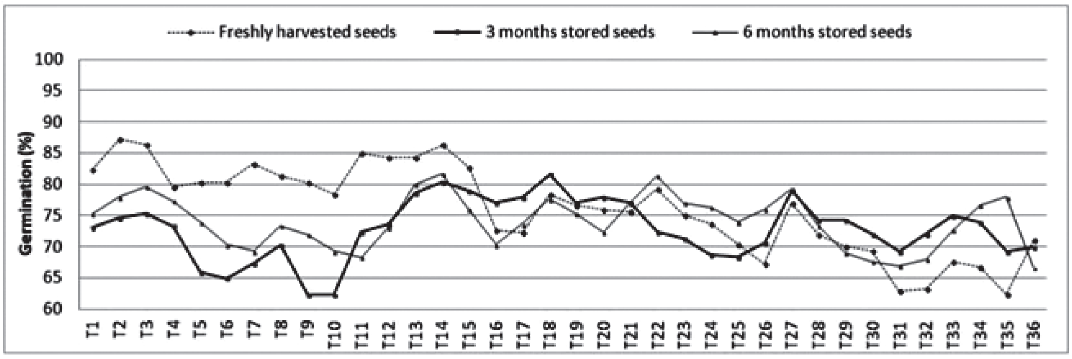
The highest germination (71.00%) was in freshly harvested seeds followed by seeds stored upto three months after harvesting (70.00%) and six months after harvesting (66.67%) when primed with water (control). Seeds treated with growth regulators and chemicals improved the germination of *Coreopsis lanceolata* (Fig. 1). Thiourea@600 ppm showed the highest germination (87.33%), which was at par to kinetin@50 ppm (86.33%) but significantly higher than control (71.00%) in freshly harvested seeds. In three month stored seeds, potassium nitrate@50 ppm gave the highest germination (81.67%) followed by kinetin@50 ppm (80.33%). A significant improvement over control (70.00%) was also observed with GA@25 ppm (79.00%) treatment. In six month stored seeds, kinetin@50 ppm and boric acid@25 ppm resulted in 81.67 and 81.33% germination, respectively. Other chemicals, which also exhibited significant differences, were thiourea@700 ppm (79.67%) and GA@25 ppm (79.33%) as compared with control (66.67%). Priming with Thiourea@600 ppm resulted in maximum germination percentage in *Coreopsis*.

Gaillardia aristata Push.

Three month stored seeds showed highest per cent germination followed by freshly harvested seeds and six month stored seeds under hydropriming, chemical and growth regulator priming methods. The response of seed germination to different doses of growth regulators was significantly positive (Fig. 2) and the highest germination was recorded with boric acid@10 ppm (74.00%), followed by potassium nitrate@50 ppm (73.33%) and kinetin@50 ppm (72.25%) in freshly harvested seeds. The minimum germination (62.00%) was recorded from hydroprimed seeds. In three months stored seeds, the seeds treated with thiourea@800 ppm resulted in the highest germination (79.67%) followed by thiourea@700 ppm (78.00%) and potassium nitrate@50 ppm (77.00%). Among the other chemicals, GA@25 ppm and boric acid@10 ppm with 76.00% germination were also effective. The minimum germination was recorded in control (64.00%). In six month stored seeds, seeds treated with boric acid@10 ppm and thiourea@800 ppm showed 67.33 and 66.67% germination, respectively. The treatment with ethrel@25 ppm and kinetin@5 ppm also resulted in 65.67 % germination in both compared with 45.33% in control. In Gaillardia, thiourea@800 ppm was found best in increasing germination percentage.

Gazania splendens L.

Among all the priming treatments, highest per cent germination was recorded in freshly harvested seeds whereas least per cent germination was recorded in seeds stored for six months (Fig. 3). In freshly harvested seeds, boric acid@50 ppm was the most effective treatments with 96.67% germination compared with 91.00% in



