*Pak. J. Biotechnol. Vol. 20(2), 293-300, **2023*** http://doi.org/10.34016/pjbt.2023.20.02.779

Research Article

OPEN ACCESS

Available on http://www.pjbt.org
Pakistan Journal of Biotechnology
(PJBT)
(P-ISSN: 1812-1837 and E-ISSN: 2312-7791)

HYDRO-PRIMING DURATIONS IMPROVE THE GERMINATION AND VEGETATIVE GROWTH OF OKRA (ABELMOSCHUS ESCULENTUS VAR. SABZ PARI).

Niaz Ahmed Wahocho[1], Muzamil Farooque Jamali[1*], Noor-un-Nisa Memon[1], Waqas Ahmad[2], Khalid Hussain Talpur[3], Piar Ali Shar[4], Afifa Talpur[1], Sohail Ahmed Otho[5], Fayaz Ali Jamali[1]

[1]Department of Horticulture, Sindh Agriculture University Tandojam, Pakistan
[2]College of Agriculture, University of Layyah, Pakistan
[3]Department of Soil Science, Sindh Agriculture University Tandojam, Pakistan
[4]Department of Plant Breeding and Genetics, Sindh Agriculture University Tandojam, Pakistan
[5]Department of Entomology, Sindh Agriculture University Tandojam, Pakistan
***Corresponding Author's email address**: **nawahocho@gmail.com**

Article Received 11-05-2023, Article Revised 16-08-2023, Article Accepted 10-10-2023.

ABSTRACT

The quality production of vegetable crops heavily reliant on faster and consistent germination of seeds. Due to harder seed coat, the seed germination and uniform seedling establishment in the field is always a problem in okra. Hydro-priming is one of the ideal, cheapest and environmentally friendly strategies to enhance the germination process of okra. The field trial was therefore designed in Department of Horticulture, Sindh Agriculture University Tandojam, Pakistan during 2022 to test the influence of seed hydro-priming durations on seed germination and vegetative growth of okra. The single factor randomized complete block design with three replications was followed to perform the trial. The seeds of Sabz pari, one of the most popular and widely grown varieties of the country were primed by applying six hydro-priming durations (viz; P1; Control, P_2: 12 hours, P_3: 18 hours, P_4: 24 hours, P_5: 36 hours, and P_6: 48 hours). Signification variation was found in most of the traits with the application of hydro-priming durations. The hydro-priming duration (48 hours) showed maximum water uptake and seed germination whereas, unprimed seed (control) recorded lower water uptake and germination. Likewise, tallest plants with maximum vigour with respect to seedling vigour index was recorded in 48 hours hydro-priming duration followed by 36 hours hydro-priming duration whereas smallest plant with less vigour was observed in control. The 48 hours priming duration also showed positive effect on leaf and root growth and development. Thus it is suggested that 48 hours seed hydro-priming duration may be practiced to enhance the germination and better vegetative growth of okra

Keyword: Okra, Germination, Hydro- priming duration, Sabz pari and Water uptake

INTRODUCTION

The okra, *Abelmoschus esculentus* (Malvaceae) is one of the popular summer vegetable crops that is generally grown from February-July in Pakistan. Due to its highly nutritious value it very popular among farming community and generally grown in all agro-ecological zones of the country. The okra likes warm weather and performs well on sandy loam soil with pH range between5-6 (Shahid *et al.*, 2013). The optimal germination takes place at temperature between 24-30 ^{0}C (Hassanpouraghdam *et al.*, 2009). Okra is mainly cultivated for its highly delicious tender pods (Arif *et al.*, 2014). It offers diverse nutritional and health benefits. The okra seed is rich in anti-oxidants which helps to prevent from multiple forms of cancer (Hsu *et al.*, 2003; Wang *et al.*, 2003).). Likewise, okra pods are also rich sources of flavonoid antioxidants such as lutein, xanthine and beta carotene etc. Its pods are rich in minerals, protein and vitamins A, B and C. Moreover, stem of the plant is also of high economical value and used in paper industry'' (Kumar *et al.*, 2010; Farinde *et al.*, 2007; Maurya *et al.*, 2013). The faster and uniform germination of seed is pre-requisite for higher yield and quality production of okra (Lima & Marcos, 2010). Due to its thick and hard seed coat, the acquisition of water in the seed occurs gradually, emergence of okra in the field is therefore always a great problem (Moyin-Jesu, 2007). In order to enhance the seed germination, different approaches including priming is applied in okra (Mereddy *et al.*, 2015). Seed priming is cost effective and good approach for improving the performance of crop (Sedghi *et al.*, 2010). It is a physiological approach that is involved hydration of seed in water or any priming agent to enhance physiological processes necessary for seed germination without radicle emergence (Premsekhar & Rajashree, 2009). Several line of evidence have shown that diverse horticultural crop species respnononded positively to priming with regards to seed germination, stand establishment and higher crop yield (Di Girolamo & Barbanti, 2012).

