Environment and Ecology 40 (3C) :1653—1663, July—September 2022
ISSN 0970-0420

Seed Priming and Storage Interaction Affects the Flowers Quality for Annual Chrysanthermum *(Chrysanthemum Coronarium)*

Poonam Dahiya, Manpreet Kaur, S.K. Sehrawat, Ritu Yadav, Ajay Verma

Received 21May 2022, Accepted 11 June 2022, Published 26 August 2022

ABSTRACT

Interaction effects of priming and storage on Chrysanthermum seeds were estimated to pint out the positive affect to improve the plant stand and other flowering traits. Of the genotypes screened for seed quality in fresh and accelerated seeds during storage, genotype 1 performed significantly better as compared to other genotypes. Priming with 0.5% KNO_3 in fresh and accelerated aged seeds showed significant improvement in seed quality parameters. The storage of seeds for (0, 2,4,6,8 and 10 months duration) exhibited better quality parameters after the seeds treated with 0.5% KNO_3. Priming treatments were found more effective in improving the seed quality parameters in accelerated aged seeds and in case of storage duration also.

Keywords Accelerated ageing, Priming, $CaCl_2$, KNO_3, GA_3.

Poonam Dahiya[1], Manpreet Kaur[1]*, Ritu Yadav[1]
Department of Horticulture, CCS Haryana Agricultural University, Hisar, India

S.K. Sehrawat
College of Agriculture and Director of Research CCSHAU, Hisar, India

Ajay Verma
ICAR-Indian Institute of Wheat & Barley Research, Karnal 132001, Haryana, India
Email :1294manpreet@gmail.com
*Corresponding author

INTRODUCTION

The quality of the seed had been assessed by genetic purity and germination percentage after proper storage (Adinde *et al*. 2020). The number of standardized tests to check the quality and storability of different crop seeds has been proposed International Seed Testing Association (Dorajeerao and Mokashi 2021). The seed has been emphasized as an important component of the strategy to improve agricultural production and the good quality of seed would prove to be as a catalyst for realizing potential of all other inputs (Jena and Mohanty 2021). Deterioration of stored seed is a serious problem in India therefore seed priming has been exploited to increase the seed quality of stored seed lot (Kedar *et al*. 2022).Seed deterioration is the inseparable aspect of ageing. The climatic conditions

of country favors seed deterioration even under ambient storage conditions resulted loss of seeds viability (Raj and Raj 2019). Complete avoidance of seed deterioration during storage is not possible, it can be however, slowed down or maintained through altering storage techniques and conditions (Mirmazloum *et al.* 2020). Several techniques have been developed to maintain the viability of seeds by treating them with fungicides, chemicals, growth regulators.

Annual chrysanthemum is recognized as highly remunerative flower crop, but its successful cultivation for higher yield potential and quality of flowers is suffered with several limiting factors (Tymoszuk and Kulus 2020). The production of pure and viable seeds with ambient germination percentage, healthy growth and vigour, flowering and better quality of flowers have been figured out with use of certain growth regulators, balanced use of fertilizers and improving the cultural practices (Sisodia *et al*. 2018, Tymoszuk 2021). There are various treatments with chemicals like GA_3, Calcium chloride and KNO_3, are found beneficial to increase the storage life of the seeds (Vishvanathan *et al.* 2020). The priming treatments hydrate the seed to a point where germination process begins. More important is to stimulate the cost-effective strategies that ensures better crop stand and quality would supplement to farmers returns (Waqas *et al*. 2019).

MATERIALS AND METHODS

The seed material for the present investigation was collected from Horticulture farm, Department of Horticulture CCS Haryana Agricultural University Hisar. The present study was carried out on annual chrysanthemum seeds of four lines which were harvested during April 2018-19. The harvested seeds of Genotype-1 (White double), Genotype-2(Yellow semi double) , Genotype-3(White semi double) and Genotype-4(Yellow double) were exposed to priming treatments for 6 hours along with control treatment as hydro priming, Calcium Chloride $CaCl_2$ @ 2%, 4%, Potassium Nitrate KNO_3@ 0.5%, 1.0% and Gibberellic acid GA_3@ 100, 200, 300 ppm followed by dehydration at room temperature. Data were recorded for 15 days on a daily basis for emergence with subsequent seedling assessment protocol as given in the handbook of the Association of Official Seed Analysts (Reddy 2018). Ultimate germination percentage was calculated at the end of 15th day. Sufficient number of seeds from different seed genotypes were placed over filter paper soaked in solution of the desired treatment in a beaker and kept it at room temperature. The seeds were allowed to imbibe solution for 6 h in all the treatments. After the completion of treatment period, the seeds were dehydrated at room temperature. SAS version 9.3 along with JMP 9 was exploited for analysis and graphical presentations.