(T1 =Thiourea @500ppm, T2 =Thiourea @600ppm, T3 = Thiourea @700ppm, T4 = Thiourea 800ppm, T5 = Thiourea @900ppm, T6 = BA @5ppm, T7 = BA @10ppm, T8 = BA @25ppm, T9 = BA @50ppm, T10 = BA @75ppm, T11 + Kinetin @5ppm, T12 = Kinetuin @10ppm, T13 = Kinetin @25ppm, T14 = Kinetin @50ppm, T15 = @75ppm, T16 = Potassium nitrate @10ppm, T17 = Potassium @25ppm, T18 = Potassium @50ppm, T19 = Potassium @75ppm, T20 = Potassium @100ppm, T21 = Boric acid @10ppm, T22 = Boric acid @25ppm, T23 = Boric acid @50ppm, T24 = Boric acid @75ppm, T25 = Boric acid @100ppm, T26 = GA @10ppm, T27 = GA @25ppm, T28 = GA @50ppm, T29 = GA @75ppm, T30 = GA @100ppm, T31 = Ethrel @10ppm, T32 = Ethrel @25ppm, T33 = Ethrel @50ppm, T34 = Tthrel @75ppm, T35 = Ethrel @100ppm, T36 = Distilled water)

Fig. 1 : Effect of chemical treatment on seed germination (%) in *Coreopsis lanceolata*

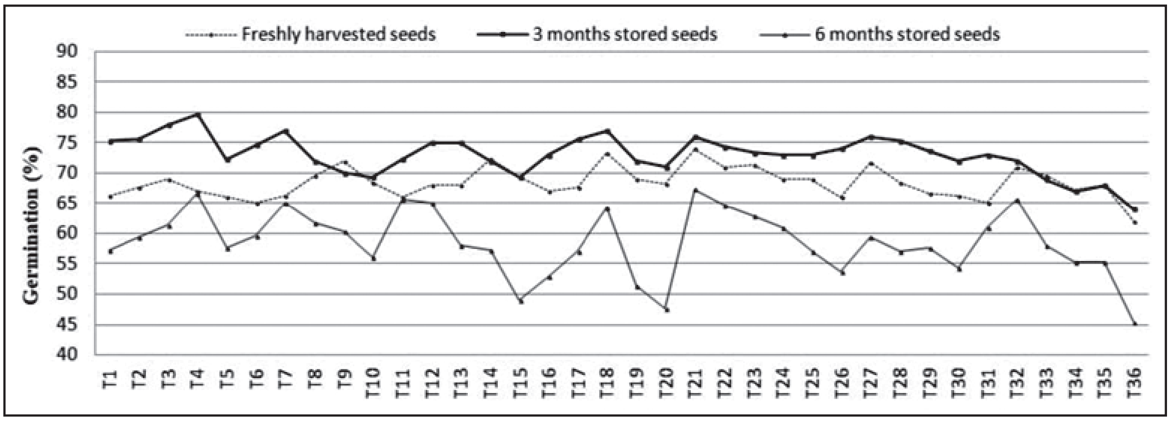


Fig. 2 : Effect of chemical treatment on seed germination (%) in *Gaillardia aristata*

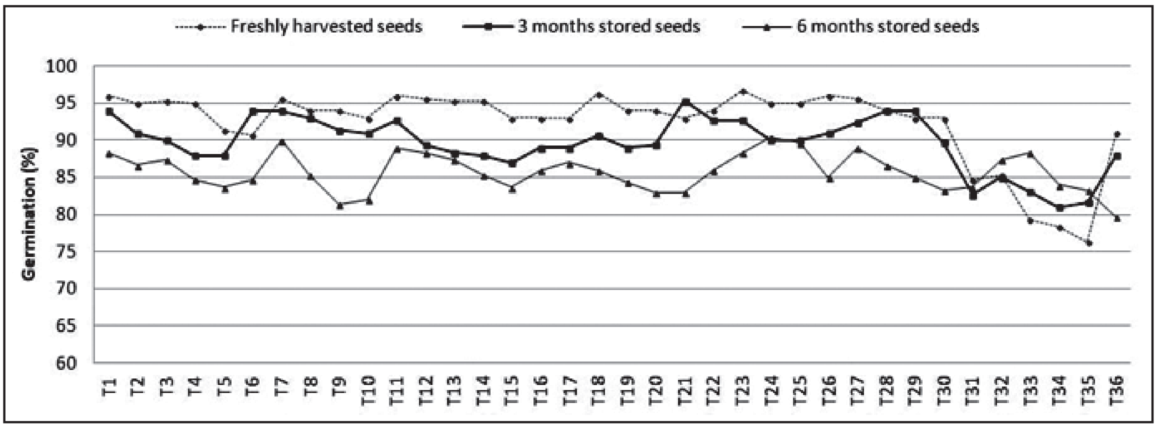


Fig. 3 : Effect of chemical treatment on seed germination (%) in *Gazania splendens*