The benefits of priming including breaking of seed dormancy, rapid germination, seedling establishment and nutrient and water use efficiency all have been well documented (Anwar *et al*., 2010). Priming has long been described as key strategy to improve the germination and seedling vigour and eventually affect the performance of crops in terms of higher yield (Muhammad *et al*., 2007). Primed seeds take less time for seed germination in comparison with unprimed seed and also show uniformity in seed emergence that lead to better seedling establishment and crop productivity (Moyin-Jesu, 2007). Moreover, available reports reveals that primed seed are less vulnerable to stress conditions (Gopalan *et al*., 1989; Shah and Shafi. 2011; Mohammadi 2009; Sedghi *et al*., 2010; Binang *el al*., 2012).Hydro-priming is one of the fundamental and environmentally friendly practice that is generally done by soaking the seed in the water for specific period followed by re-drying prior to sowing of seed in the field(Tania *et al*., 2019).This results effective imbibition of water in the seed that makes seed coat soft enough and trounce the seed dormancy for early, rapid and uniform germination of the seed (Pandita *et al*., 2007).A large number of crop species showed positive response to hydro- priming in terms of uniform seed germination, early emergence, vigorous seedlings and better crop establishment (Harris *et al*., 2002, Hsu *et al*., 2003; Wang *et al*., 2003). The seed coat of okra is hard and often takes more time to make softer the seed coat for early seed emergence that led to delayed germination (Lamichhane *et al*., 2021). Moreover, sluggish and irregular emergence is the major problem in the okra seed which results uneven seed emergence low water and fertilizer efficiency and eventually lower yield (Kaur *et al*., 2015; Lutts *et al*., 2016). Hydro-priming is one of the key strategies to overcome the delayed and sluggish germination of okra (Tania *et al*., 2020). Several lines of evidence have revealed that okra responded positively to hydro-priming durations for seed growth and yield associated attributes (Saleem, 2013; Raturi, 2013; Demir & Ermis 2003; Afzal *et al*., 2005; Varierf *et al*., 2010). Each crop species has certain priming period for better seed germination which is generally lower than safe limit (Harris *et al*., 2002). In order to achieve the better impact, the knowledge of exact priming duration is mandatory. In case of okra, the knowledge about the proper hydro-priming duration is lacking in the country, especially in the Sindh province of Pakistan. The present study was therefore conducted to assess the germination and growth performance of okra under various hydro-priming duration and to determine the optimum seed hydro-priming duration for okra under agro-climatic conditions of Tandojam, Sindh Province, Pakistan.

MATERIALS AND METHODS

Experimental Site and Weather conditions: The experiment was performed at the experimental field of Department of Horticulture, Sindh Agriculture University Tandojam, Pakistan. The experimental site lies at 28°35'N to 81°37'E. The soil used in the study was non-saline silty loam, where spinach was cultivated before the study. It is divided by four different seasons: rainy monsoon (June-October), cold winter (November-February), and warm spring (March-May). Trial was performed from February2022 to March 19, 2022.

Experimental design: The experimental design was a single factor Randomized Complete Block Design (RCBD) with three replications The okra seed of variety (Sabz pari) was studied under six hydro-priming treatments including P1; Control (No priming), P2: 12 hours, P3: 18 hours, P4: 24 hours, P5: 36 hours, and P6: 48 hours). In control treatment seeds were not soaked in water. The seed used in the study had a high genetic and physiological purity with at least 80% germination.

Data Recording: Water uptake %: The weight of seeds was initially measured on digital weight balance. After that seeds were fully soaked separately in 200 millimeters (ml) of tap water in a plastic cup at room temperature (25 ^{0}C). The seeds weight was re-measured after removing external water to calculate water uptake (Imbibition) % as

Water uptake %: Weight of seeds after priming-weight of seeds before priming
---x100
Weight of seeds before priming

Seeds were then dried in the shed for three hours and sown in the experimental field. The study area comprised of 150 meters and divided into 18 plots. The seeds were sown keeping the space of 15x10 cm between rows and plants.

Germination %: The germinated seeds were observed on daily basis up to 15 days. The germination% was measured by the procedure described by using following formula (Larsen and Andreasen, 2004).

$$\textbf{GP} = \sum n/N \times 100$$

Where n is number of germinated seeds at each counting and N is total seeds in each treatment

Seedlings vigour index: Seedling vigour index was measured by applying the following formula.

Germination % x Seedling length (cm).

Plant height: Plant height (cm) was measured at the interval of two days up to 15 DAS from seven sample plants, each from every row of treatment plots.

Number of leaves per plant: Number of leaves per plant was counted from five random samples of each treatment and their averages were calculated.

Root depth (cm): Root depth was measured with a measuring tap by taking three random samples from each treatment.

Data analysis: The obtained data were set manually for treatment wise and then analyzed using one-way analysis of variance (ANOVA) with Statistix (2008) software source. Least significant difference Test (LSD) at 0.05 probability level was followed to compare the difference between means of treatments.

