*International Journal of Plant & Soil Science*

***34(23): 156-163, 2022; Article no.IJPSS.92176***
***ISSN: 2320-7035***

# Effect of Seed Priming on Germination, Plant Growth and Flowering of Cockscomb (*Celosia spp.*) Under Prayagraj Agro Climatic Conditions

**Ch. Priyanka [a*#], Vijay Bahadur [b†] and V. M. Prasad [c]**

*[a] Horticulture (Floriculture and Landscaping), Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India.*
*[b] Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India.*
*[c] Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj – 211007, Uttar Pradesh, India.*

***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

***Article Information***

DOI: 10.9734/IJPSS/2022/v34i2331575

**Open Peer Review History:**
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/92176

***Original Research Article***

***Received 17 July 2022***
***Accepted 20 September 2022***
***Published 23 September 2022***

## ABSTRACT

The present experiment was carried out during August, 2021 to January, 2022 in Research Field, Department of Horticulture, SHUATS, Prayagraj. The experiment was conducted in Completely Randomized Block Design (CRBD), with nine treatments, replicated thrice, with an aim to identify the most suitable variety under the agro climatic conditions of Prayagraj. From the present experimental findings, It is concluded from the present investigations that nine treatments under study showed significant variation in all the parameters observed. To study on effect of seed priming on germination, plant growth and flowering of cockscomb (*Celosia spp*.). The experiment consisted with two varieties i.e *Celosia cristata* L. and *Celosia argentea* var. *spicata*. seeds were primed with $CaCl_2$ and salicylic acid. *Celosia cristata* L. Seeds were primed with $CaCl_2$ (0.56% and (2%), Salicylic Acid (0.02% and 0.04%). *Celosia argentea* var. *spicata* seed were primed with $CaCl_2$ (4% and 6%), Salicylic Acid (0.06% and 0.08%) the best performance in terms of Days to first seedling emergence (8.33), Days to 50% emergence (11.33), Mean emergence time (11.20), Emergence percentage (92), Emergence index (2), Vigor index (901.33), plant height (68.55 cm),

*[#] Research Scholar, M.Sc. (Agriculture);*
*[†] Professor;*
**Corresponding author: E-mail: ch.priyanka818@gmail.com;*

number of leaves (47.44), days taken to flower bud formation (21.88), days taken to flowering (31.88), number of flowers per plant (25.44) and benefit cost ratio (7.58) gave best result in $T_5$ Salicylic acid 0.004% as compared to other treatments in terms of seedling, growth and floral parameters.

*Keywords: Cockscomb; seed priming; salicylic acid; $CaCl_2$.*

## 1. INTRODUCTION

Cockscomb is an attractive ornamental plant with beautiful vibrant coloured inflorescence. Due to the flower's resemblance to the head of a cock, it is commonly known as cockscomb. Although they are often lower in size, these non woody plants can typically reach heights of up to one foot. In addition to a few Asian nations, it is frequently grown in Africa, South America, and India. The plants thrive both indoors and outdoors and are disease-resistant. Due to their susceptibility to fungal infections, these plants thrive in areas that are not shaded and require well-drained soil. Cockscomb blossoms have a surface that is tightly packed and velvety, like brain tissue. The lighter, fluffier, and hairier surfaces of the various types of plumes blow freely in the wind and are more firmly grounded. The seeds may easily be used to grow more plants because they are highly resilient. These plants can be propagated during the summer months in cooler climates. Three months out of every year are dedicated to growing this annual plant. Its growth and development require a temperature of 60°F Grant, [1].