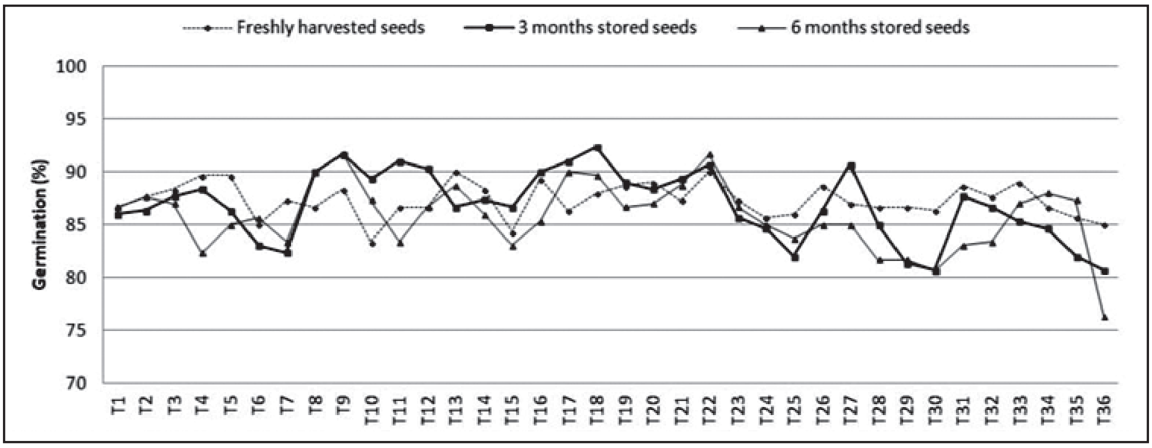


Fig. 4 : Effect of chemical treatment on seed germination (%) in *Matthiola incana*

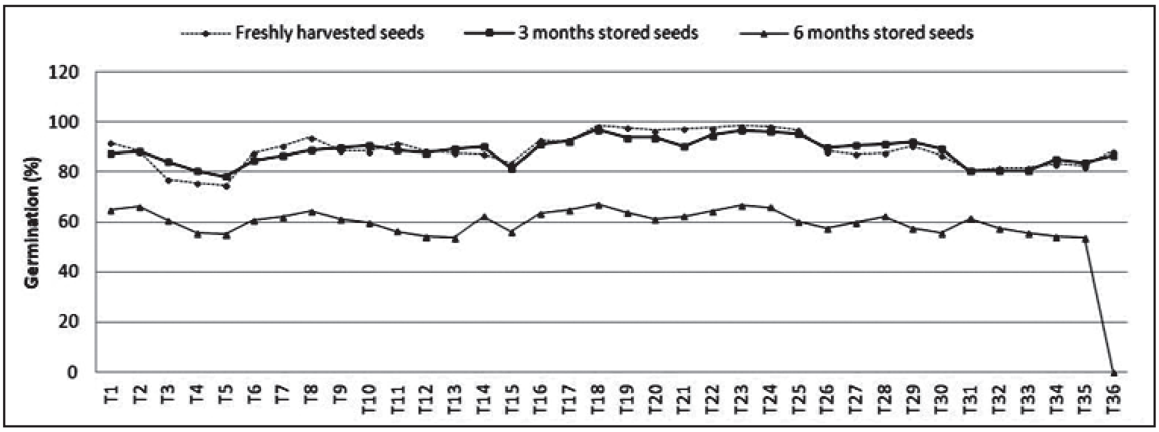


Fig. 5 : Effect of chemical treatment on seed germination (%) in *Nemesia strumosa*