RESULTS

Water imbibition (%): The hydro-priming showed significant variation in water imbibition % (figure. 1). The maximum imbibition (water uptake) % in the seed was observed with application of increasing hydro-priming duration. The maximum imbibition percent (41.33) and (39.30) was recorded in the seeds that were primed for 48 hours and 36 hours durations, respectively. The lower hydro-priming durations 6, 12, 18 and 24 hours showed significantly less water imbibition %. The minimum imbibition (water uptake) 27.37% in the seed was noted in case of control (unprimed seed). It was further noted that water acquisition in the seed increased up to 36 hours duration. The results of 36 hours duration slightly varied with the results of 48 hours duration Moreover, it is noteworthy that the water imbibition % is directly proportion to hydro-priming durations.

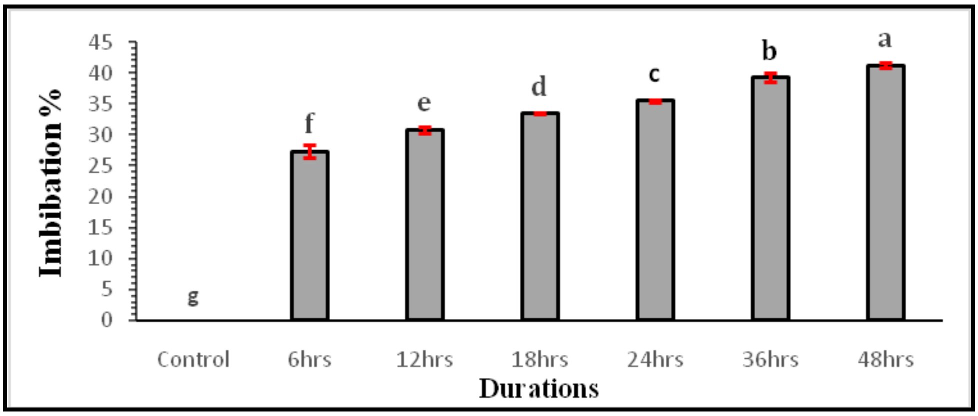

Figure1. Effect of Seed priming durations on Imbibition % of Okra

Seed Germination: The substantial increase in seed germination was observed with increasing hydro-priming durations (Table. 1). The 48 hours seed hydro-priming duration showed maximum germination (70.83%) and control un-primed seeds recorded lowest germination (50.03%) at 10 days. It was further observed that seed germination was relatively higher when hydro-primed for 48 hours duration in comparison with lesser hydro-priming durations. However, seed germination hydro-primed for 48 hours (70.83%) 36 hours (67.67%) and 24 hours (67.33%) were statistically at par at 10 days interval. Likewise, after 15 days of sowing the maximum germination was noted in hydro-primed seeds in comparison with control. The highest germination (82.33%) was observed in seeds primed for 48 hours duration and the un-primed seeds (control) had the minimum germination (67.50%). Most of the hydro-priming durations showed significant effect on seed germination. However seed germination at 36 hours (80.33%) were statistically near to 48 hours hydro-primed seeds. Moreover, no substantial differences were observed within the treatments horizontally.

Table 1 Seed germination (%) of okra response to various hydro-priming duration at different days

Treatment	**Germination (%) of seeds at different days**				
	Day 4	**Day6**	**Day8**	**Day10**	**Day15**
Control (No- Hydro priming)	12.20 ^{f}	23.23^{g}	40.16^{g}	50.03^{e}	67.50^{g}
6 hours of hydropriming	13.70 ^{e}	25.50^{f}	42.16^{f}	52.43^{d}	67.50^{g}
12 hours of hydrpriming	16.00 ^{d}	26.76^{e}	44.16^{e}	53.16^{cd}	70.16 ^{e}
18 hours of hydroproming	17.16 ^{c}	27.50^{d}	45.66^{d}	54.10^{c}	71.83 ^{d}
24 hours of hydropriming	18.16 ^{c}	28.50^{c}	47.833^{c}	67.33 ^{c}	78.83 ^{c}
36 hours of hydropriming	19.83 ^{b}	32.33^{b}	51.50^{b}	69.66 ^{a}	80.33 ^{b}
48 hours of hydropriming	21.16 ^{a}	33.33^{a}	52.50^{a}	70.83^{a}	82.33 a
LSD (=0.005)	1.0489	0.4941	0.8535	1.3255	1.2403
SE ±	0.4814	0.2268	0.3917	0.6084	0.5693

Plant height: The different priming durations exhibited considerable effect on plant height as revealed in (Table-1). The plant height increased simultaneously with increasing priming durations. The tallest plants were observed on 48 hours pre-sowing hydro-priming duration, which was considerably greater than other priming durations but were similar with 36 hours priming duration. At 15 days of sowing recorded seedling height was noted to be relatively greater (18.92cm) for the seeds primed for 48 hours in comparison with other priming treatments. The lowest seedling height was noted in unprimed seeds (4.42 cm). The hydro-priming durations for 6, 12, 18, 24 and 36 hours showed plant height (5.78 cm), (5.97 cm), (6.83cm), (8.71 cm) and (11.87 cm), respectively. However, no statistical variation was observed horizontally within the treatment with respect to days.