In beds and mixed borders, cockscomb creates a spectacular display. Their leaves and blooms can be eaten like vegetables. Plumosa and Spicata kinds work well for fresh flower bouquets, whereas Cristata cultivars flourish in containers. All dry successfully. Celosia can be preserved by removing the leaves, cutting the flower heads off before the seeds form, and hanging the flowers upside down in a warm location with adequate air circulation. The flowers are bitter, styptic, astringent, depurative, urinary sadative, antibacterial, constipating, and corrective of alexiteric, febrifuge, and urinary pigments. The plant's edible leaves and astringent blossoms are used in India to treat diarrhoea, haemorrhoids, and bloody stools National Research Council, [2]. To cure dysentery, use the seed decoction Shanmugam et al. [3]. The leaves are also used in Chinese medicine to cure worms, inflammation, menstrual bleeding, and diarrhoea Navarra, [4]. Hepatoprotective effects of the C. cristata seeds have been reported Wang et al. [5]. Additionally, the herb possesses antioxidant and anti-aging qualities Pyo et al. [6]. Leprosy, skin conditions, burning feeling, diarrhoea, fever, headache, internal bleeding, herpesleukorrhea, menorrhagia, liver disorders, wounds, and ulcers have all been proven to benefit from their use. Leaf juice is used to treat illnesses. The seed is hypotensive and ophthalmic. It is used to treat hypertension, blood pressure, bloodshot eyes, and blurred vision Cai et al. [7].

Seed priming is generally a physiological seed quality improvement method which offers a hydration treatment that permits controlled imbibition and induction of the pre-germinate metabolism (activation), but the radicle emergence is prevented. Mondal et al. [8]. In many horticultural plants, various seed priming strategies are employed to improve stand, allometric characteristics, uniform emergence, and shorter emergence times Ashraf et al. [9]. Among them were hormonal priming, osmohardening, osmoconditioning, and hydropriming Basra et al. [10]. According to Afzal et al. [11], different seed priming techniques have been thoroughly developed in many plants. Seed priming is also effective under suboptimal field conditions such salinity stress, high or low temperature, and low moisture availability to plants Basra et al. [12]. Halopriming is an effective pre-germination strategy, according to Patade et al. [13] for reversing the negative effects of salinity and drought on sugarcane. Afzal et al. [14] found that priming increased salt tolerance in wheat crop plants and was associated with increased potassium and calcium uptake, higher seedling vigour, and lower Na+ build-up. This study's goal was to determine how seed priming affected seedling growth, plant growth and flowering of cockscomb under Prayagraj agro climatic condition.

## 2. MATERIALS AND METHODS

The field experiment was carried out at Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj to find out the best performing varieties for this region.

## 2.1 Geographical Location of the Experimental Site

The experimental site is being located at a latitude of 25.41° North and longitude of 81.84° East, with an altitude of 98 meters above the mean sea level (MSL).

## 2.2 Climatic Conditions in the Experimental Area

The experiment was carried out at the Department of Research Field, Department of Horticulture, Naini Agriculture Institute, Sam Higginbottom University of Agriculture, Technology, and Science, Prayagraj (2021-22), which is located in the agro-climatic zone of Uttar Pradesh (sub-tropical belt)Prayagraj is a city in the Indian state of Uttar Pradesh. Prayagraj is located in agro-climate zone IV, which is known as the "middle Gangetic plains." The site of the experiment is located at 98 metres above sea level at 25.57° N latitude 81.51°E longitude and has a typical subtropical climate with summer and winter extremes. The maximum temperature of the location reaches up to 46°C - 48°C and rarely falls as low as 4°C-5°C during winter. The average rainfall in this area is around 1027 mm annually with maximum concentration during July to September with few showers and drizzles in winter.

## 2.3 Biologic Material

The experiment was conducted with Two cockscomb varieties were used. They were *Celosia cristata* ($V_1$); *Celosia argentea* var. *spicata* ($V_2$).

## 2.4 The Experimental Design and Parameters Determined

### 2.4.1 Experimental design

The trail was laid out in Completely Randomized block design (CRBD) with 9 treatments which have been replicated 3 times. Two cockscomb varieties were used. They were *Celosia cristata* ($V_1$); *Celosia argentea* var. *spicata* ($V_2$).

### 2.4.2 Seedling Parameters

Days to first seedling emergence, Days to 50% emergence, Mean emergence time, Emergence percentage, Emergence index, Vigor index.

### 2.4.3 Growth Parameters

Growth parameters measured in term plant height (cm), number of leaves per plant at 30,60, 90 and 120 days after transplanting.

### 2.4.4 Floral parameters

Days taken to flower bud formation, Days taken to flowering, Number of flowers per plant.

## 2.5 Statistical Analysis

The results and data were subjected to statistical analysis separately by using analysis of variance technique (ANOVA). The difference among treatments means was compared by using least significant difference test at 5% probability levels. To run this analysis OPSTAT Online Agriculture Data Analysis Tool by O.P. Sheoran statistical software was used.