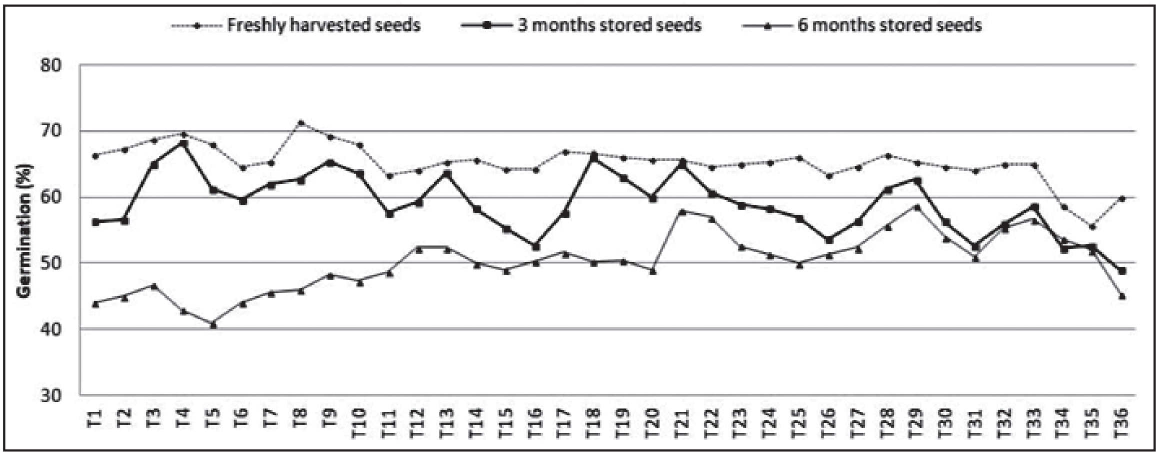


Fig. 6 : Effect of chemical treatment on seed germination (%) in *Verbena hybrida*

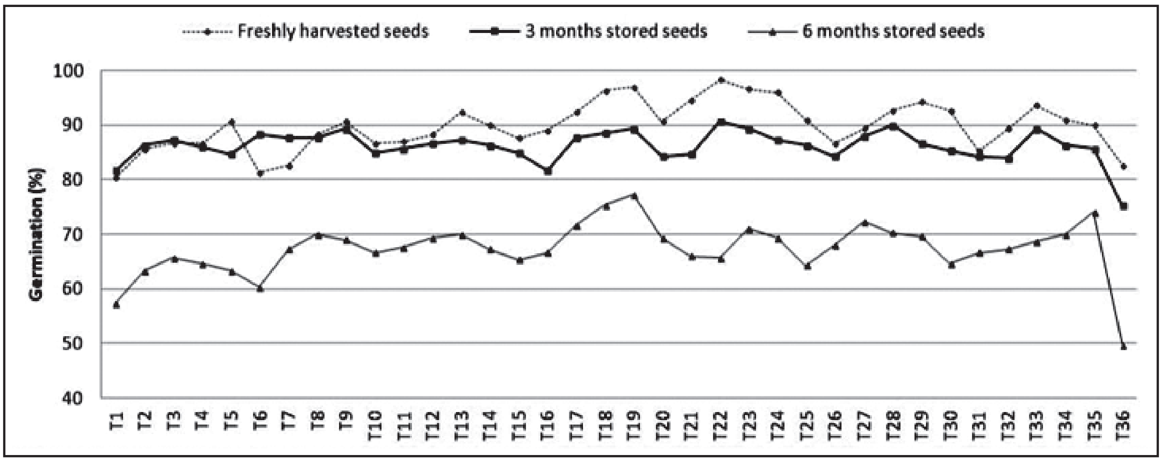


Fig. 7 : Effect of chemical treatment on seed germination (%) in *Viola tricolor*

control. Thiourea@500 ppm, kinetin@5 ppm and GA@10 ppm also showed significant improvement in the seed germination with 96.00% count in each treatment. In three month stored seeds, boric acid@10 ppm had the highest germination (95.33%) followed by GA@50 ppm and BA@5 ppm (94.00%) whereas only 88.00% with control. In six month stored seeds, boric acid@75 ppm and BA@10 ppm resulted in higher germination (90.33% and 90.00%, respectively). The results showed that GA@25 ppm and kinetin@5 ppm improved the germination to 89.00% than 79.67% in control. In Gazania, boric acid@50 ppm was recorded as the best priming treatment.