RESULTS AND DISCUSSION

Germination percentage

All of the priming treatments had shown a significant effect on the germination percentage of the annual chrysanthemum (Fig. 1). Standard germination (minimum) of annual chrysanthemum was 50%. Primed seeds stored for 8 months have shown above 50% of germination percentage and after 8 months, the germination percentage falls below the minimum standard germination (Sidana *et al*. 2019). Germination percentage decreased significantly with time period of storage for all the seed priming treatments. Storage of seeds for 2, 4, 6, 8 and 10 months of duration observed best average values by treatment T4 (0.5% KNO3) and seeds of genotype G1 found superior among all four genotypes. At 0 month storage period treatment T4 (0.5% KNO_3) and genotype G1 was highly significant compared to all other treatments and genotypes. For 2, 4, 6, 8 and 10 month storage, T4 and G1 produced highest germination percentage. The positive effect of KNO_3 may be possible due to its role in influencing the permeability of membranes, which ultimately cause activation of enzymes involved in protein synthesis, carbohydrate metabolism (Szollosi *et al*. 2020).

Shoot length

The perusal of Fig. 2 revealed that the fresh seeds treated with 0.5% KNO_3 exhibited significantly higher shoot length than that of other treatments taken in the experiment and genotype G1 is found superior among all four genotypes. Significant decrease in the shoot length was observed with 2, 4, 6, 8 and 10 months

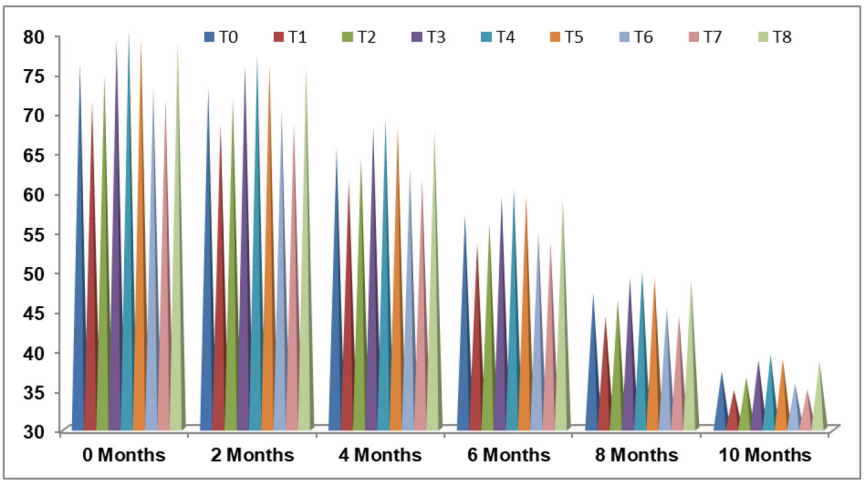

Fig. 1. Seed priming and storage affects germination percentage.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature.
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.
T_7 – 00 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.
T_8 –300 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.

of the storage duration. Effect of priming treatments on shoot length of annual chrysanthemum seeds is explained in Figure 2. It was recorded that treatment T4 (0.5% KNO_3) and G1 was highly significant compared to all other treatments and genotypes respectively. The better performance of KNO_3 may be due to lower electrical conductivity of the seed leachates, high amount of total and reducing sugars along with increase in alpha-amylase activity (Mangena 2019).

Root length

The fresh seeds treated with 0.5% KNO_3 exhibited significantly higher average root length (Figure 3) than that of other treatments taken in the experiment and genotype G1 is found superior among all four genotypes. Significant decrease in the root length was seen with the storage duration of 2, 4, 6, 8 and 10 months. It was seen that treatment T4 (0.5% KNO_3) was highly significant compared to all other treatments whereas genotype G1 was highly significant as compare to all other genotypes. During the storage months similar trend was noticed (Rakshit *et al*. 2015). The better performance of KNO_3 might be due to its accumulation in the embryo and during priming the embryo expands and hence, compresses the endosperm. The compression force of embryo and hydrolytic activities on the endosperm cell walls may also deform the tissues that lost their flexibility due to dehydration, producing free space and facilitating root protrusion after rehydration and also due to the presence of essential nutrients like nitrate and potassium, priming with KNO_3 can results into further growth of primed seedlings (Zulueta *et al.* 2015).

Seedling length

The data in Fig. 4 revealed that the fresh seeds treated with 0.5% KNO_3 significantly higher average seedling length than that of other treatments taken in the experiment and genotype G1 was found superior among all four genotypes. Significant decrease in the seedling length was observed for 2, 4, 6, 8 and 10 months of the storage duration for all the seed priming treatments irrespective of genotypes as similar behavior expressed by four considered genotypes of chrysanthemum (Ullah *et al*. 2019).