# 3. RESULTS AND DISCUSSION

## 3.1 Seedling Parameter

Seedling parameters data are shown in Table 1. The number of Days to first seedling emergence was from 8.33 to 6.33.The maximum days to first emergence was found from $T_5$ (salicylic acid 0.04%) (8.33), followed by $T_8$ (salicylic acid 0.06%) (7.66), whereas the minimum days to first emergence was found in $T_7$ (CaCl2 6%) (6.33). Similar results were found in Khan et al. [15].

Significantly, the maximum days to 50% emergence was found from $T_5$ (Salicylic Acid 0.04%) (11.33), followed by $T_8$ (salicylic acid 0.06%) (11), whereas the minimum days to 50% emergence was found in $T_7$ ($CaCl_2$ 6%) (8). Seed priming through salicylic acid helps in the supply of the required nutrients and easy mobilization of food and early erection of plumule and radicle from the seed over other treatments and the results are in accordance with Varier et al*.* [16] Ghassemi-Golezani et al. [17] revealed that as the seed coat ruptures there is a chance of occurrence of soil borne diseases inturn as the seeds treated with salicylic acid holds resistance against any soil borne diseases and pathogens. Thus helping in the early and healthy emergence of seedling.

Significantly, the maximum mean emergence time was found from $T_5$ (Salicylic Acid 0.04%) (11.20), followed by $T_8$ (salicylic acid 0.06%) (10.92), whereas the minimum mean emergence time was found in $T_7$ ($CaCl_2$ 6%) (8.34). Kim et al*.* [18] stated from the experiments on Aster

koraiensis (Korean daisy) that mean germination time is the time taken for the seed to germinate as if in the treated seeds will germinate at a faster pace than the other seeds. During the seed treatment with salicylic acid the seed coat ruptures and helps in faster germination and early erection of radicle and plumule thereby reducing the mean emergence time.

Significantly, the maximum Emergence percentage was found from $T_5$ (Salicylic Acid 0.04%) (96), followed by $T_8$ (salicylic acid 0.06%) (94.66), whereas the minimum Emergence percentage was found in $T_7$ ($CaCl_2$ 6%) (92). Seed priming with Salicylic acid lead to high activities of antioxidant defensive enzymes and increase the tolerance level to abiotic stresses such as salt and drought which increased the emergence rate and the results are in accordance with Sedghi et al. [19]. Seed priming with salicylic acid (SA) enhanced seed vigor and salt tolerance there by enabling the seed coat to rupture and helping in enhancing the faster germination and provide the seeds with resistance from soil borne diseases. Similar results were shown by Varier et al. [16] and Ghassemi-Golezani et al. [17].

Significantly, the maximum Emergence index was found from $T_5$ (Salicylic Acid 0.04%) (2), followed by $T_8$ (salicylic acid 0.06%) (1.89), whereas the minimum Emergence index was found in $T_7$ ($CaCl_2$ 6%) (1.52) Similar results were found in Mavi et al. [20].

Significantly, the maximum Vigor index was found from $T_5$ (Salicylic Acid 0.04%) (901.33), followed by $T_8$ (salicylic acid 0.06%) (882.66), whereas the minimum Vigor index was found in $T_7$ ($CaCl_2$ 6%) (768). Seed priming with Salicylic acid may improve seed germination through synthesizing proteins, nucleic acid, enzymes; increasing respiratory action and energy reutilization by enhancing its vigor index as well as emergence energy and finally rise of radicle and plumule in primed seeds. Similar results were found in Pahoja et al. [21].

## 3.2 Growth Parameter

Growth parameters data are shown in Table 2. The range of plant height was from 68.55 to 40.88 cm. The tallest plant was found from $T_5$ (salicylic acid 0.04%) (68.55 cm), followed by $T_8$ (salicylic acid 0.06%) (67.33cm), whereas the lowest plant height was recorded in $T_7$ (CaCl2 6%) (40.88 cm). Salicylic acid increases plant growth by increasing the rate of cell division and cell growth in meristematic regions and reduces the damage of abiotic stresses in plants. It also interacts with plant hormones under different conditions. This compound inhibits the reduction of auxin and cytokinin hormones under stress. Considering the role of these hormones in the growth of plant cells, Salicylic acid improves the growth of plants and the results are in accordance with Mavi et al. [20].