***Matthiola incana* R. Br.**

A considerable variation in germination due to chemical treatments as compared to hydroprimed seeds (85.00%) was recorded in seeds stored for different durations (Fig. 4). The per cent germination in freshly harvested seeds and seeds stored for three months was significantly more as compared to those seeds stored for six months. The seeds treated with kinetin and boric acid @25ppm each resulted in maximum germination (90.00%) and it was at par with ethrel@50 ppm (89.00%) and thiourea@800 ppm (89.67%) in freshly harvested seeds. However, after storage of three months potassium nitrate@50 ppm presented the highest germination (92.33%), which was at par with BA@50 ppm (91.67%), boric acid@25 ppm (90.67%) and GA@25 ppm (90.67%). The least germination (80.67%) was recorded under control. In storage of six months, seeds treated with BA@50 ppm and boric acid@25 ppm resulted in the highest and constant germination (91.67%) followed by potassium nitrate@25 ppm (90.00%). The least germination (76.33%) was observed in hydroprimed seeds. In Matthiola, potassium nitrate was found best in increasing germination percentage.

***Nemesia strumosa* Benth.**

The freshly harvested seeds and seeds stored for three months did not show much difference in per cent germination whereas there was decrease in per cent germination in control and all priming methods when seeds of *Nemesia* were stored for a period of six months (Fig. 5). Seeds treated with potassium nitrate@50 ppm and boric acid@50 ppm resulted in the highest germination of 98.67% in freshly harvested seeds. BA@25 ppm and thiourea@500 ppm also increased the germination significantly (94.00% and 92.00%, respectively) than the control (88.33%). Similarly, in three months stored seeds, potassium nitrate@50 ppm and boric acid@50 ppm resulted in 97.00% and 96.67% germination, respectively. Apart from these chemicals, GA and BA@75 ppm each also effectively increased the germination to 92.00% and 90.67%, respectively. Six months of seed storage recorded highest germination (67.33%) with potassium nitrate@50 ppm having non-significant differences with boric acid@50 ppm (66.67%). However, thiourea@600 ppm and BA@25 ppm resulted in significantly higher germination *viz*., 66.33% and 64.33%, respectively. Priming with potassium nitate@50 ppm and boric acid@50 ppm resulted in maximum germination percentage in *Nemesia*.

***Verbena hybrida* Voss.**

A significant decrease in per cent germination from freshly harvested seeds followed by seeds stored for three months to seeds stored for six months was recorded under all treatments (Fig. 6). There was improvement in germination after seed treatment, the most effective treatment in freshly harvested seeds was BA@25 ppm presenting the highest germination of 71.33%, followed by thiourea@800 ppm with 69.67% and BA@50 ppm with 69.33%. The minimum germination was observed in hydroprimed seed (60.00%). In three months stored seeds, thiourea@800 ppm resulted in maximum germination (68.33%), which was followed by potassium nitrate and BA@50 ppm each (66.00% and 65.33%, respectively). However, seed treatment with boric acid@10 ppm also showed non-significant differences with 65.00% germination. It was followed by GA@75 ppm with 62.67%, compared with 49.00% in control. Similarly in seeds stored for six months, GA@75 ppm and boric acid@10 ppm resulted in 58.67% and 58.00% germination respectively, compared with 41.00% in control. In *Verbena*, BA@25 ppm was recorded as the best priming treatment.

Viola tricolor L.

It is evident from the data presented in Fig. 7 that freshly harvested seeds recorded highest per cent germination under all priming methods followed by seeds stored for three months and six months. In freshly harvested seeds, maximum germination (98.33%) was recorded with boric acid 25@ppm followed by potassium nitrate@75 ppm (97.00%), whereas it was 82.67% in control. The seed treatment with GA@75 ppm and ethrel@50 ppm also showed significant improvement with 94.33% and 93.67%, respectively. The least germination recorded under control was 75.33% in three month stored seeds. Maximum germination recorded with boric acid@25 ppm was 90.67%, followed by 89.33 % with BA@50 ppm, ethrel@50 ppm and potassium nitrate@75 ppm. The maximum germination was recorded with potassium nitrate@75 ppm (77.33%) in six month stored seeds. Ethrel@100 ppm and GA@25 ppm also presented significant improvement with 74.00% and 72.33% germination, respectively. In *Viola*, BA@25 ppm was recorded as the best priming treatment.