Seedling dry weight

The various priming treatments had significant effect

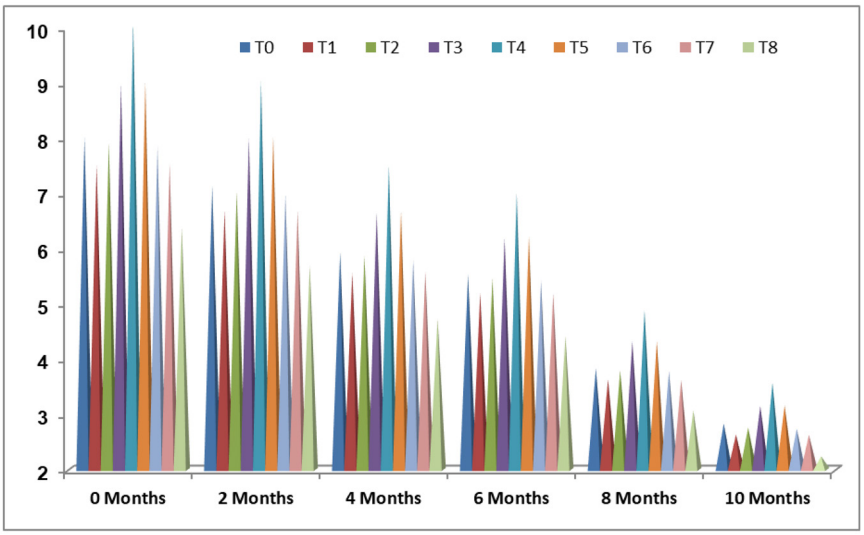

Fig. 2. Seed priming and storage affects shoot length.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature.
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_7 – 200 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_8 – 300 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.

on the seedling dry weight in annual chrysanthemum. The data in figure revealed that the fresh seeds treated with 0.5% KNO_3 significantly higher average seedling dry weight than that of other treatments taken in the experiment and genotype G1 is found superior among all four genotypes. Significant decrease in the seedling dry weight is observed with the storage duration of 2, 4, 6, 8 and 10 months. The variations found in seedling dry weight due to the priming treatments and fresh annual chrysanthemum seeds are given in the Fig. 5. Treatment T4 (0.5% KNO3) was highly significant as compared to all other treatments taken, whereas genotype G1 was highly significant as compared to all other genotypes at 0 month storage. For rest of storage period, similar results were observed. The better performance of KNO_3 is possible due to in particular, potassium ions leads to the activation of many enzymes involved in the formation of starch and protein. Potassium ions can also be absorbed by plant cells and may activate many enzymes which are essential for photosynthesis and respiration processes and the formation of starch and proteins. K+ion would act as co-enzyme that favors additional anabolic processes when compared to the other treatments (Hawa *et al*. 2018).

Vigour index-2

The perusal of Fig. 6 explained that fresh seeds treated with 0.5% KNO_3 exhibited significantly higher average vigour index than that of other treatments taken in the experiment and genotype G1 is found superior among all four genotypes. Significant decrease in the vigour index is observed with the storage duration of 2, 4, 6, 8 and 10 months as the germination percentage and seedling dry weight is also go on decreasing with the storage duration. The perusal of data presented in figure indicated that T4 (0.5% KNO_3) was proved highly significant if we compare it to all other treatments whereas genotype G-1 49 was

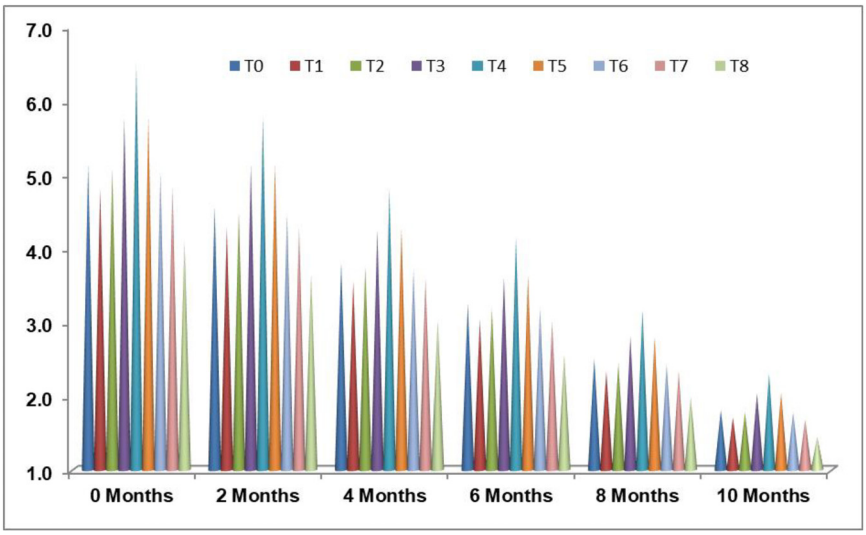

Fig. 3. Seed priming and storage affects root length.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature.
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.
T_7 – 200ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_8 – 300ppm GA_3 (Soaking for 6 h) and dehydration at room temperature,