Significantly, the number of leaves per plant was high in $T_5$ (salicylic acid 0.04%) (47.44), followed by $T_8$ (salicylic acid 0.06%) (46.11), and whereas the lowest number of leaves was found in the $T_7$ (CaCl2 6%) (36). More number of leaves per plant might be due to the fact that predenied division and enlargement of central cell in the leaf axis would be possible due to morphactin like salicylic acid as stated by Tavili et al. [22]. The exogenous application of Salicylic acid had effect on increased photosynthetic activity and cell division which enhances the number of leaves per plant. Salicylic acid induces alterations in leaf anatomy that consist of a reduced width of the epidermis and mesophyll tissue. Such changes correlate ultra-structurally with an increase in chloroplast volume, swelling of grana thylakoids, and coagulation of the stroma resulted into increase in leaf number. Similar results were found by Szopinska et al. [23] and Bahareh et al. [24].

## 3.3 Floral Parameter

Floral parameters data are shown in Table 3. Significantly, among all the treatment, the treatment 5 (salicylic acid 0.04%) (21.88) was recorded the maximum days for flower bud formation, which is followed by the treatment 8 (salicylic acid 0.06%) (21.66). Whereas the minimum days for flower bud formation was recorded in the treatment 7 (CaCl2 6%) ( 15.44). Once reaching the flowering stage, plants would allocate most of the current assimilates to support flower development and therefore the growth rates of vegetative plant parts would be reduced. Mushtaq et al. [25] reported from the experiments on Gladiolus alatus that higher days to flower bud initiation might have been possible due to more vigor and from the biochemical activities that were started helping in the early branches and bud formation by the plant as a result of better photosynthetic activities with sufficient availability of nutrients from the seed treatment during the growth stages. The results are in acceptance with Sharma et al. [26] and Pahoja et al. [21].

**Table 1. Effect of Seed Priming on Seedling parameters of Cockscomb**

| Treatment symbol | Treatments | Days to seedling emergence | Days to 50% seedling emergence | Mean emergence time | Percentage of seedling Emergence | Emergence index | Vigor index |
|---|---|---|---|---|---|---|---|
| $T_1$ | Control | 7.66 | 10 | 9.78 | 94.66 | 1.89 | 882.66 |
| $T_2$ | $CaCl_2$ (0.56%) | 7.33 | 10 | 9.65 | 93.33 | 1.68 | 850.66 |
| $T_3$ | $CaCl_2$ (2%) | 7.33 | 8.66 | 8.56 | 92 | 1.68 | 832 |
| $T_4$ | Salicylic Acid (0.02%) | 7.66 | 11 | 10.92 | 96 | 1.94 | 901.33 |
| $T_5$ | Salicylic Acid (0.04%) | 8.33 | 11.33 | 11.2 | 96 | 2 | 901.33 |
| $T_6$ | $CaCl_2$ (4%) | 6.33 | 8.33 | 8.45 | 92 | 1.68 | 818.66 |
| $T_7$ | $CaCl_2$ (6%) | 6.33 | 8 | 8.34 | 92 | 1.53 | 768 |
| $T_8$ | Salicylic Acid (0.06%) | 7.66 | 11 | 10.92 | 96 | 1.94 | 901.33 |
| $T_9$ | Salicylic Acid (0.08%) | 7.66 | 10.66 | 10.76 | 94.66 | 1.89 | 901.33 |
| **F Test** | | **S** | **S** | **S** | **S** | **S** | **S** |
| SE.d(±) | | 0.47 | 0.49 | 0.39 | 1.08 | 0.13 | 40.28 |
| CD@5% | | 0.99 | 1.05 | 0.82 | 2.30 | 0.28 | 85.29 |
| CV | | 7.83 | 6.15 | 4.86 | 1.41 | 9.19 | 5.72 |