Table-2 Plant height (cm) of Okra response to various hydro-priming duration at different days

Treatment	**Plant Height (cm) of okra at different days**				
	Day 4	**Day6**	**Day8**	**Day10**	**Day15**
Control (No- Hydro priming)	3.100 g	3.170 g	3.733 g	4.140f	4.423 g
6 hours of hydropriming	4.927 f	5.237 f	3.767 f	4.143f	4.780 f
12 hours of hydrpriming	5.040 e	5.340 e	5.483 e	5.650e	5.827 e
18 hours of hydroproming	5.170 d	5.543 d	5.750 d	7.423d	7.573d
24 hours of hydropriming	7.620 c	7.133 c	7.327 c	8.417c	8.713 c
36 hours of hydropriming	10.530b	10.793b	7.327 c	10.880b	11.807 b
48 hours of hydropriming	13.340 a	16.170a	17.057a	18.323a	18.923 a
LSD (=0.005)	0.0634	0.0238	0.0107	0.0299	0.0179
SE ±	0.0291	0.0109	4.9303	0.0137	8.2300
CV%	0.50	0.18	0.08	0.20	0.12
Grand Mean	7.1038	7.6267	7.7495	8.4252	8.7210

Seedling vigour index (SVI): The seedling vigour index significantly increased with seed hydro-priming durations (Figure. 2). Plants produced from seed that were primed for 48 hours duration had a maximum seedling vigour index (3018.6) followed by 36 hours pre-soaking seed duration (2764.6). The lower hydro-priming durations 6 hours, 12 hours, 18 hours and 24 hours showed seedling vigour index (1131.1), (1409.2), (1867.2) and (2441.4), respectively. The minimum seedling vigour index (840.97) was observed in un-primed seeds (control).

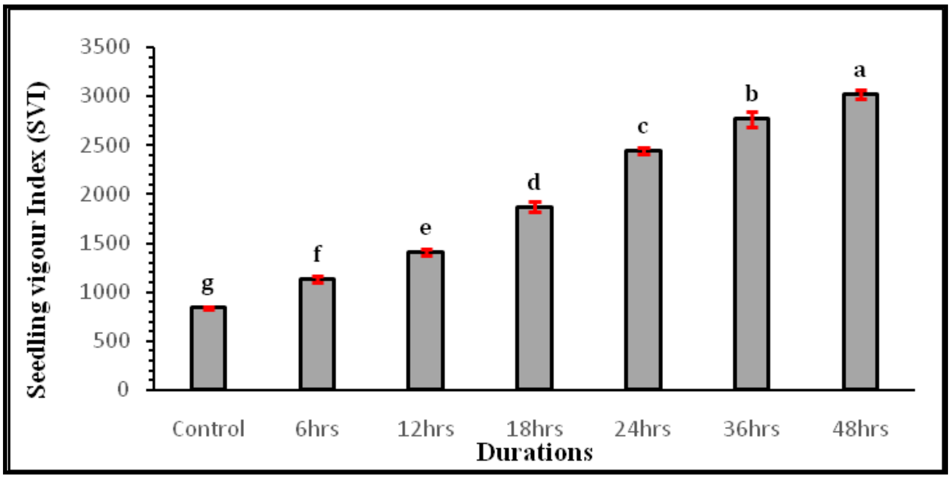

Figure 2. Effect of Seed priming durations on Seedling Vigour index (SVI) of Okra

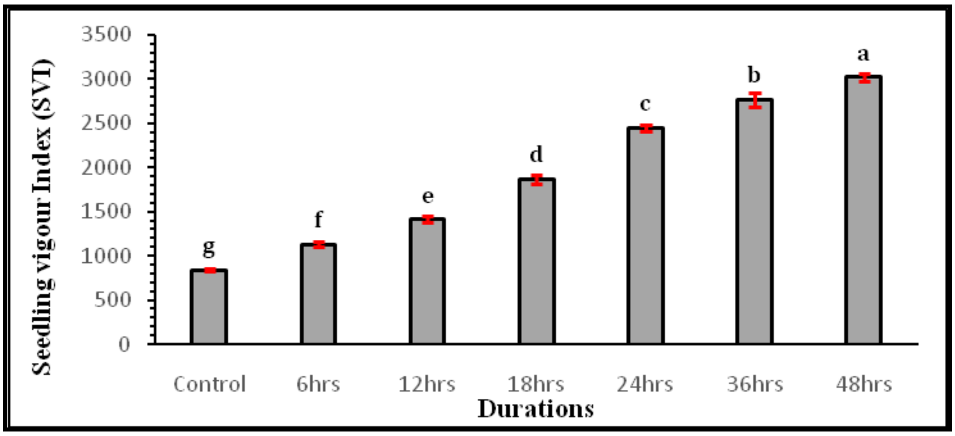

Table. 2. Effect of Seed priming durations on Seedling Vigour index (SVI) of Okra