highly significant compared to all other genotypes at 0 month storage. Similar results were observed in more month storage of annual chrysanthemum seeds (Hawa *et al*. 2018a). Our results are similar to the finding of Tiwari *et al* (2014) in pigeon pea seeds. The better performance of KNO_3 might be because of decreased electrolyte leakage and increase in the level of soluble sugar contents which are proportional to increased vigour index in annual chrysanthemum seeds under different storage period (Bagheri *et al* 2019).

Electrical conductivity

The various priming treatments had significant effect on the electrical conductivity in Annual chrysanthemum (Fig. 7). The fresh seeds treated with 0.5% KNO_3 significantly lower electrical conductivity than that of other treatments taken in the experiment and genotype G1 was found superior among all the four studied genotypes. Significant increase in the electrical conductivity was observed with 2, 4, 6, 8 and 10 months of storage for the primed seeds. Electrical conductivity in the annual chrysanthemum seeds of different treatment at 0 month storage was found desirable in the treatment T4 compared to all other treatments (Dutta 2018). Among different genotypes G1 was highly significant as compared to other genotypes as presented in the figure. This might be due to destructive changes in cellular membrane system resulting in more leakage of organic solutes (free sugars, fatty acids and amino acids) (Padhi *et al.* 2018). Damage to membrane system can be repaired and protected from such changes by invigouration treatments with KNO_3 as evidenced by low electrical conductivity of seed leachates, which presumably have extended the viability of seeds. The differential EC values observed among the seed treatments indicate the nature and extent of membrane protection offered, which may not be the similar in all seed

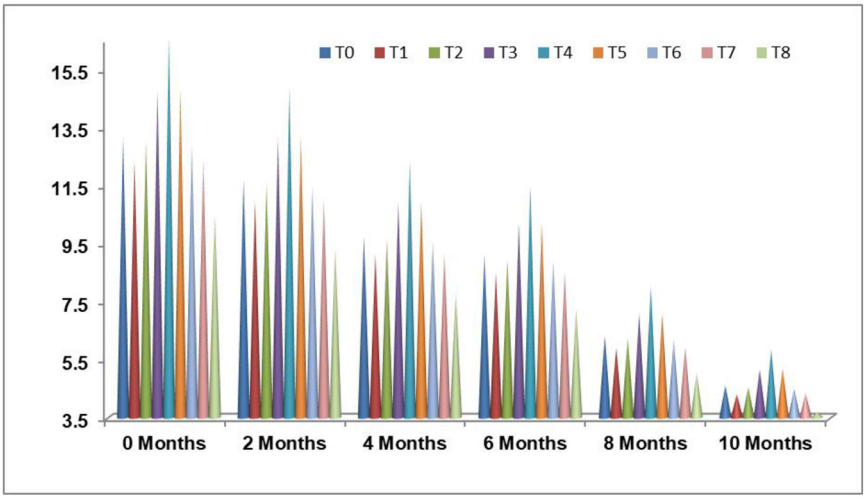

Fig. 4. Seed priming and storage affects seedling length.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_7 – 200 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_8 – 300 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.

priming treatments, thus resulting in difference in EC (Damalas *et al.* 2019).

Catalase activity

The data in Fig. 8 revealed that fresh seeds treated with 0.5% KNO_3 exhibited significantly higher catalase activity than that of other treatments taken in the experiment and genotype G1 is found superior among all four genotypes. Significant decrease in the catalase activity is observed with the storage duration of 2, 4, 6, 8 and 10 months, respectively. During the course of present study, activities of enzymes i.e. catalase, peroxidase, dehydrogenase and superoxidedimutase are affected by different storage and treatment conditions (Pangtu *et al.* 2018). Effect of priming treatment on these activities if enzyme of annual chrysanthemum seeds was explained with the help of figure. It was observed that treatment T4 (0.5% KNO_3) was highly significant compared to all other treatments whereas genotype G1 was highly significant as compared to all other genotypes at 0 month storage. There appears to be some correlation between the decline in gaseous exchange and reduced activity of respiratory enzyme i.e, dehy rogenase and peroxidase in non viable seeds (Mustafa *et al.* 2017).

Peroxidase activity

The various priming treatments had significant effect on the peroxidase activity. Marginal changes had observed among primed seeds for 0 and 2 months of storage. The data in Fig. 9 revealed that fresh seeds treated with 0.5% KNO_3 exhibited significantly higher catalase activity as compared to other treatments taken in the experiment and genotype G1 is found superior among all four genotypes. Significant decrease in the peroxidase activity was observed with the storage duration of 2, 4, 6, 8 and 10 months, respectively.