**Table 2. Effect of Seed Priming on Growth parameters of Cockscomb at different days after transplanting (DAT)**

| Treatment symbol | Treatments | Plant height | | | | Leaves | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **30 DAT** | **60 DAT** | **90 DAT** | **120 DAT** | **30 DAT** | **60 DAT** | **90 DAT** | **120 DAT** |
| $T_1$ | Control | 15.66 | 24 | 45.11 | 53.11 | 18.22 | 26.66 | 31.99 | 43.88 |
| $T_2$ | $CaCl_2$ (0.56%) | 14.55 | 22.88 | 44.66 | 53.66 | 18 | 26.33 | 31.77 | 43.22 |
| $T_3$ | $CaCl_2$ (2%) | 13.33 | 20.77 | 41.44 | 53.66 | 17.88 | 25.55 | 30.66 | 42.88 |
| $T_4$ | Salicylic Acid (0.02%) | 17.22 | 30.22 | 50.44 | 65.88 | 18.66 | 26.88 | 32.55 | 45.22 |
| $T_5$ | Salicylic Acid (0.04%) | 19.22 | 40.33 | 60.55 | 68.55 | 19.11 | 28.66 | 35.33 | 47.44 |
| $T_6$ | $CaCl_2$ (4%) | 12.66 | 19.33 | 40.11 | 52.33 | 17.55 | 25.22 | 31.44 | 41.55 |
| $T_7$ | $CaCl_2$ (6%) | 10.66 | 19 | 32.33 | 40.88 | 15.33 | 25.22 | 31.44 | 36 |
| $T_8$ | Salicylic Acid (0.06%) | 17.66 | 30.44 | 57.77 | 67.33 | 18.88 | 28.66 | 32.66 | 46.11 |
| $T_9$ | Salicylic Acid (0.08%) | 16 | 27.33 | 50.11 | 58.33 | 18.55 | 26.66 | 32 | 45.11 |
| **F-Test** | | **S** | **S** | **S** | **S** | **S** | **S** | **S** | **S** |
| SED(≠) | | 2.17 | 5.70 | 7.44 | 7.93 | 0.95 | 1.10 | 1.12 | 2.95 |
| CD@5% | | 4.61 | 12.06 | 15.76 | 16.79 | 2.02 | 2.33 | 2.37 | 6.25 |
| CV | | 17.53 | 26.81 | 19.43 | 17.02 | 6.49 | 5.07 | 4.27 | 8.31 |

**Table 3. Effect of Seed Priming on Floral parameters of Cockscomb**

| Treatment symbol | Treatments | Days taken to flower bud initiation | Days taken to flowering | No of flowers per plant | | | |
|---|---|---|---|---|---|---|---|
| | | | | 30 DAT | 60 DAT | 90 DAT | 120 DAT |
| $T_1$ | Control | 19.11 | 29.55 | 6.11 | 12.11 | 16.77 | 22.77 |
| $T_2$ | $CaCl_2$ (0.56%) | 17.55 | 29.11 | 5.33 | 11.88 | 16.66 | 21.44 |
| $T_3$ | $CaCl_2$ (2%) | 17.33 | 27.55 | 5 | 9.88 | 14.77 | 20.55 |
| $T_4$ | Salicylic Acid (0.02%) | 19.44 | 31.66 | 8 | 12.88 | 17.55 | 23.22 |
| $T_5$ | Salicylic Acid (0.04%) | 21.88 | 31.88 | 8.44 | 14.33 | 18.88 | 25.44 |
| $T_6$ | $CaCl_2$ (4%) | 16.88 | 27.33 | 4.33 | 8.44 | 13.22 | 18.66 |
| $T_7$ | $CaCl_2$ (6%) | 15.44 | 25.44 | 3.66 | 8.11 | 13 | 17.77 |
| $T_8$ | Salicylic Acid (0.06%) | 21.66 | 31.66 | 8.33 | 13.44 | 18.33 | 24.33 |
| $T_9$ | Salicylic Acid (0.08%) | 19.33 | 30.55 | 7 | 12.33 | 16.88 | 23 |
| **F Test** | | **S** | **S** | **S** | **S** | **S** | **S** |
| SE.d(±) | | 1.10 | 1.22 | 1.54 | 1.86 | 1.83 | 2.22 |
| CD@5% | | 2.34 | 2.58 | 3.27 | 3.95 | 3.88 | 4.71 |
| CV | | 7.23 | 5.08 | 30.3 | 19.9 | 13.82 | 12.44 |