Seed deterioration due to age is an unavoidable phenomenon, and the maximum that can be done is to slow down the rate of deterioration (Coolbear, 1995). Seed deterioration refers to the loss of seed quality *i.e.*, vigour and viability due to ageing and unfavorable environmental variables such as increased temperature, relative air humidity, and oxygen/carbon dioxide ratio during the pre-harvest (field weathering), harvest (handling) and post-harvest (storage) periods (Kapoor *et al.,* 2010; Farhoudi, 2012; Jyoti and Malik, 2013). A number of metabolic abnormalities accumulating in embryonic and non-embryonic tissues have been attributed for seed quality loss owing to ageing due to storage and unfavourable conditions (Sisman, 2005; Khan *et al.,* 2016). Seed ageing is linked to cellular alterations such as membrane breakdown, leakage of solutes, lower energy metabolism, impairment in RNA and protein synthesis and degradation of DNA (Kibinza *et al*., 2006; Jyoti and Malik, 2013), all of which have a negative impact on seed quality and germination. The initial quality of seed and the way in which it was kept or stored influenced seed quality and viability during storage (Jyoti and Malik, 2013). Seed performance decreases as seed deterioration increases.

The germination is the transition period between resting and growth stage of plant and is considered complete at the time of visible radicle emergence. The major storage reserves in the seed are proteins, carbohydrates and lipids, which are converted to amino acids or sugars to fuel for early growth of the embryo. The dry seeds contain many gibberellins in the form of conjugates. During germination, conjugates are hydrolyzed and the content of free gibberellins increases rapidly. Gibberellins activate the synthesis of hydrolytic enzymes responsible for the degradation of reserve substances of seeds, especially of alpha amylase, protease and lipase. In principle, gibberellins enhance the cell elongation to push the radicle through the endosperm and seed coat. Whereas cytokinins stimulate the cell division, which is connected with its stimulating effect on the production of proteins necessary for the cell cycle and increase the sink capacity of the tissues. It stimulates the germination by increasing the activities of amino acids and sugars.

Thereby, exogenous application of GA_3 and kinetin stimulates the germination activities of seeds, irrespective of their age and kind. These results are in line with the findings of Carpenter and Ostmark (1992) in *Coreopsis*, where 54 to 81% improvement in germination was recorded with 25 ppm kinetin and 100 ppm GA. Seeds treated with GA also improved the germination in marigold (Sharga *et al.,* 1970), zinnia (Grzesik and Chojnowski, 1992), *Ocimum sanctum* (Arularasu and Sambandamurthi, 1999), balsam (Singh and Karki, 2003) and China aster (*Callistephus chinensis* L. Nees) cv. Kamini (Sidana *et al.,*2019) Seeds of *Dianthus caryophyllus* primed with GA showed higher germination percentage as compared to Kinetin and Indole 3-acetic acid (IAA) (Roychowdhury *et al.,* 2012).

The promotive effects of BA on speeding and enhancing seed germination per cent, rate and seedling growth features of *Moringa oleifera* were linked to the significant role of cytokinins in the synthesis of hydrolytic enzymes for the mobilisation of food reserves in germinated seeds. BA also participates in the synthesis of enzyme proteins via messenger RNA and DNA (Abd El-Dayem *et al.,* 2021).

Ethrel (2-chloroethylphosphonic acid), an ethylene-releasing regulator, increases the rate of respiration, degrades the tissues and increases the permeability of seed membrane. The seed treatment of *Viola tricolor* with ethrel@100 ppm showed 74.00% germination, compared with 49.67% in control after 6 months of storage. Matriconditioning of *Helichrysum bracteatum* seeds with Micro-Cel E in the presence of ethephon (1500 mg/litre), kinetin (20 mg/litre) and GA_3 (300 mg/litre) improved the seed performance and seedling emergence (Grzesik and Nowak, 1998).

Seeds treated with kinetin, boric acid and potassium nitrate increased the germination in *Gazania*, *Matthiola* and *Nemesia*. Probably, these nitrogenous compounds stimulate the germination by increasing the endogenous seed cytokinin, which interact with growth inhibitors to regulate the metabolic activities of the seed. These results are in tune with the findings of Vimala and Pratap (2014) who recorded improvement in germination of China Aster with the treatment of potassium nitrate. Padhi *et al.* (2018) reported that thiourea (0.2%) treatment improved germination of gladiolus cormels cv. Tiger Flame. KNO_3 promoted germination by causing biochemical changes like hydrolysis and increased enzyme production, which improves cell wall elasticity and therefore promotes germination. Afzal *et al.* (2009) found similar results when they studied the influence of halopriming treatments on marigold seed germination. Ghassemi-Golezani *et al.* (2010) studied the effects of different osmopriming treatments (KNO_3 and NaCl) on seed invigoration and field performance of winter rapeseed cultivars and found that salt priming, especially KNO_3 priming, reduced mean germination time and increased seedling size when compared to non-primed seeds.