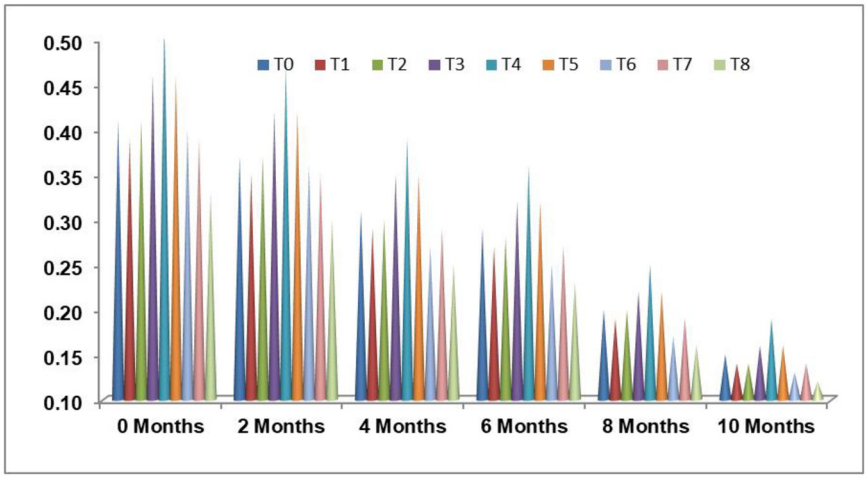

Fig. 5. Seed priming and storage affects seedling dry weight.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature.
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_7 – 200 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_8 – 300 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.

Dehydrogenase activity

An increase in DHA activities had been expressed by treatments from 0 to 10 months of storage. However, only marginal change observed among treatments from 8 to 10 months of storage. The perusal of figure 10 revealed that fresh seeds treated with 0.5% KNO_3 exhibited significantly desirable dehydrogenase activity as compare to other treatments taken in this experiment. Genotype G1 was found superior among all the four studied genotypes for the present study. Significant increase in the dehydrogenase activity was observed with the 2, 4, 6, 8 and 10 months of storage duration.

Superoxidedimutase activity

Variation among the SOD activity values among primed genotypes seeds vis-à-vis their storage duration portrayed in Fig. 11. The fresh seeds treated with 0.5% KNO_3 exhibited significantly desirable SOD activity over the other treatments (Fig. 11) and genotype G1 was found superior among all four genotypes. More or less similar values were expressed by primed seeds for 0 and 2 months of storage. Primed treatments T3 and T6 achieved more values in comparison to other treatments irrespective of storage duration. Significant increase in the superoxidedimutase activity was observed with the storage duration of 2, 4, 6, 8 and 10 months.

CONCLUSION

After accelerated aging of the seed genotypes, genotype1 was found to have significantly higher standard germination as compared to other seed genotype indicating superiority over others genotypes taken in this experiment, treatment T4 (0.5% KNO_3) shown higher standard germination as compared to other treatments. Priming of fresh and aged seeds with 0.5% KNO_3 significantly improved all the parameters viz., seedling length, viability percentage, dry weight, vigour index, enzyme activity, standard germination. Also, in case of electrical conductivity genotype1 and T4 given better results as compare to all other

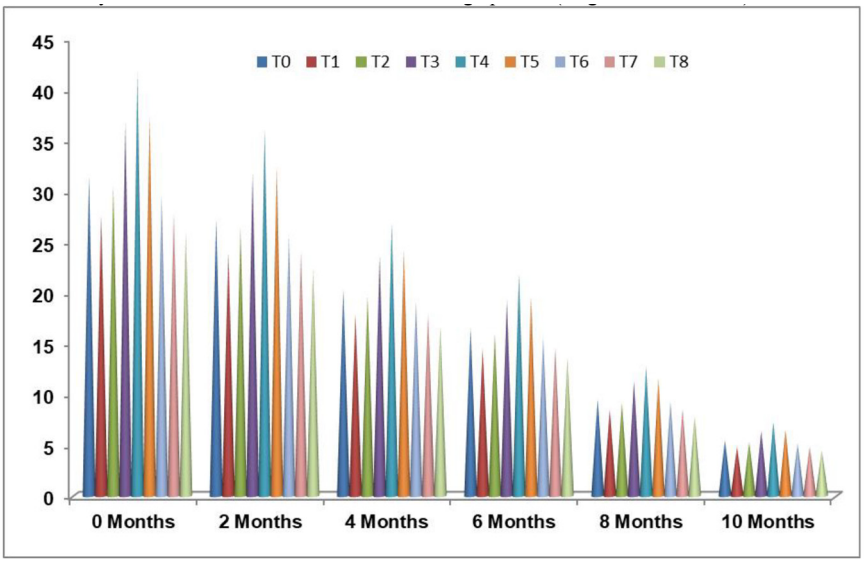

Fig. 6. Seed priming and storage affects vigour index 2.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_7 – 200 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_8 – 300 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.