Significantly, among all the treatment, the treatment 5 (salicylic acid 0.04%) (31.88) was recorded the maximum days taken to flowering, which is followed by the treatment 8 (salicylic acid 0.06%) (31.66). Whereas the minimum days taken to flowering was recorded in the treatment 7 (CaCl2 6%) (25.44). The abundant supply of mineral nutrients was directly involved in the protoplasmic constituents and accelerates the process of cell division and elongation which in turn resulted in increased days to flowering as stated by Tavili et al. [22] and Pahoja et al. [21] said that higher number of flowers per plant might have been possible due to more vigor and strength attained by the plant as a result of better photosynthetic activities with sufficient availability of nutrients from the seed treatment during the growth stages. The results are in acceptance with Mavi et al. [20].

Significantly, among all the treatment, the treatment 5 (salicylic acid 0.04%) (25.44) was recorded the highest number of flowers per plant, which is followed by the treatment 8 (salicylic acid 0.06%) (24.33). Whereas the minimum number of flowers per plant was recorded in the treatment 7 (CaCl2 6%) (17.77). Rubio-Moraga et al. [27] stated that the role of Salicylic acid is attributable to improve vegetative growth and that lead to an increase in the absorption of nutrients, also it promotes photosynthesis in plant that lead to carbohydrate manufacturing which affected clearly in the differentiation of flowers and increased their number. Salicylic acid also involve in Auxin increasing, which enhance flower growth, whereas the elongation of vase life due to Salicylic acid role as an ethylene biosynthesis inhibitor that blocks the induction effect of ethylene on ACC-oxidase (1-aminocyclopropane-1- carboxylic acid) activity inhibition and consequently a delaying in flower senescence's symptoms occur and the results are in accordance with Tavili et al. [22].

## 4. CONCLUSION

It is concluded from the present investigation that seed priming significantly affected all the studied attributes. $T_5$ Salicylic Acid 0.04% i.e variety Celosia cristata L. was found superior in all the parameters like seedling parameters, growth parameters and floral parameters. As for economics concerned, $T_5$ Salicylic acid 0.04% i.e variety Celosia cristata L. has found best in seed yield with maximum B:C ratio 7.58.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES


1. Grant WF. A cytological study of *Celosia argentea, C. argentea var. Cristata*, and their hybrids. Botanical Gazette. 2012;115: 323-336.
2. National Research Council. Lost Crops of Africa. Volume II: Vegetables. The National Academies Home. Washington. 2006; 93-95.
3. Shanmugam S, Annadurai M, Rajendran K. Ethnomedicinal plants used to cure diarrhea and dysentery in Pachalur Hills of Dindigul district in Tamil Nadu, Southern Indian Journal of Applied Pharmacology Science. 2011;1:94-97.
4. Navarra T. The Encyclopedia of Vitamins, Minerals and Supplements. Facts on File, Inc.New York. 2004;2nd edn:44.
5. Wang Y, Ziyang L, Qing BW, Mei LG. A novel hepatoprotective from *Celosia cristata* L. Fitoterapia.2010;81:1246-1252.
6. Pyo YH, Yoon MY, Son JH, Choe TB. The effect of *Celosia cristata* L. ethanol extract on antioxidant and antiaging activity. Korean Journal of Biotechnology and Bioenergy. 2008;23:431-438.
7. Cai Y, Sun M, Schliemann W, Corke H. Chemical stability and colorant properties of betaxanthin pigments from Celosia argentea. Journal of Agriculture and Food Chemistry. 2001;49:4429-4435.
8. Ashraf M, Foolad MR. Does halopriming improve germination and seedling vigour in marigold (*Targetes spp*.). Seed Science Technology. 2005; 37:436-445.
9. Basra SMA, Farooq M, Tabassum R. Physiological and biochemical aspects of seed vigour enhancement treatments in fine rice (*Oryza sativa* L.). Seed Science Technology. 2005;33:623-628.
10. Afzal I, Basra SMA, Iqbal A. The effects of seed soaking with plant growth regulators on seedling vigour of wheat under salinity stress. J Stress Physiology and Biochemistry. 2005;1:6-14.
11. Basra SMA, Farooq M, Rehman H, Saleem BA. Improving the germination and early seedling growth in melon (*Cucumis melo* L.) by pre-sowing salicylicate treatments. International Journal of Agriculture Biology. 2007;9:550-554.