The results showed that all the annuals stored for different time intervals gave differential response to seed germination with different concentrations of chemicals. As in *Coreopsis lanceolata*, maximum germination in freshly harvested seeds was achieved with thiourea@600 ppm (87.33%), in three months stored seeds with potassium nitrate@50 ppm (81.67%) and in six months stored seeds with kinetin@50 ppm (81.67 %). However, in *Gazania splendens*, boric acid@50 ppm and boric acid@75 ppm showed higher germination (96.67 and 90.33%) in freshly harvested seeds and seeds stored for six months, respectively. Whereas in seeds stored for three months, 95.33% germination was observed with boric acid@10 ppm. Similarly, in *Gaillardia aristata, Matthiola incana, Nemesia strumosa, Verbena hybrida* and *Viola tricolor* response was variable with different concentration of chemicals in all the storage durations. Overall, a trend emerged in all the annuals that germination was higher in freshly harvested seed and it declined linearly with passage of time. It was also observed that growth regulators enhanced the germination with significant effect than the control.

REFERENCES

A.S.P.B. 2003. Regulations on the Sale of Planting Seed in Arkansas. American Society of Plant Biologists. Arkansas state plant board, Box 1069, Little Rock, Arkansas-072203.

Abd El-Dayem, Faten, H.M., Ismaeil, H.M., Abd El-Aal, M.M.M. and Eid, R.S.M. 2021. Influence of seeds soaking with Benzyladenine, Paclobutrazol, algae extract, some mineral nutrients and Lithovit on seeds germination and seedling growth of *Moringa olifera* plant. *Pl. Biotech.,* 179-188.

Afzal, I., Ashraf, S., Qasim, M., Basra, S.M.A. and Shahid, M. 2009. Does halopriming improve germination and seedling vigour in marigold (*Tagetes* spp.)? *Seed Sci. Technol.,***37:** 436-445.

Afzal, I., Basra, S.M.A., Ahmad, M., Cheema, M.A., Warraich, E.A. and Khaliq, A. 2002. Effect of priming and growth regulator treatment on emergence and seedling growth of hybrid maize (*Zea mays*). *Int. J. Agric. Biol.,* **4:** 303-306.

Arularasu, P. and Sambandamurthi, S. 1999. Effect of gibberellic acid, nitrogen and spacing on herbage yield and oil yield in tulsi (*Ocimum sanctum* L.). *South Ind. Hort.*, **7**(1/6): 370-372.

Carpenter, W.J. and Ostmark, E.R. 1992. Growth regulators and storage temperature govern germination of Coreopsis seed. *Hort. Sci.*, **27**(11): 1190-1193.

Coolbear, P. 1995. Seed Quality. Food Products Press. New York, pp. 223-277.

Farhoudi, R. 2012. Evaluation effect of KNO_3 seed priming on seedling growth and cell membrane damage of sunflower (*Helianthus annus*) under salt stress. *Am. Eurasian J. Agric. Environ. Sci.,***12**(3): 384-388.

Ghassemi-Golezani, K., Jabbarpour, S., Zehtab-Salmasi, S. and Mohammadi, A. 2010. Response of winter rapeseed (*Brassica napus* L.) cultivars to salt priming of seeds. *Afr. J. Agric. Res.,***5**(10): 1089-1094.

Grzesik, M. and Chojnowski, M. 1992. Effect of growth regulators on plant-growth and seed yield of *Zinnia elegans* Red Man'. *Seed Sci. Technol.,* **20**(2): 327-330.

Grzesik, M. and Nowak, J. 1998. Effects of matriconditioning and hydropriming on *Helichrysum bracteatum* L. seed germination, seedling emergence and stress tolerance. *Seed Sci. Technol.,* **26**(2): 363-376.

Jyoti and Malik, C.P. 2013. Seed deterioration: a review. *IJLPR*, **2:** 374-385.