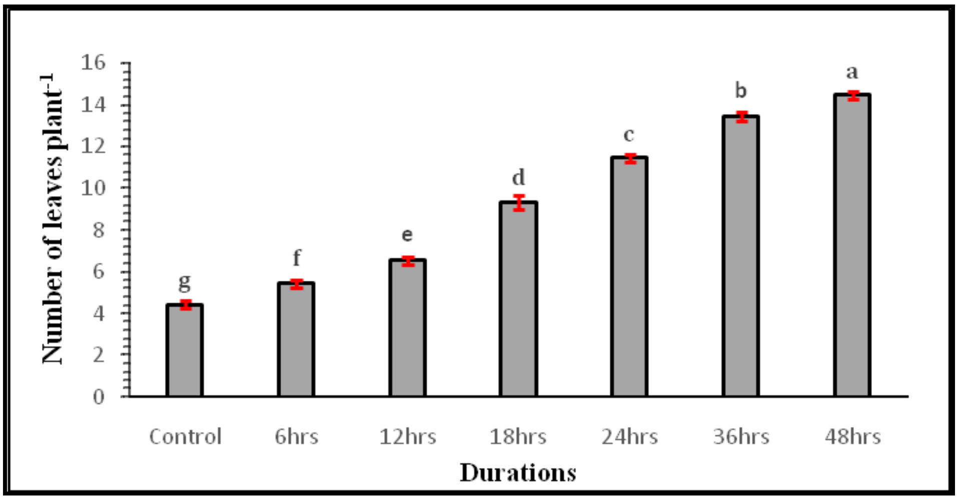

Figure 3. Effect of Seed priming durations on Number of leaves per plant of Okra

Number of leaves plant^{-1}: Statistical analysis demonstrated substantial differences among hydro-priming durations. The results exhibited a significant impact of priming durations on plant growth and subsequently leaves of okra (figure. 3). The seeds primed for 48 hours showed maximum leaves (14.44). Correspondingly, 36 hours duration also marked a significant increase in leaves in an individual plant. However, less difference for number of leaves was noted between 36 hours and 48 hours hydro-priming durations at 0.05 probability level. Thepriming durations 6 hours, 12 hours, 18 hours and 24 hours are also found highly effective in enhancing the growth of plants and recorded more leaves in plants in comparison with control. The less leaves (4.4) were recorded in plants emerged from seeds that were not primed with water.

Root Depth (cm): The root depth revealed a considerable variation in response to different hydro-priming durations (figure. 4). The maximum root depth(12.7cm) was found when seeds were primed for a period of 48 hours. Likewise, seeds primed for 36 hours ranked second and resulted in (10.43 cm) root depth. The smaller roots (4.4 cm) were produced in a plant whose seeds were left untreated. The priming durations 6 hours, 12 hours, 18 hours and 24 hours also had a significant effect on root length and revealed (5.67 cm), (7.76 cm), (7.76 cm) and (10.43 cm) root length. It is noteworthy that slight difference was observed between 48 hours and 36hours hydro-priming durations