12. Patade VY, Bhargava S, Suprasanna P. Halopriming imparts tolerance to salt and PEG induced drought stress in sugarcane. Agriculture Ecosystem and Environment. 2009;134:24-28.
13. Afzal I, Rauf S, Basra SMA, Murtaza G. Halopriming improves vigor, metabolism of reserves and ionic contents in wheat seedlings under salt stress. Plant Soil Environment. 2008;54:382-388.
14. Mondal S, Bose B, Kharwar R, Upadhyay R, Dubey N, Raghuwanshi R. An Impact of Seed Priming on Disease Resistance. Microbial Diversity and Biotechnology in Food Security. 2014; 193–203.
15. Khan HA, Ayub CM, Pervez MA, Bilal RM, Shahid MA, and Ziaf K. Effect of seed priming with NaCl on salinity tolerance of hot pepper (*Capsicum annuum* L.) at seedling stage. Soil & Environ. 2009; 28(1):81-87
16. Varier, Anuradha Vari, Alice Dadlani, Malavika. The subcellular basis of seed priming Current Science. 2010;VL - 99
17. Ghassemi-Golezani K, Chadordooz-Jeddi A, Nasrullahzadeh S, and Moghaddam M. Influence of hydro-priming duration on field performance of pinto bean (*Phaseolus vulgaris* L.) cultivars African Journal of Agricultural Research. 2010;5(9):893-897.
18. Kang, Won Sik, Kim, Min Geun, Kim, Soo Young, Han Sim Hee, Kim, Du Hyun. Effect of Seed Priming and Pellet Coating Materials on Seedling Emergence of Aster koraiensis Journal of Korean Society of Forest Science. 2020;109:41-49.
19. Sedghi M, Ali N, and Esmaielpour B. Effect of seed priming on germination and seedling growth of two medicinal plants under salinity Emirates Journal of Food and Agriculture. 2010;22(2):130-139.
20. Mavi K, Ermis S, Demir I. The Effect of Priming on Tomato Rootstock Seeds in Relation to Seedling Growth. Asian Journal of Plant Sciences. 2006;5:940-947.
21. Pahoja VM, Siddiqui S, Javed, Umrani H. Response of hydropriming and osmopriming on germination and seedling growth of sunflower (*Helianthus annuus* l.) under salt stress. International Journal of Agricultural Science and Research. 2013 3:71 – 80.
22. Tavili A, Zare S, Amir Moosavi S, and Enayati A. Effects of Priming Techniques on Seed Germination and Early Growth Characteristics of *Bromus tomentellus* L. and *Bromus inermis* L. Notulae Scientia Biologicae. 2010;2:104-108.
23. Szopińska D, Politycka B. The effects of hydro- and osmopriming on the germination, vigour and hydrolytic enzymes activity of common zinnia (*Zinnia elegans* Jacq.) seeds. Folia Hort. 2016; 28:13-11.
24. Bahareh J, Shekari F, Azimi RM, Zangani E. Effect of priming by salicylic acid on germination and seedling growth of safflower seeds under cacl2stress. International Journal of Agriculture. 2012;2(s):1097-1105.
25. Mushtaq S, Ahmad Hafiz I, ZiaHasan S, Arif M, Asif M, Rafique S, Rasheed M, Ali M, and Shahid Iqbal M. Evaluation of seed priming on germination of *Gladiolus alatus*. African Journal of Biotechnology. 2012; 11(52):11520-11523.
26. Sharma R, Dilta BS, Baweja HS, Poonam kumari, Thaneshwari. Effect of Seed Priming and Planting Dates on Growth, Flowering and Seed Production of Pansy (*Viola x wittrockiana* Gams.) Annals of Biology.2018;34(2):176-180.
27. Rubio-Moraga, Ángela, Ahrazem, Oussama, Perez-Clemente, Gómez-Cadenas, Aurelio, Molina R, Gomez-Gomez Lourdes. Apical dominance in saffron and the involvement of the branching enzymes CCD7 and CCD8 in the control of bud sprouting. BMC Plant Biology. 2014;14:171.



*Peer-review history:*
*The peer review history for this paper can be accessed here:*
*https://www.sdiarticle5.com/review-history/92176*