Kapoor, N., Arya, A., Siddiqui, M.A., Amir, A. and Kumar, H. 2010. Seed deterioration in chickpea (*Cicer arietinum* L.) under accelerated ageing. *Asian J. Pl. Sci.,***9:** 158-162.

Karimi, M. and Varyani, M. 2016. Role of priming technique in germination parameters of calendula (*Calendula officinalis* L.) Seed. *J. Agric. Sci.,* **61**(3): 215-226.

Khan, F.A., Maqbool, R., Narayan, S., Bhat, S.A., Narayan, R. and Khan, F.U. 2016. Reversal of age-induced seed deterioration through priming in vegetable crops– A review. *Adv. Plants Agric. Res.,***4**(6): 00159.

Kibinza, S., Vinel, D., Come, D., Bailly, C. and Corbineau, F. 2006. Sunflower seed deterioration as related to moisture content during ageing, energy metabolism and active oxygen species scavenging. *Physiol. Plant.,***128:** 496-506.

Kumari, P., Bordolui, S.K. and Sadhukhan, R. 2017. Seed quality deterioration of some winter flowers during storage. *J. Crop Weed*, **13**(1): 164-169.

Nawaz, J., Hussain. M., Jabbar, A., Nadeem, G.A., Sajid, M., Subtain, M. and Shabbir, I. 2013. Seed priming a technique. *Int. J. Agric. Crop Sci.,***6:** 1373-1381.

Padhi, M., Sisodia, A., Pal, S., Kapri, M. and Singh, A.K. 2018. Growing media, GA_3 and thiourea stimulates growth and rooting in gladiolus cormels cv. Tiger Flame. *J. Pharmacogn. Phytochem.,* **7**(3): 1919-1922.

Paparella, S., Araújo, S.S., Rossi, G., Wijayasinghe, M., Carbonera, D. and Balestrazzi, A. 2015. Seed priming: State of the art and new perspectives. *Plant Cell Rep.,***34:** 1281-1293.

Parera, A.C. and Cantliffe, D.J. 1994. Pre-sowing seed priming. *Hortic. Rev.,* 16109-148.

Pill, W.G. and Necker, A.D. 2001. The effects of seed treatments on germination and establishment of Kentucky bluegrass (*Poa pratense* L.). *Seed Sci. Technol.,***29:** 65-72.

Roychowdhury, R., Mamgain, A., Ray, S. and Tah, J. 2012. Effect of gibberellic acid, kinetin and Indole 3-Acetic Acid on seed germination performance of *Dianthus caryophyllus* (Carnation). *Agric. Conspec. Sci.,***77**(3): 157-160.

Sharga, A.N., Motilal, V.S. and Basario, K.K. 1970. Effect of gibberellic acid (seed treatment) on the germination, vegetative growth, quantity and quality of marigold flowers (*T. erecta* L.). *Sci. Cult.,***36**(5): 279-280.

Sidana, G., Hembrom, R., Sisodia, A., Padhi, M. and Singh, A.K. 2019. Effect of seed priming on seedling growth in China aster cv. Kamini. *J. Pharmacogn. Phytochem.,***8**(5): 372-375.

Singh, A.K. and Karki, K. 2003. Effect of grading and GA_3 on germination and seedling growth attributes in balsam. *Progress Hortic.,***35**(2):158-160.

Sisman, C. 2005. Quality losses in temporary sunflower stores and influences of storage conditions on quality losses during storage. *J. Cent. Eur. Agric.,***6:** 143-150.

Sudhagar, S. 2013. Production and marketing of cut flower (rose and gerbera) in Hosur Taluk. *IJBMI*, **2**(5): 15-25.

Tzortzakis, N.G. 2009. Effect of pre-sowing treatment on seed germination and seedling vigour in endive and chicory. *Horti. Sci.*, **36:** 117-125.

Vimala, B. and Pratap, M. 2014. Effect of different priming methods on seed quality, biochemical changes and storability of China Aster (*Callistephus chinensis* L. Nees). *J. Hort.,***1:** 115.

Zaidi, M.S., Tabatabaei, A., Younesi, E., Rostami, M.R. and Mombeni, M. 2013. Hormone priming improves germination characteristics and enzyme activity of sorghum seeds *(Sorghum bicolor* L.) under accelerated ageing. *Cercetari Agronomice Moldova*, **46:** 49-55**.**