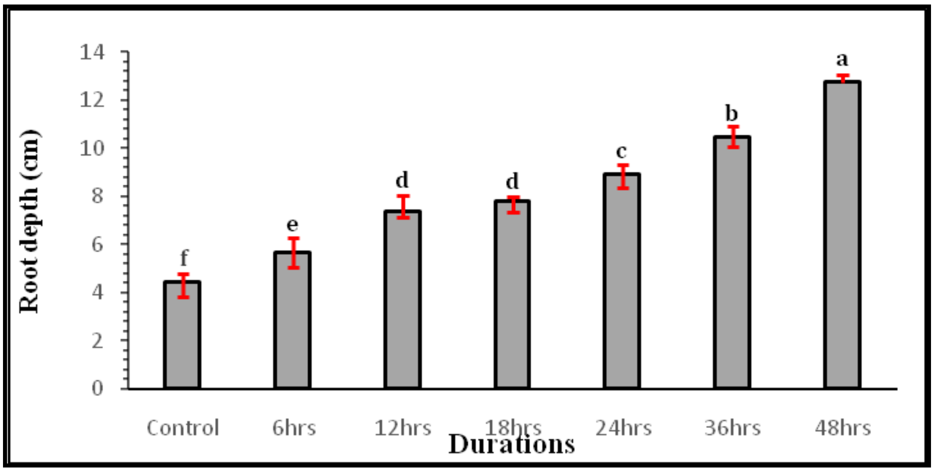

Figure 4. Effect of Seed priming durations on Root depth (cm) of Okra

DISCUSSION

The seed priming with different sources and durations enhanced the germination because before priming, seeds are inactive due to low moisture content (Adhikari *et al*.,2021) so when the seeds were primed with any source, the water imbibition occurs in the seed and seed dormancy breaks up that lead to better and uniform germination of seeds (Tripathy and Maity. 2009; Lutts *et al*., 2016). Similarly, in our study hydro-priming durations also improved the seed germination and seedling growth of okra. It is observed in our study that long priming duration (48 hours) showed better germination in comparison with control and other priming duration. The okra seed is hard and considerable time is required to make softer the seed coat that leads to delay germination. So, when seeds are soaked in water for longer periods that may cause better and uniform germination of the seed(Rahman *et al.* 2016; Lamichhane *et al*., 2021).Similar findings are also reported on other crop species (Baig *et al*., 2020;Farooque *et al*., 2005; Alam *et al*., 2013).It is well reported that each crop species requires certain quantity of water to enter into the lag phase of germination where pre-germination metabolic processes occurs (Sharma *et al*. 2014) so when seeds treats with water or any salt for long period it will allow to acquire water easily and may lead to better activation of enzymes that may enhance germination and seedling growth (Mohammadikenarmereki, 2014). Moreover, it is also well documented that priming with hot water may also remove pathogen infestations within the seed (Lutts *et al*., 2016; Bajehbaj, 2010). In the present study, the water imbibition cure showed two phases of germination of okra. In the first phase water consumption of the seed is high and it lasts up to 36hours. In the second phase less acquisition of water in the seed happened because stable position occurred as substantial amount of water is consumed by atmosphere and significant quantity of water is lost by evaporation. After the completion of both phases the expansion of embryo occurs and germination process is usually completed. The early and uniform germination of the seeds results in faster growth of the plants making plants taller (Afzal *et al*., 2002). In our study, plants emerged from the treated seed grow taller than those produced from untreated seed. Correspondingly similar results were also documented by Adhikari *et al*. (2021) who found positive effect of priming on plant height of bitter gourd. The positive influence of priming on plant height may be associated with the initiation of different biological activities in the seed that may lead to better growth of plants with maximum height. The better height of the plants is also attributed to the better growth and development of roots subsequently better nutrient acquisition occurred that might lead to taller plants (Shakuntala *et al*., 2020). In our study, an increased seedling vigour index was observed in response to priming durations (Figure-2). The increased seedling vigour index in primed seeds is attributed to better enzymatic activities that caused dehydrogenase and increase amylase production that enhanced biochemical activities in the seed resultantly plants with maximum seedling vigour index were produced (Arif *et al*., 2008). Similar beneficial effects of priming were also observed by other researchers on diverse crop species including (Kumar *et al*., 2010; Siemonsma and Kouama, 2004). Priming lead to the foundation of improved root system of plant which is directly associated with better uptake of nutrients and rapid growth that resulted vigorous seedlings.

Hydro-priming showed positive effect on leaves of plants (Figure-3). This reflect that hydro-priming triggers early emergence of seed which is considered to be change from seed germination to vegetative growth of plants (Damalas *et al*., 2019). As leaves are the main photosynthetic organs of most green plants and generally known as food factory of plant. The whole plant food is manufactured in the leaves and conservation of food for future consumption also occurs in the leaf (Ratikanta, 2011). The healthy leaves with better length and width is pre-requisite for satisfactory growth of plants (Mehta *et al*., 2014). In this study, early emergence and faster growth of plants produced from primed seeds led to better vegetative growth, seedling height, subsequently vigorous plants with maximum leaves were produced. Lee & Kim, (2000) also found positive effect of priming on seedling growth and leaf area. Several other workers have also reported that plant vegetative growth including leaves in individual plants is highly influenced by seed priming. Root depth is one of the main traits that considerably affect the growth and development of any plant species (Grover and Yadev, 2004). Pre-soaking hydro-priming duration significantly augmented the root length of plants in this study. The noticeable increased root depth under hydro-priming is due to occurrence of certain physiological changes in the seed that enhanced the biochemical activities of embryo and activated the food reserves that caused increased root length. The other researchers including (Sevik & Guney, 2013; Jyoti *et al*., 2016) also recorded similar findings.

CONCLUSION

Priming of the seed is one of the sustainable approaches to overcome sluggish and uneven germination of okra. The findings of our study further witnessed the significance of priming for okra. The pre-sowing hydro-priming periods had positive effect on seed germination and other associated seedling and root growth parameters of okra. The priming durations 36 hours and 48 hours significantly augmented the water uptake in the seed thus showed increased and uniform germination with better shoot and root growth, but the results of both these hydro-priming durations are statistically at par. Hence, 36 hours hydro-priming duration may be recommended to secure better germination and higher seedling and root growth and development of okra. However, further study under open large field conditions is needed to validate the similar beneficial effect of hydro-priming duration.

ACKNOWLEDGEMENT

The author is highly indebted and acknowledge the contributions of whole team of researcher for support and technical guidance.

AUTHOR CONTRIBUTIONS

Conceptualization, Niaz Ahmed wahocho and Muzamil Farooque Jamali; Methodology, Noor-un-Nisa Memon and Muzamil Farooque Jamali; Validation, Niaz Ahmed Wahocho and Waqas Ahmad; Formal analysis, Khalid Hussain Talpur and

Afifa Talpur; Investigation, Sohail Ahmed Otho, Fayaz Ali Jamali and Afifa Talpur; Resources, Noor-un-Nisa Memon, Piar Ali Shar; Writing– original draft, Niaz Ahmed Wahocho and Muzamil Farooque Jamali; Writing – review & editing, Waqas Ahmad, and Fayaz Ali Jamali.

REFERENCES

Adhikari, B., Dhital, P. R., Ranabhat, S., & Poudel, H. Effect of seed hydro-priming durations on germination and seedling growth of bitter gourd (Momordica charantia). PloS one, **16**(8), e0255258. (2021).

Afzal, I., Ahmad, N., Basra, S. M. A., Ahmad, R., & Iqbal, A. Effect of different seed vigour enhancement techniques on hybrid maize (Zea mays L.). *Pakistan Journal of Agricultural Sciences Pakistan*. (2002).