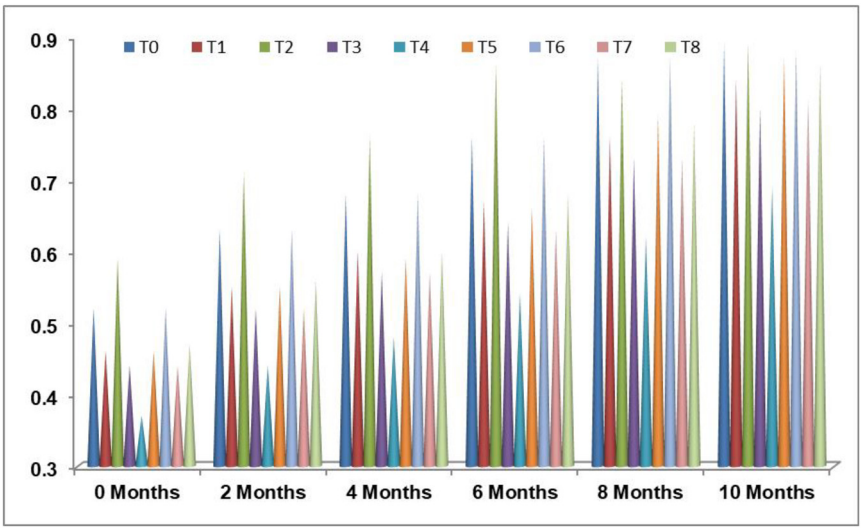

Fig. 7. Seed priming and storage affects electrical conductivity.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature.
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_7 – 200 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.
T_8 – 300 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.

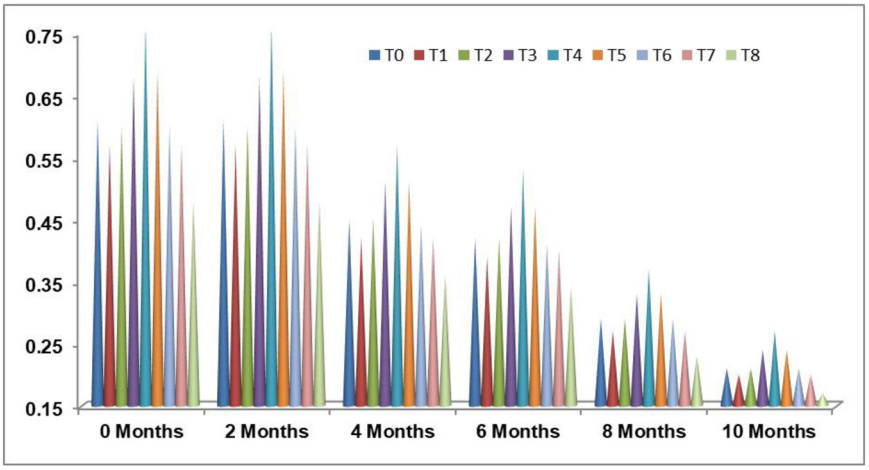

Fig. 8. Seed priming and storage affects Catalase activity.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature.
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature.
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100 ppm GA_3 (Soaking for 6 h) and dehydration at room temperatureT_7 – 200 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_8 – 300 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.

genotype and treatments taken here in this experiment and it decrease the permeability of cell membrane by repairing process which results in to lower electrical conductivity, clearly forward and confirm that prim-

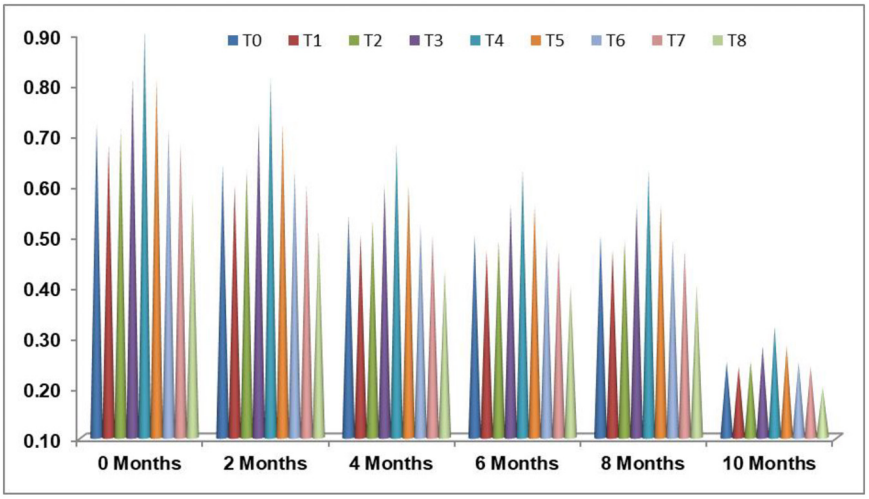

Fig. 9. Seed priming and storage affects Peroxidase activity.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.
T_7 – 200 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_8 – 300 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.