Alam, A., Amin, N., Ara, N., Ali, M., & Ali, I. Effect of various sources and durations of priming on spinach seeds. *Pakistan Journal of Botany*,**45**(3), 773-777. (2013).

Ali, S., Adnan, M., Ibrahim, M., Saleem, N., & Khan, I. A. (2016). Effect of seed priming on growth parameters of Okra (Abelmoschus esculentus L.). *Pure and Applied Biology*,**5**(1), 165. (2016).

Anwar, F., Rashid, U., Ashraf, M., & Nadeem, M. Okra (Hibiscus esculentus) seed oil for biodiesel production. *Applied Energy*,**87**(3), 779-785. (2010).

Arif, M. Seed priming maize for improving emergence and seedling growth. *Sarhad Journal of Agriculture (Pakistan)*,**21**:4(2005).

Arif, M., Jan, M. T., Marwat, K. B., & Khan, M. A. Seed priming improves emergence and yield of soybean. *Pakistan Journal of Botany*,**40**(3), 1169-1177. (2008).

Baig, K. K., Ara, N., Ali, S., Khan, B. P., Wahab, A., & Rabbani, U. Effect of seed priming on bitter gourd with different sources of phosphorus at various soaking durations. *Pure and Applied Biology (PAB)*,**9**(1), 80-90. (2020).

Bajehbaj, A. A. The effects of NaCl priming on salt tolerance in sunflower germination and seedling grown under salinity conditions. *African Journal of Biotechnology*,9:12(2010).

Binang, W. B., Shiyam, J. O., & Ntia, J. D. Effect of seed priming method on agronomic performance and cost effectiveness of rainfed, dry-seeded NERICA rice. *Research Journal of Seed Science*,**5**(4), 136-143. (2012).

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

Demir, I., & Ermis, S. I. T. K. I. Effect of controlled hydration treatment on germination and seedling growth under salt stress during development in tomato seeds. *European Journal of Horticultural Science*,**68**(2), 53-58 (2003).

Di Girolamo, G., & Barbanti, L. Treatment conditions and biochemical processes influencing seed priming effectiveness. *Italian Journal of Agronomy*,**7**(2), e25-e25. (2012).

Farinde, A. J., Owolarafe, O. K., & Ogungbemi, O. I. An overview of production, processing, marketing and utilisation of okra in egbedore local government area of Osun State, Nigeria. *Agricultural Engineering International: CIGR Journal*. (2007).

Farooq, M. S. M. A., Basra, S. M. A., Saleem, B. A., Nafees, M., & Chishti, S. A. Enhancement of tomato seed germination and seedling vigor by Osmo priming. *Pak. J. Agri. Sci*,**42**, 3-4. (2005).

Gopalan, C., Ramasastri, B. V., & Balasubramanian, S. C. Nutritive value of Indian foods: National Institute of Nutrition. Indian Council of Medical Research, Hyderabad, India Revised Ed, 110–125. (1989).

Grover, J. K., & Yadav, S. P. Pharmacological actions and potential uses of Momordica charantia: a review. *Journal of ethnopharmacology*,**93**(1), 123-132 (2004).

Harris, D., Tripathi, R. S., & Joshi, A. On-farm seed priming to improve crop establishment and yield in dry direct-seeded rice. *Direct seeding: Research Strategies and Opportunities, International Research Institute, Manila, Philippines*, 231-240. (2002).

Hassanpouraghdam, M. B., Pardaz, J. E., & Akhtar, N. F. The effect of osmo-priming on germination and seedling growth of Brassica napus L. under salinity conditions. *Journal of Food, Agriculture and Environment*,**7**(2), 620-622(2009).

Lamichhane, A., Mamata, K. C., & Shrestha, M. Effect of seed priming on germination of okra (Abelmoschus esculentus var. Arka Anamika). *Malaysian Journal of Sustainable Agriculture (MJSA)*,**5**(2), 111-114 (2021).

Hsu, C. C., Chen, C. L., Chen, J. J., & Sung, J. M. Accelerated aging-enhanced lipid peroxidation in bitter gourd seeds and effects of priming and hot water soaking treatments. *Scientia Horticulturae*,**98(**3), 201-212. (2003).

Jamil, M., & Rha, E. S. Gibberellic acid (GA3) enhance seed water uptake, germination and early seedling growth in sugar beet under salt stress. *Pakistan Journal of Biological Sciences*,**10(**4), 654-658.(2007).

Jyoti, B., Gaurav, S. S., & Pant, U. Use of growth regulators as priming agent for improvement of seed vigour in tomato (Lycopersicum esculentum). *of Applied and Natural Science*,**8**(1), 84-87. (2016).

Kaur, H., Chawla, N., & Pathak, M. Effect of different seed priming treatments and priming duration on biochemical parameters and agronomic characters of okra (Abelmoschus esculentus L.). *International Journal of Plant Physiology and Biochemistry*,**7**(1), 1-11. (2015).

Kumar, S., Dagnoko, S., Haougui, A., Ratnadass, A., Pasternak, N., & Kouame, C. (2010). Okra (Abelmoschus spp.) in West and Central Africa: Potential and progress on its improvement. (2010).

Lee, S., & Kim, J. Total sugars, α-amylase activity, and germination after priming of normal and aged rice seeds. *Korean Journal of Crop Science*,**45**(2), 108-111. (2000).

Lima, L. B. D., & Marcos Filho, J. Cucumber (Cucumis sativus) seed priming methods and germination at different temperatures. *Revista Brasileira de Sementes*,**32**, 138-147. (2010).

Lutts, S., Benincasa, P., Wojtyla, L., Kubala, S., Pace, R., Lechowska, K., & Garnczarska, M. Seed priming: new comprehensive approaches for an old empirical technique. *New challenges in seed biology-basic and translational research driving seed technology*,**46**(2016).

Maurya, R. P., Bailey, J. A., & Chandler, J. S. A. Impact of plant spacing and picking interval on the growth, fruit quality and yield of okra (Abelmoschus esculentus (L.) Moench). *American Journal of Agriculture and forestry*,**1**(4), 48-54. (2013).

Mehta, D. K., Kanwar, H. S., Thakur, A. K., Thakur, S., & Thakur, K. S. Standardization of seed hydro-priming duration in bitter gourd, Momordica charantia L. *International Journal of Bio-resource and Stress Management*,**5**(1), 98-101. (2014).

Mereddy, R. Solid matrix priming improves seedling vigor of okra seeds. In *Proceedings of the Oklahoma Academy of Science* (pp. 33-37). (2000).

Mohammadi, G. R. The influence of NaCl priming on seed germination and seedling growth of canola (Brassica napus L.) under salinity conditions. *American-Eurasian Journal of Agricultural and Environmental Science*,**5**(5), 696-700. (2009).

Mohammadikenarmereki, G. Studies of factors effecting an improvement of seed production and seed quality in okra, seed hardness and methods of overcoming this problem. (2014).

Moyin-Jesu, E. I. Use of plant residues for improving soil fertility, pod nutrients, root growth and pod weight of okra (Abelmoschus esculentum L). *Bioresource technology*,**98**(11), 2057-2064. (2007).

Pandita, V. K., Anand, A., & Nagarajan, S. Enhancement of seed germination in hot pepper following presowing treatments. *Seed Science and Technology*,**35**(2), 282-290. (2007).

Perveen, A., Naqvi, I. M., Shah, R., & Hasnain, A. Comparative germination of barley seeds (Hordeum vulgare) soaked in alkaline media and effects on starch and soluble proteins. *Journal of Applied Sciences and Environmental Management*,**12(**3) (2008).

Premsekhar, M., & Rajashree, V. Influence of organic manures on growth, yield and quality of okra. *American-Eurasian Journal of Sustainable Agriculture*, **3**(1), 6-8. (2009).

Maiti, R. Seed priming: efficient farmers’ technology to improve seedling vigour, seedling establishment and crop productivity. *International Journal of Bio-resource and Stress Management*,**2**(Sep 3), i-iv. (2011).

Raturi, H. C. *Studies on seed priming in cucumber (Cucumis sativus L.)* (Doctoral dissertation, Doctoral dissertation). (2013).

Sedghi, M., Nemati, A., & Esmaielpour, B. Effect of seed priming on germination and seedling growth of two medicinal plants under salinity. *Emirates Journal of Food and Agriculture*, 130-139. (2010).

Sevik, H., & Guney, K. Effects of IAA, IBA, NAA, and GA3 on rooting and morphological features of Melissa officinalis L. stem cuttings. *The Scientific World Journal*, **1** *Jan* (2013).

Shahid, M. R., Amjad, M., Ziaf, K., Jahangir, M. M., Ahmad, S., Iqbal, Q., & Nawaz, A. Growth, yield and seed production of okra as influenced by different growth regulators. *Pakistan Journal of Agricultural Sciences*,**50**:3 (2013).

Shakuntala, N. M., Kavya, K. P., Macha, S. I., Kurnalliker, V., & Patil, M. G. Studies on standardization of water soaking duration on seed quality in cucumber (Cucumis sativus L.) seeds. *Journal of Pharmacognosy and Phytochemistry*, **9**(4), 1400-1404. (2020).

Tania, S. S., Hossain, M. M., & Hossain, M. A. Effects of hydropriming on seed germination, seedling growth and yield of bitter gourd: Hydropriming of bitter gourd seeds. *Journal of the Bangladesh Agricultural University*,**17**(3), 281-287. (2019).

Varier, A., Vari, A. K., & Dadlani, M. The subcellular basis of seed priming. *Current Science*, 450-456. (2010).

Wahid, A., Noreen, A., Basra, S. M., Gelani, S., & Farooq, M. Priming-induced metabolic changes in sunflower (Helianthus annuus) achenes improve germination and seedling growth. *Botanical Studies*,**49**(2), 343-350. (2008).

Wang, H. Y., Chen, C. L., & Sung, J. M. Both warm water soaking and Matri conditioning treatments enhance anti-oxidation of bitter gourd seeds germinated at sub-optimal temperature. *Seed Science and Technology*,**31**(1), 47-56. (2003)