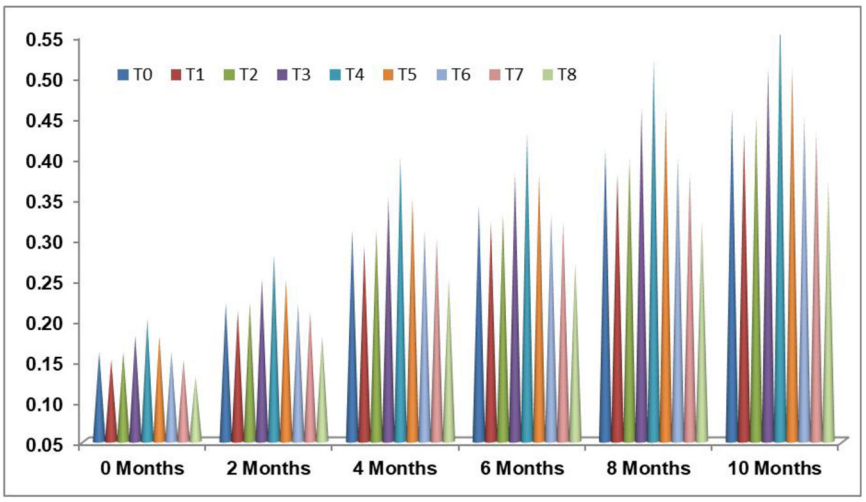

Fig. 10. Seed priming and storage affects DHA activity.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature.
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_7 – 200 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_8 – 300 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.

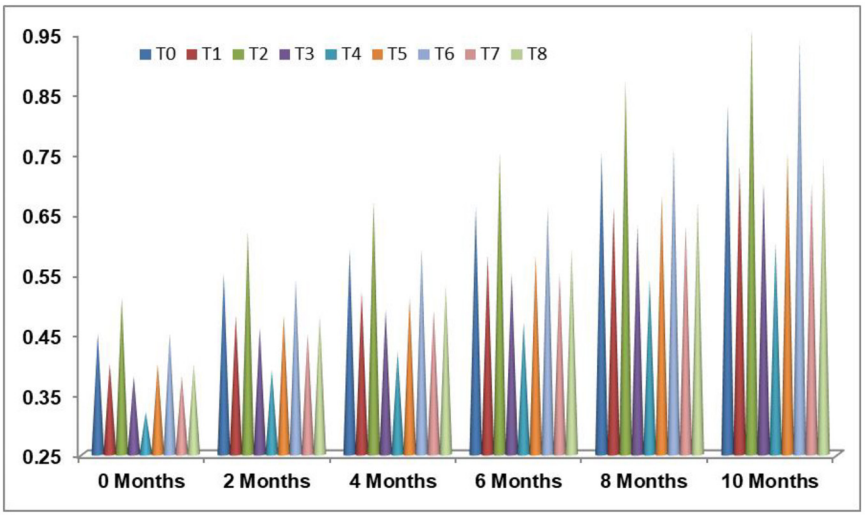

Fig. 11. Seed priming and storage affects SOD activity.

T_0 – Untreated (control)
T_1 – Hydration (Soaking for 6 h) and dehydration at room temperature
T_2 – 2% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_3 – 4% $CaCl_2$ (Soaking for 6 h) and dehydration at room temperature
T_4 – 0.5% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_5 – 1% KNO_3 (Soaking for 6 h) and dehydration at room temperature
T_6 – 100 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.
T_7 – 200 ppm GA_3 (Soaking for 6 h) and dehydration at room temperature
T_8 – 300ppm GA_3 (Soaking for 6 h) and dehydration at room temperature.

ing boost the repair mechanism of seed. Priming with 0.5% KNO_3 in fresh, extracted seeds storage duration seeds (2, 4, 6, 8 and 10 month) shown significant improvement in the quality of the seeds.

REFERENCES

Adinde J, Omeje TE, Uche OJ, Agu CJ (2020) Impact of hydro-priming duration on seed germination and emergence indices of sweet basil. *J Agric Sci Prac* 5: 1–7.

Bagheri N, Alizadeh O, Sharaf Zadeh S, Aref F, Ordookhani K (2019) Evaluation of auxin priming and plant growth promoting Rhizobacteria on yield and yield components of wheat under drought stress. *Euras J Biosci* 13: 711–716.

Damalas CA, Koutroubas SD, Fotiadis S, Damalas A, Koutroubas D (2019) Hydro-priming effects on seed germination and field performance of faba bean in spring sowing. *Agriculture* 9: 201.

Dorajeerao AVD, Mokashi AN (2021) Yield and quality parameters of garland chrysanthemum (chrysanthemum coronarium l.) as influenced by growth regulators/chemicals. *Ind J Pl Sci* 41(1):16-21.

Dutta P (2018) Seed Priming: New Vistas and Contemporary Perspectives; Springer, pp 3–22.

Hawa RA, Gonane SU, Panchbhai DM (2018a) Effect of planting on yield of annual chrysanthemum. *Int J Agric Sci* 10:6890-6892.

Hawa RA, Gonane SU, Panchbhai DM (2018)Effect of planting time and pinching on flower quality of annual chrysanthemum *J Pharmacog Phytochem* 10(1):80-83.

Jena S, and Mohanty CR (2021) Effect of spacing on growth and flowering of annual chrysanthemum (*Chrysanthemum coronarium* L.). *The Pharma Innov J* 10 (2):495-498.

Kedar DP, Panchbhai DM, Chatse DB (2022) Effect of different methods for increasing growth, flowering and yield of annual chrysanthemum. *The Pharma Innov J* 11(3): 1003-1006.

Mangena P (2019) Effect of Hormonal Seed Priming on Germination, Growth, Yield and Biomass Allocation in Soybean Grown under Induced Drought Stress. *Ind J Agric Sci: A-441.*

Mirmazloum I, Kiss A, Erdelyi E, Marta L, Nemeth EZ, Radacsi P (2020) The effect of osmopriming on seed germination and early seedling characteristics of *Carum carvi* L. *Agriculture* 10: 94.

Mustafa HS, Mahmood T, Ullah A, Sharif A, Bhatti AN, Nadeem M, Ali R (2017) Role of seed priming to enhance growth and development of crop plants against biotic and abiotic stress. *Bull Biol All Sci* 2: 1–11.

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

Pangtu S, Sharma BP, Dilta BS, Chaudhary SVS (2018) Effect of seed priming on seed parameters of China aster (*Callistephus chinensis* (L) Nees.). *Agric Int* 5(1):43-48.

Raj A, Raj S (2019) Seed priming: An approach towards agricultural sustainability. *J Appl Nat Sci* 11: 227–234.

Rakshit A, Sunita K, Pal S, Singh A, Singh HB (2015) Bio-priming mediated nutrient use efficiency of crop species. In Nutrient Use Efficiency: From Basics to Advances; Springer: New Delhi, India, pp 181–191.

Reddy PP (2018) Bio-priming of seeds. In recent advances in crop protection; springer: New Delhi, India 2012: 83–90.

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

Sisodia A, Padhi M, Pal AK, Barman K, Singh AK Seed (2018) Priming on Germination, Growth and Flowering in Flowers and Ornamental Trees. In: Rakshit A, Singh H (eds). Advances in Seed Priming, Springer pp 263-288.

Szollosi R, Molnár Á, Kondar S, Kolbert Z (2020) Dual effect of nanomaterials on germination and seedling growth: Stimulation vs. phytotoxicity. *Plants* 9: 1745.

Tymoszuk A (2021) Silver nanoparticles effects on *In vitro* germination, growth, and biochemical activity of tomato, radish, and Kkle sedlings. *Materials* 14: 5340.

Tymoszuk A, Kulus D (2020) Silver nanoparticles induce genetic, biochemical, and phenotype variation in chrysanthemum. *PCTOC 1*43: 331–344.

Ullah A, Farooq M, Hussain M, Wakeel A (2019) Zinc seed priming improves stand establishment, tissue zinc concentration and early seedling growth of chickpea. *J Anim Pl Sci.* 29: 1049–1053.

Vishvanathan M , Rathnavel G , Karunanandham K , Vellaichamy G, Adhimoolam K, Jegadeesan R (2020) Seed priming: A feasible strategy to enhance drought tolerance in crop plants. *Int J Mol Sci* 21: 8258

Waqas M, Korres NE, Khan MD, Nizami AS, Deeba F, Ali I, Hussain H (2019) Advances in the Concept and Methods of Seed Priming Singapore, pp 11–41.

Zulueta R R, Hernández MLG, Murillo AB, Rueda PEO, Capistrán LL, Diéguez ET, Cordoba M (2015) Effect of hydro-priming and biopriming on seed germination and growth of two Mexican Fir Tree Species in danger of extinction. *Forests* 6 : 3109–3122.